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April 7, 2023

Advanced Clean Fleets
California Air Resources Board
1001 I Street,
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(Submitted via the Workshop Comment Submittal Form and by email to zevfleet@arb.ca.gov)

Re: Comments on Advanced Clean Fleets (ACF) Regulation 15-Day Rulemaking Package

The Western States Petroleum Association (WSPA) and the American Fuel & Petrochemical Manufacturers (collectively the "Associations") appreciate the opportunity to comment on the 15-Day Rulemaking Package for the proposed Advanced Clean Fleets (ACF) Regulation, posted by the California Air Resources Board (CARB) on March 23, 2023 ahead of the Public Hearing to be held on April 27, 2023.[1]

WSPA is a non-profit trade association that represents companies that import and export, produce, refine, transport and market petroleum, petroleum products, natural gas and other energy supplies in California and four other western states, and has been an active participant in air quality planning issues for over 30 years.

AFPM is a national trade association representing the refining and petrochemical industries. AFPM members produce most of the gasoline and diesel fuel consumed in California and are directly affected by this proposed rule.

The Associations appreciate the additional stakeholder engagement efforts CARB made since releasing the 45-day rulemaking package. This afforded CARB leadership and staff an opportunity to better understand the significant outstanding concerns and known implementation challenges for the proposed rule. Unfortunately, the 15-day rulemaking package does little to alleviate those concerns. At this point, WSPA strongly recommends that CARB should do the following:

1. We ask CARB to defer adoption until Staff can present a regulation that can be feasibly implemented given the known permitting and other challenges (absent state and federal legislative action to address) and anticipated CEQA-related lawsuits (absent state legislative action to modify) that would reasonably be expected to delay the necessary infrastructure and renewable energy capacity build-out at the scale that this proposed regulation is dependent upon.

2. Given that CARB itself has acknowledged the presence of multiple barriers (including, but not limited to, permitting and infrastructure build out) to ACF implementation over the next several years, if CARB proceeds with this proposed regulation, the CARB Board should establish twice-yearly status reports from staff that include input from affected stakeholders gathered from public workshops so that expeditious corrective action, if needed, can be taken by CARB.

[1] CARB. Notice of Public Hearing to Consider Proposed Advanced Clean Fleets Regulation on April 27, 2023. Available at: https://content.govdelivery.com/accounts/CARB/bulletins/351d401. Accessed: March 2023.

3. CARB should expand the Qualified Research Laboratory Test Fleet exemption to include laboratory fleets that perform lubrication, fuel and fuel additive research for internal combustion engine advancement.
4. CARB should re-consider key points raised in this letter with regards to CEQA considerations for alternative technologies, a Clean Air Act waiver, permitting challenges, infrastructure readiness, and the environmental impact of zero emission vehicles (ZEVs).

Indeed, CARB's own 2022 Scoping Plan Update repeatedly acknowledged that "significant areas of uncertainty include permitting wait times…" and that "the successful rate of deployment of clean technology and fuels—including consumer adoption patterns, economic recovery from the pandemic, and the permitting and build-out of necessary new assets and reuse of existing assets to produce and deliver clean energy—" would be essential.[2] The state has yet to address permitting reform to enable implementation of ACF on the timeline envisioned. The proposed mandates in the ACF regulation are so infeasible that even CARB has recognized that it will effectively be a regulation by exceptions (see comments below).

WSPA has been an active participant in the ACF rulemaking process, submitting written comments dated May 10, 2021;[3] October 29, 2021;[4] and October 17, 2022[5] and providing oral testimony at the workshops and Board hearings held on October 27, 2022; January 13, 2023; and February 13, 2023. These comment letters have been included as attachments below. Despite this significant engagement, CARB has not addressed many of the outstanding concerns WSPA has raised, including but not limited to the following:

- CEQA considerations related to alternative technologies: CARB should follow an objective technology-neutral policy approach and allow the use of low-carbon-intensity (low-CI), low-NO_X technologies as an alternative ZEVs in the proposed ACF regulation. These technologies are commercially available now, would generate greater near-term reductions in NO_X emissions, and not be subject to the fundamental issues related to technology/infrastructure readiness of ZEVs. The rate at which emission reductions can be accomplished is critical to the state's Clean Air Act obligations to attain national air quality standards. But to date, CARB has failed to appropriately consider these technology options as alternatives within the Environmental Analysis (EA) for the regulation, despite evidence of their benefits as discussed in the attached comment letters dated May 10, 2021; October 29, 2021; and October 17, 2022, and the Ramboll Heavy-Heavy Duty Truck Case Study

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2 CARB 2022 Scoping Plan Update at page 98, 109. Available at https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf. Accessed: March 2023.
3 WSPA. 2021. Comments on ACF Regulation March Workshops. May 10. Available here: https://www.arb.ca.gov/lists/com-attach/36-acf-comments-ws-UCdTJlUkAzFVDFMy.pdf. Accessed: March 2023.
4 WSPA. 2021. Comments on ACF Regulation September Workshop. October 29. Available here: https://www.arb.ca.gov/lispub/comm2/iframe_bccomdisp.php?listname=acf-comments-ws&comment_num=109&virt_num=94. Accessed: March 2023.
5 WSPA. 2022. Comments on ACF Regulation Initial Statement of Reasons (ISOR) and Draft Environmental Analysis (EA). October 17. Available here: https://www.arb.ca.gov/lists/com-attach/292-acf2022-Wi1VIAFwVGZQCVc2.pdf. Accessed: March 2023.

presented to CARB staff on May 20, 2021.[6] Failure to consider such technologies would violate the agency's duty to consider "reasonable alternatives" under California Government Code Section 11346.2(b)(4)(A),[7] which is defined as including "alternatives that are proposed as less burdensome and equally effective in achieving the purposes of the regulation."[8] Such failure also violates the CEQA Guidelines, which specify that CARB must consider a reasonable range of alternatives that "shall include those that could feasibly accomplish most of the basic objectives of the project and could avoid or substantially lessen one or more of the significant effects."[9] CARB is also prohibited from predetermining a particular method to narrow the alternatives it considers for achieving the agency's ultimate policy goals. When examining whether or not alternatives or particular features have been foreclosed by the agency, courts look "to the surrounding circumstances to determine whether, as a practical matter, the agency has committed itself to the project as a whole or to any particular features, so as to effectively preclude any alternatives or mitigation measures that CEQA would otherwise require to be considered."[10] By not adequately considering the use of low-CI, low-NO_X technologies and relying on ZEVs, CARB has effectively predetermined the outcome of this rulemaking.

- Clean Air Act Waiver: In order for the ACF rule to be legally adopted and enforced in California and/or other Section 177 states, CARB must acquire a waiver under the Clean Air Act from the United States Environmental Protection Agency (USEPA). The U.S. Supreme Court and Ninth Circuit decisions direct so, especially given that under Supreme Court precedent, a purchasing mandate that regulates vehicles to meeting prescribed emission standards was considered likely to be preempted.[11] CARB cannot enforce any rule that would be preempted prior to EPA's authorization.[12] CARB may need to defer implementation of the regulation given recent delays in the USEPA's Clean Air Act waiver process. CARB needs to estimate when the petition for a waiver will be submitted to USEPA and when they expect action in response from USEPA. CARB must clarify how enforcement will be deferred if a decision is not made on the waiver before the beginning of any rule implementation requirements.[13]

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[6] Ramboll. 2021. Multi-Technology Pathways to Achieve California's Air Quality and Greenhouse Gas Goals: Heavy-Heavy-Duty Truck Case Study. February 1. Available here: https://www.arb.ca.gov/lists/com-attach/78-sp22-kickoff-ws-B2oFdgBtUnUAbwAt.pdf. Accessed: March 2023.

[7] *See also* Cal. Health & Safety Code § 57005 (less costly but equally effective alternatives).

[8] California Government Code Section 11346.2(b)(4)(A) also states that when an agency proposes to "mandate the use of specific technologies or equipment or prescribe specific actions or procedures, the imposition of performance standards shall be considered as an alternative." Contrary to CARB's position, *see* ISOR at 269-70, WSPA also argues that the proposed rule is a technology mandate.

[9] Cal. Code Regs. tit. 14, § 15126.6(c).

[10] *Save Tara v. City of W. Hollywood*, 45 Cal. 4th 116, 139 (2008), as modified (Dec. 10, 2008).

[11] *See Engine Mfrs. Ass'n v. S. Coast Air Quality Mgmt. Dist.*, 541 U.S. 246, 258–59 (2004); *Jensen Family Farms, Inc. v. Monterey Bay Unified Air Pollution Control Dist.*, 644 F.3d 934, 940 (9th Cir. 2011) ("[A] state regulation requiring that vehicles or engines not emit more than a certain amount of a given pollutant . . . is easily a 'standard relating to the control of emissions.'").

[12] *Pacific Merchant Shipping Ass'n v. Goldstene*, 517 F.3d 1108, 1115 (2008) (requiring that the Clean Air Act statute which would preempt the California rule "requires California to obtain EPA authorization *prior to* enforcement." (emphasis added)).

[13] "The Clean Air Act allows California to seek a waiver of the preemption which prohibits states from enacting emission standards for new motor vehicles. ***EPA must grant a waiver, however, before California's rules may***

- Infrastructure Readiness: CARB must take into consideration the serious concerns regarding infrastructure readiness that have been raised by multiple stakeholders and that still remain. These concerns are fundamental to the technical feasibility of the proposed regulation (including the timetables) and whether regulated parties will be able to meet these mandates. As discussed previously,[14] CARB must broadly consider a wide range of impacts to the state's economy, and also has a statutory duty to consider technological feasibility,[15] of which infrastructure readiness is intrinsically a part. Utilities have repeatedly raised concerns that the timeline for infrastructure buildout necessary for individual fleets to transition to ZEVs can be as much as 10 years, yet CARB has effectively been silent on all of the issues raised above, both at the economic and technological levels. Demanding that fleets electrify within the timeline proposed under ACF is unreasonable and unrealistic. Utilities have expressed concern that local substation capacity upgrade timelines may often exceed the five years permitted under the Site Electrification Delay extension. More critically, utilities have cited lack of electricity transmission infrastructure as a barrier to meeting local electricity demand growth. CARB must also consider the electricity demand that will be caused by concurrent state efforts to electrify other sectors, such as the residential and light-duty vehicle sectors. Electricity demand for medium- and heavy-duty battery electric vehicles (BEVs) cannot be considered in isolation. Rather those impacts must be considered as part of the broader energy system for supply, distribution, and system reliability. Furthermore, failure to consider how increased electricity demand may necessitate the buildout of additional gas infrastructure, thereby increasing emissions, violates CEQA.[16]

- Life Cycle Impacts and Leakage: CARB has failed to consider life cycle greenhouse gas (GHG) impacts or leakage of emissions from vehicle and battery production and disposal that is likely to result from the ACF regulation as proposed. CARB has a statutory duty to minimize the emissions leakage potential of any regulatory activities under California Health and Safety Code Section 38562(b)(8), and the agency's failure to even consider the leakage issue raised in WSPA's multiple comment letters violates CEQA.[17] CARB has suggested that lifecycle GHG emissions impacts for the manufacture of ZEVs and batteries was conducted under the Advanced Clean Trucks (ACT) regulation,[18] however no reference to such analysis was found within the ACT regulatory documents. Ramboll, on behalf of WSPA, attempted to contact CARB staff regarding these claims on March 3, 2023, and March 21, 2023, and have yet to receive a response. Even if such an analysis was conducted separately, CARB would need to present and discuss the application of such analysis (if it exists) as part of the proposed ACF regulation. This discussion should address the applicability of the analysis to the currently proposed regulation and address any needed

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be enforced. " [***Emphasis added***] From https://www.epa.gov/state-and-local-transportation/vehicle-emissions-california-waivers-and-authorizations. Accessed April 2023.

14 *See* pages 2–4 of the comment letter, *supra*.

15 *See* Health & Safety Code §§ 38560, 38562, 39602.5, 43013, 43018.

16 *See* Cal. Code Regs. tit. 17, § 60004.2.

17 The agency's failure in this regard also violates CEQA, which requires that the Draft EA contain "[a] discussion and consideration of environmental impacts, adverse or beneficial, and feasible mitigation measures which could minimize significant adverse impacts identified," as well as "[a] discussion of cumulative and growth-inducing impacts." Cal. Code Regs. title17, § 60004.2(a).

18 CARB Staff comment during ACF Workshop on February 13, 2023.

changes in the analysis, considering the currently proposed regulation was not developed at the time the original analysis purportedly was prepared.

- Critical Mineral Impacts: Under numerous California laws,[19] CARB must broadly consider a wide range of impacts to the state's economy, and the agency must also consider a regulation's cost-effectiveness and technological feasibility. Notwithstanding these statutory requirements, CARB has not evaluated the impact this regulation will have on California's demand for critical mineral resources, in combination with other adopted and planned regulations such as Advanced Clean Cars II (ACC II), and whether this rising demand can be met given existing supply chain concerns and competing global demands for these scarce resources. As discussed in the comment letter on the ACC II regulation dated May 31, 2022,[20] the U.S. is disproportionately reliant on international supplies of the critical minerals necessary for ZEV and battery production, increasing this risk. Ninety-one percent of the lithium that the U.S. imports is sourced from Chile and Argentina.[21] Relatedly, China controls an outsized portion of the production of aluminum, cobalt, graphite, molybdenum, and other minerals needed to produce electric vehicles compared to other foreign nations that produce those minerals. To the extent CARB has failed to consider the cumulative environmental impacts increased mining could have in California, the agency must also fully consider these impacts in its Environmental Assessment.[22]

- Battery Recycling: CARB has not adequately established a plan for the end-of-life treatment for the volume of batteries that will be produced under these regulations or quantified their emissions impacts. CARB must consider sustainability in the supply, processing and utilization of resources supporting ZEV and vehicle components. Sustainability must not stop at tailpipe emissions but extend into other critical elements including environmental impacts from mining and production of batteries such as water quality, biodiversity and land use changes, waste management and the protection of human rights, and these requirements must be incorporated into the ACF rule. The agency's failure to address any of the above concerns not only violates CEQA[23]—it also contravenes CARB's duty to consider the regulation's technological feasibility and the regulation's impact on the state's economy.[24]

- Tire Wear and Road Dust Emissions: In violation of CEQA,[25] CARB has failed to assess particulate matter impacts from tire wear or entrained road dust, which have the potential to be greater in electric vehicles compared to their internal combustion engine vehicle (ICEV)

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[19] *See, e.g.*, Cal. Health & Safety Code §§ 38560, 38562, 39602.5, 43013, 43018, 43018.5, 43101; *see also* Cal. Gov't Code 11346.3 (significant economic impact assessment).

[20] Ramboll. 2022. Comments on ACC II Regulation Initial statement of Reasons Documents. May 31. Available here: https://www.arb.ca.gov/lists/com-attach/477-accii2022-AHcAdQBxBDZSeVc2.pdf. Accessed: March 2023.

[21] U.S. Geological Survey. 2021. Mineral Commodity Summaries 2022. January 31. Available at: https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf. Accessed: March 2023.

[22] *See* Cal. Code Regs. tit. 17, § 60004.2.

[23] *See id.*

[24] See footnotes 10, 11, and 13, among others. In addition, the agency's inadequate analysis on end-of-life treatment of batteries undermines its compliance with the duty to consider reasonable alternatives, since low-CI, low-NO_X technologies do not implicate the harms stemming from increased use of batteries or other ZEV components. *See, e.g.*, Cal. Health & Safety Code § 57005 (equally effective alternatives); Cal. Gov't Code § 11346.2(b)(4)(A) (reasonable alternatives); Cal. Code Regs. tit. 14, § 15126.6(c) (CEQA Guidelines on alternatives).

[25] *See, e.g.*, discussion *supra* page 3 (the need to analyze all significant adverse environmental impacts).

counterparts. As noted in previous WSPA comments and based on CARB's own emission models and inventories,[26] the tire wear and entrained road dust emissions account for >80% of the total PM emissions associated with medium- and heavy-duty vehicles. There is a high correlation between entrained road dust and tire wear emissions and vehicle weight.[27,28,29] In addition, a study by the American Transportation Research Institute (ATRI)[30] found that the weight of a BEV Class 8 Sleeper Cab tractor is nearly double that of a comparable ICEV, weighing 32,016 pounds (lbs) versus 18,216 lbs. Therefore, converting ICEVs to ZEVs under the proposed ACF regulation would significantly increase the average vehicle weight on California roadways, which in turn would increase the entrained road dust emissions. There also exists overall truck weight restrictions, which if enforced, would require a greater number of ZEVs to move the same tonnage of cargo, thus increasing vehicle miles traveled and PM emissions. If heavier ZEV trucks are allowed under the regulation, then the increase in entrained road dust due to vehicle weight must be quantitatively evaluated. Including these emissions in the analysis could potentially change the conclusions of CARB's analysis and the finding of significance in the Draft EA. Hence, CARB must evaluate these emissions.

Instead of addressing the above concerns, the Proposed 15-Day Changes add further challenges and new layers of complexity to the proposed regulation. The Proposed 15-Day Changes magnify our concern that CARB is failing to comply with its statutory duty to consider technological feasibility, cost effectiveness, and economic implications.

- The Associations are concerned that the change of the 100% ZEV sales mandate from 2040 to 2036 is arbitrary and fails to appropriately analyze the feasibility of such an acceleration. This sales requirement would impact all vehicles and fleets (such as those in low-population areas and in private non-high-priority fleets), not just the fleets covered by the ACF. CARB failed to demonstrate that the 2040 target would be feasible, given concerns about vehicle availability, infrastructure readiness, and critical minerals demand. Suggesting an earlier deadline only exacerbates these problems and makes the regulation even more unachievable. This change represents a dramatic departure from the draft regulatory documents and the ZEV sales percentage schedule outlined in the Advanced Clean Trucks regulation, which currently requires that 55% of Class 2b-3 vehicles, 75% of Class 4-8 vehicles, and 40% of Class 7-8 tractors sold be ZEV in 2035, just one year before this new requirement would take effect.[31] We believe that CARB should consider the proposed acceleration to 2036 as a separate rulemaking as it impacts a broader set of stakeholders

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[26] c.f., https://ww2.arb.ca.gov/criteria-pollutant-emission-inventory-data. Accessed March 2023.
[27] CARB. Miscellaneous Process Methodology 7.9: Entrained Road Travel, Paved Road Dust. 2021. Available here: https://ww3.arb.ca.gov/ei/areasrc/fullpdf/2021_paved_roads_7_9.pdf. Accessed: March 2023.
[28] Woo, Sang-Hee, Jang, Hyungjoon, et al. "Comparison of total PM emissions emitted from electric and internal combustion engine vehicles: An experimental analysis". October 2022. Available here: https://www.sciencedirect.com/science/article/pii/S004896972204058X. Accessed: March 2023.
[29] Timmers, Victor and Peter Achten. "Non-exhaust PM emissions from electric vehicles". March 2016. Available here: http://www.soliftec.com/NonExhaust%20PMs.pdf. Accessed: March 2023.
[30] ATRI. Understanding the CO_2 Impacts of Zero-Emission Trucks. 2022. Available here: https://truckingresearch.org/wp-content/uploads/2022/05/ATRI-Environmental-Impacts-of-Zero-Emission-Trucks-Exec-Summary-5-2022.pdf. Accessed: March 2023.
[31] CARB. 2021. ACT Final Regulatory Order. March 15. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf. Accessed: March 2023.

not previously targeted by the proposed ACF regulation. Therefore, this proposed requirement needs a separate feasibility, emissions, and cost-benefit analyses.

- The exemptions provided in the Proposed 15-Day Changes are highly complicated and convoluted and fail to address stakeholder concerns with vehicle availability, energy availability, or infrastructure readiness. Fleets in California are very diverse, and it is not feasible to apply a single regulatory framework in a one-size-fits-all approach. In response to the Draft ACF rule language, WSPA created a flow diagram that highlighted the complexity of the High Priority Fleets regulation compliance pathways and the number of steps necessary to apply for the various exemptions available (see Attachment A). This flowchart was presented to CARB staff and the CARB Board during the Board hearing on October 27, 2022. Since then, the regulation has only become even more complex. As currently written, there are at least 10 exemptions and/or extensions in the Proposed High Priority Fleets Regulation, including the Waste and Wastewater Fleets provision, that fleet owners must consider on top of the two regulatory schedules in order to manage their compliance status.
- Beyond the administrative burden of the regulation, the amendments fail to address concerns repeatedly raised by stakeholders. As previously stated, electric utilities have expressed concern that timelines for substation upgrades necessary to meet charging infrastructure electricity demand can exceed the five years allowed under the Site Electrification Delay Extension. Due to the significant concerns about the suitability of BEV technology for many heavy-duty applications, California and many fleet operators are also exploring hydrogen technology options. But that hydrogen energy system is still being conceptualized. The long lead time for hydrogen infrastructure development is not currently accounted for under the Infrastructure Delay Extensions. CARB has not addressed how this will be handled within the proposed ACF regulation, which continues to present compliance uncertainty for fleet operators. Stakeholders have also commented that the Waste and Wastewater Fleets provision restricts their ability to utilize the renewable natural gas that will soon be generated due to Senate Bill 1383 (2016). Similarly, the ZEV Purchase Exemption limits fleets' abilities to engage in a competitive bidding process by only requiring that one manufacturer produce a vehicle for it to be considered available.

In addition, we request that CARB consider the following exemption:

- <u>Qualified Research Laboratory Test Fleet Exemption</u>: This would be an exemption for qualified research laboratories that perform lubrication, fuel, and fuel additive research for internal combustion engine advancement in-line with global goals for energy transition to renewables and hydrogen. Petrochemical and lubricant industries maintain a specialized fleet of test vehicles to support research and development of fuels, fuel additives, and lubricants which should fall under a definition of "test fleet." These test vehicles are not used to transport goods or provide service and represent a comparatively small number of vehicles. These test vehicles are typically operated on a chassis dynamometer and, when appropriately registered and licensed, will occasionally operate on the roadway to conduct real-world testing. This research is critical to enable the reliable supply of our products globally, including renewable fuels and hydrogen. Fuel additives developed at research centers are used to meet or exceed minimum USEPA and CARB fuel requirements. CARB staff should consider modifying the definition of “test fleet” to be more inclusive of all research test vehicles to maintain and encourage innovation across the state. The recommended modification to the proposed ACF language would be:

- “Test fleet” means vehicles owned and operated by a manufacturer or a laboratory under the North American Industry Classification System (NAICS) Code 541715 (Research and Development in the Physical, Engineering, and Life Sciences) that are not used for commercial purposes. Rather, “test fleet” vehicle use is appropriate: to demonstrate functionality to buyers; to test durability; ~~or~~ to gather data for engine or vehicle certification or-research; ~~and~~ for vehicles operating under a CARB-issued experimental permit as authorized by California Health and Safety Code section 43014; and for vehicles operating to test fuels, fuel additives, lubricants or other technical qualification for research or certification.

Given the diversity of concerns that still remain, CARB should reevaluate the feasibility of implementing the timeline of the proposed ACF regulation.

Thank you for the consideration of our comments. We would welcome the opportunity to discuss these concerns in more detail. If you have any immediate questions, please contact Tanya DeRivi with WSPA at tderivi@wspa.org or Patrick Kelly with AFPM at pkelly@afpm.org. We look forward to working with you on these important issues.

Sincerely,

Tanya DeRivi
Senior Director, Climate Policy
WSPA

Patrick Kelly
Senior Director, Fuel & Vehicle Policy
AFPM

Attachment A: ACF High Priority and Federal Fleets Requirements Compliance Flowchart
Attachment B: Comments on ACF Regulation ISOR and Draft EA
Attachment C: Comments on ACF Regulation September 2021 Workshop
Attachment D: Comments on ACF Regulation March 2021 Workshops

ATTACHMENT A

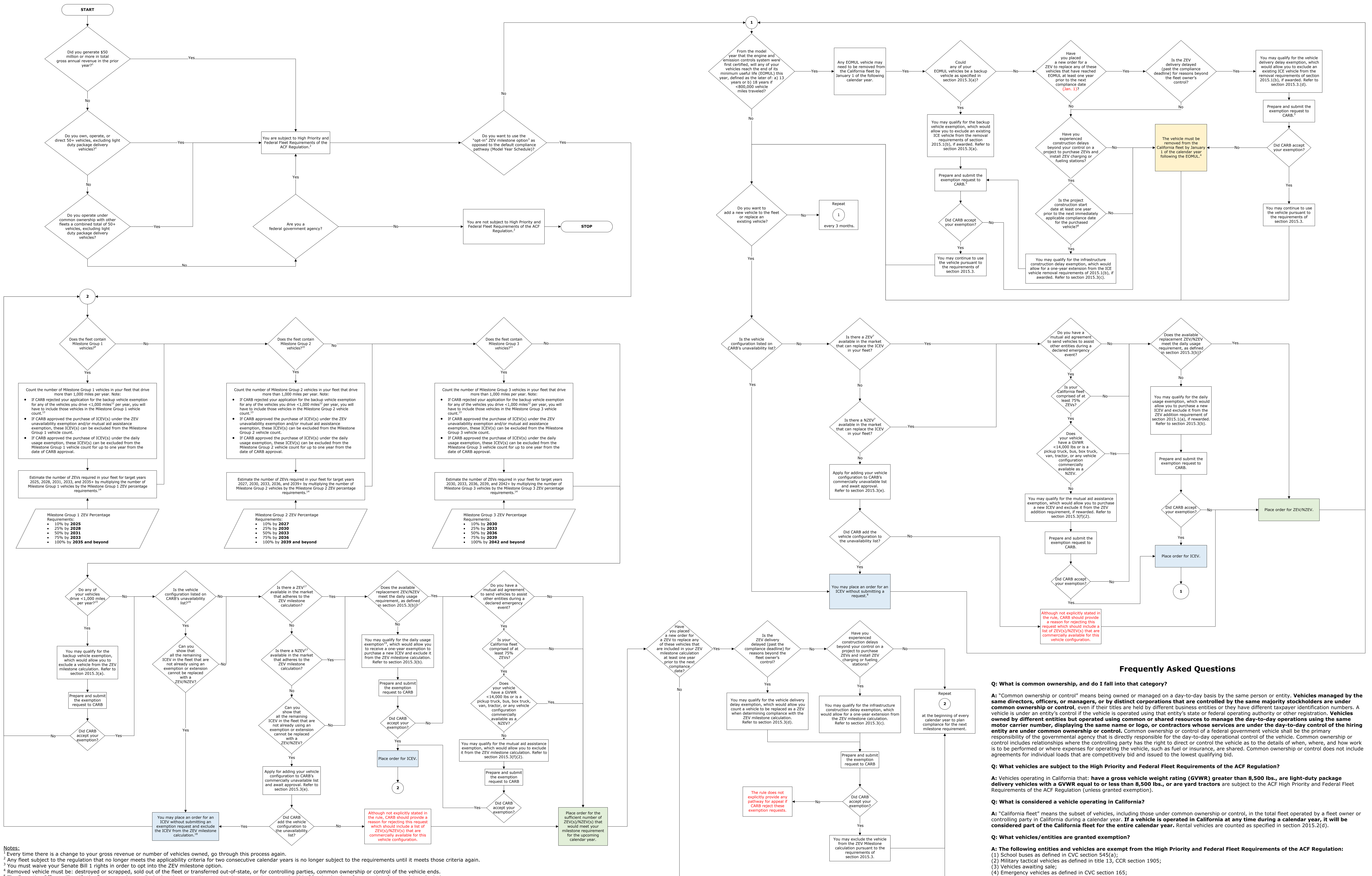
ACF High Priority and Federal Fleets Requirements Compliance Flowchart

Please note that this flowchart was drafted in September 2022. It does not reflect the new 15-day package exemptions and timelines. These new changes are expected to increase the flowchart's complexity (and associated regulatory burden).

Please note Ramboll's interpretation of proposed regulatory requirements are for discussion purposes only and not to be used for compliance.

The first page is an overview of the requirements. The second page is frequently asked questions, and the remaining pages are a step-by-step walkthrough the requirements and exemptions.

Advanced Clean Fleets (ACF) High Priority and Federal Fleets Requirements Compliance Flowchart



Notes:
1 Every time there is a change to your gross revenue or number of vehicles owned, go through this process again.
2 Any fleet subject to the regulation that no longer meets the applicability criteria for two consecutive calendar years is no longer subject to the requirements until it meets those criteria again.
3 You must waive your Senate Bill 1 rights in order to opt into the ZEV milestone option.
4 Removed vehicle must be: destroyed or scrapped, sold out of the fleet or transferred out-of-state, or for controlling parties, common ownership or control of the vehicle ends.
5 The Executive Officer will notify the fleet owner by email whether the exemption or extension request is approved within 30 calendar days from receipt of a complete submission.
6 Delays in acquiring permits that prevent/delay the start of construction do NOT qualify for an exemption.
7 NZEVs with a 2035 model year or older are counted the same as ZEVs for the purpose of complying with the requirements of sections 2015.1 and 2015.2.2.
8 You must comply with the reporting and recordkeeping requirements of section 2015.4(i) and 2015.5(j).
9 "Milestone group 1" means the light-duty package delivery vehicles, box trucks, vans, buses with two axles, and yard tractors in the California fleet.
10 "Milestone group 2" means the work trucks, day cab tractors, and buses with three axles in the California fleet.
11 "Milestone group 3" means the sleeper cab tractors and specialty vehicles within the California fleet.
12 You may exclude mileage accrued when the vehicle is operated in support of a declared emergency event as specified in section 2015.3(f)(1).
13 Details on applying for the backup vehicle exemption is provided in Figure 4.
14 A fleet's ZEV requirement in a given year is the sum Group 1, Group 2, and Group 3 Milestone Percentage Requirements. This requirement can be met with a combination of vehicles from any Milestone Group.
15 You may exclude mileage accrued when the vehicle is operated in support of a declared emergency event as specified in section 2015.3(f)(1).
16 The list will include commercially unavailable vehicles with a GVWR greater than 14,000 lbs. and will not include pickup trucks, two-axle buses, box trucks, vans, or any tractors.
17 NZEVs with a 2035 model year or older are counted the same as ZEVs for the purpose of complying with the requirements of sections 2015.1 and 2015.2.2.
18 You must comply with the reporting and recordkeeping requirements of section 2015.4(i) and 2015.5(j).
19 A vehicle under the Daily Usage Exemption cannot be placed anywhere in the California fleet while meeting the daily usage needs of any existing vehicle in the fleet provided the criteria specified in section 2015.3(b) are met.

The answers to the FAQs are Ramboll's interpretation of the regulatory requirements and are not to be considered legal advice for compliance purposes. Ramboll's interpretation of proposed regulatory requirements for discussion purposes only and not to be used for compliance.

Frequently Asked Questions

Q: What is common ownership, and do I fall into that category?

A: "Common ownership or control" means being owned or managed on a day-to-day basis by the same person or entity. **Vehicles managed by the same directors, officers, or managers, or by distinct corporations that are controlled by the same majority stockholders are under common ownership or control**, even if their titles are held by different business entities or they have different taxpayer identification numbers. A vehicle is under an entity's control if the vehicle is operated using that entity's state or federal operating authority or other registration. **Vehicles owned by different entities but operated using common or shared resources to manage the day-to-day operations using the same motor carrier number, displaying the same name or logo, or contractors whose services are under the day-to-day control of the hiring entity are under common ownership or control.** Common ownership or control of a federal government vehicle shall be the primary responsibility of the governmental agency that is directly responsible for the day-to-day operational control of the vehicle. Common ownership or control includes relationships where the controlling party has the right to direct or control the vehicle as to the details of when, where, and how work is to be performed or where expenses for operating the vehicle, such as fuel or insurance, are shared. Common ownership or control does not include agreements for individual loads that are competitively bid and issued to the lowest qualifying bid.

Q: What vehicles are subject to the High Priority and Federal Fleet Requirements of the ACF Regulation?

A: Vehicles operating in California that: **have a gross vehicle weight rating (GVWR) greater than 8,500 lbs., are light-duty package delivery vehicles with a GVWR equal to or less than 8,500 lbs., or are yard tractors** are subject to the ACF High Priority and Federal Fleet Requirements of the ACF Regulation (unless granted exemption).

Q: What is considered a vehicle operating in California?

A: "California fleet" means the subset of vehicles, including those under common ownership or control, in the total fleet operated by a fleet owner or controlling party in California during a calendar year. **If a vehicle is operated in California at any time during a calendar year, it will be considered part of the California fleet for the entire calendar year.** Rental vehicles are counted as specified in section 2015.2(d).

Q: What vehicles/entities are granted exemption?

A: The following entities and vehicles are exempt from the High Priority and Federal Fleet Requirements of the ACF Regulation:
(1) School buses as defined in CVC section 545(a);
(2) Military tactical vehicles as defined in title 13, CCR section 1905;
(3) Vehicles awaiting sale;
(4) Emergency vehicles as defined in CVC section 165;
(5) Historical vehicles;
(6) Dedicated snow removal vehicles;
(7) Two-engine vehicles;
(8) Heavy cranes as defined in title 13, CCR section 2021(b)(16);
(9) Transit vehicles subject to the Innovative Clean Transit regulation commencing with title 13, CCR section 2023;
(10) Vehicles subject to the regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards commencing with title 13, CCR section 2479; and
(11) Public agencies and vehicles owned by them that are subject to the regulation for State and Local Government Fleets commencing with title 13, CCR section 2013.

Q: How do I show proof of my revenue?

A: Entities that are subject to the ACF High Priority and Federal Fleet Requirements on the basis of gross annual revenues per section 2015(a)(1) (you are an entity or combination of entities operating under common ownership or control that have $50 million or more in total gross annual revenue in the prior year) **must keep and provide tax filing records that show your gross annual revenues.**

Advanced Clean Fleets (ACF) – High Priority and Federal Fleets Requirements Frequently Asked Questions

Q: What is common ownership, and do I fall into that category?

A: "Common ownership or control" means being owned or managed on a day-to-day basis by the same person or entity. **Vehicles managed by the same directors, officers, or managers, or by distinct corporations that are controlled by the same majority stockholders are under common ownership or control**, even if their titles are held by different business entities or they have different taxpayer identification numbers. A vehicle is under an entity's control if the vehicle is operated using that entity's state or federal operating authority or other registration. **Vehicles owned by different entities but operated using common or shared resources to manage the day-to-day operations using the same motor carrier number, displaying the same name or logo, or contractors whose services are under the day-to-day control of the hiring entity are under common ownership or control.** Common ownership or control of a federal government vehicle shall be the primary responsibility of the governmental agency that is directly responsible for the day-to-day operational control of the vehicle. Common ownership or control includes relationships where the controlling party has the right to direct or control the vehicle as to the details of when, where, and how work is to be performed or where expenses for operating the vehicle, such as fuel or insurance, are shared. Common ownership or control does not include agreements for individual loads that are competitively bid and issued to the lowest qualifying bid.

Q: What vehicles are subject to the High Priority and Federal Fleet Requirements of the ACF Regulation?

A: Vehicles operating in California that: **have a gross vehicle weight rating (GVWR) greater than 8,500 lbs., are light-duty package delivery vehicles with a GVWR equal to or less than 8,500 lbs., or are yard tractors** are subject to the ACF High Priority and Federal Fleet Requirements of the ACF Regulation (unless granted exemption).

Q: What is considered a vehicle operating in California?

A: "California fleet" means the subset of vehicles, including those under common ownership or control, in the total fleet operated by a fleet owner or controlling party in California during a calendar year. **If a vehicle is operated in California at any time during a calendar year, it will be considered part of the California fleet for the entire calendar year.** Rental vehicles are counted as specified in section 2015.2(d).

Q: What vehicles/entities are granted exemption?

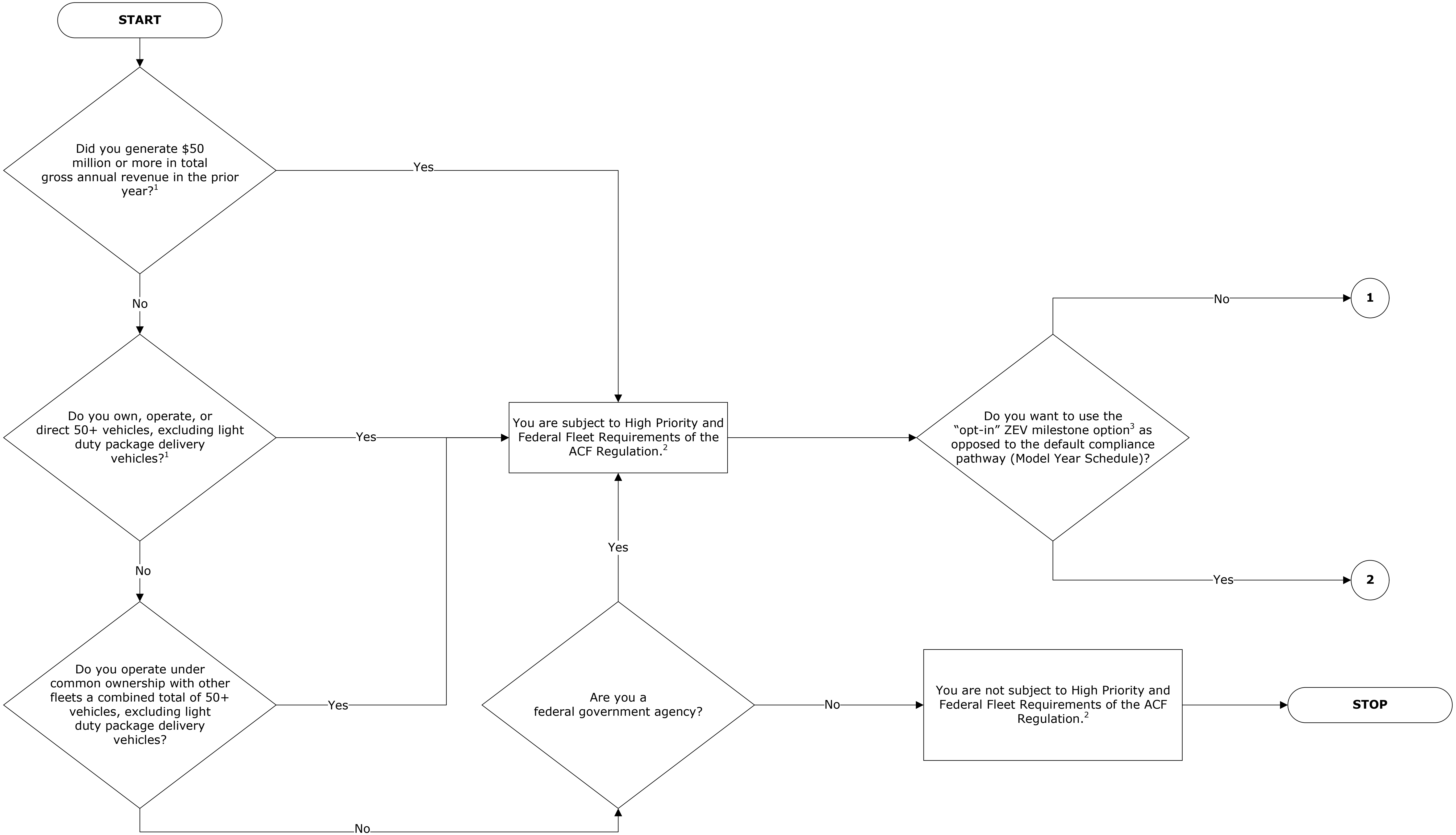
A: The following entities and vehicles are exempt from the High Priority and Federal Fleet Requirements of the ACF Regulation:
(1) School buses as defined in CVC section 545(a);
(2) Military tactical vehicles as defined in title 13, CCR section 1905;
(3) Vehicles awaiting sale;
(4) Emergency vehicles as defined in CVC section 165;
(5) Historical vehicles;
(6) Dedicated snow removal vehicles;
(7) Two-engine vehicles;
(8) Heavy cranes as defined in title 13, CCR section 2021(b)(16);
(9) Transit vehicles subject to the Innovative Clean Transit regulation commencing with title 13, CCR section 2023;
(10) Vehicles subject to the regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards commencing with title 13, CCR section 2479; and
(11) Public agencies and vehicles owned by them that are subject to the regulation for State and Local Government Fleets commencing with title 13, CCR section 2013.

Q: How do I show proof of my revenue?

A: Entities that are subject to the ACF High Priority and Federal Fleet Requirements on the basis of gross annual revenues per section 2015(a)(1) (you are an entity or combination of entities operating under common ownership or control that have $50 million or more in total gross annual revenue in the prior year) **must keep and provide tax filing records that show your gross annual revenues.**

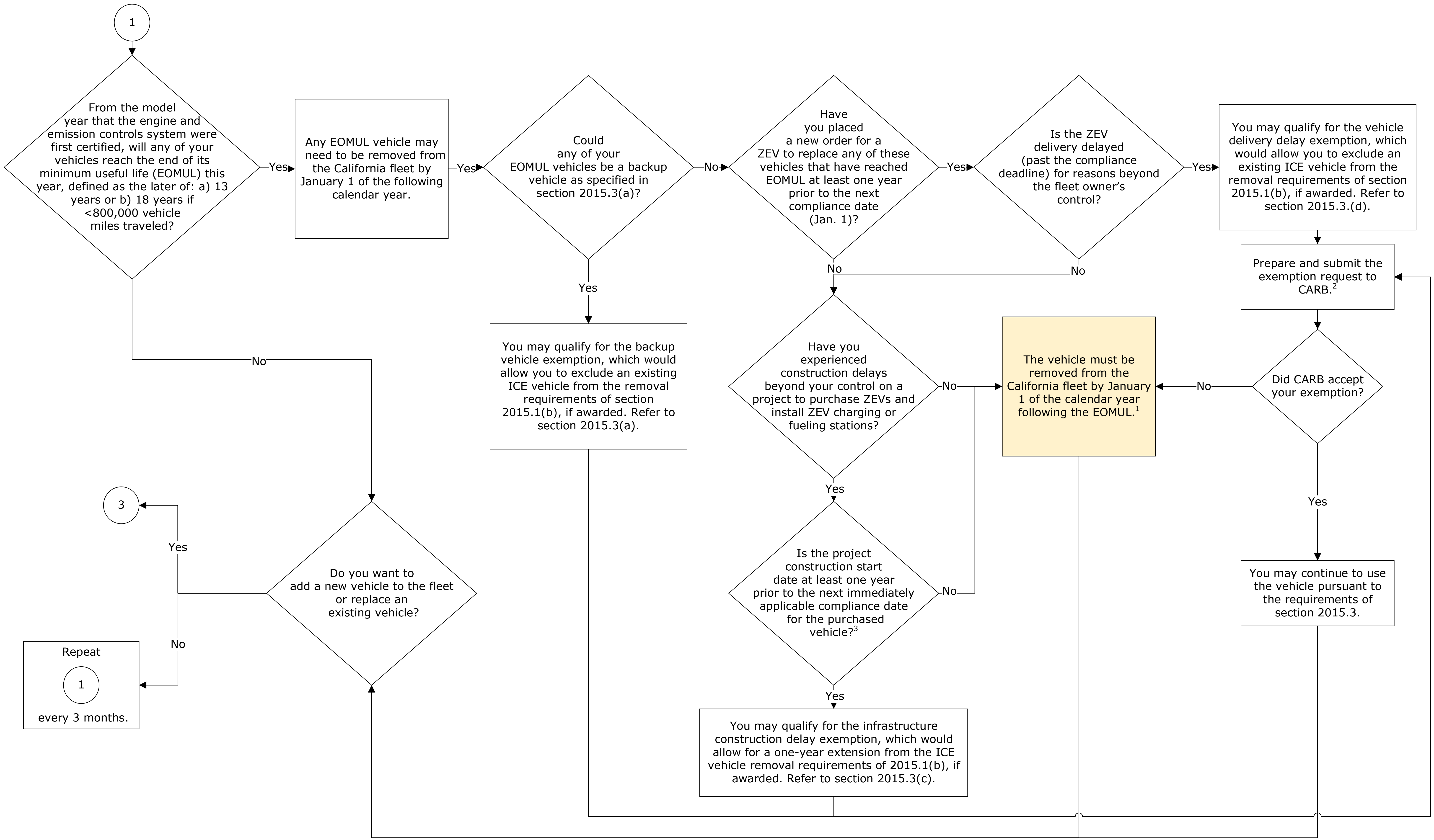
Figure 1. Advanced Clean Fleets (ACF) Applicability Flow Chart

The answers to the FAQs are Ramboll's interpretation of the regulatory requirements and are not to be considered legal advice for compliance purposes



Notes:
[1] Every time there is a change to your gross revenue or number of vehicles owned, go through this process again.
[2] Any fleet subject to the regulation that no longer meets the applicability criteria for two consecutive calendar years is no longer subject to the requirements until it meets those criteria again.
[3] You must waive your Senate Bill 1 rights in order to opt into the ZEV milestone option.

Figure 2. Model Year Schedule: Required End of Useful Life Retirement for ICE Vehicles



Notes:

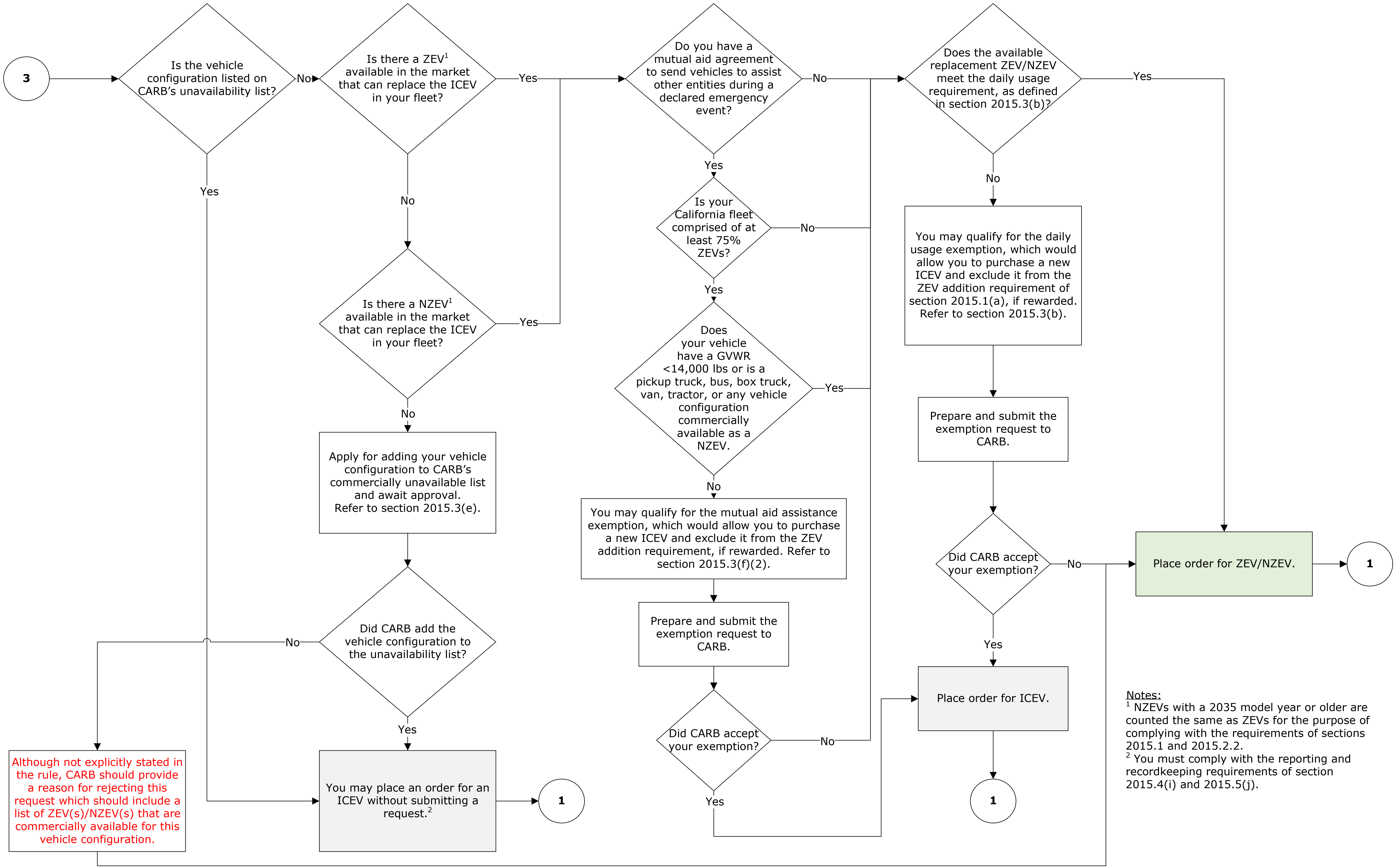
[1] Removed vehicle must be: destroyed or scrapped, sold out of the fleet or transferred out-of-state, or for controlling parties, common ownership or control of the vehicle ends.

[2] The Executive Officer will notify the fleet owner by email whether the exemption or extension request is approved within 30 calendar days from receipt of a complete submission.

[3] Delays in acquiring permits that prevent/delay the start of construction do NOT qualify for an exemption.

Figure 3. Model Year Schedule: Vehicle Additions

The answers to the FAQs are Ramboll's interpretation of the regulatory requirements and are not to be considered legal advice for compliance purposes

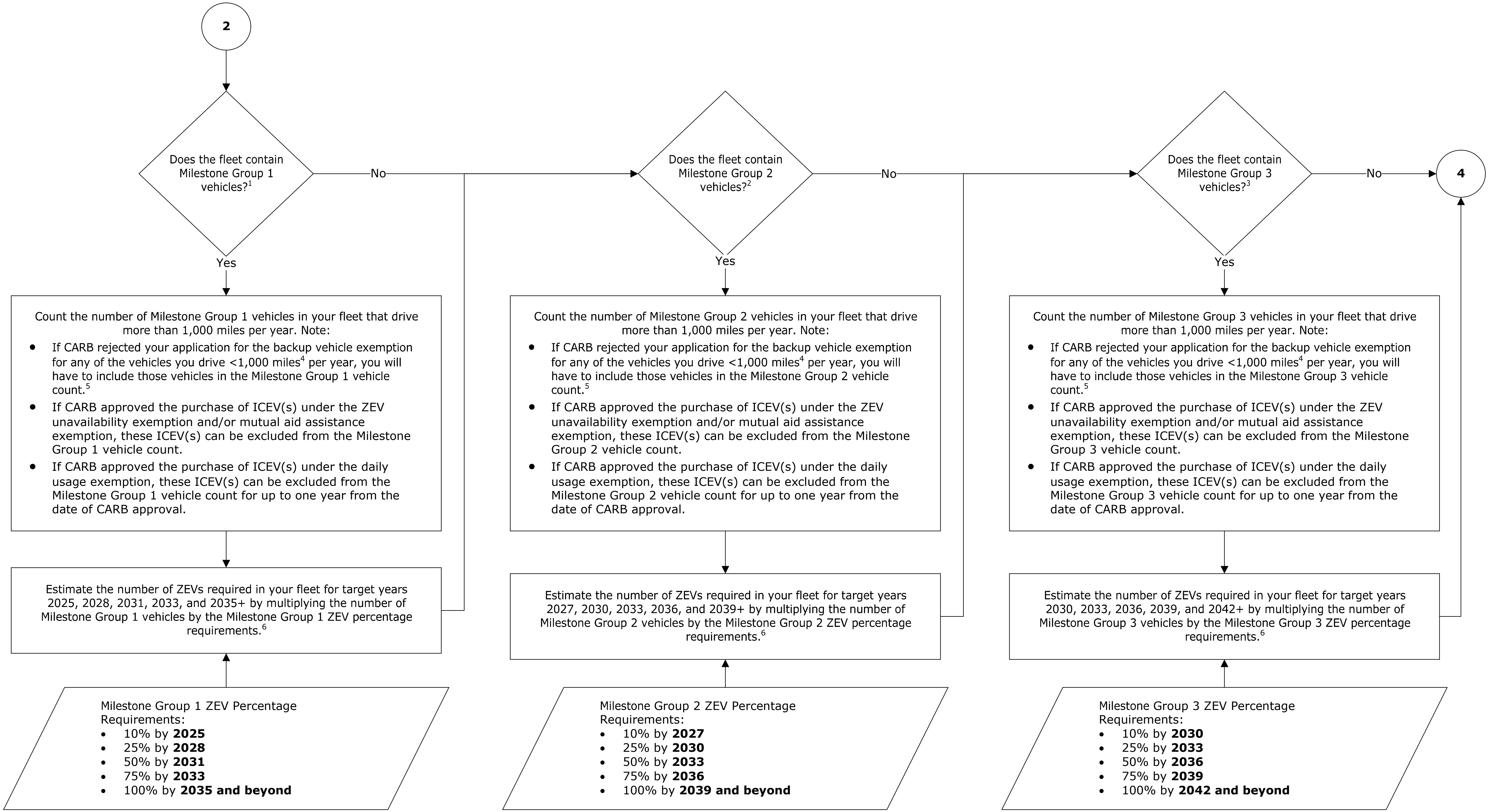


Notes:
[1] NZEVs with a 2035 model year or older are counted the same as ZEVs for the purpose of complying with the requirements of sections 2015.1 and 2015.2.2.
[2] You must comply with the reporting and recordkeeping requirements of section 2015.4(i) and 2015.5(j).

Ramboll's interpretation of proposed regulatory requirements for discussion purposes only and not to be used for compliance

Figure 4. Zero Emission Vehicle (ZEV) Milestone Compliance Option
[If you have rental vehicles in your fleet, refer to section 2015.2(d)]

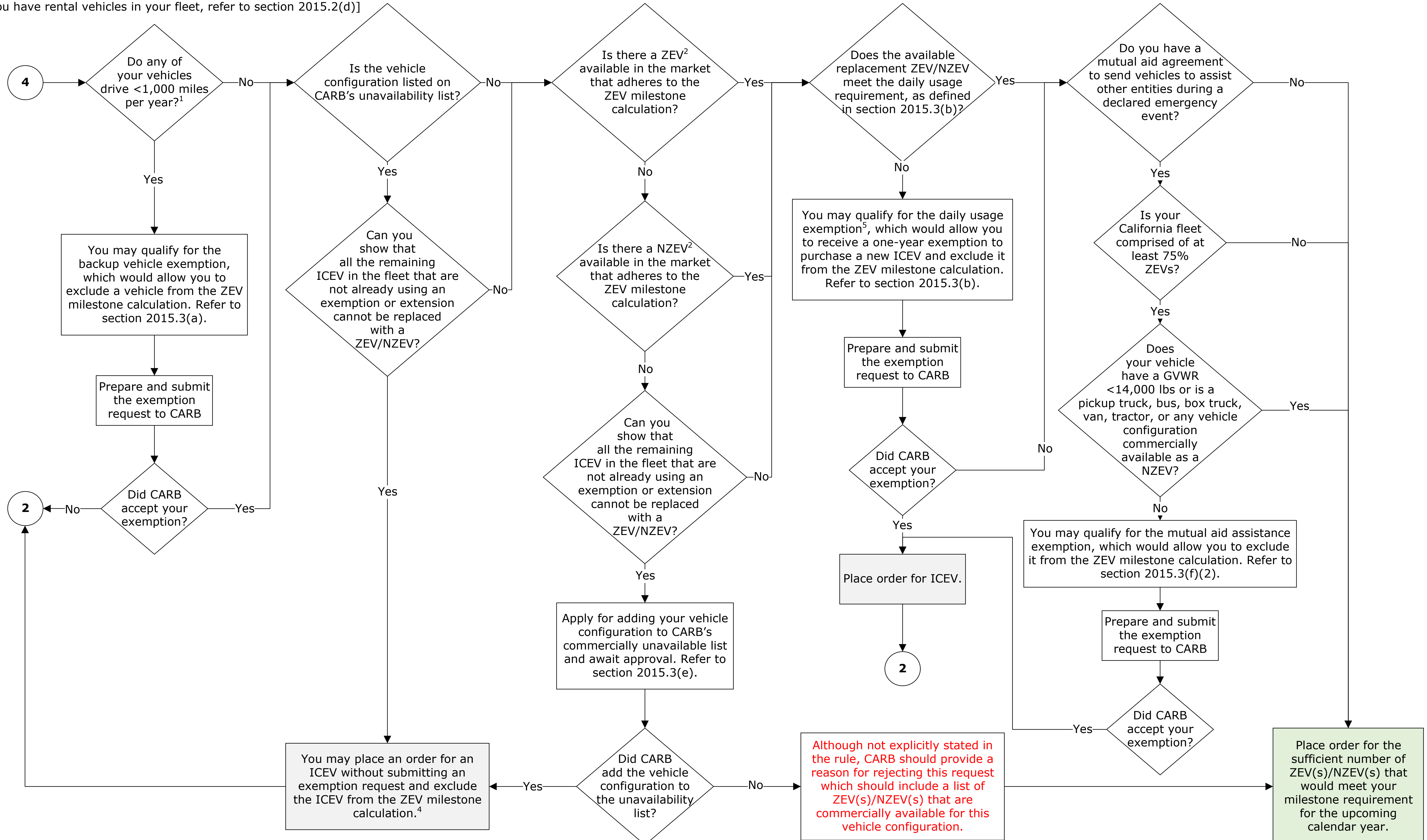
The answers to the FAQs are Ramboll's interpretation of the regulatory requirements and are not to be considered legal advice for compliance purposes



Notes:
[1] "Milestone group 1" means the light-duty package delivery vehicles, box trucks, vans, buses with two axles, and yard tractors in the California fleet.
[2] "Milestone group 2" means the work trucks, day cab tractors, and buses with three axles in the California fleet.
[3] "Milestone group 3" means the sleeper cab tractors and specialty vehicles within the California fleet.
[4] You may exclude mileage accrued when the vehicle is operated in support of a declared emergency event as specified in section 2015.3(f)(1).
[5] Details on applying for the backup vehicle exemption is provided in Figure 4.
[6] A fleet's ZEV requirement in a given year is the sum Group 1, Group 2, and Group 3 Milestone Percentage Requirements. This requirement can be met with a combination of vehicles from any Milestone Group.

Figure 5. Zero Emission Vehicle (ZEV) Milestone Compliance Option (Continued)
[If you have rental vehicles in your fleet, refer to section 2015.2(d)]

The answers to the FAQs are Ramboll's interpretation of the regulatory requirements and are not to be considered legal advice for compliance purposes



Notes:
[1] You may exclude mileage accrued when the vehicle is operated in support of a declared emergency event as specified in section 2015.3(f)(1).
[2] NZEVs with a 2035 model year or older are counted the same as ZEVs for the purpose of complying with the requirements of sections 2015.1 and 2015.2.2.
[3] The list will include commercially unavailable vehicles with a GVWR greater than 14,000 lbs. and will not include pickup trucks, two-axle buses, box trucks, vans, or any tractors.
[4] You must comply with the reporting and recordkeeping requirements of section 2015.4(i) and 2015.5(j).
[5] A vehicle under the Daily Usage Exemption cannot be placed anywhere in the California fleet while meeting the daily usage needs of any existing vehicle in the fleet provided the criteria specified in section 2015.3(b) are met.

Figure 6. Zero Emission Vehicle (ZEV) Milestone Compliance Option (Post-ZEV/NZEV Order)
[If you have rental vehicles in your fleet, refer to section 2015.2(d)]

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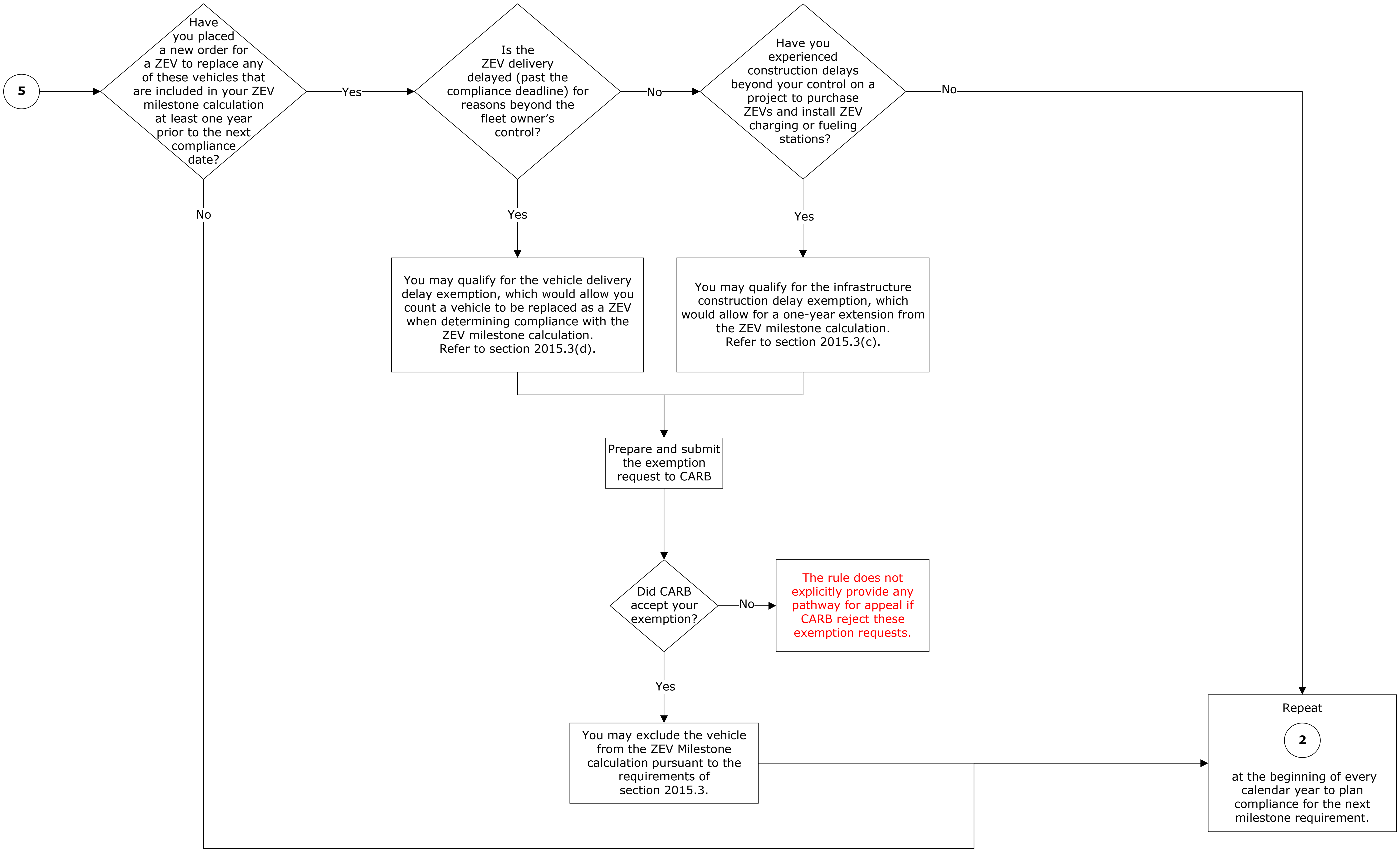


ATTACHMENT B

Comments on ACF Regulation ISOR and Draft EA

Tanya DeRivi
Vice President, Climate Policy
Western States Petroleum Association

October 17, 2022

Advanced Clean Fleets
California Air Resources Board
1001 I Street,
Sacramento, CA 95814

(Submitted via the Workshop Comment Submittal Form and by email to zevfleet@arb.ca.gov)

Re: Comments on Advanced Clean Fleets Regulation ISOR Draft EA

The Western States Petroleum Association (WSPA) appreciates the opportunity to comment on the Initial Statement of Reasons (ISOR) and included Draft Environmental Analysis (EA) for the proposed Advanced Clean Fleets (ACF) Regulation, posted by the California Air Resources Board (CARB) on August 30, 2022 ahead of the Public Hearing on October 27, 2022.[1] WSPA is a non-profit trade association that represents companies that import and export, produce, refine, transport and market petroleum, petroleum products, natural gas and other energy supplies in California and four other western states, and has been an active participant in air quality planning issues for over 30 years.

WSPA members are both fuel providers and fleet operators under the proposed ACF regulations. As an organization, we are not in support of the current proposed regulation for the reasons summarized below and detailed in Attachment A. The current ACF proposal excludes and precludes criteria pollutant and greenhouse gas emission reductions that a multi-technology/multi-fuel strategy using commercially available, CARB-certified trucks fueled by low carbon-intensity fuels can provide. An affordable and reliable multi-fuel strategy does not rely upon an unprecedented expansion of electric generation, transmission and distribution infrastructure and can reduce emissions while electric infrastructure is developed. The current ACF proposal needs to be revised to capture the emission reduction benefits of a multi-technology/multi-fuel strategy. We encourage CARB to hold a workshop to address these and other key stakeholder suggestions and then revise the proposal, ISOR and Draft EA before presenting the ACF for adoption. As our members are fuel providers and fleet owners that would be regulated under the ACF, we also ask that CARB include Low Carbon Fuels Standard (LCFS) staff as part of the ACF rulemaking process to assess and harmonize the direct and indirect effects of the ACF rule on the LCFS program, and vice versa.

Fuel suppliers in California, across the United States (U.S.), and worldwide are investing billions of dollars to produce low-carbon renewable fuels such as renewable diesel (RD), biodiesel (BD)

1 CARB. Notice of Public Hearing to Consider Proposed Advanced Clean Fleets Regulation on October 27, 2022. Available at: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/notice2.pdf. Accessed: October 2022.

and renewable natural gas (RNG) for medium-duty vehicles and heavy-duty vehicles (MDV/HDV). These investments are encouraged and often required by regulations such as LCFS and Cap-and-Trade regulations on the U.S. West Coast and Canada, and by the federal Renewable Fuels Standard (RFS). Industry continues to make progress in reducing the carbon intensity of these fuels by optimizing feedstock sources and feedstocks, manufacturing processes and transportation.

These trends are most evident in California, where WSPA-member companies and others have invested heavily to produce renewable fuels for MDV/HDV. Per CARB LCFS data, nearly 3.4 million gallons per day of BD and RD are currently supplied to California consumers,[2] which is 34% of current total California diesel demand.[3] CARB's LCFS regulation effectively requires these products and the investments necessary to deliver them. CARB has publicly supported many of the announced renewable fuels projects.[4]

CARB's proposed zero-emission vehicle (ZEV) mandate risks stranding billions of dollars of private investment that has already been made in direct response to CARB's own LCFS regulation. We encourage CARB to provide a compliance option for renewable fuels in the proposed ACF.

Additionally, there are numerous deficiencies and/or omissions in the ISOR and Draft EA analyses, including but not limited to those below that must be addressed before CARB takes action on the proposed ACF.

- <u>Inadequate Environmental Assessment</u>: CARB has failed to fully assess the impacts of the proposed ACF regulation on particulate matter (PM) and greenhouse gas (GHG) emissions, critical mineral resources, and California's water supply. Additionally, CARB has failed to evaluate an alternative that would allow for low-carbon intensity (low-CI), low-NO_X technologies to compete with ZEVs in their alternative analyses presented in the draft Environmental Assessment for the proposed ACF. Refer to Comments A.2 through A.7 in Attachment A for further details.
- <u>Inadequate Electric Grid Assessment</u>: CARB must perform a more in-depth assessment of the impacts to the electric grid as a result of the ACF proposal to fully assess the impact on California's infrastructure and economy. This assessment should account for the costs associated with upgrades to the California grid infrastructure (new and upgraded generation, transmission, and distribution) and the costs associated with the installation of public and private electric vehicle (EV) chargers. Additionally, CARB has not addressed the feasibility

[2] CARB. 2022. Low Carbon Fuel Standard Quarterly Data Spreadsheet. July 31. Available here: https://ww2.arb.ca.gov/sites/default/files/2022-08/quarterlysummary_073122_0.xlsx. Accessed: October 2022.

[3] CARB. 2022. EMFAC Emissions Inventory. Available here: https://arb.ca.gov/emfac/emissions-inventory/d1a08e88bd07b3f76564d6d3b1fa544ec97e6400. Accessed: October 2022.

[4] CARB. Cleaner fuels have now replaced more than 3 billion gallons of diesel fuel under the Low Carbon Fuel Standard. Available at: https://ww2.arb.ca.gov/news/cleaner-fuels-have-now-replaced-more-3-billion-gallons-diesel-fuel-under-low-carbon-fuel. Accessed: October 2022.

of the current grid to expand to meet the additional demand that the draft regulation would present. Refer to Comments A.8 through A.11 in Attachment A for further details.

- Inadequate Exemption Language: CARB has failed to adequately consider the lead time needed for permitting electric charging infrastructure, and the process for appealing a rejected exemption request. Refer to Comments A.12 through A.14 in Attachment A for further details.

Conclusion

WSPA strongly encourages CARB to address the above deficiencies to ensure that CARB complies with its legal obligations under the California Health and Safety Code (HSC), Administrative Procedure Act (APA), and California Environmental Quality Act (CEQA). Specifically, CARB has a legal duty to address the following:

- *Leakage:* HSC § 38562(b)(8) requires CARB to minimize the "leakage" potential of any regulatory activities. In its ACF Proposal, CARB fails to consider the leakage potential of its ZEV mandate, based on an accurate lifecycle analysis of the GHG emissions associated with electric vehicles and associated infrastructure, as well as residual demand for liquid fuels for internal combustion engine vehicles (ICEV) remaining in 2040 and beyond.
- *Feasible Regulatory Alternatives:* Under Government Code § 11346.2(b)(4)(A), when CARB proposes a regulation that would mandate the use of specific technologies or equipment, or prescribe specific actions or procedures, it must consider performance standards as an alternative. The ACF proposal includes a 100% ZEV sales mandate for new medium- and heavy-duty vehicles beginning in the 2040 model year and beyond. This is not a performance standard; it is a technology mandate.[5] Further, CEQA requires CARB to consider a reasonable range of alternatives that "shall include those that could feasibly accomplish most of the basic objectives of the project and could avoid or substantially lessen one or more of the significant effects." Cal. Code Regs. title 14, § 15126.6(c). CARB has failed to evaluate and/or analyze a technology neutral performance-based standard that would allow low-carbon fuel and engine technologies to compete with ZEVs in their alternative analyses presented in the Draft EA and the Standardized Regulatory Impact Assessment (SRIA) for the proposed ACF, as discussed in Comment 9.
- *Additional Environmental Impacts*: CARB's Draft EA does not consider potentially significant environmental impacts, in contravention of CARB's CEQA obligations. CEQA requires that the Draft EA contain "[a] discussion and consideration of environmental impacts, adverse or beneficial, and feasible mitigation measures which could minimize significant adverse impacts identified," as well as "[a] discussion of cumulative and growth-inducing impacts." Cal. Code Regs. title17, § 60004.2(a). As detailed in Comments 5-8, CARB's Draft EA is deficient in several respects—CARB fails to account for energy impacts associated with increased electricity production, impacts on hydrology and water quality from increased hydrogen production, impacts from mining of lithium and other rare earth metals, and cumulative impacts for the State's electrical generation, transmission, and distribution infrastructure.
- *Cost-Effectiveness and Economic Impacts:* As described in Comments 3, 4, and 9, CARB's analysis does not adequately consider significant economic impacts stemming from the ACF

[5] CARB asserts that "[t]he proposed ACF regulation does not prescribe any specific technology or any equipment – rather, it allows regulated entities to acquire affected categories of any medium- and heavy-duty vehicles that have demonstrated that they emit zero emissions of criteria or GHG emissions," ISOR, at 269-70.

Proposal. HSC §§ 38562 and 43018 and APA § 11346.3 require CARB to broadly consider a wide range of impacts to the state's economy, including competitive impacts to California business enterprises.[6] As detailed below, this assessment must consider economic impacts to utilities stemming from the electrification of the transportation sector experienced, as well as lifecycle GHG impacts from ZEV technologies. Further, CARB must consider any less costly but equally effective alternatives pursuant to HSC § 57005. The ISOR and associated rulemaking document do not satisfy this obligation because nowhere does CARB compare the lifecycle emissions analysis of ZEVs and highly efficient low emission vehicles, which impose significantly fewer infrastructure expenses while achieving equivalent or greater GHG emissions reductions on a faster timeline.

- *Technological Feasibility:* Various provisions of the HSC require CARB to consider technological feasibility for proposed motor vehicle standards, including HSC §§ 38560, 38562, 39602.5, 43013, and 43018.[7] This consideration must assess whether vehicle manufacturers have the technology and resources to rapidly shift to producing electric vehicles—a relatively new technology category that requires different resources than traditional vehicles—by the millions, as well as whether there is a reliable supply of fuel (electricity, hydrogen) and the infrastructure to deliver the fuel. CARB must perform a complete and sufficient assessment of the technological feasibility of the ACF ZEV mandates including but not limited to the assessment of mineral resource availability, impacts to the California electric grid, and application of ZEVs to long-distance use cases, as detailed in Comments 5 and 10, below.

Finally, we note that the ACF ISOR does not reference the need to obtain a Clean Air Act waiver from the U.S. Environmental Protection Agency (unlike for both the Advanced Clean Trucks and Advanced Clean Cars II regulations, which did). While the Clean Air Act grants California certain leeway to address localized pollution, the Energy and Policy Conservation Act's broad preemption provision prevents CARB from adopting such regulations when they are "related to" fuel economy, regardless of any accompanying localized pollution benefits.

Thank you for consideration of our comments. We would welcome the opportunity to discuss these concerns in more detail. If you have any immediate questions, please feel free to contact me at tderivi@wspa.org. We look forward to working with you on these important issues.

Sincerely,

Tanya DeRivi

Tanya DeRivi
Vice President, Climate Policy
WSPA

Attachment A: Detailed Comments

[6] Notably, in its ISOR, CARB cites these provisions as authorizing the ACF Proposal. *See* ISOR, at 236, 269.
[7] CARB cites these provisions as providing authority for the ACF Proposal in the ISOR. *See* ISOR, at 236-37.

WSPA

ATTACHMENT A

Detailed Comments

As noted in the cover letter, detailed comments are provided below:

A.1 The California Air Resources Board (CARB) must address previous comments made by WSPA which include but are not limited to the following.

- The rule should include a compliance pathway for low-NO_X trucks operating on lower-carbon-intensity fuels (including renewable diesel and renewable natural gas), consistent with the expeditious path to criteria air pollutant and greenhouse gas (GHG) reduction goals;
- As noted in recent studies, more than one battery electric (BE) truck would be required to perform the work of a single internal combustion engines (ICE) vehicle.[8,9] CARB does not account for the additional BE trucks that would be needed to replace ICE trucks in the emissions inventory modeling and cost analysis; and
- The proposed rule should include explicit regulatory offramps that link the targets to battery electric vehicle (BEV), fuel cell electric vehicles (FCEV) and related electrical generation/transmission/distribution/charging infrastructure availability in each end-use and duty-cycle.
- WSPA incorporates by reference the previous comments submitted by WSPA throughout the ACF rulemaking process.[10]

Comments on Draft EA/ISOR

A.2 The ISOR and Draft EA fail to assess all of the impacts of the proposed ACF regulation on the statewide particulate matter emission inventory.

As noted on Page 15 of the Draft EA one of the primary objectives of the proposed ACF regulation is to "accelerate the deployment of Zero-Emission Vehicles (ZEVs) that achieve the maximum emissions reduction possible from medium- and heavy-duty vehicles to assist in the attainment of NAAQS for criteria air pollutants."[11] Several regions of the State are in non-attainment of the Federal PM_{10} and $PM_{2.5}$ standards.[12] Hence CARB should analyze the impacts of the proposed ACF regulation on total statewide and region specific PM_{10} and $PM_{2.5}$ emissions inventories and not limit its analysis to just the

8 As noted in the 2020 NCST study on short haul good movement, even with improved battery technology in 2030, 1.2 BE trucks would be required to replace a single diesel truck. This number would be even higher in the early compliance years.

9 Genevieve Giuliano, Maged Dessouky, Sue Dexter, Jiawen Fang, Shichun Hu, Seiji Steimetz, Thomas O'Brien, Marshall Miller, Lewis Fulton. 2020. Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement: A Research Report from the National Center for Sustainable Transportation. Available at: https://escholarship.org/uc/item/0nw4q530. Accessed: October 2022.

10 WSPA. 2021. Comments on Advanced Clean Fleets March Workshop. May 10. Available here: https://www.arb.ca.gov/lists/com-attach/36-acf-comments-ws-UCdTJlUkAzFVDFMy.pdf. Accessed: October 2022. WSPA. 2021. Comments on ACF Regulation September Workshop. October 29. Available here: https://www.arb.ca.gov/lists/com-attach/109-acf-comments-ws-VCNSJ1EgADIKU1c2.pdf. Accessed: October 2022.

11 CARB. 2022. Advanced Clean Fleets Draft Environmental Analysis. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appd.pdf. Accessed: October 2022

12 Ambient Air Quality Standards Designation Tool. Available here: https://ww2.arb.ca.gov/aaqs-designation-tool. Accessed: October 2022.

portions of the particulate matter inventories where it projects reductions with the adoption of this regulation.[13]

While the ISOR provides estimates for the changes in exhaust particulate matter and break wear**, <u>it does not assess particulate matter impacts from tire wear or entrained road dust</u>**. The ZEV vehicles that would replace the existing ICE vehicles under the proposed ACF are generally heavier and would cause greater tire wear and entrained road dust emissions. If heavier zero emission (ZE) trucks are allowed under the regulation, then the impacts of these on increased entrained road dust must be quantitatively evaluated. If overall truck weight restrictions remain enforced, additional ZE trucks would be needed to move the same tonnage of cargo. If truck weight restrictions are increased for ZE trucks, increased emissions of tire wear and entrained road dust must be accounted for. The tire wear and entrained road dust emissions account for >80% of the total PM emissions associated with medium and heavy-duty vehicles. Including these emissions in the analysis could potentially change the conclusions of CARB's analysis and the significance finding of the Draft EA, hence CARB must evaluate these emissions.

As shown in CARB's methodology for Entrained Road Travel and Paved Road Dust,[14] the AP-42 emission factor equation used to estimate paved road dust emissions per vehicle mile travelled is proportional to vehicle weight. ZEVs add significant weight as compared to comparable ICE vehicle models. A study by the American Transportation Research Institute (ATRI)[15] found that the weight of a BEV Class 8 Sleeper Cab tractor is nearly double that of a comparable internal combustion engine vehicle (ICEV), weighing 32,016 pounds (lbs) versus 18,216 lbs. So, converting ICEV to ZEVs under the proposed ACF regulation would significantly increase the average vehicle weight on the California roadways, which in turn would increase the entrained road dust emission factors and emissions.

CARB also assumes that tire wear emissions for ZEV are the same as ICE vehicles and takes no consideration of how the significant increase in ZEV vehicle weight as compared to ICE vehicles will increase tire wear emissions. The 2016 study titled "Non-Exhaust PM Emissions from Electric Vehicles"[16] concluded that increased vehicle weight would increase both tire wear and entrained road dust emissions. The assumption that a ZEV, which would have a higher average weight, would have the same tire wear emissions as an ICE is made without citation and should be reassessed and evaluated in the ACF ISOR.

The cost benefit analysis in the Standardized Regulatory Impact Assessment (SRIA) for the proposed ACF estimated monetized health benefits associated with the reductions in exhaust and brake wear particulate matter emissions. These benefits were used to calculate the benefit-cost ratio of the proposed regulation. As noted in the above

[13] California Health & Safety Code ("HSC") § 39602.5 requires CARB to consider ambient air quality standards and attainment in its ACF Proposal.

[14] CARB. Miscellaneous Process Methodology 7.9: Entrained Road Travel, Paved Road Dust. 2021. Available here: https://ww3.arb.ca.gov/ei/areasrc/fullpdf/2021_paved_roads_7_9.pdf. Accessed: October 2022.

[15] ATRI. Understanding the CO_2 Impacts of Zero-Emission Trucks. 2022. Available here: https://truckingresearch.org/wp-content/uploads/2022/05/ATRI-Environmental-Impacts-of-Zero-Emission-Trucks-Exec-Summary-5-2022.pdf. Accessed: October 2022.

[16] Timmers, Victor and Peter Achten. "Non-exhaust PM emissions from electric vehicles". March 2016. Available here: http://www.soliftec.com/NonExhaust%20PMs.pdf. Accessed: October 2022.

paragraphs there are other portions of the total particulate matter emissions (e.g., tire wear and entrained road dust) that would increase as a result of the proposed ACF and have not been considered. CARB should complete their benefit-cost analysis to consider all changes in total particulate matter emissions and associated health impacts.

A.3 CARB did not conduct a full life-cycle greenhouse gas emissions assessment for the vehicle/fuel system to assess GHG emission impacts of their proposal and alternatives. This results in a misrepresentation of the impacts of the proposed regulation.

To understand the potential GHG impacts of the proposed ACF regulation, CARB **must quantitatively assess the proposal.** This should include cost-effectiveness and cost-benefit analysis.[17] CARB's proposal fails to consider the following:

- Upstream fuel cycle GHG emissions are not considered, and
- GHG emissions associated with vehicle production and end of life-cycle (e.g., recycling) changes required by the proposed regulation are not considered.

Taken together, these could be significant, particularly for battery production impacts associated with battery electric vehicles and fuel cell electric vehicles as compared to ICEVs.

Assessing the upstream fuel cycle GHG emissions is necessary when considering zero emission vehicles due to the nature of GHG emissions as global pollutants. GHG emissions are global pollutants that enter the atmospheric carbon stock and cause global consequences, no matter the point of origin. While GHG emissions may not be present at the tailpipe for a (so-called) ZEV technology, these emissions still are emitted elsewhere and therefore must be accounted for in the benefit-cost and emissions reductions analyses. Not including the upstream emissions is misleading and overstates the potential emission reductions.

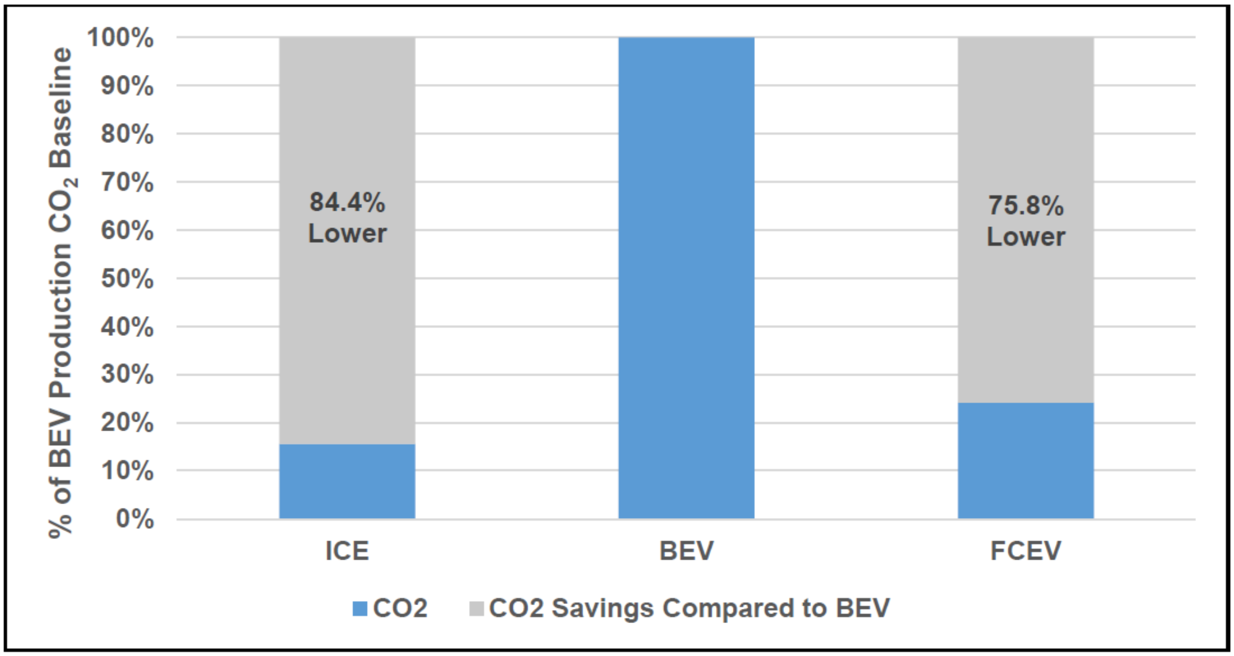
Additionally, CARB is inconsistent in citing the emissions they have considered. In both Appendix C: Standardized Regulatory Impact Assessment and the ISOR it is specifically noted the assessment "is focused on tank-to-wheel (TTW) emissions, and does not include upstream emissions."[18,19] But the Draft EA claims that "upstream emissions associated with the generation of electricity used for ZEVs… are considered in the reduction benefits of the Proposed Project."[20] CARB must update their analyses to include the upstream emissions for all fuels including electricity in the SRIA, ISOR, and the Draft EA.

Additionally, the GHG emissions associated with vehicle production should be accounted for in the analysis. This is especially important for ZEV technologies, which have components (i.e., batteries) that generate significant additional emissions during vehicle

[17] HSC §§ 38560, 39602.5, and 43013 require CARB to assess the cost-effectiveness of a regulation.
[18] CARB. 2022. Appendix C: Original Standard Regulatory Impact Assessment Submitted to Department of Finance. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appc.pdf. Accessed: October 2022.
[19] CARB. 2022. Staff Report: Initial Statement of Reasons. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf. Accessed: October 2022.
[20] CARB. 2022. Appendix D: Draft Environmental Analysis for the Advanced Clean Fleets Rule. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appd.pdf. Accessed: October 2022.

production. A recently published study by ATRI analyzed the life-cycle emissions of a Class 8 Sleeper Cab vehicle and found that the vehicle production emissions for BEVs to be ~6 times higher than the corresponding ICEV counterpart (**Figure 1**).[21] CARB has claimed in the Advanced Clean Cars II (ACC II) Response to Comments (RTC) that "the emission benefits from the use of these materials (e.g. battery and vehicle materials) in BEVs would ultimately offset the emissions from combustion of gasoline, diesel, and other fossil fuels from the development and use of these battery materials resources."[22] However this argument is unfounded. Accounting for the vehicle cycle emissions could potentially change the conclusions of CARB's analysis and therefore must be assessed in order to understand the full environmental impacts of each technology.

Figure 1. Vehicle Cycle Emissions from Class 8 Sleeper Cabs[23]



While the ISOR estimated the reductions in tailpipe GHG emissions from the proposed ACF regulation, it fails to fully quantify the changes in upstream (well-to-tank) GHG emissions or the potential increases in vehicle cycle emissions that would occur with the implementation of this proposal. CARB must fully assess the GHG emissions impact that this regulation could have on the global carbon stock. Any assessment that does not recognize the full life-cycle GHG impacts misrepresents the actual environmental effects of the proposed regulation and would lead to factually incorrect conclusions that undermine any rationale for adoption of the proposed rule. Inclusion of the life-cycle emissions would allow for a better pathway to achieve the emission reduction objectives.

21 ATRI. 2022. Understanding the CO2 Impacts of Zero-Emission Trucks. May 3. Available here: https://truckingresearch.org/2022/05/03/understanding-the-co2-impacts-of-zero-emission-trucks/. Accessed: October 2022.

22 CARB. 2022. Response to Comments on the Draft Environmental Analysis for the Advanced Clean Cars II Program. August 24. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciirtc1.pdf.

23 Ibid. ATRI. 2022. Understanding the CO2 Impacts of Zero-Emission Trucks. May 3. Available here: https://truckingresearch.org/2022/05/03/understanding-the-co2-impacts-of-zero-emission-trucks/. Accessed: October 2022.

A.4 CARB should include low-CI, low-NO_X combustion technologies in its evaluation of alternatives since that pathway can meet the objectives of the regulation, as listed below.

The purpose of the California Environmental Quality Act (CEQA) is to identify project alternatives that can achieve the proposed project's objectives in the least environmentally impactful way. Low-NO_X trucks and renewable, low-CI fuels are commercially available in large scale today. As discussed in previous comment letters and Ramboll's "Multi-Technology Scenarios: Heavy-Heavy Duty Truck Sector," deploying low-NO_X vehicles coupled with low-CI fuels could deliver earlier and more cost-effective NO_X and GHG emission reduction benefits than the ZEV-centric approach the draft ACF regulation has taken.[24] The study compared the well-to-wheel emissions of different vehicle types, taking into consideration the emissions associated with fuel production and tailpipe emissions, and found that the environmental goals of the program could be met sooner and with greater certainty given that these technologies are commercially available. The growing potential for renewable fuels with negative carbon intensities provide further opportunities to achieve greater GHG emission reductions.

Further, many of these renewable fuels do not require the extensive infrastructure build-out that would be required to implement the ZEV-centric approach in the ACF proposal, allowing for an immediate delivery of emissions benefits and minimizing the costs of and risk for delays in the proposed regulation. Hence, CARB must consider and evaluate these technology/fuel pathways as alternatives to the proposed ACF regulation rather than dismissing them as "not meeting the objectives."[25]

The objectives of the ACF as listed in the ISOR,[26] do not preclude the consideration of these technology/fuel pathways as described below:

- Objective 1 is to "accelerate the deployment of ZEVs that achieve the maximum emission reductions possible."[27] This does not preclude the deployment of other technology options, such as low-CI, low-NOx combustion engines. For example, the Ramboll HHDT Case Study, [28] which CARB has had access to for over a year, showed that a ZEVs-only strategy does not achieve the maximum emission reductions possible. A fleet mix that deployed a wider range of technologies, including ZEVs, FCEVs, and low-CI, low-NOx combustion engines, out-performed the ZEV-only deployment strategy in the near-term and achieved equitable emission reductions in the long-term.
- Objectives 2 and 3 are to "reduce the State's dependence on petroleum as an energy resource and support the use of diversified fuels in the state's transportation fleet" and "decrease GHG emissions in support of statewide GHG reduction goals."[29] There are

[24] Ramboll "Multi-Technology Scenarios: Heavy-Heavy Duty Truck Sector". 2021. Available here: https://www.arb.ca.gov/lists/com-attach/78-sp22-kickoff-ws-B2oFdgBtUnUAbwAt.pdf. Accessed: October 2022.
[25] HSC § 57005 requires CARB to consider any less costly but equally effective regulatory alternatives.
[26] CARB. 2022. Staff Report: Initial Statement of Reasons. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf. Accessed: October 2022.
[27] Ibid.
[28] Ramboll "Multi-Technology Scenarios: Heavy-Heavy Duty Truck Sector". 2021. Available here: https://www.arb.ca.gov/lists/com-attach/78-sp22-kickoff-ws-B2oFdgBtUnUAbwAt.pdf. Accessed: October 2022.
[29] CARB. 2022. Staff Report: Initial Statement of Reasons. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf. Accessed: October 2022.

many renewable liquid and gaseous options that already serve as alternatives to petroleum fuels. Recent data from CARB's LCFS website shows that 800,000 gallons per day of biodiesel, 2.5 million gallons per day of renewable diesel and over 170 million diesel gallon equivalents of renewable natural gas were supplied to the California fuels market in 2021.[30] The renewable diesel and biodiesel together supplied 34% of total California diesel demand.[31] In a multi-technology/multi-fuel alternative, renewable fuels can already serve today and can continue to serve in the future as low-CI fuel options to reduce statewide GHG emissions.

- Objective 6 is to "lead the transition of California's medium- and heavy-duty transportation sector from internal combustion to all electric powertrains."[32] However, CARB's mission under the Clean Air Act is to "promote and protect public health, welfare, and ecological resources through effective reduction of air pollutants while recognizing and considering effects on the economy,"[33] not to mandate a specific vehicle technology and this listed objective may not legally be included in the regulatory framework.

While the Draft EA included alternatives that considered low-NO_X trucks and renewable, low-CI fuels, these alternatives were crafted in a way that they could be easily rejected and in some cases the reasoning for rejecting the alternatives was flawed. See additional discussion on Alternatives 3 and 8 below:

- Alternative 3: the Best Available Control Technology (BACT) concept would allow for the purchase of a ZEV, if available, then near zero emission vehicle (NZEV), and then the cleanest certified engine for compliance. CARB rejected this alternative because the emissions benefits of additional cleaner engines in the fleet would already be accounted for in the Heavy-Duty Omnibus regulation, California's Low Carbon Fuel Standard program, and the federal Renewable Fuel Standard (RFS). This reasoning is flawed for the following reasons: (a) the ACF regulation is a fleet rule; Alternative 3 would require faster turnover of the vehicles to the cleanest certified engine, thereby providing additional near-term NO_X emissions while ZEV fueling infrastructure develops, and (b) the fuels used to power ZEVs (hydrogen and electricity) are also covered under the LCFS program.
- Alternative 8 would allow fleets to use natural gas trucks as well as ZEVs to meet the ZEV requirements of the proposed ACF until 2040, when the 100% ZEV sales requirements begin. CARB rejected this alternative by stating that the shift of combustion engine purchases from diesel and gasoline to natural gas would not achieve emission reductions when compared to the baseline because the Heavy-Duty Omnibus regulation allows engine manufacturers to average their engine emissions to meet the standard. There is no rational basis for excluding natural gas trucks that meet the optional low-NOx standards as the alternative to ZEVs given that CARB's

30 CARB. 2022. Low Carbon Fuel Standard Quarterly Data Spreadsheet. July 31. Available here: https://ww2.arb.ca.gov/sites/default/files/2022-08/quarterlysummary_073122_0.xlsx. Accessed: October 2022.
31 CARB. 2022. EMFAC Emissions Inventory. Available here: https://arb.ca.gov/emfac/emissions-inventory/d1a08e88bd07b3f76564d6d3b1fa544ec97e6400. Accessed: October 2022.
32 CARB. 2022. Staff Report: Initial Statement of Reasons. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf. Accessed: October 2022.
33 CARB. Available here: https://ww2.arb.ca.gov/about. Accessed: October 2022.

2016 Mobile Source State Implementation Plan (SIP)[34] demonstrated NO_X reductions could be achieved by low-NO_X trucks and CARB has certified numerous low-NOx truck engines.[35] Another reason that CARB offers for rejecting this natural gas truck alternative is that "ICEV purchases … would not reduce GHG emissions."[36] Instead CARB could have imposed an additional requirement that the natural gas vehicles that qualify as alternatives to ZEVs use renewable low-CI natural gas. Such an approach would help achieve GHG reductions that could be similar to or even greater than those provided by the ZEVs.

A.5 The cumulative impacts analysis for the proposed ACF regulation is inadequate.

The Draft EA references the environmental analyses of the 2030 Target Scoping Plan Update of 2017 and the Community Air Protection Blueprint of 2018. But neither plan evaluates the impacts of the increased electrical generation, transmission, and distribution infrastructure that would result from a regulation such as the proposed ACF. Furthermore, both of these documents are in the process of being updated, as required under statute, with significant changes that are reasonably foreseen and must be acknowledged and included along with ACF in this cumulative impact analysis.

As discussed later in Comment A.9 through Comment A.12, an assessment of the impacts of the proposed ACF on the State's electric grid has to be analyzed in the Draft EA. Besides this, the cumulative impacts of the proposed ACF and the recently adopted Advanced Clean Cars II regulation on the State's electrical generation, transmission, and distribution infrastructure should be evaluated and disclosed in the Draft EA.

A.6 The Draft EA analysis of the impacts of the proposed ACF regulation on mineral resources is inadequate as it fails to quantify the amount of metals that would have to be mined for battery production.

While the Draft EA lists the estimated reserves of lithium, platinum, and other elements in Tables 5 through 10, it fails to estimate the quantity of these elements that would have to be mined to produce the ZEVs required by the proposed ACF regulation.[37] CARB must quantitatively assess the impact the regulation will have on the state/worldwide demand of lithium and other rare earth metals, and the emissions that will be produced as a result of mining and shipping these materials.

The Draft EA should consider environmental impacts from mining of semi-precious metals and potential mitigations. The document does not address the potential hazards, construction, noise, or other impacts and potential mitigations for these impacts. There is mining of lithium that is likely to occur within the state (e.g., Lithium Valley) and CARB must, at the very least, assess the additional mining of rare earth metals that would be driven by the additional ZEVs required by this regulation and analyze the potential impacts associated with additional lithium mining in the State. Additionally, as noted

[34] Available: https://ww2.arb.ca.gov/resources/documents/2016-state-strategy-state-implementation-plan-federal-ozone-and-pm25-standards and https://ww3.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf. Accessed: October 2022.

[35] Available: https://ww2.arb.ca.gov/new-vehicle-and-engine-certification-executive-orders and https://www.epa.gov/sites/default/files/2021-01/documents/420f21002.pdf. Accessed: October 2022.

[36] CARB. 2022. Appendix D: Draft Environmental Analysis for the Advanced Clean Fleets Rule. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appd.pdf. Accessed: October 2022.

[37] Ibid.

above in Comment A.3, CARB must assess the GHG impacts of lithium mining and processing to analyze the full lifecycle GHG impacts of this regulation.

A.7 The Draft EA fails to evaluate the impacts of the large quantities of water that would be needed for renewable hydrogen production on the State's water supply.

CARB has not analyzed the impacts on hydrology and water quality that increased hydrogen production would necessarily require. CARB must quantify and assess the impact that increasing hydrogen production will have on the State's water supply. This is important because the State is already facing moderate to extreme drought conditions[38] and increasing water demand would put additional strain on an already extended supply system. The Hydrogen Decarbonization Pathways Report by the Hydrogen Council projects that gross water demand for hydrogen in 2030 could range from 9.9 kilogram (kg) water per kg of H_2 (lower heating value [LHV]) to 7,427.6 kg water per kg of H_2 (LHV) depending on the feedstock used.[39]

Comments on Electric Grid

A.8 The Draft Environmental Assessment fails to evaluate the operational impacts of the proposed ACF regulation on the State's energy demand and necessary transmission/distribution infrastructure.

While the Draft EA states that the proposed program "may also impact peak and based load period demand for electricity and other forms of energy," it fails to quantify the changes in energy demand.[40] In CARB's ACC II Response to Comments document, CARB asserted that "studies have shown no major technical challenges or risks have been identified that would prevent a growing electric vehicle fleet at the generation or transmission level, especially in the near-term."[41] One of the studies[42] cited for this claim that researched the grid's future capacity based on historical generation clearly stated that:

> "…this historical comparison overlooks factors that have changed energy generation over the years, such as market decoupling of energy supply from vertically integrated utilities. These periods of high growth in generation correspond to times in which the installation of large baseload generation (fossil and nuclear) were common. This may not be the case in the future, and other factors such as how ready utilities are to install new capacity, sufficient utility

38 State of California: California Drought Action. Current Drought Conditions. Available here: https://drought.ca.gov/current-drought-conditions/. Accessed: October 2022.

39 Hydrogen Council. 2021 Hydrogen Decarbonization Pathways. January. Available here: https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf. Accessed: October 2022.

40 CARB. 2022. Appendix D: Draft Environmental Analysis for the Advanced Clean Fleets Rule. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appd.pdf. Accessed: October 2022.

41 CARB. 2022. Response to Comments on the Draft Environmental Analysis for the Advanced Clean Cars II Program. August 24. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciirtc1.pdf. Accessed: October 2022.

42 US Drive. 2019. Summary Report on EVs at Scale and the U.S. Electric Power System. November. Available here: https://www.energy.gov/sites/prod/files/2019/12/f69/GITT%20ISATT%20EVs%20at%20Scale%20Grid%20Summary%20Report%20FINAL%20Nov2019.pdf. Accessed: October 2022.

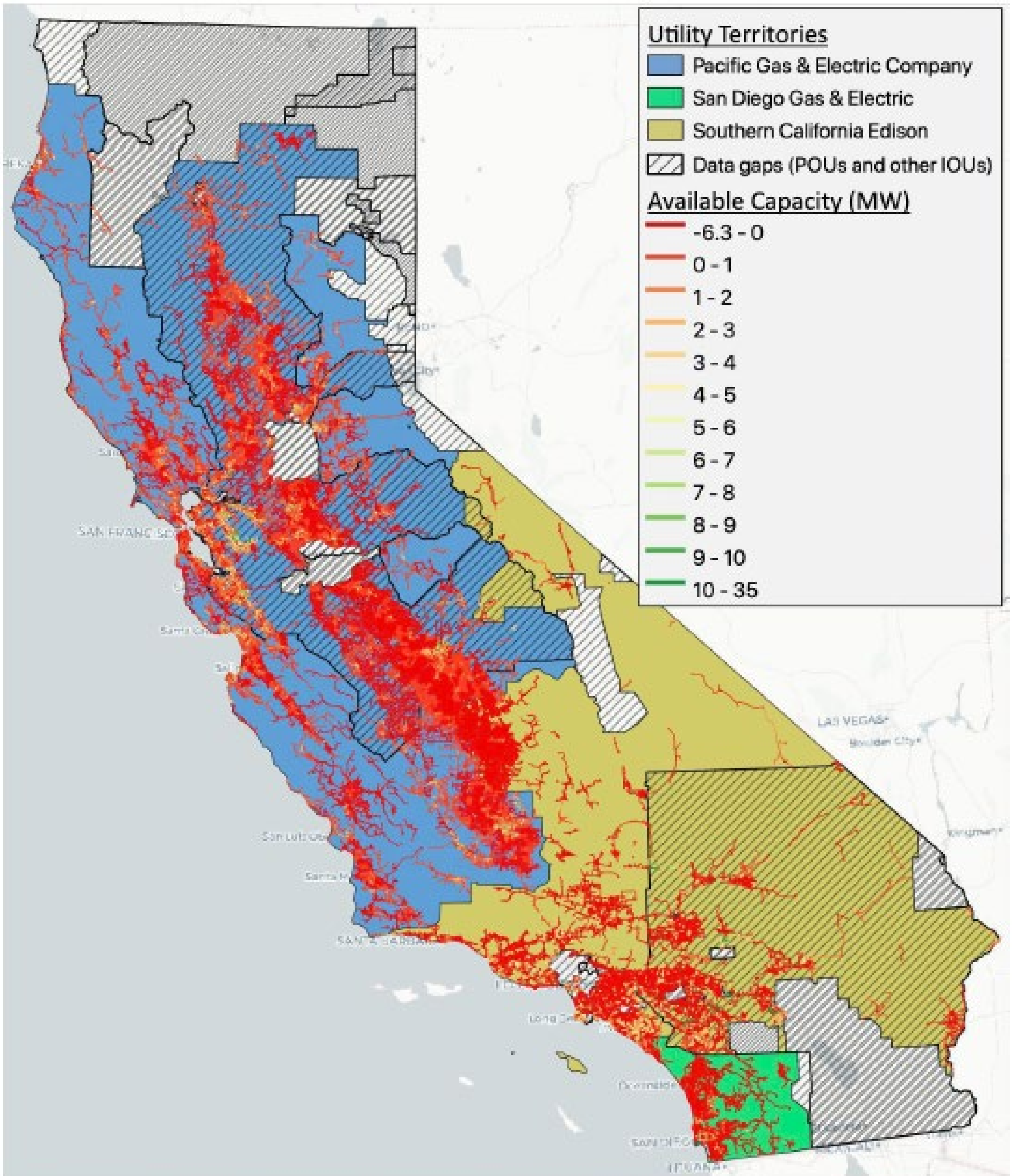
> labor, capital, land use, environmental regulations, reliability requirements, and the policy environment should all be considered."

As noted in the quote above, the readiness of utilities to install new capacity must be assessed before asserting that the grid is able to handle the capacity EVs (especially heavy-duty EVs) will require.[43] The Capacity Analysis from California Energy Commission's (CEC) EDGE Model (**Figure 2** below, obtained from Page 49 in the Final ACC II EA[44]) shows the grid has no additional capacity to add electrical load for charging EVs in most circuits. You can see this in numerical terms in **Figure 3** (obtained from Virtual Medium and Heavy-duty Infrastructure Workgroup Meeting - Electricity and the Grid on January 12, 2022), which details the capacity of circuits to integrate additional load. This figure illustrates that 30% to 76% of circuit segments have no capacity to integrate additional load. Thus, no appreciable charging capacity can be added to most of these circuits without the expenditure and time for additional construction of needed transmission and distribution infrastructure.

[43] HSC §§ 38560, 38562, 39602.5, 43013, and 43018 require CARB to assess technological feasibility for its ACF Proposal.

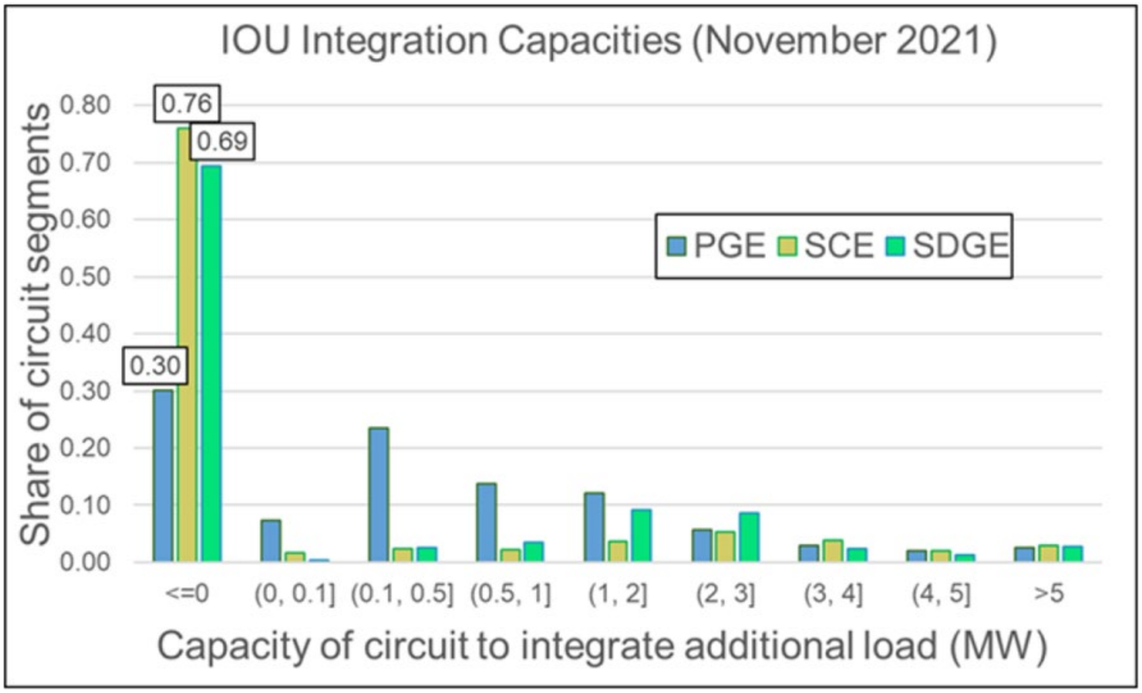
[44] CARB. 2022. Final Environmental Analysis for the Advanced Clean Cars II Program. August 24. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifinalea.docx. Accessed: October 2022.

Figure 2. Capacity Analysis from CEC's EDGE Model[45] (dark red indicates no available additional capacity)



45 CARB. 2022. Final Environmental Analysis for the Advanced Clean Cars II Program. August 24. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifinalea.docx. Accessed: October 2022.

Figure 3. Capacity of circuits to integrate additional loads[46]



The replacement of ICEVs with ZEVs under this program would result in a significant shift in the type of energy used to fuel the transportation sector that would generate significant decreases in liquid fuel use and significant increases in electricity and hydrogen use. The Draft EA cannot reasonably claim to assess the impact on the State's energy demand without quantifying these changes in energy use for various fuel types.

CARB has not provided any analysis of the feasibility of the proposed regulation given the significant increase of charging infrastructure, electrical generation and transmission and distribution infrastructure that would be required to support a ZEV fleet.

CARB has cited growth in the electric utilities sector and noted that new infrastructure will be needed to support this transition, however, CARB has failed to account for the costs of the infrastructure needed for this regulation in the SRIA, and have instead ascribed benefits to the electric utilities sector for job growth. CARB's analysis is incomplete and misleading. CARB must evaluate the full economic impact to electric utilities because of this regulation rather than just claim the benefits while ignoring the associated costs.

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[46] Presented during the January 12, 2022 CARB Virtual Medium and Heavy-Duty Infrastructure Workgroup Meeting - Electricity and the Grid (Part 1). Workgroup meeting recording available here: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events. Accessed: October 2022.

A.9 The Draft EA must analyze the operational peak and base electricity demand associated with the proposed project and evaluate the feasibility and costs of upgrading the grid to meet the demand within the timeframe of the proposed project.

CARB must quantitatively assess the energy resource inadequacy to meet proposed ACF regulatory requirement issues raised by stakeholders. In addition, for the CEQA analysis in the Final EA, CARB would have to either provide substantive information that the effect of inadequate energy/infrastructure resources are less than significant and/or assess mitigations for the likely significant impacts.[47] The cumulative impact assessment must also look at the cumulative effect of the ACF and the approved ACC II regulation.[48]

In the Final ACC II EA, CARB recognized that “electrification of California’s transportation sector, particularly when combined with increased electrification of the state’s building stock, will pose a significant new challenge to grid planning and require investments in transmission and local distribution systems”.[49] Using the EVI-Pro 2 model, CARB projected the electricity demand for light-duty vehicle (LDV) charging in 2030 over a 24-hour period, reaching around 5,400 megawatts at peak charging times, increasing electricity demand by up to 25% (**Figure 4**). It is equally if not more important for CARB to conduct a similar analysis on the impacts to the electricity grid due to the ACF regulation because of the significantly greater power required for heavy-duty vehicle (HDV) chargers, 150 kilowatts (kW) or greater for Class 7-8 tractors versus 19 kW or less required for LDV Level 2 chargers. The heavy localization of future HDV charging infrastructure will compound this issue, straining local electricity infrastructure, given that CARB expects most electric vehicle supply equipment (EVSE) to be installed in central depots or yards where trucks are parked overnight.[50]

CARB must assess the level of infrastructure upgrades that would be required to support the peak load under these scenarios and whether it is feasible to upgrade the grid infrastructure to meet the demand within the timeframe of the proposed project. A representative from an energy utility commented during the March 10, 2022 public workshop that their 10-year planning window may need to be expanded to 15 years. Long lead items such as high-scale transmission can take upwards of 7-10 years to build, while distribution infrastructure for individual HDV projects require a minimum of 4 months of utility construction and can take 18-24 months to complete overall.[51] Given that 1.5 million Class 2b-8 ZEVs would need to be deployed statewide by 2048 and the phased-in fleet

[47] CEQA requires that the Draft EA and Final EA contain “[a] discussion and consideration of environmental impacts, adverse or beneficial, and feasible mitigation measures which could minimize significant adverse impacts identified.” Cal. Code Regs. tit.17, § 60004.2(a).

[48] *See id.*

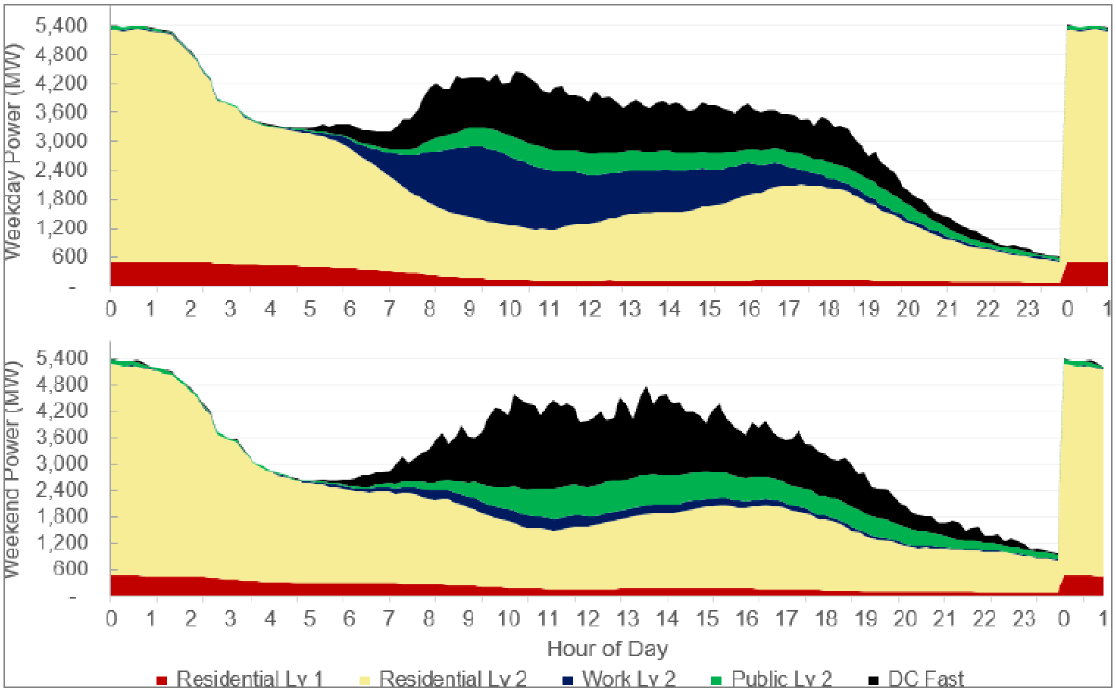
[49] CARB. 2022. Final Environmental Analysis for the Advanced Clean Cars II Program. August 24. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifinalea.docx. Accessed: October 2022.

[50] CARB. 2022. Appendix C: Original Standard Regulatory Impact Assessment Submitted to Department of Finance. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appc.pdf. Accessed: October 2022.

[51] CARB Workshop Recording of ACF Virtual Medium and Heavy-Duty Infrastructure Workgroup Meetings - Electricity and the Grid (Part 2). March 2022. CARB Workshop web page (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events) includes link to recording at: https://youtu.be/uLYrDh-pKQI. Accessed: October 2022.

transition begins in 2024, there seems to be too little time to complete these necessary upgrades.[52]

Figure 4. ACC II EA Projected 2030 Statewide Plug-in EV Charging Load for Intraregional Travel of 8 Million LD ZEVs in EVI-Pro2[53]



CARB claims in the ACF Draft EA that "increased deployment of ZEVs could result in a relatively small increase [in] production of electricity and hydrogen fuel"[54] and would have a less than significant cumulative impact to the energy sector without citing any data, modeling, or sources for this claim. Given the accelerated Senate Bill 100 (2018) and Senate Bill 1020 (2022) renewable energy targets for California's energy generation and the cumulative energy impacts of electrification under ACC II, ACF, and measures for building electrification, the state will become ever more reliant on its electric infrastructure in the coming decades. Although CARB states that the long-term operational-related utilities and service systems impacts are "beyond the authority of CARB and not within its purview," CARB has a responsibility as the CEQA lead agency to ensure that the energy impacts of regulations it puts forward are assessed and consistent with the proposed regulatory requirements and are technologically feasible within the timeframes it proposed.

52 CARB. 2022. Staff Report: Initial Statement of Reasons. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf. Accessed: October 2022.

53 CARB. 2022. Final Environmental Analysis for the Advanced Clean Cars II Program. August 24. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/acciifinalea.docx. Accessed: October 2022.

54 CARB. 2022. Appendix D: Draft Environmental Analysis for the Advanced Clean Fleets Rule. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appd.pdf. Accessed: October 2022.

A.10 CARB did not consider costs for updates to the electric grid infrastructure or costs for recycling and disposal of EV batteries in their calculation of the benefit-cost ratio for the deployment of ZEV technologies.

CARB estimated a benefit-cost ratio of 1.5 for the proposed ACF regulation in the SRIA.[55] This value was calculated as a ratio of the benefits associated with the rulemaking to the total costs for vehicle ownership. The list of costs considered are summarized in Table 38 of the SRIA and provided here for easy reference: vehicle cost (vehicle cost, sales tax, federal excise tax, residual values), fuel cost (gasoline, diesel, electricity, hydrogen fuel cost, fuel taxes), LCFS revenue, infrastructure costs (depot/retail charger costs, infrastructure upgrades, charger maintenance), maintenance costs (vehicle maintenance costs, maintenance bay upgrades), midlife overhaul costs, and other costs (diesel exhaust fluid [DEF] consumption, registration fees, depreciation, insurance, transitional costs, reporting costs). Additionally, the health benefits associated with avoided health outcomes of fine particulate matter ($PM_{2.5}$) emissions and changes in tax/fee revenues for state and local governments are incorporated into the calculation.

Similar to CARB's analysis for the ACC II regulation, while the costs considered in the calculation include the costs on the customer side of the meter, CARB has failed to account for:

- costs to upgrade the electric grid infrastructure for additional generation, distribution, and transmission necessary to support BEVs[56] (i.e., CARB staff claims, without foundation, these costs would be embedded in fuel costs on page 75 of the ISOR), and
- costs for recycling and disposal of the electric vehicle batteries and the potential environmental hazards that may result from recycling and disposal.

Within the ISOR, CARB staff states that "costs are not incorporated on the utility's side of the meter as those are the responsibility of the utility as specified in Assembly Bill 841 and are implemented by each IOU [investor owned utility]" despite the fact that these costs would be a direct impact of this regulation. This regulation would cause increases to the State's energy demand that will directly require upgrades to the state's energy infrastructure.[57]

As noted in the California Energy Commission's "Deep Decarbonization in a High Renewables Future",[58] these costs would be substantial. That study estimated a cumulative cost of $0.52 trillion from 2020-2030, $0.77 trillion from 2020-2035, and $1.82 trillion from 2020-2050 for upgrading and maintaining the electric grid under a High Electrification Scenario to meet the State's GHG targets of 40% reduction from 1990 levels by 2030 and 80% reduction by 2050. Additionally, the Senate Bill 1020 legislation[59]

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[55] CARB. 2022. Appendix C: Original Standard Regulatory Impact Assessment Submitted to Department of Finance. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appc.pdf. Accessed: October 2022

[56] CARB. 2022. Staff Report: Initial Statement of Reasons. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf. Accessed: October 2022.

[57] Ibid.

[58] E3 2018 Deep Decarbonization PATHWAYS Report. Available here: https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2018-012.pdf. Accessed: October 2022.

[59] SB1020, Chapter 361, Statutes of 2022. Available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB1020. Accessed October, 2022.

sets new interim targets for renewable energy requirements in California and requires 90% zero-carbon energy by 2035 and 95% by 2040. Senate Bill 1020 also requires that the policy "shall not increase carbon emissions elsewhere in the western grid." This acceleration could require additional investments to be needed earlier and thus could create additional challenges especially with the additional demand that would be generated by the penetration of zero-emission trucks. It is noteworthy that the High Electrification Scenario assumes only an 18% penetration of ZEV in the in-state MDV/HDV vehicle fleet by 2050, which is significantly lower than that proposed under the ACF. Hence, costs for grid infrastructure upgrades and maintenance could be much higher and CARB should evaluate and disclose these costs.

CARB similarly fails to discuss costs for recycling and disposal of the electric vehicle batteries and the potential environmental hazards that may result from recycling and disposal, despite recognizing that such impacts exist in the Draft EA. A report by Kelleher Environmental entitled "Research Study on Reuse and Recycling of Batteries Employed in Electric Vehicles" highlights some key concerns that may result in substantial costs associated with the regulation.[60] Both the reuse and recycling of EV batteries are hindered by a lack of collection infrastructure necessary to bring large numbers of batteries to a central location to exploit economies of scale. Transportation is expensive and highly regulated as used EV batteries are classified as hazardous waste. Further, the technologies that promise to achieve high recovery rates for the metals contained in EV battery cathodes have not yet been proven at commercial scale and there is uncertainty regarding aftermarket values for the materials recovered, particularly as battery chemistries continue to evolve.

As stated in the Draft EA, California is the largest market for EVs in the U.S. and by 2027, an estimated 45,000 EV batteries could be retired within the state.[61] CARB acknowledges that the proposed project could result in a significant cumulative impact on mineral sources.[62] Such an impact should be included in the benefit-cost ratio of the Proposed ACF regulation.

A.11 CARB's sensitivity analysis does not consider the potential impacts of ACF and other regulations, such as ACC II, to California's electricity grid and electric fuel costs and only evaluates a fixed 10% increase in costs.

CARB's projected electricity costs for the ACF Total Cost of Ownership[63] are modeled using CEC's "Revised Transportation Energy Demand Forecast, 2018-2030"[64] and U.S. Energy Information Administration (EIA) 2018 Annual Energy Outlook.[65] However, neither

60 Kelleher Environmental. 2020. Research Study on Reuse and Recycling of Batteries Employed in Electric Vehicles Prepared for Energy API. November. Available here: https://www.api.org/-/media/Files/Oil-and-Natural-Gas/Fuels/EV%20Battery%20Reuse%20Recyc%20API%20Summary%20Report%2024Nov2020.pdf. Accessed: October 2022.

61 CARB. 2022. Appendix D: Draft Environmental Analysis for the Advanced Clean Fleets Rule. August 30. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appd.pdf. Accessed: October 2022.

62 Ibid.

63 CARB. 2022. Total Cost of Ownership Discussion Document. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appg.pdf Accessed: October 2022.

64 CEC. 2018. "Revised Transportation Energy Demand Forecast, 2018-2030". April. Available here: https://efiling.energy.ca.gov/getdocument.aspx?tn=223241. Accessed: October 2022.

65 EIA. 2018. Annual Energy Outlook 2018. February. Available here: https://www.eia.gov/outlooks/archive/aeo18/. Accessed: October 2022.

of these projections consider the potential impacts of ACC II and ACF on the electricity grid infrastructure, generation requirements, and future electricity costs, leading to potentially significant underestimations and uncertainties in future electric fueling costs.[66]

Figure 12 in the Total Cost of Ownership document shows little change in the costs of charging from 2027 through 2040 for all vehicle classes, from \$0.15 to \$0.25/kW hour (kWh) for Class 2b-3 Cargo Vans through Class 8 Day Cabs and \$0.40 to \$0.45/kWh for Class 8 Sleeper Day Cabs.[67] The sensitivity analysis applies a fixed factor of 10% to the costs provided as a seeming upper bound for the ZEV fuel costs without accounting for potential spikes to electricity costs as a result of increased electricity demand from the wide array of programs within the 2022 State SIP Strategy, including ACF and ACC II.

CARB provides no foundation for its assumption that electricity costs will remain constant in the future.

Comments on Draft ACF Language

WSPA member companies operate truck fleets in their operating facilities and for transporting crude oil, finished products to retail locations, and other materials. The proposed ACF would impact these truck fleets by 1) requiring new ZEV truck purchases and 2) potentially increasing operating costs.

The ACF could change ownership of truck fleets. Current large fleets that would be subject to the rule could experience higher truck purchase costs and higher operating costs than smaller fleets not subject to the rule. This could change truck ownership, discouraging large fleets.

Trucks delivering fuel from terminals to retail locations also optimally operate with cargo loads near the maximum total vehicle operating weight limit. Future BEV and/or FCEV trucks could be heavier than current ICE trucks, which would reduce the volume of cargo that they could haul while still meeting the weight limits. If this were to prove to be true, then fuel haulers could only respond by making more trips with the same number of trucks to deliver the same volume of fuel, and/or by purchasing and using more trucks. Both situations could increase operating costs for fuel haulers which could translate to higher costs to the consumer. We encourage CARB to consider these business realities in its consideration of the ACF, and to consider the following issues with the currently drafted ACF language.

A.12 The proposed ACF regulation requires fleet owners to use specific kilowatt-hour per mile values to estimate the ZEV ranges for the daily usage exemption; however, there are no requirements for manufacturers to meet these kilowatt-hours per mile values in the Advanced Clean Trucks (ACT) regulation.

Within the Daily Usage Exemption in the High Priority and Federal Fleets and State and Local Governments regulations, CARB requires fleet owners to convert the rated energy capacity of the commercially available ZEV into “range of the vehicle” in miles using a factor based on vehicle class established by the regulation. CARB has provided no documentation to explain why these values were selected.

[66] CEC. 2018. “Revised Transportation Energy Demand Forecast, 2018-2030”. April. https://efiling.energy.ca.gov/getdocument.aspx?tn=223241. Accessed: October 2022.
[67] CARB. 2022. Total Cost of Ownership Discussion Document. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appg.pdf Accessed: October 2022.

Given that there is no complementary energy efficiency standard for ZEVs in the Advanced Clean Trucks rule or any other manufacturer requirement for heavy-duty ZEVs other than a minimum all-electric range of 75 miles for NZEVs,[68] there is no guarantee that the vehicles available for fleets to purchase will have energy efficiencies remotely resembling the values presented in the regulation. CARB should instead base this exemption on the real-world mileage and duty cycles achieved by the ZEVs or establish manufacturing criteria that supports the needs of fleet owners.

A.13 The provided exemptions do not adequately consider the lead time needed for permitting electric charging infrastructure upgrades and reliability of charging systems unique to heavy duty applications.

While the provided exemptions provide an extension for fleet owners to add a ZEV to their fleet based on delivery delays and delays in construction outside of the fleet owners' control, there is no such extension to account for delays in the permitting process, which has been a regular focus of concern among stakeholders at nearly every workgroup meeting held for the proposed ACF regulation.

In the ACF workshop on March 10, 2022, a representative from the Governor's Office of Business and Economic Development (GO-Biz) stated that permit streamlining was a focus for the Governor's Office and would like a better understanding of installation and permitting timelines.[69] However, there has been no reflection of these concerns within the regulation. The exemptions, as written, only take into consideration facility-side delays in construction, which does not account for the actual timeline of installing infrastructure. Facilities must first work with utilities to have sufficient power delivered to the site, which as previously discussed can take over a year, then acquire the permits necessary to begin construction.

Stakeholders are already experiencing permitting delays of over a year, and with the influx of infrastructure upgrades and permitting requests that will be submitted to utilities and state agencies as a result of this proposed regulation, these delays will likely stretch even longer.[70] In order to qualify for the infrastructure delay exemption, a facility would need to begin development of their site at least two and a half years in advance of the regulatory deadlines (e.g., four months, if not more, for utility power distribution upgrades; and one year, if not more, to acquire the necessary permitting in order to begin construction one year in advance of the regulatory deadline and qualify for the construction delay exemption).[71] Given that requirements for the State and Local

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68 CARB. 2019. Advanced Clean Trucks Final Regulation Order. December. Available here: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf. Accessed: October 2022.

69 CARB Workshop Recording of Virtual Medium and Heavy-Duty Infrastructure Workgroup Meetings - Electricity and the Grid (Part 2). March 2022. CARB Workshop web page (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events) includes link to recording at: https://youtu.be/uLYrDh-pKQI. Accessed: October 2022.

70 CARB Workshop Recording of Public Workshop on Draft ACF Regulation Provisions. July 2022. CARB Workshop web page (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events) includes link to recording at: https://youtu.be/N0cDTVp-m8Q. Accessed: October 2022.

71 CARB Workshop Recording of ACF Virtual Medium and Heavy-Duty Infrastructure Workgroup Meetings - Electricity and the Grid (Part 2). March 2022. CARB Workshop web page (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events) includes link to recording at: https://youtu.be/uLYrDh-pKQI. Accessed: October 2022. And CARB Workshop Recording of Public Workshop on Draft ACF Regulation Provisions. July 2022. CARB Workshop web page (https://ww2.arb.ca.gov/our-

Government Fleets regulation and the High Priority Fleets regulation begin on January 1, 2024, it may already be too late for these fleets to qualify for this exemption. CARB must take into consideration stakeholders' comments regarding the lack of certainty for permitting timelines and other delays that can occur before construction begins and expand on the list of exemptions and extensions allowed under the regulation.

A.14 CARB must update the proposed ACF rule language to clarify what fleets should do if their request for adding a vehicle configuration to the ZEV unavailability list or for an exemption is rejected.

The proposed ACF rule language does not describe the process that would occur following the rejection of an application for adding a vehicle configuration to CARB's ZEV unavailability list. We request that CARB update the rule language to state that CARB staff will respond to such a request within two weeks. We also request that the rule language be updated to state that in the event CARB staff reject the request to add a vehicle configuration to the ZEV unavailability request, they should provide an explanation for the reason for rejection as well as list of commercially available make/models of ZEV(s)/NZEV(s) for said vehicle configuration to the applicant. This would allow for fleets to understand why their request was rejected, while also providing them necessary information on commercially available vehicles that they could purchase.

The proposed rule language does not explicitly provide any pathway for appeal if CARB rejects a fleet's application for the ZEV delivery delay and/or infrastructure construction delay exemptions. CARB must update the rule language to include a clearly defined appeal process for fleet owners whose applications for such exemptions are denied.

work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events) includes link to recording at: https://youtu.be/N0cDTVp-m8Q. Accessed: October 2022.

ATTACHMENT C

Comments on ACF Regulation September 2021 Workshops

Sophie R. Ellinghouse
Director, California Policy

October 29, 2021

Submitted via the Workshop Comment Submittal Form and by email to zevfleet@arb.ca.gov

Advanced Clean Fleets
California Air Resources Board
1001 I Street,
Sacramento, CA 95814

Re: Comments on Advanced Clean Fleets (ACF) Regulation September Workshop

The Western States Petroleum Association (WSPA) appreciates the opportunity to comment on the September 9, 2021 public workshop held by the California Air Resources Board (CARB) on the proposed Advanced Clean Fleets (ACF) Regulation.[1] WSPA is a non-profit trade association that represents companies that export for, produce, refine, transport and market petroleum, petroleum products, natural gas and other energy supplies in California and four other western states, and has been an active participant in air quality planning issues for over 30 years.

We appreciate that CARB has extended the ACF rulemaking schedule to mid- to late-2022. This timeframe is more reasonable for a regulation that will directly impact every Californian . We also appreciate that CARB staff has made available an initial draft of ACF rule language and cost assumptions so that stakeholders can more meaningfully participate in the rulemaking process. With this transmittal, we are presenting the following high-level comments:

Section I – Summary of Comments on Draft Regulatory Language[2,3,4,5]

1. CARB should consider major modifications to the ACF to recognize the low GHG and NO_X potential of other vehicle/fuel systems. CARB could accomplish this by specifying acceptable near-zero-emission vehicle/fuel systems and incorporating them into the regulation by either 1) exempting those systems from the ZEV conversion requirements or 2) granting them partial or full ZEV credit. To support this modification, CARB should

[1] CARB. Notice of Public Workshop on Draft Regulatory Language and Updated Cost Assumptions for the Advanced Clean Fleets Regulation on September 9, 2021. Available at: https://content.govdelivery.com/accounts/CARB/bulletins/2ec4aad. Accessed: September 2021.

[2] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – 2040 100 Percent ZEV Sales Requirement. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909draft100zev_ADA.pdf. Accessed: September 2021.

[3] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – Public Fleet Requirements. September 9. Available at: Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909acfdraftpub_ADA.pdf. Accessed September 2021.

[4] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – High Priority and Federal Fleet Requirements. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909acfdraft_highpriofed_ADA.pdf. Accessed: September 2021.

[5] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – High Priority and Federal Fleet Requirements. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909acfdraftdrayage.pdf. Accessed: September 2021.

evaluate and compare the emission reduction capability and cost-effectiveness of other near-zero-emission systems versus the current ZEV options of BEV and FCEV. This is the only way to address stakeholder and public concerns about the current ACF's reliance on BEVs given the technology pathway's known feasibility issues and inability to achieve the near-term NO_X reductions CARB has committed to in the most polluted areas of the state.

2. CARB must demonstrate that fleet ZEV targets are technically and commercially feasible per the timing outlined in the proposed regulation and allow for reasonable exemptions where gaps are identified. This demonstration should include, at a minimum, 1) a 5-year (e.g., 2024-2028) forecast of the expected supply availability of ZEV vehicles by vehicle class, service, and manufacturer to California, 2) a projected 5-year demand for the same vehicles per the regulations' requirements, and 3) a review of existing and funded ZEV infrastructure to prevent an imbalance of supply and demand. This demonstration should be conducted by an independent State agency, such as the California Energy Commission (CEC) on a recurring schedule and exemptions should be based on the results of this feasibility analysis. The proposed exemptions do not provide proper allowances for small fleets, emergency vehicles, and specialty vehicles for which a ZEV transition may have serious consequences for the fleets' functionality and include no off-ramp language or flexibility for fleets in the future.

3. The proposed 2040 100% ZEV Sales Requirement represents a significant increase in ZEV sales from what is required under the current ACT rule, which requires 55% of Class 2b-3 trucks, 75% of Class 4-8 trucks, and 40% of truck tractors sales to be ZEV by 2035. We recommend that CARB consider this proposal as a separate rulemaking as it impacts a broader set of stakeholders not previously targeted by the proposed ACF regulation. Therefore, a separate feasibility, emissions, and cost-benefit analyses is needed for this requirement. This sales requirement would impact all vehicles and fleets (such as those in low-population areas and in private non-high-priority fleets), not just the fleets covered by the ACF.

4. CARB must revise the current requirements for drayage and high priority and federal fleets that allow old diesel trucks to remain on the road until the end of their useful life and preventing air districts from meeting near-term criteria air pollutant reduction targets, by considering near-zero-emission vehicle/fuel systems as a potential alternative as described under Comment 1.

5. CARB must standardize the recordkeeping requirements across all proposed ACF regulations to minimize the burden on fleet owners, truck owners, ports / terminal / intermodal railyard operators and manufacturers.

Western States Petroleum Association 1415 L Street, Suite 900, Sacramento, CA 95814 916.803.7674 wspa.org

Section II – Summary of Comments on Draft ACF Total Cost of Ownership (TCO) Discussion Document[6]

6. CARB's cost analysis underestimates the cost of transitioning to BEV technology as it does not include costs associated with increased electricity production necessary to power them and transmission / distribution infrastructure changes needed to bring the power to the fleets.

7. CARB's TCO analysis underestimates the total ownership costs of a ZEV.

8. CARB overestimates the TCO for natural gas vehicles by including costs for NG vehicle infrastructure that already exists in California.

9. CARB has not addressed the feasibility of meeting potential hydrogen fuel requirements resulting from the proposed ACF regulation.

10. CARB's treatment of infrastructure costs and LCFS credits is inconsistent (and potentially erroneous) across vehicle technologies assessed in the ACF TCO document.

11. CARB must address the inconsistencies in the constant dollar costs in the TCO analysis and provide the basis for several assumptions related to ZEV costs.

Section III – Comments previously submitted to CARB Staff

12. We respectfully request that CARB respond to the specific items we raised in our previous comment letter dated April 17, 2021.[7]

Each of these twelve comments are discussed in further detail in the Attachment.

Sincerely,

Sophie R. Ellinghouse
Director, California Policy

Attachment – Comment Details

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[6] CARB. 2021. Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document". September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf. Accessed: September 2021

[7] 2021. WSPA. Comments on the Advanced Clean Fleet Regulation March Workshops. April 17. Available at: https://www.arb.ca.gov/lists/com-attach/36-acf-comments-ws-UCdTJlUkAzFVDFMy.pdf. Accessed: September 2021.

ATTACHMENT – COMMENT DETAILS

This Attachment provides greater detail on the twelve itemized comments raised in the main letter.

Section I – Comments on Draft Regulatory Language[8,9,10,11]

1. **CARB should consider major modifications to the ACF to recognize the low GHG and NO_X potential of other vehicle/fuel systems. CARB could accomplish this by specifying acceptable near-zero-emission vehicle/fuel systems and incorporating them into the regulation by either 1) exempting those systems from the ZEV conversion requirements or 2) granting them partial or full ZEV credit. To support this modification, CARB should evaluate and compare the emission reduction capability and cost-effectiveness of other** near-**zero-emission systems versus the current ZEV options of BEV and FCEV. This is the only way to address stakeholder and public concerns about the current ACF's reliance on BEVs given the technology pathway's known feasibility issues and inability to achieve the near-term NO_X reductions CARB has committed to in the most polluted areas of the state.**

   The Federal Clean Air Act (CAA) requires CARB to consider the effect of regulations on regional air pollution, particularly in South Coast (SC) and San Joaquin Valley (SJV) air basins that have to meet upcoming ozone attainment deadlines in 2023 and 2031. Unfortunately, CARB has not only failed to deliver on the mobile source commitments in the 2016 State Implementation Plan (SIP), but it continues to focus on longer-term air quality and climate targets (post-2037) which clearly undermine the State's ability to meet its near-term Federal CAA obligations (2023 and 2031) by undercutting commercially-available near-zero-emission low-NO_X technologies.

   As noted by several stakeholders, the ZEV technologies required by the proposed ACF regulation cannot meet the needs of all the end uses for medium-duty (MD) and heavy-duty (HD) fleets. Hence, CARB's ZEV-centric approach will place significant limitations on fleets whose needs cannot be served by this technology. While CARB notes that the proposed ACF regulation could generate 20.4 tons per day (tpd) reduction in NO_X emissions by 2031 and a 54.3 tpd NO_X reduction by 2037 (to a total of approximately 100 tpd),[12] it fails to provide the details of the methodology used to estimate these emission reductions. As a result, it is not clear if these emission reductions include the increased emissions associated

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[8] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – 2040 100 Percent ZEV Sales Requirement. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909draft100zev_ADA.pdf. Accessed: September 2021.

[9] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – Public Fleet Requirements. September 9. Available at: Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909acfdraftpub_ADA.pdf. Accessed September 2021.

[10] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – High Priority and Federal Fleet Requirements. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909acfdraft_highpriofed_ADA.pdf. Accessed: September 2021.

[11] CARB. 2021. Advanced Clean Fleets Regulation – Proposed Draft Regulation Language – High Priority and Federal Fleet Requirements. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909acfdraftdrayage.pdf. Accessed: September 2021.

[12] 2021. CARB. Advanced Clean Fleet Regulation Workshop Staff Presentation, Slide 20. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-09/210909acfpres_ADA.pdf. Accessed: September 2021.

with increased power production that is required to make the ZEV transition. Further, it is unclear if these reductions are indeed achievable as the technological feasibility and commercial availability of ZEV technologies has not be established. Therefore, it is imperative that CARB provide alternate options for fleet owners to comply with this regulation.

As stated in our comment letter dated April 17, 2021[13] WSPA reiterates the need for CARB to conduct a comprehensive assessment of available multi-technology fuel-neutral strategies to identify acceptable near-zero-emission vehicle/fuel systems that could deliver earlier and more cost-effective air quality and greenhouse gas reductions benefits that the proposed ZEV-centric approach which does not address the needs of all vehicle end uses. After completing this evaluation, CARB should incorporate these near-zero-emission vehicle/fuel systems into the regulation by either 1) exempting those systems from the ZEV conversion requirements or 2) granting them partial or full ZEV credit. This approach would provide alternative options for medium-duty (MD) and heavy-duty (HD) fleets to generate the emission reductions needed to meet the near-term Federal CAA attainment deadlines as well as the long-term climate goals.

Additionally, CARB must work with the Governor's office to expand and update his current budget proposal for $915 million in investments for ZEV charging infrastructure[14] to include investments in low carbon fuel infrastructure that would power these near-zero-emission vehicle/fuel systems.

2. **CARB must demonstrate that fleet ZEV targets are technically and commercially feasible per the timing outlined in the proposed regulation and allow for reasonable exemptions where gaps are identified. This demonstration should include, at a minimum, 1) a 5-year (e.g., 2024-2028) forecast of the expected supply availability of ZEV vehicles by vehicle class, service, and manufacturer to California, 2) a projected 5-year demand for the same vehicles per the regulations' requirements, and 3) a review of existing and funded ZEV infrastructure to prevent an imbalance of supply and demand. This demonstration should be conducted by an independent State agency, such as the California Energy Commission (CEC) on a recurring schedule and exemptions should be based on the results of this feasibility analysis. The proposed exemptions do not provide proper allowances for small fleets, emergency vehicles, and specialty vehicles for which a ZEV transition may have serious consequences for the fleets' functionality and include no off-ramp language or flexibility for fleets in the future.**

As noted under Comment 1, stakeholders have repeatedly voiced concerns that ZEVs cannot serve all the end uses for MD/HD fleets. Further, CARB's assumption in the Draft

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[13] 2021. WSPA. Comments on the Advanced Clean Fleet Regulation March Workshops. April 17. Available at: https://www.arb.ca.gov/lists/com-attach/36-acf-comments-ws-UCdTJlUkAzFVDFMy.pdf. Accessed: September 2021.

[14] CEC 2022 Scoping Plan Update Workshop: Zero-Emission Vehicle Infrastructure. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-06/cec_sp_kickoff-transportation_june2021.pdf. Accessed September 2021.

Cost Discussion Document[15] that one BE truck can perform the work of one diesel truck is unrealistic for several end uses. A recent study[16] conducted by the National Center for Sustainable Transportation (NCST) on Short Haul Goods Movement indicates that 1.4 BE trucks are needed to replace a diesel truck in calendar year 2024. Further the high capital costs of the ZEVs and the lack of public charging infrastructure impose additional burdens on small fleet owners that do not have sufficient cash flow for large down payments or real estate to install chargers. While CARB has included some exemptions in the proposed ACF regulations, there do not address all the above-mentioned issues.

To develop reasonable exemptions that address gaps in ZE technology development and implementation, CARB must solicit the assistance of an independent State agency, such as the CEC, to conduct a comprehensive evaluation of the technical and commercial feasibility of the ZE vehicle penetration timing in the proposed regulation. This should include, at a minimum, a demonstration of 1) a 5-year (e.g., 2024-2028) forecast of the expected supply availability of ZEV vehicles by vehicle class, service, and manufacturer to California, 2) a projected 5-year demand for the same vehicles per the regulations' requirements, and 3) a review of existing and funded ZEV infrastructure to prevent an imbalance of supply and demand. Additionally, the independent State agency must also conduct an ongoing (annual or biannual) analysis of the technological feasibility and commercial viability of implementing the proposed ZEV pathways for various MD/HD vehicle end uses and publish/maintain a list of available ZE vehicle make and models that could be deployed for each end use on their website. This would inform fleet owners of the currently available technology that would meet the needs of their fleet. The CEC is already tracking the progress of electric vehicle penetration and charging infrastructure deployment in the light duty vehicle sector[17,18] and can potentially expand their existing tracking system to encompass the MD/HD vehicle sector.

Additional WSPA notes the following issues related to the exemptions that proposed in the draft ACF regulation:

- For a high priority or federal fleet to be eligible for the Daily Mileage Exemption, the fleet owner must show that (a) 10% of vehicles in the fleet must first be ZEVs, (b) the mileage needs of the vehicle cannot be met by a ZEV for 3 days out of a 30-day period, and (c) that no ZEV infrastructure is available along the vehicle's routes. Many stakeholders agree that a mileage exemption does not capture the full duty requirements of vehicles and an exemption should instead be granted based on the power and hours of operation requirements. Specialty vehicles that do not have high mileage but do have high duty cycles (operating for several days in the field at a time) may be incompatible with

[15] 2021. Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf. Accessed September 2021.

[16] 2020.Genevieve Giuliano, Maged Dessouky, Sue Dexter, Jiawen Fang, Shichun Hu, Seiji Steimetz, Thomas O'Brien, Marshall Miller, Lewis Fulton, . Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement: A Research Report from the National Center for Sustainable Transportation. Available at: https://escholarship.org/uc/item/0nw4q530. Accessed: September 2021.

[17] CEC. Zero Emission Vehicle and Infrastructure Statistics. Available at: https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics. Accessed: September 2021.

[18] CEC. Tracking Progress. Available at: https://www.energy.ca.gov/data-reports/tracking-progress. Accessed: September 2021.

existing ZEV technology but are not afforded an exemption under the proposed rule. Further, the requirement that 10% of the fleet should be ZEVs seems absurd, particularly for specialty vehicle fleets where ZEVs will not be able to meet their operational needs.

- Under the proposed public fleet requirements, public fleets whose jurisdiction is solely in a designated low population county need not meet the 50% ZEV purchase requirement from 2024-2026. Removing this interim purchasing requirement does not address the need for the establishing a widespread ZEV infrastructure by 2027 when the 100% purchase requirement kicks in. CARB must make further attestations that the infrastructure required to support ZEV fleets will be available in low-population counties before prescribing a fleet purchasing requirement for public fleets.

- There is no exemption for small fleets in the proposed drayage truck requirements. Many drayage truck fleets are dependent on a secondary vehicle market, which does not yet exist for HD ZEVs. Further, as noted earlier, small fleet owners would need a public ZEV fueling infrastructure in place to make this ZEV transition. The lack of guarantees on both of these fronts is very concerning as it would force a several small drayage fleet owners out of business, resulting in a shortage of drayage trucks which could trigger supply chain disruptions at seaports during periods of cargo surges.

- The proposed requirements for high priority, federal and public fleets provide exemptions for emergency vehicles if 75% of trucks of that body type within a fleet are ZEV. This would significantly reduce the number of vehicles available to respond in emergencies such as earthquakes or forest fires that could impact the electric grid and associated ZE fueling infrastructure. The ACF regulation appears to imply that an out-of-state vehicle/vehicle fleet operating in California to assist in a state of emergency would become subject to the ACF after 30 days. The inclusion of this provision further puts Californians at risk as it discourages out-of-state entities from providing aid in emergency situations, which in dire situations can last much longer than 30 days. Further, the definition of emergency vehicles is extremely limited to just energy and water sectors and should be expanded to all essential service vehicles.

As noted in Comment 1 and our previous comment letter dated April 17, 2021[19] alternative technologies such as near-zero-emission vehicle operating on renewable fuels have the potential to generate the emission reduction benefits desired under this program. CARB should consider incorporating these technologies as an alternative compliance option for specialty vehicle fleets, public fleets in designated low population counties, small fleet owners, and emergency vehicles.

3. **The proposed 100% ZEV Sales Requirement represents a significant increase in ZEV sales from what is required under the current ACT rule, which requires 55% of Class 2b-3 trucks, 75% of Class 4-8 trucks, and 40% of truck tractors sales to be ZEV by 2035. We recommend that CARB consider this proposal as a separate rulemaking as**

[19] 2021. WSPA. Comments on the Advanced Clean Fleet Regulation March Workshops. April 17. Available at: https://www.arb.ca.gov/lists/com-attach/36-acf-comments-ws-UCdTJlUkAzFVDFMy.pdf. Accessed: September 2021.

it impacts a broader set of stakeholders not previously targeted by the proposed ACF regulation. Therefore, a separate feasibility, emissions, and cost-benefit analyses is needed for this requirement. This sales requirement would impact all vehicles and fleets (such as those in low-population areas and in private non-high-priority fleets), not just the fleets covered by the ACF.

The proposed 100% ZEV Sales Requirement[20] represents a significant increase from the ZEV sales percentage requirements under the current Advanced Clean Trucks Regulation,[21] i.e., 55% for Class 2b-3 trucks, 75% for Class 4-8 trucks, and 40% for truck tractors in 2035 and beyond. The scope and potential impact of this 100% ZEV Sales Requirement extends far beyond the rest of the proposed ACF regulations, which primarily focus on fleet composition of high priority, federal, public, and drayage fleets. Additionally, as noted under Comment 1, ZEV technologies cannot address the needs of all end uses for MD/HD fleets. It is CARB's responsibility to understand impediments to ZE technology implementation and use the lessons learned from previous programs such the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) to proactively manage this transition. Given the lack of certainty regarding BEV and FCEV technological development for certain end uses and projected infrastructure availability in low-population areas, it is imperative that CARB evaluate the technological feasibility of ZEVs, and include flexibilities in this rulemaking to ensure that alternative fuel/technology vehicles are available in the market for fleets that cannot find a ZEV to meet their needs. As such WSPA recommends that the 2040 100% ZEV Sales Requirement be considered as a separate rulemaking as it affects a broader set of stakeholders, including engine manufacturers and their customers not previously targeted by the proposed ACF regulation. This 100% ZEV Sales Requirement also requires a separate feasibility, emissions, and cost-benefit analyses.

4. **CARB must revise the current requirements for drayage and high priority and federal fleets that allow old diesel trucks to remain on the road until the end of their useful life and preventing air districts from meeting near-term criteria air pollutant reduction targets, by considering near-zero-emission vehicle/fuel systems as a potential alternative as described under Comment 1.**

As written, the proposed Alternative Compliance requirements (Section 95692.1(c)) allows a fleet to remain in compliance as long as all ICE vehicles owned by the fleet were purchased prior to January 1, 2024 and remain within their minimum useful life. This allows for fleet owners to pre-buy quantities of ICE vehicles immediately before the regulatory deadline, delaying the emissions benefits of the program and disrupting the usual purchasing cycle of fleets that this proposed regulation is based on. In the example given by CARB staff during the September 9th ACF public workshop, trucks are expected to have approximately 13 years before their minimum useful life, which forces model year (MY) 2015 vehicles and earlier to retire by 2028-2030, which is in line with the 2035 100% ZEV timeline. However by

[20] CARB. 2021. Advanced Clean Fleets Regulation. Proposed Draft Regulation Language. 2040 100 Percent ZEV Sales Requirement. September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909draft100zev_ADA.pdf. Accessed September 2021.

[21] Final Regulation Order. Advanced Clean Trucks Regulation Available at: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf. Accessed September 2021.

this logic, a MY 2023 vehicle, or perhaps an entire fleet of MY 2023 vehicles, would be in compliance through 2036 and beyond, completely undermining the emission reductions outlined by this proposed regulation. CARB staff stated that the potential for pre-buy is unavoidable, raising concerns that CARB's proposed emission reduction strategy is vulnerable to delays in ZEV adoption. This loophole needs to be closed by considering near-zero-emission vehicle/fuel systems as a potential alternative as described under Comment 1.

5. **CARB must standardize the recordkeeping requirements across all proposed ACF regulations to minimize the burden on fleet owners, truck owners, ports / terminal / intermodal railyard operators and manufacturers.**

   As noted in Table 1, CARB is requiring several different timelines (5 to 8 years) for the recordkeeping requirement in the proposed requirements for private, federal, public, and drayage fleets. This generates additional work for fleet owners, truck operators, ports / terminal/ intermodal railyard operators, and manufacturers who have to understand and track varying rule requirements. Therefore we request CARB standardize these requirements across all ACF regulations.

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Table 1. Recorkeeping Requirements			
Rule Section	**Responsible Party**	**Details of Records Maintained**	**Time Period for Maintenance of Records**
95692.5 (a), (C)	Fleets owner	• Entity and vehicle documentation • Shipping documentation • Emergency operation documentation • Gross annual revenue documentation • Backup Vehicle Records	8 years
95692.5 (a)	Truck operator	Documentation that identifies the entity that is responsible to pay the driver and any applicable shipping paperwork or other documentation that identifies the origin and destination of the cargo and the pick up and termination destination of the cargo.	8 years
95691(d)(4)	Drayage Truck Operator	• Dispatching drayage motor carrier's contact information • Documentation on the destination of the cargo, chassis, and intermodal equipment (container, etc.)	Not defined
95691(d)(5)(E)	Drayage Motor Carrier and Common Owner or Controller Requirements	Maintian following details for all contracted or dispatched drayage trucks sent to a seaport or intermodal railyard: • Truck dispatch date and time • Shipping paper or tracking number • Truck license plate number and issuing state • Drayage Truck Registry (DTR) identification number	5 years

Table 1. Recorkeeping Requirements			
Rule Section	**Responsible Party**	**Details of Records Maintained**	**Time Period for Maintenance of Records**
95691(d)(6)(B)	Marine and Seaport Terminal and Intermodal Railyard	Collect the following information on the dispacting drayage motor carrier • Business name of dispatching drayage motor carrier; • Contact person's name; • Street address, city, state, zip code; • Phone number of the dispatching drayage motor carrier; and • Shipping paper or tracking number Collect the following information for each drayage truck subject to this regulation that enters the facility or property: • Entry date and time • Exit date and time • Registered owner's name • Operator's name • Operator's liscense name • License plate number state of issuance • Vehicle Identification Number (VIN)	5 years

Table 1. Recorkeeping Requirements			
Rule Section	**Responsible Party**	**Details of Records Maintained**	**Time Period for Maintenance of Records**
95693.4	Public Agency	A list of vehicles in the fleet including the vehicle identification number, license plate, vehicle type, vehicle model year, fuel and drivetrain type, vehicle registration information, purchase orders, and public bid contracts. If using exemptions, the fleet owner must keep records used to qualify for the exemptions.	8 years after information is initially reported and 3 years after the vehicle is retired
95694 (g)	Manufacturer	Maintain the following information for each on-road vehicle produced and delivered for sale in California for each model year: • VIN • Fuel and drivetrain type • If the vehicle is not a ZEV, documentation showing the vehicle is an authorized emergency vehicle • Documentation showing vehicle delivery to the ultimate purchaser at a location in California	8 years

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Section II – Comments on the Draft ACF TCO Discussion Document[22]

6. **CARB's cost analysis inadequate as it does not consider costs associated with increased electricity production necessary to power them and transmission / distribution infrastructure changes needed to bring the power to the fleets.**

   While CARB has prepared a total cost of ownership analysis that estimates potential cost to fleet owners, it fails to consider the costs incurred by public and private utilities for upgrading the State's infrastructure to support the vast increase of ZEV MD and HD trucks that will result from this ruling. As noted in the California Energy Commission's "Deep Decarbonization in a High Renewables Future", [23] these costs can be substantial. This study estimates a cumulative cost of $0.52 trillion from 2020-2030, $0.77 trillion from 2020-2035, and $1.82 trillion from 2020-2050 for upgrading and maintaining the electric grid under a High Electrification Scenario which meets the State's GHG targets of 40% reduction form 1990 levels by 2030 and 80% reduction by 2050. It is noteworthy that the High Electrification Scenario assumes only an 18% penetration of ZEV in the in-state MD/HD vehicle fleet by 2050, which is significantly lower than that proposed under the ACF. Hence, costs for grid infrastructure upgrades and maintenance could be much higher and CARB should evaluate and disclose these costs.

7. **CARB's TCO analysis underestimates the total ownership costs of a ZEV**

   CARB's TCO analysis contains numerous assumptions and claims that grossly underrepresent the true total cost of ownership of a ZEV. It is imperative that CARB address these misrepresentations in order to provide a fair comparison of the TCO across the different vehicle technologies.

   - **CARB underestimates the TCO of BE trucks by assuming that one BE truck can replace one diesel truck.** CARB's TCO analysis fails to acknowledge that a single BE truck will not be able to replace a diesel truck for several end use applications, thereby underestimating the costs for BEVs. As noted in the 2020 NCST study[24] on short haul good movement, even with improved battery technology in 2030, 1.2 BE trucks would be required to replace a since diesel truck. This number would be even higher in the early compliance years.

   - **CARB has not accounted for the uncertainty of future LCFS credit prices, which could be even lower especially if demand for deficit-generating fuels are reduced.** LCFS credit revenue depends on future market conditions and availability of credit deficits from the production of higher carbon intensity fuels. With the declining sale of

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[22] CARB. 2021. Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document". September 9. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf. Accessed: September 2021

[23] E3 2018 Deep Decarbonization PATHWAYS Report. Available https://www.ethree.com/projects/deepdecarbonization-california-cec/. Accessed September 2021.

[24] Genevieve Giuliano, Maged Dessouky, Sue Dexter, Jiawen Fang, Shichun Hu, Seiji Steimetz, Thomas O'Brien, Marshall Miller, Lewis Fulton. 2020. Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement: A Research Report from the National Center for Sustainable Transportation. Available at: https://escholarship.org/uc/item/0nw4q530. Accessed: September 2021.

fossil fuels (higher carbon intensity fuels) the LCFS deficits would also decline greatly over time.

- **CARB fails to acknowledge that TCO for BEV/FCEV vehicles which rely on retail charging/refueling could be significantly higher.** Several fleets particularly small fleets that do not own the real estate needed to install on-site charging/fueling infrastructure would utilize retail charging/fueling facilities to comply with this regulation. Hence, they would not receive the LCFS credits that CARB has included in the TCO analysis. Excluding the reductions in cost associated with the LCFS credits would significantly increase the TCO for ZEVs. For example the TCO for MY2025 BE day cab would increase by 49%.

- **CARB's overly optimistic projections in battery cost reductions underrepresent the BEV purchase price**. CARB continues to use the Bloomberg Energy's light-duty (LD) battery cost assumptions with a five-year delay to reflect battery price projects for Class 4 to Class 8 trucks consistent with their analyses in the ACT regulation. The have however assumed lower battery prices for Class 2b-3 vehicles by applying a 2-year delay to the Bloomberg Energy's light-duty (LD) battery cost assumptions. As noted previously in Ramboll's assessment of multi-technology pathways for the heavy-heavy-duty truck sector in California,[25] these costs reductions are overly optimistic resulting in a lower TCO for BEVs.

- **CARB's BEV charger costs are likely underestimated as they do not account for chargers with a rating of 150-350 kW**. Table 14 of the TCO Discussion Document assumes that charger costs would range from $5,000 for a 19kW charger to $75,000 for 150kW charger. However as noted in South Coast Air Quality Management District's (SCAQMD's) Final Staff Report on the Warehouse Indirect Source Rule,[26] 350kW chargers could be installed for ZE trucks that could cost as much as $140,000.

- **CARB residual value for ZE trucks are overestimated as they fail to account for the accelerated depreciation rates for ZEV**. CARB analysis assumes that ZEVs depreciate at the same rate as diesel powered vehicles (Page 31 of the TCO Discussion Document). This is inconsistent with the historical trends which indicate an accelerated depreciation of ZEVs compared to their diesel counterparts. A recent white paper prepared by CALSTART for the International ZEV Alliance found that ZEVs have a more rapid rate of depreciation compared to their diesel counterparts, leading to a higher capital cost.[27] Additionally, Fleet Forward found that the biggest cost factor for BEVs is

[25] The report was submitted as an attachment to WSPA previous comment on the ACF Regulation letter dated April 17, 2021. It is also available at: https://www.wspa.org/resource/ramboll-multi-technology-pathways-study/. Accessed: September 2021.

[26] SCAQMD. 2020. Final Staff Report on the Warehouse Indirect Source Rule. Available at: http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2021/2021-May7-027.pdf?sfvrsn=10. May 7. Accessed: September 2021.

[27] Dan Welch, Cristiano Facanha, Rob Kroon, David Bruil, Floris Jousma, and Harm Weken. 2020. Moving Zero-Emission Freight Toward Commercialization. October. Available at: https://globaldrivetozero.org/site/wp-content/uploads/2020/12/Moving-Zero-Emission-Freight-Toward-Commercialization.pdf. Accessed: September 2021.

depreciation, which strongly impacts the TCO associated with these vehicles.[28] As battery technology continues to improve and change, the technology outdates itself rapidly, leading to a depreciation that is faster than diesel vehicles. There is no sign that the improvements in ZEV technology will slow; so the depreciation of these vehicles will most likely continue to be much higher than diesel vehicles for several years.

8. **CARB overestimates the TCO for natural gas vehicles by including costs for NG vehicle infrastructure that already an exists in California.**

   CARB's TCO analysis assumes that the deployment of natural gas vehicles will require infrastructure upgrades of $40,000 per vehicle that add to the total cost of ownership of the vehicle. However, this assumption is unfounded. A robust infrastructure of fueling locations for natural gas has been available for over 5 years and additional stations do not appear to be needed for an expanded fleet of trucks.[29] Maps of the nearly 200 public-access natural gas fueling stations in California and 850 fueling stations in the nation are available through the California Natural Gas Vehicle Coalition and the Alternative Fuels Data Center.[30,31] It is notable that CARB did not include any infrastructure costs for FCEV when the number of hydrogen gas stations currently available in California is far lower (only 62) [32] than the NG fueling stations. This unequal treatment of NG and FCEV in the TCO analysis makes the results look more favorable for BE and FCE trucks as compared to NG trucks. CARB should update their analyses to remove any infrastructure costs associated with NG trucks.

9. **CARB has not addressed the feasibility of meeting potential hydrogen fuel requirements resulting from the proposed ACF regulation.**

   CARB has not assessed the viability and feasibility of meeting potential hydrogen fuel demand that may result from the proposed ACF regulation. CARB assumes that hydrogen refueling stations will be "available at strategic locations around seaports and major distribution hubs", (Page 20 of the TCO Discussion Document) but does not provide any analysis to demonstrate that this will be adequate to support the number of hydrogen-fueled trucks that would likely result from the proposed ACF regulation. Further, CARB estimates in their Annual Evaluation of Fuel Cell Vehicle Deployment Report[33] that potential hydrogen sales for transportation will be around 14 million kg/year in 2027. However, per a study

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[28] 2021. Electric Models: Depreciation Still Drags Down Ownership Costs. March 2. Available at: https://www.fleetforward.com/10137843/electric-models-depreciation-still-drags-down-ownership-costs. Accessed: September 2021.

[29] California Energy Commission. Transportation Natural Gas in California. Available at: https://ww2.energy.ca.gov/almanac/transportation_data/cng-lng.html. Accessed: September 2021.

[30] California Natural Gas Vehicle Coalition. Fueling Stations. Available at: https://cngvc.org/news/fueling-stations/. Accessed: September 2021.

[31] United Stated Department of Energy. Natural Gas Fueling Station Locations. Available at: https://afdc.energy.gov/fuels/natural_gas_locations.html#/find/nearest?fuel=CNG. Accessed: September 2021.

[32] CARB. 2021. 2021 Annual Evaluation of Fuel Cell Electric Vehicle Deployment. September. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-09/2021_AB-8_FINAL.pdf. Accessed: September 2021.

[33] 2021 Annual Evaluation of Fuel Cell Electric Vehicle Deployment. Available at: https://ww2.arb.ca.gov/sites/default/files/2021-09/2021_AB-8_FINAL.pdf. Accessed: September 2021.

performed by the University of California Institute of Transportation Studies,[34] the projected annual demand for hydrogen fuel from MD/HD drayage trucks alone in California could be as high as 200,000 kg/day in 2027 (which works out to 52 million kg/year assuming operations for 260 days/year). We encourage CARB to engage industry stakeholders to evaluate the adequacy of hydrogen fuel and demonstrate that it is a feasible approach to reducing emissions from California's truck fleet.

10. CARB's treatment of infrastructure costs and LCFS credits is inconsistent (and potentially erroneous) across vehicle technologies assessed in the ACF TCO document.

CARB is grossly inconsistent in their treatment of infrastructure costs and taking credit for associated LCFS credits (or lack thereof) in their ACF TCO assessment:

- In the TCO for sleeper cab tractors BEVs, CARB staff has assumed zero costs for charging infrastructure since they have assumed sleeper cab tractors will only use publicly accessible retail charging (Page 30 of the TCO Discussion Document). However, they further claim that charging station operators "will pass-through LCFS credit revenue to fleets" and account for LCFS credits which lower operational costs for sleeper cab tractor BEVs. CARB needs to clearly substantiate this assumption, especially since they note in the TCO document that LCFS credits "are typically claimed by the fuel producer" (Page 23 of the TCO Discussion Document).

- In the TCO for hydrogen vehicles, CARB staff have assumed zero infrastructure costs, stating that hydrogen refueling stations will be "available at strategic locations around seaports and major distribution hubs" (Page 20 of the TCO Discussion Document). However, they include LCFS credits which lower the lifetime vehicle costs by up to $72,000. This is incorrect, as LCFS credits "are typically claimed by the fuel producer" as CARB have acknowledged elsewhere in their TCO.

It is imperative that CARB evaluate the costs associated with all vehicle technologies in a fair and consistent manner, instead of cherry-picking assumptions that appear to suit their narrative and are unsubstantiated.

11. CARB must address the inconsistencies in the constant dollar costs in the TCO analysis and provide the basis for several assumptions related to ZEV costs.

CARB uses inconsistent constant dollar values throughout the TCO report as noted below:

- Page 10 of the TCO Cost Discussion Document states that, "This analysis follows Department of Finance guidelines and as a result uses <u>2020 constant dollars</u> and does not use discount rates."

- Page 17 of the TCO Cost Discussion Document states that, "Gasoline and diesel fuel prices to 2030 are taken from the California Energy Commission's (CEC) "Fuel Price

[34] Gouzhen Li, Joan Ogden, Marshall Miller. 2021. Hydrogen Infrastructure Requirements for Zero-Emission Freight Applications in California. March 1. Available at: https://escholarship.org/content/qt5cs440qj/qt5cs440qj.pdf?t=qq2kyr. Accessed: September 2021

Forecasts" and are adjusted to 2021 dollars using the California consumer price index (CPI)."

- Page 20 of the TCO Cost Discussion Document states that, "Electricity price changes over time are modeled using CEC's "Revised Transportation Energy Demand Forecast, 2018-2030", adjusted to 2018 dollars using California CPI."

We request CARB to review and update the TCO analysis so all costs are represented by a single baseline constant dollar values.

Further, CARB fails to provide a basis for the following assumptions related to ZEV costs:

- Page 13 of the TCO Cost Discussion Document states that "the final retail price of a ZEV is the sum of the total component costs adjusted by an additional ten percent for other upfront costs such as research, development, retooling, and overhead."
- Page 14 of the TCO Cost Discussion Document states that, "Staff then modeled an additional 35 percent buffer to account for battery degradation and some operational variability."
- Page 15 of the TCO Cost Discussion Document states that, "The hydrogen fuel cell vehicles are modeled using a 10-kWh battery and a fuel cell stack whose power output is half the vehicle's peak power needs."

We request CARB to review these assumptions and reference the source documentation they used to develop them in the TCO Cost Discussion Document.

Section III – Comments previously submitted to CARB Staff

12. CARB must respond to our previous comment letter dated April 17, 2021 following the March 4th ACF workshop.

WSPA submitted the following comments as part of its April 17, 2021 comment letter[35] in response to the ACF public workshop held on March 2nd and 4th. We request that CARB review and respond to these comments which are summarized below:

1. Update the proposed ACF to be consistent with state and federal requirements, including its near term Federal Clean Air Act (CAA) obligations in 2023 and 2031 that it has shown can be met using commercially available low-NOx technologies.
2. Include multi-technology, fuel neutral strategies project alternatives in its Environmental Assessment (EA).
3. Consider the full lifecycle emissions from combinations of vehicle technologies and alternative transportation fuels, including but not limited to, the use of:
    - Renewable natural gas, hydrogen, gasoline, and diesel fuels

[35] 2021. WSPA. Comments on the Advanced Clean Fleet Regulation March Workshops. April 17. Available at: https://www.arb.ca.gov/lists/com-attach/36-acf-comments-ws-UCdTJlUkAzFVDFMy.pdf. Accessed: September 2021.

- Lower carbon petroleum fuels
- Ethanol
- Biodiesel
- Synthetic fuels
- Advanced biofuels (e.g., cellulose)
- Electricity (accounting for renewable and non-renewable sources)

4. Conduct assessments used to determine whether fleet ZEV targets are technically and commercially feasible and allow for exemptions for circumstances beyond fleet control,
5. Determine the cost of charging/fueling infrastructure and grid updates that would be needed to meet the ACF zero emission vehicle (ZEV) targets.
6. Share the cost and emissions data with related assumptions used in the ACF analysis.

ATTACHMENT D

Comments on ACF Regulation March 2021 Workshop

Tiffany Roberts
Vice President, Regulatory Affairs

April 17, 2021

(Submitted by email to zevfleet@arb.ca.gov)

California Air Resources Board
1001 I Street,
Sacramento, CA 95814

***Re:* Comments on Advanced Clean Fleets (ACF) Regulation March Workshops**

The Western States Petroleum Association (WSPA) appreciates the opportunity to comment on the March 2nd and 4th public workshops held by the California Air Resources Board (CARB) on its proposed Advanced Clean Fleets (ACF) Regulation.[1] WSPA is a non-profit trade association that represents companies that export for, produce, refine, transport and market petroleum, petroleum products, natural gas and other energy supplies in California and four other western states, and has been an active participant in air quality planning issues for over 30 years.

WSPA is formally requesting the following CARB actions:

1. Update the proposed ACF to be consistent with state and federal requirements, including its near term Federal Clean Air Act (CAA) obligations in 2023 and 2031 that it has shown can be met using commercially-available low-NOx technologies.
2. Include multi-technology, fuel neutral strategies project alternatives in its Environmental Assessment (EA).
3. Consider the full lifecycle emissions from combinations of vehicle technologies and alternative transportation fuels, including but not limited to, the use of:
   - Renewable natural gas, hydrogen, gasoline, and diesel fuels
   - Lower carbon petroleum fuels
   - Ethanol
   - Biodiesel
   - Synthetic fuels
   - Advanced biofuels (e.g. cellulose)
   - Electricity (accounting for renewable and non-renewable sources)
4. Conduct assessments used to determine whether fleet ZEV targets are technically and commercially feasible and allow for exemptions for circumstances beyond fleet control,
5. Determine the cost of charging/fueling infrastructure and grid updates that would be needed to meet the ACF zero emission vehicle (ZEV) targets.
6. Share the cost and emissions data with related assumptions used in the ACF analysis.

[1] CARB Notice of Public Workshop Meeting on March 2, 2021 and March 4, 2021. Available at: https://ww2.arb.ca.gov/resources/documents/mailout-msc-21-2103. Accessed March 2021.

These formal requests are based on reasons detailed in the sections below and necessary for CARB to be consistent with California Senate Bill (SB) 44 and the Governor's Executive Order (EO) N-79-20.

1. Comments on Consistency with State and Federal Guidelines

The Governor's Executive Order (EO) N-79-20[2] directed that CARB develop and propose regulations and strategies that are "consistent with State and Federal law" to meet the zero emission vehicle targets set forth in the EO. Such statutory obligations include the Federal Clean Air Act (CAA), which requires CARB's regulations to consider their effect on regional air pollution including measures to reduce near-term (pre-2031) emissions of oxides of nitrogen (NO_X) that are needed in the South Coast Air Basin (SCAB) and San Joaquin Valley (SJV) in order for the air districts to meet the ozone attainment deadlines in 2023 and 2031.

Unfortunately, CARB has not only failed to deliver on the mobile source commitments in the 2016 State Implementation Plan (SIP), but it continues to focus on longer-term air quality targets (post-2037) and actions that clearly undermine the State's ability to meet its near-term Federal CAA obligations (2023 and 2031) by undercutting commercially-available low-NOx technologies.

This defect was evident in CARB's recent ACF presentation during the South Coast Air Quality Management District's (SCAQMD's) 2022 Air Quality Management Plan (AQMP) Mobile Source Working Group Meeting on March 24th, 2020.[3] Failure to address near-term attainment deadlines makes the proposed ACF incompatible with the State's obligations under the Federal CAA and, thereby, the proposed ACF is also incompatible with the Governor's EO.

EO N-79-20 also states that any regulatory actions that CARB takes to meet the zero emission vehicle targets stated in the EO must also be consistent with "technological feasibility and cost effectiveness". As such, CARB is required to conduct feasibility and cost-effectiveness analyses in a timely manner and share related results and technical spreadsheets with stakeholders. These analyses (some of which are detailed below) should have been developed to inform the design of the proposed rule requirements and implementation schedules. Since that was not done, it is crucial that they now be conducted and shared before more detailed rule provisions are drafted.

Further, California Senate Bill 44 (SB 44)[4] requires CARB to "to establish a process to identify medium-duty and heavy-duty vehicle segments that can more quickly reduce motor vehicle emissions with a beachhead market analysis." As noted in the comments below, zero emission vehicles (ZEVs) are not yet commercially available for several heavy-duty vehicle uses. Hence, WSPA strongly urges CARB to assess alternative multi-technology/fuel pathways to achieving the overall goals of the Governor's EO rather than focus on a prescriptive narrow technology

[2] EO N-79-20. Available at: https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf. Accessed March 2021.

[3] SCAQMD. 2022 AQMP Mobile Source Working Group for Heavy-Duty Trucks Meeting #2. Available at: http://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/2022-aqmp-mobile-source-working-groups. Accessed March 2021.

[4] CA SB 44. Available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201920200SB44. Accessed March 2021.

approach. This will help the State meet its obligation under Federal and State law to employ all-feasible-measures to comply with near-term air quality attainment deadlines as well as the longer-term GHG goals in a manner that is technically feasible and cost effective. Further details on potential multi-technology/fuel pathways are provided in the comments below.

2. <u>Comments on Project Alternatives</u>

2.1. CARB should hold a more complete scoping meeting to discuss project alternatives and needed technical analyses with stakeholders.

At the March 2nd and 4th ACF public workshops, CARB announced that it is currently soliciting alternative proposals that will meet ACF goals and will accept these proposals by 31st March 2021. As previously noted in the WSPA comment letter[5] dated March 18, 2021 regarding CARB's Notice of Preparation (NOP) for the Environmental Assessment (EA) of the ACF regulation, the March 2021 ACF public workshops did not serve as adequate stakeholder scoping meeting for alternatives. Rather than redirecting the job of developing project alternatives onto stakeholders, CARB needs to hold a scoping meeting with stakeholders to discuss potential alternative multi-technology pathways for these vehicle categories.

2.2. As part of its assessment of project alternatives within the Environmental Assessment, CARB should explore and analyze multiple project alternatives that include multi-technology, fuel-neutral strategies including the use of multiple low-NOx, low-emission vehicle technologies, and renewable liquid and gaseous fuels.

WSPA requests that, consistent with CEQA, CARB conduct a comprehensive assessment of project alternatives, including the use of multi-technology, fuel-neutral strategies consistent with State's greenhouse gas reduction targets and federal clean air act attainment deadlines. ***<u>Ramboll's technical work suggests that expanded implementation of low-NOx vehicles, coupled with increased introduction of renewable liquid and gaseous fuels, offers significantly lower carbon intensity pathways - with many pathways resulting in "negative carbon" pathways - that could deliver earlier and more cost-effective air quality and greenhouse gas reduction benefits than the ZEV-centric approach that postpones air quality emission reductions for decades but is nonetheless currently proposed by CARB.</u>*** We have attached Ramboll's independent assessment of multi-technology pathways for the heavy-heavy duty truck sector in California to this comment letter. WSPA requests that CARB conduct a similar analysis for all ACF target sectors to identify alternative pathways to achieving the state's air quality and climate targets. Unlike the current ACF proposal, this approach would be consistent with other State programs to reduce short-lived climate pollutants and encourage biofuels/renewable fuel usage. WSPA requests that CARB evaluate multiple project alternatives, including alternatives that incorporate the increased use of renewable liquid and gaseous fuels, and low-NOx low-emission vehicle technologies, as well as market-based emission reduction strategies in the medium- and heavy-duty vehicle sector to meet the State's greenhouse gas reduction

[5] WSPA and American Fuel & Petrochemical Manufacturers (AFPM) ACF NOP Comment letter was submitted by email to CARB.

targets. Additionally, CARB must explore performance-based approaches, such as off-road fleet average emission factor standards, that allow for the use of a range of fuel and technology combinations to achieve cost-effective emission reductions. These approaches should consider the full lifecycle emissions from all fuel and vehicle technologies combinations, including manufacturing and recycling of batteries.

3. <u>Comments on Need for an Energy Neutral Approach</u>

3.1. As part of the project alternative assessment, CARB must identify and include energy-neutral strategies that complement emission reductions from vehicle technology advancements. CARB's use of the term "zero emission vehicle" is not only misleading, but also disregards the potential for renewable fuels to achieve even lower lifecycle emission reductions.

Identifying measures to develop and improve vehicle technologies is only one part of the equation in the path to reducing transportation emissions. CARB has identified battery electric vehicles (BEV) and hydrogen fuel cell electric vehicles (FCEV) as "zero emission vehicles" when in fact these vehicles are only "zero emission" at the tailpipe. Emissions from production and transportation of fuels (often termed as "well-to-tank" or "upstream" emissions) and the manufacturing and disposal of the batteries (which are additional to existing to trucks) are non-zero for these so called "zero emission vehicles".

Additionally, there are alternative fuels (as listed in the next section) with the potential for negative carbon emissions that may result in even lower well-to-wheel carbon emissions when compared to the BEV and FCEV technologies that CARB has misleadingly labeled as "zero emissions". By utilizing this misleading label, CARB is refusing to consider other pathways that can achieve significant emission reductions.

Hence, CARB should consider existing fuel-side solutions that could complement emission reductions from improvements in vehicle technologies while developing the ACF regulation. A list of these fuels with GHG-reducing potential that should be analyzed is provided in the next comment.

3.2. Given the increasing potential for alternative fuels to achieve significant emission reductions, CARB must consider the following fuels in its assessment. CARB's assessment should reflect the potential future carbon intensity (CI) of each fuel and resulting lifecycle emission reductions that could be achieved.

- **Renewable natural gas (solely or in combination with traditional natural gas)**
- **Renewable hydrogen (solely or in combination with traditional hydrogen)**
- **Lower carbon petroleum fuels**
- **Renewable diesel**
- **Renewable gasoline**
- **Ethanol**
- **Biodiesel**
- **Synthetic fuels**
- **Advanced biofuels (e.g. cellulose)**
- **Electricity (accounting for renewable and non-renewable sources)**

These fuels are available today (i.e., "drop-in") to deliver near-term air quality benefits when combined with Low-NOx vehicle technologies. Further, with greater production and/or improvements in the development of these alternative fuel pathways, the carbon intensity of these fuels could decrease, thereby providing the GHG reductions needed to meet the State's long-term climate goals. Hence, CARB needs to include, as part of its assessment of project alternatives, an assessment of future availability and carbon intensities of the aforementioned alternative fuels.

There are many examples of the increasing promise from alternative fuels. Since 2020, California has seen a significant increase in renewable diesel potential, with major independent refiners all planning renewable diesel projects.[6] GNA's 2020 report[7] has concluded that renewable natural gas (RNG) usage has increased by 475% between 2015 and 2019. Additionally, GNA reported that RNG comprised approximately 80% of California transportation NG usage in 2019. Further, the report found that the average CI of RNG reduced by 59% in 2019 as compared to 2018. These fuels offer significantly lower carbon intensities than traditional fuels, with many pathways resulting in "negative carbon" pathways, as seen with the production of RNG from diary biogas.

In addition to these alternative fuels, CARB should also include as part of the analysis the potential for reductions in the carbon intensity of petroleum fuels which deliver GHG emissions reductions for vehicles on the road today. CARB has already recognized the potential for these reductions under the Innovative Crude and Refinery Investment pathway provisions as part of the Low Carbon Fuel Standard (LCFS). This would include energy efficiency improvements, carbon capture and storage (CCS), and the use of renewable energy in refinery and upstream operations.

4. **Comments on the ACF Workshop Presentation**

4.1. Consistent with the directive from Governor's executive order N-79-20[2], CARB should explicitly include language in the proposed ACF regulation to allow for exemptions for circumstances beyond fleet control. This must include cases where no zero emission vehicles (ZEV) are commercially available to meet a fleet's specific operational needs. This exemption should be offered for all fleet categories. Further, CARB should clearly define what "commercially available" means in the regulatory language.

While CARB staff had noted at the ACF March workshops that federal and private fleets would be able to apply for exemptions for "circumstances beyond fleet control" and for cases where "no ZEV or NZEV is commercially available," CARB should clearly define what "commercially available" means in the regulatory language. Additionally, CARB should allow drayage fleets to apply for the same exemptions offered to federal and private fleets. Finally, as indicated in the Governor's Executive Order (EO) N-79-20[2], CARB must implement existing ZEV targets "consistently with technological feasibility

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[6] Argus Media. Available at: https://www.argusmedia.com/en/news/2052092-renewable-diesel-makes-inroads-in-california. Accessed April 2021.

[7] GNA 2020 State of Sustainable Fleets Report. Available at: https://www.stateofsustainablefleets.com/. Accessed April 2021.

and cost-effectiveness" taken into consideration. As such, WSPA recommends that CARB allow for exemptions if there are no commercially available vehicles that fully meet the operational requirements of a fleet's complete duty cycle. Several stakeholders representing essential services voiced concerns that ZEVs would be unable to meet their fleet duty cycles or specialty vehicle services that are needed to provide their essential services. If there are no ZEVs that are able to meet these requirements, technological feasibility would not be achieved.

4.2. CARB should release the assessments conducted to determine whether the fleet ZEV targets are technically feasible and meet cost effectiveness, as required by the Governor's EO N-79-20. Further, CARB should release the data used to estimate the NO_x reductions from the proposed ACF regulation presented at the March ACF workshops.

At the March ACF workshops, CARB staff noted that they arrived at the ZEV phase in schedule in slide 50 of the presentation based on their assessments of which vehicle types would be ready for electrification or ZEV turn over. CARB should release the methodology used to determine this ZEV phase in schedule and elaborate on how they determined that these targets are technically feasible and commercially available. Further, WSPA requests that CARB make the data used to estimate NO_x reductions from the proposed ACF regulation publicly available to stakeholders for review and comment.

5. Comments on Upcoming Infrastructure and Cost Workgroups

At the March ACF workshops, CARB staff noted that there will be two upcoming working group meetings in April/May to discuss infrastructure and costs related to the ACF. We provide the following comments on these upcoming workshops for CARB consideration.

5.1. Representatives from the CEC and California Public Utility Commission (CPUC) should be present at the April Infrastructure Workgroup and should provide an update on how these agencies plan to meet the infrastructure needs to support zero emission vehicle (ZEV) targets proposed by the ACF.

The CEC AB 2127 report[8] was recently released to examine existing and future charging infrastructure needs in California. The report estimates that an additional 157,000 DC fast chargers would be needed to meet the CARB Draft Mobile Source Strategy 2030 target of 180,000 medium-duty and heavy-duty electric vehicles. Given the new vehicle ZEV targets proposed by the ACF, CARB must work with utilities and agencies to determine the additional charging and fueling infrastructure needed to meet these targets. Further, additional analysis is needed to determine if generation capacity, transmission and distribution infrastructure is ready to support increased electricity demand as a result of increased vehicle electrification.

5.2. CARB should work with the CEC to determine the cost of installing additional fueling infrastructure as well as the cost of upgrading the grid to meet both the state's carbon neutrality targets and the ZEV targets proposed by the ACF.

[8] CEC AB2127 Report. Available at: https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127. Accessed March 2021.

The CEC AB 2127 and 2020 Draft IEPR do not provide cost estimates for the additional investments needed to meet the state's carbon neutrality targets, ZEV targets issued by the Governor's executive orders EO B-48-18[9] and EO N-79-20[10], or the ZEV targets proposed by ACF. CARB should work with the CEC to assess the additional capital investments to install additional fueling infrastructure and the cost of grid upgrades to support the proposed ACF targets.

6. Comments on Public Process

6.1. WSPA requests that CARB post the SCAQMD 2022 AQMP Mobile Source Working Group presentations and meeting information on the CARB ACF webpage.

The information presented at SCAQMD's 2022 AQMP Mobile Source Working Group Meetings provide additional details regarding emission benefits of the ACF regulation including South Coast specific data that will be relevant for all stakeholders. CARB should ensure that all stakeholders have access to these materials on CARB's public facing website.

6.2. WSPA requests that CARB post all available California Environmental Quality Act (CEQA) documents on the CARB ACF webpage.

Given stakeholder concerns surrounding the access to information regarding CEQA environmental analysis of the proposed ACF rule, we recommend that CARB post all available CEQA documents on the ACF CARB page, including the released Notice of Preparation (NOP) of the Environmental Assessment (EA), comments submitted to the NOP, and other relevant documents.

6.3. WSPA requests that CARB provide detailed cost assumptions and sources used in the ACF economic assessment. Further, WSPA requests that a range of cost assumptions are presented given the uncertainty of future fuel and technology costs. CARB should assess the cost of all vehicle technologies and fuel combinations in order to evaluate the cost effectiveness all vehicle technology options.

In the 2019 Advanced Clean Trucks (ACT) Initial Statement of Reasons (ISOR)[11], CARB staff conducted a total cost of ownership (TCO) analysis for diesel, battery electric, and hydrogen fuel cell vehicles. This assessment used optimistic assumptions for capital costs of vehicles and assumed that vehicle owners would be able to receive value from the LCFS program for the entire lifetime of the vehicle to cover fueling costs. These assumptions unrealistically rely on the owners of charging infrastructure passing that value to vehicle or fleet owners. WSPA requests that CARB provide a detailed list of all cost assumptions, sources, and reasoning for selecting specific assumptions. Further,

[9] Available at: https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html. Accessed: March 2021.

[10] Available at: https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf. Accessed: March 2021.

[11] CARB ACT Regulatory Documents. Available at: https://ww2.arb.ca.gov/rulemaking/2019/advancedcleantrucks. Accessed March 2021.

WSPA requests that CARB include cost scenarios where fleet owners are unable to use LCFS credits to discount fueling costs of their vehicles. Finally, WSPA requests that CARB also include in its ACF economic assessment a TCO analysis for near-zero emission vehicles, including Low-NOx natural gas vehicles, as well as the use of renewable fuels.

Conclusion

Thank you for consideration of our comments. We would welcome the opportunity to discuss these ideas in more detail. If you have any immediate questions, please feel free to contact me at troberts@wspa.org. We look forward to working with you on these important issues.

Sincerely,

Tiffany Krista Roberts

Tiffany Roberts,
Vice President, Regulatory Affairs
Western States Petroleum Association

Attachment: "Multi-Technology Pathways To Achieve California's Air Quality And Greenhouse Gas Goals: Heavy-Heavy-Duty Truck Case Study", Ramboll (February 2021)

Prepared for
Western States Petroleum Association

Prepared by
Ramboll US Consulting, Inc.
Los Angeles, California

Project Number
1690017786-001

Date
February 1, 2021

MULTI-TECHNOLOGY PATHWAYS TO ACHIEVE CALIFORNIA'S AIR QUALITY AND GREENHOUSE GAS GOALS:

HEAVY-HEAVY-DUTY TRUCK CASE STUDY

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APPENDICES

ACRONYMS AND ABBREVIATIONS

ACT:	Advanced Clean Truck
AC Transit:	Alameda Contra Costa Transit District
AEO:	Annual Energy Outlook
AG:	agriculture
AW:	dairy digester/animal waste
AQMP:	Air Quality Management Plan
BD:	biodiesel
BEB:	battery electric bus
BEV:	battery electric vehicle
CAA:	Clean Air Act
CA-GREET:	California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
CARB:	California Air Resources Board
CEC:	California Energy Commission
CI:	carbon intensity
DSL:	diesel
EER:	energy economy ratio
EMA:	Energy Marketers of America
EMFAC2017:	Emission Factor Model
EV:	electric vehicle
GHG:	greenhouse gases
g/bhp-hr:	grams per brake horsepower hour
HDV:	heavy-duty vehicle
HHDT:	heavy-heavy-duty truck
ICCT:	International Council on Clean Transportation
ICT:	Innovative Clean Transit
ISOR:	Initial Statement of Reasons
kWh:	kilowatt hour
LCFS:	Low Carbon Fuel Standard
LFG:	landfill gas
MHDV:	medium- and heavy- duty vehicle
META Tool:	Mobile Emissions Toolkit for Analysis

MSS:	Mobile Source Strategy
MY:	model year
NG:	natural gas
NO_X:	oxides of nitrogen
PM:	particulate matter
$PM_{2.5}$:	particulate matter less than 2.5 microns in diameter
RNG:	renewable natural gas
RNWD/RD:	renewable diesel
SB 44:	Senate Bill 44
SCAB:	South Coast Air Basin
SCAQMD:	South Coast Air Quality Management District
SIP:	State Implementation Plan
SJV:	San Joaquin Valley
SJVAPCD:	San Joaquin Valley Air Pollution Control District
SWCV:	solid waste collection vehicles
TCO:	total cost of ownership
T&D:	transmission and distribution
US EIA:	United States Energy Information Administration
USEPA:	United States Environmental Protection Agency
WWTP:	wastewater treatment plants
ZEB:	zero emission bus
ZEV:	zero emission vehicle

EXECUTIVE SUMMARY

California Senate Bill 44[1] (SB 44) requires the California Air Resources Board (CARB) to "update the 2016 mobile source strategy to include a comprehensive strategy for the deployment of medium-duty and heavy-duty vehicles in the state for the purpose of bringing the state into compliance with federal ambient air quality standards and reducing motor vehicle greenhouse gas emissions from the medium-duty and heavy-duty vehicle sector." In response, CARB developed the 2020 Draft Mobile Source Strategy (MSS)[2], which delivered a single electrification-centric approach that has failed to meet the 2023 and 2031 air quality goals, abandoned its 2016 MSS commitments, did not analyze for any alternatives, and failed to look at cost and feasibility as SB 44 required. Further, CARB does not deliver pre-2032 near-term (or short-term) reductions required for non-attainment areas to meet 2023 and 2031 federal health standard deadlines, which were promised to these impacted communities. It also ignored the potential role of renewable liquid and gaseous fuels in meeting longer-term (post-2032) greenhouse gas reduction goals.

As on-road truck emissions are a primary control measure category in non-attainment areas, Ramboll conducted an analysis of one specific sector within the MSS, California's heavy-heavy- duty truck (HHDT) fleet, to identify multiple vehicle technology and fuel pathways that could achieve these near-term air quality goals while being consistent with the meeting of the state's long-term climate goals. The multi-technology analysis of the HHDT sector in this report began in June 2020 after the original CARB 2020 MSS presentation in March 2020.[3] The main conclusions of our analysis are summarized below:

> CARB's 2020 Mobile Source Strategy **did not deliver** pre-2032 near-term (or short-term) reductions required for non-attainment areas to meet 2023 and 2031 federal health standard deadlines. Ramboll's analysis of **multi-technology pathways**, which include a combination of low-emission (75% to 100% lower) vehicle technologies and fuel mixes (including lower carbon intensity liquid and gaseous fuels), demonstrates that there are faster paths to meeting near-term federal health requirements, making progress on state climate goals and achieving greater reductions per dollar spent.

- Expanded implementation of zero-emission and Low-NO_X vehicles, coupled with increased introduction of renewable liquid and gaseous fuels, can deliver earlier (as shown in **Figure ES-1**) and more cost-effective benefits than a zero-emission vehicle (ZEV)-only approach.
- As advanced low-emitting trucks are commercially available[4] to deliver benefits to communities sooner, multi-technology pathways can help achieve emission reductions without reliance on infrastructure and technology upgrades that will take years to resolve.
- There is a growing potential for renewable fuels, including those with negative carbon intensity, to meet achieve GHG reductions, which CARB has not acknowledged fully in the MSS nor assessed

[1] California Senate Bill 44. Available at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB44. Accessed January 2021.

[2] CARB Mobile Source Strategy. Available at: https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy. Accessed January 2021.

[3] CARB Mobile Source Strategy March 2020 Presentation. Available at: https://ww3.arb.ca.gov/planning/sip/2020mss/pres_marwbnr.pdf. Accessed January 2021.

[4] Optional Low NO_X Certified Heavy-Duty Engines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/onroad/optionnox/optional_low_nox_certified_hd_engines.pdf. Accessed: January 2021.

the potential for early and cost-effective GHG reductions through these multi-technology vehicle pathways.

- Low-emission heavy-heavy-duty trucks are cost-competitive with (or cheaper than) battery electric vehicles (BEVs). This is true even though battery technology promises (such as greater energy density/lower cost) have not been adequately demonstrated and related transmission/distribution infrastructure cost have not been included in the state's analyses.

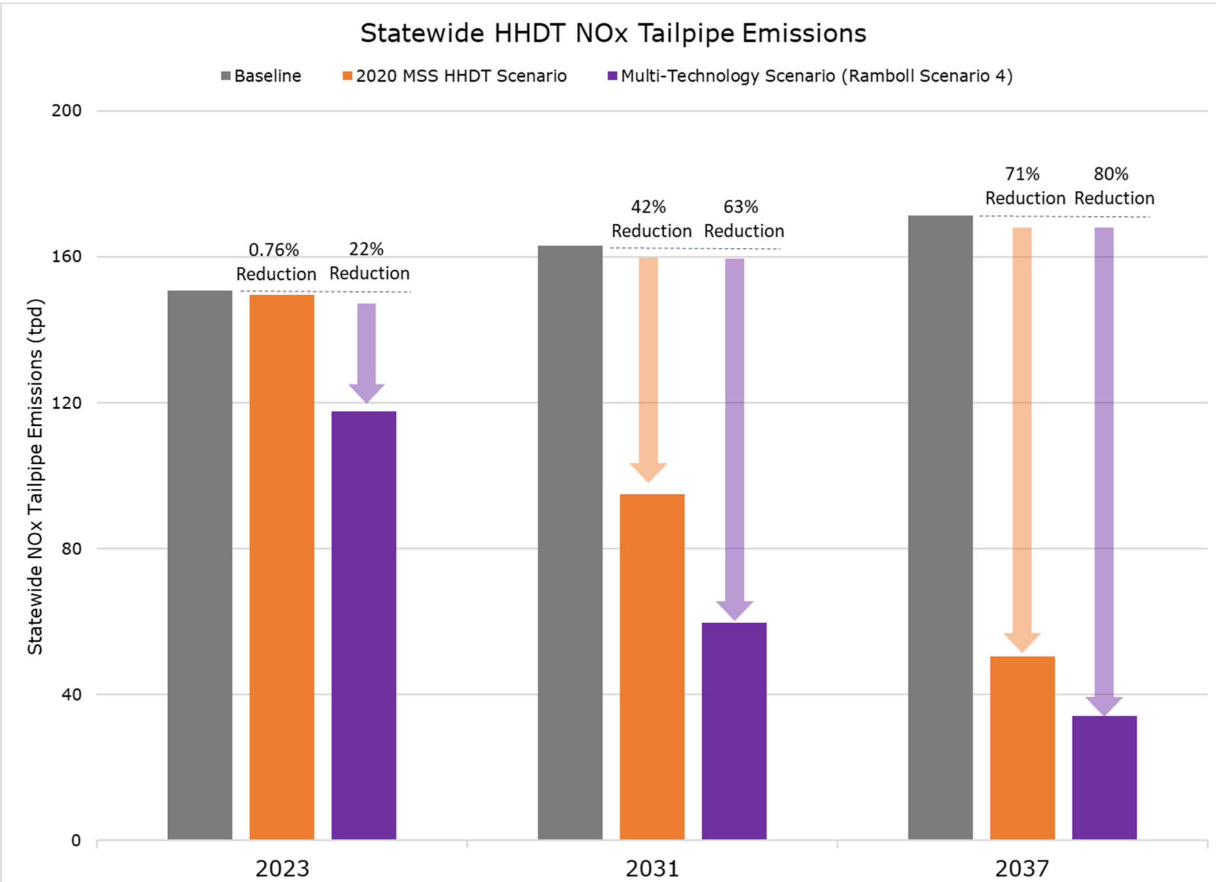

Figure ES-1. Statewide NO_X HHDT Tailpipe Emissions

These conclusions emphasize the need for CARB to conduct a similar analyses across all mobile source sectors, not just the heavy-heavy-duty truck sector, in order to identify existing opportunities to meet state emission reduction commitments consistent with the federal Clean Air Act, fulfill SB 44 requirements, and comprehensively assess the costs and timelines for potential GHG reduction strategies. The analysis also identified information gaps, unsupported technical and cost assumptions, and areas of future research. The lack of citations and/or justifications for the analysis assumptions and inputs used in CARB's Mobile Emissions Toolkit for Analysis (META Tool) needs to be remedied as CARB revises the 2020 MSS and develops future rulemaking on Advanced Clean Cars 2, Advanced Clean Fleets and other rules.

Taking the Next Steps

Several commenters[5] have agreed that the 2020 MSS (and its development process, technical analyses, public process) were inadequate when compared with SB 44 requirements and the previous 2016 MSS. The South Coast Air Quality Management District (SCAQMD) comments[6] noted that "[T]he lack of discussion of the 2023 8-hour ozone attainment date in the South Coast Air Basin in the draft Mobile Source Strategy is very disturbing and likely unlawful[.]" and "given the need for both short-term and long-term reductions, ***considerations must be given for both technologies that are commercially available today (e.g., near-zero technologies) as well as technologies that are being developed and demonstrated (e.g., zero-emission technologies)***." The San Joaquin Valley Air Pollution Control District (SJVAPCD) comments[7] noted that "given the need for both short-term and long-term reductions, considerations must be given for both technologies that are commercially available today (e.g., near-zero technologies) as well as technologies that are being developed and demonstrated (e.g., zero-emission technologies)[.]" and "the District recommends that CARB more clearly articulate the existing commitments included in the 2018 Supplement and 2018 PM2.5 Plan that calls for ***the deployment of a combination of zero and near-zero technology as the most effective and achievable strategy for securing the needed near-term emissions reductions in the San Joaquin Valley and South Coast***."

Based on the results of this study and concerns raised by the local air quality districts, this paper offers the following recommendations:

- CARB should revise the 2020 MSS to include scenarios that assess the increased use of renewable liquid and gaseous fuels and low-NO_X technologies, as well as the expanded use of market-based emission reduction strategies, to achieve emission reductions consistent with SB44 requirements.
- Each scenario must be evaluated for technical feasibility, and as such would require an analysis of future fueling infrastructure availability.
- CARB should assess the associated cost of each MSS scenario in order to identify cost-effective pathways to achieving the state's emission goals, including citations and justifications for assumptions of projected costs and range of potential costs (when uncertainty is high).
- A robust economic analysis is needed of the economic impacts on affected stakeholders (and the public, who ultimately pays). The public, stakeholders, and the legislature need this information to make informed decisions about the path to achieving California's emission goals.

CARB must be transparent and unbiased in the rulemaking process. CARB should conduct technical working groups to foster stakeholder participation in scenario development and assessment, address cost data gaps identified in this study, and ensure that reasonable and achievable strategies are developed that meet SB 44 requirements. Multi-technology pathways can help the state achieve faster and more certain emission reductions to fulfil its commitment to non-attainment communities while expanding ways to reduce greenhouse gas emissions.

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[5] Public Comments on the Workshop Discussion Draft 2020 Mobile Source Strategy. Available at: https://ww2.arb.ca.gov/resources/documents/workshop-discussion-draft-2020-mobile-source-strategy-comments-received. Accessed: January 2021.

[6] South Coast Air Quality Management District Comments on the Draft 2020 Mobile Source Strategy dated October 20, 2020. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-11/SouthCoastAQMD_Comment-WorkshopDiscussionDraft2020MSS.pdf. Accessed: January 2021.

[7] San Joaquin Valley Air Pollution Control District Comments on the Draft 2020 Mobile Source Strategy dated October 21, 2020. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-11/SJVAPCD_Comment-WorkshopDiscussionDraft2020MSS.pdf. Accessed: January 2021.

1. INTRODUCTION

1.1 CARB 2020 MSS Summary

The California Air Resources Board (CARB) first released the Mobile Source Strategy (MSS) in 2016,[8] which introduced a set of measures to reduce emissions from mobile sources to meet the State's air quality and climate goals over the subsequent fifteen years. A list of proposed policy measures coupled with CARB action dates and estimated emission reductions was provided in the 2016 MSS. In 2019, California Senate Bill 44 (SB 44) directed CARB to update the 2016 MSS by January 1, 2021 to bring the state in compliance with federal air quality standards and reduce greenhouse gas (GHG) emissions from the medium- and heavy-duty vehicle sector. CARB released a Workshop Discussion Draft of the 2020 MSS[9] on September 30th, 2020 followed by a Draft 2020 MSS[10] on November 24th, 2020 to inform and provide direction on future CARB rulemaking to meet the State's air quality and climate goals and to meet SB 44 requirements.

1.2 Purpose of this Study

The 2020 MSS draft is focused on meeting the State's long-term climate goals through the exploration of electrification concepts and scenarios across the mobile source sectors. There is, however, an immediate need to assess multiple vehicle/fuel technology pathways for significantly reducing oxides of nitrogen (NO_X) emissions from mobile sources, particularly heavy-heavy-duty trucks (HHDTs),[11] in order to meet the upcoming federal Clean Air Act (CAA) ozone attainment deadlines in 2023 and 2031 for South Coast Air Basin (SCAB) and San Joaquin Valley (SJV). While the 2016 MSS identified near-zero technologies such as Low NO_X natural gas (NG) engines and plug in hybrid vehicle (PHEV) technologies as potential pathways to help achieve these near-term NO_X reductions, the 2020 MSS does not address these much needed near-term NO_X reductions; instead it focuses on a vehicle electrification pathways to achieve the State's long-term climate goals.

Since the 2020 MSS does not address the NO_X reductions needed to the State's near-term air quality goals, Ramboll conducted an analysis of California's HHDT fleet to identify multiple vehicle technology and fuel pathways that could help achieve these near-term air quality goals while still meeting the long-term climate goals. This white paper provides a summary of the methodology, results, and conclusions of Ramboll's analysis. The results of these analyses can be used as a basis for further discussion with CARB, air districts, and stakeholders to amend the deficiencies in the current 2020 MSS and its related feasibility, cost, and socioeconomic analyses.

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8 CARB. 2016. Mobile Source Strategy. May. Available at: https://ww3.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf. Accessed: January 2021.

9 CARB. 2020. Workshop Discussion Draft 2020 Mobile Source Strategy. September 30. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-09/Workshop_Discussion_Draft_2020_Mobile_Source_Strategy.pdf. Accessed: January 2021.

10 CARB. 2020. Draft 2020 Mobile Source Strategy. November 24. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-11/Draft_2020_Mobile_Source_Strategy.pdf. Accessed: January 2021.

11 HHDTs make up the largest portion of mobile source NO_X emissions in the SCAB and SJV as shown in the 2020 NO_X mobile source emission inventories for these areas. Available at: https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php. Accessed: January 2021.

2. MULTI-TECHNOLOGY SCENARIOS: HEAVY-HEAVY-DUTY TRUCK SECTOR EXAMPLE

The 2020 MSS assumes an aggressive penetration rate for zero emission vehicles (ZEVs) in the heavy-duty vehicle (HDV) sector which includes an ambitious phase-in for newer vehicles and an accelerated turnover of older and higher emitting vehicles in order to meet California's long-term climate goals. **Figure 2-1** below presents the vehicle technology fleet mix of the statewide HDV population proposed in the 2020 MSS ("CARB's 2020 MSS Scenario") at CARB's March 2020 Presentation. As shown in the figure, this scenario assumes that the fraction of ZEV in the HDV fleet will increase from ~0% in 2020 to 21% in 2031, 44% in 2037, 76% in 2045, and 80% in 2050.[12] While the 2020 MSS Workshop Discussion Draft briefly evaluates an alternative Low-NO_X "concept" that assumes an accelerated turnover to Low-NO_X vehicles, CARB does not consider or access other scenarios that use a mix of alternative vehicle and fuel technologies to achieve the California's long-term climate goals.

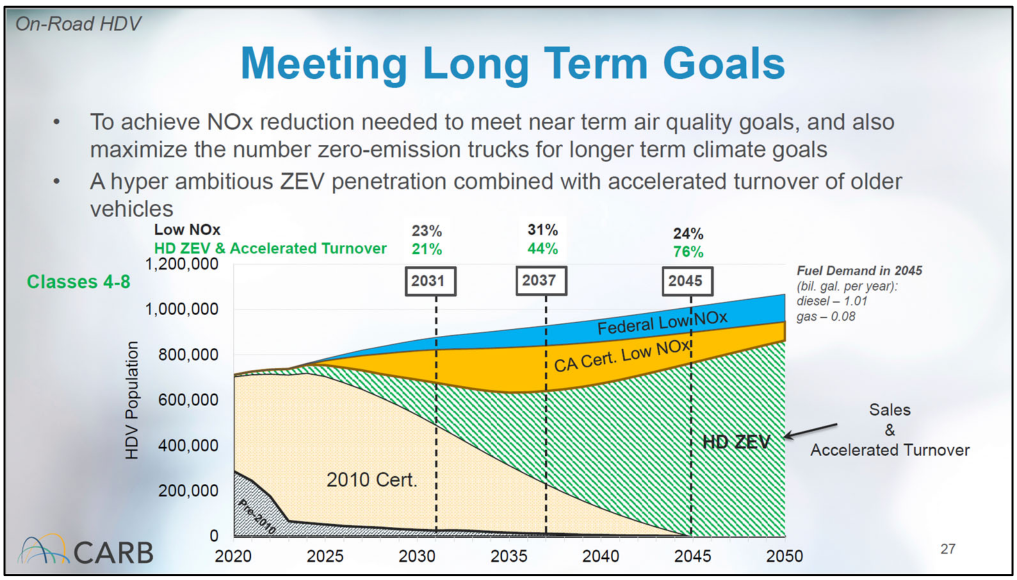

Figure 2-1. Heavy-Duty Vehicle Fleet Mix for 2020 MSS[13]

Ramboll's analysis presented in this report evaluates the emission benefits of a series of multi-technology scenarios for a sub-set of the statewide HDV fleet consisting of diesel heavy-heavy-duty trucks (HHDTs) excluding solid waste collection vehicles (SWCV). The purpose of this analysis is to evaluate if there are other vehicle/fuel technology pathways besides CARB's 2020 MSS Scenario that could achieve the State's long-term climate goals while also meeting the near-term air quality goals. CARB does not provide a breakdown between the types of heavy-duty ZEVs modeled in its

[12] On November 24, 2020, CARB released the Draft 2020 MSS with fleet mix assumptions that differ slightly from those seen in Figure 3-1. The heavy-duty ZEV fleet mix Draft 2020 MSS are as follows: 24% in 2031, 48% in 2037, and 77% in 2045 (obtained from Draft META tool that accompanies the Draft 2020 MSS. Available at: https://ww3.arb.ca.gov/planning/sip/2020mss/draft_META.zip. Accessed: January 2021.). As Ramboll's analysis was conducted before the Draft 2020 MSS was released, it uses fleet mix percentages from the March 2020 presentation.

[13] CARB, 2020. Long-term strategy for 2020 MSS. CARB 2020 Mobile Source Strategy Public Webinar, March 25, 2020. Available at: https://ww3.arb.ca.gov/planning/sip/2020mss/pres_marwbnr.pdf. Accessed: January 2021.

long-term scenarios. As CARB assumes that the heavy-duty ZEV population will be predominately battery electric vehicles[14] (BEVs), Ramboll's scenario analysis models ZEVs as BEVs only.

A brief description of the analyzed scenarios is presented below. **Figure 2-2** presents vehicle technology fleet mixes for these scenarios. A detailed matrix of all scenarios can be found in **Appendix A.**

- **S1 - CARB Long-Term Scenario**: As shown in **Figure 2-2**, the fleet mix for this scenario assumes an aggressive penetration rate for BEV with an accelerated turnover of pre-2024 vehicles to achieve the following fractions of BEV in future calendar years that are similar to the CARB 2020 MSS Scenario: 44% in 2037, 76% in 2045, and 80% in 2050. The fraction of California Low NO_X diesel (CA Low NO_X DSL) vehicles and Federal Low NO_X diesel (Federal Low NO_X DSL) vehicles in future years is also maintained at values similar to the CARB 2020 MSS Scenario.
- **S2 – Low NO_X NG with ACT**: In this scenario, Ramboll assumed that the sales fractions of BEV in HHDTs for model year 2024 and beyond are equal to the purchase mandate stated in CARB's Advanced Clean Truck (ACT) Regulation[15] and that the fraction of Federal Low NO_X DSL HHDTs in the statewide fleet is maintained at values similar to the CARB 2020 MSS Scenario. All other new (model year [MY] 2024 and beyond) vehicles are assumed to be Low NO_X natural gas (Low NO_X NG) vehicles that are commercially available in the market today. Note, an accelerated turnover of pre-2024 vehicles, at a rate similar to the CARB 2020 MSS Scenario, is also assumed with these vehicles turning over to newer alternative technology vehicles (e.g., Federal Low NO_X DSL, Low NO_X NG, and BEV).
- **S3 – Low NO_X NG without ACT**: This scenario is identical to scenario S2 with the following exception: all BEV in S2 are replaced with Low NO_X NG vehicles.
- **S4 – Low NO_X NG with SCAQMD 2016 AQMP & ACT**: This scenario is similar to scenario S2, but assumes early adoption of Low NO_X NG HHDTs to meet or exceed South Coast Air Quality Management District's (SCAQMD's) 2016 Air Quality Management Plan (AQMP) projections for NG truck population in calendar years 2023 and 2031.[16] The conventional DSL fleet is adjusted to accommodate the early adoption of Low NO_X NG HHDTs while the sales fraction of BEVs for model year 2024 and beyond remains equal to the purchase mandate stated in CARB's ACT Regulation. Accelerated turnover of older vehicles is included as described in S2.
- **S5 – CA Low NO_X DSL with ACT**: This scenario is identical to scenario S2 with the following exception: CA Low NO_X DSL HHDTs are used to replace the Low NO_X NG HHDTs in S2.
- **S6 – CA Low NO_X DSL without ACT**: This scenario is identical to scenario S3 with the following exception: CA Low NO_X DSL vehicles are used to replace the Low NO_X NG in S3.

[14] CARB 2020 MSS Discussion Draft assumes that roughly 90% of the light-duty ZEV population in 2030 are BEVs and 75% in 2045.

[15] Available at: https://ww3.arb.ca.gov/regact/2019/act2019/30dayatta.pdf. Accessed: January 2021.

[16] SCAQMD 2016 AQMP Final Socioeconomic Report Appendix 2-A. Available at: https://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/final/appfinal_030817.pdf?sfvrsn=2. Accessed: January 2021.

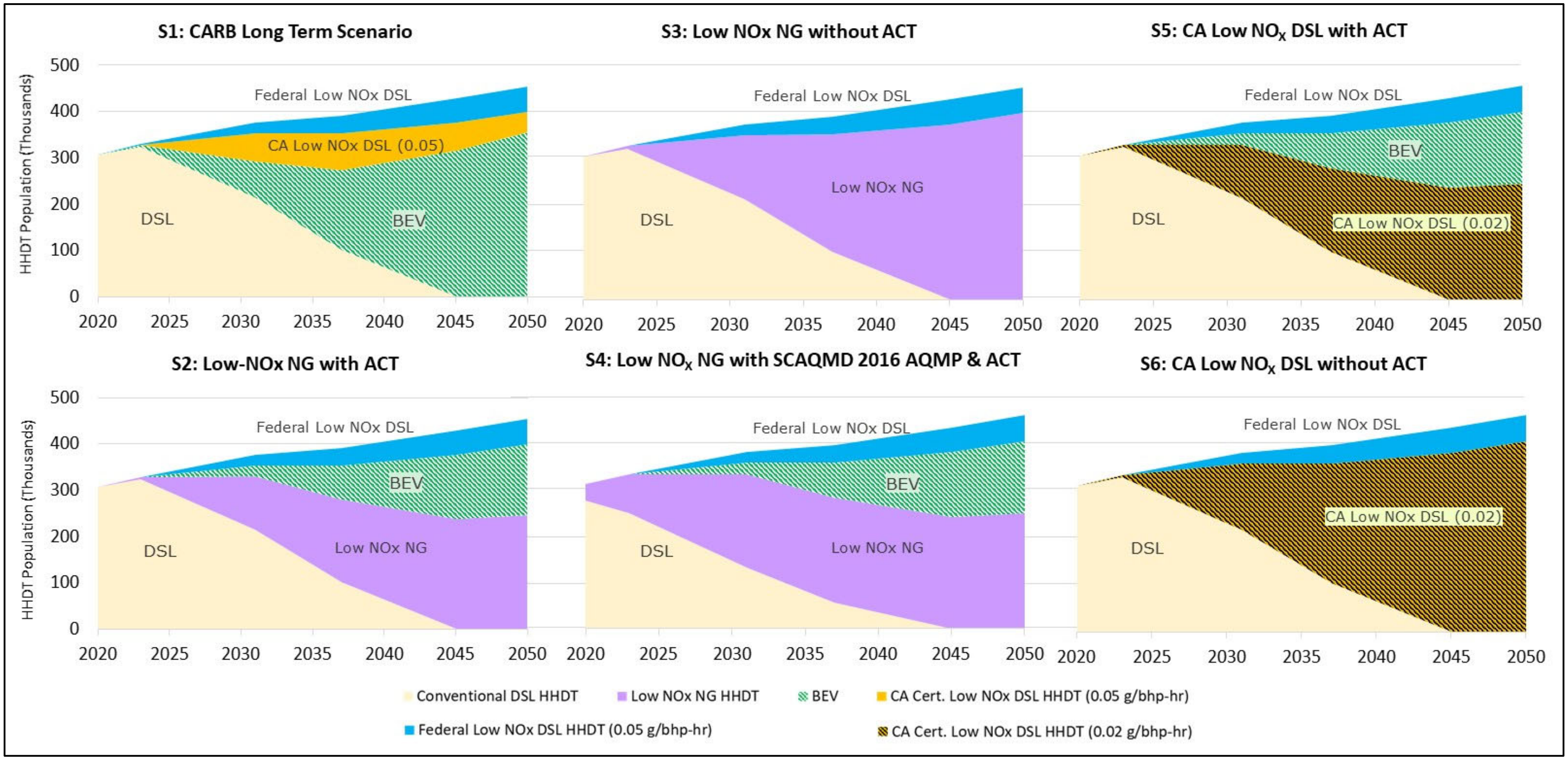

Figure 2-2. Diesel Heavy-Heavy-Duty Truck Fleet Mixes for Ramboll Scenario Analysis

- Ramboll also analyzed a baseline scenario **S0 – Baseline EMFAC2017** which represents the default fleet mix for HHDTs in the EMFAC2017 model,[17] which assumes that all new trucks will meet the 2010 United States Environmental Agency (USEPA) standard.[18] This scenario is used as a baseline to evaluate incremental emission benefits in this analysis.

Besides evaluating the above mentioned scenarios for NO_X and GHG emissions benefits, Ramboll also performed an comparative analysis of the projected total cost of ownership (TCO) and vehicle lifetime emissions of five heavy-heavy-duty truck (HHDT) technologies: Conventional diesel HHDT, Federal Low NO_X diesel HHDT, CA Low NO_X HHDT, Low NO_X NG HHDT, and Battery Electric HHDT. Details on the methodologies used for the scenario and TCO analysis are presented in **Section 4** and **Section 5**.

[17] CARB EMFAC 2017 v1.02. Available at: https://arb.ca.gov/emfac/2017/. Accessed December 2020.

[18] Available at: http://www.meca.org/regulation/us-epa-20072010-heavyduty-engine-and-vehicle-standards-and-highway-diesel-fuel-sulfur-control-requirements. Accessed: December 2020.

3. SCENARIO ANALYSIS METHODOLOGY

This Section describes the methodology used for Ramboll's scenario analysis. Detailed modeling inputs, outputs, and methodology are provided in **Appendix A.**

3.1 Renewable Fuel Sub-Scenarios

Ramboll analyzed four versions of scenarios S1 through S6 to explore the use of renewable fuels to achieve greenhouse gas emission reductions. These sub-scenarios are summarized in **Table 3-1** below.

Table 3-1. Renewable Fuels Sub-Scenarios

Sub-Scenarios	Sub-Scenario Descriptions
"A1" Sub-Scenarios	"A1" Scenarios assume that conventional diesel and conventional NG from fossil fuels are used to fuel 100% of the diesel and Low-NO_X NG vehicle populations, respectively, in future calendar years.
"B1" Sub-Scenarios	"B1" Scenarios assume that renewable diesel (RD) from tallow and renewable NG from landfill gas (RNG-LFG) are used to fuel 100% of the diesel and Low-NO_X NG vehicle populations, respectively, in future calendar years.
"C1" Sub-Scenarios	"C1" Scenarios are hypothetical scenarios that assume a composite mix of renewable fuels are used to fuel 100% of the diesel and Low-NO_X NG vehicle populations. For these scenarios, Ramboll assumed that the carbon intensity (CI) of renewable diesel would be an average across all renewable diesel and biodiesel CIs reported in the Low Carbon Fuel Standard (LCFS) Fuel Pathway Table.[19] Ramboll also assumed that source mix for RNG would be 50% LFG, 25% wastewater treatment plants (WWTP), and 25% agriculture (AG). "C1" scenarios are only calculated for calendar year 2045.
"C2" Sub-Scenarios	"C2" Scenarios are hypothetical scenarios that assume conventional diesel and conventional NG are used to fuel 50% of the diesel and Low-NO_X NG vehicle populations, respectively. The remaining 50% of each vehicle population is assumed to be fueled with a composite mix of renewable fuels as described in scenario C1. "C2" scenarios are only calculated for calendar year 2045.

3.2 Tailpipe (Tank-to-Wheel) Emissions

CARB's EMFAC2017 model[20] was used to estimate tailpipe emissions for NO_X and GHGs for all HHDT vehicle types included in this analysis. Specifically, EMFAC2017 was queried at the statewide level for scenario analysis years 2020, 2023, 2031, 2037, 2045 and 2050 to obtain total exhaust emissions, population, and fuel consumption data for HHDTs by model year. Tailpipe emissions for alternative technology HHDTs were calculated based on EMFAC2017 data and the assumptions in **Table 3-2**. Further details regarding tailpipe emission estimation methodology, including EMFAC2017 inputs and outputs, can be found in **Appendix A**.

[19] CARB LCFS Fuel Pathway Table. Available at: https://ww3.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx. Accessed: January 2021.

[20] Available at: https://arb.ca.gov/emfac/2017/. Accessed: January 2021

Table 3-2. Tailpipe Emission Assumptions

Vehicle Type	Tailpipe NO_X	Tailpipe GHG
Conventional Diesel HHDT	Default EMFAC Output	Default EMFAC Output
Federal Low-NO_X Diesel HHDT	**75% NO_X** reduction from conventional diesel HHDT based on 0.05 grams per brake horsepower hour (g/bhp-hr) NOx certification	Default EMFAC Output
California Certified Low-NO_X Diesel HHDT	Scenario S1: **75% NO_X** reduction from conventional diesel HHDT based on 0.05 g/bhp-hr NOx certification Scenario S5 and Scenario S6: **90% NO_X** reduction from conventional diesel HHDT based on 0.02 g/bhp-hr NO_X certification	Default EMFAC Output
Low-NO_X Natural Gas HHDT	**90% NO_X** reduction from conventional diesel HHDT based on 0.02 g/bhp-hr NO_X certification	Default EMFAC Output
Battery Electric HHDT	Zero NO_x tailpipe emissions	Zero GHG tailpipe emissions

3.3 Upstream (Well-to-Tank) Emissions

Ramboll estimated well-to-tank (i.e., "upstream") NO_X and GHG emissions associated with fuel production and distribution for each analyzed fuel type (electricity, diesel, natural gas, renewable diesel from tallow, and renewable natural gas from landfill gas) using emission factors obtained from the CA-GREET 3.0 model.[21] Developed from Argonne National Laboratory's GREET 2016 model,[22] the CA-GREET 3.0 model is used by CARB to calculate well-to-wheel (i.e., "lifecycle") emissions from transportation fuels under the California LCFS Program. Hence, use of this model to estimate upstream emissions is consist with the CARB methodologies.

For purposes of this analysis, Ramboll adjusted the electricity grid mix inputs to the CA-GREET 3.0 model based on California Energy Commission (CEC) current grid mix data[23] and projections for each of the modeled calendar years 2020, 2023, 2031, 2037, 2045 and 2050.[24] Ramboll also updated the

[21] CA-GREET 3.0 Model. Available at: https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet30-corrected.xlsm. Accessed: January 2021.

[22] Available at: https://greet.es.anl.gov/publication-greet-model. Accessed: January 2021.

[23] California Energy Commission 2018 Grid Mix Data. Available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2018-total-system-electric-generation. Accessed: January 2021.

[24] CEC 2018. Deep Decarbonization in a High Renewables Future - Implications for Renewable Integration and Electric System Flexibility, Docket 18-IEPR-06 - 223869, Slide 10. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=223869&DocumentContentId=54081. Accessed: January 2021.

default assumptions for renewable fuels transportation distances within CA-GREET 3.0 to more accurately represent distribution within California. Further details regarding CA-GREET 3.0 model inputs and outputs can be found in **Appendix A**.

Emission factors from CA-GREET 3.0 are obtained per unit of energy consumed for each fuel type. In order to calculate total upstream emissions for each scenario, the total amount of energy consumed of each fuel type is calculated using Energy Economy Ratios (EERs). EERs are dimensionless values that represent the efficiency of a fuel as used in a powertrain as compared to a reference fuel used in the same powertrain.[25] The conventional diesel fuel energy derived from EMFAC2017 for the proportion of vehicles assumed to be turned over to electric of natural gas vehicles was adjusted by the appropriate EERs for heavy-duty vehicles to obtain natural gas or electricity energy consumption. A summary of EER values used in this analysis are provided in **Appendix A**.

[25] CARB 2020. Low Carbon Fuel Standard Regulation. Available online at: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf Accessed: January 2021.

4. COST ANALYSIS METHODOLOGY

As discussed in Section 2, Ramboll conducted a total cost of ownership (TCO) analysis and cost-effectiveness analysis for five HHDT technologies: Conventional diesel HHDT, Federal Low NO_X diesel HHDT, CA Low NO_X HHDT, Low NO_X NG HHDT, and Battery Electric HHDT.

The TCO analysis includes an assessment of capital and operational costs with cost values presented in 2018 dollars. The analysis assumes the purchase of a model year (MY) 2024 truck and conducts a TCO calculation for both a 10-year (435,000 miles) and 15-year (909,900 miles) useful truck life. Where possible, cost assumptions are derived from CARB sources including the CARB ACT Regulation.[26]

Capital costs are calculated as a sum of the vehicle purchase cost and charger/charging infrastructure cost, where applicable (i.e., for battery electric trucks). Vehicle purchase costs used in this analysis do not include financing costs or incentives available from various federal, state, and local funding programs. Low-NO_X diesel truck capital costs were estimated by adding the incremental low-NO_X engine and aftertreatment to the cost of a conventional diesel truck. Vehicle purchase costs for BEVs are highly dependent on the future cost projections for batteries. Given the variability in these cost projections,[27] HHDT BEV total cost of ownership was analyzed for a MY2018 and a MY2024 vehicle. Further details regarding battery cost assumptions are provided in **Section 6.3.1** and **Appendix B.** Costs associated with the new and/or enhanced electric generation and transmission infrastructure required for deployment of BEVs are not included in this analysis.

Operational costs are calculated as a sum of fuel costs and operation & maintenance (O&M) costs. Fuel cost projections are derived from United States Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2019.[28] Potential revenue from CARB LCFS credits[29] are not included in this cost analysis. CARB ACT ISOR[27] assumes that a diesel engine rebuild is not needed for an operational life of 600,000 miles. As such, Ramboll Cost analysis does not assume any midlife overhaul costs for a diesel HHDT. As consistent with CARB ACT ISOR[27], a midlife overhaul is required for HHDT BEVs, which consists of a battery replacement in year 8 of operation.

Ramboll calculated cost-effectiveness for each HHDT technology as a ratio of the incremental total cost of ownership (compared to conventional diesel HHDT) divided by incremental tailpipe NO_X emission reductions over the vehicle lifetime (compared to a conventional diesel HHDT). Ramboll estimated tailpipe NO_X emissions for each HHDT technology using EMFAC2017 outputs for a conventional diesel HHDT and the assumptions listed in **Table 3-2**.

Refer to **Appendix B** for additional information on the methodology and assumptions used for the TCO and cost-effectiveness analysis**.**

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[26] Refer to **Appendix B** for a complete list of sources.

[27] CARB ACT ISOR[25] Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

[28] EIA AEO 2019. Table 3 Fuel Prices for the Pacific Region. Available at: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2019&region=1-9&cases=ref2019&start=2017&end=2050&f=A&linechart=ref2019-d111618a.3-3-AEO2019.1-9&map=ref2019-d111618a.4-3-AEO2019.1-9&sourcekey=0. Accessed: January 2021.

[29] LCFS Credit Generation Opportunities. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/lcfs-credit-generation-opportunities. Accessed: December 2020.

5. SCENARIO ANALYSIS EMISSIONS RESULTS

5.1 Tailpipe NO_X Emissions

Figure 5-1 below presents the estimated total NO_X tailpipe (vehicle exhaust) emissions from the statewide HHDTs excluding SWCVs for calendar year 2020 to 2050 for each modeled scenario: S0 - Baseline EMFAC2017 (represented by black line), S1 – CARB Long-Term Scenario (represented by the orange line), S2 - Low NO_X NG with ACT (represented by blue line), S3 – Low NO_X NG without ACT (represented by green line), S4 – Low NO_X NG with SCAQMD 2016 AQMP & ACT (represented by purple line), S5 – CA Low NO_X DSL with ACT (represented by yellow line), and S5 – CA Low NO_X DSL with ACT (represented by grey line). Renewable fuels are not expected to change NO_X tailpipe emissions relative to the corresponding conventional fuels they displace; therefore "A1" and "B1" sub-scenarios show the same tailpipe NO_X emission estimates for each modeled scenario.

The results of the scenario analysis demonstrate that all modeled scenarios with Low NO_X engines (S2 through S6) can achieve similar NO_X reductions (compared to the baseline Scenario S0) as the CARB Long-Term Scenario (S1) presented in the 2020 MSS. In fact, as seen in **Figure 5-1** and **Figure 5-2** Scenario S4, which assumes the early adoption of Low-NO_X NG HHDTs to meet or exceed fleet mix requirements from the SCAQMD's 2016 AQMP, achieves greater NO_X reductions (compared to the baseline Scenario S0) sooner than CARB's Long-Term Scenario (S1). The CARB scenario (S1) achieves only 3% of the tailpipe NO_X emission reductions (compared to Baseline Scenario 0) that a multi-technology deployment of near-zero emission HHDTs consistent with the 2016 MSS SIP (S4) would have achieved in 2023; even by 2031, the CARB scenario only achieves 66% of the tailpipe NO_X reductions Scenario 4 would have achieved in 2031. Strategies that fail to deploy early adoption of near-zero emission trucks as CARB committed to in the 2016 MSS SIP (a key component of the SCAQMD's 2016 AQMP[30] and SJVAPCD's 2016 San Joaquin Valley SIP[31] and 2018 supplements[32]) forgo necessary near-term NO_X emission reductions needed to meet 2023 and 2031 ozone attainment deadlines in South Coast Air Basin and San Joaquin Valley.

[30] SCAQMD. Final 2016 AQMP-CARB/EPA/SIP Submittal. Available at: https://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp. Accessed: January 2021.

[31] SJVAPCD. 2016 Plan for the 2008 8-Hour Ozone Standard. Available at: https://www.valleyair.org/Air_Quality_Plans/Ozone-Plan-2016.htm. Accessed: January 2021.

[32] SJVAPCD. 2018 PM 2.5 Plan for the San Joaquin Valley. Available at: https://www.valleyair.org/pmplans/. Accessed: January 2021.

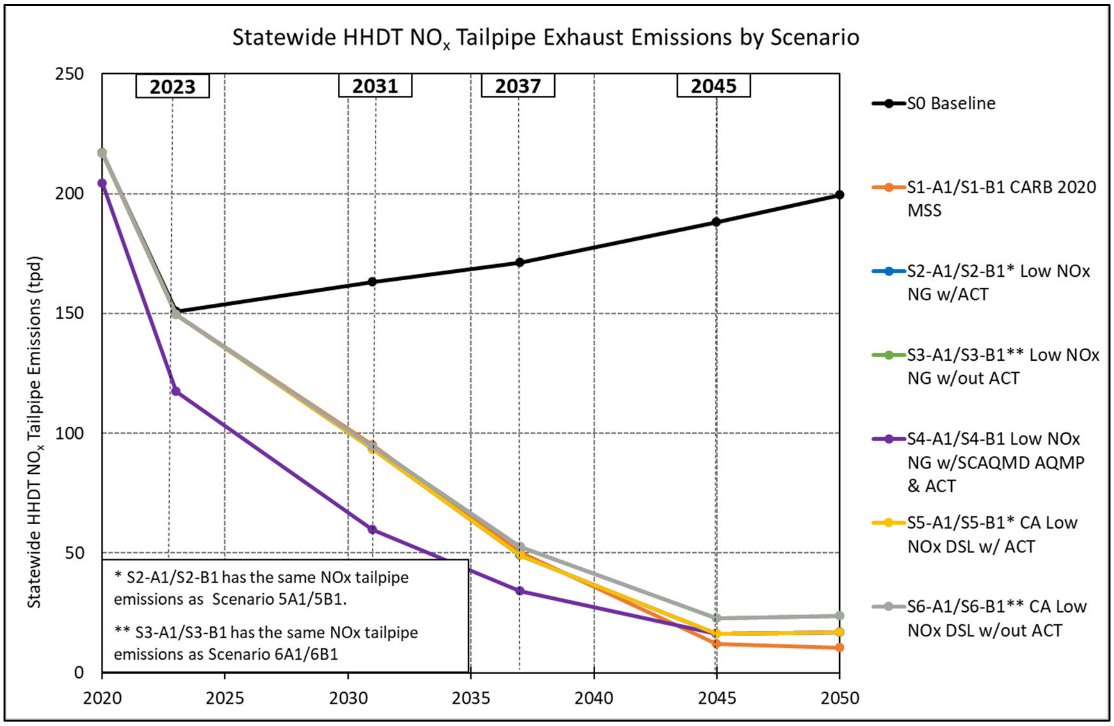

Figure 5-1. Statewide HHDT NOx Tailpipe Exhaust Emissions by Scenario

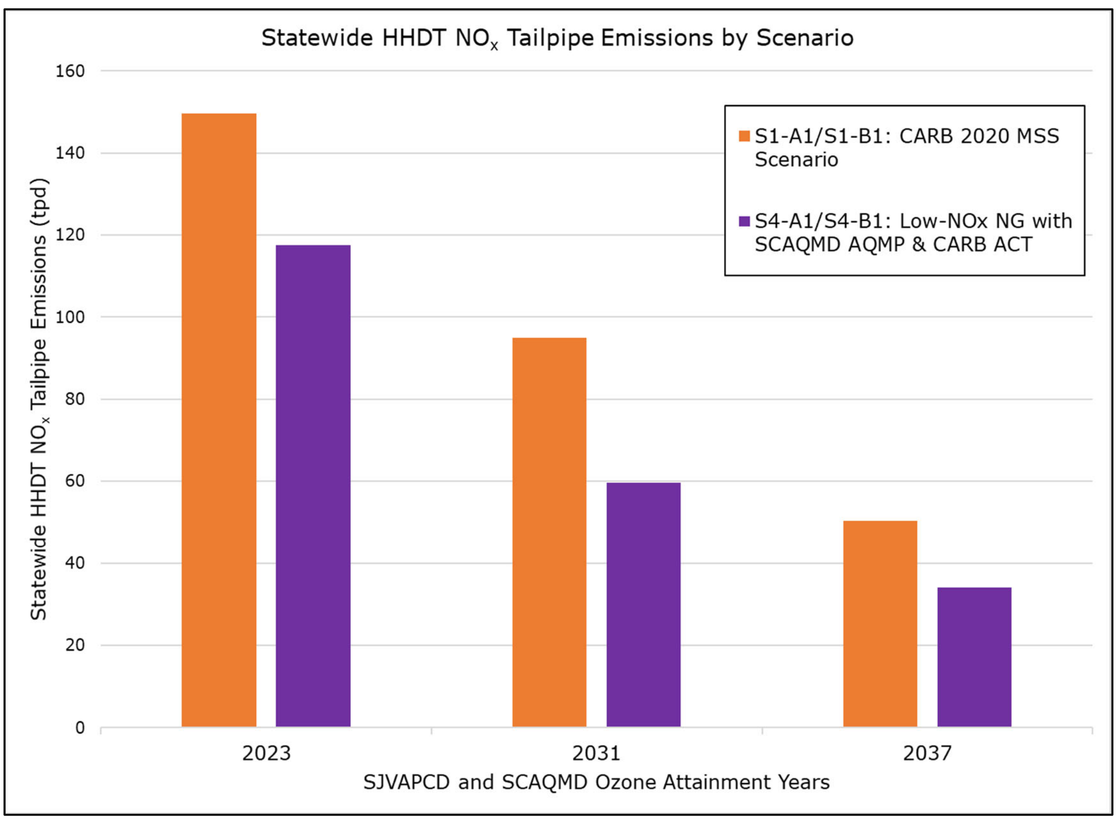

Figure 5-2. Statewide HHDT NOx Emissions Comparison by Scenario

5.2 GHG Emissions

Figure 5-3 provides a comparison of well-to-wheel ("lifecycle") GHG emissions associated with the statewide HHDT fleet excluding the SWCVs in calendar year 2045 for the following modeled scenarios: S1 – CARB Long-Term Scenario (represented by the orange bar), S2 - Low NO_X NG with ACT (represented by blue bar), S3 – Low NO_X NG without ACT (represented by green bar), S5 – CA Low NO_X DSL with ACT (represented by yellow bar), and S5 – CA Low NO_X DSL with ACT (represented by grey bar) . As summarized previously in **Table 3-1**, sub-scenarios B1, C1, and C2 explore the use of renewable fuels to generate GHG emission reductions needed to meet the State's long-term climate goals. The results presented in **Figure 5-3** show that the use of renewable fuels (sub-scenarios B1, C1, and C2) along with near-zero vehicle technologies (Scenarios S2, S3, S5, and S6) such as Low NO_X NG and Low NO_X DSL engines can generate GHG reductions similar to CARB Long-Term Scenario (S1). Further, Scenarios S2-C1 and S3-C1, which model an accelerated turnover of the statewide HHDT fleet (excluding SWVCs) to Low-NO_X NG vehicles fueled by a composite mix of renewable NG, could result negative lifecycle GHG emissions.

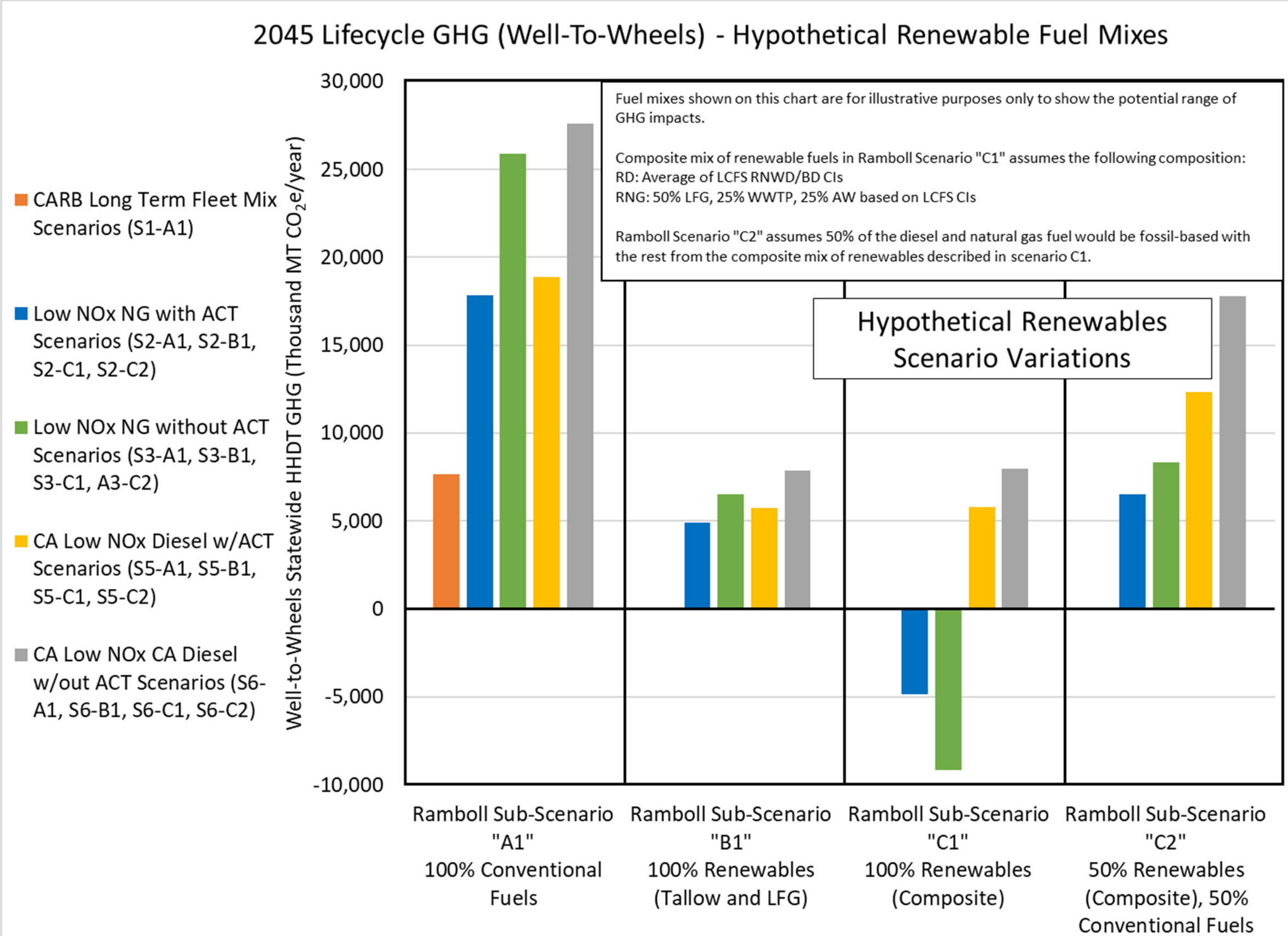

Figure 5-3. 2045 Well-to-Wheels GHG Emissions

5.3 Summary of Scenario Analysis Results

The tailpipe NO_X and lifecycle GHG emissions results of Ramboll's scenario analysis presented in Sections 5.1 and 5.2 clearly indicate that CARB can develop a multi vehicle/fuel technology pathway for mobile sources that not only achieves the much needed near-term NO_X reductions in SCAB and SJV by early adoption of Low NO_X vehicle technologies, but also achieves sufficient GHG reductions to meet the State's long-term climate goals through the increased use of liquid and gaseous renewable fuels.

6. COST ANALYSIS RESULTS

6.1 Total Cost of Ownership Results

The results of Ramboll's cost analysis demonstrate that Low-NO_X HHDTs can deliver equivalent operational cost savings as BEVs, with a lower purchase cost and without additional infrastructure investments. **Figures 6-1 and 6-2** show the projected total cost of ownership for a 10- and 15-year useful life analysis for each truck technology: Conventional Diesel HHDT (light yellow), Federal Low-NO_X Diesel HHDT (blue), CA Low-NO_X Diesel HHDT (Orange), Low-NO_X NG HHDT (purple), MY2018 BEV (green) and MY2024 BEV (green). Costs associated with charger and installation are show in hatched dark green. With the exception of BEV-2018 costs, all vehicles analyzed are MY2024 vehicles. As stated previously, Ramboll assessed the cost of both a MY2018 and MY2024 BEV given the variability in HD battery cost projections. These concerns are further elaborated in **Section 6.3.1** of this report. While the inclusion of LCFS credits for electric charging may result in up to $88,000 of revenue for a 10-year truck lifetime (up to $181,000 of revenue for a 15-year truck lifetime), the earnings from this potential revenue have not been included in the Ramboll cost analysis given uncertainties in future market conditions and availability of credit deficits in the LCFS program in future years. From these results, under both a 10-year and 15-year useful life analysis, the total projected cost of ownership for low-NO_X trucks is below that of BEVs, even without accounting for vehicle replacement ratio differences.

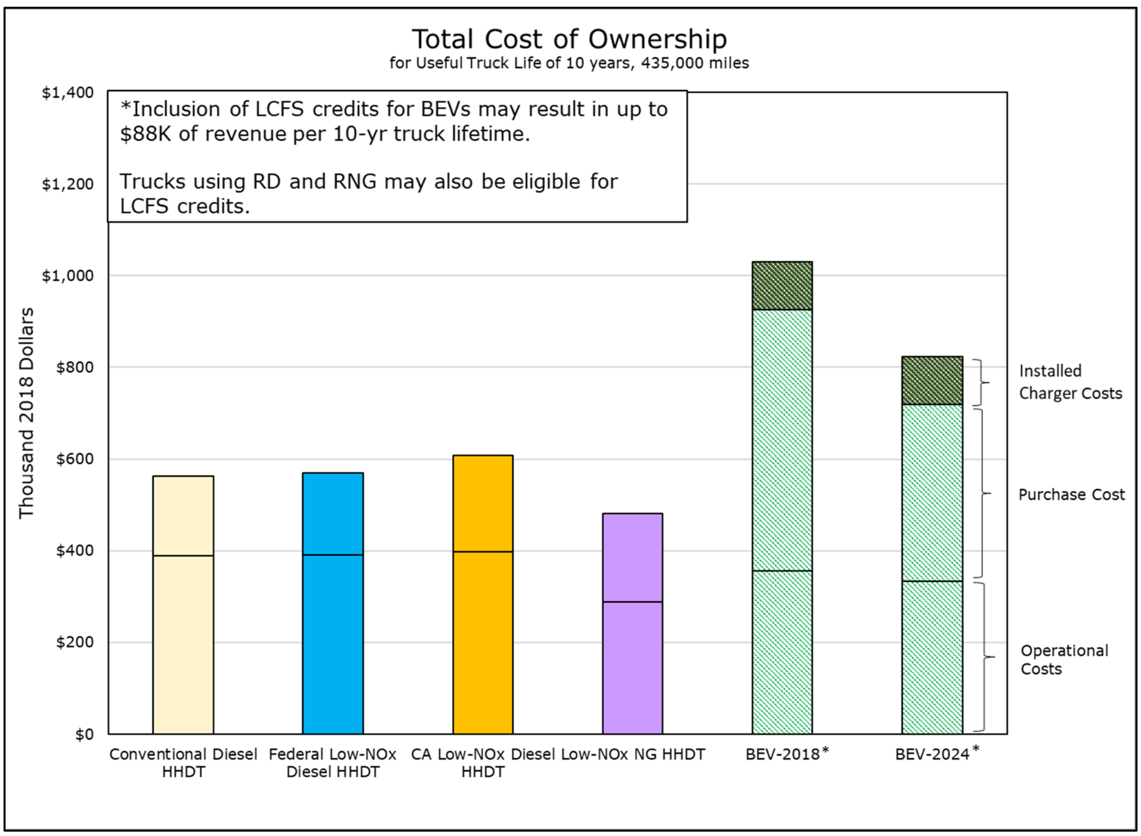

Figure 6-1. Total Cost of Ownership Results for a 10-year Useful Life

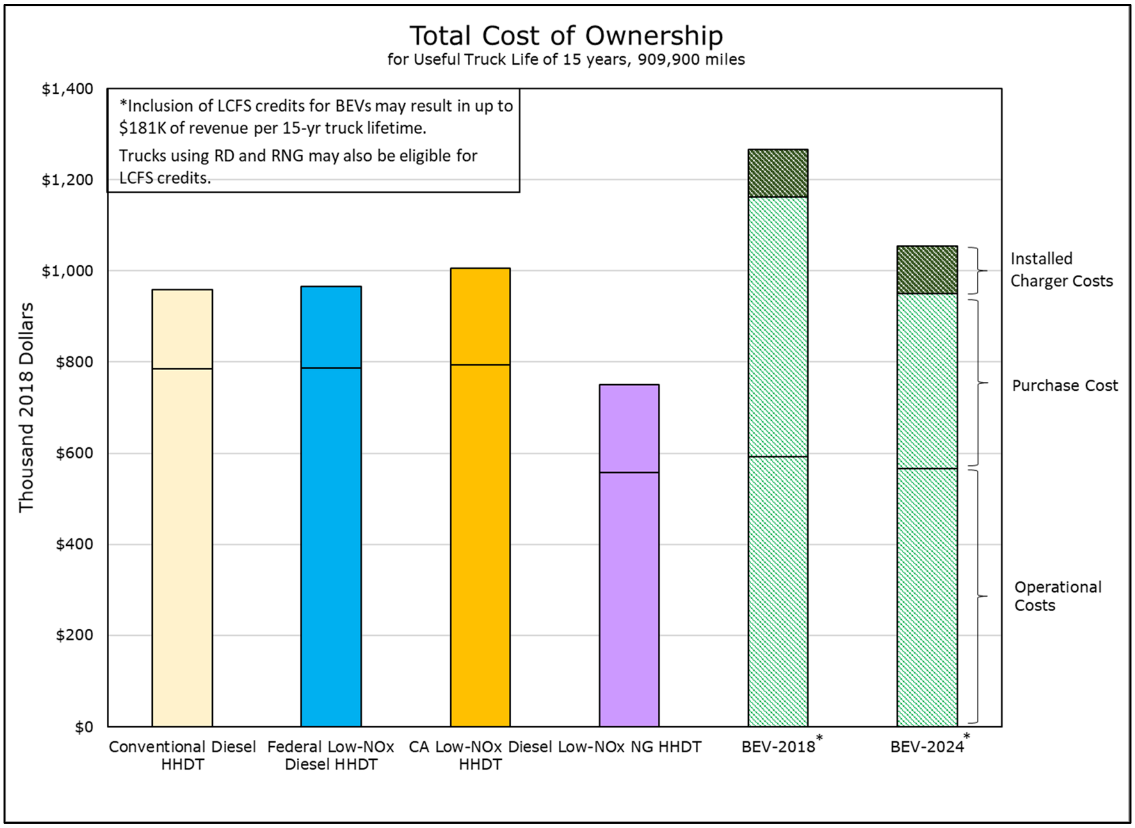

Figure 6-2. Total Cost of Ownership Results for a 15-year Useful Life

Figure 6-3 provides a comparison between the TCO analysis for conventional diesel HHDT, BEV-2018 and BEV-2024 from CARB Advanced Clean Truck (ACT) Regulation[33] and the Ramboll Analysis. Total cost of ownership is broken down by vehicle purchase cost (gray), financing costs (light blue), charger and infrastructure costs (green), and total operational costs (dark blue). Where possible, Ramboll analysis used cost assumptions from the CARB ACT regulation, nonetheless, due to the following key differences between both analyses, CARB's TCO results for BEVs (labelled as ACT ISOR 12-yr TCO in graph) are much lower than the Ramboll BEV TCO results:

- CARB's analysis reduces BEV operational costs by $130,000 to $170,000 to account for revenues generated from LCFS credits. As described earlier, Ramboll's analysis does not account for these credits.
- CARB's costs are discounted to net present value, while Ramboll's analysis reports costs in 2018 dollars.
- CARB's analysis includes financing costs for the purchase of the vehicle and charger while the Ramboll's analysis does not include this cost.
- CARB's analysis does not include infrastructure upgrade and maintenance costs in its final TCO calculation even though these assumptions are provided in the CARB ACT ISOR. Ramboll uses the cost assumptions in CARB ACT ISOR to estimate infrastructure upgrade costs.

33 CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

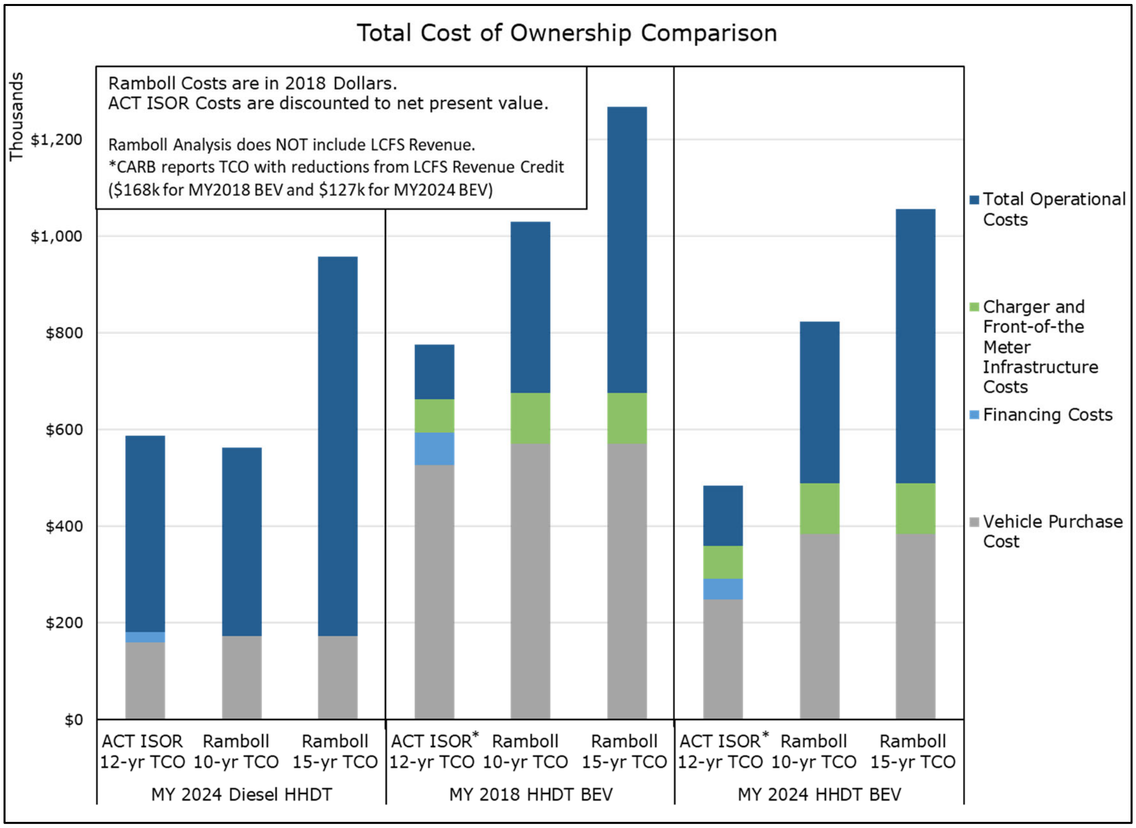

Figure 6-3. Comparison between Ramboll and CARB ACT TCO Analyses

Among the above-mentioned differences in CARB's and Ramboll's analysis approach, the primary driver for the significantly lower TCO for BEV's in CARB's analysis is the revenue generated from LCFS credits. CARB has potentially under-represented BEV operational costs by assuming significant LCFS credit offsets and projecting electricity prices up to 10% lower than those presented in the US Department of Energy's (US DOE) Annual Energy Outlook (AEO) 2018.[34] CARB estimates that LCFS credit revenues of roughly $130,000 to $170,000 per truck can be used to offset already low electricity fuel costs. This assumption fails to consider that LCFS credit revenue depends on future market conditions and availability of credit deficits from the production of higher carbon intensity fuels. Availability of LCFS credits out to the 10-15-year lifetime of a truck has not been demonstrated. Further, with the large-scale electrification of trucks that CARB is considering in the 2020 MSS, BEV truck operators who do not have the real estate to install chargers at their facility will likely charge their vehicles at private/public charging stations. There operators would; therefore, be unable to reap the benefits of LCFS credits which would go the charging station owners.

CARB's economic analysis assumes a 1:1 BEV to diesel vehicle replacement ratio, an assumption that ignores the operational implications of BEV usage in the HDT sector and provides a favorable TCO for HD BEVs compared to the diesel HDT that they replace. Previous studies on HD BEVs, specifically bus fleet operations, have shown that due to increased vehicle weight, limited battery range, long

[34] EIA AEO 2018. Table 3 Fuel Prices for the Pacific Region. Available at: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2018&region=1-9&cases=ref2018&start=2016&end=2050&f=A&linechart=ref2018-d121317a.3-3-AEO2018.1-9&map=ref2018-d121317a.4-3-AEO2018.1-9&sourcekey=0. Accessed: January 2021.

charging times and unfavorable charging windows, more than one battery electric bus (BEB) will be needed to replace a conventional diesel bus. For example, some transit agencies have found that BEBs are unable to be used on many of their "route blocks" (a route block is a vehicle schedule, the daily assignment for an individual bus). The Victor Valley Transit Agency found that BEBs can only be used on 15 of their 56 route blocks, with the optimistic assumption that BEBs are able to achieve ranges of 250 miles.[35]

Lastly, CARB's economic analysis uses highly optimistic vehicle price projections for BEVs in 2024 and beyond. As described in more detail in **Section 5.3**, these price projections rely on optimistic battery price assumptions from Bloomberg Energy's light duty vehicle battery costs,[36] and as such may overestimate the cost savings from the purchase of BEVs.

6.2 Cost Effectiveness Results

Cost-effectiveness is the measure of the cost (in dollars) of a projected vehicle technology for each ton of emissions reduced. In Ramboll's TCO analysis, NO_X tailpipe cost effectiveness is calculated by dividing the incremental TCO of a vehicle (compared to a conventional diesel HHDT) by the total lifetime tailpipe NO_X emissions reductions (compared to that of a conventional diesel HHDT). A negative cost effectiveness indicates that an HHDT technology has a lower cost compared to that of a conventional diesel HHDT and, as such, is highly cost effective in achieving emission reductions.

Figure 6-4 and Figure 6-5 show the NO_X tailpipe cost effectiveness for analyzed HHDT technology types for a 10-year and 15-year truck life, respectively. The red line illustrates the typical maximum regulatory cost effectiveness of roughly $50,000/ton of NO_x reductions.[37] The cost-effectiveness values for Low NO_X Diesel and Low NO_X NG HHDT are well below this value when considering a 10-year or 15-year truck life and are <u>always</u> more cost-effective than the BEVs. The BEV-2018 is 2 to almost 8 times less cost-effective than the typical maximum regulatory threshold of $50,000/ton of NO_X reductions (15-year and 10-year truck life, respectively). If battery costs drop as assumed by CARB 2016 HD battery paper, operational cost savings materialize (given the concerns raised above about realizing the LCFS credits), and additional behind-the-meter electrical infrastructure costs are not accounted for, the BEV-2024 cost-effectiveness is below $50,000/ton of NO_X reductions for a 15-year truck life because of the increased operational cost benefits and NO_X reductions achieved over

[35] Presentation by the Victor Valley Transit Agency at the 2019 California Desert Air Working Group. Available at: https://www.mdaqmd.ca.gov/home/showdocument?id=6973. Accessed December 2020.

[36] Bloomberg 2019 Better Batteries Report. Available at: https://www.bloomberg.com/quicktake/batteries. Accessed: December 2020.

[37] This value was estimated based on a review of the following documents:

- Cost effectiveness values for CARB's on-road heavy-duty mobile source measures reported in the SCAQMD's 2016 AQMP range from a negative value to $296,000. Available at: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/final/sociofinal_030817.pdf?sfvrsn=2. Accessed: January 2021.
- CARB's Carl Moyer Program uses a maximum cost effectiveness limit of $30,000 per weighted ton of emission reductions to evaluate funding eligibility. Available at: https://ww3.arb.ca.gov/msprog/moyer/guidelines/2017gl/2017_cmp_gl_volume_1.pdf. Accessed: January 2021.
- SCAQMD's guidance for evaluating Best Available Control Technology (BACT) uses a maximum cost effectiveness value of ~$29,000 per ton of NO_x reductions. Available at: http://www.aqmd.gov/docs/default-source/bact/cost-effectiveness-values/bact-cost-effectiveness-4th-qtr-2019.pdf. Accessed: January 2021.

the additional 5-year truck life, but is still less cost-effective than the other low-emission trucks by a factor of 2 or greater.

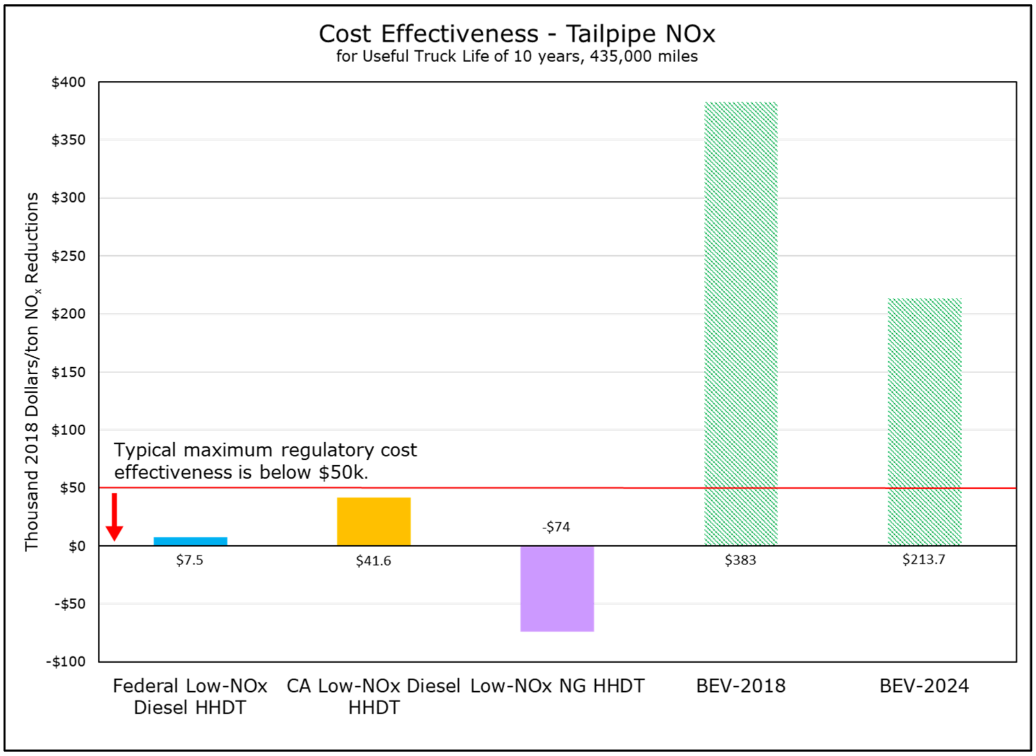

Figure 6-4. Tailpipe NO_X Cost-Effectiveness for a 10-year Truck Life

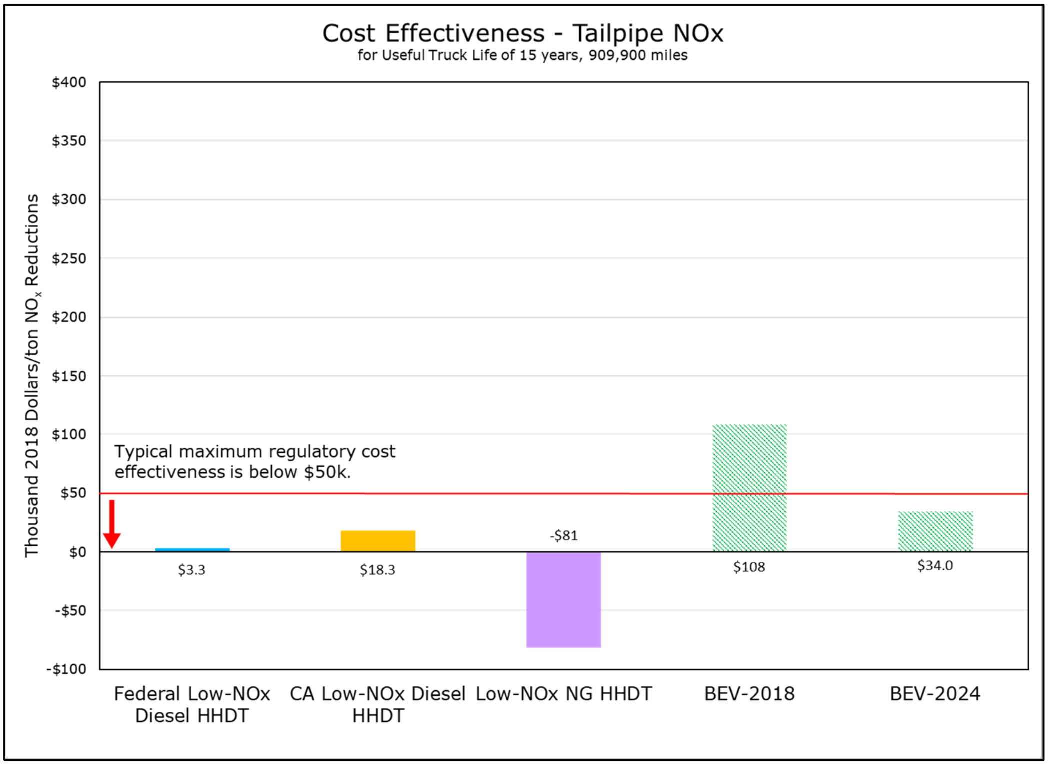

Figure 6-5. Tailpipe NO_X Cost Effectiveness for a 15-year Truck Life

6.3 Data Gaps and Key Concerns

There are a number of data gaps and concerns surrounding the assumptions used in the TCO analysis. These are discussed briefly in the following sub-sections.

6.3.1 Battery Costs and Availability

As shown in **Table 6-1** below, the CARB ACT regulation provided four data sources to future cost projections of batteries used in HHDTs. For the economic analysis that CARB performed for the ACT regulation, they used the data point that was most favorable to BEVs, Bloomberg Energy's light-duty (LD) battery cost assumptions[38] with a five-year delay, that projects a 52% decline in HHDT BEV purchase costs by 2024 as compared to 2018. As shown in **Figure 6-6**, by using the Bloomberg "5-year LD delay" projections, heavy-duty battery costs would be comparable to light-duty battery costs by 2024. This assumption that HD battery costs will see similar price declines as LD batteries has not been substantiated by existing HD battery reports. According to US DOE's 2019 Report[39] on medium- and heavy-duty vehicle (MHDV) electrification, while LDV battery costs have reduced substantially, these reductions have not been realized in the MHDV sector due to low volume purchases and customized pack specifications. The report states that MHDV-specific requirements such as high lifetime mileage, deeper discharges per cycle, overall ruggedness, and resistance to temperature extremes, along with low sales volumes are likely result in incremental vehicle costs as high as 50%-100% of the price of a conventional truck. Given these considerations, Ramboll TCO

[38] Bloomberg 2019 Better Batteries Report. Available at: https://www.bloomberg.com/quicktake/batteries. Accessed: December 2020.

[39] US DOE Medium- and Heavy-Duty Vehicle Electrification Report. Available at: https://info.ornl.gov/sites/publications/Files/Pub136575.pdf. Accessed: January 2021.

analysis conservatively uses battery cost assumptions from CARB's HD Battery Report,[40] rather than the Bloomberg "5-year LD delay" projections, to calculate the purchase cost of a MY2024 BEV. Note, for MY2018 BEV, Ramboll Analysis used purchase cost assumptions from the Bloomberg "5-year LD delay" to be consistent with CARB assumptions. BEV purchase costs used in the Ramboll TCO analysis are bolded in **Table 6-1** below.

Table 6-1. BEV Purchase Cost (without tax) by Battery Cost Source

	CARB HD Battery Paper[1]	CARB ACT ISOR[2] (Bloomberg 5-yr LD Delay)	ICCT HD Battery Estimate[1]	Bloomberg LD Projection[1]
2018 HHDT BEV Purchase Cost[3]	$437,706	**$474,930**	$288,368	$238,944
2024 HHDT BEV Purchase Cost[3]	**$320,374**	$232,155	$236,111	$193,251

Notes:

[1] These purchase costs are pulled from the CARB ACT Draft Cost Calculator, which is an attachment to the ACT ISOR rulemaking documents. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx. Accessed: December 2020.

[2] These purchase costs are pulled from Table 5 of the CARB ACT ISOR Appendix H (Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: November 2020.). Note, these values are slightly different from outputs in the CARB ACT Draft Cost Calculator.

[3] These costs assume the purchase of a 510 kWh BEV and do not include tax.

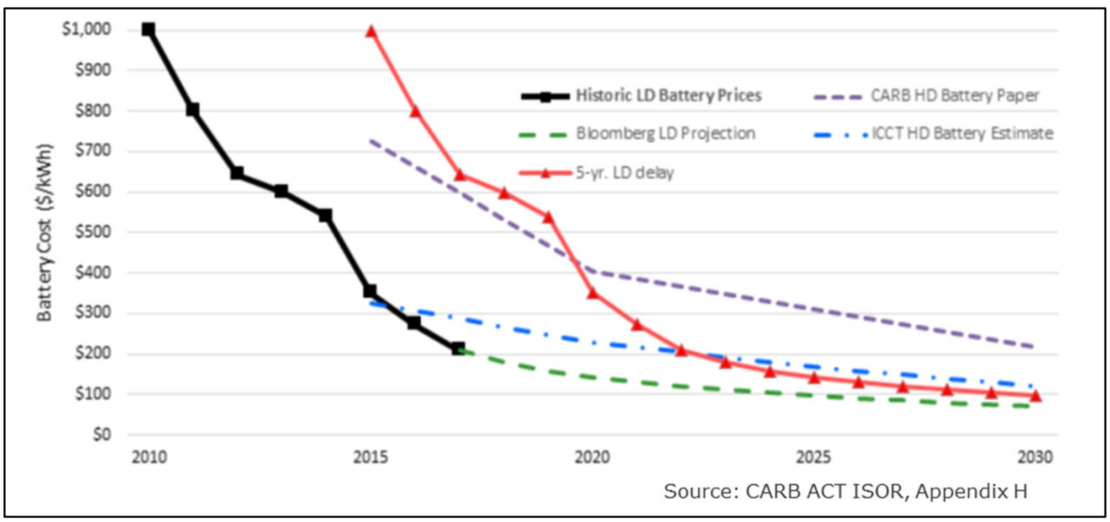

Figure 6-6. Battery Cost Projections from the CARB ACT ISOR[41]

[40] CARB 2016 Battery Cost for Heavy-Duty Electric Vehicles. Available at: https://www.arb.ca.gov/msprog/bus/battery_cost.pdf. Accessed: December 2020.

[41] CARB ACT ISOR Appendix H. Available at: Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: November 2020.

6.3.2 Government Electricity Price Projections

The CARB ACT ISOR[25] projects electricity prices at rates lower than those reported by the US Energy Information Administration (EIA) Annual Energy Outlooks (AEO) for 2018[34] and 2019[42] for the Pacific Region. As shown in **Figure 6-7** below, CARB ACT ISOR[25] sources its electricity prices from EIA AEO 2018 report and adjusts prices to be roughly $0.02/kWh lower than those reported in the 2018 report. Since CARB ACT ISOR[25] has not substantiated these lower electricity cost projections, the Ramboll Cost Analysis uses electricity prices from the most recent AEO released in 2019. **Appendix B** provides more information regarding fuel prices used in the Ramboll Cost Analysis.

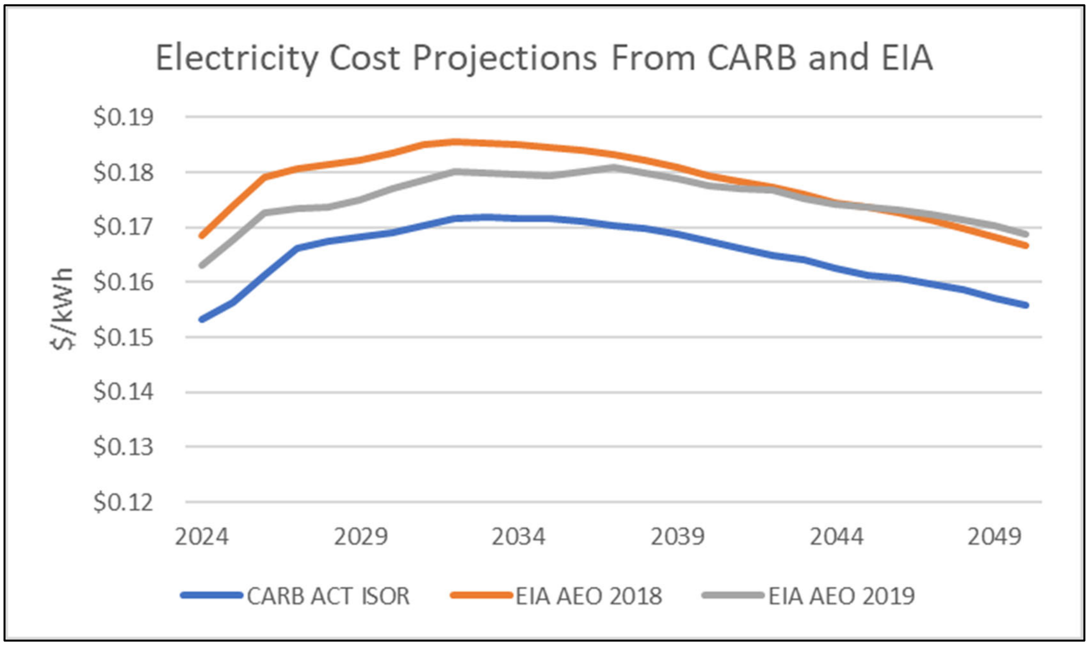

Figure 6-7. Electricity Cost Projections

6.3.3 Lack of Publicly Available Information to Make Renewable Fuel Availability and Price Projections

Due to limited literature surrounding projections of renewable fuel production and prices, Ramboll was unable to analyze the availability of renewable fuels needed to meet the fuel volumes of the renewable fuel scenarios (Scenarios "B1", "C1" and "C2"). Existing literature reports recent growth in California renewable fuel usage, with biodiesel usage tripling between 2015 and 2019 and RNG increasing by 475% in the same time frame.[43] In 2019, roughly 80% of California transportation NG usage was comprised of RNG. US RNG production is expected to grow by a factor of ten between 2025 and

[42] EIA AEO 2019. Table 3 Fuel Prices for the Pacific Region. Available at: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2019&region=1-9&cases=ref2019&start=2017&end=2050&f=A&linechart=ref2019-d111618a.3-3-AEO2019.1-9&map=ref2019-d111618a.4-3-AEO2019.1-9&sourcekey=0. Accessed: December 2020.

[43] GNA, 2020. The State of Sustainable Fleets 2020. Available at: https://www.stateofsustainablefleets.com/. Accessed: January 2021.

2040.[44] While research reports promise the growth of renewable fuels, more detailed data on fuel production and price projections are needed to access the feasibility and cost effectiveness of the renewable scenarios presented in the Ramboll Scenario and Cost analysis. Current retail prices for renewable diesel are available from the US DOE,[45] nonetheless, these reports do not provide price projections.

6.3.4 Other Unaccounted-for Costs

Additional data gaps include the need to estimate costs of increased grid generating capacity, expanded transmission and distribution (T&D), and grid impacts due to increased renewables demand in order to meet increasing electricity usage that would result from electrification of the mobile sector.

While infrastructure needed for gaseous fuel production is not expected to expand significantly, electrification strategies would require additional infrastructure upgrades. This would include, for example, the addition of in-route charging facilities for point-to-point delivery. Analyzing these additional charging infrastructure costs, among other grid related improvements, would require close collaboration with other government agencies in order to estimate and prepare for such a transition.

In 2020, Energy Marketers of America (EMA) conducted a national utility infrastructure study which concluded that EV transmission and distribution (T&D) infrastructure costs would be roughly $5,100 per EV for an average 10-year vehicle life.[46] This study reviewed three nation-wide 2030 electrification scenarios of light-duty EVs and on-road freight EVs. Depending on the EV penetration scenario, total T&D investments can range from $35–$146 billion by 2030. If these costs were borne solely by EV owners, each owner would have to pay more than $500 a year per EV or $9 every time they completely charge their 75-kWh battery vehicle. Given the results of this study, further research is needed to estimate the cost of new EV infrastructure in California.

Lastly, recent regulatory reporting by California transit agencies strongly cautions against uncritically accepting CARB's estimates of electric vehicle and related infrastructure costs. Recent reports from transit agencies[47,48,49,50] have shown that CARB projections[51] in the Innovative Clean Transit (ICT) regulation are significantly different from real world experiences. As seen in the graph below, these reports have demonstrated that Transit operators face BEV charging infrastructure costs significantly higher than CARB ICT estimates. some transit agencies have found that zero emission buses (ZEBs)

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[44] American Gas Foundation, 2019. Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, Figure 6. Available at: https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/. Accessed: January 2021.

[45] US Department of Energy Alternative Fuels Data Center, Alternative Fuel Price Report. Available online at: https://afdc.energy.gov/fuels/prices.html. Accessed: January 2021.

[46] EMA Utility Investments and Consumer Costs of Electric Vehicle Charging Infrastructure. Available at: https://www.energymarketersofamerica.org/ema_today/attachments/Energy_Marketers_of_America_Study-Utility_Infrastructure_for_EVs.pdf. Accessed: January 2021.

[47] AC Transit Rollout Plan. Available at: http://www.actransit.org/wp-content/uploads/AC-Transit-ZEB-Rollout-Plan_06102020.pdf. Accessed: January 2021.

[48] Foothill Transit Rollout Plan. Available at: http://foothilltransit.org/wp-content/uploads/2014/05/Burns-McDonnell-In-Depot-Charging-and-Planning-Study.pdf. Accessed: January 2021.

[49] Long Beach Transit ZEB Rollout Plan. Available at: https://cafcp.org/sites/default/files/Long-Beach-Transit-Zero-Emission-Rollout-Plan.pdf. Accessed: January 2021.

[50] Omnitrans ZEB Rollout Plan. Available at: https://www.gosbcta.com/wp-content/uploads/2020/05/Final-Omnitrans-Rollout-Plan.pdf. Accessed: January 2021.

[51] CARB ICT Cost Calculator. Available at: https://ww2.arb.ca.gov/resources/documents/battery-electric-truck-and-bus-charging-cost-calculator. Accessed: January 2021.

are unable to be used on many of their "route blocks" (a route block is a vehicle schedule, the daily assignment for an individual bus). Further, the Victor Valley Transit Agency found that ZEBs can only be used on 15 of their 56 route blocks, with the optimistic assumption that ZEBs are able to achieve ranges of 250 miles.[52] These concerns may also affect medium- and heavy-duty fleets. For example, this may result in:

- the need for fleets to purchase more ZEVs to meet the same operating capacity as the vehicles they are replacing;
- fleet operators finding that portions of their fleet cannot run their full routes; and
- infrastructure costs significantly higher than cost estimates.

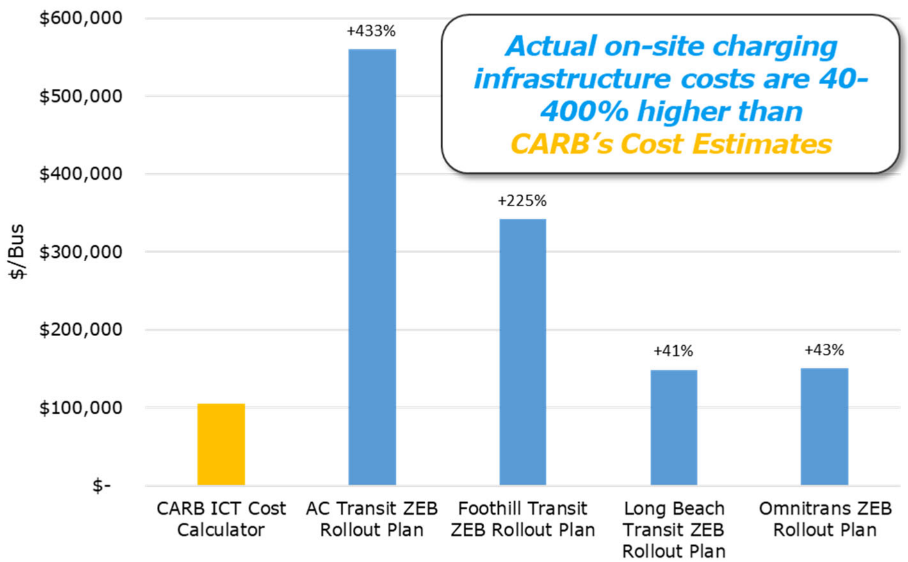

Figure 6-8. Zero Emission Bus (ZEB) Depot Charging Infrastructure Costs

52 Presentation by the Victor Valley Transit Agency at the 2019 California Desert Air Working Group. Available at: https://www.mdaqmd.ca.gov/home/showdocument?id=6973. Accessed October 2020.

7. CONCLUSIONS

7.1 Summary of Analysis Conclusions

Ramboll's analysis suggests that expanded implementation of zero-emission and low-NO_X vehicles, coupled with increased introduction of renewable liquid and gaseous fuels, can deliver earlier and more cost-effective benefits than a ZEV only approach. As advanced low-emitting trucks are commercially available to deliver benefits to communities sooner, with greater certainty, multi-technology pathways can help achieve emission reductions without reliance on infrastructure and technology upgrades that will take years to resolve. The main conclusions of our analysis are summarized below:

Meeting Emission Goals

- Near-term NO_X reductions and long-term GHG goals can be achieved with a mix of advanced low-emitting trucks and renewable fuels;
- A ZEV-only strategy will not deliver required near-term NO_X reductions needed in at-risk environmental justice communities;
- BEV technology has potential for longer-term emission benefits, but relies upon technology and infrastructure developments outside CARB's control or ability to incentivize; and
- There is a growing potential for renewable fuels, including those with negative carbon intensity, to meet long-term GHG reductions.

Achieving Cost effectiveness

- Low-emission heavy-heavy-duty trucks are cost-competitive with (or cheaper than) BEVs;
- Battery technology promises (greater energy density/lower cost) have been assumed but have not been demonstrated; and
- Low-emission heavy-heavy-duty trucks are currently certified and commercially available at scale today.[53]

These conclusions emphasize the need for CARB to conduct a similar analysis across all mobile source sectors, not just the heavy-heavy-duty truck sector, in order to identify existing opportunities to meet state emission goals earlier and more cost effectively.

7.2 Next Steps- Technical

By focusing on a strategy that relies on only on ZEVs, CARB's Mobile Source Strategy falls short of its Clean Air Act commitments to deliver ready, dependable near-term benefits. As such robust scenario analysis coupled with a fleet wide cost-benefit analysis should instead be conducted to develop a reasonable and achievable strategy for California's mobile source sector to meet state emission goals. Such an analysis should build out and evaluate multiple scenarios beyond the singular pathway proposed in the current MSS draft. This includes scenarios that assess the increased use of renewable liquid and gaseous fuels and low-NO_X technologies, as well as the use of market-based emission reduction strategies like Cap-and-Trade, to achieve emission reductions. Further, each scenario must be evaluated for technical feasibility, and as such would require an analysis of future fueling

[53] Optional Low NO_X Certified Heavy-Duty Engines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/onroad/optionnox/optional_low_nox_certified_hd_engines.pdf. Accessed: January 2021.

availability. This would include an assessment of electric grid reliability and availability of infrastructure that would be needed to support a potential transition to a larger ZEV fleet.

In addition to the exploration of multiple scenarios, CARB should assess all associated cost of each MSS scenario in order to identify cost-effective pathways to achieving the state's emission goals. This would include providing citations and justifications for assumptions of projected costs and, as necessary, include a range of potential costs when uncertainty is determined to be high. Further, a robust economic analysis is needed to identity the economic impacts on affected stakeholders.

Performing a robust feasibility and cost analysis as laid out in this section will help to provide the public, stakeholders, and the legislature with sufficient information to make informed decisions about the path to achieving California's emission goals.

7.3 Next Steps- Regulatory

In conducting technical analysis that will inform policy decisions, CARB should remain transparent and unbiased in the rulemaking process. As part of this process, CARB should conduct technical working groups to foster stakeholder participation in scenario development and assessment. Such coordination will help to address cost data gaps identified in **Section 5.3.** and ensure that reasonable and achievable strategies are developed in accordance with SB 44 requirements.

Our analysis confirms that a ZEV-centric approach that only focuses on long-term reductions will not provide the necessary near-term reductions needed to attain federal health standards in the most affected communities in California. With the urgency to achieve near-term criteria pollutant emission reductions, CARB must explore a variety of multi-technology pathways that can help the state achieve faster and surer emission reductions to fulfil its commitment to AB 617 communities and non-attainment areas. For longer-term greenhouse gas reduction goals, CARB should consider a variety of multi-technology pathways to broaden the use of lower carbon-intensity fuels and carbon capture technologies to complement electrification (with attendant statewide infrastructure improvement costs and delays) to reduce greenhouse gas emissions.

APPENDIX A
SCENARIO ANALYSIS ASSUMPTIONS AND DETAILED METHODOLOGY

This Appendix describes the methodology used to calculate tailpipe and upstream emissions for the Ramboll scenario analysis. A list of all tables accompanying this appendix is located after this analysis description. Refer to **Table A-1** provides a list of the analysed scenarios. Refer to **Section 2** of the main document for further details on the scenarios.

Tailpipe Emissions

CARB's EMFAC2017 model[1] was used to estimate tailpipe emissions for oxides of nitrogen (NO_X) and greenhouse gases (GHGs) for all heavy-heavy duty trucks (HHDT) types included in this analysis. Because Ramboll's analysis considers a sub-set of the statewide heavy duty vehicle (HDV) fleet consisting of diesel HHDTs excluding solid waste collection vehicles (SWCV), EMFAC2017 was queried separately for all HHDTs and for SWCVs. First, EMFAC2017 was queried at the statewide level for scenario analysis years 2020, 2023, 2031, 2037, 2045 and 2050 to obtain total exhaust emissions, population, and fuel consumption data for all diesel HHDTs by model year. Specific inputs used in this query are as follows:

- Run Mode: Emissions
- Region Type: Statewide
- Region: California
- Calendar Year: 2020, 2023, 2031, 2037, 2045 and 2050
- Season: Annual
- Vehicle Category: EMFAC2007 Categories - HHDT
- Model Year: All Model Years
- Speed: Aggregated
- Fuel: DSL

Subsequently, EMFAC2017 was queried for all calendar years listed above using the same configuration but for T7 SWCVs using EMFAC2011 vehicle categories. All EMFAC outputs are included in **Table A-2 through Table A-43.**

To obtain data for the adjusted statewide HHDT fleet considered in this analysis, EMFAC outputs for diesel T7 SWCVs were subtracted from corresponding EMFAC outputs for all diesel HHDTs (which included diesel T7 SWCV) for each calendar year. The resulting data, representative of total exhaust emissions, population, and fuel consumption for the statewide diesel HHDT fleet excluding T7 SWCVs, was used to determine emissions and fuel consumption in the baseline scenario S0.

For the other scenarios considered in this analysis, tailpipe emissions for alternative technology HHDTs were calculated based on the adjusted EMFAC2017 data, fleet mix percentages, and the tailpipe emissions assumptions in **Table 3-2** of the main document. Specifically, total NO_X emissions for each calendar year in each scenario were determined using the percentage of the fleet comprised of each HHDT type in each model year and the percentage reduction in NO_X emissions relative to conventional diesel HHDT for each

[1] EMFAC2017 Database v1.0.2. Note this analysis was conducted before the release of EMFAC2017 v.1.0.3. Available at: https://arb.ca.gov/emfac/2017/. Accessed January 2021.

alternative HHDT technology type. Thus, tailpipe emissions were determined first on a per model year basis to account for the population of each HHDT type in each model year and the reduction in tailpipe NO_X emissions achieved by each HHDT type, and total emissions in each calendar year were calculated as the sum of tailpipe emissions across all HHDT types and all model years in that calendar year.

The fleet mix composition for each model year in each calendar year was determined based on the specific technology penetration assumptions for each scenario, as described in **Section 2** of the main document and shown in **Table A-1**. Similar to the 2020 MSS, accelerated turnover of older model year HHDTs to newer vehicles is assumed in all scenarios for calendar years 2031, 2037, 2045, and 2050, and calendar year 2023 for Scenario S4. Specifically, Ramboll's analysis assumes that a fraction of pre-2024 model year (i.e., all model years up to and including 2023) diesel HHDTs are retired and replaced with newer model year alternative HHDT technologies (i.e., low-NOx diesel, low-NOx NG, BEVs) in order to achieve 2020 MSS targets for conventional diesel HHDTs (i.e., Pre-2010 and 2010 Cert.) and the required penetration of newer, alternative HHDT technologies specific to each scenario in the target calendar years. The following describes the procedure used to implement accelerated turnover:

- First, the percentage of the EMFAC-derived HHDT population comprised of pre-2024 vehicles is determined for each target calendar year and compared to the percentage given in CARB's 2020 MSS Long Term Fleet Mix.
- The ratio of these to percentages provides the scaling factor that is used to determine the number of HHDTs in each pre-2024 model year that should be retired, and the population of HHDTs in all model years up to and including 2023 is adjusted accordingly.
- Next, the scaling factor for newer model year HHDTs is determined to ensure that the same number of trucks retried are allocated to the newer model years. This scaling factor is then applied to the EMFAC-derived population of all post-2023 model year HHDTs to obtain the adjusted population data.
- The resulting adjusted HHDT population data for each model year is then used as the basis to determine the fleet mix composition, which are based on the specific technology penetration assumptions for each scenario.

Accelerated turnover calculations are carried out separately for each calendar year but consistently across all scenarios, such that the scaling factors and number of trucks turned over varies between calendar years but is the same across all scenarios in a given calendar year. The resulting fleet mix population data for each scenario, aggregated by model year, is presented in **Figure 3-2** of the main document. Detailed population breakdown by HHDT technology type and model year for each calendar year are presented in **Table A-2 through Table A-43.**

Tailpipe emissions for GHGs are calculated using the same general methodology as tailpipe NO_X emissions. Note however that only BEVs provide a reduction in tailpipe GHG emissions and all other HHDT types are assumed to have the same tailpipe GHG emissions as conventional diesel HHDTs, as described in **Table 3-2** of the main document. Specifically, BEVs are assumed to have zero tailpipe emissions of CO_2, CH_4, and N_2O. GHG emissions are reported in units of carbon dioxide equivalent (CO_2e). CO_2e is calculated based on CO_2, CH_4, and N_2O emissions, using global warming potentials (GWPs) from the International Panel on

Climate Change (IPCC) Fourth Assessment Report (AR4).[2] The GWPs used for CO_2, CH_4, and N_2O are 1, 25, and 298, respectively.

GREET Model Inputs and Assumptions

Ramboll estimated well-to-tank (i.e., "upstream") NO_X and GHG emissions associated with fuel production and distribution for each analyzed fuel type (electricity, diesel, natural gas, renewable diesel from tallow, and renewable natural gas from landfill gas) using emission factors obtained from the CA-GREET 3.0 model. A summary of these emission factors is provided in **Table A-44**.

For purposes of this analysis, Ramboll adjusted the electricity grid mix inputs to the CA-GREET 3.0 model based on California Energy Commission (CEC) current grid mix data[3] and projections for each of the modeled calendar years 2020, 2023, 2031, 2037, 2045 and 2050.[4] **Table A-45** summarizes electricity grid mix inputs into the GREET model.

Ramboll also updated the default assumptions for renewable fuels transportation distances within CA-GREET 3.0 to more accurately represent fuel production and distribution within California. RNG pipeline distance is taken from CARB CA-GREET NG distribution assumptions.[5] Tallow and renewable diesel transportation distances are updated based on biodiesel rendering and retail facilities in California, as reported by Argonne National Laboratory[6] (ANL) and the Environmental Defense Fund.[7] Details regarding the adjusted metrics are provided in **Table A-46**.

As the conventional fuels are not expected to be sourced by in-state feedstock only, this analysis assumes that feedstock electricity mix for conventional fuels comes from a U.S. average grid mix. Electricity grid mix for production and processing of all fuels was assumed to come from a California grid-average electricity mix (CAMx).

Emission factors from CA-GREET 3.0 are obtained per unit of energy consumed for each fuel type. In order to calculate total upstream emissions for each scenario, the total amount of energy consumed of each fuel type is calculated using Energy Economy Ratios (EERs). EERs are dimensionless values that represent the efficiency of a fuel as used in a powertrain as compared to a reference fuel used in the same powertrain. A summary of EER values used in this analysis are provided in **Table A-47**. EER values for Low-NOx Diesel and NG trucks were

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[2] Greenhouse Gas Protocol. Available at: https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf. Accessed January 2021

[3] California Energy Commission 2018 Grid Mix Data. Available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2018-total-system-electric-generation. Accessed December 2020.

[4] CEC 2018. Deep Decarbonization in a High Renewables Future - Implications for Renewable Integration and Electric System Flexibility, Docket 18-IEPR-06 - 223869, Slide 10. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=223869&DocumentContentId=54081. Accessed: December 2020.

[5] CA-GREET3.0 Lookup Table Pathways Technical Support Documentation. Available at: https://ww2.arb.ca.gov/sites/default/files/classic//fuels/lcfs/ca-greet/lut-doc.pdf. Accessed: August 2020.

[6] ANL Tallow-Based Diesel Pathway in GREET. Available at: https://greet.es.anl.gov/publication-tallow-13. Accessed: August 2020.

[7] EDF Biodiesel in California. Available at: https://www.edf.org/sites/default/files/sites/default/files/content/Biodiesel%20Value%20Chain%20-%20August%202013.pdf. Accessed: August 2020.

sourced from CARB Low Carbon Fuel Standard.[8] EER values for battery electric trucks were adjusted to be consistent with HHDT BEV fuel economies reported in the CARB ACT regulation.[9]

8 LCFS Regulation, 2019. Table 5. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf. Accessed November 2020.

9 CARB ACT Cost Calculator. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx. Accessed November 2020.

APPENDIX A TABLES
SCENARIO ANALYSIS ASSUMPTIONS AND DETAILED METHODOLOGY

APPENDIX A TABLES

Ramboll HHDT Scenarios

Scenario #	Scenario Name	Assumptions	Conventional DSL	Federal Low NO_x DSL	CA Cert. Low NO_x DSL	Low NO_x NG	BEV	Fuel Pathway For Diesel and NG	Scenario Description
0	Baseline EMFAC2017	**Fleet Mix**	EMFAC2017					100% Fossil	Fleet mixes and emissions will match EMFAC2017 Baseline projections.
		Tailpipe Emission Standard							
S1-A1	CARB Long Term Fleet Mix (includes Accelerated ZEV Turnover) - Fossil Fuel	**Fleet Mix**	CARB Long-Term Fleet Mix (0% starting 2045)[1]	CARB Long-Term Fleet Mix (12% by 2050)	CARB Long-Term Fleet Mix (8% by 2050)	CARB Long-Term Fleet Mix (Assume 0% of Fleet for all years)	CARB Long-Term Fleet Mix (81% by 2050)	100% Fossil	Fleet Mixes will match CARB Long-Term Scenario.[2] Low-NO_x Diesel tailpipe emissions standards are based on CARB 2019 Proposed Standards.[3]
		Tailpipe Emission Standard	EMFAC2017	0.05 g/bhp-hr	0.05 g/bhp-hr		No Tailpipe Emissions		
S1-B1	CARB Long Term Fleet Mix (includes Accelerated ZEV Turnover) - Renewable Fuel	**Fleet Mix**	Same as 1A					100% Renewable[4] (DSL-Tallow; CNG-LFG)	
		Tailpipe Emission Standard							
S2-A1	Low NO_x CNG with ACT - Fossil Fuel	**Fleet Mix**	CARB Long-Term Fleet Mix (0% starting 2045)[1]	CARB Long-Term Fleet Mix (12% by 2050)	Assume 0% of Fleet for all Calendar Years	Remaining Fleet Mix	ACT Mandate for CA Trucks (40% by 2050)	100% Fossil	BEV fleet mixes will meet ACT ZEV Mandates[5]. Low-NO_x Diesel tailpipe emissions standards based on CARB 2019 Proposed Standards.[3] Low NOx NG standards based on CARB 2016 MSS.[6]
		Tailpipe Emission Standard	EMFAC2017	0.05 g/bhp-hr		0.02 g/bhp-hr	No Tailpipe Emissions		
S2-B1	Low NO_x CNG with ACT - Renewable Fuel	**Fleet Mix**	Same as 2A					100% Renewable[4] (DSL-Tallow; CNG-LFG)	
		Tailpipe Emission Standard							
S3-A1	Low NO_x CNG - Fossil Fuel	**Fleet Mix**	CARB Long-Term Fleet Mix (0% starting 2045)[1]	CARB Long-Term Fleet Mix (12% by 2050)	Assume 0% of Fleet for all Calendar Years	Remaining Fleet Mix	Assume 0% of Fleet for all Calendar Years	100% Fossil	No penetration of BEVs for all calendar years. Low-NO_x Diesel tailpipe emissions standards based on CARB 2019 Proposed Standards.[3] Low NO_x NG standards based on 2016 MSS.[6]
		Tailpipe Emission Standard	EMFAC2017	0.05 g/bhp-hr		0.02 g/bhp-hr			
S3-B1	Low NO_x CNG - Renewable Fuels	**Fleet Mix**	Same as 3A					100% Renewable[4] (DSL-Tallow; CNG-LFG)	
		Tailpipe Emission Standard							
S4-A1	Scenario 2 with 2016 SCAQMD AQMP - Fossil Fuel	**Fleet Mix**	CARB Long-Term Fleet Mix (0% starting 2045)[1]	CARB Long-Term Fleet Mix (12% by 2050)	Assume 0% of Fleet for all Calendar Years	2016 AQMP Fleet Mix (82,300 CNG Trucks by 2023)	ACT Mandate for CA Trucks (40% by 2050)	100% Fossil	Same as Scenario 2, but assumes early adoption of Low NOx NG vehicles to meet or exceed SCAQMD 2016 AQMP projections for 2023 and 2031.[7] Conventional DSL fleet is adjusted to accommodate early adoption of NG vehicles. BEV penetration will meet ACT ZEV Mandates.[5]
		Tailpipe Emission Standard	EMFAC2017	0.05 g/bhp-hr		0.02 g/bhp-hr	No Tailpipe Emissions		
S4-B1	Scenario 2 with 2016 SCAQMD AQMP - Renewable Fuel	**Fleet Mix**	Same as 4A					100% Renewable[4] (DSL-Tallow; CNG-LFG)	
		Tailpipe Emission Standard							
S5-A1	Low NO_x CA Diesel with ACT - Fossil Fuel	**Fleet Mix**	CARB Long-Term Fleet Mix (0% starting 2045)[1]	CARB Long-Term Fleet Mix (12% by 2050)	Remaining Fleet Mix	Assume 0% of Fleet for all Calendar Years	ACT Mandate for CA Trucks (40% by 2050)	100% Fossil	BEV fleet mixes will meet ACT ZEV Mandates[5]. No penetration of Low-NO_x NG for all calendar years. CA Low-NO_x Diesel tailpipe emissions assume 0.02 g/bhp-hr standards are achieved.
		Tailpipe Emission Standard	EMFAC2017	0.05 g/bhp-hr	0.02 g/bhp-hr		No Tailpipe Emissions		
S5-B1	Low NOx CA Diesel with ACT- Renewable Fuel	**Fleet Mix**	Same as 2A					100% Renewable[4] (DSL-Tallow; CNG-LFG)	
		Tailpipe Emission Standard							
S6-A1	Low NOx CA Diesel without ACT - Fossil Fuel	**Fleet Mix**	CARB Long-Term Fleet Mix (0% starting 2045)[1]	CARB Long-Term Fleet Mix (12% by 2050)	Remaining Fleet Mix	Assume 0% of Fleet for all Calendar Years	Assume 0% of Fleet for all Calendar Years	100% Fossil	No penetration of BEVs or Low-NO_x NG for all calendar years. CA Low-NOx Diesel tailpipe emissions assume 0.02 g/bhp-hr standards are achieved.
		Tailpipe Emission Standard	EMFAC2017	0.05 g/bhp-hr	0.02 g/bhp-hr				
S6-B1	Low NOx CA Diesel without ACT - Renewable Fuels	**Fleet Mix**	Same as 3A					100% Renewable[4] (DSL-Tallow; CNG-LFG)	
		Tailpipe Emission Standard							

Notes:

[1] All scenarios except Scenario 0 include an accelerated fleet turnover assumption similar to CARB Long Term Fleet Mix that results in 0% conventional DSL starting in 2045 and 12% Federal Low NOx DSL in 2050

[2] CARB 2020 Mobile Source Strategy March 25, 2020 Webinar Presentation. Available at: https://ww3.arb.ca.gov/planning/sip/2020mss/pres_marwbnr.pdf. Accessed: July 2020.

[3] CARB Heavy-Duty Low NOx Program September 2019 Workshop. Available at: https://ww2.arb.ca.gov/sites/default/files/classic//msprog/hdlownox/files/workgroup_20190926/staff/01_hde_standards.pdf?_ga=2.98823766.992508391.1594658953-836277372.1571089290. Accessed: July 2020.

[4] Renewable diesel and natural gas are assumed to have zero tailpipe CO_2 emissions.

[5] CARB Advanced Clean Truck Rule. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/30dayattb.pdf. Accessed: July 2020.

[6] CARB 2016 Mobile Source Strategy. Available at: https://ww2.arb.ca.gov/resources/documents/2016-mobile-source-strategy. Accessed: July 2020.

[7] SCAQMD 2016 AQMP Final Socioeconomic Report Appendix 2-A. Available at: https://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/final/appfinal_030817.pdf?sfvrsn=2. Accessed: July 2020.

Abbreviations:

ACT - Advanced Clean Truck Rule
AQMP - Air Quality Management Plan
BEV - battery electric vehicle
bhp-hr - break horsepower hour
CA Cert. - California certified
CARB - California Air Resources Board
CNG - compressed natural gas
CO_2 - carbon dioxide
DSL - diesel
g - gram
HHDT - heavy-heavy-duty truck
LFG - landfill gas
MSS - Mobile Source Strategy
NG - natural gas
NOx - oxides of nitrogen
SCAQMD - South Coast Air Quality Management District
ZEV - zero emission vehicle

Model Year	EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	100%	12,688	44,579,225
2019	12,851	5.6	3,844	0.007	0.60	343	100%	12,851	46,069,473
2020	8,537	3.3	2,461	0.004	0.39	219	100%	8,537	29,496,897
2021	4,246	1.1	575	0.002	0.09	51	100%	4,246	6,891,960

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	5.9	3,720	0.007	0.58
2019	0%	0	0	5.6	3,844	0.007	0.60
2020	0%	0	0	3.3	2,461	0.004	0.39
2021	0%	0	0	1.1	575	0.002	0.09

Notes:

[1] EMFAC data shown here are obtained directly from EMFAC2017.

[2] Fleet mix percentages in this scenario are obtained directly from EMFAC2017.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the EMFAC data.

[4] Energy consumption is calculated based on EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are obtained directly from EMFAC2017 in this scenario.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	EMFAC2017 Output[1] Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Conventional DSL Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	100%	15,699	46,494,284
2019	15,755	7.5	4,119	0.008	0.65	367	100%	15,755	49,364,115
2020	14,758	7.0	4,076	0.008	0.64	363	100%	14,758	48,851,177
2021	13,866	6.3	3,442	0.008	0.54	307	100%	13,866	41,250,943
2022	13,999	6.1	3,590	0.008	0.56	320	100%	13,999	43,027,237
2023	9,671	3.7	2,395	0.005	0.38	213	100%	9,671	28,707,076
2024	4,843	1.3	599	0.003	0.09	53	100%	4,843	7,172,863

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_x	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	7.6	3,880	0.008	0.61
2019	0%	0	0	7.5	4,119	0.008	0.65
2020	0%	0	0	7.0	4,076	0.008	0.64
2021	0%	0	0	6.3	3,442	0.008	0.54
2022	0%	0	0	6.1	3,590	0.008	0.56
2023	0%	0	0	3.7	2,395	0.005	0.38
2024	0%	0	0	1.3	599	0.003	0.09

Notes:

[1] EMFAC data shown here are obtained directly from EMFAC2017.

[2] Fleet mix percentages in this scenario are obtained directly from EMFAC2017.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the EMFAC data.

[4] Energy consumption is calculated based on EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are obtained directly from EMFAC2017 in this scenario.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

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CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
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EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	175	0.10	9.4	0.000	0.001	0.84	100%	175	112,374
1988	235	0.13	13	0.000	0.002	1.1	100%	235	151,922
1989	294	0.17	16	0.000	0.002	1.4	100%	294	189,030
1990	270	0.16	15	0.000	0.002	1.3	100%	270	177,527
1991	233	0.15	12	0.000	0.002	1.1	100%	233	142,277
1992	183	0.12	10	0.000	0.002	0.87	100%	183	116,485
1993	140	0.09	7.9	0.000	0.001	0.71	100%	140	95,261
1994	138	0.09	8.0	0.000	0.001	0.71	100%	138	96,100
1995	170	0.11	10	0.000	0.002	0.91	100%	170	122,715
1996	167	0.11	10	0.000	0.002	0.90	100%	167	120,764
1997	163	0.11	10	0.000	0.002	0.85	100%	163	114,460
1998	153	0.11	10	0.000	0.002	0.90	100%	153	120,608
1999	208	0.18	14	0.000	0.002	1.3	100%	208	169,415
2000	246	0.21	17	0.000	0.003	1.5	100%	246	198,328
2001	281	0.21	17	0.000	0.003	1.5	100%	281	204,106
2002	317	0.22	18	0.000	0.003	1.6	100%	317	211,549
2003	287	0.14	18	0.000	0.003	1.6	100%	287	211,008
2004	291	0.12	18	0.000	0.003	1.6	100%	291	209,839
2005	372	0.16	23	0.000	0.004	2.0	100%	372	273,985
2006	425	0.19	27	0.000	0.004	2.4	100%	425	319,695
2007	573	0.24	37	0.000	0.006	3.3	100%	573	445,598
2008	595	0.15	31	0.000	0.005	2.8	100%	595	371,545
2009	690	0.15	36	0.000	0.006	3.2	100%	690	433,363
2010	356	0.07	19	0.000	0.003	1.7	100%	356	222,974
2011	441	0.05	22	0.000	0.004	2.0	100%	441	267,310
2012	19,805	6.6	2,242	0.004	0.35	200	100%	19,805	26,866,514
2013	11,462	5.5	2,037	0.003	0.32	182	100%	11,462	24,410,727
2014	13,052	5.1	2,102	0.004	0.33	187	100%	13,052	25,194,573
2015	23,841	8.4	3,662	0.007	0.58	326	100%	23,841	43,882,716
2016	26,961	10	4,078	0.01	0.64	363	100%	26,961	48,868,299
2017	31,181	10	4,244	0.009	0.67	378	100%	31,181	50,860,206
2018	10,710	4.0	1,675	0.004	0.26	149	100%	10,710	20,074,268
2019	12,144	4.7	1,963	0.005	0.31	175	100%	12,144	23,528,898
2020	13,758	5.7	2,379	0.006	0.37	212	100%	13,758	28,508,004
2021	15,079	6.5	2,397	0.006	0.38	214	100%	15,079	28,725,379
2022	17,317	8.0	2,991	0.008	0.47	267	100%	17,317	35,843,367
2023	23,269	12	4,495	0.01	0.71	401	100%	23,269	53,863,869
2024	20,136	10	3,698	0.01	0.58	330	100%	20,136	44,323,511
2025	20,975	11	4,195	0.01	0.66	374	100%	20,975	50,271,835
2026	20,497	11	4,412	0.01	0.69	393	100%	20,497	52,879,863
2027	20,024	11	4,331	0.01	0.68	386	100%	20,024	51,907,076
2028	18,309	9.4	4,128	0.01	0.65	368	100%	18,309	49,470,673
2029	17,211	8.4	3,970	0.010	0.62	354	100%	17,211	47,574,498
2030	16,613	7.6	3,900	0.010	0.61	348	100%	16,613	46,733,779
2031	10,661	4.3	2,402	0.006	0.38	214	100%	10,661	28,788,156
2032	5,437	1.4	644	0.003	0.10	57	100%	5,437	7,713,862

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	0%	0	0	0%	0	0	0%	0	0
2025	0%	0	0	0%	0	0	0%	0	0
2026	0%	0	0	0%	0	0	0%	0	0
2027	0%	0	0	0%	0	0	0%	0	0
2028	0%	0	0	0%	0	0	0%	0	0
2029	0%	0	0	0%	0	0	0%	0	0
2030	0%	0	0	0%	0	0	0%	0	0
2031	0%	0	0	0%	0	0	0%	0	0
2032	0	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.10	9.4	0.000	0.001
1988	0%	0	0	0.13	13	0.000	0.002
1989	0%	0	0	0.17	16	0.000	0.002
1990	0%	0	0	0.16	15	0.000	0.002
1991	0%	0	0	0.15	12	0.000	0.002
1992	0%	0	0	0.12	10	0.000	0.002
1993	0%	0	0	0.09	7.9	0.000	0.001
1994	0%	0	0	0.09	8.0	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.11	10	0.000	0.002
1998	0%	0	0	0.11	10	0.000	0.002
1999	0%	0	0	0.18	14	0.000	0.002
2000	0%	0	0	0.21	17	0.000	0.003
2001	0%	0	0	0.21	17	0.000	0.003
2002	0%	0	0	0.22	18	0.000	0.003
2003	0%	0	0	0.14	18	0.000	0.003
2004	0%	0	0	0.12	18	0.000	0.003
2005	0%	0	0	0.16	23	0.000	0.004
2006	0%	0	0	0.19	27	0.000	0.004
2007	0%	0	0	0.24	37	0.000	0.006
2008	0%	0	0	0.15	31	0.000	0.005
2009	0%	0	0	0.15	36	0.000	0.006
2010	0%	0	0	0.07	19	0.000	0.003
2011	0%	0	0	0.05	22	0.000	0.004
2012	0%	0	0	6.6	2,242	0.004	0.35
2013	0%	0	0	5.5	2,037	0.003	0.32
2014	0%	0	0	5.1	2,102	0.004	0.33
2015	0%	0	0	8.4	3,662	0.007	0.58
2016	0%	0	0	10	4,078	0.01	0.64
2017	0%	0	0	10	4,244	0.009	0.67
2018	0%	0	0	4.0	1,675	0.004	0.26
2019	0%	0	0	4.7	1,963	0.005	0.31
2020	0%	0	0	5.7	2,379	0.006	0.37
2021	0%	0	0	6.5	2,397	0.006	0.38
2022	0%	0	0	8.0	2,991	0.008	0.47
2023	0%	0	0	12	4,495	0.01	0.71
2024	0%	0	0	10	3,698	0.01	0.58
2025	0%	0	0	11	4,195	0.01	0.66
2026	0%	0	0	11	4,412	0.01	0.69
2027	0%	0	0	11	4,331	0.01	0.68
2028	0%	0	0	9.4	4,128	0.01	0.65
2029	0%	0	0	8.4	3,970	0.010	0.62
2030	0%	0	0	7.6	3,900	0.010	0.61
2031	0%	0	0	4.3	2,402	0.006	0.38
2032	0%	0	0	1.4	644	0.003	0.10

Notes:

[1] EMFAC data shown here are obtained directly from EMFAC2017.

[2] Fleet mix percentages in this scenario are obtained directly from EMFAC2017.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the EMFAC data.

[4] Energy consumption is calculated based on EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are obtained directly from EMFAC2017 in this scenario.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	75	0.05	3.9	0.000	0.001	0.35	100%	75	47,317
1994	94	0.05	4.8	0.000	0.001	0.42	100%	94	57,084
1995	130	0.07	6.7	0.000	0.001	0.59	100%	130	79,873
1996	134	0.08	6.8	0.000	0.001	0.61	100%	134	81,980
1997	131	0.07	6.6	0.000	0.001	0.59	100%	131	79,331
1998	117	0.07	6.4	0.000	0.001	0.57	100%	117	76,415
1999	150	0.11	8.5	0.000	0.001	0.76	100%	150	101,977
2000	166	0.12	10	0.000	0.002	0.85	100%	166	114,626
2001	181	0.12	10	0.000	0.002	0.88	100%	181	118,851
2002	193	0.13	10	0.000	0.002	0.90	100%	193	121,512
2003	164	0.07	9.3	0.000	0.001	0.83	100%	164	111,673
2004	161	0.06	9.1	0.000	0.001	0.81	100%	161	108,865
2005	200	0.08	12	0.000	0.002	1.0	100%	200	139,150
2006	227	0.10	13	0.000	0.002	1.2	100%	227	160,976
2007	306	0.12	19	0.000	0.003	1.7	100%	306	225,401
2008	329	0.08	17	0.000	0.003	1.5	100%	329	201,692
2009	389	0.09	20	0.000	0.003	1.8	100%	389	239,857
2010	206	0.04	10	0.000	0.002	0.94	100%	206	125,743
2011	263	0.03	13	0.000	0.002	1.1	100%	263	153,971
2012	8,969	2.7	905	0.002	0.14	81	100%	8,969	10,850,749
2013	4,884	2.3	844	0.001	0.13	75	100%	4,884	10,111,625
2014	5,575	2.3	920	0.002	0.14	82	100%	5,575	11,024,466
2015	10,887	4.2	1,802	0.003	0.28	161	100%	10,887	21,597,772
2016	11,839	4.2	1,806	0.004	0.28	161	100%	11,839	21,639,565
2017	15,963	4.4	1,940	0.004	0.30	173	100%	15,963	23,245,601
2018	5,542	1.9	779	0.002	0.12	69	100%	5,542	9,330,010
2019	6,531	2.2	908	0.002	0.14	81	100%	6,531	10,880,678
2020	7,555	2.6	1,064	0.002	0.17	95	100%	7,555	12,750,708
2021	8,675	3.0	1,060	0.003	0.17	94	100%	8,675	12,701,740
2022	10,535	3.8	1,347	0.004	0.21	120	100%	10,535	16,143,648
2023	13,855	5.9	2,024	0.005	0.32	180	100%	13,855	24,261,600
2024	13,533	5.3	1,724	0.005	0.27	154	100%	13,533	20,662,715
2025	15,085	6.2	2,019	0.006	0.32	180	100%	15,085	24,194,862
2026	16,881	7.2	2,375	0.007	0.37	212	100%	16,881	28,459,718
2027	18,671	8.3	2,646	0.008	0.42	236	100%	18,671	31,706,518
2028	20,424	10	3,093	0.009	0.49	276	100%	20,424	37,072,964
2029	21,972	11	3,583	0.01	0.56	319	100%	21,972	42,935,501
2030	23,020	12	4,027	0.01	0.63	359	100%	23,020	48,263,523
2037	23,699	12	4,465	0.01	0.70	398	100%	23,699	53,515,434
2032	23,052	12	4,643	0.01	0.73	414	100%	23,052	55,644,560
2033	22,627	12	4,837	0.01	0.76	431	100%	22,627	57,966,231
2034	20,981	11	4,668	0.01	0.73	416	100%	20,981	55,937,866
2035	19,875	10	4,533	0.01	0.71	404	100%	19,875	54,328,050
2036	18,831	8.6	4,372	0.01	0.69	390	100%	18,831	52,390,503
2037	11,862	4.7	2,651	0.006	0.42	236	100%	11,862	31,768,688
2038	6,109	1.6	710	0.003	0.11	63	100%	6,109	8,512,215

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	0%	0	0	0%	0	0	0%	0	0
2025	0%	0	0	0%	0	0	0%	0	0
2026	0%	0	0	0%	0	0	0%	0	0
2027	0%	0	0	0%	0	0	0%	0	0
2028	0%	0	0	0%	0	0	0%	0	0
2029	0%	0	0	0%	0	0	0%	0	0
2030	0%	0	0	0%	0	0	0%	0	0
2037	0%	0	0	0%	0	0	0%	0	0
2032	0%	0	0	0%	0	0	0%	0	0
2033	0%	0	0	0%	0	0	0%	0	0
2034	0%	0	0	0%	0	0	0%	0	0
2035	0%	0	0	0%	0	0	0%	0	0
2036	0%	0	0	0%	0	0	0%	0	0
2037	0%	0	0	0%	0	0	0%	0	0
2038	0%	0	0	0%	0	0	0%	0	0

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**NO_X**	**CO_2**	**CH_4**	**N_2O**
1993	0%	0	0	0.05	3.9	0.000	0.001
1994	0%	0	0	0.05	4.8	0.000	0.001
1995	0%	0	0	0.07	6.7	0.000	0.001
1996	0%	0	0	0.08	6.8	0.000	0.001
1997	0%	0	0	0.07	6.6	0.000	0.001
1998	0%	0	0	0.07	6.4	0.000	0.001
1999	0%	0	0	0.11	8.5	0.000	0.001
2000	0%	0	0	0.12	10	0.000	0.002
2001	0%	0	0	0.12	10	0.000	0.002
2002	0%	0	0	0.13	10	0.000	0.002
2003	0%	0	0	0.07	9.3	0.000	0.001
2004	0%	0	0	0.06	9.1	0.000	0.001
2005	0%	0	0	0.08	12	0.000	0.002
2006	0%	0	0	0.10	13	0.000	0.002
2007	0%	0	0	0.12	19	0.000	0.003
2008	0%	0	0	0.08	17	0.000	0.003
2009	0%	0	0	0.09	20	0.000	0.003
2010	0%	0	0	0.04	10	0.000	0.002
2011	0%	0	0	0.03	13	0.000	0.002
2012	0%	0	0	2.7	905	0.002	0.14
2013	0%	0	0	2.3	844	0.001	0.13
2014	0%	0	0	2.3	920	0.002	0.14
2015	0%	0	0	4.2	1,802	0.003	0.28
2016	0%	0	0	4.2	1,806	0.004	0.28
2017	0%	0	0	4.4	1,940	0.004	0.30
2018	0%	0	0	1.9	779	0.002	0.12
2019	0%	0	0	2.2	908	0.002	0.14
2020	0%	0	0	2.6	1,064	0.002	0.17
2021	0%	0	0	3.0	1,060	0.003	0.17
2022	0%	0	0	3.8	1,347	0.004	0.21
2023	0%	0	0	5.9	2,024	0.005	0.32
2024	0%	0	0	5.3	1,724	0.005	0.27
2025	0%	0	0	6.2	2,019	0.006	0.32
2026	0%	0	0	7.2	2,375	0.007	0.37
2027	0%	0	0	8.3	2,646	0.008	0.42
2028	0%	0	0	10	3,093	0.009	0.49
2029	0%	0	0	11	3,583	0.01	0.56
2030	0%	0	0	12	4,027	0.01	0.63
2037	0%	0	0	12	4,465	0.01	0.70
2032	0%	0	0	12	4,643	0.01	0.73
2033	0%	0	0	12	4,837	0.01	0.76
2034	0%	0	0	11	4,668	0.01	0.73
2035	0%	0	0	10	4,533	0.01	0.71
2036	0%	0	0	8.6	4,372	0.01	0.69
2037	0%	0	0	4.7	2,651	0.006	0.42
2038	0%	0	0	1.6	710	0.003	0.11

Notes:

[1] EMFAC data shown here are obtained directly from EMFAC2017.

[2] Fleet mix percentages in this scenario are obtained directly from EMFAC2017.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the EMFAC data.

[4] Energy consumption is calculated based on EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are obtained directly from EMFAC2017 in this scenario.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
2001	92	0.06	4.7	0.000	0.001	0.42	100%	92	55,864
2002	126	0.08	6.1	0.000	0.001	0.55	100%	126	73,692
2003	117	0.05	5.8	0.000	0.001	0.52	100%	117	69,583
2004	117	0.04	5.8	0.000	0.001	0.52	100%	117	69,938
2005	141	0.05	7.1	0.000	0.001	0.63	100%	141	84,978
2006	149	0.06	7.7	0.000	0.001	0.68	100%	149	91,926
2007	186	0.07	10	0.000	0.002	0.89	100%	186	119,191
2008	190	0.05	9.4	0.000	0.001	0.84	100%	190	113,113
2009	208	0.05	10	0.000	0.002	0.93	100%	208	124,512
2010	103	0.02	5.1	0.000	0.001	0.45	100%	103	60,761
2011	124	0.01	5.8	0.000	0.001	0.52	100%	124	69,981
2012	3,164	0.88	279	0.001	0.04	25	100%	3,164	3,344,913
2013	1,607	0.74	266	0.000	0.04	24	100%	1,607	3,183,366
2014	1,758	0.74	291	0.001	0.05	26	100%	1,758	3,492,142
2015	3,339	1.4	569	0.001	0.09	51	100%	3,339	6,824,423
2016	3,387	1.2	514	0.001	0.08	46	100%	3,387	6,158,622
2017	4,827	1.2	537	0.001	0.08	48	100%	4,827	6,430,112
2018	1,762	0.58	238	0.001	0.04	21	100%	1,762	2,851,512
2019	2,149	0.69	284	0.001	0.04	25	100%	2,149	3,404,717
2020	2,509	0.83	339	0.001	0.05	30	100%	2,509	4,060,186
2021	2,963	1.0	350	0.001	0.06	31	100%	2,963	4,200,368
2022	3,605	1.2	440	0.001	0.07	39	100%	3,605	5,271,072
2023	4,481	1.5	550	0.001	0.09	49	100%	4,481	6,596,556
2024	5,241	1.7	576	0.002	0.09	51	100%	5,241	6,908,530
2025	6,104	2.0	676	0.002	0.11	60	100%	6,104	8,100,000
2026	7,152	2.4	794	0.002	0.12	71	100%	7,152	9,515,611
2027	8,184	2.8	872	0.003	0.14	78	100%	8,184	10,447,069
2028	9,405	3.2	1,001	0.003	0.16	89	100%	9,405	11,995,147
2029	10,888	3.8	1,166	0.004	0.18	104	100%	10,888	13,973,007
2030	12,611	4.4	1,359	0.004	0.21	121	100%	12,611	16,288,180
2045	14,300	5.4	1,661	0.005	0.26	148	100%	14,300	19,910,222
2032	16,271	6.5	2,006	0.006	0.32	179	100%	16,271	24,038,562
2033	18,271	7.6	2,358	0.007	0.37	210	100%	18,271	28,256,371
2034	20,665	9.0	2,802	0.008	0.44	250	100%	20,665	33,577,632
2035	22,814	10	3,274	0.010	0.51	292	100%	22,814	39,232,932
2036	24,632	12	3,762	0.01	0.59	335	100%	24,632	45,082,949
2037	26,123	13	4,272	0.01	0.67	381	100%	26,123	51,193,009
2038	26,997	14	4,724	0.01	0.74	421	100%	26,997	56,619,599
2039	27,480	14	5,157	0.01	0.81	460	100%	27,480	61,800,167
2040	26,050	14	5,193	0.01	0.82	463	100%	26,050	62,236,336
2041	25,105	13	5,312	0.01	0.83	473	100%	25,105	63,663,029
2042	22,635	11	4,974	0.01	0.78	443	100%	22,635	59,613,985
2043	21,270	10	4,789	0.01	0.75	427	100%	21,270	57,388,548
2044	20,106	9.0	4,590	0.01	0.72	409	100%	20,106	55,011,066
2045	12,634	5.0	2,768	0.007	0.44	247	100%	12,634	33,169,181
2046	6,495	1.7	741	0.004	0.12	66	100%	6,495	8,884,377

Table A-6. NOx and GHG Tailpipe Emissions for Scenario 0 in Calendar Year 2045
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	0%	0	0	0%	0	0	0%	0	0
2025	0%	0	0	0%	0	0	0%	0	0
2026	0%	0	0	0%	0	0	0%	0	0
2027	0%	0	0	0%	0	0	0%	0	0
2028	0%	0	0	0%	0	0	0%	0	0
2029	0%	0	0	0%	0	0	0%	0	0
2030	0%	0	0	0%	0	0	0%	0	0
2045	0%	0	0	0%	0	0	0%	0	0
2032	0%	0	0	0%	0	0	0%	0	0
2033	0%	0	0	0%	0	0	0%	0	0
2034	0%	0	0	0%	0	0	0%	0	0
2035	0%	0	0	0%	0	0	0%	0	0
2036	0%	0	0	0%	0	0	0%	0	0
2037	0%	0	0	0%	0	0	0%	0	0
2038	0%	0	0	0%	0	0	0%	0	0
2039	0%	0	0	0%	0	0	0%	0	0
2040	0%	0	0	0%	0	0	0%	0	0
2041	0%	0	0	0%	0	0	0%	0	0
2042	0%	0	0	0%	0	0	0%	0	0
2043	0%	0	0	0%	0	0	0%	0	0
2044	0%	0	0	0%	0	0	0%	0	0
2045	0%	0	0	0%	0	0	0%	0	0
2046	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2001	0%	0	0	0.06	4.7	0.000	0.001
2002	0%	0	0	0.08	6.1	0.000	0.001
2003	0%	0	0	0.05	5.8	0.000	0.001
2004	0%	0	0	0.04	5.8	0.000	0.001
2005	0%	0	0	0.05	7.1	0.000	0.001
2006	0%	0	0	0.06	7.7	0.000	0.001
2007	0%	0	0	0.07	10	0.000	0.002
2008	0%	0	0	0.05	9.4	0.000	0.001
2009	0%	0	0	0.05	10	0.000	0.002
2010	0%	0	0	0.02	5.1	0.000	0.001
2011	0%	0	0	0.01	5.8	0.000	0.001
2012	0%	0	0	0.88	279	0.001	0.04
2013	0%	0	0	0.74	266	0.000	0.04
2014	0%	0	0	0.74	291	0.001	0.05
2015	0%	0	0	1.4	569	0.001	0.09
2016	0%	0	0	1.2	514	0.001	0.08
2017	0%	0	0	1.2	537	0.001	0.08
2018	0%	0	0	0.58	238	0.001	0.04
2019	0%	0	0	0.69	284	0.001	0.04
2020	0%	0	0	0.83	339	0.001	0.05
2021	0%	0	0	1.0	350	0.001	0.06
2022	0%	0	0	1.2	440	0.001	0.07
2023	0%	0	0	1.5	550	0.001	0.09
2024	0%	0	0	1.7	576	0.002	0.09
2025	0%	0	0	2.0	676	0.002	0.11
2026	0%	0	0	2.4	794	0.002	0.12
2027	0%	0	0	2.8	872	0.003	0.14
2028	0%	0	0	3.2	1,001	0.003	0.16
2029	0%	0	0	3.8	1,166	0.004	0.18
2030	0%	0	0	4.4	1,359	0.004	0.21
2045	0%	0	0	5.4	1,661	0.005	0.26
2032	0%	0	0	6.5	2,006	0.006	0.32
2033	0%	0	0	7.6	2,358	0.007	0.37
2034	0%	0	0	9.0	2,802	0.008	0.44
2035	0%	0	0	10	3,274	0.010	0.51
2036	0%	0	0	12	3,762	0.01	0.59
2037	0%	0	0	13	4,272	0.01	0.67
2038	0%	0	0	14	4,724	0.01	0.74
2039	0%	0	0	14	5,157	0.01	0.81
2040	0%	0	0	14	5,193	0.01	0.82
2041	0%	0	0	13	5,312	0.01	0.83
2042	0%	0	0	11	4,974	0.01	0.78
2043	0%	0	0	10	4,789	0.01	0.75
2044	0%	0	0	9.0	4,590	0.01	0.72
2045	0%	0	0	5.0	2,768	0.007	0.44
2046	0%	0	0	1.7	741	0.004	0.12

Notes:

[1] EMFAC data shown here are obtained directly from EMFAC2017.

[2] Fleet mix percentages in this scenario are obtained directly from EMFAC2017.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the EMFAC data.

[4] Energy consumption is calculated based on EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are obtained directly from EMFAC2017 in this scenario.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	82	0.03	4.1	0.000	0.001	0.37	100%	82	49,174
2007	132	0.04	6.6	0.000	0.001	0.59	100%	132	79,672
2008	156	0.04	7.6	0.000	0.001	0.68	100%	156	90,995
2009	181	0.04	8.9	0.000	0.001	0.79	100%	181	106,208
2010	90	0.02	4.4	0.000	0.001	0.39	100%	90	52,143
2011	106	0.01	4.8	0.000	0.001	0.43	100%	106	57,864
2012	1,478	0.33	101	0.000	0.02	9.0	100%	1,478	1,207,021
2013	750	0.28	99	0.000	0.02	8.9	100%	750	1,192,404
2014	777	0.30	115	0.000	0.02	10	100%	777	1,374,836
2015	1,536	0.62	252	0.000	0.04	22	100%	1,536	3,021,320
2016	1,630	0.59	241	0.001	0.04	21	100%	1,630	2,889,636
2017	2,386	0.59	251	0.001	0.04	22	100%	2,386	3,002,314
2018	887	0.29	116	0.000	0.02	10	100%	887	1,390,448
2019	1,087	0.35	139	0.000	0.02	12	100%	1,087	1,669,054
2020	1,265	0.41	166	0.000	0.03	15	100%	1,265	1,987,822
2021	1,465	0.48	169	0.000	0.03	15	100%	1,465	2,020,660
2022	1,760	0.59	209	0.001	0.03	19	100%	1,760	2,502,994
2023	2,161	0.73	259	0.001	0.04	23	100%	2,161	3,102,175
2024	2,493	0.83	270	0.001	0.04	24	100%	2,493	3,239,609
2025	2,909	1.0	317	0.001	0.05	28	100%	2,909	3,802,943
2026	3,483	1.1	378	0.001	0.06	34	100%	3,483	4,525,444
2027	4,089	1.3	422	0.001	0.07	38	100%	4,089	5,058,290
2028	4,861	1.6	505	0.001	0.08	45	100%	4,861	6,057,599
2029	5,793	1.9	607	0.002	0.10	54	100%	5,793	7,272,512
2030	6,787	2.3	713	0.002	0.11	64	100%	6,787	8,549,670
2050	7,893	2.7	837	0.002	0.13	75	100%	7,893	10,032,270
2032	9,119	3.1	976	0.003	0.15	87	100%	9,119	11,701,451
2033	10,570	3.6	1,130	0.003	0.18	101	100%	10,570	13,541,512
2034	12,402	4.3	1,331	0.004	0.21	119	100%	12,402	15,952,622
2035	14,345	5.1	1,555	0.005	0.24	139	100%	14,345	18,633,374
2036	16,120	6.1	1,885	0.006	0.30	168	100%	16,120	22,588,671
2037	17,993	7.2	2,237	0.007	0.35	199	100%	17,993	26,803,159
2038	19,907	8.4	2,593	0.008	0.41	231	100%	19,907	31,070,008
2039	22,021	10	3,013	0.009	0.47	269	100%	22,021	36,113,252
2040	24,085	11	3,476	0.01	0.55	310	100%	24,085	41,659,449
2041	26,029	12	3,991	0.01	0.63	356	100%	26,029	47,825,120
2042	27,606	14	4,519	0.01	0.71	403	100%	27,606	54,152,315
2043	28,488	15	4,980	0.01	0.78	444	100%	28,488	59,679,625
2044	28,931	15	5,411	0.02	0.85	482	100%	28,931	64,850,659
2045	27,286	14	5,420	0.02	0.85	483	100%	27,286	64,956,609
2046	26,307	14	5,542	0.01	0.87	494	100%	26,307	66,420,856
2047	23,687	12	5,184	0.01	0.81	462	100%	23,687	62,130,013
2048	22,283	11	5,001	0.01	0.79	446	100%	22,283	59,930,609
2049	21,009	9.4	4,781	0.01	0.75	426	100%	21,009	57,302,967
2050	13,154	5.2	2,874	0.007	0.45	256	100%	13,154	34,442,748
2051	6,775	1.8	1,178	0.004	0.19	105	100%	6,775	14,114,877

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	0%	0	0	0%	0	0	0%	0	0
2025	0%	0	0	0%	0	0	0%	0	0
2026	0%	0	0	0%	0	0	0%	0	0
2027	0%	0	0	0%	0	0	0%	0	0
2028	0%	0	0	0%	0	0	0%	0	0
2029	0%	0	0	0%	0	0	0%	0	0
2030	0%	0	0	0%	0	0	0%	0	0
2050	0%	0	0	0%	0	0	0%	0	0
2032	0%	0	0	0%	0	0	0%	0	0
2033	0%	0	0	0%	0	0	0%	0	0
2034	0%	0	0	0%	0	0	0%	0	0
2035	0%	0	0	0%	0	0	0%	0	0
2036	0%	0	0	0%	0	0	0%	0	0
2037	0%	0	0	0%	0	0	0%	0	0
2038	0%	0	0	0%	0	0	0%	0	0
2039	0%	0	0	0%	0	0	0%	0	0
2040	0%	0	0	0%	0	0	0%	0	0
2041	0%	0	0	0%	0	0	0%	0	0
2042	0%	0	0	0%	0	0	0%	0	0
2043	0%	0	0	0%	0	0	0%	0	0
2044	0%	0	0	0%	0	0	0%	0	0
2045	0%	0	0	0%	0	0	0%	0	0
2046	0%	0	0	0%	0	0	0%	0	0
2047	0%	0	0	0%	0	0	0%	0	0
2048	0%	0	0	0%	0	0	0%	0	0
2049	0%	0	0	0%	0	0	0%	0	0
2050	0%	0	0	0%	0	0	0%	0	0
2051	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV Fleet Mix[2] (%)	BEV Population[3]	BEV Energy Consumption[4] (MJ/day)	Tailpipe Emission Estimates[5] (tons/day) NO_X	CO_2	CH_4	N_2O
2006	0%	0	0	0.03	4.1	0.000	0.001
2007	0%	0	0	0.04	6.6	0.000	0.001
2008	0%	0	0	0.04	7.6	0.000	0.001
2009	0%	0	0	0.04	8.9	0.000	0.001
2010	0%	0	0	0.02	4.4	0.000	0.001
2011	0%	0	0	0.01	4.8	0.000	0.001
2012	0%	0	0	0.33	101	0.000	0.02
2013	0%	0	0	0.28	99	0.000	0.02
2014	0%	0	0	0.30	115	0.000	0.02
2015	0%	0	0	0.62	252	0.000	0.04
2016	0%	0	0	0.59	241	0.001	0.04
2017	0%	0	0	0.59	251	0.001	0.04
2018	0%	0	0	0.29	116	0.000	0.02
2019	0%	0	0	0.35	139	0.000	0.02
2020	0%	0	0	0.41	166	0.000	0.03
2021	0%	0	0	0.48	169	0.000	0.03
2022	0%	0	0	0.59	209	0.001	0.03
2023	0%	0	0	0.73	259	0.001	0.04
2024	0%	0	0	0.83	270	0.001	0.04
2025	0%	0	0	1.0	317	0.001	0.05
2026	0%	0	0	1.1	378	0.001	0.06
2027	0%	0	0	1.3	422	0.001	0.07
2028	0%	0	0	1.6	505	0.001	0.08
2029	0%	0	0	1.9	607	0.002	0.10
2030	0%	0	0	2.3	713	0.002	0.11
2050	0%	0	0	2.7	837	0.002	0.13
2032	0%	0	0	3.1	976	0.003	0.15
2033	0%	0	0	3.6	1,130	0.003	0.18
2034	0%	0	0	4.3	1,331	0.004	0.21
2035	0%	0	0	5.1	1,555	0.005	0.24
2036	0%	0	0	6.1	1,885	0.006	0.30
2037	0%	0	0	7.2	2,237	0.007	0.35
2038	0%	0	0	8.4	2,593	0.008	0.41
2039	0%	0	0	10	3,013	0.009	0.47
2040	0%	0	0	11	3,476	0.01	0.55
2041	0%	0	0	12	3,991	0.01	0.63
2042	0%	0	0	14	4,519	0.01	0.71
2043	0%	0	0	15	4,980	0.01	0.78
2044	0%	0	0	15	5,411	0.02	0.85
2045	0%	0	0	14	5,420	0.02	0.85
2046	0%	0	0	14	5,542	0.01	0.87
2047	0%	0	0	12	5,184	0.01	0.81
2048	0%	0	0	11	5,001	0.01	0.79
2049	0%	0	0	9.4	4,781	0.01	0.75
2050	0%	0	0	5.2	2,874	0.007	0.45
2051	0%	0	0	1.8	1,178	0.004	0.19

Notes:

[1] EMFAC data shown here are obtained directly from EMFAC2017.

[2] Fleet mix percentages in this scenario are obtained directly from EMFAC2017.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the EMFAC data.

[4] Energy consumption is calculated based on EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are obtained directly from EMFAC2017 in this scenario.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	100%	12,688	44,579,225
2019	12,851	5.6	3,844	0.007	0.60	343	100%	12,851	46,069,473
2020	8,537	3.3	2,461	0.004	0.39	219	100%	8,537	29,496,897
2021	4,246	1.1	575	0.002	0.09	51	100%	4,246	6,891,960

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**NO_X**	**CO_2**	**CH_4**	**N_2O**
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	5.9	3,720	0.007	0.58
2019	0%	0	0	5.6	3,844	0.007	0.60
2020	0%	0	0	3.3	2,461	0.004	0.39
2021	0%	0	0	1.1	575	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	100%	15,699	46,494,284
2019	15,755	7.5	4,119	0.008	0.65	367	100%	15,755	49,364,115
2020	14,758	7.0	4,076	0.008	0.64	363	100%	14,758	48,851,177
2021	13,866	6.3	3,442	0.008	0.54	307	100%	13,866	41,250,943
2022	13,999	6.1	3,590	0.008	0.56	320	100%	13,999	43,027,237
2023	9,671	3.7	2,395	0.005	0.38	213	100%	9,671	28,707,076
2024	4,843	1.3	599	0.003	0.09	53	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	484	717,286	25%	1,211	1,793,216	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	7.6	3,880	0.008	0.61
2019	0%	0	0	7.5	4,119	0.008	0.65
2020	0%	0	0	7.0	4,076	0.008	0.64
2021	0%	0	0	6.3	3,442	0.008	0.54
2022	0%	0	0	6.1	3,590	0.008	0.56
2023	0%	0	0	3.7	2,395	0.005	0.38
2024	65%	3,148	1,539,490	0.11	209	0.001	0.03

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	166	0.09	8.9	0.000	0.001	0.79	100%	166	106,532
1988	223	0.13	12	0.000	0.002	1.1	100%	223	144,024
1989	279	0.16	15	0.000	0.002	1.3	100%	279	179,202
1990	256	0.15	14	0.000	0.002	1.3	100%	256	168,297
1991	221	0.14	11	0.000	0.002	1.0	100%	221	134,880
1992	173	0.11	9.2	0.000	0.001	0.82	100%	173	110,429
1993	132	0.09	7.5	0.000	0.001	0.67	100%	132	90,308
1994	131	0.08	7.6	0.000	0.001	0.68	100%	131	91,104
1995	161	0.11	10	0.000	0.002	0.87	100%	161	116,335
1996	159	0.11	10	0.000	0.002	0.85	100%	159	114,485
1997	155	0.10	9.1	0.000	0.001	0.81	100%	155	108,509
1998	145	0.10	10	0.000	0.001	0.85	100%	145	114,337
1999	197	0.17	13	0.000	0.002	1.2	100%	197	160,607
2000	233	0.20	16	0.000	0.002	1.4	100%	233	188,016
2001	267	0.20	16	0.000	0.003	1.4	100%	267	193,494
2002	300	0.21	17	0.000	0.003	1.5	100%	300	200,551
2003	272	0.13	17	0.000	0.003	1.5	100%	272	200,037
2004	276	0.12	17	0.000	0.003	1.5	100%	276	198,929
2005	353	0.15	22	0.000	0.003	1.9	100%	353	259,740
2006	403	0.18	25	0.000	0.004	2.3	100%	403	303,073
2007	543	0.22	35	0.000	0.006	3.1	100%	543	422,431
2008	564	0.14	29	0.000	0.005	2.6	100%	564	352,228
2009	654	0.15	34	0.000	0.005	3.1	100%	654	410,832
2010	337	0.07	18	0.000	0.003	1.6	100%	337	211,381
2011	419	0.05	21	0.000	0.003	1.9	100%	419	253,413
2012	18,775	6.3	2,125	0.004	0.33	189	100%	18,775	25,469,698
2013	10,866	5.2	1,931	0.003	0.30	172	100%	10,866	23,141,590
2014	12,373	4.9	1,993	0.004	0.31	178	100%	12,373	23,884,682
2015	22,601	8.0	3,471	0.007	0.55	309	100%	22,601	41,601,211
2016	25,559	9.1	3,866	0.010	0.61	345	100%	25,559	46,327,589
2017	29,560	9.2	4,023	0.009	0.63	359	100%	29,560	48,215,934
2018	10,153	3.8	1,588	0.004	0.25	142	100%	10,153	19,030,587
2019	11,512	4.5	1,861	0.004	0.29	166	100%	11,512	22,305,607
2020	13,043	5.4	2,255	0.005	0.35	201	100%	13,043	27,025,846
2021	14,295	6.2	2,272	0.006	0.36	203	100%	14,295	27,231,919
2022	16,417	7.5	2,835	0.007	0.45	253	100%	16,417	33,979,835
2023	22,059	12	4,261	0.010	0.67	380	100%	22,059	51,063,434
2024	21,715	11	3,988	0.01	0.63	355	0%	0	0
2025	22,619	12	4,524	0.01	0.71	403	0%	0	0
2026	22,104	12	4,758	0.01	0.75	424	0%	0	0
2027	21,594	11	4,671	0.01	0.73	416	0%	0	0
2028	19,744	10	4,452	0.01	0.70	397	0%	0	0
2029	18,560	9.0	4,281	0.01	0.67	382	0%	0	0
2030	17,915	8.2	4,205	0.01	0.66	375	0%	0	0
2031	11,497	4.6	2,590	0.006	0.41	231	0%	0	0
2032	5,864	1.6	694	0.003	0.11	62	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	2,171	4,779,835	25%	5,429	11,949,588	0%	0	0
2025	10%	2,262	5,421,301	30%	6,786	16,263,902	0%	0	0
2026	10%	2,210	5,702,550	35%	7,736	19,958,924	0%	0	0
2027	15%	3,239	8,396,467	35%	7,558	19,591,756	0%	0	0
2028	15%	2,962	8,002,355	40%	7,898	21,339,614	0%	0	0
2029	20%	3,712	10,260,841	45%	8,352	23,086,893	0%	0	0
2030	20%	3,583	10,079,515	50%	8,958	25,198,789	0%	0	0
2031	20%	2,299	6,209,013	45%	5,174	13,970,280	0%	0	0
2032	10%	586	831,861	40%	2,345	3,327,443	0%	0	0

Model Year	BEV Fleet Mix[2] (%)	BEV Population[3]	BEV Energy Consumption[4] (MJ/day)	Tailpipe Emission Estimates[5] (tons/day) NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.09	8.9	0.000	0.001
1988	0%	0	0	0.13	12	0.000	0.002
1989	0%	0	0	0.16	15	0.000	0.002
1990	0%	0	0	0.15	14	0.000	0.002
1991	0%	0	0	0.14	11	0.000	0.002
1992	0%	0	0	0.11	9.2	0.000	0.001
1993	0%	0	0	0.09	7.5	0.000	0.001
1994	0%	0	0	0.08	7.6	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.10	9.1	0.000	0.001
1998	0%	0	0	0.10	10	0.000	0.001
1999	0%	0	0	0.17	13	0.000	0.002
2000	0%	0	0	0.20	16	0.000	0.002
2001	0%	0	0	0.20	16	0.000	0.003
2002	0%	0	0	0.21	17	0.000	0.003
2003	0%	0	0	0.13	17	0.000	0.003
2004	0%	0	0	0.12	17	0.000	0.003
2005	0%	0	0	0.15	22	0.000	0.003
2006	0%	0	0	0.18	25	0.000	0.004
2007	0%	0	0	0.22	35	0.000	0.006
2008	0%	0	0	0.14	29	0.000	0.005
2009	0%	0	0	0.15	34	0.000	0.005
2010	0%	0	0	0.07	18	0.000	0.003
2011	0%	0	0	0.05	21	0.000	0.003
2012	0%	0	0	6.3	2,125	0.004	0.33
2013	0%	0	0	5.2	1,931	0.003	0.30
2014	0%	0	0	4.9	1,993	0.004	0.31
2015	0%	0	0	8.0	3,471	0.007	0.55
2016	0%	0	0	9.1	3,866	0.010	0.61
2017	0%	0	0	9.2	4,023	0.009	0.63
2018	0%	0	0	3.8	1,588	0.004	0.25
2019	0%	0	0	4.5	1,861	0.004	0.29
2020	0%	0	0	5.4	2,255	0.005	0.35
2021	0%	0	0	6.2	2,272	0.006	0.36
2022	0%	0	0	7.5	2,835	0.007	0.45
2023	0%	0	0	12	4,261	0.010	0.67
2024	65%	14,114	10,258,817	1.0	1,396	0.004	0.22
2025	60%	13,572	10,740,531	1.2	1,809	0.005	0.28
2026	55%	12,157	10,356,256	1.3	2,141	0.006	0.34
2027	50%	10,797	9,241,582	1.4	2,335	0.006	0.37
2028	45%	8,885	7,927,023	1.4	2,448	0.006	0.38
2029	35%	6,496	5,929,144	1.5	2,783	0.007	0.44
2030	30%	5,375	4,992,314	1.4	2,944	0.007	0.46
2031	35%	4,024	3,587,828	0.75	1,684	0.004	0.26
2032	50%	2,932	1,373,383	0.19	347	0.002	0.05

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Table A-11. NOx and GHG Tailpipe Emissions for Scenario 1 in Calendar Year 2037

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	66	0.04	3.5	0.000	0.001	0.31	100%	66	42,043
1994	83	0.05	4.2	0.000	0.001	0.38	100%	83	50,721
1995	115	0.07	5.9	0.000	0.001	0.53	100%	115	70,970
1996	119	0.07	6.1	0.000	0.001	0.54	100%	119	72,842
1997	117	0.06	5.9	0.000	0.001	0.52	100%	117	70,488
1998	104	0.06	5.7	0.000	0.001	0.50	100%	104	67,898
1999	133	0.10	7.6	0.000	0.001	0.67	100%	133	90,610
2000	147	0.11	8.5	0.000	0.001	0.76	100%	147	101,850
2001	161	0.11	8.8	0.000	0.001	0.79	100%	161	105,603
2002	172	0.11	9.0	0.000	0.001	0.80	100%	172	107,968
2003	146	0.06	8.3	0.000	0.001	0.74	100%	146	99,226
2004	143	0.06	8.1	0.000	0.001	0.72	100%	143	96,731
2005	178	0.07	10	0.000	0.002	0.92	100%	178	123,640
2006	202	0.09	12	0.000	0.002	1.1	100%	202	143,033
2007	272	0.11	17	0.000	0.003	1.5	100%	272	200,277
2008	292	0.07	15	0.000	0.002	1.3	100%	292	179,211
2009	346	0.08	18	0.000	0.003	1.6	100%	346	213,122
2010	183	0.04	9.3	0.000	0.001	0.83	100%	183	111,727
2011	234	0.03	11	0.000	0.002	1.0	100%	234	136,809
2012	7,969	2.4	804	0.002	0.13	72	100%	7,969	9,641,296
2013	4,340	2.0	750	0.001	0.12	67	100%	4,340	8,984,556
2014	4,954	2.0	817	0.001	0.13	73	100%	4,954	9,795,650
2015	9,674	3.7	1,601	0.003	0.25	143	100%	9,674	19,190,427
2016	10,519	3.7	1,604	0.004	0.25	143	100%	10,519	19,227,562
2017	14,184	3.9	1,723	0.004	0.27	154	100%	14,184	20,654,585
2018	4,924	1.7	692	0.002	0.11	62	100%	4,924	8,290,062
2019	5,803	1.9	807	0.002	0.13	72	100%	5,803	9,667,889
2020	6,713	2.3	945	0.002	0.15	84	100%	6,713	11,329,480
2021	7,708	2.6	942	0.003	0.15	84	100%	7,708	11,285,971
2022	9,361	3.4	1,197	0.003	0.19	107	100%	9,361	14,344,235
2023	12,311	5.2	1,799	0.004	0.28	160	100%	12,311	21,557,339
2024	14,157	5.5	1,804	0.005	0.28	161	0%	0	0
2025	15,781	6.4	2,112	0.006	0.33	188	0%	0	0
2026	17,659	7.5	2,484	0.007	0.39	221	0%	0	0
2027	19,532	8.7	2,768	0.008	0.44	247	0%	0	0
2028	21,365	10	3,236	0.010	0.51	288	0%	0	0
2029	22,985	11	3,748	0.01	0.59	334	0%	0	0
2030	24,081	12	4,213	0.01	0.66	375	0%	0	0
2037	24,791	13	4,671	0.01	0.73	416	0%	0	0
2032	24,114	13	4,857	0.01	0.76	433	0%	0	0
2033	23,670	12	5,060	0.01	0.80	451	0%	0	0
2034	21,948	11	4,883	0.01	0.77	435	0%	0	0
2035	20,791	10	4,742	0.01	0.75	423	0%	0	0
2036	19,699	9.0	4,573	0.01	0.72	408	0%	0	0
2037	12,409	5.0	2,773	0.007	0.44	247	0%	0	0
2038	6,391	1.7	743	0.003	0.12	66	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	1,416	2,161,542	25%	3,539	5,403,855	0%	0	0
2025	10%	1,578	2,531,043	30%	4,734	7,593,128	0%	0	0
2026	10%	1,766	2,977,192	35%	6,181	10,420,173	0%	0	0
2027	15%	2,930	4,975,264	35%	6,836	11,608,949	0%	0	0
2028	15%	3,205	5,817,346	40%	8,546	15,512,922	0%	0	0
2029	20%	4,597	8,983,030	45%	10,343	20,211,817	0%	0	0
2030	20%	4,816	10,097,767	50%	12,040	25,244,417	0%	0	0
2037	12%	2,975	6,717,948	5%	1,240	2,799,145	0%	0	0
2032	10%	2,411	5,821,019	40%	9,646	23,284,077	0%	0	0
2033	10%	2,367	6,063,891	35%	8,285	21,223,618	0%	0	0
2034	10%	2,195	5,851,702	30%	6,585	17,555,106	0%	0	0
2035	12%	2,495	6,819,958	5%	1,040	2,841,649	0%	0	0
2036	12%	2,364	6,576,732	5%	985	2,740,305	0%	0	0
2037	12%	1,489	3,988,015	5%	620	1,661,673	0%	0	0
2038	12%	767	1,068,563	5%	320	445,235	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1993	0%	0	0	0.04	3.5	0.000	0.001
1994	0%	0	0	0.05	4.2	0.000	0.001
1995	0%	0	0	0.07	5.9	0.000	0.001
1996	0%	0	0	0.07	6.1	0.000	0.001
1997	0%	0	0	0.06	5.9	0.000	0.001
1998	0%	0	0	0.06	5.7	0.000	0.001
1999	0%	0	0	0.10	7.6	0.000	0.001
2000	0%	0	0	0.11	8.5	0.000	0.001
2001	0%	0	0	0.11	8.8	0.000	0.001
2002	0%	0	0	0.11	9.0	0.000	0.001
2003	0%	0	0	0.06	8.3	0.000	0.001
2004	0%	0	0	0.06	8.1	0.000	0.001
2005	0%	0	0	0.07	10	0.000	0.002
2006	0%	0	0	0.09	12	0.000	0.002
2007	0%	0	0	0.11	17	0.000	0.003
2008	0%	0	0	0.07	15	0.000	0.002
2009	0%	0	0	0.08	18	0.000	0.003
2010	0%	0	0	0.04	9.3	0.000	0.001
2011	0%	0	0	0.03	11	0.000	0.002
2012	0%	0	0	2.4	804	0.002	0.13
2013	0%	0	0	2.0	750	0.001	0.12
2014	0%	0	0	2.0	817	0.001	0.13
2015	0%	0	0	3.7	1,601	0.003	0.25
2016	0%	0	0	3.7	1,604	0.004	0.25
2017	0%	0	0	3.9	1,723	0.004	0.27
2018	0%	0	0	1.7	692	0.002	0.11
2019	0%	0	0	1.9	807	0.002	0.13
2020	0%	0	0	2.3	945	0.002	0.15
2021	0%	0	0	2.6	942	0.003	0.15
2022	0%	0	0	3.4	1,197	0.003	0.19
2023	0%	0	0	5.2	1,799	0.004	0.28
2024	65%	9,202	4,639,253	0.48	631	0.002	0.10
2025	60%	9,469	5,014,432	0.64	845	0.002	0.13
2026	55%	9,712	5,406,804	0.85	1,118	0.003	0.18
2027	50%	9,766	5,476,031	1.1	1,384	0.004	0.22
2028	45%	9,614	5,762,582	1.4	1,780	0.005	0.28
2029	35%	8,045	5,190,771	1.8	2,436	0.007	0.38
2030	30%	7,224	5,001,354	2.1	2,949	0.008	0.46
2037	83%	20,577	15,342,795	0.55	794	0.002	0.12
2032	50%	12,057	9,610,369	1.6	2,429	0.007	0.38
2033	55%	13,019	11,012,479	1.4	2,277	0.006	0.36
2034	60%	13,169	11,593,231	1.1	1,953	0.005	0.31
2035	83%	17,257	15,575,770	0.43	806	0.002	0.13
2036	83%	16,350	15,020,279	0.38	777	0.002	0.12
2037	83%	10,300	9,108,035	0.21	471	0.001	0.07
2038	83%	5,305	2,440,439	0.07	126	0.001	0.02

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0	0	0	0	0	0	0%	0	0
2002	0	0	0	0	0	0	0%	0	0
2003	0	0	0	0	0	0	0%	0	0
2004	0	0	0	0	0	0	0%	0	0
2005	0	0	0	0	0	0	0%	0	0
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	5,738	1.9	631	0.002	0.10	56	0%	0	0
2025	6,682	2.2	740	0.002	0.12	66	0%	0	0
2026	7,830	2.6	869	0.002	0.14	77	0%	0	0
2027	8,960	3.0	954	0.003	0.15	85	0%	0	0
2028	10,297	3.5	1,096	0.003	0.17	98	0%	0	0
2029	11,921	4.1	1,276	0.004	0.20	114	0%	0	0
2030	13,807	4.8	1,488	0.005	0.23	133	0%	0	0
2045	15,655	5.9	1,819	0.006	0.29	162	0%	0	0
2032	17,813	7.1	2,196	0.007	0.35	196	0%	0	0
2033	20,003	8.3	2,581	0.008	0.41	230	0%	0	0
2034	22,623	10	3,067	0.009	0.48	273	0%	0	0
2035	24,976	11	3,584	0.01	0.56	319	0%	0	0
2036	26,967	13	4,118	0.01	0.65	367	0%	0	0
2037	28,599	14	4,677	0.01	0.74	417	0%	0	0
2038	29,556	15	5,172	0.01	0.81	461	0%	0	0
2039	30,085	16	5,646	0.02	0.89	503	0%	0	0
2040	28,520	15	5,685	0.02	0.89	507	0%	0	0
2041	27,485	14	5,816	0.02	0.91	518	0%	0	0
2042	24,780	12	5,446	0.01	0.86	485	0%	0	0
2043	23,286	11	5,243	0.01	0.82	467	0%	0	0
2044	22,012	10	5,025	0.01	0.79	448	0%	0	0
2045	13,831	5.5	3,030	0.007	0.48	270	0%	0	0
2046	7,111	1.9	812	0.004	0.13	72	0%	0	0

Table A-12. NOx and GHG Tailpipe Emissions for Scenario 1 in Calendar Year 2045
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	574	756,340	25%	1,434	1,890,850	0%	0	0
2025	10%	668	886,781	30%	2,005	2,660,344	0%	0	0
2026	10%	783	1,041,761	35%	2,741	3,646,164	0%	0	0
2027	15%	1,344	1,715,605	35%	3,136	4,003,078	0%	0	0
2028	15%	1,544	1,969,828	40%	4,119	5,252,875	0%	0	0
2029	20%	2,384	3,059,507	45%	5,364	6,883,890	0%	0	0
2030	20%	2,761	3,566,433	50%	6,903	8,916,082	0%	0	0
2045	12%	1,879	2,615,706	5%	783	1,089,877	0%	0	0
2032	10%	1,781	2,631,722	40%	7,125	10,526,888	0%	0	0
2033	10%	2,000	3,093,484	35%	7,001	10,827,195	0%	0	0
2034	10%	2,262	3,676,051	30%	6,787	11,028,154	0%	0	0
2035	12%	2,997	5,154,227	5%	1,249	2,147,595	0%	0	0
2036	12%	3,236	5,922,773	5%	1,348	2,467,822	0%	0	0
2037	12%	3,432	6,725,482	5%	1,430	2,802,284	0%	0	0
2038	12%	3,547	7,438,400	5%	1,478	3,099,333	0%	0	0
2039	12%	3,610	8,118,998	5%	1,504	3,382,916	0%	0	0
2040	12%	3,422	8,176,299	5%	1,426	3,406,791	0%	0	0
2041	12%	3,298	8,363,731	5%	1,374	3,484,888	0%	0	0
2042	12%	2,974	7,831,788	5%	1,239	3,263,245	0%	0	0
2043	12%	2,794	7,539,421	5%	1,164	3,141,425	0%	0	0
2044	12%	2,641	7,227,079	5%	1,101	3,011,283	0%	0	0
2045	12%	1,660	4,357,601	5%	692	1,815,667	0%	0	0
2046	12%	853	1,167,185	5%	356	486,327	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2001	0%	0	0	0	0	0	0
2002	0%	0	0	0	0	0	0
2003	0%	0	0	0	0	0	0
2004	0%	0	0	0	0	0	0
2005	0%	0	0	0	0	0	0
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	65%	3,730	1,623,310	0.17	221	0.001	0.03
2025	60%	4,009	1,756,867	0.22	296	0.001	0.05
2026	55%	4,307	1,891,916	0.30	391	0.001	0.06
2027	50%	4,480	1,888,283	0.38	477	0.001	0.08
2028	45%	4,633	1,951,285	0.48	603	0.002	0.09
2029	35%	4,172	1,767,911	0.67	830	0.003	0.13
2030	30%	4,142	1,766,430	0.85	1,042	0.003	0.16
2045	83%	12,994	5,973,883	0.25	309	0.001	0.05
2032	50%	8,906	4,344,912	0.89	1,098	0.003	0.17
2033	55%	11,002	5,617,998	0.94	1,162	0.003	0.18
2034	60%	13,574	7,282,892	1.0	1,227	0.004	0.19
2035	83%	20,730	11,771,489	0.48	609	0.002	0.10
2036	83%	22,383	13,526,734	0.54	700	0.002	0.11
2037	83%	23,737	15,360,002	0.60	795	0.002	0.12
2038	83%	24,531	16,988,202	0.64	879	0.002	0.14
2039	83%	24,971	18,542,585	0.66	960	0.003	0.15
2040	83%	23,671	18,673,453	0.63	967	0.003	0.15
2041	83%	22,813	19,101,520	0.60	989	0.003	0.16
2042	83%	20,568	17,886,641	0.53	926	0.002	0.15
2043	83%	19,327	17,218,918	0.47	891	0.002	0.14
2044	83%	18,270	16,505,576	0.42	854	0.002	0.13
2045	83%	11,480	9,952,115	0.23	515	0.001	0.08
2046	83%	5,902	2,665,677	0.08	138	0.001	0.02

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	2,595	0.86	281	0.001	0.04	25	0%	0	0
2025	3,028	1.0	330	0.001	0.05	29	0%	0	0
2026	3,626	1.2	393	0.001	0.06	35	0%	0	0
2027	4,257	1.4	439	0.001	0.07	39	0%	0	0
2028	5,060	1.7	526	0.001	0.08	47	0%	0	0
2029	6,031	2.0	632	0.002	0.10	56	0%	0	0
2030	7,066	2.4	743	0.002	0.12	66	0%	0	0
2050	8,217	2.8	872	0.003	0.14	78	0%	0	0
2032	9,494	3.2	1,017	0.003	0.16	91	0%	0	0
2033	11,004	3.8	1,176	0.004	0.18	105	0%	0	0
2034	12,911	4.5	1,386	0.004	0.22	124	0%	0	0
2035	14,935	5.3	1,619	0.005	0.25	144	0%	0	0
2036	16,783	6.4	1,962	0.006	0.31	175	0%	0	0
2037	18,732	7.5	2,328	0.007	0.37	208	0%	0	0
2038	20,725	8.7	2,699	0.008	0.42	241	0%	0	0
2039	22,925	10	3,137	0.009	0.49	280	0%	0	0
2040	25,074	11	3,619	0.01	0.57	323	0%	0	0
2041	27,099	13	4,155	0.01	0.65	370	0%	0	0
2042	28,740	14	4,704	0.01	0.74	419	0%	0	0
2043	29,658	15	5,184	0.01	0.81	462	0%	0	0
2044	30,119	16	5,634	0.02	0.89	502	0%	0	0
2045	28,407	15	5,643	0.02	0.89	503	0%	0	0
2046	27,387	14	5,770	0.02	0.91	514	0%	0	0
2047	24,660	12	5,397	0.01	0.85	481	0%	0	0
2048	23,198	11	5,206	0.01	0.82	464	0%	0	0
2049	21,872	10	4,978	0.01	0.78	444	0%	0	0
2050	13,695	5.4	2,992	0.007	0.47	267	0%	0	0
2051	7,053	1.8	1,226	0.004	0.19	109	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	260	337,270	25%	649	843,175	0%	0	0
2025	10%	303	395,918	30%	908	1,187,754	0%	0	0
2026	10%	363	471,136	35%	1,269	1,648,977	0%	0	0
2027	15%	639	789,915	35%	1,490	1,843,135	0%	0	0
2028	15%	759	945,969	40%	2,024	2,522,585	0%	0	0
2029	20%	1,206	1,514,257	45%	2,714	3,407,079	0%	0	0
2030	20%	1,413	1,780,183	50%	3,533	4,450,457	0%	0	0
2050	12%	986	1,253,331	5%	411	522,221	0%	0	0
2032	10%	949	1,218,218	40%	3,797	4,872,872	0%	0	0
2033	10%	1,100	1,409,784	35%	3,851	4,934,242	0%	0	0
2034	10%	1,291	1,660,800	30%	3,873	4,982,400	0%	0	0
2035	12%	1,792	2,327,866	5%	747	969,944	0%	0	0
2036	12%	2,014	2,822,001	5%	839	1,175,834	0%	0	0
2037	12%	2,248	3,348,517	5%	937	1,395,215	0%	0	0
2038	12%	2,487	3,881,574	5%	1,036	1,617,323	0%	0	0
2039	12%	2,751	4,511,626	5%	1,146	1,879,844	0%	0	0
2040	12%	3,009	5,204,512	5%	1,254	2,168,547	0%	0	0
2041	12%	3,252	5,974,789	5%	1,355	2,489,495	0%	0	0
2042	12%	3,449	6,765,245	5%	1,437	2,818,852	0%	0	0
2043	12%	3,559	7,455,772	5%	1,483	3,106,572	0%	0	0
2044	12%	3,614	8,101,789	5%	1,506	3,375,745	0%	0	0
2045	12%	3,409	8,115,025	5%	1,420	3,381,260	0%	0	0
2046	12%	3,286	8,297,953	5%	1,369	3,457,480	0%	0	0
2047	12%	2,959	7,761,898	5%	1,233	3,234,124	0%	0	0
2048	12%	2,784	7,487,127	5%	1,160	3,119,636	0%	0	0
2049	12%	2,625	7,158,856	5%	1,094	2,982,857	0%	0	0
2050	12%	1,643	4,302,930	5%	685	1,792,888	0%	0	0
2051	12%	846	1,763,371	5%	353	734,738	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	65%	1,687	723,873	0.08	98	0.000	0.02
2025	60%	1,817	784,381	0.10	132	0.000	0.02
2026	55%	1,994	855,619	0.13	177	0.000	0.03
2027	50%	2,128	869,421	0.18	220	0.001	0.03
2028	45%	2,277	937,064	0.23	289	0.001	0.05
2029	35%	2,111	875,001	0.33	411	0.001	0.06
2030	30%	2,120	881,712	0.41	520	0.001	0.08
2050	83%	6,820	2,862,421	0.12	148	0.000	0.02
2032	50%	4,747	2,011,250	0.40	508	0.001	0.08
2033	55%	6,052	2,560,272	0.42	529	0.002	0.08
2034	60%	7,747	3,290,331	0.45	554	0.002	0.09
2035	83%	12,396	5,316,501	0.22	275	0.001	0.04
2036	83%	13,929	6,445,032	0.27	334	0.001	0.05
2037	83%	15,547	7,647,515	0.32	396	0.001	0.06
2038	83%	17,202	8,864,939	0.37	459	0.001	0.07
2039	83%	19,028	10,303,884	0.43	533	0.002	0.08
2040	83%	20,812	11,886,333	0.49	615	0.002	0.10
2041	83%	22,492	13,645,531	0.55	706	0.002	0.11
2042	83%	23,855	15,450,815	0.61	800	0.002	0.13
2043	83%	24,616	17,027,875	0.64	881	0.002	0.14
2044	83%	24,999	18,503,282	0.66	958	0.003	0.15
2045	83%	23,578	18,533,512	0.63	959	0.003	0.15
2046	83%	22,732	18,951,293	0.60	981	0.003	0.15
2047	83%	20,468	17,727,023	0.52	918	0.002	0.14
2048	83%	19,254	17,099,486	0.47	885	0.002	0.14
2049	83%	18,154	16,349,764	0.42	846	0.002	0.13
2050	83%	11,367	9,827,254	0.23	509	0.001	0.08
2051	83%	5,854	4,027,277	0.08	208	0.001	0.03

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	100%	12,688	44,579,225
2019	12,851	5.6	3,844	0.007	0.60	343	100%	12,851	46,069,473
2020	8,537	3.3	2,461	0.004	0.39	219	100%	8,537	29,496,897
2021	4,246	1.1	575	0.002	0.09	51	100%	4,246	6,891,960

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	5.9	3,720	0.007	0.58
2019	0%	0	0	5.6	3,844	0.007	0.60
2020	0%	0	0	3.3	2,461	0.004	0.39
2021	0%	0	0	1.1	575	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	100%	15,699	46,494,284
2019	15,755	7.5	4,119	0.008	0.65	367	100%	15,755	49,364,115
2020	14,758	7.0	4,076	0.008	0.64	363	100%	14,758	48,851,177
2021	13,866	6.3	3,442	0.008	0.54	307	100%	13,866	41,250,943
2022	13,999	6.1	3,590	0.008	0.56	320	100%	13,999	43,027,237
2023	9,671	3.7	2,395	0.005	0.38	213	100%	9,671	28,707,076
2024	4,843	1.3	599	0.003	0.09	53	0%	0	0

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	484	717,286	0%	0	0	86%	4,141	6,814,220

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	7.6	3,880	0.008	0.61
2019	0%	0	0	7.5	4,119	0.008	0.65
2020	0%	0	0	7.0	4,076	0.008	0.64
2021	0%	0	0	6.3	3,442	0.008	0.54
2022	0%	0	0	6.1	3,590	0.008	0.56
2023	0%	0	0	3.7	2,395	0.005	0.38
2024	5%	218	106,580	0.14	572	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
1987	166	0.09	8.9	0.000	0.001	0.79	100%	166	106,532
1988	223	0.13	12	0.000	0.002	1.1	100%	223	144,024
1989	279	0.16	15	0.000	0.002	1.3	100%	279	179,202
1990	256	0.15	14	0.000	0.002	1.3	100%	256	168,297
1991	221	0.14	11	0.000	0.002	1.0	100%	221	134,880
1992	173	0.11	9.2	0.000	0.001	0.82	100%	173	110,429
1993	132	0.09	7.5	0.000	0.001	0.67	100%	132	90,308
1994	131	0.08	7.6	0.000	0.001	0.68	100%	131	91,104
1995	161	0.11	10	0.000	0.002	0.87	100%	161	116,335
1996	159	0.11	10	0.000	0.002	0.85	100%	159	114,485
1997	155	0.10	9.1	0.000	0.001	0.81	100%	155	108,509
1998	145	0.10	10	0.000	0.001	0.85	100%	145	114,337
1999	197	0.17	13	0.000	0.002	1.2	100%	197	160,607
2000	233	0.20	16	0.000	0.002	1.4	100%	233	188,016
2001	267	0.20	16	0.000	0.003	1.4	100%	267	193,494
2002	300	0.21	17	0.000	0.003	1.5	100%	300	200,551
2003	272	0.13	17	0.000	0.003	1.5	100%	272	200,037
2004	276	0.12	17	0.000	0.003	1.5	100%	276	198,929
2005	353	0.15	22	0.000	0.003	1.9	100%	353	259,740
2006	403	0.18	25	0.000	0.004	2.3	100%	403	303,073
2007	543	0.22	35	0.000	0.006	3.1	100%	543	422,431
2008	564	0.14	29	0.000	0.005	2.6	100%	564	352,228
2009	654	0.15	34	0.000	0.005	3.1	100%	654	410,832
2010	337	0.07	18	0.000	0.003	1.6	100%	337	211,381
2011	419	0.05	21	0.000	0.003	1.9	100%	419	253,413
2012	18,775	6.3	2,125	0.004	0.33	189	100%	18,775	25,469,698
2013	10,866	5.2	1,931	0.003	0.30	172	100%	10,866	23,141,590
2014	12,373	4.9	1,993	0.004	0.31	178	100%	12,373	23,884,682
2015	22,601	8.0	3,471	0.007	0.55	309	100%	22,601	41,601,211
2016	25,559	9.1	3,866	0.010	0.61	345	100%	25,559	46,327,589
2017	29,560	9.2	4,023	0.009	0.63	359	100%	29,560	48,215,934
2018	10,153	3.8	1,588	0.004	0.25	142	100%	10,153	19,030,587
2019	11,512	4.5	1,861	0.004	0.29	166	100%	11,512	22,305,607
2020	13,043	5.4	2,255	0.005	0.35	201	100%	13,043	27,025,846
2021	14,295	6.2	2,272	0.006	0.36	203	100%	14,295	27,231,919
2022	16,417	7.5	2,835	0.007	0.45	253	100%	16,417	33,979,835
2023	22,059	12	4,261	0.010	0.67	380	100%	22,059	51,063,434
2024	21,715	11	3,988	0.01	0.63	355	0%	0	0
2025	22,619	12	4,524	0.01	0.71	403	0%	0	0
2026	22,104	12	4,758	0.01	0.75	424	0%	0	0
2027	21,594	11	4,671	0.01	0.73	416	0%	0	0
2028	19,744	10	4,452	0.01	0.70	397	0%	0	0
2029	18,560	9.0	4,281	0.01	0.67	382	0%	0	0
2030	17,915	8.2	4,205	0.01	0.66	375	0%	0	0
2031	11,497	4.6	2,590	0.006	0.41	231	0%	0	0
2032	5,864	1.6	694	0.003	0.11	62	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	2,171	4,779,835	0%	0	0	86%	18,566	45,408,434
2025	10%	2,262	5,421,301	0%	0	0	84%	18,932	50,418,096
2026	10%	2,210	5,702,550	0%	0	0	81%	17,904	51,322,947
2027	15%	3,239	8,396,467	0%	0	0	72%	15,602	44,936,647
2028	15%	2,962	8,002,355	0%	0	0	68%	13,426	40,308,160
2029	20%	3,712	10,260,841	0%	0	0	60%	11,136	34,202,804
2030	20%	3,583	10,079,515	0%	0	0	56%	10,032	31,358,493
2031	20%	2,299	6,209,013	0%	0	0	52%	5,979	17,937,150
2032	10%	586	831,861	0%	0	0	54%	3,166	4,991,164

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.09	8.9	0.000	0.001
1988	0%	0	0	0.13	12	0.000	0.002
1989	0%	0	0	0.16	15	0.000	0.002
1990	0%	0	0	0.15	14	0.000	0.002
1991	0%	0	0	0.14	11	0.000	0.002
1992	0%	0	0	0.11	9.2	0.000	0.001
1993	0%	0	0	0.09	7.5	0.000	0.001
1994	0%	0	0	0.08	7.6	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.10	9.1	0.000	0.001
1998	0%	0	0	0.10	10	0.000	0.001
1999	0%	0	0	0.17	13	0.000	0.002
2000	0%	0	0	0.20	16	0.000	0.002
2001	0%	0	0	0.20	16	0.000	0.003
2002	0%	0	0	0.21	17	0.000	0.003
2003	0%	0	0	0.13	17	0.000	0.003
2004	0%	0	0	0.12	17	0.000	0.003
2005	0%	0	0	0.15	22	0.000	0.003
2006	0%	0	0	0.18	25	0.000	0.004
2007	0%	0	0	0.22	35	0.000	0.006
2008	0%	0	0	0.14	29	0.000	0.005
2009	0%	0	0	0.15	34	0.000	0.005
2010	0%	0	0	0.07	18	0.000	0.003
2011	0%	0	0	0.05	21	0.000	0.003
2012	0%	0	0	6.3	2,125	0.004	0.33
2013	0%	0	0	5.2	1,931	0.003	0.30
2014	0%	0	0	4.9	1,993	0.004	0.31
2015	0%	0	0	8.0	3,471	0.007	0.55
2016	0%	0	0	9.1	3,866	0.010	0.61
2017	0%	0	0	9.2	4,023	0.009	0.63
2018	0%	0	0	3.8	1,588	0.004	0.25
2019	0%	0	0	4.5	1,861	0.004	0.29
2020	0%	0	0	5.4	2,255	0.005	0.35
2021	0%	0	0	6.2	2,272	0.006	0.36
2022	0%	0	0	7.5	2,835	0.007	0.45
2023	0%	0	0	12	4,261	0.010	0.67
2024	5%	977	710,226	1.2	3,809	0.01	0.60
2025	6%	1,425	1,127,756	1.3	4,239	0.01	0.67
2026	9%	1,989	1,694,660	1.2	4,330	0.01	0.68
2027	13%	2,753	2,356,604	1.2	4,075	0.01	0.64
2028	17%	3,357	2,994,653	1.1	3,695	0.009	0.58
2029	20%	3,712	3,388,083	1.0	3,425	0.009	0.54
2030	24%	4,300	3,993,852	0.87	3,196	0.008	0.50
2031	28%	3,219	2,870,263	0.47	1,865	0.004	0.29
2032	36%	2,111	988,836	0.12	444	0.002	0.07

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	66	0.04	3.5	0.000	0.001	0.31	100%	66	42,043
1994	83	0.05	4.2	0.000	0.001	0.38	100%	83	50,721
1995	115	0.07	5.9	0.000	0.001	0.53	100%	115	70,970
1996	119	0.07	6.1	0.000	0.001	0.54	100%	119	72,842
1997	117	0.06	5.9	0.000	0.001	0.52	100%	117	70,488
1998	104	0.06	5.7	0.000	0.001	0.50	100%	104	67,898
1999	133	0.10	7.6	0.000	0.001	0.67	100%	133	90,610
2000	147	0.11	8.5	0.000	0.001	0.76	100%	147	101,850
2001	161	0.11	8.8	0.000	0.001	0.79	100%	161	105,603
2002	172	0.11	9.0	0.000	0.001	0.80	100%	172	107,968
2003	146	0.06	8.3	0.000	0.001	0.74	100%	146	99,226
2004	143	0.06	8.1	0.000	0.001	0.72	100%	143	96,731
2005	178	0.07	10	0.000	0.002	0.92	100%	178	123,640
2006	202	0.09	12	0.000	0.002	1.1	100%	202	143,033
2007	272	0.11	17	0.000	0.003	1.5	100%	272	200,277
2008	292	0.07	15	0.000	0.002	1.3	100%	292	179,211
2009	346	0.08	18	0.000	0.003	1.6	100%	346	213,122
2010	183	0.04	9.3	0.000	0.001	0.83	100%	183	111,727
2011	234	0.03	11	0.000	0.002	1.0	100%	234	136,809
2012	7,969	2.4	804	0.002	0.13	72	100%	7,969	9,641,296
2013	4,340	2.0	750	0.001	0.12	67	100%	4,340	8,984,556
2014	4,954	2.0	817	0.001	0.13	73	100%	4,954	9,795,650
2015	9,674	3.7	1,601	0.003	0.25	143	100%	9,674	19,190,427
2016	10,519	3.7	1,604	0.004	0.25	143	100%	10,519	19,227,562
2017	14,184	3.9	1,723	0.004	0.27	154	100%	14,184	20,654,585
2018	4,924	1.7	692	0.002	0.11	62	100%	4,924	8,290,062
2019	5,803	1.9	807	0.002	0.13	72	100%	5,803	9,667,889
2020	6,713	2.3	945	0.002	0.15	84	100%	6,713	11,329,480
2021	7,708	2.6	942	0.003	0.15	84	100%	7,708	11,285,971
2022	9,361	3.4	1,197	0.003	0.19	107	100%	9,361	14,344,235
2023	12,311	5.2	1,799	0.004	0.28	160	100%	12,311	21,557,339
2024	14,157	5.5	1,804	0.005	0.28	161	0%	0	0
2025	15,781	6.4	2,112	0.006	0.33	188	0%	0	0
2026	17,659	7.5	2,484	0.007	0.39	221	0%	0	0
2027	19,532	8.7	2,768	0.008	0.44	247	0%	0	0
2028	21,365	10	3,236	0.010	0.51	288	0%	0	0
2029	22,985	11	3,748	0.01	0.59	334	0%	0	0
2030	24,081	12	4,213	0.01	0.66	375	0%	0	0
2037	24,791	13	4,671	0.01	0.73	416	0%	0	0
2032	24,114	13	4,857	0.01	0.76	433	0%	0	0
2033	23,670	12	5,060	0.01	0.80	451	0%	0	0
2034	21,948	11	4,883	0.01	0.77	435	0%	0	0
2035	20,791	10	4,742	0.01	0.75	423	0%	0	0
2036	19,699	9.0	4,573	0.01	0.72	408	0%	0	0
2037	12,409	5.0	2,773	0.007	0.44	247	0%	0	0
2038	6,391	1.7	743	0.003	0.12	66	0%	0	0

Table A-17. NOx and GHG Tailpipe Emissions for Scenario 2 in Calendar Year 2037

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	1,416	2,161,542	0%	0	0	86%	12,104	20,534,650
2025	10%	1,578	2,531,043	0%	0	0	84%	13,209	23,538,696
2026	10%	1,766	2,977,192	0%	0	0	81%	14,304	26,794,732
2027	15%	2,930	4,975,264	0%	0	0	72%	14,112	26,626,876
2028	15%	3,205	5,817,346	0%	0	0	68%	14,528	29,302,186
2029	20%	4,597	8,983,030	0%	0	0	60%	13,791	29,943,433
2030	20%	4,816	10,097,767	0%	0	0	56%	13,485	31,415,274
2037	12%	2,975	6,717,948	0%	0	0	53%	13,090	32,843,299
2032	10%	2,411	5,821,019	0%	0	0	54%	13,022	34,926,115
2033	10%	2,367	6,063,891	0%	0	0	54%	12,782	36,383,345
2034	10%	2,195	5,851,702	0%	0	0	54%	11,852	35,110,212
2035	12%	2,495	6,819,958	0%	0	0	53%	10,978	33,342,015
2036	12%	2,364	6,576,732	0%	0	0	53%	10,401	32,152,911
2037	12%	1,489	3,988,015	0%	0	0	53%	6,552	19,496,964
2038	12%	767	1,068,563	0%	0	0	53%	3,375	5,224,086

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1993	0%	0	0	0.04	3.5	0.000	0.001
1994	0%	0	0	0.05	4.2	0.000	0.001
1995	0%	0	0	0.07	5.9	0.000	0.001
1996	0%	0	0	0.07	6.1	0.000	0.001
1997	0%	0	0	0.06	5.9	0.000	0.001
1998	0%	0	0	0.06	5.7	0.000	0.001
1999	0%	0	0	0.10	7.6	0.000	0.001
2000	0%	0	0	0.11	8.5	0.000	0.001
2001	0%	0	0	0.11	8.8	0.000	0.001
2002	0%	0	0	0.11	9.0	0.000	0.001
2003	0%	0	0	0.06	8.3	0.000	0.001
2004	0%	0	0	0.06	8.1	0.000	0.001
2005	0%	0	0	0.07	10	0.000	0.002
2006	0%	0	0	0.09	12	0.000	0.002
2007	0%	0	0	0.11	17	0.000	0.003
2008	0%	0	0	0.07	15	0.000	0.002
2009	0%	0	0	0.08	18	0.000	0.003
2010	0%	0	0	0.04	9.3	0.000	0.001
2011	0%	0	0	0.03	11	0.000	0.002
2012	0%	0	0	2.4	804	0.002	0.13
2013	0%	0	0	2.0	750	0.001	0.12
2014	0%	0	0	2.0	817	0.001	0.13
2015	0%	0	0	3.7	1,601	0.003	0.25
2016	0%	0	0	3.7	1,604	0.004	0.25
2017	0%	0	0	3.9	1,723	0.004	0.27
2018	0%	0	0	1.7	692	0.002	0.11
2019	0%	0	0	1.9	807	0.002	0.13
2020	0%	0	0	2.3	945	0.002	0.15
2021	0%	0	0	2.6	942	0.003	0.15
2022	0%	0	0	3.4	1,197	0.003	0.19
2023	0%	0	0	5.2	1,799	0.004	0.28
2024	5%	637	321,179	0.61	1,722	0.005	0.27
2025	6%	994	526,515	0.70	1,979	0.006	0.31
2026	9%	1,589	884,750	0.80	2,261	0.007	0.36
2027	13%	2,490	1,396,388	1.0	2,415	0.007	0.38
2028	17%	3,632	2,176,976	1.1	2,686	0.008	0.42
2029	20%	4,597	2,966,155	1.2	2,998	0.009	0.47
2030	24%	5,779	4,001,083	1.3	3,202	0.009	0.50
2037	35%	8,727	6,506,824	1.1	3,027	0.008	0.48
2032	36%	8,681	6,919,465	1.0	3,109	0.009	0.49
2033	36%	8,521	7,208,168	1.0	3,238	0.008	0.51
2034	36%	7,901	6,955,938	0.88	3,125	0.008	0.49
2035	35%	7,318	6,605,628	0.83	3,073	0.008	0.48
2036	35%	6,934	6,370,046	0.74	2,963	0.007	0.47
2037	35%	4,368	3,862,685	0.41	1,797	0.004	0.28
2038	35%	2,250	1,034,981	0.14	481	0.002	0.08

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0	0	0	0	0	0	0%	0	0
2002	0	0	0	0	0	0	0%	0	0
2003	0	0	0	0	0	0	0%	0	0
2004	0	0	0	0	0	0	0%	0	0
2005	0	0	0	0	0	0	0%	0	0
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	5,738	1.9	631	0.002	0.10	56	0%	0	0
2025	6,682	2.2	740	0.002	0.12	66	0%	0	0
2026	7,830	2.6	869	0.002	0.14	77	0%	0	0
2027	8,960	3.0	954	0.003	0.15	85	0%	0	0
2028	10,297	3.5	1,096	0.003	0.17	98	0%	0	0
2029	11,921	4.1	1,276	0.004	0.20	114	0%	0	0
2030	13,807	4.8	1,488	0.005	0.23	133	0%	0	0
2045	15,655	5.9	1,819	0.006	0.29	162	0%	0	0
2032	17,813	7.1	2,196	0.007	0.35	196	0%	0	0
2033	20,003	8.3	2,581	0.008	0.41	230	0%	0	0
2034	22,623	10	3,067	0.009	0.48	273	0%	0	0
2035	24,976	11	3,584	0.01	0.56	319	0%	0	0
2036	26,967	13	4,118	0.01	0.65	367	0%	0	0
2037	28,599	14	4,677	0.01	0.74	417	0%	0	0
2038	29,556	15	5,172	0.01	0.81	461	0%	0	0
2039	30,085	16	5,646	0.02	0.89	503	0%	0	0
2040	28,520	15	5,685	0.02	0.89	507	0%	0	0
2041	27,485	14	5,816	0.02	0.91	518	0%	0	0
2042	24,780	12	5,446	0.01	0.86	485	0%	0	0
2043	23,286	11	5,243	0.01	0.82	467	0%	0	0
2044	22,012	10	5,025	0.01	0.79	448	0%	0	0
2045	13,831	5.5	3,030	0.007	0.48	270	0%	0	0
2046	7,111	1.9	812	0.004	0.13	72	0%	0	0

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	574	756,340	0%	0	0	86%	4,906	7,185,231
2025	10%	668	886,781	0%	0	0	84%	5,593	8,247,067
2026	10%	783	1,041,761	0%	0	0	81%	6,343	9,375,851
2027	15%	1,344	1,715,605	0%	0	0	72%	6,474	9,181,662
2028	15%	1,544	1,969,828	0%	0	0	68%	7,002	9,922,098
2029	20%	2,384	3,059,507	0%	0	0	60%	7,152	10,198,356
2030	20%	2,761	3,566,433	0%	0	0	56%	7,732	11,095,569
2045	12%	1,879	2,615,706	0%	0	0	53%	8,266	12,787,894
2032	10%	1,781	2,631,722	0%	0	0	54%	9,619	15,790,332
2033	10%	2,000	3,093,484	0%	0	0	54%	10,802	18,560,905
2034	10%	2,262	3,676,051	0%	0	0	54%	12,217	22,056,309
2035	12%	2,997	5,154,227	0%	0	0	53%	13,188	25,198,442
2036	12%	3,236	5,922,773	0%	0	0	53%	14,239	28,955,778
2037	12%	3,432	6,725,482	0%	0	0	53%	15,100	32,880,135
2038	12%	3,547	7,438,400	0%	0	0	53%	15,606	36,365,513
2039	12%	3,610	8,118,998	0%	0	0	53%	15,885	39,692,877
2040	12%	3,422	8,176,299	0%	0	0	53%	15,058	39,973,018
2041	12%	3,298	8,363,731	0%	0	0	53%	14,512	40,889,352
2042	12%	2,974	7,831,788	0%	0	0	53%	13,084	38,288,741
2043	12%	2,794	7,539,421	0%	0	0	53%	12,295	36,859,392
2044	12%	2,641	7,227,079	0%	0	0	53%	11,622	35,332,388
2045	12%	1,660	4,357,601	0%	0	0	53%	7,303	21,303,829
2046	12%	853	1,167,185	0%	0	0	53%	3,755	5,706,238

	BEV			**Tailpipe Emission Estimates[5] (tons/day)**			
Model Year	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**NO_X**	**CO_2**	**CH_4**	**N_2O**
2001	0%	0	0	0	0	0	0
2002	0%	0	0	0	0	0	0
2003	0%	0	0	0	0	0	0
2004	0%	0	0	0	0	0	0
2005	0%	0	0	0	0	0	0
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	5%	258	112,383	0.21	603	0.002	0.09
2025	6%	421	184,471	0.24	693	0.002	0.11
2026	9%	705	309,586	0.28	791	0.002	0.12
2027	13%	1,142	481,512	0.33	833	0.002	0.13
2028	17%	1,750	737,152	0.37	909	0.003	0.14
2029	20%	2,384	1,010,235	0.45	1,021	0.003	0.16
2030	24%	3,314	1,413,144	0.51	1,131	0.003	0.18
2045	35%	5,511	2,533,502	0.49	1,179	0.004	0.19
2032	36%	6,413	3,128,337	0.56	1,405	0.004	0.22
2033	36%	7,201	3,677,235	0.66	1,652	0.005	0.26
2034	36%	8,144	4,369,735	0.78	1,963	0.006	0.31
2035	35%	8,792	4,992,246	0.94	2,322	0.007	0.37
2036	35%	9,493	5,736,639	1.1	2,669	0.008	0.42
2037	35%	10,067	6,514,121	1.2	3,030	0.009	0.48
2038	35%	10,404	7,204,635	1.2	3,352	0.009	0.53
2039	35%	10,590	7,863,843	1.3	3,658	0.01	0.58
2040	35%	10,039	7,919,344	1.2	3,684	0.01	0.58
2041	35%	9,675	8,100,885	1.2	3,769	0.010	0.59
2042	35%	8,723	7,585,660	1.0	3,529	0.009	0.55
2043	35%	8,197	7,302,481	0.92	3,397	0.008	0.53
2044	35%	7,748	6,999,955	0.82	3,256	0.008	0.51
2045	35%	4,869	4,220,656	0.45	1,963	0.005	0.31
2046	35%	2,503	1,130,504	0.15	526	0.002	0.08

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	2,595	0.86	281	0.001	0.04	25	0%	0	0
2025	3,028	1.0	330	0.001	0.05	29	0%	0	0
2026	3,626	1.2	393	0.001	0.06	35	0%	0	0
2027	4,257	1.4	439	0.001	0.07	39	0%	0	0
2028	5,060	1.7	526	0.001	0.08	47	0%	0	0
2029	6,031	2.0	632	0.002	0.10	56	0%	0	0
2030	7,066	2.4	743	0.002	0.12	66	0%	0	0
2050	8,217	2.8	872	0.003	0.14	78	0%	0	0
2032	9,494	3.2	1,017	0.003	0.16	91	0%	0	0
2033	11,004	3.8	1,176	0.004	0.18	105	0%	0	0
2034	12,911	4.5	1,386	0.004	0.22	124	0%	0	0
2035	14,935	5.3	1,619	0.005	0.25	144	0%	0	0
2036	16,783	6.4	1,962	0.006	0.31	175	0%	0	0
2037	18,732	7.5	2,328	0.007	0.37	208	0%	0	0
2038	20,725	8.7	2,699	0.008	0.42	241	0%	0	0
2039	22,925	10	3,137	0.009	0.49	280	0%	0	0
2040	25,074	11	3,619	0.01	0.57	323	0%	0	0
2041	27,099	13	4,155	0.01	0.65	370	0%	0	0
2042	28,740	14	4,704	0.01	0.74	419	0%	0	0
2043	29,658	15	5,184	0.01	0.81	462	0%	0	0
2044	30,119	16	5,634	0.02	0.89	502	0%	0	0
2045	28,407	15	5,643	0.02	0.89	503	0%	0	0
2046	27,387	14	5,770	0.02	0.91	514	0%	0	0
2047	24,660	12	5,397	0.01	0.85	481	0%	0	0
2048	23,198	11	5,206	0.01	0.82	464	0%	0	0
2049	21,872	10	4,978	0.01	0.78	444	0%	0	0
2050	13,695	5.4	2,992	0.007	0.47	267	0%	0	0
2051	7,053	1.8	1,226	0.004	0.19	109	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	260	337,270	0%	0	0	86%	2,219	3,204,066
2025	10%	303	395,918	0%	0	0	84%	2,534	3,682,036
2026	10%	363	471,136	0%	0	0	81%	2,937	4,240,226
2027	15%	639	789,915	0%	0	0	72%	3,076	4,227,507
2028	15%	759	945,969	0%	0	0	68%	3,441	4,764,882
2029	20%	1,206	1,514,257	0%	0	0	60%	3,619	5,047,525
2030	20%	1,413	1,780,183	0%	0	0	56%	3,957	5,538,347
2050	12%	986	1,253,331	0%	0	0	53%	4,339	6,127,395
2032	10%	949	1,218,218	0%	0	0	54%	5,127	7,309,307
2033	10%	1,100	1,409,784	0%	0	0	54%	5,942	8,458,701
2034	10%	1,291	1,660,800	0%	0	0	54%	6,972	9,964,800
2035	12%	1,792	2,327,866	0%	0	0	53%	7,885	11,380,679
2036	12%	2,014	2,822,001	0%	0	0	53%	8,861	13,796,450
2037	12%	2,248	3,348,517	0%	0	0	53%	9,890	16,370,527
2038	12%	2,487	3,881,574	0%	0	0	53%	10,943	18,976,585
2039	12%	2,751	4,511,626	0%	0	0	53%	12,105	22,056,839
2040	12%	3,009	5,204,512	0%	0	0	53%	13,239	25,444,282
2041	12%	3,252	5,974,789	0%	0	0	53%	14,308	29,210,080
2042	12%	3,449	6,765,245	0%	0	0	53%	15,175	33,074,532
2043	12%	3,559	7,455,772	0%	0	0	53%	15,660	36,450,439
2044	12%	3,614	8,101,789	0%	0	0	53%	15,903	39,608,744
2045	12%	3,409	8,115,025	0%	0	0	53%	14,999	39,673,455
2046	12%	3,286	8,297,953	0%	0	0	53%	14,461	40,567,771
2047	12%	2,959	7,761,898	0%	0	0	53%	13,021	37,947,059
2048	12%	2,784	7,487,127	0%	0	0	53%	12,249	36,603,732
2049	12%	2,625	7,158,856	0%	0	0	53%	11,549	34,998,851
2050	12%	1,643	4,302,930	0%	0	0	53%	7,231	21,036,548
2051	12%	846	1,763,371	0%	0	0	53%	3,724	8,620,923

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	5%	117	50,114	0.10	269	0.001	0.04
2025	6%	191	82,360	0.11	310	0.001	0.05
2026	9%	326	140,010	0.13	358	0.001	0.06
2027	13%	543	221,702	0.15	383	0.001	0.06
2028	17%	860	354,002	0.18	437	0.001	0.07
2029	20%	1,206	500,001	0.22	505	0.001	0.08
2030	24%	1,696	705,370	0.25	564	0.002	0.09
2050	35%	2,892	1,213,943	0.23	565	0.002	0.09
2032	36%	3,418	1,448,100	0.26	651	0.002	0.10
2033	36%	3,961	1,675,814	0.30	753	0.002	0.12
2034	36%	4,648	1,974,199	0.35	887	0.003	0.14
2035	35%	5,257	2,254,709	0.44	1,049	0.003	0.16
2036	35%	5,907	2,733,315	0.53	1,272	0.004	0.20
2037	35%	6,594	3,243,284	0.62	1,509	0.005	0.24
2038	35%	7,295	3,759,589	0.72	1,749	0.005	0.27
2039	35%	8,070	4,369,840	0.84	2,033	0.006	0.32
2040	35%	8,826	5,040,951	1.0	2,345	0.007	0.37
2041	35%	9,539	5,787,020	1.1	2,692	0.008	0.42
2042	35%	10,117	6,552,635	1.2	3,048	0.009	0.48
2043	35%	10,440	7,221,460	1.3	3,359	0.009	0.53
2044	35%	10,602	7,847,175	1.3	3,651	0.01	0.57
2045	35%	9,999	7,859,995	1.2	3,657	0.01	0.57
2046	35%	9,640	8,037,175	1.2	3,739	0.010	0.59
2047	35%	8,680	7,517,967	1.0	3,497	0.009	0.55
2048	35%	8,166	7,251,830	0.91	3,374	0.008	0.53
2049	35%	7,699	6,933,876	0.81	3,226	0.008	0.51
2050	35%	4,821	4,167,703	0.45	1,939	0.005	0.30
2051	35%	2,483	1,707,953	0.15	795	0.002	0.12

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	100%	12,688	44,579,225
2019	12,851	5.6	3,844	0.007	0.60	343	100%	12,851	46,069,473
2020	8,537	3.3	2,461	0.004	0.39	219	100%	8,537	29,496,897
2021	4,246	1.1	575	0.002	0.09	51	100%	4,246	6,891,960

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	5.9	3,720	0.007	0.58
2019	0%	0	0	5.6	3,844	0.007	0.60
2020	0%	0	0	3.3	2,461	0.004	0.39
2021	0%	0	0	1.1	575	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	100%	15,699	46,494,284
2019	15,755	7.5	4,119	0.008	0.65	367	100%	15,755	49,364,115
2020	14,758	7.0	4,076	0.008	0.64	363	100%	14,758	48,851,177
2021	13,866	6.3	3,442	0.008	0.54	307	100%	13,866	41,250,943
2022	13,999	6.1	3,590	0.008	0.56	320	100%	13,999	43,027,237
2023	9,671	3.7	2,395	0.005	0.38	213	100%	9,671	28,707,076
2024	4,843	1.3	599	0.003	0.09	53	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	484	717,286	0%	0	0	90%	4,358	7,172,863

Model Year	BEV Fleet Mix[2] (%)	BEV Population[3]	BEV Energy Consumption[4] (MJ/day)	Tailpipe Emission Estimates[5] (tons/day) NO_X	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	7.6	3,880	0.008	0.61
2019	0%	0	0	7.5	4,119	0.008	0.65
2020	0%	0	0	7.0	4,076	0.008	0.64
2021	0%	0	0	6.3	3,442	0.008	0.54
2022	0%	0	0	6.1	3,590	0.008	0.56
2023	0%	0	0	3.7	2,395	0.005	0.38
2024	0%	0	0	0.14	599	0.003	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	166	0.09	8.9	0.000	0.001	0.79	100%	166	106,532
1988	223	0.13	12	0.000	0.002	1.1	100%	223	144,024
1989	279	0.16	15	0.000	0.002	1.3	100%	279	179,202
1990	256	0.15	14	0.000	0.002	1.3	100%	256	168,297
1991	221	0.14	11	0.000	0.002	1.0	100%	221	134,880
1992	173	0.11	9.2	0.000	0.001	0.82	100%	173	110,429
1993	132	0.09	7.5	0.000	0.001	0.67	100%	132	90,308
1994	131	0.08	7.6	0.000	0.001	0.68	100%	131	91,104
1995	161	0.11	10	0.000	0.002	0.87	100%	161	116,335
1996	159	0.11	10	0.000	0.002	0.85	100%	159	114,485
1997	155	0.10	9.1	0.000	0.001	0.81	100%	155	108,509
1998	145	0.10	10	0.000	0.001	0.85	100%	145	114,337
1999	197	0.17	13	0.000	0.002	1.2	100%	197	160,607
2000	233	0.20	16	0.000	0.002	1.4	100%	233	188,016
2001	267	0.20	16	0.000	0.003	1.4	100%	267	193,494
2002	300	0.21	17	0.000	0.003	1.5	100%	300	200,551
2003	272	0.13	17	0.000	0.003	1.5	100%	272	200,037
2004	276	0.12	17	0.000	0.003	1.5	100%	276	198,929
2005	353	0.15	22	0.000	0.003	1.9	100%	353	259,740
2006	403	0.18	25	0.000	0.004	2.3	100%	403	303,073
2007	543	0.22	35	0.000	0.006	3.1	100%	543	422,431
2008	564	0.14	29	0.000	0.005	2.6	100%	564	352,228
2009	654	0.15	34	0.000	0.005	3.1	100%	654	410,832
2010	337	0.07	18	0.000	0.003	1.6	100%	337	211,381
2011	419	0.05	21	0.000	0.003	1.9	100%	419	253,413
2012	18,775	6.3	2,125	0.004	0.33	189	100%	18,775	25,469,698
2013	10,866	5.2	1,931	0.003	0.30	172	100%	10,866	23,141,590
2014	12,373	4.9	1,993	0.004	0.31	178	100%	12,373	23,884,682
2015	22,601	8.0	3,471	0.007	0.55	309	100%	22,601	41,601,211
2016	25,559	9.1	3,866	0.010	0.61	345	100%	25,559	46,327,589
2017	29,560	9.2	4,023	0.009	0.63	359	100%	29,560	48,215,934
2018	10,153	3.8	1,588	0.004	0.25	142	100%	10,153	19,030,587
2019	11,512	4.5	1,861	0.004	0.29	166	100%	11,512	22,305,607
2020	13,043	5.4	2,255	0.005	0.35	201	100%	13,043	27,025,846
2021	14,295	6.2	2,272	0.006	0.36	203	100%	14,295	27,231,919
2022	16,417	7.5	2,835	0.007	0.45	253	100%	16,417	33,979,835
2023	22,059	12	4,261	0.010	0.67	380	100%	22,059	51,063,434
2024	21,715	11	3,988	0.01	0.63	355	0%	0	0
2025	22,619	12	4,524	0.01	0.71	403	0%	0	0
2026	22,104	12	4,758	0.01	0.75	424	0%	0	0
2027	21,594	11	4,671	0.01	0.73	416	0%	0	0
2028	19,744	10	4,452	0.01	0.70	397	0%	0	0
2029	18,560	9.0	4,281	0.01	0.67	382	0%	0	0
2030	17,915	8.2	4,205	0.01	0.66	375	0%	0	0
2031	11,497	4.6	2,590	0.006	0.41	231	0%	0	0
2032	5,864	1.6	694	0.003	0.11	62	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	2,171	4,779,835	0%	0	0	90%	19,543	47,798,351
2025	10%	2,262	5,421,301	0%	0	0	90%	20,358	54,213,007
2026	10%	2,210	5,702,550	0%	0	0	90%	19,894	57,025,496
2027	15%	3,239	8,396,467	0%	0	0	85%	18,355	52,866,643
2028	15%	2,962	8,002,355	0%	0	0	85%	16,783	50,385,200
2029	20%	3,712	10,260,841	0%	0	0	80%	14,848	45,603,739
2030	20%	3,583	10,079,515	0%	0	0	80%	14,332	44,797,846
2031	20%	2,299	6,209,013	0%	0	0	80%	9,198	27,595,615
2032	10%	586	831,861	0%	0	0	90%	5,277	8,318,607

Model Year	BEV Fleet Mix[2] (%)	BEV Population[3]	BEV Energy Consumption[4] (MJ/day)	Tailpipe Emission Estimates[5] (tons/day) NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.09	8.9	0.000	0.001
1988	0%	0	0	0.13	12	0.000	0.002
1989	0%	0	0	0.16	15	0.000	0.002
1990	0%	0	0	0.15	14	0.000	0.002
1991	0%	0	0	0.14	11	0.000	0.002
1992	0%	0	0	0.11	9.2	0.000	0.001
1993	0%	0	0	0.09	7.5	0.000	0.001
1994	0%	0	0	0.08	7.6	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.10	9.1	0.000	0.001
1998	0%	0	0	0.10	10	0.000	0.001
1999	0%	0	0	0.17	13	0.000	0.002
2000	0%	0	0	0.20	16	0.000	0.002
2001	0%	0	0	0.20	16	0.000	0.003
2002	0%	0	0	0.21	17	0.000	0.003
2003	0%	0	0	0.13	17	0.000	0.003
2004	0%	0	0	0.12	17	0.000	0.003
2005	0%	0	0	0.15	22	0.000	0.003
2006	0%	0	0	0.18	25	0.000	0.004
2007	0%	0	0	0.22	35	0.000	0.006
2008	0%	0	0	0.14	29	0.000	0.005
2009	0%	0	0	0.15	34	0.000	0.005
2010	0%	0	0	0.07	18	0.000	0.003
2011	0%	0	0	0.05	21	0.000	0.003
2012	0%	0	0	6.3	2,125	0.004	0.33
2013	0%	0	0	5.2	1,931	0.003	0.30
2014	0%	0	0	4.9	1,993	0.004	0.31
2015	0%	0	0	8.0	3,471	0.007	0.55
2016	0%	0	0	9.1	3,866	0.010	0.61
2017	0%	0	0	9.2	4,023	0.009	0.63
2018	0%	0	0	3.8	1,588	0.004	0.25
2019	0%	0	0	4.5	1,861	0.004	0.29
2020	0%	0	0	5.4	2,255	0.005	0.35
2021	0%	0	0	6.2	2,272	0.006	0.36
2022	0%	0	0	7.5	2,835	0.007	0.45
2023	0%	0	0	12	4,261	0.010	0.67
2024	0%	0	0	1.3	3,988	0.01	0.63
2025	0%	0	0	1.4	4,524	0.01	0.71
2026	0%	0	0	1.3	4,758	0.01	0.75
2027	0%	0	0	1.4	4,671	0.01	0.73
2028	0%	0	0	1.2	4,452	0.01	0.70
2029	0%	0	0	1.2	4,281	0.01	0.67
2030	0%	0	0	1.1	4,205	0.01	0.66
2031	0%	0	0	0.60	2,590	0.006	0.41
2032	0%	0	0	0.18	694	0.003	0.11

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
1993	66	0.04	3.5	0.000	0.001	0.31	100%	66	42,043
1994	83	0.05	4.2	0.000	0.001	0.38	100%	83	50,721
1995	115	0.07	5.9	0.000	0.001	0.53	100%	115	70,970
1996	119	0.07	6.1	0.000	0.001	0.54	100%	119	72,842
1997	117	0.06	5.9	0.000	0.001	0.52	100%	117	70,488
1998	104	0.06	5.7	0.000	0.001	0.50	100%	104	67,898
1999	133	0.10	7.6	0.000	0.001	0.67	100%	133	90,610
2000	147	0.11	8.5	0.000	0.001	0.76	100%	147	101,850
2001	161	0.11	8.8	0.000	0.001	0.79	100%	161	105,603
2002	172	0.11	9.0	0.000	0.001	0.80	100%	172	107,968
2003	146	0.06	8.3	0.000	0.001	0.74	100%	146	99,226
2004	143	0.06	8.1	0.000	0.001	0.72	100%	143	96,731
2005	178	0.07	10	0.000	0.002	0.92	100%	178	123,640
2006	202	0.09	12	0.000	0.002	1.1	100%	202	143,033
2007	272	0.11	17	0.000	0.003	1.5	100%	272	200,277
2008	292	0.07	15	0.000	0.002	1.3	100%	292	179,211
2009	346	0.08	18	0.000	0.003	1.6	100%	346	213,122
2010	183	0.04	9.3	0.000	0.001	0.83	100%	183	111,727
2011	234	0.03	11	0.000	0.002	1.0	100%	234	136,809
2012	7,969	2.4	804	0.002	0.13	72	100%	7,969	9,641,296
2013	4,340	2.0	750	0.001	0.12	67	100%	4,340	8,984,556
2014	4,954	2.0	817	0.001	0.13	73	100%	4,954	9,795,650
2015	9,674	3.7	1,601	0.003	0.25	143	100%	9,674	19,190,427
2016	10,519	3.7	1,604	0.004	0.25	143	100%	10,519	19,227,562
2017	14,184	3.9	1,723	0.004	0.27	154	100%	14,184	20,654,585
2018	4,924	1.7	692	0.002	0.11	62	100%	4,924	8,290,062
2019	5,803	1.9	807	0.002	0.13	72	100%	5,803	9,667,889
2020	6,713	2.3	945	0.002	0.15	84	100%	6,713	11,329,480
2021	7,708	2.6	942	0.003	0.15	84	100%	7,708	11,285,971
2022	9,361	3.4	1,197	0.003	0.19	107	100%	9,361	14,344,235
2023	12,311	5.2	1,799	0.004	0.28	160	100%	12,311	21,557,339
2024	14,157	5.5	1,804	0.005	0.28	161	0%	0	0
2025	15,781	6.4	2,112	0.006	0.33	188	0%	0	0
2026	17,659	7.5	2,484	0.007	0.39	221	0%	0	0
2027	19,532	8.7	2,768	0.008	0.44	247	0%	0	0
2028	21,365	10	3,236	0.010	0.51	288	0%	0	0
2029	22,985	11	3,748	0.01	0.59	334	0%	0	0
2030	24,081	12	4,213	0.01	0.66	375	0%	0	0
2037	24,791	13	4,671	0.01	0.73	416	0%	0	0
2032	24,114	13	4,857	0.01	0.76	433	0%	0	0
2033	23,670	12	5,060	0.01	0.80	451	0%	0	0
2034	21,948	11	4,883	0.01	0.77	435	0%	0	0
2035	20,791	10	4,742	0.01	0.75	423	0%	0	0
2036	19,699	9.0	4,573	0.01	0.72	408	0%	0	0
2037	12,409	5.0	2,773	0.007	0.44	247	0%	0	0
2038	6,391	1.7	743	0.003	0.12	66	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	1,416	2,161,542	0%	0	0	90%	12,741	21,615,421
2025	10%	1,578	2,531,043	0%	0	0	90%	14,203	25,310,426
2026	10%	1,766	2,977,192	0%	0	0	90%	15,893	29,771,924
2027	15%	2,930	4,975,264	0%	0	0	85%	16,602	31,325,736
2028	15%	3,205	5,817,346	0%	0	0	85%	18,160	36,627,733
2029	20%	4,597	8,983,030	0%	0	0	80%	18,388	39,924,577
2030	20%	4,816	10,097,767	0%	0	0	80%	19,265	44,878,963
2037	12%	2,975	6,717,948	0%	0	0	88%	21,816	54,738,832
2032	10%	2,411	5,821,019	0%	0	0	90%	21,703	58,210,191
2033	10%	2,367	6,063,891	0%	0	0	90%	21,303	60,638,909
2034	10%	2,195	5,851,702	0%	0	0	90%	19,754	58,517,021
2035	12%	2,495	6,819,958	0%	0	0	88%	18,296	55,570,025
2036	12%	2,364	6,576,732	0%	0	0	88%	17,335	53,588,185
2037	12%	1,489	3,988,015	0%	0	0	88%	10,920	32,494,941
2038	12%	767	1,068,563	0%	0	0	88%	5,624	8,706,809

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1993	0%	0	0	0.04	3.5	0.000	0.001
1994	0%	0	0	0.05	4.2	0.000	0.001
1995	0%	0	0	0.07	5.9	0.000	0.001
1996	0%	0	0	0.07	6.1	0.000	0.001
1997	0%	0	0	0.06	5.9	0.000	0.001
1998	0%	0	0	0.06	5.7	0.000	0.001
1999	0%	0	0	0.10	7.6	0.000	0.001
2000	0%	0	0	0.11	8.5	0.000	0.001
2001	0%	0	0	0.11	8.8	0.000	0.001
2002	0%	0	0	0.11	9.0	0.000	0.001
2003	0%	0	0	0.06	8.3	0.000	0.001
2004	0%	0	0	0.06	8.1	0.000	0.001
2005	0%	0	0	0.07	10	0.000	0.002
2006	0%	0	0	0.09	12	0.000	0.002
2007	0%	0	0	0.11	17	0.000	0.003
2008	0%	0	0	0.07	15	0.000	0.002
2009	0%	0	0	0.08	18	0.000	0.003
2010	0%	0	0	0.04	9.3	0.000	0.001
2011	0%	0	0	0.03	11	0.000	0.002
2012	0%	0	0	2.4	804	0.002	0.13
2013	0%	0	0	2.0	750	0.001	0.12
2014	0%	0	0	2.0	817	0.001	0.13
2015	0%	0	0	3.7	1,601	0.003	0.25
2016	0%	0	0	3.7	1,604	0.004	0.25
2017	0%	0	0	3.9	1,723	0.004	0.27
2018	0%	0	0	1.7	692	0.002	0.11
2019	0%	0	0	1.9	807	0.002	0.13
2020	0%	0	0	2.3	945	0.002	0.15
2021	0%	0	0	2.6	942	0.003	0.15
2022	0%	0	0	3.4	1,197	0.003	0.19
2023	0%	0	0	5.2	1,799	0.004	0.28
2024	0%	0	0	0.63	1,804	0.005	0.28
2025	0%	0	0	0.74	2,112	0.006	0.33
2026	0%	0	0	0.87	2,484	0.007	0.39
2027	0%	0	0	1.1	2,768	0.008	0.44
2028	0%	0	0	1.2	3,236	0.010	0.51
2029	0%	0	0	1.5	3,748	0.01	0.59
2030	0%	0	0	1.6	4,213	0.01	0.66
2037	0%	0	0	1.5	4,671	0.01	0.73
2032	0%	0	0	1.5	4,857	0.01	0.76
2033	0%	0	0	1.4	5,060	0.01	0.80
2034	0%	0	0	1.3	4,883	0.01	0.77
2035	0%	0	0	1.2	4,742	0.01	0.75
2036	0%	0	0	1.1	4,573	0.01	0.72
2037	0%	0	0	0.59	2,773	0.007	0.44
2038	0%	0	0	0.20	743	0.003	0.12

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0	0	0	0	0	0	0%	0	0
2002	0	0	0	0	0	0	0%	0	0
2003	0	0	0	0	0	0	0%	0	0
2004	0	0	0	0	0	0	0%	0	0
2005	0	0	0	0	0	0	0%	0	0
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	5,738	1.9	631	0.002	0.10	56	0%	0	0
2025	6,682	2.2	740	0.002	0.12	66	0%	0	0
2026	7,830	2.6	869	0.002	0.14	77	0%	0	0
2027	8,960	3.0	954	0.003	0.15	85	0%	0	0
2028	10,297	3.5	1,096	0.003	0.17	98	0%	0	0
2029	11,921	4.1	1,276	0.004	0.20	114	0%	0	0
2030	13,807	4.8	1,488	0.005	0.23	133	0%	0	0
2045	15,655	5.9	1,819	0.006	0.29	162	0%	0	0
2032	17,813	7.1	2,196	0.007	0.35	196	0%	0	0
2033	20,003	8.3	2,581	0.008	0.41	230	0%	0	0
2034	22,623	10	3,067	0.009	0.48	273	0%	0	0
2035	24,976	11	3,584	0.01	0.56	319	0%	0	0
2036	26,967	13	4,118	0.01	0.65	367	0%	0	0
2037	28,599	14	4,677	0.01	0.74	417	0%	0	0
2038	29,556	15	5,172	0.01	0.81	461	0%	0	0
2039	30,085	16	5,646	0.02	0.89	503	0%	0	0
2040	28,520	15	5,685	0.02	0.89	507	0%	0	0
2041	27,485	14	5,816	0.02	0.91	518	0%	0	0
2042	24,780	12	5,446	0.01	0.86	485	0%	0	0
2043	23,286	11	5,243	0.01	0.82	467	0%	0	0
2044	22,012	10	5,025	0.01	0.79	448	0%	0	0
2045	13,831	5.5	3,030	0.007	0.48	270	0%	0	0
2046	7,111	1.9	812	0.004	0.13	72	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	574	756,340	0%	0	0	90%	5,164	7,563,401
2025	10%	668	886,781	0%	0	0	90%	6,014	8,867,814
2026	10%	783	1,041,761	0%	0	0	90%	7,047	10,417,613
2027	15%	1,344	1,715,605	0%	0	0	85%	7,616	10,801,955
2028	15%	1,544	1,969,828	0%	0	0	85%	8,752	12,402,622
2029	20%	2,384	3,059,507	0%	0	0	80%	9,536	13,597,807
2030	20%	2,761	3,566,433	0%	0	0	80%	11,045	15,850,813
2045	12%	1,879	2,615,706	0%	0	0	88%	13,777	21,313,157
2032	10%	1,781	2,631,722	0%	0	0	90%	16,032	26,317,219
2033	10%	2,000	3,093,484	0%	0	0	90%	18,003	30,934,842
2034	10%	2,262	3,676,051	0%	0	0	90%	20,361	36,760,514
2035	12%	2,997	5,154,227	0%	0	0	88%	21,979	41,997,404
2036	12%	3,236	5,922,773	0%	0	0	88%	23,731	48,259,631
2037	12%	3,432	6,725,482	0%	0	0	88%	25,167	54,800,225
2038	12%	3,547	7,438,400	0%	0	0	88%	26,009	60,609,188
2039	12%	3,610	8,118,998	0%	0	0	88%	26,475	66,154,795
2040	12%	3,422	8,176,299	0%	0	0	88%	25,097	66,621,697
2041	12%	3,298	8,363,731	0%	0	0	88%	24,187	68,148,920
2042	12%	2,974	7,831,788	0%	0	0	88%	21,807	63,814,568
2043	12%	2,794	7,539,421	0%	0	0	88%	20,492	61,432,320
2044	12%	2,641	7,227,079	0%	0	0	88%	19,370	58,887,313
2045	12%	1,660	4,357,601	0%	0	0	88%	12,172	35,506,382
2046	12%	853	1,167,185	0%	0	0	88%	6,258	9,510,397

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2001	0%	0	0	0	0	0	0
2002	0%	0	0	0	0	0	0
2003	0%	0	0	0	0	0	0
2004	0%	0	0	0	0	0	0
2005	0%	0	0	0	0	0	0
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	0%	0	0	0.22	631	0.002	0.10
2025	0%	0	0	0.26	740	0.002	0.12
2026	0%	0	0	0.30	869	0.002	0.14
2027	0%	0	0	0.37	954	0.003	0.15
2028	0%	0	0	0.43	1,096	0.003	0.17
2029	0%	0	0	0.54	1,276	0.004	0.20
2030	0%	0	0	0.63	1,488	0.005	0.23
2045	0%	0	0	0.70	1,819	0.006	0.29
2032	0%	0	0	0.82	2,196	0.007	0.35
2033	0%	0	0	1.0	2,581	0.008	0.41
2034	0%	0	0	1.1	3,067	0.009	0.48
2035	0%	0	0	1.3	3,584	0.01	0.56
2036	0%	0	0	1.5	4,118	0.01	0.65
2037	0%	0	0	1.7	4,677	0.01	0.74
2038	0%	0	0	1.8	5,172	0.01	0.81
2039	0%	0	0	1.8	5,646	0.02	0.89
2040	0%	0	0	1.7	5,685	0.02	0.89
2041	0%	0	0	1.7	5,816	0.02	0.91
2042	0%	0	0	1.5	5,446	0.01	0.86
2043	0%	0	0	1.3	5,243	0.01	0.82
2044	0%	0	0	1.2	5,025	0.01	0.79
2045	0%	0	0	0.64	3,030	0.007	0.48
2046	0%	0	0	0.22	812	0.004	0.13

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	2,595	0.86	281	0.001	0.04	25	0%	0	0
2025	3,028	1.0	330	0.001	0.05	29	0%	0	0
2026	3,626	1.2	393	0.001	0.06	35	0%	0	0
2027	4,257	1.4	439	0.001	0.07	39	0%	0	0
2028	5,060	1.7	526	0.001	0.08	47	0%	0	0
2029	6,031	2.0	632	0.002	0.10	56	0%	0	0
2030	7,066	2.4	743	0.002	0.12	66	0%	0	0
2050	8,217	2.8	872	0.003	0.14	78	0%	0	0
2032	9,494	3.2	1,017	0.003	0.16	91	0%	0	0
2033	11,004	3.8	1,176	0.004	0.18	105	0%	0	0
2034	12,911	4.5	1,386	0.004	0.22	124	0%	0	0
2035	14,935	5.3	1,619	0.005	0.25	144	0%	0	0
2036	16,783	6.4	1,962	0.006	0.31	175	0%	0	0
2037	18,732	7.5	2,328	0.007	0.37	208	0%	0	0
2038	20,725	8.7	2,699	0.008	0.42	241	0%	0	0
2039	22,925	10	3,137	0.009	0.49	280	0%	0	0
2040	25,074	11	3,619	0.01	0.57	323	0%	0	0
2041	27,099	13	4,155	0.01	0.65	370	0%	0	0
2042	28,740	14	4,704	0.01	0.74	419	0%	0	0
2043	29,658	15	5,184	0.01	0.81	462	0%	0	0
2044	30,119	16	5,634	0.02	0.89	502	0%	0	0
2045	28,407	15	5,643	0.02	0.89	503	0%	0	0
2046	27,387	14	5,770	0.02	0.91	514	0%	0	0
2047	24,660	12	5,397	0.01	0.85	481	0%	0	0
2048	23,198	11	5,206	0.01	0.82	464	0%	0	0
2049	21,872	10	4,978	0.01	0.78	444	0%	0	0
2050	13,695	5.4	2,992	0.007	0.47	267	0%	0	0
2051	7,053	1.8	1,226	0.004	0.19	109	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	260	337,270	0%	0	0	90%	2,336	3,372,701
2025	10%	303	395,918	0%	0	0	90%	2,725	3,959,178
2026	10%	363	471,136	0%	0	0	90%	3,263	4,711,362
2027	15%	639	789,915	0%	0	0	85%	3,618	4,973,538
2028	15%	759	945,969	0%	0	0	85%	4,301	5,956,103
2029	20%	1,206	1,514,257	0%	0	0	80%	4,825	6,730,033
2030	20%	1,413	1,780,183	0%	0	0	80%	5,653	7,911,924
2050	12%	986	1,253,331	0%	0	0	88%	7,231	10,212,325
2032	10%	949	1,218,218	0%	0	0	90%	8,544	12,182,179
2033	10%	1,100	1,409,784	0%	0	0	90%	9,904	14,097,835
2034	10%	1,291	1,660,800	0%	0	0	90%	11,620	16,608,001
2035	12%	1,792	2,327,866	0%	0	0	88%	13,142	18,967,798
2036	12%	2,014	2,822,001	0%	0	0	88%	14,769	22,994,084
2037	12%	2,248	3,348,517	0%	0	0	88%	16,484	27,284,212
2038	12%	2,487	3,881,574	0%	0	0	88%	18,238	31,627,641
2039	12%	2,751	4,511,626	0%	0	0	88%	20,174	36,761,398
2040	12%	3,009	5,204,512	0%	0	0	88%	22,065	42,407,136
2041	12%	3,252	5,974,789	0%	0	0	88%	23,847	48,683,467
2042	12%	3,449	6,765,245	0%	0	0	88%	25,292	55,124,220
2043	12%	3,559	7,455,772	0%	0	0	88%	26,099	60,750,732
2044	12%	3,614	8,101,789	0%	0	0	88%	26,505	66,014,573
2045	12%	3,409	8,115,025	0%	0	0	88%	24,998	66,122,425
2046	12%	3,286	8,297,953	0%	0	0	88%	24,101	67,612,952
2047	12%	2,959	7,761,898	0%	0	0	88%	21,701	63,245,098
2048	12%	2,784	7,487,127	0%	0	0	88%	20,414	61,006,220
2049	12%	2,625	7,158,856	0%	0	0	88%	19,248	58,331,418
2050	12%	1,643	4,302,930	0%	0	0	88%	12,051	35,060,913
2051	12%	846	1,763,371	0%	0	0	88%	6,207	14,368,205

Table A-25. NOx and GHG Tailpipe Emissions for Scenario 3 in Calendar Year 2050

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_x	CO_2	CH_4	N_2O
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	0%	0	0	0.10	281	0.001	0.04
2025	0%	0	0	0.12	330	0.001	0.05
2026	0%	0	0	0.14	393	0.001	0.06
2027	0%	0	0	0.17	439	0.001	0.07
2028	0%	0	0	0.21	526	0.001	0.08
2029	0%	0	0	0.26	632	0.002	0.10
2030	0%	0	0	0.31	743	0.002	0.12
2050	0%	0	0	0.33	872	0.003	0.14
2032	0%	0	0	0.37	1,017	0.003	0.16
2033	0%	0	0	0.43	1,176	0.004	0.18
2034	0%	0	0	0.52	1,386	0.004	0.22
2035	0%	0	0	0.62	1,619	0.005	0.25
2036	0%	0	0	0.75	1,962	0.006	0.31
2037	0%	0	0	0.89	2,328	0.007	0.37
2038	0%	0	0	1.0	2,699	0.008	0.42
2039	0%	0	0	1.2	3,137	0.009	0.49
2040	0%	0	0	1.4	3,619	0.01	0.57
2041	0%	0	0	1.5	4,155	0.01	0.65
2042	0%	0	0	1.7	4,704	0.01	0.74
2043	0%	0	0	1.8	5,184	0.01	0.81
2044	0%	0	0	1.8	5,634	0.02	0.89
2045	0%	0	0	1.7	5,643	0.02	0.89
2046	0%	0	0	1.7	5,770	0.02	0.91
2047	0%	0	0	1.5	5,397	0.01	0.85
2048	0%	0	0	1.3	5,206	0.01	0.82
2049	0%	0	0	1.2	4,978	0.01	0.78
2050	0%	0	0	0.64	2,992	0.007	0.47
2051	0%	0	0	0.22	1,226	0.004	0.19

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	25%	3,172	11,144,806
2019	12,851	5.6	3,844	0.007	0.60	343	10%	1,285	4,606,947
2020	8,537	3.3	2,461	0.004	0.39	219	0%	0	0
2021	4,246	1.1	575	0.002	0.09	51	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	75%	9,516	37,149,354
2019	0%	0	0	0%	0	0	90%	11,566	46,069,473
2020	0%	0	0	0%	0	0	100%	8,537	32,774,330
2021	0%	0	0	0%	0	0	100%	4,246	7,657,733

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_x	CO_2	CH_4	N_2O
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	1.9	3,720	0.007	0.58
2019	0%	0	0	1.1	3,844	0.007	0.60
2020	0%	0	0	0.33	2,461	0.004	0.39
2021	0%	0	0	0.11	575	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	25%	3,925	11,623,571
2019	15,755	7.5	4,119	0.008	0.65	367	10%	1,575	4,936,412
2020	14,758	7.0	4,076	0.008	0.64	363	0%	0	0
2021	13,866	6.3	3,442	0.008	0.54	307	0%	0	0
2022	13,999	6.1	3,590	0.008	0.56	320	0%	0	0
2023	9,671	3.7	2,395	0.005	0.38	213	0%	0	0
2024	4,843	1.3	599	0.003	0.09	53	0%	0	0

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	75%	11,774	38,745,237
2019	0%	0	0	0%	0	0	90%	14,179	49,364,115
2020	0%	0	0	0%	0	0	100%	14,758	54,279,085
2021	0%	0	0	0%	0	0	100%	13,866	45,834,381
2022	0%	0	0	0%	0	0	100%	13,999	47,808,041
2023	0%	0	0	0%	0	0	100%	9,671	31,896,751
2024	10%	484	717,286	0%	0	0	86%	4,141	6,814,220

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	2.5	3,880	0.008	0.61
2019	0%	0	0	1.4	4,119	0.008	0.65
2020	0%	0	0	0.70	4,076	0.008	0.64
2021	0%	0	0	0.63	3,442	0.008	0.54
2022	0%	0	0	0.61	3,590	0.008	0.56
2023	0%	0	0	0.37	2,395	0.005	0.38
2024	5%	218	106,580	0.14	572	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	166	0.09	8.9	0.000	0.001	0.79	100%	166	106,532
1988	223	0.13	12	0.000	0.002	1.1	100%	223	144,024
1989	279	0.16	15	0.000	0.002	1.3	100%	279	179,202
1990	256	0.15	14	0.000	0.002	1.3	100%	256	168,297
1991	221	0.14	11	0.000	0.002	1.0	100%	221	134,880
1992	173	0.11	9.2	0.000	0.001	0.82	100%	173	110,429
1993	132	0.09	7.5	0.000	0.001	0.67	100%	132	90,308
1994	131	0.08	7.6	0.000	0.001	0.68	100%	131	91,104
1995	161	0.11	10	0.000	0.002	0.87	100%	161	116,335
1996	159	0.11	10	0.000	0.002	0.85	100%	159	114,485
1997	155	0.10	9.1	0.000	0.001	0.81	100%	155	108,509
1998	145	0.10	10	0.000	0.001	0.85	100%	145	114,337
1999	197	0.17	13	0.000	0.002	1.2	100%	197	160,607
2000	233	0.20	16	0.000	0.002	1.4	100%	233	188,016
2001	267	0.20	16	0.000	0.003	1.4	100%	267	193,494
2002	300	0.21	17	0.000	0.003	1.5	100%	300	200,551
2003	272	0.13	17	0.000	0.003	1.5	100%	272	200,037
2004	276	0.12	17	0.000	0.003	1.5	100%	276	198,929
2005	353	0.15	22	0.000	0.003	1.9	100%	353	259,740
2006	403	0.18	25	0.000	0.004	2.3	100%	403	303,073
2007	543	0.22	35	0.000	0.006	3.1	100%	543	422,431
2008	564	0.14	29	0.000	0.005	2.6	100%	564	352,228
2009	654	0.15	34	0.000	0.005	3.1	100%	654	410,832
2010	337	0.07	18	0.000	0.003	1.6	100%	337	211,381
2011	419	0.05	21	0.000	0.003	1.9	100%	419	253,413
2012	18,775	6.3	2,125	0.004	0.33	189	100%	18,775	25,469,698
2013	10,866	5.2	1,931	0.003	0.30	172	100%	10,866	23,141,590
2014	12,373	4.9	1,993	0.004	0.31	178	100%	12,373	23,884,682
2015	22,601	8.0	3,471	0.007	0.55	309	100%	22,601	41,601,211
2016	25,559	9.1	3,866	0.010	0.61	345	100%	25,559	46,327,589
2017	29,560	9.2	4,023	0.009	0.63	359	100%	29,560	48,215,934
2018	10,153	3.8	1,588	0.004	0.25	142	25%	2,538	4,757,647
2019	11,512	4.5	1,861	0.004	0.29	166	10%	1,151	2,230,561
2020	13,043	5.4	2,255	0.005	0.35	201	0%	0	0
2021	14,295	6.2	2,272	0.006	0.36	203	0%	0	0
2022	16,417	7.5	2,835	0.007	0.45	253	0%	0	0
2023	22,059	12	4,261	0.010	0.67	380	0%	0	0
2024	21,715	11	3,988	0.01	0.63	355	0%	0	0
2025	22,619	12	4,524	0.01	0.71	403	0%	0	0
2026	22,104	12	4,758	0.01	0.75	424	0%	0	0
2027	21,594	11	4,671	0.01	0.73	416	0%	0	0
2028	19,744	10	4,452	0.01	0.70	397	0%	0	0
2029	18,560	9.0	4,281	0.01	0.67	382	0%	0	0
2030	17,915	8.2	4,205	0.01	0.66	375	0%	0	0
2031	11,497	4.6	2,590	0.006	0.41	231	0%	0	0
2032	5,864	1.6	694	0.003	0.11	62	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	75%	7,615	15,858,823
2019	0%	0	0	0%	0	0	90%	10,361	22,305,607
2020	0%	0	0	0%	0	0	100%	13,043	30,028,717
2021	0%	0	0	0%	0	0	100%	14,295	30,257,688
2022	0%	0	0	0%	0	0	100%	16,417	37,755,372
2023	0%	0	0	0%	0	0	100%	22,059	56,737,149
2024	10%	2,171	4,779,835	0%	0	0	86%	18,566	45,408,434
2025	10%	2,262	5,421,301	0%	0	0	84%	18,932	50,418,096
2026	10%	2,210	5,702,550	0%	0	0	81%	17,904	51,322,947
2027	15%	3,239	8,396,467	0%	0	0	72%	15,602	44,936,647
2028	15%	2,962	8,002,355	0%	0	0	68%	13,426	40,308,160
2029	20%	3,712	10,260,841	0%	0	0	60%	11,136	34,202,804
2030	20%	3,583	10,079,515	0%	0	0	56%	10,032	31,358,493
2031	20%	2,299	6,209,013	0%	0	0	52%	5,979	17,937,150
2032	10%	586	831,861	0%	0	0	54%	3,166	4,991,164

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.09	8.9	0.000	0.001
1988	0%	0	0	0.13	12	0.000	0.002
1989	0%	0	0	0.16	15	0.000	0.002
1990	0%	0	0	0.15	14	0.000	0.002
1991	0%	0	0	0.14	11	0.000	0.002
1992	0%	0	0	0.11	9.2	0.000	0.001
1993	0%	0	0	0.09	7.5	0.000	0.001
1994	0%	0	0	0.08	7.6	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.10	9.1	0.000	0.001
1998	0%	0	0	0.10	10	0.000	0.001
1999	0%	0	0	0.17	13	0.000	0.002
2000	0%	0	0	0.20	16	0.000	0.002
2001	0%	0	0	0.20	16	0.000	0.003
2002	0%	0	0	0.21	17	0.000	0.003
2003	0%	0	0	0.13	17	0.000	0.003
2004	0%	0	0	0.12	17	0.000	0.003
2005	0%	0	0	0.15	22	0.000	0.003
2006	0%	0	0	0.18	25	0.000	0.004
2007	0%	0	0	0.22	35	0.000	0.006
2008	0%	0	0	0.14	29	0.000	0.005
2009	0%	0	0	0.15	34	0.000	0.005
2010	0%	0	0	0.07	18	0.000	0.003
2011	0%	0	0	0.05	21	0.000	0.003
2012	0%	0	0	6.3	2,125	0.004	0.33
2013	0%	0	0	5.2	1,931	0.003	0.30
2014	0%	0	0	4.9	1,993	0.004	0.31
2015	0%	0	0	8.0	3,471	0.007	0.55
2016	0%	0	0	9.1	3,866	0.010	0.61
2017	0%	0	0	9.2	4,023	0.009	0.63
2018	0%	0	0	1.2	1,588	0.004	0.25
2019	0%	0	0	0.85	1,861	0.004	0.29
2020	0%	0	0	0.54	2,255	0.005	0.35
2021	0%	0	0	0.62	2,272	0.006	0.36
2022	0%	0	0	0.75	2,835	0.007	0.45
2023	0%	0	0	1.2	4,261	0.010	0.67
2024	5%	977	710,226	1.2	3,809	0.01	0.60
2025	6%	1,425	1,127,756	1.3	4,239	0.01	0.67
2026	9%	1,989	1,694,660	1.2	4,330	0.01	0.68
2027	13%	2,753	2,356,604	1.2	4,075	0.01	0.64
2028	17%	3,357	2,994,653	1.1	3,695	0.009	0.58
2029	20%	3,712	3,388,083	1.0	3,425	0.009	0.54
2030	24%	4,300	3,993,852	0.87	3,196	0.008	0.50
2031	28%	3,219	2,870,263	0.47	1,865	0.004	0.29
2032	36%	2,111	988,836	0.12	444	0.002	0.07

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	66	0.04	3.5	0.000	0.001	0.31	100%	66	42,043
1994	83	0.05	4.2	0.000	0.001	0.38	100%	83	50,721
1995	115	0.07	5.9	0.000	0.001	0.53	100%	115	70,970
1996	119	0.07	6.1	0.000	0.001	0.54	100%	119	72,842
1997	117	0.06	5.9	0.000	0.001	0.52	100%	117	70,488
1998	104	0.06	5.7	0.000	0.001	0.50	100%	104	67,898
1999	133	0.10	7.6	0.000	0.001	0.67	100%	133	90,610
2000	147	0.11	8.5	0.000	0.001	0.76	100%	147	101,850
2001	161	0.11	8.8	0.000	0.001	0.79	100%	161	105,603
2002	172	0.11	9.0	0.000	0.001	0.80	100%	172	107,968
2003	146	0.06	8.3	0.000	0.001	0.74	100%	146	99,226
2004	143	0.06	8.1	0.000	0.001	0.72	100%	143	96,731
2005	178	0.07	10	0.000	0.002	0.92	100%	178	123,640
2006	202	0.09	12	0.000	0.002	1.1	100%	202	143,033
2007	272	0.11	17	0.000	0.003	1.5	100%	272	200,277
2008	292	0.07	15	0.000	0.002	1.3	100%	292	179,211
2009	346	0.08	18	0.000	0.003	1.6	100%	346	213,122
2010	183	0.04	9.3	0.000	0.001	0.83	100%	183	111,727
2011	234	0.03	11	0.000	0.002	1.0	100%	234	136,809
2012	7,969	2.4	804	0.002	0.13	72	100%	7,969	9,641,296
2013	4,340	2.0	750	0.001	0.12	67	100%	4,340	8,984,556
2014	4,954	2.0	817	0.001	0.13	73	100%	4,954	9,795,650
2015	9,674	3.7	1,601	0.003	0.25	143	100%	9,674	19,190,427
2016	10,519	3.7	1,604	0.004	0.25	143	100%	10,519	19,227,562
2017	14,184	3.9	1,723	0.004	0.27	154	100%	14,184	20,654,585
2018	4,924	1.7	692	0.002	0.11	62	25%	1,231	2,072,516
2019	5,803	1.9	807	0.002	0.13	72	10%	580	966,789
2020	6,713	2.3	945	0.002	0.15	84	0%	0	0
2021	7,708	2.6	942	0.003	0.15	84	0%	0	0
2022	9,361	3.4	1,197	0.003	0.19	107	0%	0	0
2023	12,311	5.2	1,799	0.004	0.28	160	0%	0	0
2024	14,157	5.5	1,804	0.005	0.28	161	0%	0	0
2025	15,781	6.4	2,112	0.006	0.33	188	0%	0	0
2026	17,659	7.5	2,484	0.007	0.39	221	0%	0	0
2027	19,532	8.7	2,768	0.008	0.44	247	0%	0	0
2028	21,365	10	3,236	0.010	0.51	288	0%	0	0
2029	22,985	11	3,748	0.01	0.59	334	0%	0	0
2030	24,081	12	4,213	0.01	0.66	375	0%	0	0
2037	24,791	13	4,671	0.01	0.73	416	0%	0	0
2032	24,114	13	4,857	0.01	0.76	433	0%	0	0
2033	23,670	12	5,060	0.01	0.80	451	0%	0	0
2034	21,948	11	4,883	0.01	0.77	435	0%	0	0
2035	20,791	10	4,742	0.01	0.75	423	0%	0	0
2036	19,699	9.0	4,573	0.01	0.72	408	0%	0	0
2037	12,409	5.0	2,773	0.007	0.44	247	0%	0	0
2038	6,391	1.7	743	0.003	0.12	66	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	75%	3,693	6,908,385
2019	0%	0	0	0%	0	0	90%	5,223	9,667,889
2020	0%	0	0	0%	0	0	100%	6,713	12,588,312
2021	0%	0	0	0%	0	0	100%	7,708	12,539,967
2022	0%	0	0	0%	0	0	100%	9,361	15,938,038
2023	0%	0	0	0%	0	0	100%	12,311	23,952,598
2024	10%	1,416	2,161,542	0%	0	0	86%	12,104	20,534,650
2025	10%	1,578	2,531,043	0%	0	0	84%	13,209	23,538,696
2026	10%	1,766	2,977,192	0%	0	0	81%	14,304	26,794,732
2027	15%	2,930	4,975,264	0%	0	0	72%	14,112	26,626,876
2028	15%	3,205	5,817,346	0%	0	0	68%	14,528	29,302,186
2029	20%	4,597	8,983,030	0%	0	0	60%	13,791	29,943,433
2030	20%	4,816	10,097,767	0%	0	0	56%	13,485	31,415,274
2037	12%	2,975	6,717,948	0%	0	0	53%	13,090	32,843,299
2032	10%	2,411	5,821,019	0%	0	0	54%	13,022	34,926,115
2033	10%	2,367	6,063,891	0%	0	0	54%	12,782	36,383,345
2034	10%	2,195	5,851,702	0%	0	0	54%	11,852	35,110,212
2035	12%	2,495	6,819,958	0%	0	0	53%	10,978	33,342,015
2036	12%	2,364	6,576,732	0%	0	0	53%	10,401	32,152,911
2037	12%	1,489	3,988,015	0%	0	0	53%	6,552	19,496,964
2038	12%	767	1,068,563	0%	0	0	53%	3,375	5,224,086

Table A-29. NOx and GHG Emissions Tailpipe for Scenario 4 in Calendar Year 2037

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1993	0%	0	0	0.04	3.5	0.000	0.001
1994	0%	0	0	0.05	4.2	0.000	0.001
1995	0%	0	0	0.07	5.9	0.000	0.001
1996	0%	0	0	0.07	6.1	0.000	0.001
1997	0%	0	0	0.06	5.9	0.000	0.001
1998	0%	0	0	0.06	5.7	0.000	0.001
1999	0%	0	0	0.10	7.6	0.000	0.001
2000	0%	0	0	0.11	8.5	0.000	0.001
2001	0%	0	0	0.11	8.8	0.000	0.001
2002	0%	0	0	0.11	9.0	0.000	0.001
2003	0%	0	0	0.06	8.3	0.000	0.001
2004	0%	0	0	0.06	8.1	0.000	0.001
2005	0%	0	0	0.07	10	0.000	0.002
2006	0%	0	0	0.09	12	0.000	0.002
2007	0%	0	0	0.11	17	0.000	0.003
2008	0%	0	0	0.07	15	0.000	0.002
2009	0%	0	0	0.08	18	0.000	0.003
2010	0%	0	0	0.04	9.3	0.000	0.001
2011	0%	0	0	0.03	11	0.000	0.002
2012	0%	0	0	2.4	804	0.002	0.13
2013	0%	0	0	2.0	750	0.001	0.12
2014	0%	0	0	2.0	817	0.001	0.13
2015	0%	0	0	3.7	1,601	0.003	0.25
2016	0%	0	0	3.7	1,604	0.004	0.25
2017	0%	0	0	3.9	1,723	0.004	0.27
2018	0%	0	0	0.54	692	0.002	0.11
2019	0%	0	0	0.37	807	0.002	0.13
2020	0%	0	0	0.23	945	0.002	0.15
2021	0%	0	0	0.26	942	0.003	0.15
2022	0%	0	0	0.34	1,197	0.003	0.19
2023	0%	0	0	0.52	1,799	0.004	0.28
2024	5%	637	321,179	0.61	1,722	0.005	0.27
2025	6%	994	526,515	0.70	1,979	0.006	0.31
2026	9%	1,589	884,750	0.80	2,261	0.007	0.36
2027	13%	2,490	1,396,388	1.0	2,415	0.007	0.38
2028	17%	3,632	2,176,976	1.1	2,686	0.008	0.42
2029	20%	4,597	2,966,155	1.2	2,998	0.009	0.47
2030	24%	5,779	4,001,083	1.3	3,202	0.009	0.50
2037	35%	8,727	6,506,824	1.1	3,027	0.008	0.48
2032	36%	8,681	6,919,465	1.0	3,109	0.009	0.49
2033	36%	8,521	7,208,168	1.0	3,238	0.008	0.51
2034	36%	7,901	6,955,938	0.88	3,125	0.008	0.49
2035	35%	7,318	6,605,628	0.83	3,073	0.008	0.48
2036	35%	6,934	6,370,046	0.74	2,963	0.007	0.47
2037	35%	4,368	3,862,685	0.41	1,797	0.004	0.28
2038	35%	2,250	1,034,981	0.14	481	0.002	0.08

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0	0	0	0	0	0	0%	0	0
2002	0	0	0	0	0	0	0%	0	0
2003	0	0	0	0	0	0	0%	0	0
2004	0	0	0	0	0	0	0%	0	0
2005	0	0	0	0	0	0	0%	0	0
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	5,738	1.9	631	0.002	0.10	56	0%	0	0
2025	6,682	2.2	740	0.002	0.12	66	0%	0	0
2026	7,830	2.6	869	0.002	0.14	77	0%	0	0
2027	8,960	3.0	954	0.003	0.15	85	0%	0	0
2028	10,297	3.5	1,096	0.003	0.17	98	0%	0	0
2029	11,921	4.1	1,276	0.004	0.20	114	0%	0	0
2030	13,807	4.8	1,488	0.005	0.23	133	0%	0	0
2045	15,655	5.9	1,819	0.006	0.29	162	0%	0	0
2032	17,813	7.1	2,196	0.007	0.35	196	0%	0	0
2033	20,003	8.3	2,581	0.008	0.41	230	0%	0	0
2034	22,623	10	3,067	0.009	0.48	273	0%	0	0
2035	24,976	11	3,584	0.01	0.56	319	0%	0	0
2036	26,967	13	4,118	0.01	0.65	367	0%	0	0
2037	28,599	14	4,677	0.01	0.74	417	0%	0	0
2038	29,556	15	5,172	0.01	0.81	461	0%	0	0
2039	30,085	16	5,646	0.02	0.89	503	0%	0	0
2040	28,520	15	5,685	0.02	0.89	507	0%	0	0
2041	27,485	14	5,816	0.02	0.91	518	0%	0	0
2042	24,780	12	5,446	0.01	0.86	485	0%	0	0
2043	23,286	11	5,243	0.01	0.82	467	0%	0	0
2044	22,012	10	5,025	0.01	0.79	448	0%	0	0
2045	13,831	5.5	3,030	0.007	0.48	270	0%	0	0
2046	7,111	1.9	812	0.004	0.13	72	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	574	756,340	0%	0	0	86%	4,906	7,185,231
2025	10%	668	886,781	0%	0	0	84%	5,593	8,247,067
2026	10%	783	1,041,761	0%	0	0	81%	6,343	9,375,851
2027	15%	1,344	1,715,605	0%	0	0	72%	6,474	9,181,662
2028	15%	1,544	1,969,828	0%	0	0	68%	7,002	9,922,098
2029	20%	2,384	3,059,507	0%	0	0	60%	7,152	10,198,356
2030	20%	2,761	3,566,433	0%	0	0	56%	7,732	11,095,569
2045	12%	1,879	2,615,706	0%	0	0	53%	8,266	12,787,894
2032	10%	1,781	2,631,722	0%	0	0	54%	9,619	15,790,332
2033	10%	2,000	3,093,484	0%	0	0	54%	10,802	18,560,905
2034	10%	2,262	3,676,051	0%	0	0	54%	12,217	22,056,309
2035	12%	2,997	5,154,227	0%	0	0	53%	13,188	25,198,442
2036	12%	3,236	5,922,773	0%	0	0	53%	14,239	28,955,778
2037	12%	3,432	6,725,482	0%	0	0	53%	15,100	32,880,135
2038	12%	3,547	7,438,400	0%	0	0	53%	15,606	36,365,513
2039	12%	3,610	8,118,998	0%	0	0	53%	15,885	39,692,877
2040	12%	3,422	8,176,299	0%	0	0	53%	15,058	39,973,018
2041	12%	3,298	8,363,731	0%	0	0	53%	14,512	40,889,352
2042	12%	2,974	7,831,788	0%	0	0	53%	13,084	38,288,741
2043	12%	2,794	7,539,421	0%	0	0	53%	12,295	36,859,392
2044	12%	2,641	7,227,079	0%	0	0	53%	11,622	35,332,388
2045	12%	1,660	4,357,601	0%	0	0	53%	7,303	21,303,829
2046	12%	853	1,167,185	0%	0	0	53%	3,755	5,706,238

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2001	0%	0	0	0	0	0	0
2002	0%	0	0	0	0	0	0
2003	0%	0	0	0	0	0	0
2004	0%	0	0	0	0	0	0
2005	0%	0	0	0	0	0	0
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	5%	258	112,383	0.21	603	0.002	0.09
2025	6%	421	184,471	0.24	693	0.002	0.11
2026	9%	705	309,586	0.28	791	0.002	0.12
2027	13%	1,142	481,512	0.33	833	0.002	0.13
2028	17%	1,750	737,152	0.37	909	0.003	0.14
2029	20%	2,384	1,010,235	0.45	1,021	0.003	0.16
2030	24%	3,314	1,413,144	0.51	1,131	0.003	0.18
2045	35%	5,511	2,533,502	0.49	1,179	0.004	0.19
2032	36%	6,413	3,128,337	0.56	1,405	0.004	0.22
2033	36%	7,201	3,677,235	0.66	1,652	0.005	0.26
2034	36%	8,144	4,369,735	0.78	1,963	0.006	0.31
2035	35%	8,792	4,992,246	0.94	2,322	0.007	0.37
2036	35%	9,493	5,736,639	1.1	2,669	0.008	0.42
2037	35%	10,067	6,514,121	1.2	3,030	0.009	0.48
2038	35%	10,404	7,204,635	1.2	3,352	0.009	0.53
2039	35%	10,590	7,863,843	1.3	3,658	0.01	0.58
2040	35%	10,039	7,919,344	1.2	3,684	0.01	0.58
2041	35%	9,675	8,100,885	1.2	3,769	0.010	0.59
2042	35%	8,723	7,585,660	1.0	3,529	0.009	0.55
2043	35%	8,197	7,302,481	0.92	3,397	0.008	0.53
2044	35%	7,748	6,999,955	0.82	3,256	0.008	0.51
2045	35%	4,869	4,220,656	0.45	1,963	0.005	0.31
2046	35%	2,503	1,130,504	0.15	526	0.002	0.08

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	2,595	0.86	281	0.001	0.04	25	0%	0	0
2025	3,028	1.0	330	0.001	0.05	29	0%	0	0
2026	3,626	1.2	393	0.001	0.06	35	0%	0	0
2027	4,257	1.4	439	0.001	0.07	39	0%	0	0
2028	5,060	1.7	526	0.001	0.08	47	0%	0	0
2029	6,031	2.0	632	0.002	0.10	56	0%	0	0
2030	7,066	2.4	743	0.002	0.12	66	0%	0	0
2050	8,217	2.8	872	0.003	0.14	78	0%	0	0
2032	9,494	3.2	1,017	0.003	0.16	91	0%	0	0
2033	11,004	3.8	1,176	0.004	0.18	105	0%	0	0
2034	12,911	4.5	1,386	0.004	0.22	124	0%	0	0
2035	14,935	5.3	1,619	0.005	0.25	144	0%	0	0
2036	16,783	6.4	1,962	0.006	0.31	175	0%	0	0
2037	18,732	7.5	2,328	0.007	0.37	208	0%	0	0
2038	20,725	8.7	2,699	0.008	0.42	241	0%	0	0
2039	22,925	10	3,137	0.009	0.49	280	0%	0	0
2040	25,074	11	3,619	0.01	0.57	323	0%	0	0
2041	27,099	13	4,155	0.01	0.65	370	0%	0	0
2042	28,740	14	4,704	0.01	0.74	419	0%	0	0
2043	29,658	15	5,184	0.01	0.81	462	0%	0	0
2044	30,119	16	5,634	0.02	0.89	502	0%	0	0
2045	28,407	15	5,643	0.02	0.89	503	0%	0	0
2046	27,387	14	5,770	0.02	0.91	514	0%	0	0
2047	24,660	12	5,397	0.01	0.85	481	0%	0	0
2048	23,198	11	5,206	0.01	0.82	464	0%	0	0
2049	21,872	10	4,978	0.01	0.78	444	0%	0	0
2050	13,695	5.4	2,992	0.007	0.47	267	0%	0	0
2051	7,053	1.8	1,226	0.004	0.19	109	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	260	337,270	0%	0	0	86%	2,219	3,204,066
2025	10%	303	395,918	0%	0	0	84%	2,534	3,682,036
2026	10%	363	471,136	0%	0	0	81%	2,937	4,240,226
2027	15%	639	789,915	0%	0	0	72%	3,076	4,227,507
2028	15%	759	945,969	0%	0	0	68%	3,441	4,764,882
2029	20%	1,206	1,514,257	0%	0	0	60%	3,619	5,047,525
2030	20%	1,413	1,780,183	0%	0	0	56%	3,957	5,538,347
2050	12%	986	1,253,331	0%	0	0	53%	4,339	6,127,395
2032	10%	949	1,218,218	0%	0	0	54%	5,127	7,309,307
2033	10%	1,100	1,409,784	0%	0	0	54%	5,942	8,458,701
2034	10%	1,291	1,660,800	0%	0	0	54%	6,972	9,964,800
2035	12%	1,792	2,327,866	0%	0	0	53%	7,885	11,380,679
2036	12%	2,014	2,822,001	0%	0	0	53%	8,861	13,796,450
2037	12%	2,248	3,348,517	0%	0	0	53%	9,890	16,370,527
2038	12%	2,487	3,881,574	0%	0	0	53%	10,943	18,976,585
2039	12%	2,751	4,511,626	0%	0	0	53%	12,105	22,056,839
2040	12%	3,009	5,204,512	0%	0	0	53%	13,239	25,444,282
2041	12%	3,252	5,974,789	0%	0	0	53%	14,308	29,210,080
2042	12%	3,449	6,765,245	0%	0	0	53%	15,175	33,074,532
2043	12%	3,559	7,455,772	0%	0	0	53%	15,660	36,450,439
2044	12%	3,614	8,101,789	0%	0	0	53%	15,903	39,608,744
2045	12%	3,409	8,115,025	0%	0	0	53%	14,999	39,673,455
2046	12%	3,286	8,297,953	0%	0	0	53%	14,461	40,567,771
2047	12%	2,959	7,761,898	0%	0	0	53%	13,021	37,947,059
2048	12%	2,784	7,487,127	0%	0	0	53%	12,249	36,603,732
2049	12%	2,625	7,158,856	0%	0	0	53%	11,549	34,998,851
2050	12%	1,643	4,302,930	0%	0	0	53%	7,231	21,036,548
2051	12%	846	1,763,371	0%	0	0	53%	3,724	8,620,923

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	5%	117	50,114	0.10	269	0.001	0.04
2025	6%	191	82,360	0.11	310	0.001	0.05
2026	9%	326	140,010	0.13	358	0.001	0.06
2027	13%	543	221,702	0.15	383	0.001	0.06
2028	17%	860	354,002	0.18	437	0.001	0.07
2029	20%	1,206	500,001	0.22	505	0.001	0.08
2030	24%	1,696	705,370	0.25	564	0.002	0.09
2050	35%	2,892	1,213,943	0.23	565	0.002	0.09
2032	36%	3,418	1,448,100	0.26	651	0.002	0.10
2033	36%	3,961	1,675,814	0.30	753	0.002	0.12
2034	36%	4,648	1,974,199	0.35	887	0.003	0.14
2035	35%	5,257	2,254,709	0.44	1,049	0.003	0.16
2036	35%	5,907	2,733,315	0.53	1,272	0.004	0.20
2037	35%	6,594	3,243,284	0.62	1,509	0.005	0.24
2038	35%	7,295	3,759,589	0.72	1,749	0.005	0.27
2039	35%	8,070	4,369,840	0.84	2,033	0.006	0.32
2040	35%	8,826	5,040,951	1.0	2,345	0.007	0.37
2041	35%	9,539	5,787,020	1.1	2,692	0.008	0.42
2042	35%	10,117	6,552,635	1.2	3,048	0.009	0.48
2043	35%	10,440	7,221,460	1.3	3,359	0.009	0.53
2044	35%	10,602	7,847,175	1.3	3,651	0.01	0.57
2045	35%	9,999	7,859,995	1.2	3,657	0.01	0.57
2046	35%	9,640	8,037,175	1.2	3,739	0.010	0.59
2047	35%	8,680	7,517,967	1.0	3,497	0.009	0.55
2048	35%	8,166	7,251,830	0.91	3,374	0.008	0.53
2049	35%	7,699	6,933,876	0.81	3,226	0.008	0.51
2050	35%	4,821	4,167,703	0.45	1,939	0.005	0.30
2051	35%	2,483	1,707,953	0.15	795	0.002	0.12

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	100%	12,688	44,579,225
2019	12,851	5.6	3,844	0.007	0.60	343	100%	12,851	46,069,473
2020	8,537	3.3	2,461	0.004	0.39	219	100%	8,537	29,496,897
2021	4,246	1.1	575	0.002	0.09	51	100%	4,246	6,891,960

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	5.9	3,720	0.007	0.58
2019	0%	0	0	5.6	3,844	0.007	0.60
2020	0%	0	0	3.3	2,461	0.004	0.39
2021	0%	0	0	1.1	575	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	100%	15,699	46,494,284
2019	15,755	7.5	4,119	0.008	0.65	367	100%	15,755	49,364,115
2020	14,758	7.0	4,076	0.008	0.64	363	100%	14,758	48,851,177
2021	13,866	6.3	3,442	0.008	0.54	307	100%	13,866	41,250,943
2022	13,999	6.1	3,590	0.008	0.56	320	100%	13,999	43,027,237
2023	9,671	3.7	2,395	0.005	0.38	213	100%	9,671	28,707,076
2024	4,843	1.3	599	0.003	0.09	53	0%	0	0

	Federal Low NOx DSL			**CA Cert. Low NOx DSL**			**Low NOx NG**		
Model Year	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	484	717,286	86%	4,141	6,132,798	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	7.6	3,880	0.008	0.61
2019	0%	0	0	7.5	4,119	0.008	0.65
2020	0%	0	0	7.0	4,076	0.008	0.64
2021	0%	0	0	6.3	3,442	0.008	0.54
2022	0%	0	0	6.1	3,590	0.008	0.56
2023	0%	0	0	3.7	2,395	0.005	0.38
2024	5%	218	106,580	0.14	572	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	166	0.09	8.9	0.000	0.001	0.79	100%	166	106,532
1988	223	0.13	12	0.000	0.002	1.1	100%	223	144,024
1989	279	0.16	15	0.000	0.002	1.3	100%	279	179,202
1990	256	0.15	14	0.000	0.002	1.3	100%	256	168,297
1991	221	0.14	11	0.000	0.002	1.0	100%	221	134,880
1992	173	0.11	9.2	0.000	0.001	0.82	100%	173	110,429
1993	132	0.09	7.5	0.000	0.001	0.67	100%	132	90,308
1994	131	0.08	7.6	0.000	0.001	0.68	100%	131	91,104
1995	161	0.11	10	0.000	0.002	0.87	100%	161	116,335
1996	159	0.11	10	0.000	0.002	0.85	100%	159	114,485
1997	155	0.10	9.1	0.000	0.001	0.81	100%	155	108,509
1998	145	0.10	10	0.000	0.001	0.85	100%	145	114,337
1999	197	0.17	13	0.000	0.002	1.2	100%	197	160,607
2000	233	0.20	16	0.000	0.002	1.4	100%	233	188,016
2001	267	0.20	16	0.000	0.003	1.4	100%	267	193,494
2002	300	0.21	17	0.000	0.003	1.5	100%	300	200,551
2003	272	0.13	17	0.000	0.003	1.5	100%	272	200,037
2004	276	0.12	17	0.000	0.003	1.5	100%	276	198,929
2005	353	0.15	22	0.000	0.003	1.9	100%	353	259,740
2006	403	0.18	25	0.000	0.004	2.3	100%	403	303,073
2007	543	0.22	35	0.000	0.006	3.1	100%	543	422,431
2008	564	0.14	29	0.000	0.005	2.6	100%	564	352,228
2009	654	0.15	34	0.000	0.005	3.1	100%	654	410,832
2010	337	0.07	18	0.000	0.003	1.6	100%	337	211,381
2011	419	0.05	21	0.000	0.003	1.9	100%	419	253,413
2012	18,775	6.3	2,125	0.004	0.33	189	100%	18,775	25,469,698
2013	10,866	5.2	1,931	0.003	0.30	172	100%	10,866	23,141,590
2014	12,373	4.9	1,993	0.004	0.31	178	100%	12,373	23,884,682
2015	22,601	8.0	3,471	0.007	0.55	309	100%	22,601	41,601,211
2016	25,559	9.1	3,866	0.010	0.61	345	100%	25,559	46,327,589
2017	29,560	9.2	4,023	0.009	0.63	359	100%	29,560	48,215,934
2018	10,153	3.8	1,588	0.004	0.25	142	100%	10,153	19,030,587
2019	11,512	4.5	1,861	0.004	0.29	166	100%	11,512	22,305,607
2020	13,043	5.4	2,255	0.005	0.35	201	100%	13,043	27,025,846
2021	14,295	6.2	2,272	0.006	0.36	203	100%	14,295	27,231,919
2022	16,417	7.5	2,835	0.007	0.45	253	100%	16,417	33,979,835
2023	22,059	12	4,261	0.010	0.67	380	100%	22,059	51,063,434
2024	21,715	11	3,988	0.01	0.63	355	0%	0	0
2025	22,619	12	4,524	0.01	0.71	403	0%	0	0
2026	22,104	12	4,758	0.01	0.75	424	0%	0	0
2027	21,594	11	4,671	0.01	0.73	416	0%	0	0
2028	19,744	10	4,452	0.01	0.70	397	0%	0	0
2029	18,560	9.0	4,281	0.01	0.67	382	0%	0	0
2030	17,915	8.2	4,205	0.01	0.66	375	0%	0	0
2031	11,497	4.6	2,590	0.006	0.41	231	0%	0	0
2032	5,864	1.6	694	0.003	0.11	62	0%	0	0

Table A-34. NOx and GHG Tailpipe Emissions for Scenario 5 in Calendar Year 2031
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	2,171	4,779,835	86%	18,566	40,867,590	0%	0	0
2025	10%	2,262	5,421,301	84%	18,932	45,376,287	0%	0	0
2026	10%	2,210	5,702,550	81%	17,904	46,190,652	0%	0	0
2027	15%	3,239	8,396,467	72%	15,602	40,442,982	0%	0	0
2028	15%	2,962	8,002,355	68%	13,426	36,277,344	0%	0	0
2029	20%	3,712	10,260,841	60%	11,136	30,782,524	0%	0	0
2030	20%	3,583	10,079,515	56%	10,032	28,222,643	0%	0	0
2031	20%	2,299	6,209,013	52%	5,979	16,143,435	0%	0	0
2032	10%	586	831,861	54%	3,166	4,492,048	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.09	8.9	0.000	0.001
1988	0%	0	0	0.13	12	0.000	0.002
1989	0%	0	0	0.16	15	0.000	0.002
1990	0%	0	0	0.15	14	0.000	0.002
1991	0%	0	0	0.14	11	0.000	0.002
1992	0%	0	0	0.11	9.2	0.000	0.001
1993	0%	0	0	0.09	7.5	0.000	0.001
1994	0%	0	0	0.08	7.6	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.10	9.1	0.000	0.001
1998	0%	0	0	0.10	10	0.000	0.001
1999	0%	0	0	0.17	13	0.000	0.002
2000	0%	0	0	0.20	16	0.000	0.002
2001	0%	0	0	0.20	16	0.000	0.003
2002	0%	0	0	0.21	17	0.000	0.003
2003	0%	0	0	0.13	17	0.000	0.003
2004	0%	0	0	0.12	17	0.000	0.003
2005	0%	0	0	0.15	22	0.000	0.003
2006	0%	0	0	0.18	25	0.000	0.004
2007	0%	0	0	0.22	35	0.000	0.006
2008	0%	0	0	0.14	29	0.000	0.005
2009	0%	0	0	0.15	34	0.000	0.005
2010	0%	0	0	0.07	18	0.000	0.003
2011	0%	0	0	0.05	21	0.000	0.003
2012	0%	0	0	6.3	2,125	0.004	0.33
2013	0%	0	0	5.2	1,931	0.003	0.30
2014	0%	0	0	4.9	1,993	0.004	0.31
2015	0%	0	0	8.0	3,471	0.007	0.55
2016	0%	0	0	9.1	3,866	0.010	0.61
2017	0%	0	0	9.2	4,023	0.009	0.63
2018	0%	0	0	3.8	1,588	0.004	0.25
2019	0%	0	0	4.5	1,861	0.004	0.29
2020	0%	0	0	5.4	2,255	0.005	0.35
2021	0%	0	0	6.2	2,272	0.006	0.36
2022	0%	0	0	7.5	2,835	0.007	0.45
2023	0%	0	0	12	4,261	0.010	0.67
2024	5%	977	710,226	1.2	3,809	0.01	0.60
2025	6%	1,425	1,127,756	1.3	4,239	0.01	0.67
2026	9%	1,989	1,694,660	1.2	4,330	0.01	0.68
2027	13%	2,753	2,356,604	1.2	4,075	0.01	0.64
2028	17%	3,357	2,994,653	1.1	3,695	0.009	0.58
2029	20%	3,712	3,388,083	1.0	3,425	0.009	0.54
2030	24%	4,300	3,993,852	0.87	3,196	0.008	0.50
2031	28%	3,219	2,870,263	0.47	1,865	0.004	0.29
2032	36%	2,111	988,836	0.12	444	0.002	0.07

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	66	0.04	3.5	0.000	0.001	0.31	100%	66	42,043
1994	83	0.05	4.2	0.000	0.001	0.38	100%	83	50,721
1995	115	0.07	5.9	0.000	0.001	0.53	100%	115	70,970
1996	119	0.07	6.1	0.000	0.001	0.54	100%	119	72,842
1997	117	0.06	5.9	0.000	0.001	0.52	100%	117	70,488
1998	104	0.06	5.7	0.000	0.001	0.50	100%	104	67,898
1999	133	0.10	7.6	0.000	0.001	0.67	100%	133	90,610
2000	147	0.11	8.5	0.000	0.001	0.76	100%	147	101,850
2001	161	0.11	8.8	0.000	0.001	0.79	100%	161	105,603
2002	172	0.11	9.0	0.000	0.001	0.80	100%	172	107,968
2003	146	0.06	8.3	0.000	0.001	0.74	100%	146	99,226
2004	143	0.06	8.1	0.000	0.001	0.72	100%	143	96,731
2005	178	0.07	10	0.000	0.002	0.92	100%	178	123,640
2006	202	0.09	12	0.000	0.002	1.1	100%	202	143,033
2007	272	0.11	17	0.000	0.003	1.5	100%	272	200,277
2008	292	0.07	15	0.000	0.002	1.3	100%	292	179,211
2009	346	0.08	18	0.000	0.003	1.6	100%	346	213,122
2010	183	0.04	9.3	0.000	0.001	0.83	100%	183	111,727
2011	234	0.03	11	0.000	0.002	1.0	100%	234	136,809
2012	7,969	2.4	804	0.002	0.13	72	100%	7,969	9,641,296
2013	4,340	2.0	750	0.001	0.12	67	100%	4,340	8,984,556
2014	4,954	2.0	817	0.001	0.13	73	100%	4,954	9,795,650
2015	9,674	3.7	1,601	0.003	0.25	143	100%	9,674	19,190,427
2016	10,519	3.7	1,604	0.004	0.25	143	100%	10,519	19,227,562
2017	14,184	3.9	1,723	0.004	0.27	154	100%	14,184	20,654,585
2018	4,924	1.7	692	0.002	0.11	62	100%	4,924	8,290,062
2019	5,803	1.9	807	0.002	0.13	72	100%	5,803	9,667,889
2020	6,713	2.3	945	0.002	0.15	84	100%	6,713	11,329,480
2021	7,708	2.6	942	0.003	0.15	84	100%	7,708	11,285,971
2022	9,361	3.4	1,197	0.003	0.19	107	100%	9,361	14,344,235
2023	12,311	5.2	1,799	0.004	0.28	160	100%	12,311	21,557,339
2024	14,157	5.5	1,804	0.005	0.28	161	0%	0	0
2025	15,781	6.4	2,112	0.006	0.33	188	0%	0	0
2026	17,659	7.5	2,484	0.007	0.39	221	0%	0	0
2027	19,532	8.7	2,768	0.008	0.44	247	0%	0	0
2028	21,365	10	3,236	0.010	0.51	288	0%	0	0
2029	22,985	11	3,748	0.01	0.59	334	0%	0	0
2030	24,081	12	4,213	0.01	0.66	375	0%	0	0
2037	24,791	13	4,671	0.01	0.73	416	0%	0	0
2032	24,114	13	4,857	0.01	0.76	433	0%	0	0
2033	23,670	12	5,060	0.01	0.80	451	0%	0	0
2034	21,948	11	4,883	0.01	0.77	435	0%	0	0
2035	20,791	10	4,742	0.01	0.75	423	0%	0	0
2036	19,699	9.0	4,573	0.01	0.72	408	0%	0	0
2037	12,409	5.0	2,773	0.007	0.44	247	0%	0	0
2038	6,391	1.7	743	0.003	0.12	66	0%	0	0

Table A-35. NOx and GHG Tailpipe Emissions for Scenario 5 in Calendar Year 2037

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	1,416	2,161,542	86%	12,104	18,481,185	0%	0	0
2025	10%	1,578	2,531,043	84%	13,209	21,184,827	0%	0	0
2026	10%	1,766	2,977,192	81%	14,304	24,115,258	0%	0	0
2027	15%	2,930	4,975,264	72%	14,112	23,964,188	0%	0	0
2028	15%	3,205	5,817,346	68%	14,528	26,371,967	0%	0	0
2029	20%	4,597	8,983,030	60%	13,791	26,949,090	0%	0	0
2030	20%	4,816	10,097,767	56%	13,485	28,273,746	0%	0	0
2037	12%	2,975	6,717,948	53%	13,090	29,558,969	0%	0	0
2032	10%	2,411	5,821,019	54%	13,022	31,433,503	0%	0	0
2033	10%	2,367	6,063,891	54%	12,782	32,745,011	0%	0	0
2034	10%	2,195	5,851,702	54%	11,852	31,599,191	0%	0	0
2035	12%	2,495	6,819,958	53%	10,978	30,007,813	0%	0	0
2036	12%	2,364	6,576,732	53%	10,401	28,937,620	0%	0	0
2037	12%	1,489	3,988,015	53%	6,552	17,547,268	0%	0	0
2038	12%	767	1,068,563	53%	3,375	4,701,677	0%	0	0

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**NO_X**	**CO_2**	**CH_4**	**N_2O**
1993	0%	0	0	0.04	3.5	0.000	0.001
1994	0%	0	0	0.05	4.2	0.000	0.001
1995	0%	0	0	0.07	5.9	0.000	0.001
1996	0%	0	0	0.07	6.1	0.000	0.001
1997	0%	0	0	0.06	5.9	0.000	0.001
1998	0%	0	0	0.06	5.7	0.000	0.001
1999	0%	0	0	0.10	7.6	0.000	0.001
2000	0%	0	0	0.11	8.5	0.000	0.001
2001	0%	0	0	0.11	8.8	0.000	0.001
2002	0%	0	0	0.11	9.0	0.000	0.001
2003	0%	0	0	0.06	8.3	0.000	0.001
2004	0%	0	0	0.06	8.1	0.000	0.001
2005	0%	0	0	0.07	10	0.000	0.002
2006	0%	0	0	0.09	12	0.000	0.002
2007	0%	0	0	0.11	17	0.000	0.003
2008	0%	0	0	0.07	15	0.000	0.002
2009	0%	0	0	0.08	18	0.000	0.003
2010	0%	0	0	0.04	9.3	0.000	0.001
2011	0%	0	0	0.03	11	0.000	0.002
2012	0%	0	0	2.4	804	0.002	0.13
2013	0%	0	0	2.0	750	0.001	0.12
2014	0%	0	0	2.0	817	0.001	0.13
2015	0%	0	0	3.7	1,601	0.003	0.25
2016	0%	0	0	3.7	1,604	0.004	0.25
2017	0%	0	0	3.9	1,723	0.004	0.27
2018	0%	0	0	1.7	692	0.002	0.11
2019	0%	0	0	1.9	807	0.002	0.13
2020	0%	0	0	2.3	945	0.002	0.15
2021	0%	0	0	2.6	942	0.003	0.15
2022	0%	0	0	3.4	1,197	0.003	0.19
2023	0%	0	0	5.2	1,799	0.004	0.28
2024	5%	637	321,179	0.61	1,722	0.005	0.27
2025	6%	994	526,515	0.70	1,979	0.006	0.31
2026	9%	1,589	884,750	0.80	2,261	0.007	0.36
2027	13%	2,490	1,396,388	1.0	2,415	0.007	0.38
2028	17%	3,632	2,176,976	1.1	2,686	0.008	0.42
2029	20%	4,597	2,966,155	1.2	2,998	0.009	0.47
2030	24%	5,779	4,001,083	1.3	3,202	0.009	0.50
2037	35%	8,727	6,506,824	1.1	3,027	0.008	0.48
2032	36%	8,681	6,919,465	1.0	3,109	0.009	0.49
2033	36%	8,521	7,208,168	1.0	3,238	0.008	0.51
2034	36%	7,901	6,955,938	0.88	3,125	0.008	0.49
2035	35%	7,318	6,605,628	0.83	3,073	0.008	0.48
2036	35%	6,934	6,370,046	0.74	2,963	0.007	0.47
2037	35%	4,368	3,862,685	0.41	1,797	0.004	0.28
2038	35%	2,250	1,034,981	0.14	481	0.002	0.08

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
2001	0	0	0	0	0	0	0%	0	0
2002	0	0	0	0	0	0	0%	0	0
2003	0	0	0	0	0	0	0%	0	0
2004	0	0	0	0	0	0	0%	0	0
2005	0	0	0	0	0	0	0%	0	0
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	5,738	1.9	631	0.002	0.10	56	0%	0	0
2025	6,682	2.2	740	0.002	0.12	66	0%	0	0
2026	7,830	2.6	869	0.002	0.14	77	0%	0	0
2027	8,960	3.0	954	0.003	0.15	85	0%	0	0
2028	10,297	3.5	1,096	0.003	0.17	98	0%	0	0
2029	11,921	4.1	1,276	0.004	0.20	114	0%	0	0
2030	13,807	4.8	1,488	0.005	0.23	133	0%	0	0
2045	15,655	5.9	1,819	0.006	0.29	162	0%	0	0
2032	17,813	7.1	2,196	0.007	0.35	196	0%	0	0
2033	20,003	8.3	2,581	0.008	0.41	230	0%	0	0
2034	22,623	10	3,067	0.009	0.48	273	0%	0	0
2035	24,976	11	3,584	0.01	0.56	319	0%	0	0
2036	26,967	13	4,118	0.01	0.65	367	0%	0	0
2037	28,599	14	4,677	0.01	0.74	417	0%	0	0
2038	29,556	15	5,172	0.01	0.81	461	0%	0	0
2039	30,085	16	5,646	0.02	0.89	503	0%	0	0
2040	28,520	15	5,685	0.02	0.89	507	0%	0	0
2041	27,485	14	5,816	0.02	0.91	518	0%	0	0
2042	24,780	12	5,446	0.01	0.86	485	0%	0	0
2043	23,286	11	5,243	0.01	0.82	467	0%	0	0
2044	22,012	10	5,025	0.01	0.79	448	0%	0	0
2045	13,831	5.5	3,030	0.007	0.48	270	0%	0	0
2046	7,111	1.9	812	0.004	0.13	72	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	574	756,340	86%	4,906	6,466,708	0%	0	0
2025	10%	668	886,781	84%	5,593	7,422,360	0%	0	0
2026	10%	783	1,041,761	81%	6,343	8,438,266	0%	0	0
2027	15%	1,344	1,715,605	72%	6,474	8,263,496	0%	0	0
2028	15%	1,544	1,969,828	68%	7,002	8,929,888	0%	0	0
2029	20%	2,384	3,059,507	60%	7,152	9,178,520	0%	0	0
2030	20%	2,761	3,566,433	56%	7,732	9,986,012	0%	0	0
2045	12%	1,879	2,615,706	53%	8,266	11,509,105	0%	0	0
2032	10%	1,781	2,631,722	54%	9,619	14,211,299	0%	0	0
2033	10%	2,000	3,093,484	54%	10,802	16,704,815	0%	0	0
2034	10%	2,262	3,676,051	54%	12,217	19,850,678	0%	0	0
2035	12%	2,997	5,154,227	53%	13,188	22,678,598	0%	0	0
2036	12%	3,236	5,922,773	53%	14,239	26,060,201	0%	0	0
2037	12%	3,432	6,725,482	53%	15,100	29,592,121	0%	0	0
2038	12%	3,547	7,438,400	53%	15,606	32,728,962	0%	0	0
2039	12%	3,610	8,118,998	53%	15,885	35,723,589	0%	0	0
2040	12%	3,422	8,176,299	53%	15,058	35,975,717	0%	0	0
2041	12%	3,298	8,363,731	53%	14,512	36,800,417	0%	0	0
2042	12%	2,974	7,831,788	53%	13,084	34,459,867	0%	0	0
2043	12%	2,794	7,539,421	53%	12,295	33,173,453	0%	0	0
2044	12%	2,641	7,227,079	53%	11,622	31,799,149	0%	0	0
2045	12%	1,660	4,357,601	53%	7,303	19,173,446	0%	0	0
2046	12%	853	1,167,185	53%	3,755	5,135,614	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2001	0%	0	0	0	0	0	0
2002	0%	0	0	0	0	0	0
2003	0%	0	0	0	0	0	0
2004	0%	0	0	0	0	0	0
2005	0%	0	0	0	0	0	0
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	5%	258	112,383	0.21	603	0.002	0.09
2025	6%	421	184,471	0.24	693	0.002	0.11
2026	9%	705	309,586	0.28	791	0.002	0.12
2027	13%	1,142	481,512	0.33	833	0.002	0.13
2028	17%	1,750	737,152	0.37	909	0.003	0.14
2029	20%	2,384	1,010,235	0.45	1,021	0.003	0.16
2030	24%	3,314	1,413,144	0.51	1,131	0.003	0.18
2045	35%	5,511	2,533,502	0.49	1,179	0.004	0.19
2032	36%	6,413	3,128,337	0.56	1,405	0.004	0.22
2033	36%	7,201	3,677,235	0.66	1,652	0.005	0.26
2034	36%	8,144	4,369,735	0.78	1,963	0.006	0.31
2035	35%	8,792	4,992,246	0.94	2,322	0.007	0.37
2036	35%	9,493	5,736,639	1.1	2,669	0.008	0.42
2037	35%	10,067	6,514,121	1.2	3,030	0.009	0.48
2038	35%	10,404	7,204,635	1.2	3,352	0.009	0.53
2039	35%	10,590	7,863,843	1.3	3,658	0.01	0.58
2040	35%	10,039	7,919,344	1.2	3,684	0.01	0.58
2041	35%	9,675	8,100,885	1.2	3,769	0.010	0.59
2042	35%	8,723	7,585,660	1.0	3,529	0.009	0.55
2043	35%	8,197	7,302,481	0.92	3,397	0.008	0.53
2044	35%	7,748	6,999,955	0.82	3,256	0.008	0.51
2045	35%	4,869	4,220,656	0.45	1,963	0.005	0.31
2046	35%	2,503	1,130,504	0.15	526	0.002	0.08

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	**Population**	**NOx_TOTEX (tons/day)**	**CO2_TOTEX (tons/day)**	**CH4_TOTEX (tons/day)**	**N2O_TOTEX (tons/day)**	**Fuel Consumption (1000 gal/day)**	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	2,595	0.86	281	0.001	0.04	25	0%	0	0
2025	3,028	1.0	330	0.001	0.05	29	0%	0	0
2026	3,626	1.2	393	0.001	0.06	35	0%	0	0
2027	4,257	1.4	439	0.001	0.07	39	0%	0	0
2028	5,060	1.7	526	0.001	0.08	47	0%	0	0
2029	6,031	2.0	632	0.002	0.10	56	0%	0	0
2030	7,066	2.4	743	0.002	0.12	66	0%	0	0
2050	8,217	2.8	872	0.003	0.14	78	0%	0	0
2032	9,494	3.2	1,017	0.003	0.16	91	0%	0	0
2033	11,004	3.8	1,176	0.004	0.18	105	0%	0	0
2034	12,911	4.5	1,386	0.004	0.22	124	0%	0	0
2035	14,935	5.3	1,619	0.005	0.25	144	0%	0	0
2036	16,783	6.4	1,962	0.006	0.31	175	0%	0	0
2037	18,732	7.5	2,328	0.007	0.37	208	0%	0	0
2038	20,725	8.7	2,699	0.008	0.42	241	0%	0	0
2039	22,925	10	3,137	0.009	0.49	280	0%	0	0
2040	25,074	11	3,619	0.01	0.57	323	0%	0	0
2041	27,099	13	4,155	0.01	0.65	370	0%	0	0
2042	28,740	14	4,704	0.01	0.74	419	0%	0	0
2043	29,658	15	5,184	0.01	0.81	462	0%	0	0
2044	30,119	16	5,634	0.02	0.89	502	0%	0	0
2045	28,407	15	5,643	0.02	0.89	503	0%	0	0
2046	27,387	14	5,770	0.02	0.91	514	0%	0	0
2047	24,660	12	5,397	0.01	0.85	481	0%	0	0
2048	23,198	11	5,206	0.01	0.82	464	0%	0	0
2049	21,872	10	4,978	0.01	0.78	444	0%	0	0
2050	13,695	5.4	2,992	0.007	0.47	267	0%	0	0
2051	7,053	1.8	1,226	0.004	0.19	109	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	260	337,270	86%	2,219	2,883,660	0%	0	0
2025	10%	303	395,918	84%	2,534	3,313,832	0%	0	0
2026	10%	363	471,136	81%	2,937	3,816,203	0%	0	0
2027	15%	639	789,915	72%	3,076	3,804,757	0%	0	0
2028	15%	759	945,969	68%	3,441	4,288,394	0%	0	0
2029	20%	1,206	1,514,257	60%	3,619	4,542,772	0%	0	0
2030	20%	1,413	1,780,183	56%	3,957	4,984,512	0%	0	0
2050	12%	986	1,253,331	53%	4,339	5,514,655	0%	0	0
2032	10%	949	1,218,218	54%	5,127	6,578,377	0%	0	0
2033	10%	1,100	1,409,784	54%	5,942	7,612,831	0%	0	0
2034	10%	1,291	1,660,800	54%	6,972	8,968,320	0%	0	0
2035	12%	1,792	2,327,866	53%	7,885	10,242,611	0%	0	0
2036	12%	2,014	2,822,001	53%	8,861	12,416,805	0%	0	0
2037	12%	2,248	3,348,517	53%	9,890	14,733,474	0%	0	0
2038	12%	2,487	3,881,574	53%	10,943	17,078,926	0%	0	0
2039	12%	2,751	4,511,626	53%	12,105	19,851,155	0%	0	0
2040	12%	3,009	5,204,512	53%	13,239	22,899,854	0%	0	0
2041	12%	3,252	5,974,789	53%	14,308	26,289,072	0%	0	0
2042	12%	3,449	6,765,245	53%	15,175	29,767,079	0%	0	0
2043	12%	3,559	7,455,772	53%	15,660	32,805,395	0%	0	0
2044	12%	3,614	8,101,789	53%	15,903	35,647,870	0%	0	0
2045	12%	3,409	8,115,025	53%	14,999	35,706,110	0%	0	0
2046	12%	3,286	8,297,953	53%	14,461	36,510,994	0%	0	0
2047	12%	2,959	7,761,898	53%	13,021	34,152,353	0%	0	0
2048	12%	2,784	7,487,127	53%	12,249	32,943,359	0%	0	0
2049	12%	2,625	7,158,856	53%	11,549	31,498,966	0%	0	0
2050	12%	1,643	4,302,930	53%	7,231	18,932,893	0%	0	0
2051	12%	846	1,763,371	53%	3,724	7,758,831	0%	0	0

Table A-37. NOx and GHG Tailpipe Emissions for Scenario 5 in Calendar Year 2050
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	5%	117	50,114	0.10	269	0.001	0.04
2025	6%	191	82,360	0.11	310	0.001	0.05
2026	9%	326	140,010	0.13	358	0.001	0.06
2027	13%	543	221,702	0.15	383	0.001	0.06
2028	17%	860	354,002	0.18	437	0.001	0.07
2029	20%	1,206	500,001	0.22	505	0.001	0.08
2030	24%	1,696	705,370	0.25	564	0.002	0.09
2050	35%	2,892	1,213,943	0.23	565	0.002	0.09
2032	36%	3,418	1,448,100	0.26	651	0.002	0.10
2033	36%	3,961	1,675,814	0.30	753	0.002	0.12
2034	36%	4,648	1,974,199	0.35	887	0.003	0.14
2035	35%	5,257	2,254,709	0.44	1,049	0.003	0.16
2036	35%	5,907	2,733,315	0.53	1,272	0.004	0.20
2037	35%	6,594	3,243,284	0.62	1,509	0.005	0.24
2038	35%	7,295	3,759,589	0.72	1,749	0.005	0.27
2039	35%	8,070	4,369,840	0.84	2,033	0.006	0.32
2040	35%	8,826	5,040,951	1.0	2,345	0.007	0.37
2041	35%	9,539	5,787,020	1.1	2,692	0.008	0.42
2042	35%	10,117	6,552,635	1.2	3,048	0.009	0.48
2043	35%	10,440	7,221,460	1.3	3,359	0.009	0.53
2044	35%	10,602	7,847,175	1.3	3,651	0.01	0.57
2045	35%	9,999	7,859,995	1.2	3,657	0.01	0.57
2046	35%	9,640	8,037,175	1.2	3,739	0.010	0.59
2047	35%	8,680	7,517,967	1.0	3,497	0.009	0.55
2048	35%	8,166	7,251,830	0.91	3,374	0.008	0.53
2049	35%	7,699	6,933,876	0.81	3,226	0.008	0.51
2050	35%	4,821	4,167,703	0.45	1,939	0.005	0.30
2051	35%	2,483	1,707,953	0.15	795	0.002	0.12

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	29	0.02	1.7	0.000	0.000	0.15	100%	29	19,871
1977	34	0.02	2.3	0.000	0.000	0.20	100%	34	27,331
1978	66	0.04	3.9	0.000	0.001	0.35	100%	66	47,207
1979	94	0.05	5.0	0.000	0.001	0.44	100%	94	59,761
1980	87	0.05	5.1	0.000	0.001	0.45	100%	87	61,143
1981	258	0.15	15	0.000	0.002	1.3	100%	258	180,361
1982	236	0.13	13	0.000	0.002	1.2	100%	236	156,209
1983	219	0.13	13	0.000	0.002	1.1	100%	219	151,257
1984	274	0.18	18	0.000	0.003	1.6	100%	274	214,575
1985	404	0.25	25	0.000	0.004	2.2	100%	404	301,188
1986	396	0.25	25	0.000	0.004	2.2	100%	396	301,092
1987	426	0.29	27	0.000	0.004	2.4	100%	426	324,223
1988	484	0.34	32	0.000	0.005	2.9	100%	484	387,591
1989	567	0.40	38	0.000	0.006	3.4	100%	567	454,438
1990	539	0.39	37	0.000	0.006	3.3	100%	539	446,862
1991	475	0.34	28	0.000	0.004	2.5	100%	475	335,098
1992	399	0.31	25	0.000	0.004	2.2	100%	399	301,877
1993	363	0.29	25	0.000	0.004	2.2	100%	363	295,585
1994	379	0.31	28	0.000	0.004	2.5	100%	379	330,512
1995	507	0.41	37	0.000	0.006	3.3	100%	507	443,837
1996	1,142	1.8	150	0.006	0.02	13	100%	1,142	1,800,897
1997	1,167	1.8	149	0.006	0.02	13	100%	1,167	1,790,241
1998	1,370	2.2	192	0.008	0.03	17	100%	1,370	2,305,455
1999	1,972	4.1	291	0.01	0.05	26	100%	1,972	3,484,066
2000	4,067	9.0	641	0.02	0.10	57	100%	4,067	7,683,603
2001	3,153	6.6	476	0.02	0.07	42	100%	3,153	5,706,180
2002	2,427	4.6	338	0.01	0.05	30	100%	2,427	4,046,083
2003	2,907	3.5	425	0.01	0.07	38	100%	2,907	5,088,912
2004	2,913	3.0	421	0.01	0.07	38	100%	2,913	5,047,803
2005	4,812	5.1	719	0.02	0.11	64	100%	4,812	8,613,212
2006	5,968	6.9	972	0.03	0.15	87	100%	5,968	11,650,876
2007	8,303	9.5	1,454	0.03	0.23	130	100%	8,303	17,419,576
2008	12,274	13	2,417	0.02	0.38	215	100%	12,274	28,960,284
2009	14,354	16	3,080	0.03	0.48	275	100%	14,354	36,913,677
2010	11,383	13	2,653	0.02	0.42	236	100%	11,383	31,795,323
2011	13,627	10	3,166	0.01	0.50	282	100%	13,627	37,940,166
2012	39,297	19	6,724	0.01	1.1	599	100%	39,297	80,581,115
2013	21,084	14	5,397	0.010	0.85	481	100%	21,084	64,680,893
2014	23,061	12	5,525	0.01	0.87	492	100%	23,061	66,207,976
2015	28,916	14	7,779	0.02	1.2	693	100%	28,916	93,222,050
2016	41,998	22	12,488	0.02	2.0	1,113	100%	41,998	149,658,452
2017	16,101	6.6	3,944	0.008	0.62	351	100%	16,101	47,265,405
2018	12,688	5.9	3,720	0.007	0.58	332	100%	12,688	44,579,225
2019	12,851	5.6	3,844	0.007	0.60	343	100%	12,851	46,069,473
2020	8,537	3.3	2,461	0.004	0.39	219	100%	8,537	29,496,897
2021	4,246	1.1	575	0.002	0.09	51	100%	4,246	6,891,960

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1976	0%	0	0	0%	0	0	0%	0	0
1977	0%	0	0	0%	0	0	0%	0	0
1978	0%	0	0	0%	0	0	0%	0	0
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1976	0%	0	0	0.02	1.7	0.000	0.000
1977	0%	0	0	0.02	2.3	0.000	0.000
1978	0%	0	0	0.04	3.9	0.000	0.001
1979	0%	0	0	0.05	5.0	0.000	0.001
1980	0%	0	0	0.05	5.1	0.000	0.001
1981	0%	0	0	0.15	15	0.000	0.002
1982	0%	0	0	0.13	13	0.000	0.002
1983	0%	0	0	0.13	13	0.000	0.002
1984	0%	0	0	0.18	18	0.000	0.003
1985	0%	0	0	0.25	25	0.000	0.004
1986	0%	0	0	0.25	25	0.000	0.004
1987	0%	0	0	0.29	27	0.000	0.004
1988	0%	0	0	0.34	32	0.000	0.005
1989	0%	0	0	0.40	38	0.000	0.006
1990	0%	0	0	0.39	37	0.000	0.006
1991	0%	0	0	0.34	28	0.000	0.004
1992	0%	0	0	0.31	25	0.000	0.004
1993	0%	0	0	0.29	25	0.000	0.004
1994	0%	0	0	0.31	28	0.000	0.004
1995	0%	0	0	0.41	37	0.000	0.006
1996	0%	0	0	1.8	150	0.006	0.02
1997	0%	0	0	1.8	149	0.006	0.02
1998	0%	0	0	2.2	192	0.008	0.03
1999	0%	0	0	4.1	291	0.01	0.05
2000	0%	0	0	9.0	641	0.02	0.10
2001	0%	0	0	6.6	476	0.02	0.07
2002	0%	0	0	4.6	338	0.01	0.05
2003	0%	0	0	3.5	425	0.01	0.07
2004	0%	0	0	3.0	421	0.01	0.07
2005	0%	0	0	5.1	719	0.02	0.11
2006	0%	0	0	6.9	972	0.03	0.15
2007	0%	0	0	9.5	1,454	0.03	0.23
2008	0%	0	0	13	2,417	0.02	0.38
2009	0%	0	0	16	3,080	0.03	0.48
2010	0%	0	0	13	2,653	0.02	0.42
2011	0%	0	0	10	3,166	0.01	0.50
2012	0%	0	0	19	6,724	0.01	1.1
2013	0%	0	0	14	5,397	0.010	0.85
2014	0%	0	0	12	5,525	0.01	0.87
2015	0%	0	0	14	7,779	0.02	1.2
2016	0%	0	0	22	12,488	0.02	2.0
2017	0%	0	0	6.6	3,944	0.008	0.62
2018	0%	0	0	5.9	3,720	0.007	0.58
2019	0%	0	0	5.6	3,844	0.007	0.60
2020	0%	0	0	3.3	2,461	0.004	0.39
2021	0%	0	0	1.1	575	0.002	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	53	0.03	2.9	0.000	0.000	0.26	100%	53	35,019
1980	64	0.04	3.7	0.000	0.001	0.33	100%	64	44,086
1981	209	0.12	12	0.000	0.002	1.1	100%	209	142,790
1982	208	0.11	11	0.000	0.002	1.0	100%	208	134,214
1983	196	0.11	11	0.000	0.002	1.0	100%	196	131,088
1984	241	0.15	15	0.000	0.002	1.3	100%	241	176,822
1985	357	0.21	21	0.000	0.003	1.9	100%	357	252,082
1986	331	0.20	20	0.000	0.003	1.8	100%	331	243,579
1987	345	0.22	21	0.000	0.003	1.9	100%	345	253,082
1988	370	0.26	24	0.000	0.004	2.2	100%	370	290,997
1989	420	0.29	28	0.000	0.004	2.5	100%	420	332,355
1990	382	0.28	27	0.000	0.004	2.4	100%	382	319,401
1991	331	0.24	20	0.000	0.003	1.8	100%	331	238,471
1992	279	0.22	18	0.000	0.003	1.6	100%	279	214,037
1993	235	0.20	17	0.000	0.003	1.5	100%	235	202,566
1994	257	0.21	19	0.000	0.003	1.7	100%	257	228,163
1995	341	0.29	26	0.000	0.004	2.3	100%	341	308,497
1996	354	0.29	26	0.000	0.004	2.3	100%	354	309,827
1997	358	0.27	24	0.000	0.004	2.2	100%	358	292,799
1998	350	0.29	27	0.000	0.004	2.4	100%	350	324,850
1999	484	0.48	38	0.000	0.006	3.4	100%	484	458,610
2000	570	0.55	44	0.000	0.007	3.9	100%	570	522,449
2001	630	0.52	42	0.000	0.007	3.7	100%	630	502,288
2002	683	0.50	41	0.000	0.006	3.7	100%	683	490,906
2003	607	0.31	41	0.000	0.006	3.7	100%	607	491,836
2004	588	0.27	39	0.000	0.006	3.4	100%	588	462,594
2005	722	0.33	48	0.000	0.008	4.3	100%	722	579,188
2006	789	0.37	53	0.000	0.008	4.7	100%	789	635,640
2007	1,010	0.43	69	0.000	0.01	6.1	100%	1,010	822,391
2008	958	0.24	51	0.000	0.008	4.5	100%	958	608,971
2009	1,054	0.24	57	0.000	0.009	5.1	100%	1,054	681,595
2010	516	0.11	28	0.000	0.004	2.5	100%	516	336,250
2011	601	0.08	32	0.000	0.005	2.8	100%	601	381,333
2012	36,456	15	5,160	0.010	0.81	460	100%	36,456	61,840,416
2013	23,385	13	4,715	0.009	0.74	420	100%	23,385	56,503,770
2014	25,954	12	4,907	0.01	0.77	437	100%	25,954	58,805,403
2015	43,313	18	8,476	0.02	1.3	755	100%	43,313	101,582,009
2016	51,092	25	12,180	0.03	1.9	1,086	100%	51,092	145,975,230
2017	45,093	20	10,301	0.02	1.6	918	100%	45,093	123,455,483
2018	15,699	7.6	3,880	0.008	0.61	346	100%	15,699	46,494,284
2019	15,755	7.5	4,119	0.008	0.65	367	100%	15,755	49,364,115
2020	14,758	7.0	4,076	0.008	0.64	363	100%	14,758	48,851,177
2021	13,866	6.3	3,442	0.008	0.54	307	100%	13,866	41,250,943
2022	13,999	6.1	3,590	0.008	0.56	320	100%	13,999	43,027,237
2023	9,671	3.7	2,395	0.005	0.38	213	100%	9,671	28,707,076
2024	4,843	1.3	599	0.003	0.09	53	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1979	0%	0	0	0%	0	0	0%	0	0
1980	0%	0	0	0%	0	0	0%	0	0
1981	0%	0	0	0%	0	0	0%	0	0
1982	0%	0	0	0%	0	0	0%	0	0
1983	0%	0	0	0%	0	0	0%	0	0
1984	0%	0	0	0%	0	0	0%	0	0
1985	0%	0	0	0%	0	0	0%	0	0
1986	0%	0	0	0%	0	0	0%	0	0
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	484	717,286	90%	4,358	6,455,577	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1979	0%	0	0	0.03	2.9	0.000	0.000
1980	0%	0	0	0.04	3.7	0.000	0.001
1981	0%	0	0	0.12	12	0.000	0.002
1982	0%	0	0	0.11	11	0.000	0.002
1983	0%	0	0	0.11	11	0.000	0.002
1984	0%	0	0	0.15	15	0.000	0.002
1985	0%	0	0	0.21	21	0.000	0.003
1986	0%	0	0	0.20	20	0.000	0.003
1987	0%	0	0	0.22	21	0.000	0.003
1988	0%	0	0	0.26	24	0.000	0.004
1989	0%	0	0	0.29	28	0.000	0.004
1990	0%	0	0	0.28	27	0.000	0.004
1991	0%	0	0	0.24	20	0.000	0.003
1992	0%	0	0	0.22	18	0.000	0.003
1993	0%	0	0	0.20	17	0.000	0.003
1994	0%	0	0	0.21	19	0.000	0.003
1995	0%	0	0	0.29	26	0.000	0.004
1996	0%	0	0	0.29	26	0.000	0.004
1997	0%	0	0	0.27	24	0.000	0.004
1998	0%	0	0	0.29	27	0.000	0.004
1999	0%	0	0	0.48	38	0.000	0.006
2000	0%	0	0	0.55	44	0.000	0.007
2001	0%	0	0	0.52	42	0.000	0.007
2002	0%	0	0	0.50	41	0.000	0.006
2003	0%	0	0	0.31	41	0.000	0.006
2004	0%	0	0	0.27	39	0.000	0.006
2005	0%	0	0	0.33	48	0.000	0.008
2006	0%	0	0	0.37	53	0.000	0.008
2007	0%	0	0	0.43	69	0.000	0.01
2008	0%	0	0	0.24	51	0.000	0.008
2009	0%	0	0	0.24	57	0.000	0.009
2010	0%	0	0	0.11	28	0.000	0.004
2011	0%	0	0	0.08	32	0.000	0.005
2012	0%	0	0	15	5,160	0.010	0.81
2013	0%	0	0	13	4,715	0.009	0.74
2014	0%	0	0	12	4,907	0.01	0.77
2015	0%	0	0	18	8,476	0.02	1.3
2016	0%	0	0	25	12,180	0.03	1.9
2017	0%	0	0	20	10,301	0.02	1.6
2018	0%	0	0	7.6	3,880	0.008	0.61
2019	0%	0	0	7.5	4,119	0.008	0.65
2020	0%	0	0	7.0	4,076	0.008	0.64
2021	0%	0	0	6.3	3,442	0.008	0.54
2022	0%	0	0	6.1	3,590	0.008	0.56
2023	0%	0	0	3.7	2,395	0.005	0.38
2024	0%	0	0	0.14	599	0.003	0.09

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

	Adjusted EMFAC2017 Output[1]						Conventional DSL		
Model Year	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	166	0.09	8.9	0.000	0.001	0.79	100%	166	106,532
1988	223	0.13	12	0.000	0.002	1.1	100%	223	144,024
1989	279	0.16	15	0.000	0.002	1.3	100%	279	179,202
1990	256	0.15	14	0.000	0.002	1.3	100%	256	168,297
1991	221	0.14	11	0.000	0.002	1.0	100%	221	134,880
1992	173	0.11	9.2	0.000	0.001	0.82	100%	173	110,429
1993	132	0.09	7.5	0.000	0.001	0.67	100%	132	90,308
1994	131	0.08	7.6	0.000	0.001	0.68	100%	131	91,104
1995	161	0.11	10	0.000	0.002	0.87	100%	161	116,335
1996	159	0.11	10	0.000	0.002	0.85	100%	159	114,485
1997	155	0.10	9.1	0.000	0.001	0.81	100%	155	108,509
1998	145	0.10	10	0.000	0.001	0.85	100%	145	114,337
1999	197	0.17	13	0.000	0.002	1.2	100%	197	160,607
2000	233	0.20	16	0.000	0.002	1.4	100%	233	188,016
2001	267	0.20	16	0.000	0.003	1.4	100%	267	193,494
2002	300	0.21	17	0.000	0.003	1.5	100%	300	200,551
2003	272	0.13	17	0.000	0.003	1.5	100%	272	200,037
2004	276	0.12	17	0.000	0.003	1.5	100%	276	198,929
2005	353	0.15	22	0.000	0.003	1.9	100%	353	259,740
2006	403	0.18	25	0.000	0.004	2.3	100%	403	303,073
2007	543	0.22	35	0.000	0.006	3.1	100%	543	422,431
2008	564	0.14	29	0.000	0.005	2.6	100%	564	352,228
2009	654	0.15	34	0.000	0.005	3.1	100%	654	410,832
2010	337	0.07	18	0.000	0.003	1.6	100%	337	211,381
2011	419	0.05	21	0.000	0.003	1.9	100%	419	253,413
2012	18,775	6.3	2,125	0.004	0.33	189	100%	18,775	25,469,698
2013	10,866	5.2	1,931	0.003	0.30	172	100%	10,866	23,141,590
2014	12,373	4.9	1,993	0.004	0.31	178	100%	12,373	23,884,682
2015	22,601	8.0	3,471	0.007	0.55	309	100%	22,601	41,601,211
2016	25,559	9.1	3,866	0.010	0.61	345	100%	25,559	46,327,589
2017	29,560	9.2	4,023	0.009	0.63	359	100%	29,560	48,215,934
2018	10,153	3.8	1,588	0.004	0.25	142	100%	10,153	19,030,587
2019	11,512	4.5	1,861	0.004	0.29	166	100%	11,512	22,305,607
2020	13,043	5.4	2,255	0.005	0.35	201	100%	13,043	27,025,846
2021	14,295	6.2	2,272	0.006	0.36	203	100%	14,295	27,231,919
2022	16,417	7.5	2,835	0.007	0.45	253	100%	16,417	33,979,835
2023	22,059	12	4,261	0.010	0.67	380	100%	22,059	51,063,434
2024	21,715	11	3,988	0.01	0.63	355	0%	0	0
2025	22,619	12	4,524	0.01	0.71	403	0%	0	0
2026	22,104	12	4,758	0.01	0.75	424	0%	0	0
2027	21,594	11	4,671	0.01	0.73	416	0%	0	0
2028	19,744	10	4,452	0.01	0.70	397	0%	0	0
2029	18,560	9.0	4,281	0.01	0.67	382	0%	0	0
2030	17,915	8.2	4,205	0.01	0.66	375	0%	0	0
2031	11,497	4.6	2,590	0.006	0.41	231	0%	0	0
2032	5,864	1.6	694	0.003	0.11	62	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1987	0%	0	0	0%	0	0	0%	0	0
1988	0%	0	0	0%	0	0	0%	0	0
1989	0%	0	0	0%	0	0	0%	0	0
1990	0%	0	0	0%	0	0	0%	0	0
1991	0%	0	0	0%	0	0	0%	0	0
1992	0%	0	0	0%	0	0	0%	0	0
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	2,171	4,779,835	90%	19,543	43,018,516	0%	0	0
2025	10%	2,262	5,421,301	90%	20,358	48,791,706	0%	0	0
2026	10%	2,210	5,702,550	90%	19,894	51,322,947	0%	0	0
2027	15%	3,239	8,396,467	85%	18,355	47,579,979	0%	0	0
2028	15%	2,962	8,002,355	85%	16,783	45,346,680	0%	0	0
2029	20%	3,712	10,260,841	80%	14,848	41,043,365	0%	0	0
2030	20%	3,583	10,079,515	80%	14,332	40,318,062	0%	0	0
2031	20%	2,299	6,209,013	80%	9,198	24,836,053	0%	0	0
2032	10%	586	831,861	90%	5,277	7,486,747	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
1987	0%	0	0	0.09	8.9	0.000	0.001
1988	0%	0	0	0.13	12	0.000	0.002
1989	0%	0	0	0.16	15	0.000	0.002
1990	0%	0	0	0.15	14	0.000	0.002
1991	0%	0	0	0.14	11	0.000	0.002
1992	0%	0	0	0.11	9.2	0.000	0.001
1993	0%	0	0	0.09	7.5	0.000	0.001
1994	0%	0	0	0.08	7.6	0.000	0.001
1995	0%	0	0	0.11	10	0.000	0.002
1996	0%	0	0	0.11	10	0.000	0.002
1997	0%	0	0	0.10	9.1	0.000	0.001
1998	0%	0	0	0.10	10	0.000	0.001
1999	0%	0	0	0.17	13	0.000	0.002
2000	0%	0	0	0.20	16	0.000	0.002
2001	0%	0	0	0.20	16	0.000	0.003
2002	0%	0	0	0.21	17	0.000	0.003
2003	0%	0	0	0.13	17	0.000	0.003
2004	0%	0	0	0.12	17	0.000	0.003
2005	0%	0	0	0.15	22	0.000	0.003
2006	0%	0	0	0.18	25	0.000	0.004
2007	0%	0	0	0.22	35	0.000	0.006
2008	0%	0	0	0.14	29	0.000	0.005
2009	0%	0	0	0.15	34	0.000	0.005
2010	0%	0	0	0.07	18	0.000	0.003
2011	0%	0	0	0.05	21	0.000	0.003
2012	0%	0	0	6.3	2,125	0.004	0.33
2013	0%	0	0	5.2	1,931	0.003	0.30
2014	0%	0	0	4.9	1,993	0.004	0.31
2015	0%	0	0	8.0	3,471	0.007	0.55
2016	0%	0	0	9.1	3,866	0.010	0.61
2017	0%	0	0	9.2	4,023	0.009	0.63
2018	0%	0	0	3.8	1,588	0.004	0.25
2019	0%	0	0	4.5	1,861	0.004	0.29
2020	0%	0	0	5.4	2,255	0.005	0.35
2021	0%	0	0	6.2	2,272	0.006	0.36
2022	0%	0	0	7.5	2,835	0.007	0.45
2023	0%	0	0	12	4,261	0.010	0.67
2024	0%	0	0	1.3	3,988	0.01	0.63
2025	0%	0	0	1.4	4,524	0.01	0.71
2026	0%	0	0	1.3	4,758	0.01	0.75
2027	0%	0	0	1.4	4,671	0.01	0.73
2028	0%	0	0	1.2	4,452	0.01	0.70
2029	0%	0	0	1.2	4,281	0.01	0.67
2030	0%	0	0	1.1	4,205	0.01	0.66
2031	0%	0	0	0.60	2,590	0.006	0.41
2032	0%	0	0	0.18	694	0.003	0.11

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1] Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Conventional DSL Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	66	0.04	3.5	0.000	0.001	0.31	100%	66	42,043
1994	83	0.05	4.2	0.000	0.001	0.38	100%	83	50,721
1995	115	0.07	5.9	0.000	0.001	0.53	100%	115	70,970
1996	119	0.07	6.1	0.000	0.001	0.54	100%	119	72,842
1997	117	0.06	5.9	0.000	0.001	0.52	100%	117	70,488
1998	104	0.06	5.7	0.000	0.001	0.50	100%	104	67,898
1999	133	0.10	7.6	0.000	0.001	0.67	100%	133	90,610
2000	147	0.11	8.5	0.000	0.001	0.76	100%	147	101,850
2001	161	0.11	8.8	0.000	0.001	0.79	100%	161	105,603
2002	172	0.11	9.0	0.000	0.001	0.80	100%	172	107,968
2003	146	0.06	8.3	0.000	0.001	0.74	100%	146	99,226
2004	143	0.06	8.1	0.000	0.001	0.72	100%	143	96,731
2005	178	0.07	10	0.000	0.002	0.92	100%	178	123,640
2006	202	0.09	12	0.000	0.002	1.1	100%	202	143,033
2007	272	0.11	17	0.000	0.003	1.5	100%	272	200,277
2008	292	0.07	15	0.000	0.002	1.3	100%	292	179,211
2009	346	0.08	18	0.000	0.003	1.6	100%	346	213,122
2010	183	0.04	9.3	0.000	0.001	0.83	100%	183	111,727
2011	234	0.03	11	0.000	0.002	1.0	100%	234	136,809
2012	7,969	2.4	804	0.002	0.13	72	100%	7,969	9,641,296
2013	4,340	2.0	750	0.001	0.12	67	100%	4,340	8,984,556
2014	4,954	2.0	817	0.001	0.13	73	100%	4,954	9,795,650
2015	9,674	3.7	1,601	0.003	0.25	143	100%	9,674	19,190,427
2016	10,519	3.7	1,604	0.004	0.25	143	100%	10,519	19,227,562
2017	14,184	3.9	1,723	0.004	0.27	154	100%	14,184	20,654,585
2018	4,924	1.7	692	0.002	0.11	62	100%	4,924	8,290,062
2019	5,803	1.9	807	0.002	0.13	72	100%	5,803	9,667,889
2020	6,713	2.3	945	0.002	0.15	84	100%	6,713	11,329,480
2021	7,708	2.6	942	0.003	0.15	84	100%	7,708	11,285,971
2022	9,361	3.4	1,197	0.003	0.19	107	100%	9,361	14,344,235
2023	12,311	5.2	1,799	0.004	0.28	160	100%	12,311	21,557,339
2024	14,157	5.5	1,804	0.005	0.28	161	0%	0	0
2025	15,781	6.4	2,112	0.006	0.33	188	0%	0	0
2026	17,659	7.5	2,484	0.007	0.39	221	0%	0	0
2027	19,532	8.7	2,768	0.008	0.44	247	0%	0	0
2028	21,365	10	3,236	0.010	0.51	288	0%	0	0
2029	22,985	11	3,748	0.01	0.59	334	0%	0	0
2030	24,081	12	4,213	0.01	0.66	375	0%	0	0
2037	24,791	13	4,671	0.01	0.73	416	0%	0	0
2032	24,114	13	4,857	0.01	0.76	433	0%	0	0
2033	23,670	12	5,060	0.01	0.80	451	0%	0	0
2034	21,948	11	4,883	0.01	0.77	435	0%	0	0
2035	20,791	10	4,742	0.01	0.75	423	0%	0	0
2036	19,699	9.0	4,573	0.01	0.72	408	0%	0	0
2037	12,409	5.0	2,773	0.007	0.44	247	0%	0	0
2038	6,391	1.7	743	0.003	0.12	66	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
1993	0%	0	0	0%	0	0	0%	0	0
1994	0%	0	0	0%	0	0	0%	0	0
1995	0%	0	0	0%	0	0	0%	0	0
1996	0%	0	0	0%	0	0	0%	0	0
1997	0%	0	0	0%	0	0	0%	0	0
1998	0%	0	0	0%	0	0	0%	0	0
1999	0%	0	0	0%	0	0	0%	0	0
2000	0%	0	0	0%	0	0	0%	0	0
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	1,416	2,161,542	90%	12,741	19,453,879	0%	0	0
2025	10%	1,578	2,531,043	90%	14,203	22,779,383	0%	0	0
2026	10%	1,766	2,977,192	90%	15,893	26,794,732	0%	0	0
2027	15%	2,930	4,975,264	85%	16,602	28,193,162	0%	0	0
2028	15%	3,205	5,817,346	85%	18,160	32,964,959	0%	0	0
2029	20%	4,597	8,983,030	80%	18,388	35,932,119	0%	0	0
2030	20%	4,816	10,097,767	80%	19,265	40,391,066	0%	0	0
2037	12%	2,975	6,717,948	88%	21,816	49,264,949	0%	0	0
2032	10%	2,411	5,821,019	90%	21,703	52,389,172	0%	0	0
2033	10%	2,367	6,063,891	90%	21,303	54,575,018	0%	0	0
2034	10%	2,195	5,851,702	90%	19,754	52,665,319	0%	0	0
2035	12%	2,495	6,819,958	88%	18,296	50,013,022	0%	0	0
2036	12%	2,364	6,576,732	88%	17,335	48,229,366	0%	0	0
2037	12%	1,489	3,988,015	88%	10,920	29,245,447	0%	0	0
2038	12%	767	1,068,563	88%	5,624	7,836,129	0%	0	0

Model Year	BEV Fleet Mix[2] (%)	BEV Population[3]	BEV Energy Consumption[4] (MJ/day)	Tailpipe Emission Estimates[5] (tons/day) NO_x	CO_2	CH_4	N_2O
1993	0%	0	0	0.04	3.5	0.000	0.001
1994	0%	0	0	0.05	4.2	0.000	0.001
1995	0%	0	0	0.07	5.9	0.000	0.001
1996	0%	0	0	0.07	6.1	0.000	0.001
1997	0%	0	0	0.06	5.9	0.000	0.001
1998	0%	0	0	0.06	5.7	0.000	0.001
1999	0%	0	0	0.10	7.6	0.000	0.001
2000	0%	0	0	0.11	8.5	0.000	0.001
2001	0%	0	0	0.11	8.8	0.000	0.001
2002	0%	0	0	0.11	9.0	0.000	0.001
2003	0%	0	0	0.06	8.3	0.000	0.001
2004	0%	0	0	0.06	8.1	0.000	0.001
2005	0%	0	0	0.07	10	0.000	0.002
2006	0%	0	0	0.09	12	0.000	0.002
2007	0%	0	0	0.11	17	0.000	0.003
2008	0%	0	0	0.07	15	0.000	0.002
2009	0%	0	0	0.08	18	0.000	0.003
2010	0%	0	0	0.04	9.3	0.000	0.001
2011	0%	0	0	0.03	11	0.000	0.002
2012	0%	0	0	2.4	804	0.002	0.13
2013	0%	0	0	2.0	750	0.001	0.12
2014	0%	0	0	2.0	817	0.001	0.13
2015	0%	0	0	3.7	1,601	0.003	0.25
2016	0%	0	0	3.7	1,604	0.004	0.25
2017	0%	0	0	3.9	1,723	0.004	0.27
2018	0%	0	0	1.7	692	0.002	0.11
2019	0%	0	0	1.9	807	0.002	0.13
2020	0%	0	0	2.3	945	0.002	0.15
2021	0%	0	0	2.6	942	0.003	0.15
2022	0%	0	0	3.4	1,197	0.003	0.19
2023	0%	0	0	5.2	1,799	0.004	0.28
2024	0%	0	0	0.63	1,804	0.005	0.28
2025	0%	0	0	0.74	2,112	0.006	0.33
2026	0%	0	0	0.87	2,484	0.007	0.39
2027	0%	0	0	1.1	2,768	0.008	0.44
2028	0%	0	0	1.2	3,236	0.010	0.51
2029	0%	0	0	1.5	3,748	0.01	0.59
2030	0%	0	0	1.6	4,213	0.01	0.66
2037	0%	0	0	1.5	4,671	0.01	0.73
2032	0%	0	0	1.5	4,857	0.01	0.76
2033	0%	0	0	1.4	5,060	0.01	0.80
2034	0%	0	0	1.3	4,883	0.01	0.77
2035	0%	0	0	1.2	4,742	0.01	0.75
2036	0%	0	0	1.1	4,573	0.01	0.72
2037	0%	0	0	0.59	2,773	0.007	0.44
2038	0%	0	0	0.20	743	0.003	0.12

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0	0	0	0	0	0	0%	0	0
2002	0	0	0	0	0	0	0%	0	0
2003	0	0	0	0	0	0	0%	0	0
2004	0	0	0	0	0	0	0%	0	0
2005	0	0	0	0	0	0	0%	0	0
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	5,738	1.9	631	0.002	0.10	56	0%	0	0
2025	6,682	2.2	740	0.002	0.12	66	0%	0	0
2026	7,830	2.6	869	0.002	0.14	77	0%	0	0
2027	8,960	3.0	954	0.003	0.15	85	0%	0	0
2028	10,297	3.5	1,096	0.003	0.17	98	0%	0	0
2029	11,921	4.1	1,276	0.004	0.20	114	0%	0	0
2030	13,807	4.8	1,488	0.005	0.23	133	0%	0	0
2045	15,655	5.9	1,819	0.006	0.29	162	0%	0	0
2032	17,813	7.1	2,196	0.007	0.35	196	0%	0	0
2033	20,003	8.3	2,581	0.008	0.41	230	0%	0	0
2034	22,623	10	3,067	0.009	0.48	273	0%	0	0
2035	24,976	11	3,584	0.01	0.56	319	0%	0	0
2036	26,967	13	4,118	0.01	0.65	367	0%	0	0
2037	28,599	14	4,677	0.01	0.74	417	0%	0	0
2038	29,556	15	5,172	0.01	0.81	461	0%	0	0
2039	30,085	16	5,646	0.02	0.89	503	0%	0	0
2040	28,520	15	5,685	0.02	0.89	507	0%	0	0
2041	27,485	14	5,816	0.02	0.91	518	0%	0	0
2042	24,780	12	5,446	0.01	0.86	485	0%	0	0
2043	23,286	11	5,243	0.01	0.82	467	0%	0	0
2044	22,012	10	5,025	0.01	0.79	448	0%	0	0
2045	13,831	5.5	3,030	0.007	0.48	270	0%	0	0
2046	7,111	1.9	812	0.004	0.13	72	0%	0	0

Model Year	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2001	0%	0	0	0%	0	0	0%	0	0
2002	0%	0	0	0%	0	0	0%	0	0
2003	0%	0	0	0%	0	0	0%	0	0
2004	0%	0	0	0%	0	0	0%	0	0
2005	0%	0	0	0%	0	0	0%	0	0
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	574	756,340	90%	5,164	6,807,061	0%	0	0
2025	10%	668	886,781	90%	6,014	7,981,032	0%	0	0
2026	10%	783	1,041,761	90%	7,047	9,375,851	0%	0	0
2027	15%	1,344	1,715,605	85%	7,616	9,721,760	0%	0	0
2028	15%	1,544	1,969,828	85%	8,752	11,162,360	0%	0	0
2029	20%	2,384	3,059,507	80%	9,536	12,238,027	0%	0	0
2030	20%	2,761	3,566,433	80%	11,045	14,265,732	0%	0	0
2045	12%	1,879	2,615,706	88%	13,777	19,181,841	0%	0	0
2032	10%	1,781	2,631,722	90%	16,032	23,685,498	0%	0	0
2033	10%	2,000	3,093,484	90%	18,003	27,841,358	0%	0	0
2034	10%	2,262	3,676,051	90%	20,361	33,084,463	0%	0	0
2035	12%	2,997	5,154,227	88%	21,979	37,797,664	0%	0	0
2036	12%	3,236	5,922,773	88%	23,731	43,433,668	0%	0	0
2037	12%	3,432	6,725,482	88%	25,167	49,320,202	0%	0	0
2038	12%	3,547	7,438,400	88%	26,009	54,548,270	0%	0	0
2039	12%	3,610	8,118,998	88%	26,475	59,539,315	0%	0	0
2040	12%	3,422	8,176,299	88%	25,097	59,959,528	0%	0	0
2041	12%	3,298	8,363,731	88%	24,187	61,334,028	0%	0	0
2042	12%	2,974	7,831,788	88%	21,807	57,433,112	0%	0	0
2043	12%	2,794	7,539,421	88%	20,492	55,289,088	0%	0	0
2044	12%	2,641	7,227,079	88%	19,370	52,998,582	0%	0	0
2045	12%	1,660	4,357,601	88%	12,172	31,955,744	0%	0	0
2046	12%	853	1,167,185	88%	6,258	8,559,357	0%	0	0

Model Year	BEV			Tailpipe Emission Estimates[5] (tons/day)			
	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	NO_X	CO_2	CH_4	N_2O
2001	0%	0	0	0	0	0	0
2002	0%	0	0	0	0	0	0
2003	0%	0	0	0	0	0	0
2004	0%	0	0	0	0	0	0
2005	0%	0	0	0	0	0	0
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	0%	0	0	0.22	631	0.002	0.10
2025	0%	0	0	0.26	740	0.002	0.12
2026	0%	0	0	0.30	869	0.002	0.14
2027	0%	0	0	0.37	954	0.003	0.15
2028	0%	0	0	0.43	1,096	0.003	0.17
2029	0%	0	0	0.54	1,276	0.004	0.20
2030	0%	0	0	0.63	1,488	0.005	0.23
2045	0%	0	0	0.70	1,819	0.006	0.29
2032	0%	0	0	0.82	2,196	0.007	0.35
2033	0%	0	0	1.0	2,581	0.008	0.41
2034	0%	0	0	1.1	3,067	0.009	0.48
2035	0%	0	0	1.3	3,584	0.01	0.56
2036	0%	0	0	1.5	4,118	0.01	0.65
2037	0%	0	0	1.7	4,677	0.01	0.74
2038	0%	0	0	1.8	5,172	0.01	0.81
2039	0%	0	0	1.8	5,646	0.02	0.89
2040	0%	0	0	1.7	5,685	0.02	0.89
2041	0%	0	0	1.7	5,816	0.02	0.91
2042	0%	0	0	1.5	5,446	0.01	0.86
2043	0%	0	0	1.3	5,243	0.01	0.82
2044	0%	0	0	1.2	5,025	0.01	0.79
2045	0%	0	0	0.64	3,030	0.007	0.48
2046	0%	0	0	0.22	812	0.004	0.13

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Table A-43. NOx and GHG Tailpipe Emissions for Scenario 6 in Calendar Year 2050
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

Model Year	Adjusted EMFAC2017 Output[1]						Conventional DSL		
	Population	NOx_TOTEX (tons/day)	CO2_TOTEX (tons/day)	CH4_TOTEX (tons/day)	N2O_TOTEX (tons/day)	Fuel Consumption (1000 gal/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0	0	0	0	0	0	0%	0	0
2007	0	0	0	0	0	0	0%	0	0
2008	0	0	0	0	0	0	0%	0	0
2009	0	0	0	0	0	0	0%	0	0
2010	0	0	0	0	0	0	0%	0	0
2011	0	0	0	0	0	0	0%	0	0
2012	0	0	0	0	0	0	0%	0	0
2013	0	0	0	0	0	0	0%	0	0
2014	0	0	0	0	0	0	0%	0	0
2015	0	0	0	0	0	0	0%	0	0
2016	0	0	0	0	0	0	0%	0	0
2017	0	0	0	0	0	0	0%	0	0
2018	0	0	0	0	0	0	0%	0	0
2019	0	0	0	0	0	0	0%	0	0
2020	0	0	0	0	0	0	0%	0	0
2021	0	0	0	0	0	0	0%	0	0
2022	0	0	0	0	0	0	0%	0	0
2023	0	0	0	0	0	0	0%	0	0
2024	2,595	0.86	281	0.001	0.04	25	0%	0	0
2025	3,028	1.0	330	0.001	0.05	29	0%	0	0
2026	3,626	1.2	393	0.001	0.06	35	0%	0	0
2027	4,257	1.4	439	0.001	0.07	39	0%	0	0
2028	5,060	1.7	526	0.001	0.08	47	0%	0	0
2029	6,031	2.0	632	0.002	0.10	56	0%	0	0
2030	7,066	2.4	743	0.002	0.12	66	0%	0	0
2050	8,217	2.8	872	0.003	0.14	78	0%	0	0
2032	9,494	3.2	1,017	0.003	0.16	91	0%	0	0
2033	11,004	3.8	1,176	0.004	0.18	105	0%	0	0
2034	12,911	4.5	1,386	0.004	0.22	124	0%	0	0
2035	14,935	5.3	1,619	0.005	0.25	144	0%	0	0
2036	16,783	6.4	1,962	0.006	0.31	175	0%	0	0
2037	18,732	7.5	2,328	0.007	0.37	208	0%	0	0
2038	20,725	8.7	2,699	0.008	0.42	241	0%	0	0
2039	22,925	10	3,137	0.009	0.49	280	0%	0	0
2040	25,074	11	3,619	0.01	0.57	323	0%	0	0
2041	27,099	13	4,155	0.01	0.65	370	0%	0	0
2042	28,740	14	4,704	0.01	0.74	419	0%	0	0
2043	29,658	15	5,184	0.01	0.81	462	0%	0	0
2044	30,119	16	5,634	0.02	0.89	502	0%	0	0
2045	28,407	15	5,643	0.02	0.89	503	0%	0	0
2046	27,387	14	5,770	0.02	0.91	514	0%	0	0
2047	24,660	12	5,397	0.01	0.85	481	0%	0	0
2048	23,198	11	5,206	0.01	0.82	464	0%	0	0
2049	21,872	10	4,978	0.01	0.78	444	0%	0	0
2050	13,695	5.4	2,992	0.007	0.47	267	0%	0	0
2051	7,053	1.8	1,226	0.004	0.19	109	0%	0	0

	Federal Low NOx DSL			CA Cert. Low NOx DSL			Low NOx NG		
Model Year	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)	Fleet Mix[2] (%)	Population[3]	Energy Consumption[4] (MJ/day)
2006	0%	0	0	0%	0	0	0%	0	0
2007	0%	0	0	0%	0	0	0%	0	0
2008	0%	0	0	0%	0	0	0%	0	0
2009	0%	0	0	0%	0	0	0%	0	0
2010	0%	0	0	0%	0	0	0%	0	0
2011	0%	0	0	0%	0	0	0%	0	0
2012	0%	0	0	0%	0	0	0%	0	0
2013	0%	0	0	0%	0	0	0%	0	0
2014	0%	0	0	0%	0	0	0%	0	0
2015	0%	0	0	0%	0	0	0%	0	0
2016	0%	0	0	0%	0	0	0%	0	0
2017	0%	0	0	0%	0	0	0%	0	0
2018	0%	0	0	0%	0	0	0%	0	0
2019	0%	0	0	0%	0	0	0%	0	0
2020	0%	0	0	0%	0	0	0%	0	0
2021	0%	0	0	0%	0	0	0%	0	0
2022	0%	0	0	0%	0	0	0%	0	0
2023	0%	0	0	0%	0	0	0%	0	0
2024	10%	260	337,270	90%	2,336	3,035,431	0%	0	0
2025	10%	303	395,918	90%	2,725	3,563,261	0%	0	0
2026	10%	363	471,136	90%	3,263	4,240,226	0%	0	0
2027	15%	639	789,915	85%	3,618	4,476,184	0%	0	0
2028	15%	759	945,969	85%	4,301	5,360,493	0%	0	0
2029	20%	1,206	1,514,257	80%	4,825	6,057,030	0%	0	0
2030	20%	1,413	1,780,183	80%	5,653	7,120,732	0%	0	0
2050	12%	986	1,253,331	88%	7,231	9,191,092	0%	0	0
2032	10%	949	1,218,218	90%	8,544	10,963,961	0%	0	0
2033	10%	1,100	1,409,784	90%	9,904	12,688,052	0%	0	0
2034	10%	1,291	1,660,800	90%	11,620	14,947,200	0%	0	0
2035	12%	1,792	2,327,866	88%	13,142	17,071,018	0%	0	0
2036	12%	2,014	2,822,001	88%	14,769	20,694,676	0%	0	0
2037	12%	2,248	3,348,517	88%	16,484	24,555,791	0%	0	0
2038	12%	2,487	3,881,574	88%	18,238	28,464,877	0%	0	0
2039	12%	2,751	4,511,626	88%	20,174	33,085,259	0%	0	0
2040	12%	3,009	5,204,512	88%	22,065	38,166,423	0%	0	0
2041	12%	3,252	5,974,789	88%	23,847	43,815,120	0%	0	0
2042	12%	3,449	6,765,245	88%	25,292	49,611,798	0%	0	0
2043	12%	3,559	7,455,772	88%	26,099	54,675,659	0%	0	0
2044	12%	3,614	8,101,789	88%	26,505	59,413,116	0%	0	0
2045	12%	3,409	8,115,025	88%	24,998	59,510,183	0%	0	0
2046	12%	3,286	8,297,953	88%	24,101	60,851,657	0%	0	0
2047	12%	2,959	7,761,898	88%	21,701	56,920,588	0%	0	0
2048	12%	2,784	7,487,127	88%	20,414	54,905,598	0%	0	0
2049	12%	2,625	7,158,856	88%	19,248	52,498,276	0%	0	0
2050	12%	1,643	4,302,930	88%	12,051	31,554,822	0%	0	0
2051	12%	846	1,763,371	88%	6,207	12,931,384	0%	0	0

	BEV			Tailpipe Emission Estimates[5] (tons/day)			
Model Year	**Fleet Mix[2] (%)**	**Population[3]**	**Energy Consumption[4] (MJ/day)**	**NO_X**	**CO_2**	**CH_4**	**N_2O**
2006	0%	0	0	0	0	0	0
2007	0%	0	0	0	0	0	0
2008	0%	0	0	0	0	0	0
2009	0%	0	0	0	0	0	0
2010	0%	0	0	0	0	0	0
2011	0%	0	0	0	0	0	0
2012	0%	0	0	0	0	0	0
2013	0%	0	0	0	0	0	0
2014	0%	0	0	0	0	0	0
2015	0%	0	0	0	0	0	0
2016	0%	0	0	0	0	0	0
2017	0%	0	0	0	0	0	0
2018	0%	0	0	0	0	0	0
2019	0%	0	0	0	0	0	0
2020	0%	0	0	0	0	0	0
2021	0%	0	0	0	0	0	0
2022	0%	0	0	0	0	0	0
2023	0%	0	0	0	0	0	0
2024	0%	0	0	0.10	281	0.001	0.04
2025	0%	0	0	0.12	330	0.001	0.05
2026	0%	0	0	0.14	393	0.001	0.06
2027	0%	0	0	0.17	439	0.001	0.07
2028	0%	0	0	0.21	526	0.001	0.08
2029	0%	0	0	0.26	632	0.002	0.10
2030	0%	0	0	0.31	743	0.002	0.12
2050	0%	0	0	0.33	872	0.003	0.14
2032	0%	0	0	0.37	1,017	0.003	0.16
2033	0%	0	0	0.43	1,176	0.004	0.18
2034	0%	0	0	0.52	1,386	0.004	0.22
2035	0%	0	0	0.62	1,619	0.005	0.25
2036	0%	0	0	0.75	1,962	0.006	0.31
2037	0%	0	0	0.89	2,328	0.007	0.37
2038	0%	0	0	1.0	2,699	0.008	0.42
2039	0%	0	0	1.2	3,137	0.009	0.49
2040	0%	0	0	1.4	3,619	0.01	0.57
2041	0%	0	0	1.5	4,155	0.01	0.65
2042	0%	0	0	1.7	4,704	0.01	0.74
2043	0%	0	0	1.8	5,184	0.01	0.81
2044	0%	0	0	1.8	5,634	0.02	0.89
2045	0%	0	0	1.7	5,643	0.02	0.89
2046	0%	0	0	1.7	5,770	0.02	0.91
2047	0%	0	0	1.5	5,397	0.01	0.85
2048	0%	0	0	1.3	5,206	0.01	0.82
2049	0%	0	0	1.2	4,978	0.01	0.78
2050	0%	0	0	0.64	2,992	0.007	0.47
2051	0%	0	0	0.22	1,226	0.004	0.19

Notes:

[1] EMFAC data shown here are adjusted by subtracting data for T7 SWCVs from corresponding data for all HHDTs as described in Appendix A. Accelerated turnover adjustments are included in calendar years 2031, 2037, 2045, and 2050 as described in Appendix A.

[2] Fleet mix percentages for each alternative HHDT technology type are determined based on the specific fleet mix assumptions in each scenario, as described in Section 2 of the report.

[3] Population in each model year is calculated based on the fleet mix percentages for each HHDT type and the total population in the adjusted EMFAC data.

[4] Energy consumption is calculated based on adjusted EMFAC data, using the EER for each HHDT type shown in Table A-38.

[5] Emissions from vehicles in each model year are calculated based on the fleet mix composition and the reduction in tailpipe NOx emissions achieved by each HHDT type shown in Table 3-2. Total emissions in each calendar year are calculated as the sum of tailpipe emissions across all HHDT types and all model years in each calendar year.

[6] Values in shaded cells are zero. Numbers may not add due to rounding.

Abbreviations:

BEV - battery electric vehicle
CA Cert. - California certified
CH_4 - methane
CO_2 - carbon dioxide
DSL - diesel
EER - energy economy ratio
EMFAC2017 - Emission Factor Model
gal - gallon
HHDT - heavy heavy duty truck
MJ - megajoule
N_2O - nitrous oxide
NG - natural gas
NO_x - oxides of nitrogen
T7 SWCV - solid waste collection vehicles
TOTEX - total exhaust

Table A-44. Upstream Emission Factors
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

Upstream Emission Factors by Fuel Type (g/MJ)						
Calendar Year	Diesel		CNG		Electricity	
	NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e
2023	0.015	25.3	0.047	17.6	0.084	75.3
2024	0.015	25.2	0.047	17.4	0.080	71.7
2025	0.015	25.2	0.047	17.3	0.076	68.2
2026	0.015	25.2	0.047	17.2	0.071	64.6
2027	0.015	25.1	0.047	17.1	0.067	61.0
2028	0.015	25.1	0.047	17.0	0.063	57.4
2029	0.015	25.1	0.047	16.9	0.059	53.8
2030	0.015	25.0	0.047	16.8	0.055	50.2
2031	0.015	25.0	0.046	16.6	0.051	46.6
2032	0.015	25.0	0.046	16.6	0.047	44.2
2033	0.015	25.0	0.046	16.5	0.042	41.8
2034	0.015	25.0	0.046	16.4	0.038	39.4
2035	0.015	24.9	0.046	16.3	0.033	36.9
2036	0.015	24.9	0.046	16.3	0.029	34.5
2037	0.014	24.9	0.046	16.2	0.024	32.1
2038	0.014	24.9	0.046	16.1	0.023	30.2
2039	0.014	24.9	0.046	16.1	0.021	28.2
2040	0.014	24.8	0.046	16.0	0.020	26.3
2041	0.014	24.8	0.046	15.9	0.018	24.4
2042	0.014	24.8	0.046	15.9	0.016	22.5
2043	0.014	24.8	0.046	15.8	0.015	20.6
2044	0.014	24.8	0.046	15.8	0.013	18.6
2045	0.014	24.8	0.046	15.7	0.012	16.7
2046	0.014	24.8	0.045	15.7	0.011	15.6
2047	0.014	24.7	0.045	15.6	0.010	14.5
2048	0.014	24.7	0.045	15.6	0.009	13.4
2049	0.014	24.7	0.045	15.6	0.008	12.2
2050	0.014	24.7	0.045	15.5	0.007	11.1

Notes:

[1] Upstream emission factors for years 2023, 2031, 2037, 2045 and 2050 were derived from CA-GREET3.0 model. These values were used to interpolate emission factors for all other years. Details regarding model inputs and assumptions are provided in Appendix A.

Abbreviations:

CA-GREET - California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model

CNG - compressed natural gas

CO_2e - carbon dioxide equivalent

g - gram

MJ - megajoule

NOx - nitrogen oxides

Table A-45. Electricity Grid Mix Assumptions

Appendix A Tables - Scenario Analysis
Assumptions and Detailed Methodology

Year[1,2]	Residual Oil	Natural Gas	Coal	Nuclear	Biomass	Hydro-electric	Geo-thermal	Wind	Solar
2020	0.16%	45.45%	3.30%	9.05%	2.35%	12.29%	4.54%	11.46%	11.40%
2023	0.00%	47.20%	0.00%	2.32%	3.03%	9.11%	6.97%	10.03%	21.35%
2031	0.00%	28.27%	0.00%	0.32%	1.96%	9.41%	9.85%	12.29%	37.91%
2037	0.00%	19.22%	0.00%	0.03%	0.12%	7.57%	8.98%	21.34%	42.74%
2045	0.00%	9.66%	0.00%	0.00%	0.00%	6.44%	6.71%	29.65%	47.54%
2050	0.00%	6.05%	0.00%	0.00%	0.00%	5.23%	6.64%	33.98%	48.11%

Notes:

[1] California electricity grid mix assumptions for year 2020 were taken from the most recently available CEC electricity mix data for 2018. Available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2019-total-system-electric-generation/2018. Accessed December 2020.

[2] Electricity grid projections out to 2050 were sourced from Energy and Environmental Economics (E3) 2018 Deep Decarbonization report commissioned by the CEC. Available at: https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf. Accessed November 2020.

Abbreviations:

CEC - California Energy Commission

Table A-46. Renewable Fuel GREET 3.0 Transportation Assumptions
Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

Parameter	Ramboll Assumptions	Source
RNG Pipeline Distance (mi)	1,000	CARB CA- GREET3.0 NG Pipeline Distance[1]
Tallow Transport Distance (mi)	HD Truck - 100	ANL Tallow-based Pathway in GREET[2], EDF Biodiesel in CA[3]
Renewable Diesel Transport Distance (mi)	HD Truck - 100	EDF Biodiesel in CA[3]

Notes:

[1] CA-GREET3.0 Lookup Table Pathways Technical Support Documentation. Available at: https://ww2.arb.ca.gov/sites/default/files/classic//fuels/lcfs/ca-greet/lut-doc.pdf. Accessed: August 2020.

[2] ANL Tallow-Based Diesel Pathway in GREET. Available at: https://greet.es.anl.gov/publication-tallow-13. Accessed: August 2020.

[3] EDF Biodiesel in California. Available at: https://www.edf.org/sites/default/files/sites/default/files/content/Biodiesel%20Value%20Chain%20-%20August%202013.pdf. Accessed: January 2020.

Abbreviations:

ANL - Argonne National Laboratory
CARB - California Air Resources Board
CA - California
EDF - Environmental Defense Fund
GREET - Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
HD - heavy-duty
mi - miles
NG - natural gas
RNG - Renewable Natural Gas

Table A-47. Energy Economy Ratios and Fuel Economy

Appendix A Tables - Scenario Analysis Assumptions and Detailed Methodology

Truck Technology	EER value[1]	Fuel Economy (mi/DGE)	Source	Description
Conventional Diesel HHDT	1	7.03	CARB ACT ISOR, Appendix H[1]	Fuel Economy of a MY2024 Diesel HHDT.
Low NOx Diesel HHDT	1	7.03	CARB LCFS Regulation[2]	Diesel HHDT EER value from CARB LCFS regulation was used to calculate the fuel economy for a Low-NOx Diesel HHDT.
Low NOx NG HHDT	0.9	6.33	CARB LCFS Regulation[2]	Spark Ignition CNG EER value from CARB LCFS regulation was used to calculate a Low NOx NG HHDT fuel economy.
BEV HHDT	3.029	21.3	CARB ACT Cost Calculator[3]	Fuel Economy of a MY2024 BEV HHDT.

Notes:

[1] EER values are relative to conventional diesel

[1] CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed November 2020

[2] LCFS Regulation, 2019. Table 5. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf. Accessed November 2020.

[3] CARB ACT Cost Calculator. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx. Accessed November 2020.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
CNG - compressed natural gas
DGE - diesel gallon equivalent
EER - Energy Economy Ratio
HHDT - heavy-heavy-duty truck
ISOR - Initial Statement of Reason
LDV - light duty vehicle
LCFS - Low Carbon Fuel Standard
mi - miles
MY - model year
NG - Natural Gas
NOx - nitrogen oxides

APPENDIX B TABLES
COST ANALYSIS ASSUMPTIONS AND METHODOLOGY

APPENDIX B TABLES

Table B-1. Vehicle Purchase Cost Assumptions

Technology	Purchase Cost (with tax[1])	Source	Description
Conventional Diesel Truck	$172,921	CARB ACT ISOR, Appendix H[2]	Cost of a MY2024 Class 8 Day Cab, assuming compliance with GHG Phase 2 Standards.
Federal Low-NO_x Diesel Truck	$178,623	NREL Low-NOx Diesel Cost Study[3]	The NREL Low-NOx Study, commissioned by CARB, provides a range of incremental engine and aftertreatment costs for a 12-13L Truck. For a Federal Low-NOx diesel truck, the study assumes: - 0.02 g/bhp-hr Federal NOx Regulation begins MY 2023 - 10-year useful truck life (435,000 miles) - US wide implementation Ramboll Cost Analysis adds the average of high and low incremental cost values reported in the NREL Study to the baseline cost of a conventional diesel truck as reported by the CARB ACT Cost Calculator.
CA Low-NO_x Diesel Truck	$210,876	NREL Low-NO_x Diesel Cost Study[3,4]	The NREL Low-NOx Study, commissioned by CARB, provides a range of incremental engine and aftertreatment costs for a 12-13L Truck. For a CA Low-NOx diesel truck, the study assumes: - 0.02 g/bhp hr CA NOx regulation beginning MY 2027 - extended useful truck life (15 years) - extended warranty (800,000 miles) - CA only implementation Ramboll Cost Analysis adds the average of high and low incremental cost values reported in the NREL Study to the baseline cost of a conventional diesel truck as reported by the CARB ACT Cost Calculator.
Low-NO_x NG Truck	$192,719	Port Feasibility Study[5]	Cost of a MY2018 Class 8 Drayage Truck.
2018 BEV	$569,916	CARB ACT ISOR, Appendix H[2]	Cost of a MY2018 Class 8 Truck with 510kWh battery size.
2024 BEV	$384,448	CARB ACT ISOR, Appendix H[2]	Cost of a MY2024 Class 8 Truck with 510kWh battery size. Cost projection of powertrain based on ICCT Projections[6]. Cost Projection of batteries based on Bloomberg battery projections[7] for LDVs with a five-year delay.

Notes:

[1]These purchase costs are inclusive of sales tax (8%) and Federal Excise Tax (12%).

[2]CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

[3]NREL 2020 Low-NOx Diesel Cost Study. Available at: https://www.nrel.gov/docs/fy20osti/76571.pdf. Accessed: January 2021.

[4]While the NREL Low-NOx Diesel Cost Study provides incremental engine and aftertreatment costs assuming a 0.02 g/bhp-hr Federal NOx regulation, the Ramboll total cost of ownership analysis assumes a 0.05 g/bhp-hr emission rate to calculate the total lifetime emissions of a Federal Low-NOx Truck. Please see Table B-10-1 Tailpipe Assumptions for more details.

[5]2018 Feasibility Assessment for Drayage Trucks for San Pedro Bay Ports Clean Air Action Plan, 2019. Available at: https://cleanairactionplan.org/documents/final-drayage-truck-feasibility-assessment.pdf/. Accessed: January 2021.

[6]2017 ICCT ZEV Report. Available at: https://theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf. Accessed: January 2021.

[7]Bloomberg 2019 Better Batteries Report. Available at: https://www.bloomberg.com/quicktake/batteries. Accessed: January 2021.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CA - California
CARB - California Air Resources Board
g/bhp-hr - gram per brakewear horsepower hour
GHG - greenhouse gas
ICCT - International Council on Clean Transportation
ISOR - Initial Statement of Reason
kWh - kilowatt-hour
L - liter
LDV - light duty vehicle
MY - model year
NOx - nitrogen oxides
NREL - National Renewable Energy Laboratory
ZEV - zero emission vehicle

Table B-2. Charging Infrastructure Cost Assumptions

Infrastructure Item	Cost	Unit	Source	Description
Infrastructure Purchase Cost	$50,000	$/Charger	CARB ACT ISOR, Appendix H[1]	Cost for a 100kW DC Fast charger.
Infrastructure Installation and Upgrade	$55,000	$/Charger	CARB ACT ISOR, Appendix H[1] CARB ICT ISOR[2]	Infrastructure installation and upgrade estimates include the cost of trenching, cables, and transformers. These costs are not inclusive of the costs for new and/or enhanced transmission infrastructure or generation.
Infrastructure Maintenance	$415	$/year	Port Feasibility Study[3]	Annualized maintenance cost over a 10-year truck lifetime. Cost estimate includes annual inspection costs and charger replacement every 10 years.

Notes:

[1]CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: November 2020.

[2]CARB ICT ISOR. Available at: https://ww3.arb.ca.gov/regact/2018/ict2018/isor.pdf. Accessed: January 2021.

[3]2018 Feasibility Assessment for Drayage Trucks for San Pedro Bay Ports Clean Air Action Plan, 2019. Available at: https://cleanairactionplan.org/documents/final-drayage-truck-feasibility-assessment.pdf/. Accessed: January 2021.

Abbreviations:

ACT - Advanced Clean Truck
CARB - California Air Resources Board
DC - direct current
ICT - Innovative Clean Transit
ISOR - Initial Statement of Reason
kW - kilowatt

Table B-3. Useful Truck Life Assumptions

Useful Truck Life[1]	Unit	Source	Description
10	years	EPA CFR Title 40 Chapter 1 Subchapter C Part 86 A5[2]	Existing EPA adopted useful truck life values for heavy heavy-duty (Class 8) engines.
435,000	miles/lifetime		
15	years	EPA Cleaner Trucks Initiative Proposed Rulemaking[3]	EPA proposed useful truck life update for heavy heavy-duty (Class 8) engines.
909,900	miles/lifetime		

Notes:

[1]Ramboll Cost Analysis conducts a total cost of ownership analysis for both a 10- and 15-year useful truck life.

[2]EPA CFR Title 40 Chapter 1 Subchapter C Part 86 A. Available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=0245958e1b9e7cd2a95602f83bd51858&mc=true&node=se40.21.86_1004_62&rgn=div8. Accessed: July 2020.

[3]EPA Cleaner Trucks Initiative. Available at: https://www.govinfo.gov/content/pkg/FR-2020-01-21/pdf/2020-00542.pdf. Accessed: January 2021.

Abbreviations:

CFR - Code of Federal Regulations

EPA - United States Environmental Protection Agency

Table B-4. Vehicle Maintenance Cost Assumptions

Vehicle Type	Maintenance Cost[1] ($/mile)	Source	Description
Diesel HHDT	$0.19	CARB ACT ISOR, Appendix H[2]	Ramboll Cost Analysis assumes that Low-NOx diesel and NG HHDT trucks have the same maintenace costs as a diesel HHDT.
Low NOx Diesel HHDT	$0.19	CARB ACT ISOR, Appendix H[2]	
Low NOx NG HHDT	$0.19	CARB ACT ISOR, Appendix H[2]	
HHDT BEV	$0.14	CARB ACT ISOR, Appendix H[2]	CARB ACT ISOR assumes that HHDT BEV maintenance costs are 25% lower than diesel HHDT maintenance costs.

Notes:

[1]Maintenace costs in this table are for a Regional Class 8 tractor. These values reflects the cost of labor and parts for routine maintenance, preventative maintenance, and repairing broken components.

[2]CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
NG - natural gas
NOx - nitrogen oxides

Table B-5. Midlife Overhaul Costs Assumptions

Vehicle Type	Battery Replacement Cost	Source	Description
MY 2018 BEV	**$32,432**	CARB ACT ISOR Appendix H[1]	CARB ACT ISOR assumes that a class 8 day cab will require battery replacement in year 8 of operation. CARB uses assumptions from Bloomberg's LDV battery projections with a 5-year delay to arrive at a $/kWh battery replacement cost. CARB ACT cost calculator assumes a replacement battery size of 227kWh regardless of original vehicle battery size (510kWh). Costs reported in this table are for a 227kWh battery replacement. This assumption may underestimate the overhaul cost for BEV HHDTs.
MY 2024 BEV	**$21,773**	CARB ACT Cost Calculator[2]	

Notes:

[1] CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

[2] CARB ACT Cost Calculator. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx. Accessed: Accessed: January 2021.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
kWh - kilowatt-hour
LDV - light duty vehicle
MY - model year

Table B-6. Fuel Economy Assumptions

Truck Technology	EER value[1]	Fuel Economy (mi/DGE)	Source	Description
Conventional Diesel HHDT	1	7.03	CARB ACT ISOR, Appendix H[1]	Fuel Economy of a MY2024 Diesel HHDT.
Low NOx Diesel HHDT	1	7.03	CARB LCFS Regulation[2]	Diesel HHDT EER value from CARB LCFS regulation was used to calculate the fuel economy for a Low-NOx Diesel HHDT.
Low NOx NG HHDT	0.9	6.33	CARB LCFS Regulation[2]	Spark Ignition CNG EER value from CARB LCFS regulation was used to calculate a Low NOx NG HHDT fuel economy.
BEV HHDT	3.029	21.3	CARB ACT Cost Calculator[3]	Fuel Economy of a MY2024 BEV HHDT.

Notes:

[1]EER values are relative to conventional diesel

[1]CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

[2]LCFS Regulation, 2019. Table 5. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf. Accessed: January 2021.

[3]CARB ACT Cost Calculator. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx. Accessed: January 2021.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
CNG - compressed natural gas
DGE - diesel gallon equivalent
EER - Energy Economy Ratio
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
LDV - light duty vehicle
LCFS - Low Carbon Fuel Standard
mi - miles
MY - model year
NG - Natural Gas
NO_X - nitrogen oxides

Table B-7. Vehicle Registration Fees

Annual Registration Fees[1] ($/year)	Conventional Diesel HHDT	Federal Low-NOx Diesel HHDT	CA Low-NOx Diesel HHDT	Low-NOx NG HHDT	HHDT BEV-MY2018	HHDT BEV-MY2024
Fixed Fees[2]	$247	$247	$247	$247	$95	$95
Weight Fee[3]	$2,064	$2,064	$2,064	$2,064	$358	$358
Transportation Improvement Fee[4]	$175	$175	$175	$175	$175	$175

Notes:

[1]CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

[2]Fixed registration fees are the sum of all fees that stay constant across all vehicles. These fees vary slightly from county to county; the ones shown here are specifically for Sacramento County. Low-NOx vehicles are assumed to have the same registration fees as conventional diesel trucks.

[3]Weight fees are based on the registered weight of the vehicle. This analysis assumes at all trucks are at or above 80,000 pounds. Diesel and zero-emission trucks pay different weight fees. The annual weight fee for electric vehicles greater than 10,000 pounds is $358. Low-NOx vehicles are assumed to pay the same weight fees as conventional diesel trucks.

[4]The Transportation Improvement Fee is based on vehicle purchase cost and is the same for both diesel and zero-emission vehicles. For vehicles with a price above $60,000, the fee is $175 annually. Low-NOx vehicles are assumed to pay the same Transportation Improvement Fees.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
MY - model year
NG - Natural Gas
NO_X - nitrogen oxides

Table B-8. Vehicle License Fees

Truck Age	Market Value[1,2]	Vehicle License Fees[3,4]					
		Conventional Diesel HHDT	Federal Low-NOx Diesel HHDT	CA Low-NOx Diesel HHDT	Low NOx NG HHDT	HHDT BEV-MY2018	HHDT BEV-MY2024
1	100%	$1,124	$1,161	$1,371	$1,253	$3,704	$1,811
2	90%	$1,012	$1,045	$1,234	$1,127	$3,334	$1,630
3	80%	$899	$929	$1,097	$1,002	$2,964	$1,449
4	70%	$787	$813	$959	$877	$2,593	$1,268
5	60%	$674	$697	$822	$752	$2,223	$1,086
6	50%	$562	$581	$685	$626	$1,852	$905
7	40%	$450	$464	$548	$501	$1,482	$724
8	30%	$337	$348	$411	$376	$1,111	$543
9	25%	$281	$290	$343	$313	$926	$453
10	20%	$225	$232	$274	$251	$741	$362
11	15%	$169	$174	$206	$188	$556	$272
12	15%	$169	$174	$206	$188	$556	$272
13	15%	$169	$174	$206	$188	$556	$272
14	15%	$169	$174	$206	$188	$556	$272
15	15%	$169	$174	$206	$188	$556	$272
16	15%	$169	$174	$206	$188	$556	$272
17	15%	$169	$174	$206	$188	$556	$272
18	15%	$169	$174	$206	$188	$556	$272
19	15%	$169	$174	$206	$188	$556	$272
20	15%	$169	$174	$206	$188	$556	$272

Notes:

[1]2018 Feasibility Assessment for Drayage Trucks for San Pedro Bay Ports Clean Air Action Plan, 2019. Available at: https://cleanairactionplan.org/documents/final-drayage-truck-feasibility-assessment.pdf/. Accessed: January 2021.

[2]Market value is assumed to stay constant after the 11th truck year age.

[3]CARB ACT ISOR Appendix H. Available at: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf. Accessed: January 2021.

[4]The Vehicle License fee is calculated by multiplying the market value of the vehicle by 0.65%. Vehicle Purchase costs are reported in Table B-1

[5]Insurance cost is calculated by multiplying the market value of the vehicle by 3%. Vehicle Purchase costs are reported in Table B-1.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
MY - model year
NG - Natural Gas
NO_X - nitrogen oxides

Table B-9. Vehicle Insurance Fees

Truck Age	Market Value[1,2]	Insurance Costs[1,3]					
		Conventional Diesel HHDT	Federal Low-NOx Diesel HHDT	CA Low-NOx Diesel HHDT	Low NOx NG HHDT	HHDT BEV-MY2018	HHDT BEV-MY2024
1	100%	$5,188	$5,359	$6,326	$5,782	$17,097	$8,358
2	90%	$4,669	$4,823	$5,694	$5,203	$15,388	$7,522
3	80%	$4,150	$4,287	$5,061	$4,625	$13,678	$6,686
4	70%	$3,631	$3,751	$4,428	$4,047	$11,968	$5,850
5	60%	$3,113	$3,215	$3,796	$3,469	$10,258	$5,015
6	50%	$2,594	$2,679	$3,163	$2,891	$8,549	$4,179
7	40%	$2,075	$2,143	$2,531	$2,313	$6,839	$3,343
8	30%	$1,556	$1,608	$1,898	$1,734	$5,129	$2,507
9	25%	$1,297	$1,340	$1,582	$1,445	$4,274	$2,089
10	20%	$1,038	$1,072	$1,265	$1,156	$3,419	$1,672
11	15%	$778	$804	$949	$867	$2,565	$1,254
12	15%	$778	$804	$949	$867	$2,565	$1,254
13	15%	$778	$804	$949	$867	$2,565	$1,254
14	15%	$778	$804	$949	$867	$2,565	$1,254
15	15%	$778	$804	$949	$867	$2,565	$1,254
16	15%	$778	$804	$949	$867	$2,565	$1,254
17	15%	$778	$804	$949	$867	$2,565	$1,254
18	15%	$778	$804	$949	$867	$2,565	$1,254
19	15%	$778	$804	$949	$867	$2,565	$1,254
20	15%	$778	$804	$949	$867	$2,565	$1,254

Notes:

[1] 2018 Feasibility Assessment for Drayage Trucks for San Pedro Bay Ports Clean Air Action Plan, 2019. Available at: https://cleanairactionplan.org/documents/final-drayage-truck-feasibility-assessment.pdf/. Accessed: January 2021.

[2] Market value is assumed to stay constant after the 11th truck year age.

[3] Insurance cost is calculated by multiplying the market value of the vehicle by 3%. Vehicle Purchase costs are reported in Table B-1.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
MY - model year
NG - Natural Gas
NO_X - nitrogen oxides

Table B-10. Vehicle Tailpipe Emission Assumptions

Vehicle Type	Tailpipe Emission Assumptions	
	Tailpipe NO_x	**Tailpipe GHG**
Conventional Diesel HHDT	Default EMFAC Output	Default EMFAC Output
Federal Low-NOx Diesel HHDT	**75% NO_X** reduction from existing conventional diesel vehicle based on 0.05 g/bhp-hr NOx certification[1]	Default EMFAC Output
California Certified Low-NOx Diesel HHDT	**90% NO_X** reduction from conventional diesel vehicle based on 0.02 g/bhp-hr NOx certification[2]	Default EMFAC Output
Low-NOx Natural Gas HHDT	**90% NO_X** reduction from conventional diesel vehicle based on 0.02 g/bhp-hr NOx certification[3]	Default EMFAC Output
Battery Electric HHDT	Zero NO_x tailpipe emissions	Zero GHG tailpipe emissions

Notes:

[1]EPA is currently developing regulations to establish a Low-NOx emission standard for HHDTs through the Cleaner Trucks Initiative. As no standards have been proposed, this analysis assumes a 0.05 g/bhp-hr standard for Federal Low-NOx Diesel HHDT. Available at: https://ww3.arb.ca.gov/board/books/2020/082720/20-8-2pres.pdf. Accessed: January 2021.

[2]CARB Low NOx Omnibus has implemented a 0.05 g/bhp-hr NOx standard for MY2024-2026 Diesel HHDT. For MY2027-2030 Diesel HHDT, the regulation implements a 0.02 g/bhp-hr NOx standard. Available at: https://ww3.arb.ca.gov/regact/2020/hdomnibuslownox/isor.pdf. Accessed: January 2021.

[3]A number of NG HHDT engines are currently certified to the CARB optional 0.02 g/bhp-hr NOx standard. Available at: https://ww2.arb.ca.gov/our-work/programs/heavy-duty-low-nox/about. Accessed: January 2021.

Abbreviations:

CARB - California Air Resources Board
EMFAC - Emission Estimator model
EPA - United States Environmental Protection Agency
g/bhp-hr - gram per brake horsepower hour
GHG - greenhouse gas
HHDT - heavy-heavy duty truck
MY - model year
NG - natural gas
NO_X - nitrogen oxides

Table B-11. Vehicle Tailpipe Emissions Calculations

Calendar Year	Truck Age	Tailpipe Emission Factors[1,2] (g/mile)		Tailpipe Emissions (ton/year) Conventional Diesel HHDT		Federal Low-NOx HHDT		CA Low-NOx Diesel HHDT		Low NOx NG HHDT	
		NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e
Tailpipe Emissions for a 10-year (435,00 miles) Useful Truck life											
2024	1	1.818	1122	0.087	53.820	0.022	53.820	0.009	53.820	0.009	53.820
2025	2	1.983	1121	0.095	53.748	0.024	53.748	0.010	53.748	0.010	53.748
2026	3	2.142	1120	0.103	53.721	0.026	53.721	0.010	53.721	0.010	53.721
2027	4	2.296	1118	0.110	53.630	0.028	53.630	0.011	53.630	0.011	53.630
2028	5	2.456	1119	0.118	53.678	0.029	53.678	0.012	53.678	0.012	53.678
2029	6	2.631	1123	0.126	53.871	0.032	53.871	0.013	53.871	0.013	53.871
2030	7	2.817	1133	0.135	54.346	0.034	54.346	0.014	54.346	0.014	54.346
2031	8	2.985	1142	0.143	54.760	0.036	54.760	0.014	54.760	0.014	54.760
2032	9	3.138	1151	0.150	55.169	0.038	55.169	0.015	55.169	0.015	55.169
2033	10	3.231	1159	0.155	55.566	0.039	55.566	0.015	55.566	0.015	55.566
Tailpipe Emissions for a 15-year (909,900 miles) Useful Truck life											
2024	1	1.818	1122	0.122	75.051	0.030	75.051	0.012	75.051	0.012	75.051
2025	2	1.983	1121	0.133	74.951	0.033	74.951	0.013	74.951	0.013	74.951
2026	3	2.142	1120	0.143	74.913	0.036	74.913	0.014	74.913	0.014	74.913
2027	4	2.296	1118	0.154	74.786	0.038	74.786	0.015	74.786	0.015	74.786
2028	5	2.456	1119	0.164	74.853	0.041	74.853	0.016	74.853	0.016	74.853
2029	6	2.631	1123	0.176	75.123	0.044	75.123	0.018	75.123	0.018	75.123
2030	7	2.817	1133	0.188	75.785	0.047	75.785	0.019	75.785	0.019	75.785
2031	8	2.985	1142	0.200	76.361	0.050	76.361	0.020	76.361	0.020	76.361
2032	9	3.138	1151	0.210	76.933	0.052	76.933	0.021	76.933	0.021	76.933
2033	10	3.231	1159	0.216	77.486	0.054	77.486	0.022	77.486	0.022	77.486
2034	11	3.323	1167	0.222	78.053	0.056	78.053	0.022	78.053	0.022	78.053
2035	12	3.401	1175	0.227	78.569	0.057	78.569	0.023	78.569	0.023	78.569
2036	13	3.434	1181	0.230	78.990	0.057	78.990	0.023	78.990	0.023	78.990
2037	14	3.455	1187	0.231	79.342	0.058	79.342	0.023	79.342	0.023	79.342
2038	15	3.484	1192	0.233	79.679	0.058	79.679	0.023	79.679	0.023	79.679

Notes:

[1] Tailpipe emission factors are estimated from EMFAC2017 output and adjusted using tailpipe emission assumptiosn provided in Table B-11.

[2] Global warming potential (GWP) of 25 and 298 for CH_4 and N_2O respectively were obtained from the IPCC Fifth Assessment Report, 2014 (AR5). Available at: https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf. Accessed: January 2021.

Abbreviations:

CH_4 - methane
CO_2e - carbon dioxide equivalent
EMFAC - Emission Estimator model
HHDT - heavy-heavy duty truck
g - gram
NG - natural gas
NO_X - nitrogen oxides
N_2O - nitrous oxide

Table B-12. Upstream Emission Factors

Upstream Emission Factors by Fuel Type (g/MJ)						
Calendar Year	Diesel		CNG		Electricity	
	NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e
2023	0.015	25.3	0.047	17.6	0.084	75.3
2024	0.015	25.2	0.047	17.4	0.080	71.7
2025	0.015	25.2	0.047	17.3	0.076	68.2
2026	0.015	25.2	0.047	17.2	0.071	64.6
2027	0.015	25.1	0.047	17.1	0.067	61.0
2028	0.015	25.1	0.047	17.0	0.063	57.4
2029	0.015	25.1	0.047	16.9	0.059	53.8
2030	0.015	25.0	0.047	16.8	0.055	50.2
2031	0.015	25.0	0.046	16.6	0.051	46.6
2032	0.015	25.0	0.046	16.6	0.047	44.2
2033	0.015	25.0	0.046	16.5	0.042	41.8
2034	0.015	25.0	0.046	16.4	0.038	39.4
2035	0.015	24.9	0.046	16.3	0.033	36.9
2036	0.015	24.9	0.046	16.3	0.029	34.5
2037	0.014	24.9	0.046	16.2	0.024	32.1
2038	0.014	24.9	0.046	16.1	0.023	30.2
2039	0.014	24.9	0.046	16.1	0.021	28.2
2040	0.014	24.8	0.046	16.0	0.020	26.3
2041	0.014	24.8	0.046	15.9	0.018	24.4
2042	0.014	24.8	0.046	15.9	0.016	22.5
2043	0.014	24.8	0.046	15.8	0.015	20.6
2044	0.014	24.8	0.046	15.8	0.013	18.6
2045	0.014	24.8	0.046	15.7	0.012	16.7
2046	0.014	24.8	0.045	15.7	0.011	15.6
2047	0.014	24.7	0.045	15.6	0.010	14.5
2048	0.014	24.7	0.045	15.6	0.009	13.4
2049	0.014	24.7	0.045	15.6	0.008	12.2
2050	0.014	24.7	0.045	15.5	0.007	11.1

Notes:
[1] Upstream emission factors for years 2023, 2031, 2037, 2045 and 2050 were derived from CA-GREET3.0 model. Emission factors for all other years were estimated by interpolating the emission factors for these years. Details regarding model inputs and assumptions are provided in Appendix A.

Abbreviations:
CA-GREET - California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
CNG - compressed natural gas
CO_2e - carbon dioxide equivalent
g - gram
MJ - megajoule
NOx - nitrogen oxides

Table B-13. Fuel Consumption

	Conventional Diesel HHDT	Low NOx Diesel HHDT	Low NOx NG HHDT	BEV HHDT
Fuel Economy (mpDGe)	7.03	7.03	6.33	21.29
10-year (435,00 miles) Useful Truck life				
Annual Mileage[1] (mi/yr)	43,500			
Fuel Usage (DGe/yr)	6,188	6,188	6,875	2,043
Energy Consumption (MJ/yr)	832,069	832,069	924,521	274,745
15-year (909,900 miles) Useful Truck life				
Annual Mileage[1] (mi/yr)	60,660			
Fuel Usage (DGe/yr)	8,629	8,629	9,587	2,849
Energy Consumption (MJ/yr)	1,160,306	1,160,306	1,289,229	383,128

Conversion Factor:

Diesel Energy Content[2] 134 MJ/gal

Notes:

[1]Annual Mileage is calculated by dividing useful truck life mileage by the useful truck life age.

[2]LCFS Regulation, Table 4. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf. Accessed: January 2021.

Abbreviations:

BEV - battery electric vehicle
HHDT - heavy-heavy duty truck
mi - mile
MJ - megajoule
mpDGe - miles per diesel gallon equivalent
NG - natural gas
yr - year

Table B-14. Upstream Emissions Calculations

Year	Truck Age	Upstream Emissions[1] (ton/year)							
		Conventional Diesel HHDT		Low-NOx Diesel HHDT		Low-NOx CNG HHDT		BEV HHDT	
		Diesel		Diesel		CNG		Electricity	
		NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e	NO_x	CO_2e
Upstream Emissions for a 10-year (435,00 miles) Useful Truck life									
2024	1	0.014	23	0.014	23	0.048	18	0.024	22
2025	2	0.014	23	0.014	23	0.048	18	0.023	21
2026	3	0.014	23	0.014	23	0.048	18	0.022	20
2027	4	0.014	23	0.014	23	0.048	17	0.020	18
2028	5	0.014	23	0.014	23	0.048	17	0.019	17
2029	6	0.014	23	0.014	23	0.048	17	0.018	16
2030	7	0.013	23	0.013	23	0.047	17	0.017	15
2031	8	0.013	23	0.013	23	0.047	17	0.015	14
2032	9	0.013	23	0.013	23	0.047	17	0.014	13
2033	10	0.013	23	0.013	23	0.047	17	0.013	13
Upstream Emissions for a 15-year (909,900 miles) Useful Truck life									
2024	1	0.019	32	0.019	32	0.067	25	0.034	30
2025	2	0.019	32	0.019	32	0.067	25	0.032	29
2026	3	0.019	32	0.019	32	0.067	24	0.030	27
2027	4	0.019	32	0.019	32	0.067	24	0.028	26
2028	5	0.019	32	0.019	32	0.066	24	0.027	24
2029	6	0.019	32	0.019	32	0.066	24	0.025	23
2030	7	0.019	32	0.019	32	0.066	24	0.023	21
2031	8	0.019	32	0.019	32	0.066	24	0.022	20
2032	9	0.019	32	0.019	32	0.066	24	0.020	19
2033	10	0.019	32	0.019	32	0.066	23	0.018	18
2034	11	0.019	32	0.019	32	0.066	23	0.016	17
2035	12	0.019	32	0.019	32	0.066	23	0.014	16
2036	13	0.019	32	0.019	32	0.065	23	0.012	15
2037	14	0.019	32	0.019	32	0.065	23	0.010	14
2038	15	0.019	32	0.019	32	0.065	23	0.010	13

Notes:

[1]Upstream emissions are calculated using upstream emission factors from Table B-13 and fuel consumption values in Table B-14.

Abbreviations:

BEV - battery electric vehicle

CNG - compressed natural gas

CO_2e - carbon dioxide equivalent

HHDT - heavy-heavy duty truck

NO_X - nitrogen oxides

Table B-15. Total Cost of Ownership 10-year Analysis Summary

Description	Units[1]	Conventional Diesel HHDT	Federal Low-NO_x Diesel HHDT	CA Low-NO_x Diesel HHDT	Low-NO_x NG HHDT	BEV- 2018[2]	BEV-2024[2]
Capital Costs[3]							
Purchase Cost	dollars	$172,921	$178,623	$210,876	$192,719	$569,916	$384,448
Charging Infrastructure	dollar/charger	--	--	--	--	$105,000	$105,000
Total Capital Cost	***dollars***	***$172,921***	***$178,623***	***$210,876***	***$192,719***	***$674,916***	***$489,448***
Operational Costs[4]							
Useful Truck Life	years	10					
Annual Mileage	miles/year	43,500					
Fuel Economy	mpDGe	7.03	7.03	7.03	6.3	21.3	21.3
Lifetime Fuel Cost	dollars	$246,057	$246,057	$246,057	$140,604	$132,820	$132,820
Maintenance Cost	dollars/mile	$0.19	$0.19	$0.19	$0.19	$0.14	$0.14
Lifetime Maintenance Cost	dollars	$82,650	$82,650	$82,650	$82,650	$61,988	$61,988
Lifetime Registration Fees	dollars	$31,211	$31,420	$32,604	$31,938	$27,210	$20,399
Lifetime Insurance Fees	dollars	$29,310	$30,277	$35,744	$32,666	$96,601	$65,164
Lifetime EV Charging Infrastructure Maintenance Cost	dollars	--	--	--	--	$4,150	$4,150
8-year Battery Overhaul Cost	dollars	--	--	--	--	$32,432	$49,442
Total Lifetime Operational Costs	***dollars***	***$389,228***	***$390,404***	***$397,055***	***$287,857***	***$355,201***	***$333,962***
Total Cost							
Total Cost of Ownership	***dollars***	***$562,149***	***$569,027***	***$607,932***	***$480,576***	***$1,030,117***	***$823,411***
Incremental Cost of Ownership	***dollars***	***Baseline***	***$6,877***	***$45,782***	***-$81,573***	***$467,967***	***$261,262***
Emissions[5]							
Total Lifetime Tailpipe Emissions							
NO_x	tons	1.2	0.31	0.12	0.12	0	0
CO_2e	tons	542	542	542	542	0	0
Total Lifetime Upstream Emissions							
NO_x	tons	0.14	0.14	0.14	0.48	0.19	0.19
CO_2e	tons	230	230	230	173	169	169
Total Lifetime Emissions Well-to-Wheels[6]							
NO_x	tons	1.4	0.44	0.26	0.60	0.19	0.19
CO_2e	metric tons	701	701	701	649	154	154
Cost Effectiveness[7]							
Cost Effectiveness (Total Lifetime Tailpipe)							
NO_x	dollar/ton	Baseline	$7,501	$41,610	-$74,139	$382,791	$213,709
CO_2e	dollar/MT	Baseline	N/A	N/A	N/A	$60	$91
Cost Effectiveness (Total Lifetime Well-to-Wheels[6])							
NO_x	dollar/ton	Baseline	$7,501	$41,610	-$107,460	$399,145	$222,839
CO_2e	dollar/MT	Baseline	N/A	N/A	-$1,561	$855	$478

Notes:

[1] All Costs are in 2018 dollars.

[2] BEV-2018 refers to a MY2018 HHDT. All other HHDTs assessed are MY2024 vehicles. For more details please see Table B-1.

[3] Refer to Table B-1 and Table B-2 for details on capital cost assumptions.

[4] Refer to Tables B-4 through Table B-10 for details on operational cost assumptions.

[5] Refer to Tables B-11 through B-15 for details on emission calculations and assumptions.

[6] Well-to-Wheels emissions represent the sum of vehicle tailpipe emissions and upstream emissions.

[7] Cost effectiveness is calculated by dividing the incremental TCO of a vehicle (compared to a conventional diesel HHDT) by the total lifetime emissions reductions (compared to that of a conventional diesel HHDT). A negative cost effectiveness occurs when the cost of the vehicle is less than that of a baseline conventional diesel HHDT or when lifetime emissions of the vehicle is more than the baseline conventional diesel HHDT.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CA - California
CARB - California Air Resources Board
CO_2e - carbon dioxide equivalent
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
kWh - kilowatt hour
LCFS - Low Carbon Fuel Standard
mpDGe - miles per diesel gallon equivalent
MT - Metric Ton
MY - model year
NG - natural gas
NOx - nitrogen oxides
TCO - total cost of ownership

Table B-16. Total Cost of Ownership 15-year Analysis Summary

Description	Units[1]	Conventional Diesel HHDT	Federal Low-NO_x Diesel HHDT	CA Low-NO_x Diesel HHDT	Low-NO_x NG HHDT	BEV- 2018[2]	BEV-2024[2]
Capital Costs[3]							
Purchase Cost	dollars	$172,921	$178,623	$210,876	$192,719	$569,916	$384,448
Charging Infrastructure	dollar/Charger	--	--	--	--	$105,000	$105,000
Total Capital Cost	***dollars***	***$172,921***	***$178,623***	***$210,876***	***$192,719***	***$674,916***	***$489,448***
Operational Costs[4]							
Useful Truck Life	years	15					
Annual Mileage	miles/year	60,660					
Fuel Economy	mpDGe	7.03	7.03	7.03	6.3	21.3	21.3
Lifetime Fuel Cost	dollars	$534,549	$534,549	$534,549	$301,837	$280,943	$280,943
Maintenance Cost	dollars/mile	$0.19	$0.19	$0.19	$0.19	$0.14	$0.14
Lifetime Maintenance Cost	dollars	$172,881	$172,881	$172,881	$172,881	$129,661	$129,661
Lifetime Registration Fees	dollars	$44,484	$44,721	$46,062	$45,307	$33,129	$25,413
Lifetime Insurance Fees	dollars	$33,201	$34,296	$40,488	$37,002	$109,424	$73,814
Lifetime EV Charging Infrastructure Maintenance Cost	dollars	--	--	--	--	$6,225	$6,225
8-year Battery Overhaul Cost	dollars	--	--	--	--	$32,432	$49,442
Total Lifetime Operational Costs	***dollars***	***$785,114***	***$786,446***	***$793,980***	***$557,028***	***$591,813***	***$565,498***
Total Cost							
Total Cost of Ownership	***dollars***	***$958,035***	***$965,069***	***$1,004,857***	***$749,747***	***$1,266,729***	***$1,054,946***
Incremental Cost of Ownership	***dollars***	***Baseline***	***$7,033***	***$46,821***	***-$208,289***	***$308,694***	***$96,911***
Emissions[5]							
Total Lifetime Tailpipe Emissions							
NO_x	tons	2.8	0.71	0.28	0.28	0	0
CO_2e	tons	1151	1151	1151	1151	0	0
Total Lifetime Upstream Emissions							
NO_x	tons	0.28	0.28	0.28	0.99	0.32	0.32
CO_2e	tons	480	480	480	356	309	309
Total Lifetime Emissions Well-to-Wheels[6]							
NO_x	tons	3.1	0.99	0.57	1.28	0.32	0.32
CO_2e	metric tons	1480	1480	1480	1367	281	281
Cost Effectiveness[7]							
Cost Effectiveness (Total Lifetime Tailpipe)							
NO_x	dollar/ton	Baseline	$3,293	$18,267	-$81,264	$108,394	$34,029
CO_2e	dollar/MT	Baseline	N/A	N/A	N/A	$514	$43
Cost Effectiveness (Total Lifetime Well-to-Wheels)[6]							
NO_x	dollar/ton	Baseline	$3,293	$18,267	-$112,410	$109,901	$34,502
CO_2e	dollar/MT	Baseline	N/A	N/A	-$1,850	$257	$81

Notes:

[1] All Costs are in 2018 dollars.

[2] BEV-2018 refers to a MY2018 HHDT. All other HHDTs assessed are MY2024 vehicles. For more details please see Table B-1.

[3] Refer to Table B-1 and Table B-2 for details on capital cost assumptions.

[4] Refer to Tables B-4 through Table B-10 for details on operational cost assumptions.

[5] Refer to Tables B-11 through B-15 for details on emission calculations and assumptions.

[6] Well-to-Wheels emissions represent the sum of vehicle tailpipe emissions and upstream emissions.

[7] Cost effectiveness is calculated by dividing the incremental TCO of a vehicle (compared to a conventional diesel HHDT) by the total lifetime emissions reductions (compared to that of a conventional diesel HHDT). A negative cost effectiveness occurs when the cost of the vehicle is less than that of a baseline conventional diesel HHDT or when lifetime emissions of the vehicle is more than the baseline conventional diesel HHDT.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CA - California
CARB - California Air Resources Board
CO_2e - carbon dioxide equivalent
HHDT - heavy-heavy duty truck
ISOR - Initial Statement of Reason
kWh - kilowatt hour
LCFS - Low Carbon Fuel Standard
mpDGe - miles per diesel gallon equivalent
MT - Metric Ton
MY - model year
NG - natural gas
NOx - nitrogen oxides
TCO - total cost of ownership

Table B-17. LCFS Revenue Estimation

CARB LCFS Credit Projections[1]	Units	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Electricity	$/kWh	$0.12	$0.12	$0.12	$0.12	$0.12	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
	$/DGE	$4.65	$4.56	$4.48	$4.39	$4.31	$4.22	$4.14	$4.14	$4.14	$4.14	$4.14	$4.14	$4.14	$4.14	$4.14

Potential Truck Lifetime LCFS Revenue[2] ($/HHDT)	
BEV HHDT- 10-year Useful Life	$88,210
BEV HHDT- 15-year Useful Life	$181,986

Notes:

[1]CARB ACT Cost Calculator. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx. Accessed: January 2021.

[2]Ramboll has calculated the potential LCFS revenue for BEVs across the truck lifetime using credit price projections from the ACT Cost Calculator and electricity usage assumptions detailed in Table B-13. This calculation is for illustrative purposes and assumes that the BEV HHDT owner and the BEV charging infrastructure owner are the same entity. This entity would generate credits from the LCFS program through charging of the BEV HHDT. Ramboll has not included LCFS revenue in the TCO analysis given uncertainties in future market conditions and availability of credit deficits in the LCFS program in future years.

Abbreviations:

ACT - Advanced Clean Truck
BEV - battery electric vehicle
CARB - California Air Resources Board
DGe - diesel gallon equivalent
HHDT - heavy-heavy duty truck
kWh - kilowatt hour
LCFS - Low Carbon Fuel Standard
TCO - total cost of ownership