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June 24, 2022

The Honorable Liane Randolph
Honorable Members of the Board
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812-2815

Subject: Comments on the Draft 2022 Scoping Plan Update

Dear Chair Randolph and Members of the Board:

Southern California Gas Company ("SoCalGas") appreciates the diligence of California Air Resources Board (CARB) Staff putting forth the Draft 2022 Scoping Plan Update (SPU) and organizing comprehensive workshops and presentations for the public and the CARB Board, as well as continuously being inclusive of the Environmental Justice Advisory Committee (EJAC) and stakeholders. This type of dedication to unbiased, all-encompassing ethos serves the public interest best, especially when Staff undertake the challenge of transitioning an energy system while also working within the constraints of costs, feasibility, and reliability. We applaud CARB's commitment to the public process which should serve as the model for transparent policymaking.

SoCalGas' comments highlight the following: 1) Grid reliability is critical to advancing the State's climate and clean energy goals; 2) Residential fuel cells should be a cornerstone of building decarbonization; 3) Instituting an Industrial Clean Fuels Standard will help to decarbonize the industrial sector; 4) RNG should be utilized in the transportation sector to expedite emissions reductions; 5) ZEV deployment and reduced driving demand exert differing and asymmetrical forces on decarbonization efforts and should be evaluated independently; and 6) Achieving carbon neutrality by 2045 offers the smoothest and least disruptive path to the state's decarbonization goals.

To date, much of the success of reducing electric system greenhouse gas (GHG) emissions is attributable to the California State Legislature enacting laws such as Assembly Bill (AB) 32 and Senate Bill (SB) 32, the Renewables Portfolio Standard[1] (RPS) in 2002, the Emissions Performance Standard (EPS) in 2006, regulations promulgated in response such as the Cap-and-Trade program, and the implementation of such policies by the electric utilities.[2] These mandates and incentives drove the acceleration of GHG emission reductions in the electricity sector, which has accomplished a 46 percent reduction in GHG emission below 1990 levels.[3] The RPS and the Cap-and-Trade Program continue to incentivize the development of renewables over fossil generation to serve California's load.[4]

These emission reductions offset industrial sector emissions and transportation sector emissions to help the State achieve AB 32's goal four years ahead of schedule in 2016. The electric sector already had a plethora of thermal flexible capacity that was able to integrate the renewable resources that came online in the last decade. The hard-to-abate industrial and heavy-duty transportation sectors, however, did not contribute significant GHG emission reductions. Maintaining progress and strengthening decarbonization going forward requires that the 2022 Scoping Plan Update include a robust clean fuels strategy to address the industrial and transportation sector emissions.

Today, the State faces several challenges on its pathway to achieving carbon neutrality by 2045. Most pressing are near-term threats faced by California's electric grid, such as reliability issues, which could set back the State's climate policies, as Vice Chair Siva Gunda remarked during a California Energy Commission (CEC) workshop held in June 2022.[5] Drought conditions have significantly reduced hydroelectric power capacity, while record-breaking heatwaves have increased demand for electricity. In fact, the California Independent System Operator (CAISO) and the CEC have indicated that there are significant shortfalls of supply for a 1-in-10 weather event -- roughly 1,700 megawatts (MW), which is equivalent to powering 1.2 million homes.[6] Supply shortages could be further exacerbated by extreme climatic events, such as heatwaves and droughts, occurring across the Western Interconnection which provides the State with energy supplies. Additionally, many of the State's transmission lines are located near high fire risk areas. Consequently, wildfires could jeopardize import supply.[7]

[1] *See* Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002) Renewable energy: California Renewables Portfolio Standard Program. The RPS program began as a mandate for utilities to procure 20% of their retail sales from eligible renewable resources by 2017. It was later amended to 20% by 2010, 33% by 2020, 50% by 2030 and now stands at 60% by 2030.

[2] *See* Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006) Electricity: emissions of greenhouse gases. This prohibited utilities from making long term investments in power plants that were less efficient than a combined cycle natural gas power plant, thereby effectively ending long-term contracting for coal-fired generation.

[3] CARB GHG Inventory, accessed June 2022, available at https://ww2.arb.ca.gov/ghg-inventory-archive.

[4] "California Greenhouse Gas Emissions for 2000 to 2019," CARB, July 28, 2021. At 12.

[5] See CEC Lead Commissioner Workshop to Launch Distributed Energy Resources in California's Energy Future Proceeding, June 1, 2022, available at https://www.energy.ca.gov/event/workshop/2022-06/session-1-lead-commissioner-workshop-launch-distributed-energy-resources.

[6] Neil Millar presentation: "Summer and Midterm Stack Analysis," May 20, 2022, used for September peak conditions, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=243174&DocumentContentId=76875.

[7] *See* CEC Staff Workshop on Summer and Midterm Reliability, May 20, 2022. Available at https://www.energy.ca.gov/event/workshop/2022-05/session-1-staff-workshop-summer-and-midterm-reliability.

Dispatchable electricity generation, which is often provided through conventional power plants. is currently the primary means to complement the intermittency of renewable energy and to maintain a reliable and resilient electric grid. This is because the gas grid acts as a form of electric storage by providing just-in-time molecules to ensure reliability while operating during peak demand periods and other extreme events. According to the CEC, the gas grid is a key enabler to increasing renewable resources, which are the primary source of GHG emission reductions in the electric sector.[8] Accordingly, the more intermittent resources connect to the electric grid, the higher the need for flexible generation resources to support grid reliability. It is imperative that such resources likewise decarbonize over time by utilizing fuels like green hydrogen and renewable natural gas (RNG). Moreover, the modeled 2045 alternatives highlight the need for clean fuels to support and accelerate decarbonization efforts for the hard-to-abate transportation and industrial sectors.

As CARB finalizes the Draft SPU, consideration must be given to supply shortfalls that could potentially increase as transportation and buildings electrify and supply chain issues delay installation of new energy resources. Build-out rates will affect both the rate of energy transformation and electric reliability. Thus, realistic build-out rates that consider the limitations listed above must be incorporated in any target setting. Given this a 2045 achievement target best supports power grid reliability and resiliency, enables the State's economy and workforce to adapt most smoothly to the necessary changes, and ensures more balanced and fair treatment of Californians who may be particularly sensitive to cost increases.

SoCalGas is committed to a collective, collaborative transition to cleaner energy. A well designed plan, incorporating these recommendations, will help propel the state toward a clean, resilient and reliable energy backbone to fortify California's future.

1) **Grid reliability is critical to advancing the State's climate and clean energy goals**

The Draft SPU calls for the electrification of most sectors while simultaneously increasing annual clean energy percentages of the electric grid.[9] As the State continues to decarbonize through increased electrification and consequently increased demand, there is an enhanced need for grid reliability investment. Grid reliability refers to an energy system's ability to maintain energy delivery under standard operating conditions, including normal fluctuations in demand and supply.[10] This is accomplished by having enough generation resources to meet all power demands and having enough built-in redundancy to minimize the effects of single point failures.

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[8] California Energy Commission, Final 2021 Integrated Energy Policy Report Volume III: Decarbonizing the State's Gas System, published March 2022, at 24 (Ch. 2: Gas and Electric Interdependencies), available at https://www.energy.ca.gov/data-reports/reports/integrated-energypolicy-report/2021-integrated-energy-policy-report.

[9] The CARB Draft 2022 Scoping Plan Update, published May 10, 2022, estimates that electricity demand will grow about 50% by 2035 to nearly 80% by 2045 compared to 2020. In addition, it states "in almost all sectors, electrification will play an important role. That means that the grid will need to grow at unprecedented rates and ensure reliability and resiliency through the next two decades and beyond." p. vii.

[10] American Gas Foundation, "Building a Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience," January 2021, at page 9, available at https://gasfoundation.org/2021/01/13/building-a-resilient-energy-future/.

Currently, the State's electric grid faces considerable reliability risks in the near-term, even without the increase in demand.[11]

The gas grid underpins the electric grid's reliability and enables further deployment of renewables. Gas system reliability enabled this accomplishment, providing fuel for 37 percent of the generation in 2020.[12] To achieve the necessary renewable energy goal by 2045 "annual build rates for the Proposed Scenario will need to increase over 150 percent and over 500 percent for solar and battery storage, respectively, compared to historic maximum rates."[13,14] Expanding sources of renewable energy while increasing electrification requires an unprecedented build-out of new clean energy resources, batteries, and transmission infrastructure to deliver those clean electrons to homes and businesses. During a May 20, 2022, CEC Staff Workshop on Summer and Midterm Reliability, multiple presenters highlighted that growing the renewable and battery portfolio while simultaneously increasing electric load will cause significant reliability challenges in the summers of 2022, 2023, and in the midterm (through 2026).

The build-out challenges include supply chain issues and rising transportation costs, making it difficult to finance and procure new resources. Supply chain disruptions continue to be a challenge that impact the ability of energy projects to come online in a timely matter, as highlighted by CEC staff and the California Public Utilities Commission (CPUC) Tracking Energy Development (TED) Task Force during the CEC's May 20, 2022 workshop.[15] Situations like the Auxin Circumvention Case,[16] which is constraining imports of solar panels, affect the availability of such components, adding uncertainty to the supply chain and potentially delaying the completion of renewable energy projects beyond their scheduled procurement date. According to the U.S. Energy Information Administration's (EIA) 2020 Annual Solar Photovoltaic Module Shipments Report, approximately 82 percent of the photovoltaic module imports into the U.S. came from Malaysia, Thailand, Vietnam, and South Korea, which are the countries affected by the Auxin Circumvention Case.[17] The high volume of photovoltaic modules anticipated to come from these countries suggests potential delays to solar projects is likely.

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[11] *See* Vice Chair Siva Gunda's Presentation to the State Assemble Budget Subcommittee No. 3 on Climate Crisis, Resources, Energy, Transportation's Information Hearing held June 1, 2022, available at https://abgt.assembly.ca.gov/sites/abgt.assembly.ca.gov/files/Reliability%20Overview%20for%2006.01.22%20Budget%20Sub3%20Hearing.pdf.

[12] *Ibid.*

[13] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, at page 161.

[14] Please note that these build rates do not include capacity associated with hydrogen production or any additional load to implement carbon dioxide (CO2) removal.

[15] See "CEC Staff Workshop on Summer and Midterm Reliability," CEC, May 20, 2022, available at: https://www.energy.ca.gov/event/workshop/2022-05/session-1-staff-workshop-summer-and-midterm-reliability.

[16] U.S. Department of Commerce inquiry instigated at the behest of U.S.-based Auxin Solar into whether crystalline silicon photovoltaic cells and modules imported from Cambodia, Malaysia, Thailand or Vietnam are circumventing antidumping and countervailing duty orders on such panels manufactured in China.

[17] *See* "2020 Annual Solar Photovoltaic Module Shipments Report", U.S. EIA, July 2021, available at: https://www.eia.gov/renewable/annual/solar_photo/pdf/pv_full_2020.pdf.

The Draft SPU states that to help address the challenge of high customer demand remaining into the summer evening period,[18] "resource installations that pair solar with batteries, as well as greater amounts of battery build-out are coming online currently and over the next five years."[19] However, it is important to recognize that significant barriers in the production of batteries also remain. Supply chain disruptions, oil and shipping costs, lithium cost increases, and interconnection and permitting delays are affecting the battery and lithium supply.[20] Also, note that even the most advanced batteries can only provide continuous stable energy output for limited durations of approximately four hours.[21] CAISO "predicts that as much as 15,000 MW of battery storage – of different duration levels and various technologies – will be needed to help the State reach its goal of cutting carbon from power grids by 100 percent by 2045."[22]

Additionally, there are modeling and planning risks due to unknowns of the future changing landscape, including threats of extreme heat, drought, and wildfires that are increasingly difficult to predict. California's carbon neutrality goals must be met through paths that support a reliable electric grid. Thus, as the State continues addressing the options to help build the future clean California electric grid, the gas grid will continue to support reliability. The gas grid, along with flexible generation resources that use gaseous fuel, provides ramping capabilities that enable and are necessary for intermittent resources and batteries to enter the market and contribute their maximum output while providing fuel for the grid to continue keeping the lights on well after the sun has set, the wind has died down, and 4-hour batteries have been depleted.[23,24] The CAISO 2022 Summer Assessment chart (Figure 1 below) illustrates that 7:00 PM - 8:00 PM will be the most challenging time interval, in terms of reliability.

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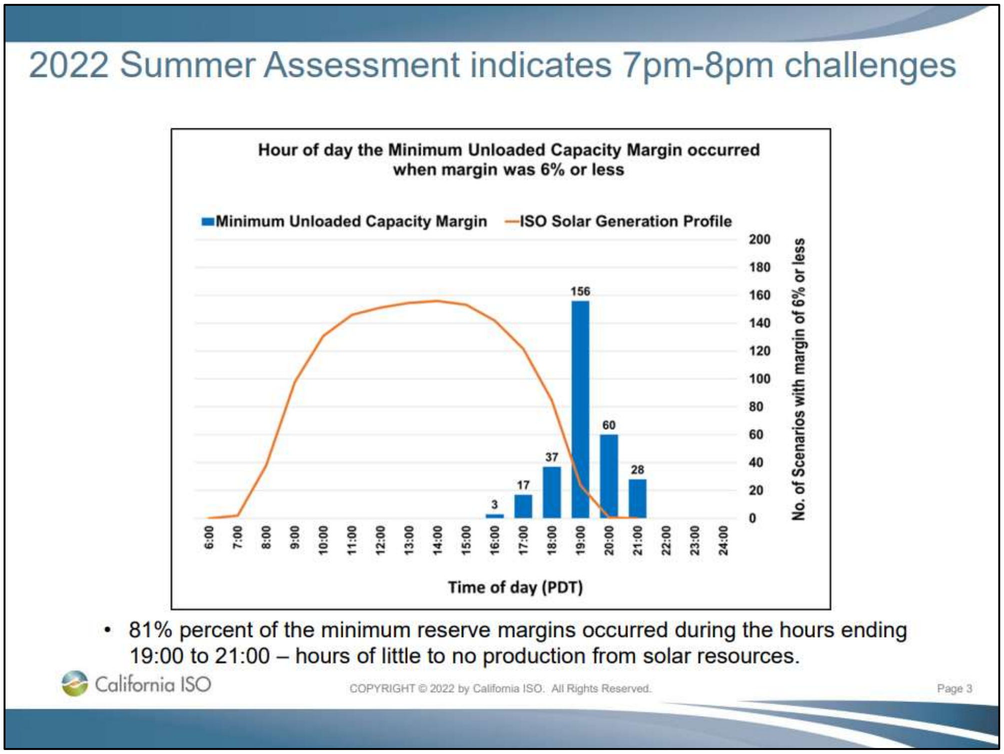
[18] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, at 158-159.
[19] *Id.* at 159.
[20] CEC Staff Workshop, *supra* note 15, remarks by Alex Morris of the California Energy Storage Alliance.
[21] National Regulatory Research Institute, *NRRI Insights*: "The Intersection of Decarbonization Policy Goals and Resource Adequacy Needs: A California Case Study," March 2021, available at https://pubs.naruc.org/pub/55D05995-155D-0A36-315C-A161357DA070.
[22] California ISO, News Release: "Largest battery storage system in US connects to California ISO grid," July 13, 2020, at http://www.caiso.com/Documents/LargestBatteryStorageSysteminUSConnectstoCaliforniaISOGrid.pdf .
[23] *See* "Flexible Resources to Help Renewables – Fast Facts", CAISO, available at: http://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf.
[24] The CAISO Fast Fact Sheet explains that to reliably manage the green grid, the ISO needs flexible resources with ramping capability.

Figure 1: CAISO 2022 Summer Assessment[25]



Installing additional solar resources will not ameliorate this reliability risk given their generation profiles do not contribute significantly to the 7 pm - 8 pm hour. Instead, firm dispatchable resources, and eventually energy storage technologies, can help address these reliability concerns. To provide a long-term solution to addressing the reliability and energy shortfalls in the evening, batteries will not cut it. Seasonal storage like green hydrogen needs to be readily available and deliverable. In the meantime, gas infrastructure will continue delivering renewable and natural gas to electric generators in support of electric reliability. As the State transitions to carbon neutrality, the gas system infrastructure can deliver clean fuels for electricity generation, resulting in clean, reliable energy that can be dispatched to meet energy system needs when solar, wind, and batteries have exhausted their output. As gas-fired generators elect to switch to clean fuels, gas infrastructure's reliability and resiliency services will continue adapting to reduce carbon intensity.

Finally, it is important to note that the Draft SPU has not yet considered the risks to grid reliability, as it is based on data points from the Senate Bill (SB) 100 Joint Agency Report.[26] The SB 100 Joint Agency Report states that while the initial analysis demonstrated that SB 100 is technically achievable, "*additional analysis is needed to evaluate reliability and other factors more comprehensively.*"[27](emphasis added) The SPU should include up-to-date modelling of

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[25] CEC Staff Workshop, *supra* note 15.
[26] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, at page iv.
[27] *See* SB 100 Joint Agency Report, published March 15, 2021, at 16.

grid reliability because of the associated risks, which are compounded by extreme climate events (drought, heat waves, and wildfires), supply chain disruptions, and tariff issues.[28] While we applaud the State Agencies for their work on grid reliability modelling, we strongly urge staff to expand the reliability testing to 2045.

2) Residential fuel cells should serve as a cornerstone of building decarbonization

SoCalGas agrees that providing resilient, decarbonized energy for all Californians should continue to be a critical aspect of California's climate, energy, and clean air goals. However, current reliability concerns are threatening to derail California's progress. The State has recognized 2022 electricity planning shortfalls; under one scenario, the shortfall is as great 1,700 MW for the summer of 2022.[29] There is concern that, due to supply chain issues and costs of transportation, this shortfall could be exacerbated over time. Consequently, California may need to fund 5,000 MW of electric generators for emergency purposes.[30] The potential for increased reliance on gasoline and diesel backup generation to ensure electric reliability continues to be validated as evidenced by the recent University of California, Irvine (UCI) presentation to the South Coast AQMD Governing Board.[31] The UCI presentation illustrated the potential significant air quality degradation and increased public health costs in disadvantaged communities from residential, commercial, and industrial gasoline and diesel backup generation during Public Safety Power Shutoff (PSPS) events in the South Coast Air Basin.[32] These impacts have also been top of mind for the Disadvantaged Communities Advisory Group (DACAG).[33] In 2021, the DACAG recommended reducing the use of diesel generators, improving communication about the scope and duration of Public Safety Power Shutoff (PSPS) events, and exploring ways the grid can remain energized through islanding in PSPS event communities with no wildfire risk.[34,35]

Residential fuel cells present an optimal solution for simultaneously addressing reliability shortages and achieving California's climate, air quality, public health, equity, and energy goals. Fuel cells could displace gasoline and diesel backup generation use during PSPS events by providing continuous power for electric appliances with negligible-to-zero GHG and criteria

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[28] *See* CEC Vice Chair Siva Gunda's Presentation to the State Assemble Budget Subcommittee No. 3 on Climate Crisis, Resources, Energy, Transportation's Information Hearing held June 1, 2022, at slide 2, available at https://abgt.assembly.ca.gov/sites/abgt.assembly.ca.gov/files/Reliability%20Overview%20for%2006.01.22%20Budget%20Sub3%20Hearing.pdf.
[29] Neil Millar's presentation "Summer and Midterm Stack Analysis," May 20, 2022, for September peak conditions, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=243174&DocumentContentId=76875.
[30] Governor's May Revise Budget, available at https://dof.ca.gov/budget/historical-budget-information/historical-budget-publications/2022-23-proposed-may-revision-adjustments-to-the-governors-budget/.
[31] *See* "Energy Future for South Coast Air Quality Management District" Jack Brouwer (University of California, Irvine), May 12, 2022, available at http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2022/spec-mtg--brd-retreat-agenda-may-2022.pdf?sfvrsn=24.
[32] *Ibid.*
[33] *See* Disadvantaged Communities Advisory Group at https://www.cpuc.ca.gov/dacag/
[34] *See* "DACAG 2021 Annual Report," CEC, p. 8, available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=240542.
[35] *See* McNamara et al. (2022), "Seeking energy equity through energy storage", The Electricity Journal 35 (2022), available at https://www.sciencedirect.com/science/article/pii/S1040619021001548#bib5

pollutant emissions from a variety of renewable and fossil fuels.[36] Fuel cells could also mitigate strain on the electric grid as more buildings and transportation segments electrify by offsetting electric demand through running "grid parallel" or "islanding." Beyond cleaner air and resilient power, fuel cells could result in cost savings for residents by reducing their electricity bills.

SoCalGas is engaged in two key efforts to help develop the fuel cell market. Utilizing funding from the 2016 AQMP, SoCalGas is completing lab testing for a residential Solid Oxide Fuel Cell (SOFC) and planning to field test four units in the South Coast Air Basin. Each unit will be retrofitted to a single-family home to power electric appliances. In addition, SoCalGas is developing new energy resilience projects for its customers to be deployed across its service territory to spur customer energy resilience investments. This program focuses on providing power resilience and reliability solutions to customers located in Tier 2 or Tier 3 High Fire Threat Districts during unplanned outages or when electric utilities de-energize powerlines during Public Safety Power Shutoff (PSPS) events to mitigate the risk of wildfires.[37] These behind-the-meter microgrids will include a long duration fuel cell plus battery storage solution with islanding capabilities. SoCalGas anticipates incorporating hydrogen into this program in the near future.

Given the benefits enumerated above, it is in the public interest for CARB to accelerate the fuel cell market in California through the 2022 SPU. To ensure equitable access to clean air and reliable energy, the 2022 SPU should include fuel cells as a cornerstone of reducing GHG emissions from residential and commercial buildings by not requiring a mitigation fee for fuel cells providing power for electric appliances and should allocate fuel cell incentives on par with electric appliance turnover incentives, especially in disadvantaged communities.

3) **An Industrial Clean Fuels Standard will support industrial sector decarbonization**

As the Draft 2022 SPU recognizes, changes in fuel use are critical to reducing GHG emissions from the industrial sector: "Decarbonizing industrial facilities depends upon displacing fossil fuel use with a mix of electrification, solar thermal heat, biomethane, low- or zero-carbon hydrogen, and other low-carbon fuels to provide energy for heat and reduce combustion emissions."[38] A transition to low-carbon gaseous fuels is especially important for industrial processes not easily electrified: "There are fewer commercially available and economically viable electrification options to replace industrial processes that require higher-temperature heat.

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[36] See Brower, Jack (2010), "On the role of fuel cells and hydrogen in a more sustainable and renewable energy future," Current Applied Physics, Volume 10, Issue 2 Supplement, March 2010 Pg S9-S17 available at https://www.sciencedirect.com/science/article/abs/pii/S1567173909004982#!.

[37] *See* SoCalGas, "Risk Assessment and Mitigation Phase Cross-Functional Factor Energy System Resilience", May 17, 2021, available at https://www.socalgas.com/sites/default/files/SCG-CFF-2_RAMP-Cross-Functional-Chapter-Climate_Change_62.pdf

[38] *Id.*, at 165.

For these processes, onsite combustion may continue to be needed, and decarbonization will require fuel substitution to hydrogen, biomethane, or other low-carbon fuels."[39]

California's industrial sector has proven hard to decarbonize and remains a significant source of GHG emissions that must be addressed to achieve the State's carbon neutrality goals. California's industrial sector accounts for 33 percent (or 661 billion cubic feet) of the State's natural gas consumption, contributes 23 percent of the State's GHG emissions, and has the second highest emissions reduction potential for meeting the 2030 targets as set forth in SB 350.[40] Process heat accounts for about 85 percent of industrial natural gas use in California.[41] Typical industrial process heating equipment includes boilers, furnaces, and evaporators, which produce heat via natural gas combustion as well as combined systems that produce both heat and electric power. Decarbonizing industrial facilities will require both electrification and changing the current fuel mix to a combination of RNG, solar thermal heat, green hydrogen or low carbon, zero carbon and carbon negative fuels.

The Draft 2022 SPU identifies a need for new regulation to motivate and accelerate electrification and the uptake of low-carbon fuels by the industrial sector: "Policies that support decarbonization strategies like electrification, use of renewable energy, and transition to alternative fuels are needed."[42]

Yet, the specific measures identified in the Draft SPU do not embrace all decarbonization pathways. For instance, industrial sector measures identified in Appendix C of the Draft SPU[43] are predominantly electrification with minimal use of hydrogen, Carbon Capture and Sequestration (CCS), and no utilization of RNG. All industry sectors are keenly interested in what the Draft SPU says about their respective industries so they can make decisions about their future. It thus would be helpful to understand CARB's decision-making process in choosing which industries are projected to use hydrogen, why some are required to convert from zero to 100 percent electric, why some industries are projected to utilize CCS, and why other industries are targeted for retirement.

In lieu of economically costly and potentially ineffective command-and-control regulations, which would be difficult to design and implement for operations as diverse as California's industrial sector, we urge CARB to apply the lessons learned from the Low Carbon Fuel Standard that is successfully decarbonizing transportation fuels in California and lean into use of market-based mechanisms. In particular, CARB should develop and adopt an Industrial Clean

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[39] *Id.* at 166-167 (internal citations omitted); *see also* Figure 4-7 "Final energy demand in industrial manufacturing … in 2020, 2035, and 2045 in the Proposed Scenario" (illustrating the energy mix necessary for the industrial sector, with major roles for hydrogen and biomethane).
[40] "Optionality, flexibility & innovation pathways for deep decarbonization in California," Energy Futures Initiative. 2019. https://energyfuturesinitiative.org/s/EFI_CA_Decarbonization_Full-b3at.pdf.
[41] California industrial energy efficiency market characterization study, XENERGY Inc., December 2001, available at http://www.calmac.org/publications/California%20Ind%20EE%20Mkt%20Characterization.pdf.
[42] *Id.*, at 166.
[43] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, Appendix C, pg. 6 & 7.

Fuel Standard that would impose a decreasing, rate-based target on regulated entities, allowing the industrial sector to achieve emission reductions in a technologically neutral manner by choosing between electrification, procuring low- and zero-carbon and carbon-negative fuels, and/or improving energy efficiency. An Industrial Clean Fuel Standard would achieve significant reductions at the least cost to the industrial sector, and in turn to all Californians, by enabling compliance flexibilities and harnessing technological innovation.

In addition, we suggest that state funded subsidies and incentives would catalyze the industrial sector's transition to low carbon fuels and equipment modernization. We encourage CARB to advocate within the context of the Administration's state budget process for such funding.

4) RNG should be utilized in the transportation sector to expedite emissions reductions

The Draft SPU states that CARB plans to "maintain aggressive zero emission vehicle goals,"[44] such as the goal to achieve 100 percent zero emission vehicle (ZEV) sales of medium-heavy-duty vehicles by 2040. The Draft SPU also recognizes that regulations should be consistent with EO N-79-20, which states that it is a "goal of the State that 100 percent of medium-and heavy-duty vehicles in the State be zero-emission by 2045 for all operations *where feasible*."[45] (emphasis added) However, the Draft SPU fails to recognize that there are a host of reasons that it may not be feasible to operate zero emission heavy-duty (HD) vehicles by 2045, such as insufficient infrastructure, refueling times, limited vehicle range, supply chain disruptions, costs, and charging patterns that diverge from typical case usages -- and the importance of having other low- and zero-carbon, and negative carbon options included in the SPU and associated state policies and programs.

As the SPU notes, future replacement of heavy-duty diesel vehicles with ZEVs "will significantly reduce GHG emissions and diesel PM emissions in low-income communities and communities of color adjacent to ports, distribution centers, and highways."[46] Significant reductions can be achieved today by utilizing RNG as a transportation fuel. RNG is currently helping California reduce GHG and criteria air pollutant emissions as a transportation fuel in negative emission heavy-duty trucks. To put this in perspective, in 2020 the utilization of RNG as a transportation fuel lowered GHG emissions at a level equivalent to taking about 760,000 passenger vehicles off the road or reducing CO_2 emissions from approximately 394 million gallons of gasoline consumed.[47] Transitioning heavy-heavy duty (HHD) trucks from diesel fuel to RNG can provide significant reductions in fugitive methane emissions from landfills and dairy manure. Switching to Optional Low NO_x RNG HHD trucks is the most cost-effective and technologically feasible pathway to obtain appreciable GHG reductions over the next decade,

[44] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, at 224.
[45] See Executive Order N-79-20, available at https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.
[46] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, at 148.
[47] RNG Coalition and NGV America, "Decarbonize Transportation with Renewable Natural Gas," April 2021, available at https://ngvamerica.org/wp-content/uploads/2021/04/Decarbonize-Transportation-with-RNG-Updated-April-16-2021.pdf.

starting today.[48] A report by the National Center for Sustainable Transportation, which focuses on environmental preservation for the U.S. Department of Transportation, found that each replacement of a diesel truck in 2024 would require 1.4 battery electric trucks due to weight and range factors,[49] whereas Optional Low NOx RNG trucks could replace diesel trucks on a one-to-one basis. A $1 Billion investment in BE trucks would result in avoided diesel emissions from approximately 1,500 diesel trucks, but approximately 2,000 battery electric trucks would be required to replace those 1,500 diesel trucks. For additional information, please also reference the Ramboll memorandum, appended to this comment letter.

The following analysis of the key trends in GHG emissions from the transportation sector in the past two decades, with a focus on the heavy-heavy-duty truck (HHDT) fleet, demonstrates the extent to which increased use of renewable lower carbon intensive (CI) fuels has already reduced GHG emissions from the statewide HHDT fleet, particularly from the solid waste collection vehicle (SWCV) fleet component thereof.[50]

Figure 2 (below) shows that increased usage of renewable lower CI fuels in the statewide HHDT fleet in the past years, from ~9% of total fuel consumption in 2015 to ~26% in 2020, resulted in a reduction in the well-to-wheel GHG emissions, from 5% in 2015 to 18% in 2020, shown as the difference between the dashed red line and the top of the shaded area.

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[48] *See* "Greener, Faster, Cheaper: A Combination Of Battery And Fuel Cell Electric Technology Is Key To Successfully Decarbonising Global Transport, Hydrogen Council," October 27, 2021, available at: https://hydrogencouncil.com/en/greener-faster-cheaper-a-combination-of-battery-and-fuel-cell-electric-technology-is-key-to-successfully-decarbonising-global-transport.
See also SoCalGas Comments on the Proposed 2022 State Strategy for the State Implementation Plan (SIP), CARB, filed March 4, 2022, Tables 2 and 4.
See also TN #242890, SoCalGas Comments on Clean Transportation Program first Advisory Committee Meeting for the 2022-2023 Investment Plan Update, Docket 22-ALT-01, Submitted on April 29, 2022 available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242890&DocumentContentId=76468 *and* TN #239890, SoCalGas Comments on the 2021-2023 Investment Plan Update for the Clean Transportation Program, DOCKET 21-ALT-01, Submitted on September 30, 2021, available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=239890&DocumentContentId=73331

[49] See "Research Report: Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement," National Center for Sustainable Transportation, 2020, available at https://escholarship.org/uc/item/0nw4q530.

[50] *See* Appendix A: Ramboll analysis "Charting historical greenhouse gas emissions from California's on-road transportation sector".

Figure 2: GHG Emissions for the Statewide HHDT Fleet (Stacked Graph: Diesel-Gasoline-NG)[51]

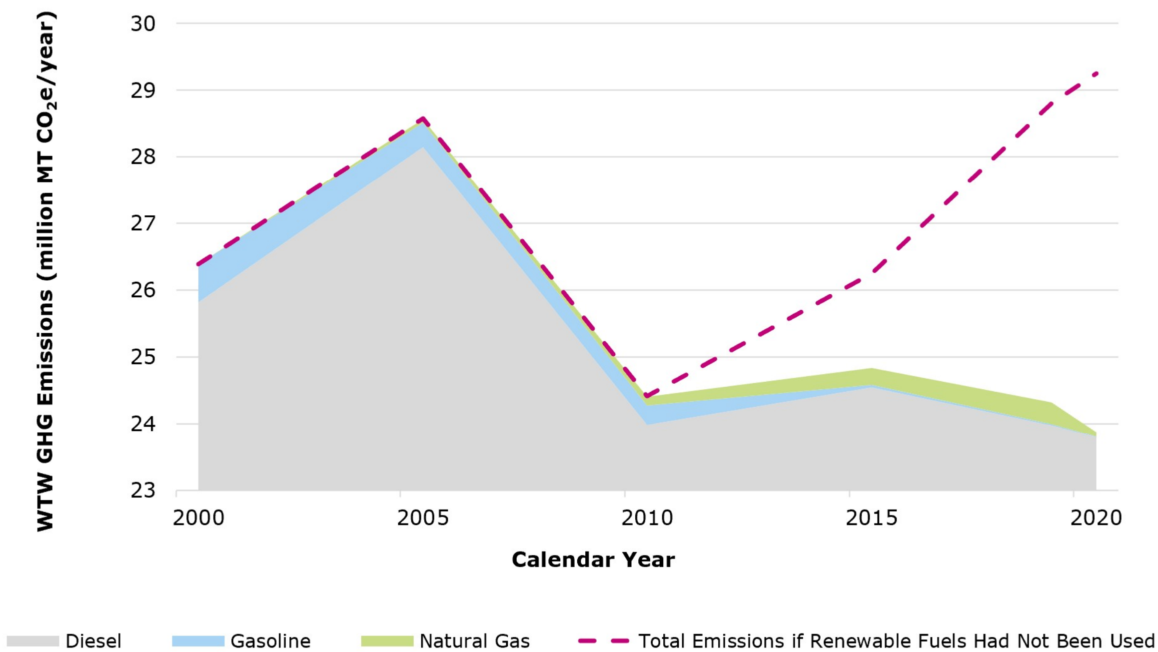
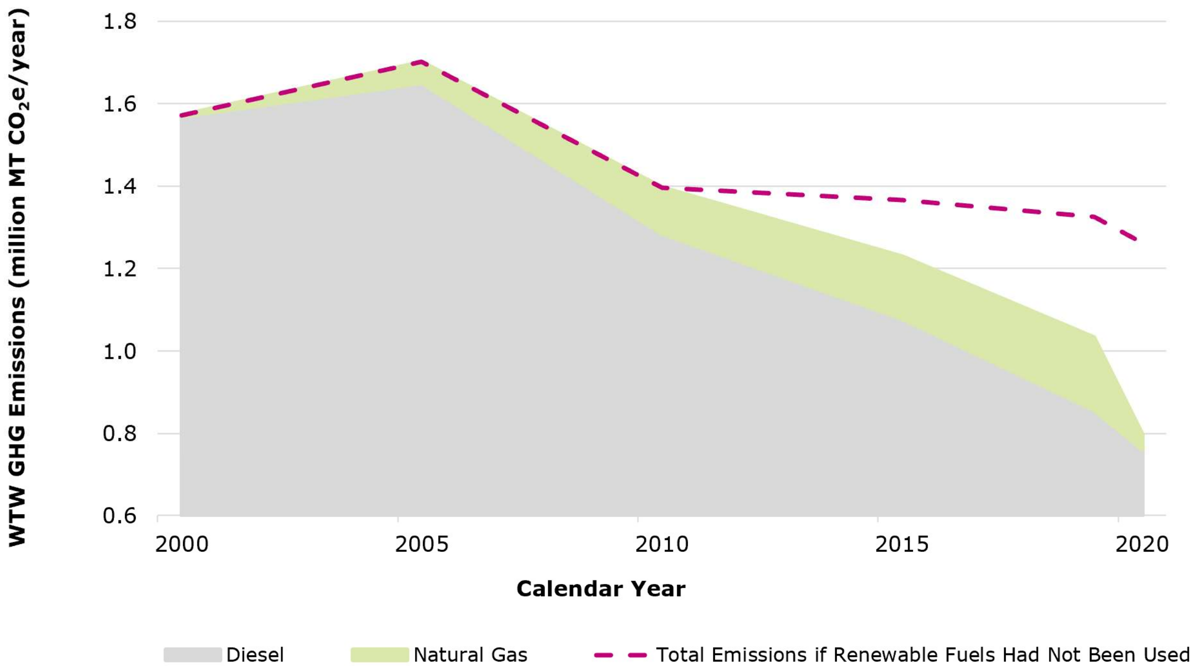


Figure 3 (below) shows GHG emissions from the SWCV sector. There is an increased penetration of natural gas vehicles in this sub-sector (~48% of the vehicle population in 2020, represented by the green area in Figure 3) as compared to HHDT fleet (~5% in 2020, represented by the green area in Figure 2). The increased penetration of natural gas vehicles in the SWVC fleet lead to an increase in the usage of renewable lower CI fuels (~22% of total fuel consumption is renewable in 2015 and ~46% is renewable in 2020) as compared to the HHDT fleet (~9% is renewable in 2015 and ~26% is renewable in 2020). As a result, the well-to-wheel GHG reductions (shown as the difference between the dashed red line and the top of the shaded area in **Figure 3**) associated with the use of renewable lower CI fuels in the SWCV fleet (10% in 2015 to 37% in 2020) are greater than the reductions for the overall HHDT fleet (5% in 2015 to 18% in 2020).

[51] *Ibid.*

Figure 3: Greenhouse Gas Emissions from Solid Waste Collection Vehicle Sector[52]



To further illustrate the reductions that can be achieved now by utilizing renewable fuels, such as RNG, in the transportation sector, the following comparative analyses of a Class 8 HHD truck powered by diesel, RNG, and electricity shows that a Class 8 Optional Low NO_X HHD RNG truck can generate greater reductions in lifecycle (well-to-wheel) GHG emissions than a BE truck when replacing a diesel truck.

Table 1 (below) shows that one Model Year (MY) 2024 Class 8 Optional Low NO_X RNG HHD truck can reduce lifecycle (well-to-wheel) GHG emissions by approximately 760 metric tonnes of carbon dioxide equivalent (MT CO_2e) over its ten-year lifetime as compared to its diesel counterpart, which is equivalent to taking almost 17 passenger vehicles off the road annually.[53] These GHG reductions are greater than those that can be achieved by replacing a diesel truck with a BE truck.[54][55]

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[52] *See* Appendix A: Ramboll analysis "Charting historical greenhouse gas emissions from California's on-road transportation sector".

[53] *See* "Greenhouse Gas Equivalencies Calculator," US EPA, March 2021, updated March 2022, available at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

[54] *Id.*

[55] *See* "Greener, Faster, Cheaper: A Combination of Battery And Fuel Cell Electric Technology Is Key To Successfully Decarbonising Global Transport, Hydrogen Council," October 27, 2021, available at: https://hydrogencouncil.com/en/greener-faster-cheaper-a-combination-of-battery-and-fuel-cell-electric-technology-is-key-to-successfully-decarbonising-global-transport.
See also SoCalGas Comments on the Proposed 2022 State Strategy for the State Implementation Plan (SIP), CARB, submitted on March 4, 2022, Tables 2 and 4.

Table 1. Class 8 HHD Trucks Well-to-Wheel GHG Emission Estimates for MY 2024

Greenhouse Gas	Units	Diesel Truck	Optional Low NO_x Natural Gas Truck	Battery Electric Truck
Tailpipe Emissions[56,57]				
CO_2 Emissions	MT/truck	614	0	0
CH_4 Emissions	MT/truck	0.00108	0.704	0
N_2O Emissions	MT/truck	0.0967	0.112	0
BC Emissions	MT/truck	0.00211	0.00026	0
Tailpipe CO_2e Emissions	MT/truck	645	51	0
Upstream Emissions				
Upstream CO_2e Emissions	MT/truck	225	54	175
Total CO_2e Emissions	**MT/truck**	**869**	**105**	**175**
Reduction of CO_2e Emissions Compared to Diesel	MT/truck	--	764	694
Percent Reduction of CO_2e Emissions Compared to Diesel	-	**--**	**87%**	**80%**

The tailpipe emissions of CO_2, methane, and black carbon were obtained from EMFAC2021 for a T7 Tractor Class 8 in California for Calendar Years 2024-2033. Lifetime emissions were integrated over an assumed vehicle lifespan of 10 years and activity level of 43,500 miles per year, based on the US EPA's definition of HHDT useful life and CARB's Low-NOx Omnibus Regulation. Upstream emission factors were calculated using the CA-GREET3.0 model for diesel and electricity generation. The electricity grid mix inputs to the model were adjusted based on California Energy Commission data for the current year and projections, with renewables comprising 47 percent in 2023 and growing to 81 percent in 2037. RNG upstream carbon intensities were obtained from the LCFS program pathway lookup tables for the following RNG feedstocks: landfill gas, food wastes, and animal waste/dairy digester gas. A weighted average of the carbon intensities is calculated based on the LCFS sales volumes in 2019-2020 before being used in these calculations.

Recent strategies and rulemaking proposals released by CARB, such as the Revised Draft 2020 MSS and the Advanced Clean Trucks (ACT) Regulation,[58,59] focus on a 100 percent Zero Emission Vehicle (ZEV) fleet beginning as early as 2024.[60] As noted by stakeholders in CARB workshops and public meetings for these regulations, ZEV technology is **not** commercially available to meet the needs of all duty cycles of the Class 8 HHD truck today. This is further reiterated in South Coast Air Quality Management District's (South Coast AQMD) letter to Partners in Environmental Justice and Environmental Health, dated August 3, 2021, wherein

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See also TN #242890, SoCalGas Comments on Clean Transportation Program first Advisory Committee Meeting for the 2022-2023 Investment Plan Update, Docket 22-ALT-01, submitted on April 29, 2022, available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242890&DocumentContentId=76468 *and* TN #239890, SoCalGas Comments on the 2021-2023 Investment Plan Update for the Clean Transportation Program, DOCKET 21-ALT-01, submitted on September 30, 2021, available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=239890&DocumentContentId=73331.

[56] "Direct Global Warming Potentials: CO_2, CH_4, and N_2O GWP values," IPCC, 2007, available at: https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html.

[57] "California's Black Carbon Emission Inventory," CARB, 2015 Edition, available at: https://ww3.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf.

[58] "Revised Draft 2020 Mobile Source Strategy," CARB, April 23, 2021, available at https://ww2.arb.ca.gov/sites/default/files/2021-04/Revised_Draft_2020_Mobile_Source_Strategy.pdf.

[59] "Advanced Clean Trucks," CARB, 2021, available at: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks.

[60] *Id.*

South Coast AQMD stated that "there are substantial challenges regarding whether the duty cycles for ZE Class 8 vehicles can meet business needs, and whether a service network is available for businesses that acquire these vehicles."[61]

Increased use of commercially available lower CI fuels can continue to reduce GHG emissions from the transportation sector today and going forward providing the collateral benefit of reducing emissions of nitrogen oxide (NOx). CARB's ZEV-centric approach, particularly for the HHD truck sector, does not result in the most health protective policy decision (greatest reduction of black carbon). Further, it prevents potential reductions in NOx and GHG emissions that can be achieved today by optional low NO_X RNG vehicles. CARB Staff working on the SPU should coordinate with CARB staff involved in the development of the MSS and HHD vehicle regulations to ensure that optional low NO_X RNG trucks are considered and included as part of the suite of fuel/technology pathways that CARB pursues to achieve the State's near term and long-term climate goals as well as meaningful reductions in criteria pollutants such as NOx.

5) ZEV deployment and driving demand reduction should be evaluated separately for clarity and transparency

The Draft SPU's scenario modeling repeatedly references a combined category entitled, "deploy ZEVs and reduce driving demand." For clarity and transparency, CARB should break out the two approaches separately – assessing the costs and benefits of deploying ZEVs independent from the costs and benefits of driving demand reduction efforts.

In Appendix C ("AB 197 Measure Analysis"), the Draft SPU articulates 29 separate measures used as part of CARB's evaluation of AB32 GHG Inventory Sectors, 10 of which are categorized under "deploy ZEVs and reduce driving demand." Of these, nine are related to electrification and fuels; only one relates to reduced driving – the assumption that vehicle miles traveled (VMT) per capita will decline 12% by 2030 and 22% by 2045.

The Draft SPU does not articulate a rationale for combining assumptions associated with ZEV deployment and those associated with reduced driving, nor does it express why it could not separate them. By bundling ZEVs with the largely unrelated VMT driving factor, CARB renders it impossible to fully and fairly evaluate the benefits and costs associated with ZEV deployment. Evaluating "reduce driving demand" as a single, separate metric would be appropriate.

Reducing VMT is an important goal in a State still highly reliant on single passenger trips in lower-density areas. The Draft SPU itself points out that "sustained VMT reductions have been difficult to achieve for much of the past decade, in large part due to entrenched transportation, land use, and housing policies and practices."[62]

In discussing reductions in VMT, the Draft SPU cites several recommendations of the AB 32 EJAC, including new roadway projects, roadway pricing strategies, and improvements to transit and bicycling, as well as autonomous vehicle deployment, ride hailing services, accelerated infill development and housing, and alignment of land use, housing, transportation and conservation

[61] Nastri, Wayne. "Letter to Partners in Environmental Justice and Environmental Health" August 3, 2021.
[62] *See* CARB Draft 2022 Scoping Plan Update, published May 10, 2022, at 155.

planning. Such a thorough and robust set of significant strategies deserves full and adequate consideration of the benefits and costs associated with reducing VMT.

Furthermore, the costs and benefits associated with expanding ZEV deployment likewise merit further and distinct review. The proposal anticipates 100% of light duty vehicle sales are ZEV by 2035, 100% of medium/heavy duty vehicle sales are ZEV by 2040, 10% of aviation is electric or hydrogen by 2045, 25% of ships use hydrogen fuel cell electric propulsion by 2045, 100% of drayage trucks are ZEV by 2030, 100% of cargo handling equipment is ZEV by 2030, 100% of new freight locomotive sales are ZEV by 2035, and 100% of other locomotive sales are ZEV by 2030. Calculating the impacts associated with achieving these results warrants careful consideration. Pairing these two substantial yet disparate topics – each of which provides significant decarbonization benefits – with this awkward combination diminishes analytical clarity, undermines review of both subjects, and likely obfuscates potential benefits.[63]

6) CARB data demonstrates that a 2045 timetable offers the most appropriate path to achieve carbon neutrality

The significance and urgency of the climate problem necessitates extensive changes to California's energy systems. In statutes and executive orders, State leaders have demonstrated a collective commitment to tackle these challenges. However, it is vital that the State remain focused on rapid and comprehensive GHG reductions in a manner that does not lead to extensive job loss, economic suffering, or disproportionate burdens on disadvantaged communities and populations traditionally forced to shoulder the negative impacts of policy decisions.

The hazards of climate change potentially impact every community within SoCalGas's service territory and throughout California. SoCalGas is committed to promoting equity relative to climate adaptation of the Company's infrastructure, operations, and service in impacted communities. Of particular concern are communities faced with high socioeconomic burdens and high exposure to one or more adverse climate hazards. These disproportionately impacted communities require specific attention and extra resources to adapt to climate change.[64]

As is typical of sweeping change, the needed transformations – including permitting and construction of extensive new and renovated infrastructure and global shifts in consumer behavior – will present a variety of technological, regulatory, fiscal, and societal hurdles. While these challenges must be surmounted in order to achieve statewide decarbonization goals in an expeditious manner, doing so within a 2045 timeframe meets the State's goals with more limited adverse impacts to the economy and workforce and better enables societal costs to be absorbed with limited disruption. It also supports energy reliability and resiliency by best enabling a smooth transition for the electric grid, which has served as the backbone to the State's decarbonization efforts. Targeting 2045 enables technologies, supply chains, and markets to adapt intelligently to a cleaner and more sustainable framework. Executive Order (EO) B-55-18 sets a goal of carbon neutrality by 2045.[65] We commend CARB for evaluating pathways beyond

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[63] *Id.* at 156.
[64] *Id.*
[65] Executive Order B-55-18, signed on September 10, 2018 by Governor Edmund G. Brown, Jr., available at https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf.

the EO of attaining carbon neutrality by 2035. However, CARB's own modeling results demonstrates that a 2045-time frame provides time for the State to build infrastructure, scale up clean energy resources, spread the build-out costs over a longer time period, and refine and deploy emerging technologies for people and businesses to rely on for decades. Further, a 2045 timeframe is supported by multiple independent, economy-wide studies.[66] A long-term approach also helps to guide the economy in the least disruptive path to a carbon neutral future by minimizing job losses and costs. Overall, the proposed timeframe of reaching carbon neutrality by 2045 will advance the public interest as this date was deemed achievable by multiple studies and is the most cost-effective target date of the modeled SPU alternatives.[67]

Conclusion

SoCalGas appreciates the opportunity to provide comments and engage with CARB and stakeholders to collectively advance the State's goal for achieving carbon neutrality by 2045. While modeling results indicate that a 2045 timeline to carbon neutrality is technically feasible, it is still a momentous undertaking that will require cohesive collaboration with state, regional, and local government, private industry, academic institutions, and communities across the country. To further strengthen the Scoping Plan Update, SoCalGas recommends that staff consider expanding decarbonization options for industries that have the capacity to utilize RNG and hydrogen and expand grid reliability testing to 2045. Reliability is critical to achieving the State's goals; additional energy resources can enable new intermittent resources and batteries to enter the market and contribute to their maximum output, while natural gas provides, and in the future green hydrogen will provide, support for the grid to continue keeping on the lights well after the sun has set, the wind has died down, and the 4-hour batteries have been depleted. To that end, we look forward to further engagement and perspectives on determining the most cost effective and technologically feasible pathways to decarbonize California.

Respectfully,

/s/ Kevin Barker

Kevin Barker
Senior Manager
Energy and Environmental Policy

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[66] E3, "Achieving Carbon Neutrality in California – PATHWAYS Scenarios Developed for the California Air Resources Board," October 2020. *See also* The Brookings Institution, CATF, E3, EDF, Stanford University, Princeton University, UC San Diego; *Issues in Science and Technology*: "California Needs Clean Firm Power, and so Does the Rest of the World: Three detailed models of the future of California's power system all show that California needs carbon-free electricity sources that don't depend on the weather"; 2021

[67] The Brookings Institution, *et al*, *Id.*

APPENDIX

RAMBOLL

ENVIRONMENT
& HEALTH

MEMORANDUM

To: Kevin Barker
Southern California Gas Company

From: Sheetal Madnani, Varalakshmi Jayaram, and Julia Lester
Ramboll US Consulting, Inc.

Subject: **CHARTING HISTORICAL GREENHOUSE GAS EMISSIONS FROM CALIFORNIA'S ON-ROAD TRANSPORTATION SECTOR**

June 17, 2022

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INTRODUCTION

The California Air Resources Board (CARB) proposes to achieve the State's greenhouse gas (GHG) reduction goals, in part, by transforming the statewide on-road vehicle fleet to zero emission vehicles (ZEVs). To do this CARB's Draft 2022 Scoping Plan Update[1] proposes the following actions: 100% of new light-duty vehicle sales are ZEV by 2035 and 100% of new medium-duty and heavy-duty vehicle (MDV/HDV) sales are ZEV by 2040. Several stakeholders have expressed concern about transitioning to a statewide ZEV fleet at the unprecedented rate proposed by CARB because of the lack of electric grid and charging infrastructure, zero emission technology readiness (particularly in the heavy-duty vehicle sector), and costs. Additionally, CARB's focus on ZEV deployment excludes the opportunities for near-term criteria air pollutant emissions reductions that can be achieved from the use of commercially available and certified low-NO_X vehicle technologies that CARB previously found[2] are needed to achieve the State's upcoming ozone attainment deadlines in 2023 and 2031.[3]

Since the establishment of the Low Carbon Fuel Standard (LCFS) program in 2011, there has been an increased penetration of drop-in renewable and low-carbon intensity fuels in California's transportation sector. These commercially available fuels can reduce GHG emissions today, and do not require significant upgrades to the State's electric grid (generation, transmission, and distribution) infrastructure. Therefore, the inclusion of these fuels in the 2022 Draft Scoping Plan Update would allow for greater near-term GHG emissions reductions.

1 CARB. 2022. Draft 2022 Scoping Plan Update. May 10. Available at: https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf. Accessed: June 2022.

2 CARB. 2016. Mobile Source Strategy. May. Available at: https://ww3.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf. Accessed: June 2022.

3 Ramboll US Consulting, Inc. 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 April 2022.

To understand the impacts of drop-in renewable and low-carbon intensity on California's greenhouse gas inventory in the last two decades, Ramboll conducted an analysis of the key trends in GHG emissions from the transportation sector in the past two decades, with a focus on the heavy-heavy-duty truck (HHDT) fleet. This analysis includes an evaluation of the population, activity, criteria air pollutant emissions, and greenhouse gas emissions associated with HHDTs. The methodology, results, and conclusions for this analysis are described in the following sections.

METHODOLOGY

The methodology and assumptions used in this analysis are described below.

- **Pollutants Assessed**: This study evaluates emissions from on-road HHDTs operating in California between calendar years 2000 and 2020. Well-to-wheel GHG emissions were assessed for the upstream processing (well-to-tank) of diesel, gasoline, and natural gas used to fuel HHDTs and the combustion (tank-to wheel or tailpipe) of these fuels in these vehicles. GHG emissions are presented in metric tons of CO_2-equivalents (CO_2e). In addition to GHG emissions, the study also assessed the tailpipe emissions for the following criteria air pollutants: oxides of nitrogen (NO_X) and particulate matter (PM_{10}).
- **Calendar Years Assessed**: Emissions were estimated in five-year increments beginning in 2000 and ending in 2020 (2000, 2005, 2010, 2015, 2020). Emissions were also assessed for 2019 to observe the most recent trends in the transportation sector before the impact of the COVID-19 pandemic in 2020.
- **Vehicle Categories Assessed**: Ramboll assessed emissions from heavy-HHDTs since this sector presents the most significant challenges to transportation electrification, due to a lack of commercial availability for ZEVs. Per data from EMFAC2021, the fuels utilized in the statewide heavy-heavy duty truck fleet in the last two decades include diesel, gasoline, and natural gas, with no presence of ZEVs noted. Of these fuels, natural gas is the least carbon-intensive, and since the maximum adoption of natural gas has been observed in the statewide solid waste collection vehicle (SWCV) fleet, Ramboll also assessed the emissions from SWCVs specifically.
- **Emissions from On-Road Fuel Combustion**: Ramboll used EMFAC2021 v1.0.1[4] (the current version of CARB's on-road mobile source emission inventory at the time of this analysis) to estimate the annual fuel consumption of HHDT in each analyzed calendar year. Additionally, EMFAC2021 data was used to estimate annual tailpipe emissions (tons/year) for NO_X and PM_{10}. Input parameters for the EMFAC2021 model run are shown below:
  - Run Mode: Emissions
  - Region: Statewide
  - Calendar Years: 2000, 2005, 2010, 2015, 2019, 2020
  - Season: Annual

[4] EMFAC2021 v1.0.1 web platform was available at: https://arb.ca.gov/emfac/emissions-inventory/, accessed: January 2022. In April 2022, CARB released an updated version of EMFAC2021 v1.0.2 which addresses a bug related to NO_X idling exhaust emissions from newer heavy-duty trucks that are affected by the Heavy-Duty Omnibus regulation (see https://content.govdelivery.com/accounts/CARB/bulletins/314a532 for further details). Since this analysis focuses on older HHDT operating between calendar year 2000 and 2020, the updates made to EMFAC2021 in v1.0.2 do not change the overall conclusions of this analysis.

- Vehicle Category: EMFAC202x – T7 Public, T7 CAIRP, T7 Utility, T7 NNOOOS, T7 NOOS, T7 Other Port, T7 POAK, T7 POLA, T7 Single Concrete/Transit Mix, T7 Single Unit Dump, T7 Single Unit Other, T7 SWCV, T7IS
- Model Year: Aggregated
- Fuel: Diesel, Gasoline, Natural Gas, Electricity
- Speed: Aggregated
- Pollutants: NO_X, PM_{10}

- **Fuels Assessed**: Per the EMFAC2021 data collected from the run described above (EMFAC results are presented in **Attachment A**), diesel, gasoline, and natural gas were the only fuels used between calendar years 2000 and 2020 in HHDTs and SWCVs (e.g., the EMFAC2021 data do not include electric HHDTs or SWCVs). For each of the three fuels, all fossil and renewable fuel components were analyzed. For diesel fuel, the components analyzed were fossil diesel, biodiesel, and renewable diesel. For gasoline fuel, the components analyzed were California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB) and ethanol. For natural gas fuel, the components analyzed were fossil compressed natural gas (fossil-CNG), fossil liquified natural gas (fossil-LNG), bio-CNG, and bio-LNG. These fuel components were selected based on the fuels published in CARB's LCFS Reporting Tool Quarterly Summary for Q1 2021 ("LCFS Quarterly Summary").[5]
- **Well-to-Wheel Carbon Intensities**: To estimate well-to-wheel greenhouse gas (GHG) emissions, Ramboll derived a well-to-wheel carbon intensity (CI) for each fuel in each analyzed calendar year as a weighted average of the CIs of the individual fuel components as described below.
  - Diesel
    - The fractions of the individual components of diesel fuel, i.e., fossil diesel, biodiesel, and renewable diesel for each analyzed calendar year are presented in **Table 1**. As noted in this table, diesel fuel was comprised of 100% fossil diesel from 2000 to 2010. From 2015 to 2020, the fractions of the fossil diesel, biodiesel, and renewable diesel in diesel fuel were calculated based on the fuel consumption data obtained from the LCFS Quarterly Summary.[6]
    - Fossil Diesel was assumed to have a constant CI value across all calendar years, obtained from CARB's CA-GREET 3.0 Lookup Table Pathways.[7] This value is presented in **Table 2**.
    - Biodiesel and renewable diesel CI values for calendar years 2015 to 2020 were derived using the LCFS Quarterly Summary[8] data. As shown in **Table 2**, quarterly CI values were combined with the quarterly fuel consumption values to estimate CI values for each calendar

[5] CARB. Low Carbon Fuel Standard Reporting Tool Quarterly Summaries. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

[6] Ibid.

[7] CARB. 2018. CA-GREET3.0 Lookup Table Pathways – Technical Support Documentation. August 13. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf. Accessed: June 2022.

[8] CARB. Low Carbon Fuel Standard Reporting Tool Quarterly Summaries. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

year. Biodiesel and renewable diesel CIs were not estimated for earlier calendars years (2000 to 2010) as these fuels were not present in diesel fuel during this time period.

    - For each calendar year, the fractions of the individual components of diesel fuel (**Table 1**) were combined with the carbon intensities of these diesel fuel components (**Table 2**) to estimate a weighted average CI for diesel fuel (**Table 3**). This weighted CI is presented in two units: grams of CO_2e per mega joule of fuel (gCO_2e/MJ) and grams of CO_2e per gallon of fuel (gCO_2e/gal).

- Gasoline

    - The fractions of the individual components of gasoline fuel, i.e., CARBOB and ethanol for each analyzed calendar year are presented in **Table 1**. For calendar years 2000-2010, these fractions were estimated based on the annual fuel consumption of gasoline fuel components obtained from the CARB report titled *California Greenhouse Gas Emissions for 2000-2019: Trends of Emissions and Other Indicators*.[9] For calendar years 2015-2020, the fractions of CARBOB and ethanol in gasoline fuel were estimated based on the fuel consumption data obtained from the LCFS Quarterly Summary.[10]

    - CARBOB was assumed to have a constant CI value across all calendar years, obtained from CARB's CA-GREET 3.0 Lookup Table Pathways.[11] This value is presented in **Table 2**.

    - Ethanol CI values for calendar years 2011 to 2020 were estimated based on the LCFS Quarterly Summary[12] data. As shown in **Table 2**, quarterly CI values were combined with the quarterly fuel consumption values to estimate annual CI values. Ethanol CI values for earlier calendar year 2000 to 2010 were assumed to be equivalent to the Ethanol CI in 2011.

    - For each calendar year, the fractions of the individual components of gasoline fuel (**Table 1**) were combined with the CIs of these fuel components (**Table 2**) to estimate a weighted average CI for gasoline fuel (**Table 4**). This weighted CI is presented in gCO_2e/MJ and gCO_2e/gal.

- Natural Gas

    - The fractions of the individual components of natural gas fuel, i.e., fossil-CNG, fossil-LNG, bio-CNG, and bio-LNG for each analyzed calendar year are presented in **Table 1**. For calendar years 2015 to 2020, these fractions were estimated based on fuel consumption

[9] CARB. 2021. California Greenhouse Gas Emissions for 2000 to 2019 – Trends of Emissions and Other Indicators. July 28. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000_2019_ghg_inventory_trends_20220516.pdf. Accessed: June 2022.

[10] CARB. Low Carbon Fuel Standard Reporting Tool Quarterly Summaries. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

[11] CARB. 2018. CA-GREET3.0 Lookup Table Pathways – Technical Support Documentation. August 13. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf. Accessed: June 2022.

[12] CARB. Low Carbon Fuel Standard Reporting Tool Quarterly Summaries. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

data obtained from the LCFS Quarterly Summary.[13] For calendar years 2000 to 2010, Ramboll conservatively assumed that natural gas fuel has only fossil fuel based components (fossil-CNG and fossil-LNG). The fractions of these fossil fuel components were estimated using 2011 fuel consumption data from the LCFS Quarterly Summary.[14]

- The CI for fossil-CNG and fossil-LNG were obtained from CARB's CA-GREET 3.0 Lookup Table Pathways,[15] and were assumed to be a constant across all analyzed calendar years.
- The CI for fossil-LNG was estimated as an average of the LCFS-certified LNG pathways[16] for non-biogenic feedstocks.
- The CIs for bio-CNG and bio-LNG were estimated using the LCFS Quarterly Summary.[17] As shown in **Table 2**, quarterly CI values from this summary were combined with the quarterly fuel consumption values to estimate annual CI values. Since there is no consumption of bio-CNG or bio-LNG in earlier years (2000 to 2010), CI values were estimated for those years.
- For each calendar year, the fractions of the individual components of natural gas fuel (**Table 1**) were combined with the carbon intensities of these fuel components (**Table 2**) to estimate a weighted average CI for natural gas fuel (**Table 5**). This weighted CI is presented in two units: gCO_2e/MJ and grams of CO_2e per gallon of diesel fuel displaced (gCO_2e/DGE).

- **Well-to-Wheel GHG Emissions**: The well-to-wheel GHG emissions for the statewide HHDT and SWCV fleets are estimated in **Table 6** and **Table 7** respectively. As noted in these tables the annual CI for each fuel (reported in gCO_2e/gal) was multiplied by the fleet specific fuel consumption (from EMFAC2021) to obtain the well-to-wheel GHG emissions for each fuel in each analyzed calendar year.
- **Well-to-Wheel GHG Emissions without Renewable Fuel Adoption**: A counterfactual scenario, where renewable fuel components are not adopted, was also assessed for the statewide HHDT and SWCV fleets in **Tables 6** and **7** respectively. The well-to-wheel GHG emissions inventories for these counterfactual scenarios were estimated as a product the fossil fuel CI and the fleet specific fuel consumption (from EMFAC2021) for each fuel in each analyzed calendar.

RESULTS

Heavy-Heavy Duty Trucks

As noted in **Figures 1** and **2**, the annual population and vehicle miles travelled (VMT) by the statewide HHDT fleet has increased over the last two decades. However, the tailpipe NO_X and PM_{10} emissions from these vehicles has reduced by 79% and 91% respectively (**Figures 3** and **4**) over the last two decades as a result of federal and state regulations such as the United States Environmental Protection Agency's

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[13] Ibid.

[14] Ibid.

[15] CARB. 2018. CA-GREET3.0 Lookup Table Pathways – Technical Support Documentation. August 13. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf. Accessed: May 2022.

[16] CARB. Current LCFS Pathways. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx. Accessed: June 2022.

[17] CARB. Low Carbon Fuel Standard Reporting Tool Quarterly Summaries. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

(USEPA's) Exhaust Emission Standards for Heavy-Duty Highway Compression-Ignition Engines[18] and CARB's Truck and Bus Regulation.[19]

[18] USEPA. 2016. Heavy-Duty Highway Compression-Ignition Engines and Urban Buses: Exhaust Emission Standards. March. EPA-420-B-16-018. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100O9ZZ.pdf. Accessed: June 2022.

[19] CARB. Truck and Bus Regulation. Available at: https://ww2.arb.ca.gov/our-work/programs/truck-and-bus-regulation. Accessed: June 2022.

Figure 1: Statewide HHDT Fleet Population

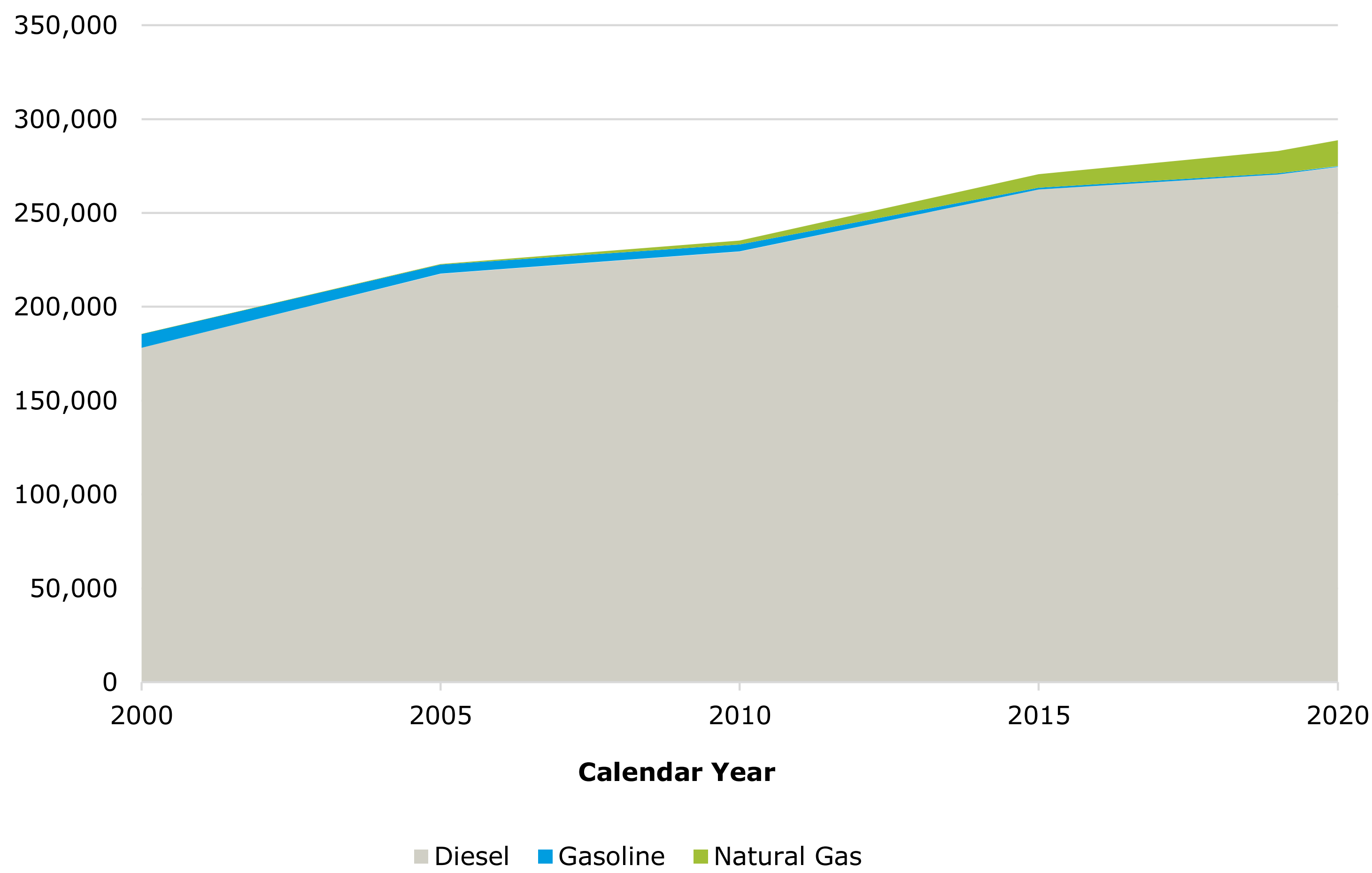


Figure 2: Vehicle Miles Travelled by the Statewide HHDT Fleet

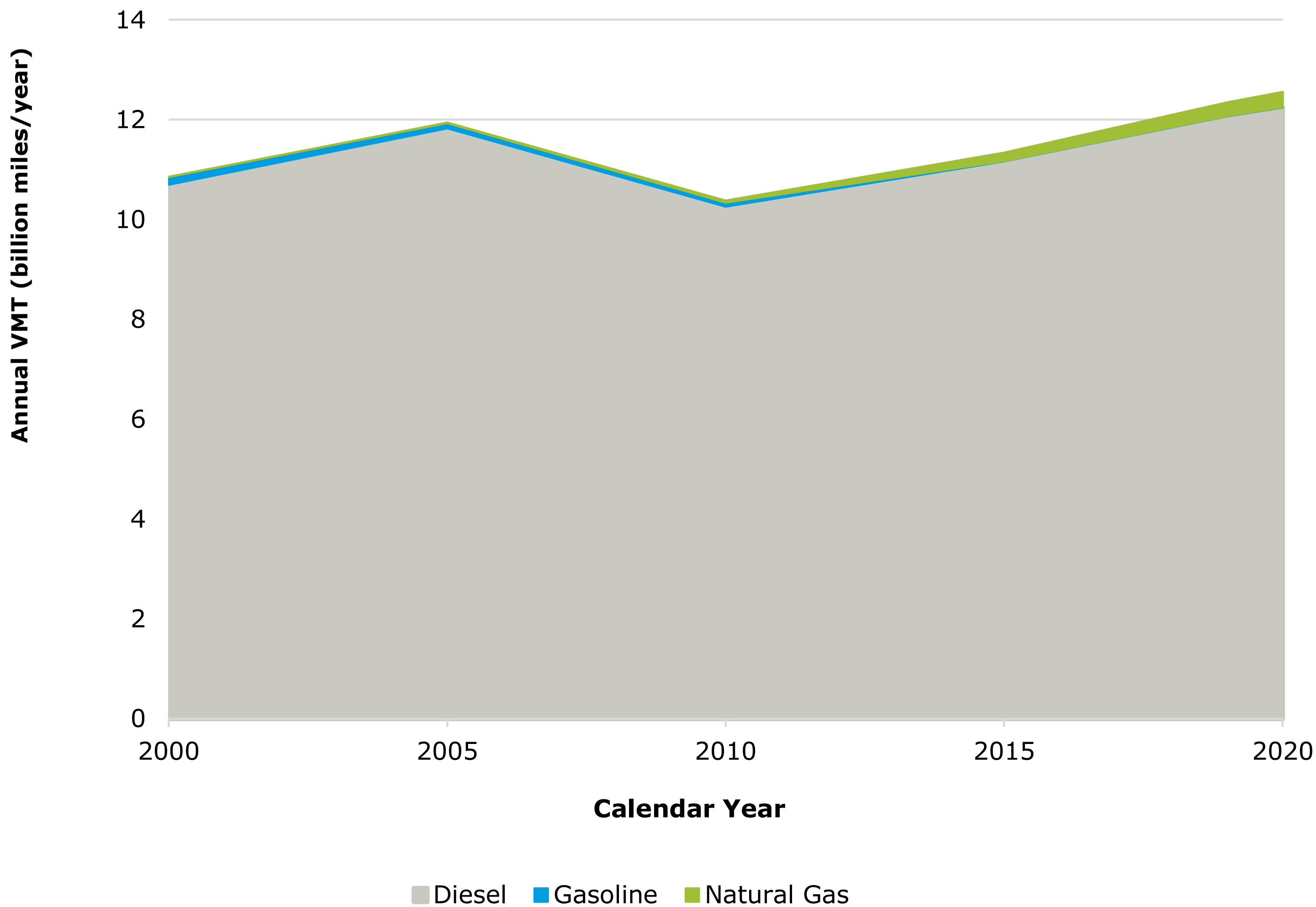


Figure 3: Tailpipe NO_X Emissions for the Statewide HHDT Fleet

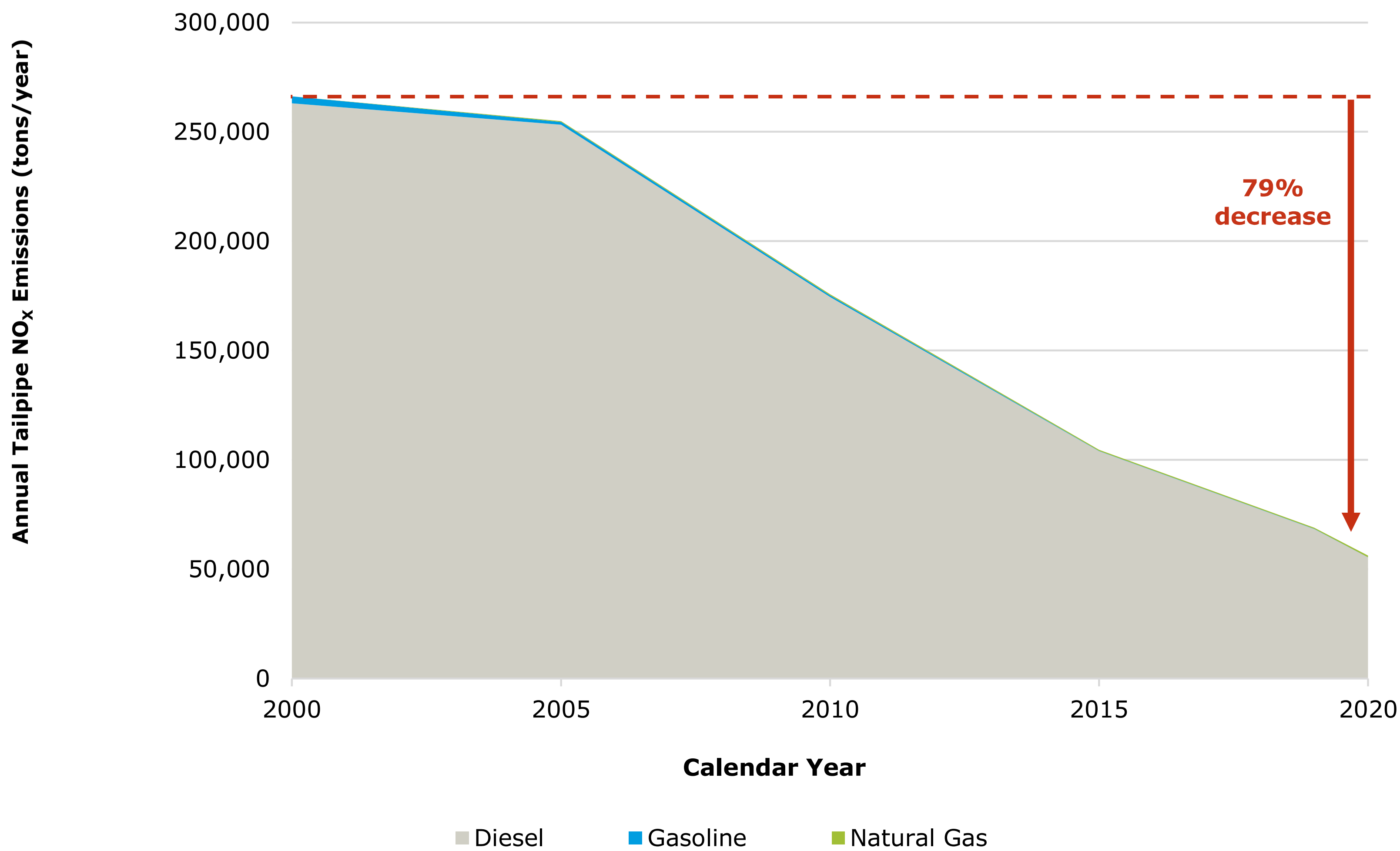
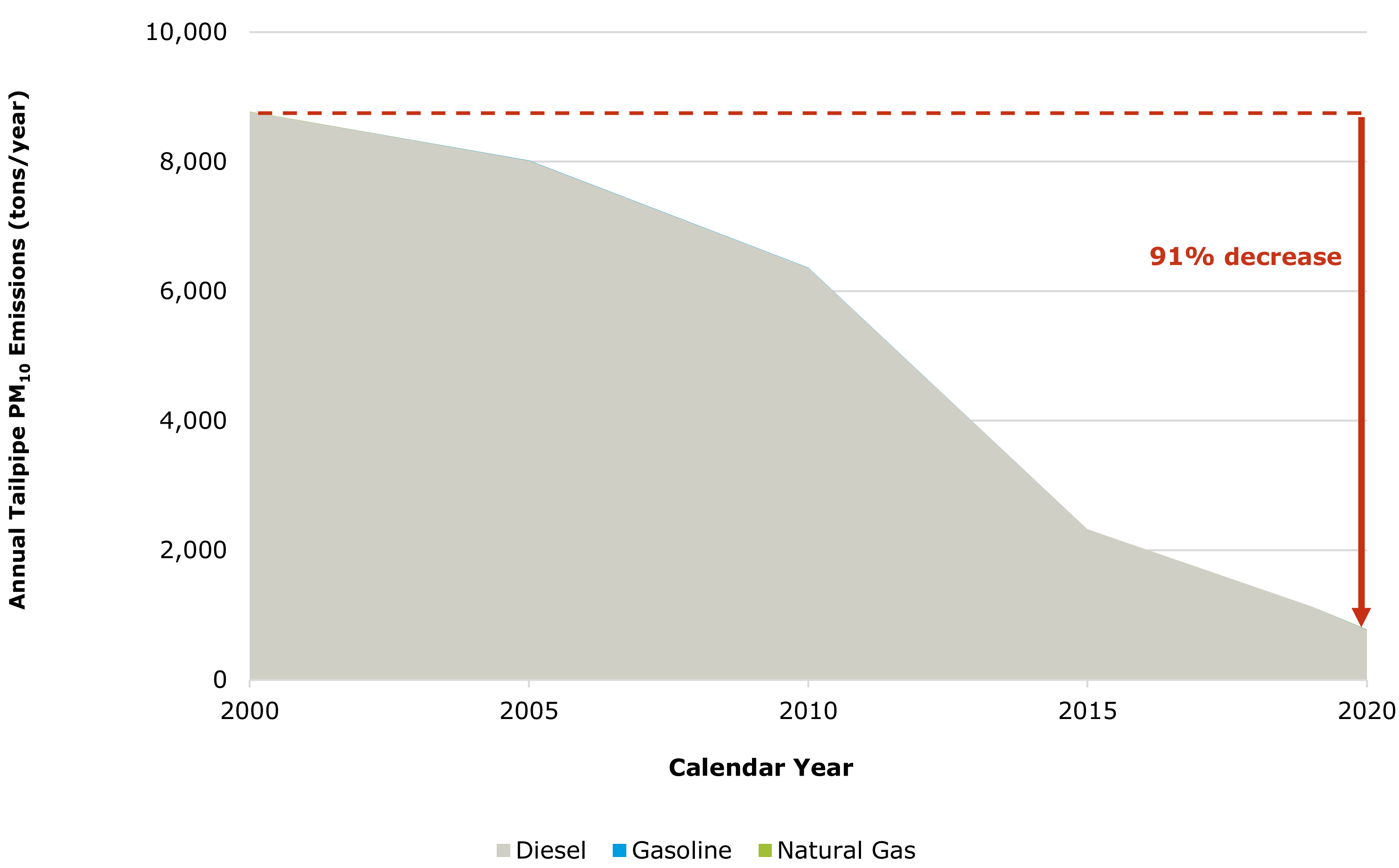


Figure 4: Tailpipe PM_{10} Emissions for the Statewide HHDT Fleet



The well-to-wheel greenhouse gas emissions from HHDTs (**Figures 5, 6, and 7**) follow a trend similar to the HHDT VMT in the early years (2000 to 2010), where there is limited penetration of renewable lower CI fuels. The decrease in emissions from 2005 to 2010 is consistent with the decrease in vehicle miles travelled from 2005 to 2010 (**Figure 2**) following the recession in the late 2000s. Increased usage of renewable lower CI fuels in the statewide HHDT fleet in later years (from ~9% of total fuel consumption in 2015 to ~26% in 2020) resulted in a reduction in the well-to-wheel GHG emissions. Increased usage of biodiesel and renewable diesel resulted in an emissions reduction of 5% in 2015 and 17% in 2020 in the diesel statewide HHDT fleet, as indicated in **Figure 5**. Increase usage of ethanol in the gasoline statewide fleet resulted in an emissions reduction of 5% in 2015 and 6% in 2020, as indicated in **Figure 6**. The most significant impact of renewable fuel adoption is seen in the natural gas HHDT fleet, in which GHG emissions were reduced by 35% in 2015 and 90% in 2020, due to increased usage of bio-CNG and bio-LNG (from 35% of total natural gas consumption in 2015 to 92% in 2020). Well-to-wheel GHG emissions reductions for natural gas HHDTs are shown in **Figure 7**, and the total fleet reductions for all three fuels are shown in **Figure 8**.

Figure 5: GHG Emissions for the Statewide HHDT Fleet (Diesel Vehicles Only)

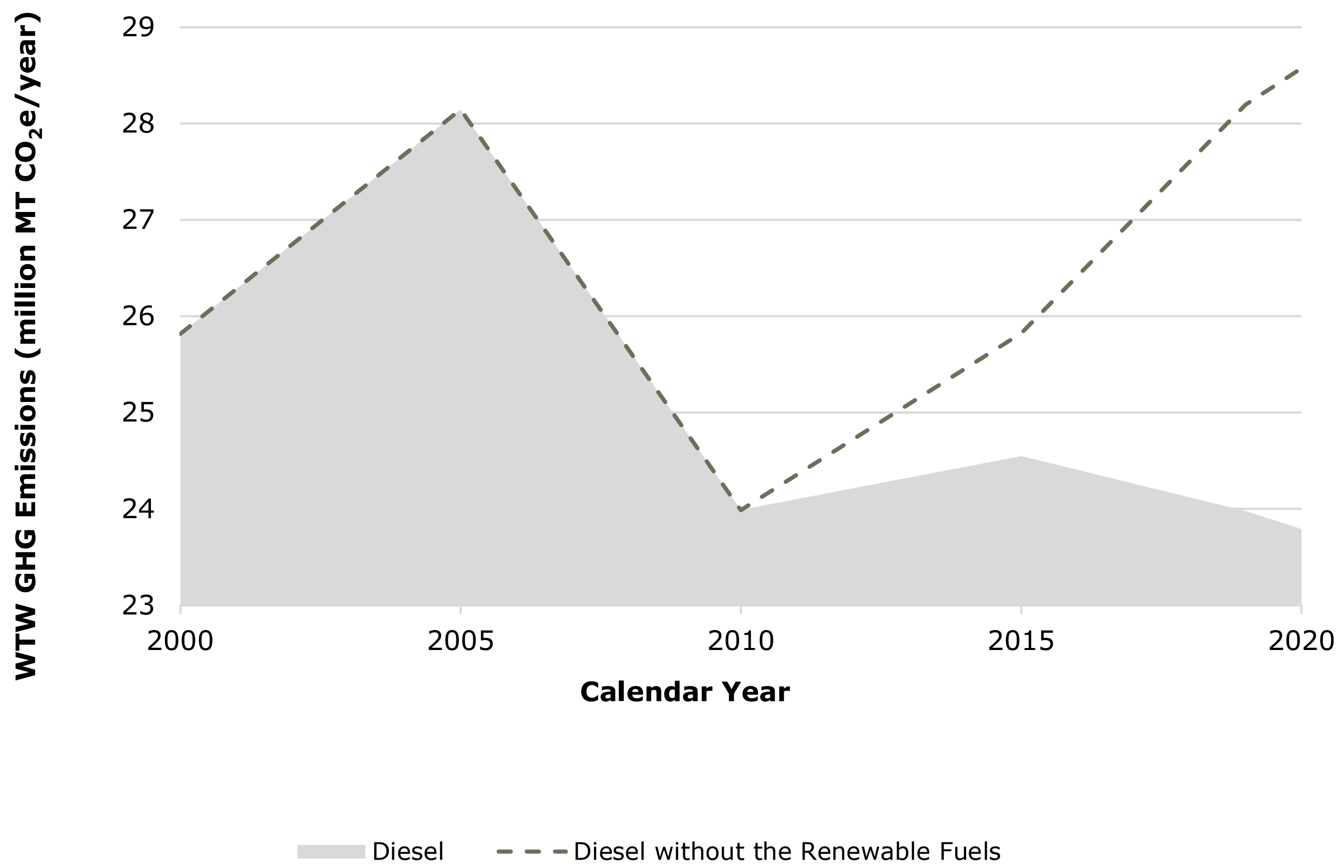


Figure 6: GHG Emissions for the Statewide HHDT Fleet (Gasoline Vehicles Only)

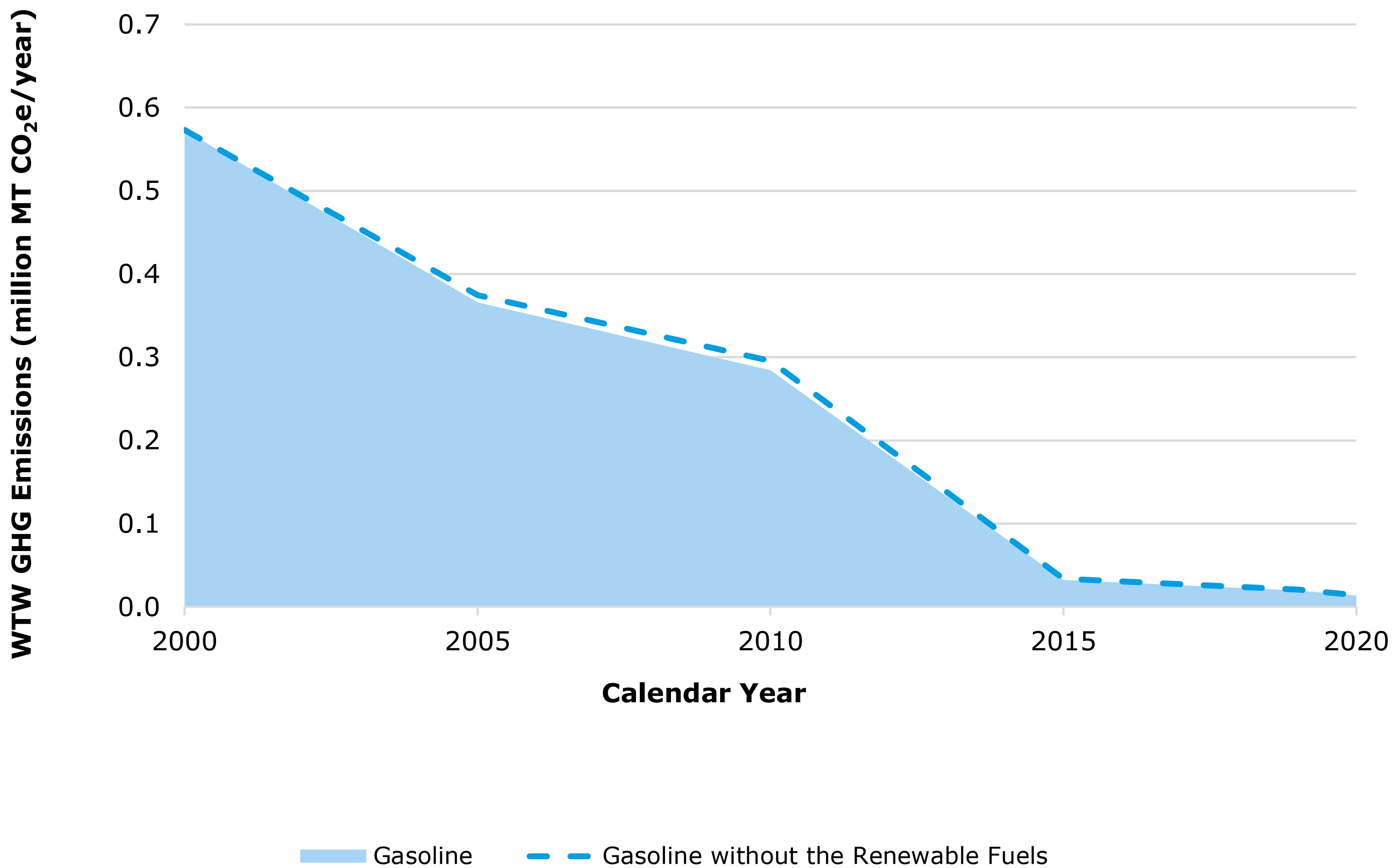


Figure 7: GHG Emissions for the Statewide HHDT Fleet (Natural Gas Vehicles Only)

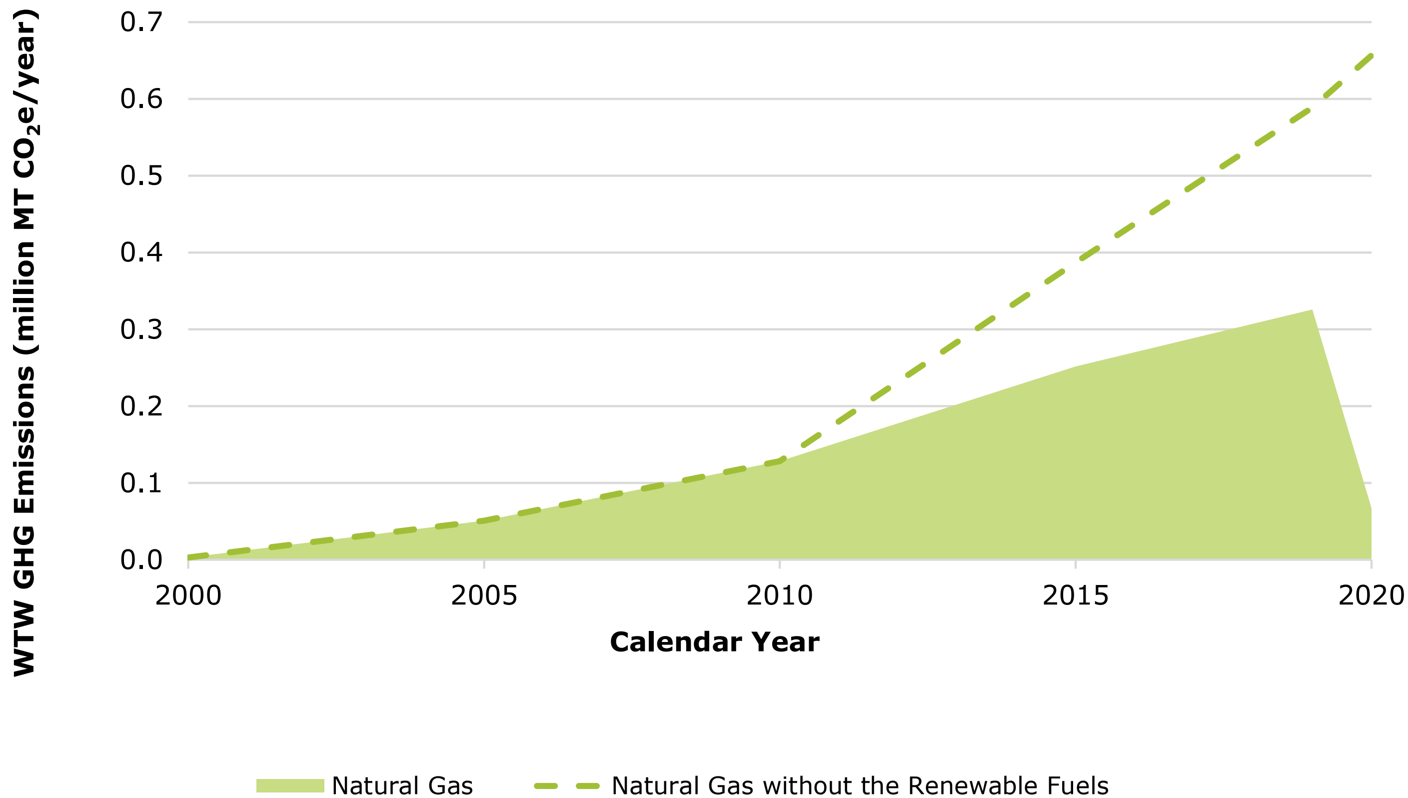
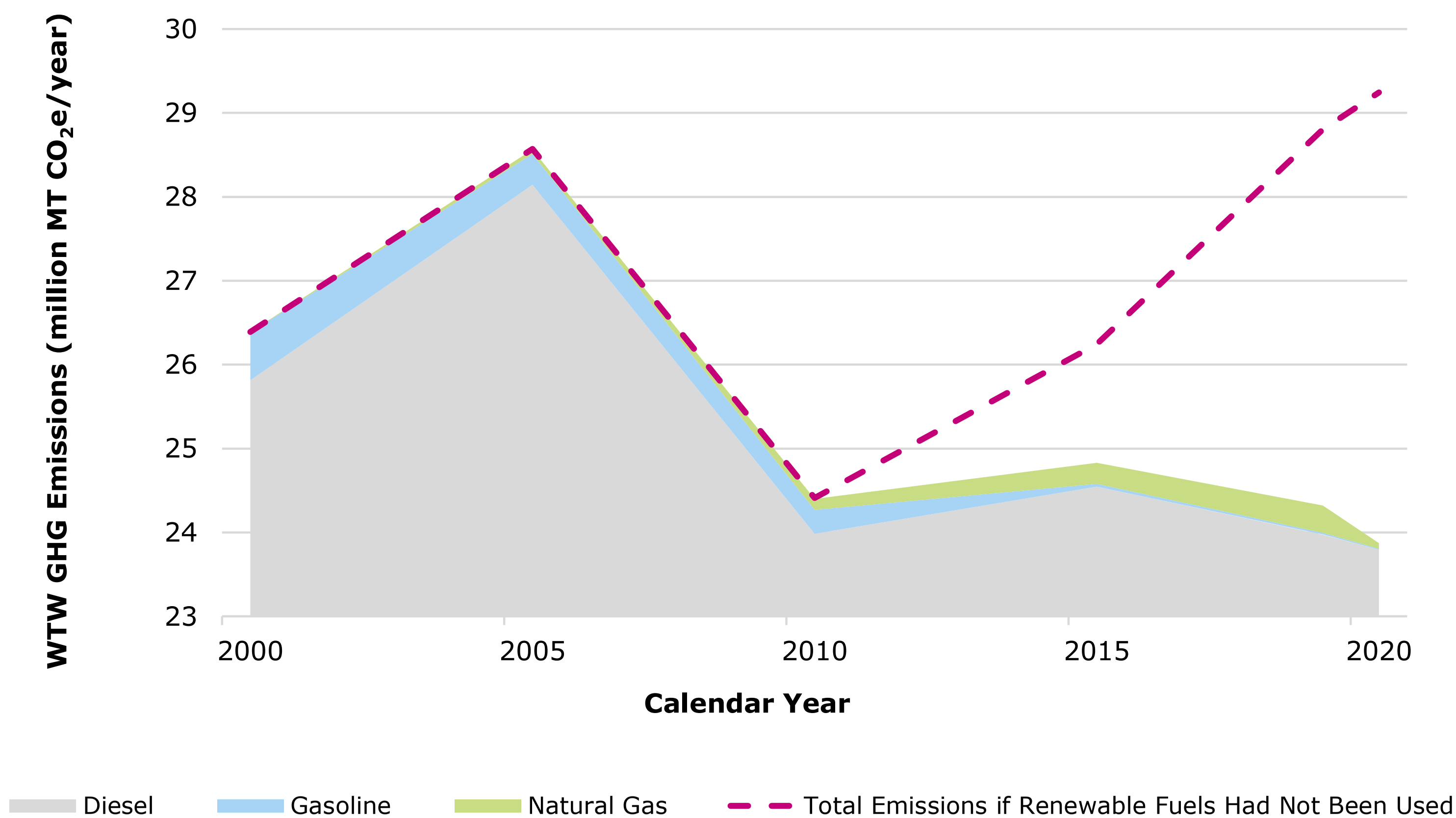


Figure 8: GHG Emissions for the Statewide HHDT Fleet
(Stacked Graph: Diesel-Gasoline-NG)



Solid Waste Collection Vehicles

The SWCV fleet is a subset of the statewide HHDT fleet. The population and VMT trends for these vehicles follow a similar trend as the HHDT fleet (see **Figures 9** and **10** for SWVCs as compared to **Figures 1** and **2** for HHDTs). However, there is an increased penetration of natural gas vehicles in this sub-sector (~48% of the vehicle population in 2020, represented by the green area in **Figure 9**) as compared to HHDT fleet (~5% in 2020, represented by the green area in **Figure 1**). As with HHDTs, the tailpipe NO_X and PM_{10} emissions from SWCVs have reduced by 57% and 91% respectively (**Figures 11** and **12**) over the last two decades, as a result of federal and state regulations such as the United States Environmental Protection Agency's (USEPA's) Exhaust Emission Standards for Heavy-Duty Highway Compression-Ignition Engines[20] and CARB's Truck and Bus Regulation.[21]

[20] USEPA. 2016. Heavy-Duty Highway Compression-Ignition Engines and Urban Buses: Exhaust Emission Standards. March. EPA-420-B-16-018. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100O9ZZ.pdf. Accessed: June 2022.

[21] CARB. Truck and Bus Regulation. Available at: https://ww2.arb.ca.gov/our-work/programs/truck-and-bus-regulation. Accessed: June 2022.

Figure 9: Statewide SWCV Fleet Population

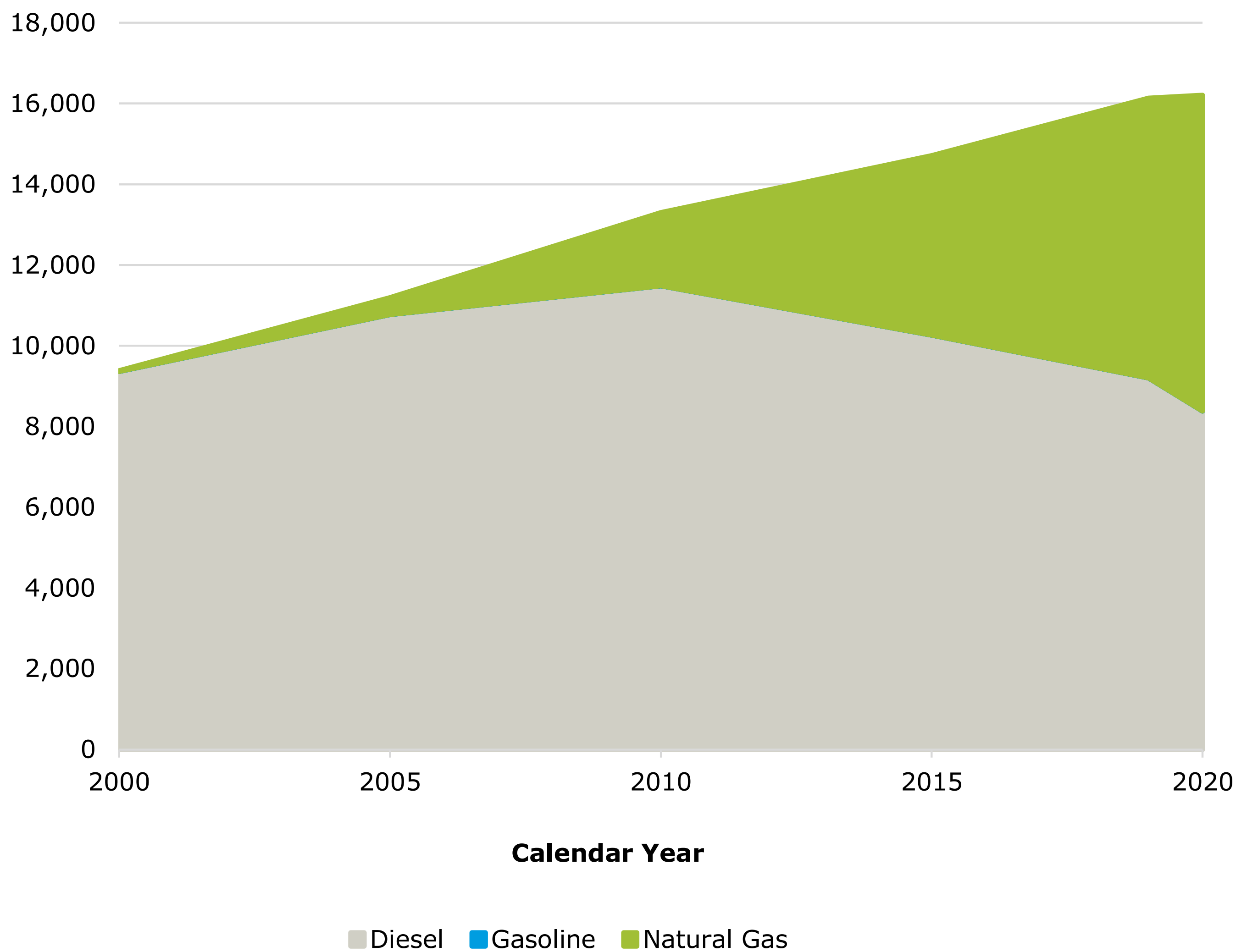


Figure 10: Vehicle Miles Travelled by the Statewide SWCV Fleet

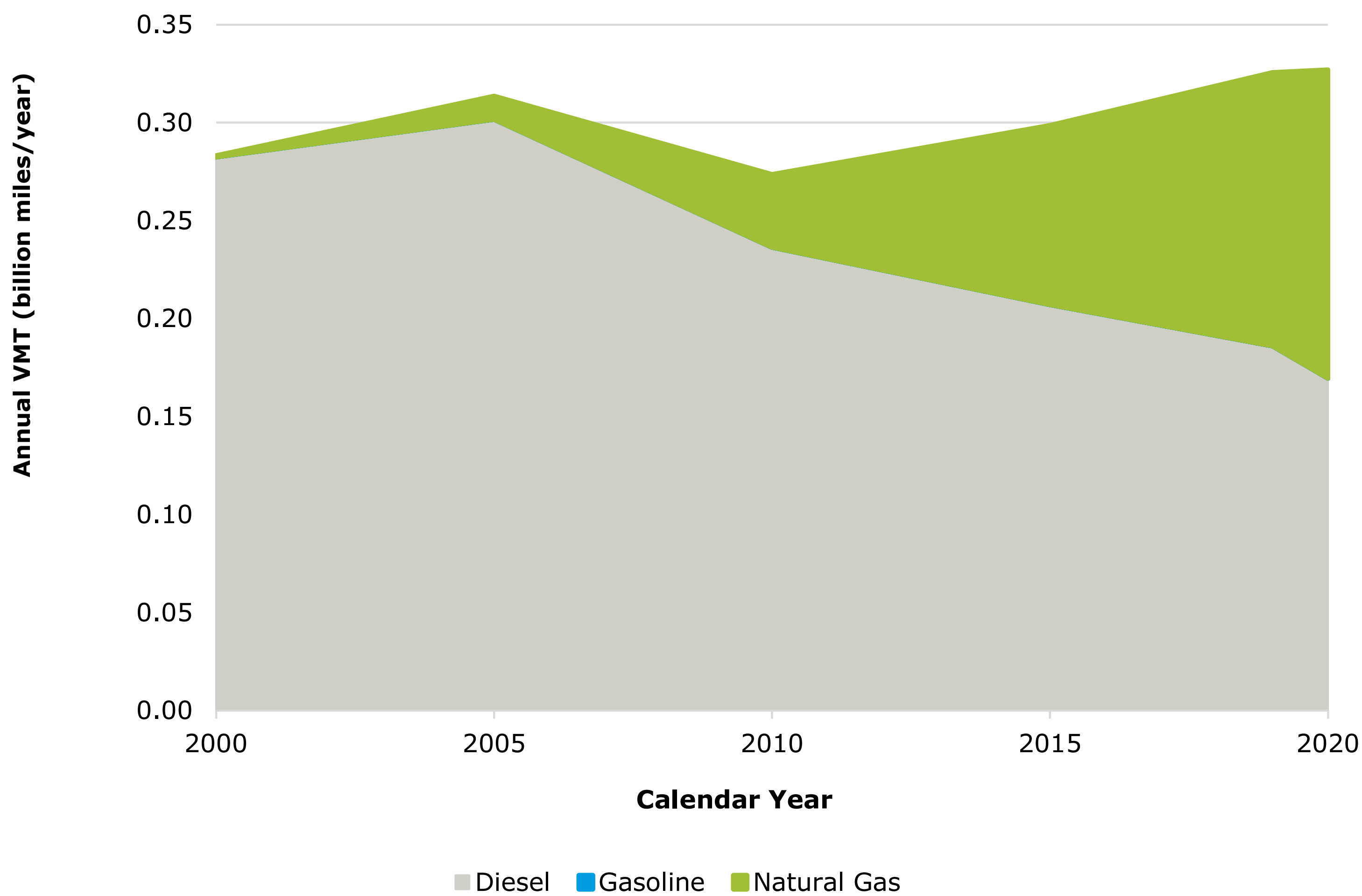


Figure 11: Tailpipe NO_X Emissions for the Statewide SWCV Fleet

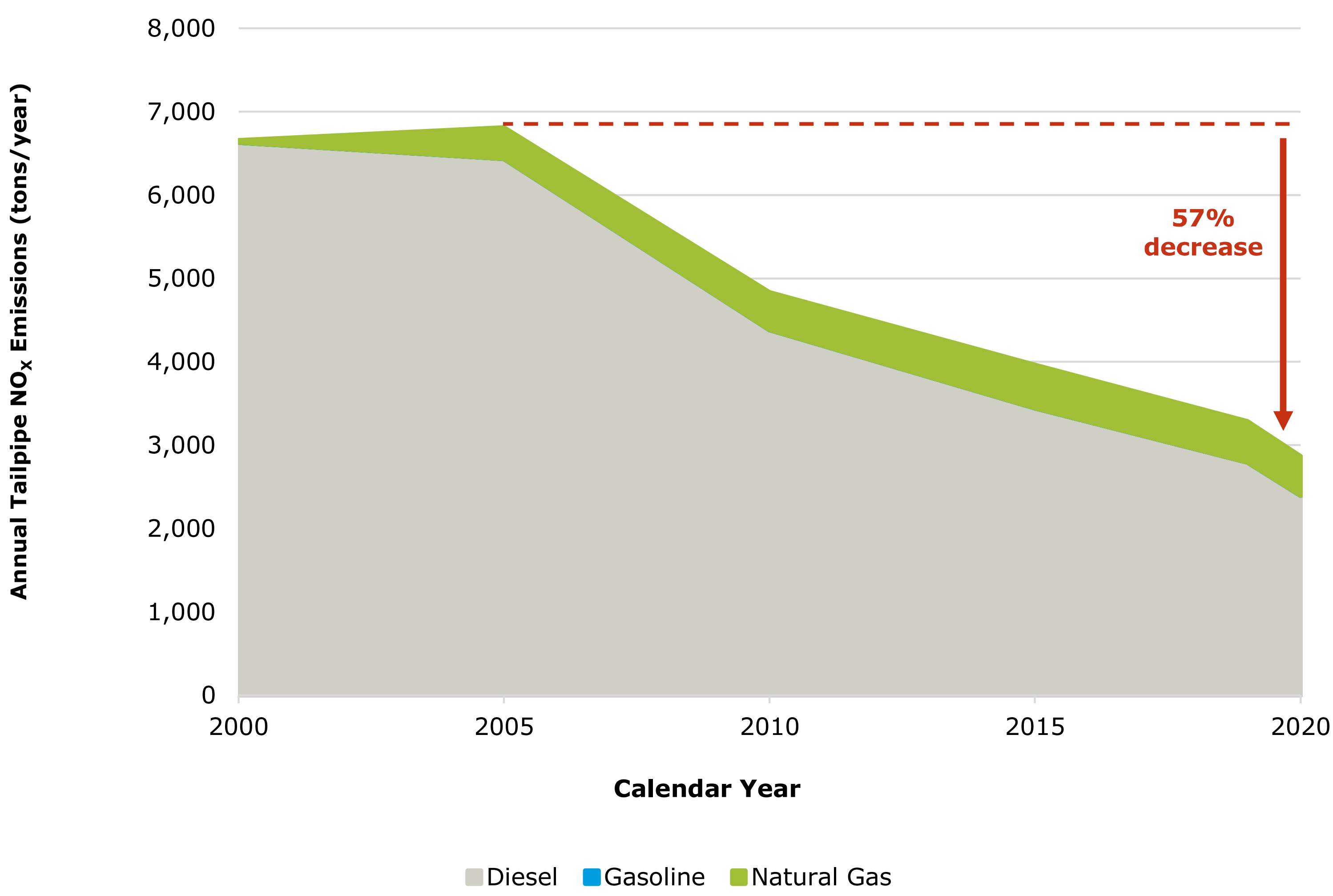
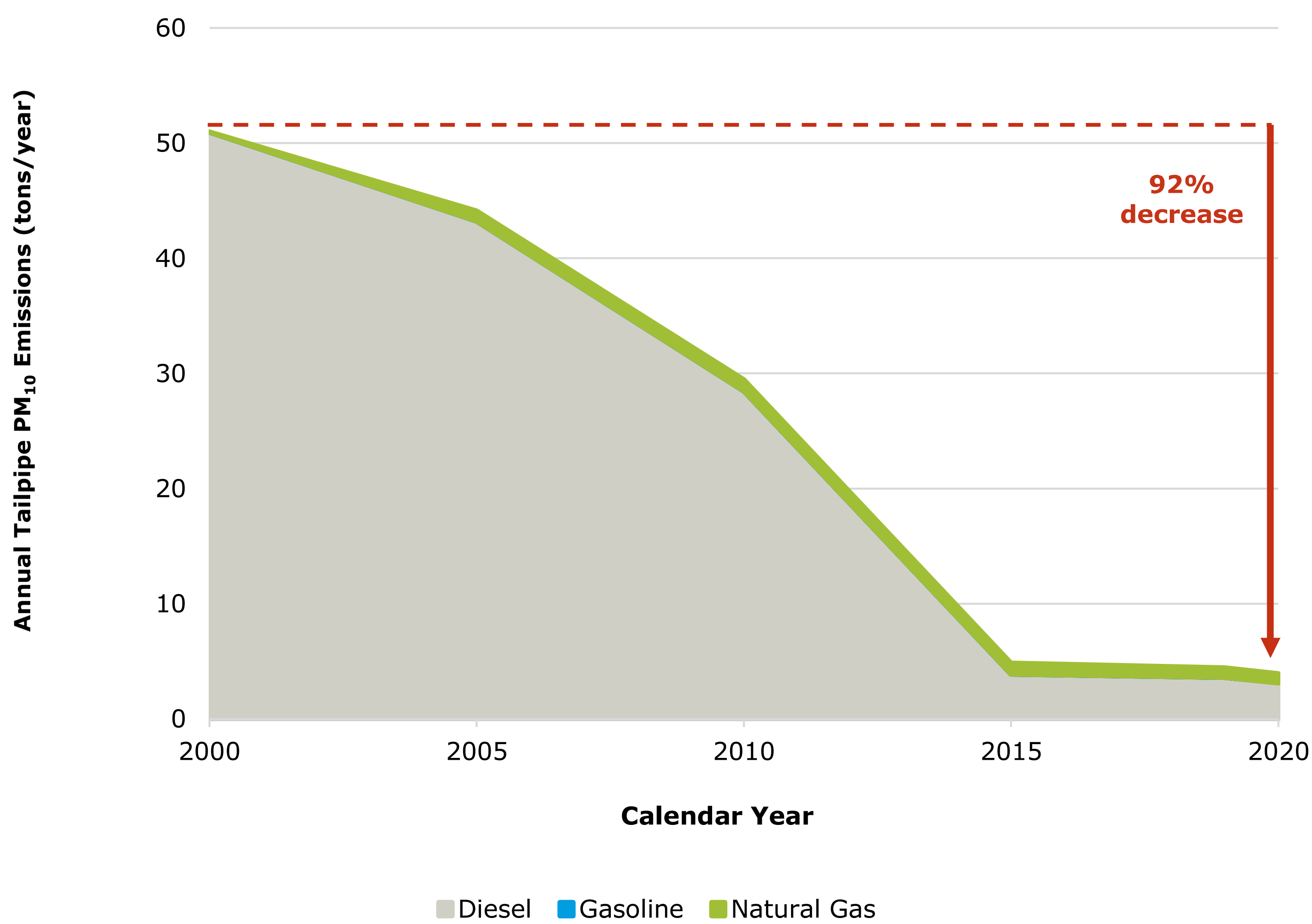


Figure 12: Tailpipe PM_{10} Emissions for the Statewide SWCV Fleet



The increased usage of renewable diesel and biodiesel reduced GHG emissions from diesel SWCVs (**Figure 13**) by 5% in 2015 and 17% in 2020, in line with the emissions reductions in the diesel HHDT fleet (**Figure 5**). Similarly, the increased usage of bio-CNG and bio-LNG reduced GHG emissions from natural gas SWCVs (**Figure 14**) by 35% in 2015 and 90% in 2020, in line with the emissions reductions in the natural gas HHDT fleet (**Figure 7**).

However, as noted in **Table 1**, the penetration of renewable low-CI fuels is higher for natural gas fuel (48% renewable content in 2015 increasing to 92% in 2020) as compared to diesel fuel (8% renewable content in 2015 and 24% renewable content in 2020). So, the increased penetration of natural gas vehicles in the SWVC fleet also leads to an increase in the usage of renewable lower CI fuels (~22% of total fuel consumption is renewable in 2015 and ~46% is renewable in 2020) as compared to the HHDT fleet (~9% is renewable in 2015 and ~26% is renewable in 2020). As a result, the total well-to-wheel GHG reductions (shown as the difference between the dashed pink line and the top of the shaded area in **Figure 15**) associated with the use of renewable lower CI fuels in the SWCV fleet (10% in 2015 to 37% in 2020) is higher than that for the HHDT fleet (5% in 2015 to 18% in 2020).

Figure 13: GHG Emissions for the Statewide SWCV Fleet (Diesel Vehicles Only)

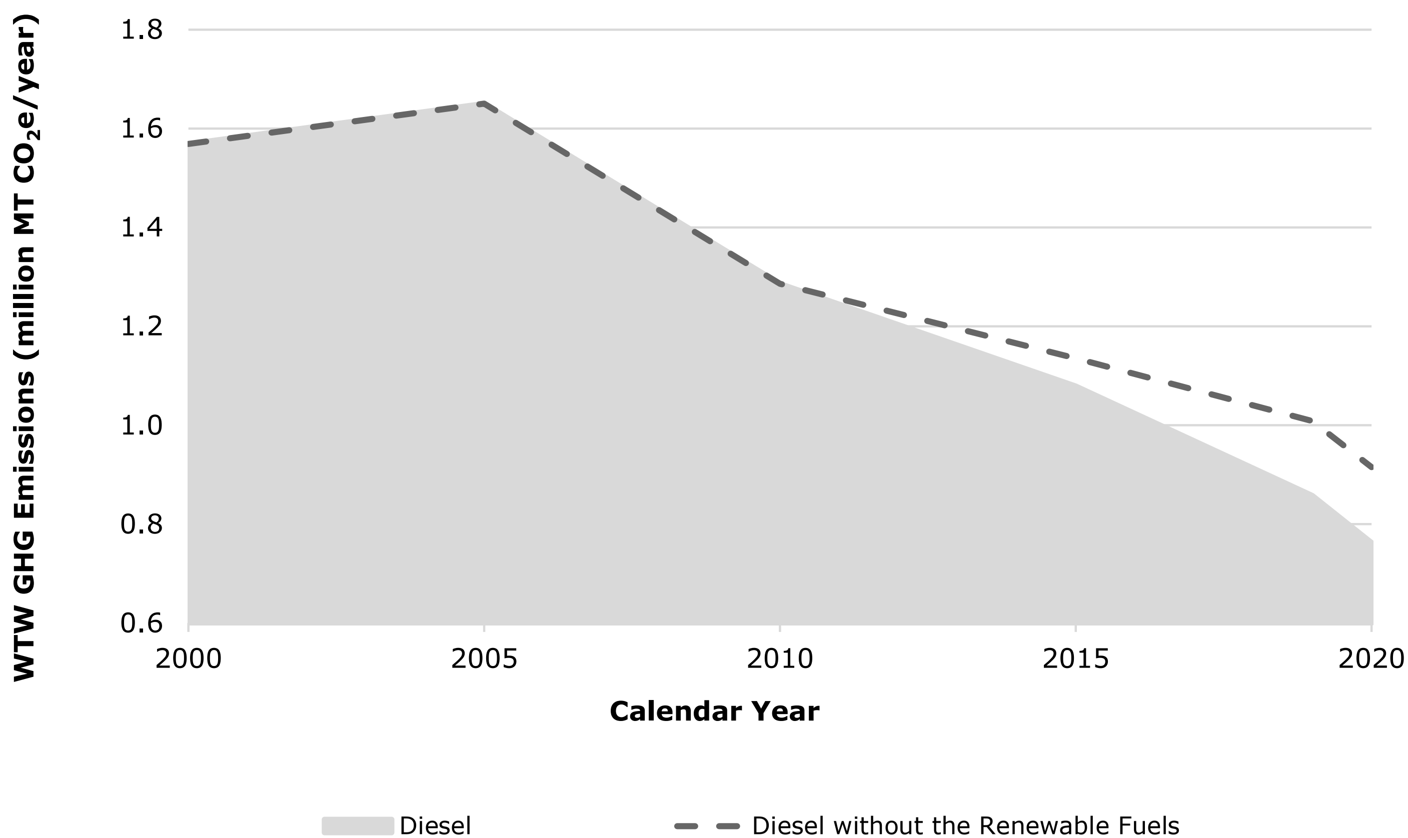


Figure 14: GHG Emissions for the Statewide SWCV Fleet (Natural Gas Vehicles Only)

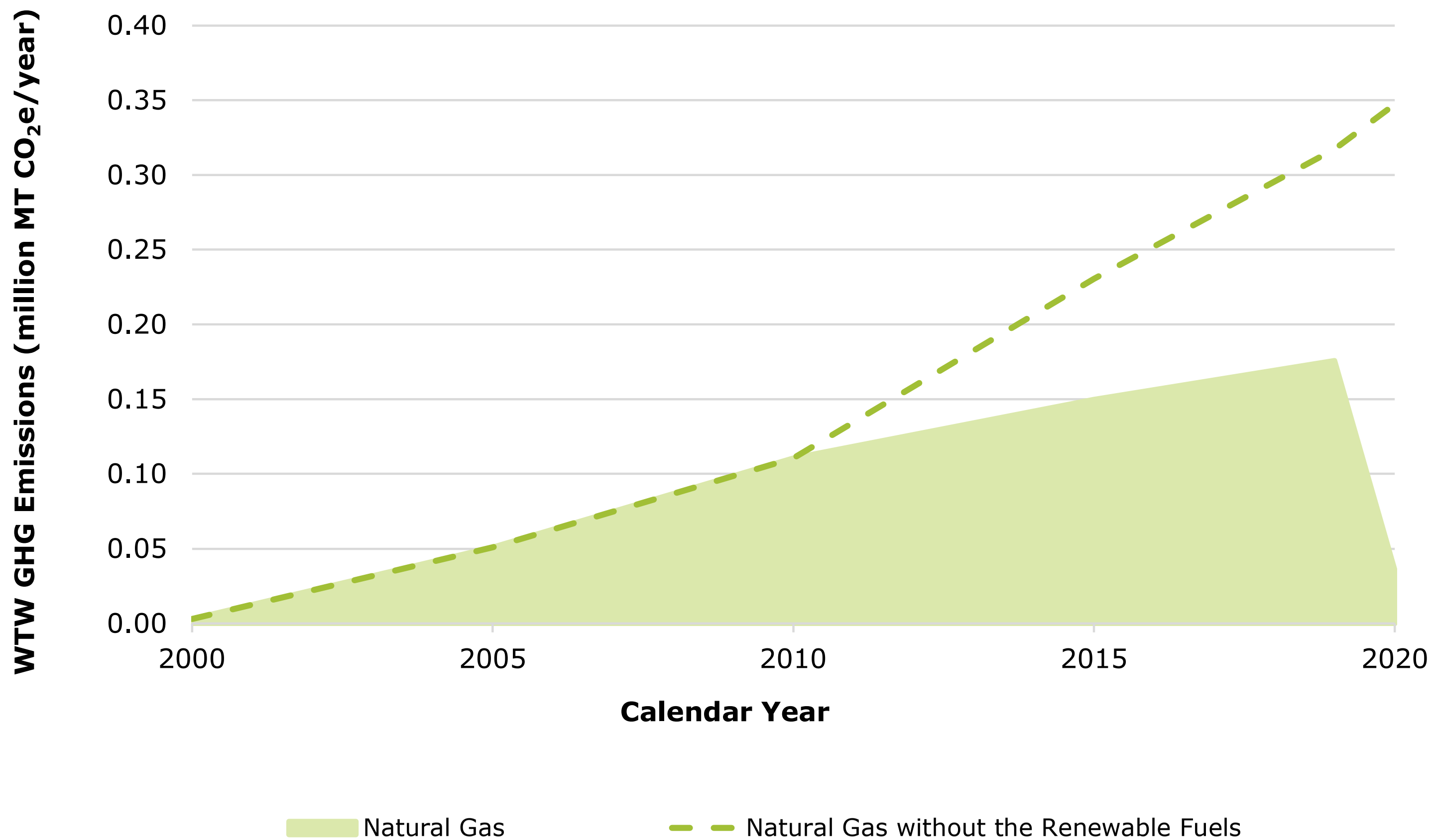
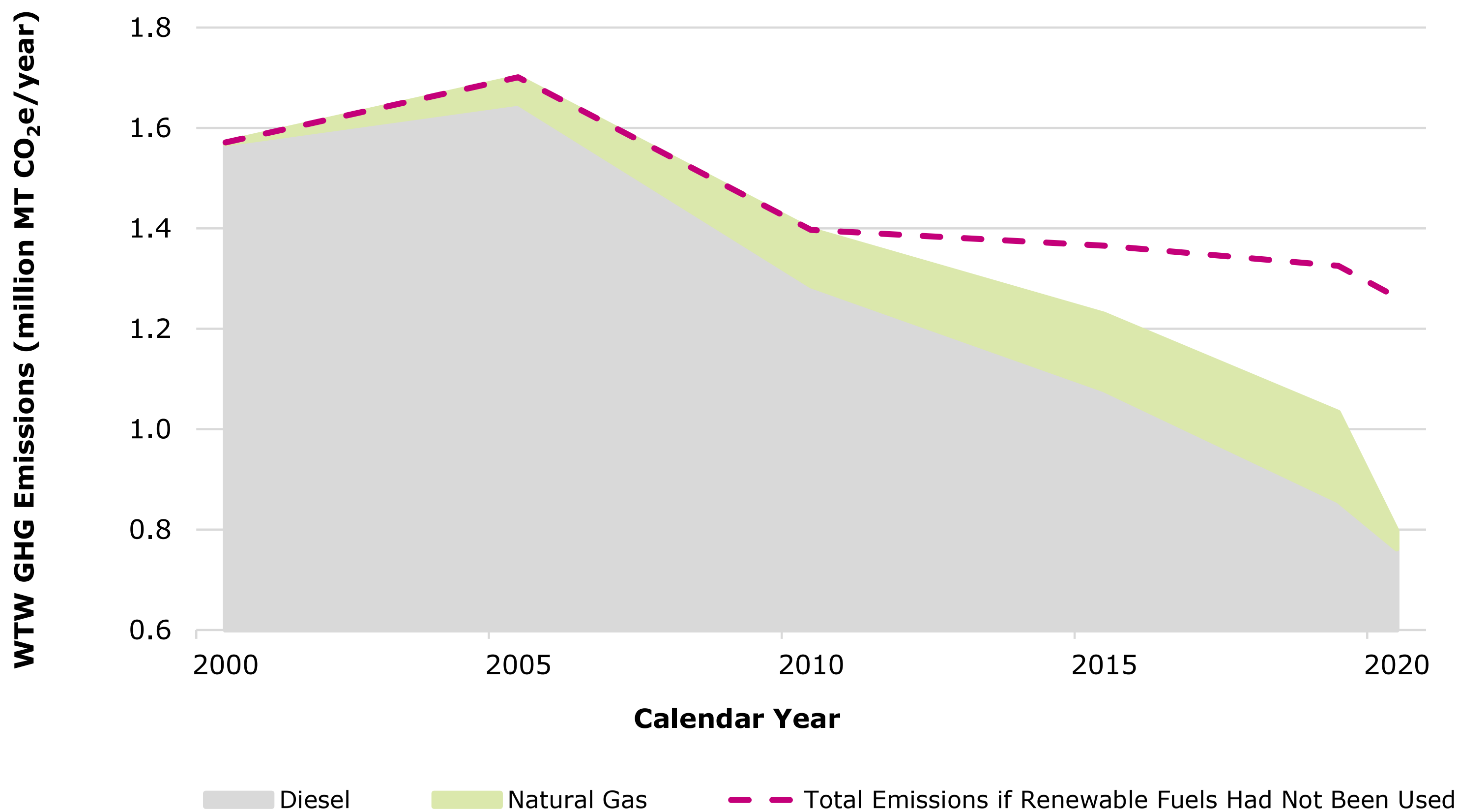


Figure 14: GHG Emissions for the Statewide SWCV Fleet (Stacked Graph: Diesel-Natural Gas)



CONCLUSION

This analysis shows that increased use of renewable lower CI fuels (~26% for HHDTs and ~46% for SWVCs) has already reduced GHG emissions from the statewide HHDT and SWVC fleet by 18% and 37% respectively, compared to if they were not used in 2015 and 2020. Increased use of commercially available lower CI fuels can continue to reduce GHG emissions from the transportation sector immediately and going forward if the use of these fuels is not restricted by CARB ZEV-centric proposals. In addition, the increasing use of these lower CI fuels can be done without the significant issues of unprecedented electric generation/infrastructure expansion, zero emission vehicle availability for all heavy-duty trucks, and related costs raised by stakeholders in comments during CARB rulemakings, workshops, and hearings.

TABLES

Table 1. Estimating Annual Fractions of Fuel Components for each Fuel Type
Southern California Gas Company
Los Angeles, California

Fuel[1]	Calendar Year	Fuel Component[2]	Statewide Consumption of Fuel Components[3,4] (million gallons)					Annual Fractions of Fuel Components[5,6]
			First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total Annual	
Diesel	2000	Fossil Diesel	n/a	n/a	n/a	n/a	2,585	1.000
		Biodiesel	n/a	n/a	n/a	n/a	0	0.000
		Renewable Diesel	n/a	n/a	n/a	n/a	0	0.000
	2005	Fossil Diesel	n/a	n/a	n/a	n/a	2,916	1.000
		Biodiesel	n/a	n/a	n/a	n/a	0	0.000
		Renewable Diesel	n/a	n/a	n/a	n/a	0	0.000
	2010	Fossil Diesel	n/a	n/a	n/a	n/a	2,561	1.000
		Biodiesel	n/a	n/a	n/a	n/a	0	0.000
		Renewable Diesel	n/a	n/a	n/a	n/a	0	0.000
	2015	Fossil Diesel	780	892	945	849	3,466	0.922
		Biodiesel	20	29	43	35	126	0.034
		Renewable Diesel	27	41	51	46	165	0.044
	2019	Fossil Diesel	685	757	791	754	2,987	0.783
		Biodiesel	42	57	57	55	212	0.055
		Renewable Diesel	160	160	133	165	618	0.162
	2020	Fossil Diesel	622	679	724	701	2,726	0.761
		Biodiesel	56	59	70	81	266	0.074
		Renewable Diesel	131	152	140	166	589	0.164
Gasoline	2000	CARBOB	n/a	n/a	n/a	n/a	14,875	0.999
		Ethanol	n/a	n/a	n/a	n/a	8	0.001
	2005	CARBOB	n/a	n/a	n/a	n/a	15,142	0.945
		Ethanol	n/a	n/a	n/a	n/a	880	0.055
	2010	CARBOB	n/a	n/a	n/a	n/a	13,514	0.905
		Ethanol	n/a	n/a	n/a	n/a	1,410	0.095
	2015	CARBOB	3,159	3,434	3,515	3,338	13,445	0.900
		Ethanol	372	390	384	352	1,499	0.100
	2019	CARBOB	3,311	3,491	3,427	3,508	13,738	0.898
		Ethanol	355	416	393	393	1,557	0.102
	2020	CARBOB	3,139	2,376	2,927	2,896	11,339	0.897
		Ethanol	375	229	366	329	1,299	0.103
Natural Gas	2000-2010	Fossil-CNG	n/a	n/a	n/a	n/a	n/a	0.710
		Fossil-LNG	n/a	n/a	n/a	n/a	n/a	0.290
	2011	Fossil-CNG	12.9	13.3	13.1	12.8	52.1	0.710
		Fossil-LNG	4.9	5.3	5.6	5.6	21.3	0.290

Table 1. Estimating Annual Fractions of Fuel Components for each Fuel Type
Southern California Gas Company
Los Angeles, California

Fuel[1]	Calendar Year	Fuel Component[2]	Statewide Consumption of Fuel Components[3,4] (million gallons)					Annual Fractions of Fuel Components[5,6]
			First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total Annual	
Natural Gas *(Continued)*	2015	Fossil-CNG	18.2	15.3	15.6	15.2	64.4	0.465
		Fossil-LNG	3.2	2.3	1.5	0.5	7.5	0.054
		Bio-CNG	6.7	10.0	11.0	11.4	39.2	0.283
		Bio-LNG	5.3	6.4	7.3	8.3	27.2	0.197
	2019	Fossil-CNG	9.7	9.5	10.7	9.4	39.4	0.219
		Fossil-LNG	0.3	0.6	0.2	0.3	1.3	0.007
		Bio-CNG	28.6	31.3	32.0	31.0	122.9	0.683
		Bio-LNG	3.6	3.6	4.6	4.6	16.4	0.091
	2020	Fossil-CNG	5.9	3.9	2.1	0.8	12.6	0.077
		Fossil-LNG	0.0	0.0	0.0	0.0	0.0	0.000
		Bio-CNG	32.8	28.8	35.7	36.3	133.6	0.814
		Bio-LNG	4.6	4.4	4.6	4.4	18.0	0.110

Notes:

[1] Fuels evaluated are based on the EMFAC 2021 outputs for heavy-heavy-duty trucks in calendar years 2000-2020. Refer to Attachment A for further details.

[2] Fuel components evaluated are derived from CARB's Low Carbon Fuel Standard (LCFS) Reporting Tool Quarterly Summary for Q1 2021. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

[3] Annual consumption of diesel and gasoline fuels for 2000-2010 are derived from Figures 6 and 7 in the 2021 CARB report titled *California Greenhouse Gas Emissions for 2000-2019: Trends of Emissions and Other Indicators.* Available at: https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000_2019_ghg_inventory_trends_20220516.pdf. Accessed: June 2022.

[4] Quarterly consumption of fuel components for calendar years 2011-2020 are obtained from fuel volumes published in CARB's Low Carbon Fuel Standard (LCFS) Reporting Tool Quarterly Summary for Q1 2021. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022. The annual consumption is estimated as the sum of the quaterly consumption for each calendar year.

[5] Annual fractions of fuel components for each fuel and calendar year are calculated based on the annual consumption of the fuel components in said calendar year.

[6] Natural gas is assumed to have only fossil fuel components prior to 2011. The annual fractions of fossil-CNG and fossil-LNG for calendar years 2000 to 2010 are assumed to be equal to the proportions of these fossil fuel components consumed in 2011.

Abbreviations:

CARB - California Air Resources Board
CARBOB - California Reformulated Gasoline Blendstock for Oxygenate Blending
CNG - compressed natural gas
EMFAC - EMission FACtors model
LCFS - Low Carbon Fuel Standard
LNG - liquified natural gas
n/a - not applicable
Q1 - First quarter of the year; January to March

Table 2. Estimating Carbon Intensities by Fuel Components
Southern California Gas Company
Los Angeles, California

Fuel Component	Calendar Year	Quarterly Statewide Consumption of Fuel Components[1] (million gallons)				Quarterly Well-to-Wheel Carbon Intensities[1] (gCO_2e/MJ)				Annualized Carbon Intensity (gCO_2e/MJ)
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	
Fossil Diesel[2]	2000-2020	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100.5
Biodiesel[3]	2015	20	29	43	35	24.9	21.9	33.5	20.7	26.0
	2019	42	57	57	55	28.5	27.0	26.2	26.4	26.9
	2020	56	59	70	81	25.9	27.3	27.1	29.9	27.7
Renewable Diesel[3]	2015	27	41	51	46	37.3	50.6	51.1	46.6	47.4
	2019	160	160	133	165	36.4	34.3	33.6	34.1	34.6
	2020	131	152	140	166	32.1	35.1	32.1	32.9	33.1
CARBOB[2]	2000-2020	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100.8
Ethanol[3,4]	2000-2010	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	87.5
	2011	356	388	389	357	88.5	87.8	87.0	86.6	87.5
	2015	372	390	384	352	82.9	82.8	81.8	78.9	81.6
	2019	355	416	393	393	66.0	63.7	59.3	59.5	62.0
	2020	375	229	366	329	60.3	62.1	57.8	57.7	59.3
Fossil-CNG[2]	2000-2020	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	79.2
Fossil-LNG[5]	2000-2020	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	88.3
Bio-CNG[3]	2015	6.7	10.0	11.0	11.4	25.9	21.3	19.3	22.1	21.7
	2019	28.6	31.3	32.0	31.0	41.3	41.8	31.0	16.8	32.6
	2020	32.8	28.8	35.7	36.3	20.7	5.4	-14.3	-25.9	-4.6
Bio-LNG[3]	2015	5.3	6.4	7.3	8.3	33.2	26.0	24.2	26.9	27.2
	2019	3.6	3.6	4.6	4.6	58.1	52.7	57.8	55.9	56.2
	2020	4.6	4.4	4.6	4.4	52.3	54.1	57.4	56.0	54.9

Notes:

[1] Obtained from CARB's LCFS Reporting Tool Quarterly Summary for Q1 2021. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

[2] Annualized carbon intensities of fossil diesel, CARBOB, and fossil-CNG are derived from CARB's CA-GREET3.0 Lookup Table Pathways document. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf. Accessed: June 2022.

[3] Annualized carbon intensities of biodiesel, renewable diesel, ethanol, bio-CNG, and bio-LNG for calendar years 2011 to 2020 are estimated as a consumption weighted average of quarterly carbon intensities for each calendar year.

[4] Annualized carbon intensities of ethanol for calendar years 2000 to 2010 were assumed to be equal to the carbon intensity of ethanol in 2011.

[5] The annualized carbon intensity of fossil-LNG is estimated as an average of the carbon intensities associated with LCFS-certified LNG pathways with non-biogenic feedstocks. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx. Accessed: June 2022.

Abbreviations:

CA-GREET - California Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model
CARB - California Air Resources Board
CARBOB - California Reformulated Gasoline Blendstock for Oxygenate Blending
gCO_2e/MJ - grams of carbon dioxide equivalent emissions per megajoule of fuel consumed
CNG - compressed natural gas
LCFS - Low Carbon Fuel Standard
LNG - liquified natural gas
n/a - not applicable

Table 3. Estimating Carbon Intensities for Diesel Fuel
Southern California Gas Company
Los Angeles, California

Calendar Year	Annual Fractions of the Fuel Components of Diesel Fuel[1]			Annualized Carbon Intensities for Fuel Components of Diesel Fuel[2] (gCO_2e/MJ)			Carbon Intensity of Diesel Fuel[3]		Carbon Intensity of Fossil Diesel (gCO_2e/gal)
	Fossil Diesel	Biodiesel	Renewable Diesel	Fossil Diesel	Biodiesel	Renewable Diesel	(gCO_2e/MJ)	(gCO_2e/gal)	
2000	1.00	0.00	0.00	100.5	--	--	100.5	13,508	13,508
2005	1.00	0.00	0.00	100.5	--	--	100.5	13,508	13,508
2010	1.00	0.00	0.00	100.5	--	--	100.5	13,508	13,508
2015	0.92	0.03	0.04	100.5	26.0	47.4	95.6	12,840	13,508
2019	0.78	0.06	0.16	100.5	26.9	34.6	85.7	11,487	13,508
2020	0.76	0.07	0.16	100.5	27.7	33.1	84.0	11,247	13,508

Notes:

[1] Obtained from Table 1.

[2] Obtained from Table 2.

[3] The carbon intensity of diesel fuel is calculated as a composition weighted average of carbon intensities of the fuel components.

[4] Obtained from CARB's LCFS Reporting Tool Quarterly Summary for Q1 2021. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

Energy Density of the Fuel Components of Diesel Fuel[4]

Fossil Diesel: 134.47 MJ/gal
Biodiesel: 126.13 MJ/gal
Renewable Diesel: 129.65 MJ/gal

Abbreviations:

CARB - California Air Resources Board
CO_2e - carbon dioxide equivalent
g - gram
gal - gallon
LCFS - Low Carbon Fuel Standard
MJ - megajoule
Q1 - First quarter of the year; January to March

Table 4. Estimating Carbon Intensities for Gasoline Fuel
Southern California Gas Company
Los Angeles, California

Calendar Year	Annual Fractions of the Fuel Components of Gasoline Fuel[1]		Annualized Carbon Intensities for Fuel Components of Gasoline Fuel[2] (gCO_2e/MJ)		Carbon Intensity of Gasoline Fuel[3]		Carbon Intensity of Fossil Gasoline, CARBOB[5] (gCO_2e/gal)
	CARBOB	Ethanol	CARBOB	Ethanol	(gCO_2e/MJ)	(gCO_2e/gal)	
2000	0.999	0.001	100.8	87.5	100.81	12,048	12,051
2005	0.945	0.055	100.8	87.5	100.09	11,781	12,051
2010	0.905	0.095	100.8	87.5	99.56	11,586	12,051
2015	0.900	0.100	100.8	81.6	98.89	11,509	12,051
2019	0.898	0.102	100.8	62.0	96.87	11,339	12,051
2020	0.897	0.103	100.8	59.3	96.55	11,309	12,051

Notes:
[1] Obtained from Table 1.
[2] Obtained from Table 2.
[3] The carbon intensity of gasoline fuel is calculated as a composition weighted average of carbon intensities of the fuel components.
[4] Obtained from CARB's LCFS Reporting Tool Quarterly Summary for Q1 2021. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

Energy Density of the Fuel Components of Gasoline Fuel[4]
Fossil Gasoline, CARBOB: 119.53 MJ/gal
Ethanol: 81.51 MJ/gal

Abbreviations:
CARB - California Air Resources Board
CARBOB - California Reformulated Gasoline Blendstock for Oxygenate Blending
CO_2e - carbon dioxide equivalent
g - gram
gal - gallon
LCFS - Low Carbon Fuel Standard
MJ - megajoule
Q1 - First quarter of the year; January to March

Table 5. Estimating Carbon Intensities for Natural Gas Fuel
Southern California Gas Company
Los Angeles, California

Calendar Year	Annual Fractions of the Fuel Components of Natural Gas Fuel[1]				Annualized Carbon Intensities for Fuel Components of Natural Gas Fuel[2] (gCO_2e/MJ)				Carbon Intensity of Natural Gas Fuel[3]		Carbon Intensity of Fossil Natural Gas Fuel[4] (gCO_2e/DGE)
	Fossil-CNG	Fossil-LNG	Bio-CNG	Bio-LNG	Fossil-CNG	Fossil-LNG	Bio-CNG	Bio-LNG	(gCO_2e/MJ)	(gCO_2e/DGE)	
2000	0.710	0.290	0.000	0.000	79.2	88.3	--	--	81.86	11,008	11,008
2005	0.710	0.290	0.000	0.000	79.2	88.3	--	--	81.86	11,008	11,008
2010	0.710	0.290	0.000	0.000	79.2	88.3	--	--	81.86	11,008	11,008
2015	0.465	0.054	0.283	0.197	79.2	88.3	21.7	27.2	53.18	7,151	11,008
2019	0.219	0.007	0.683	0.091	79.2	88.3	32.6	56.2	45.34	6,096	11,008
2020	0.077	0.000	0.814	0.110	79.2	88.3	-4.6	54.9	8.37	1,125	11,008

Notes:

[1] Obtained from Table 1.

[2] Obtained from Table 2.

[3] The carbon intensity of natural gas fuel is calculated as a composition weighted average of carbon intensities of the fuel components. These carbon intensities are also presented in gCO_2e/DGE, using the energy density of fossil diesel, which is displaced by natural gas fuel in the heavy-heavy duty truck sector.

[4] The carbon intensity of fossil natural gas fuel is assumed to be equal to the carbon intensity of natural gas fuel in 2000-2010, where the fuel components of natural gas are fossil-CNG and fossil-LNG.

[5] Obtained from CARB's LCFS Reporting Tool Quarterly Summary for Q1 2021. Available at: https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries. Accessed: June 2022.

Energy Density of the Fuel Components of Diesel Fuel[5]

Fossil Diesel: 134.47 MJ/gal

Abbreviations:

CARB - California Air Resources Board
CNG - compressed natural gas
CO_2e - carbon dioxide equivalent
DGE - diesel gallon equivalent
g - gram
LCFS - Low Carbon Fuel Standard
LNG - liquified natural gas
MJ - megajoule
Q1 - First quarter of the year; January to March

Table 6. Statewide Criteria Air Pollutant and Greenhouse Gas Emission Inventories for Heavy-Heavy Duty Trucks
Southern California Gas Company
Los Angeles, California

Calendar Year	Fuel	Vehicle Population[1]	Vehicle Miles Travelled[1] (miles/year)	Tailpipe Emissions[1] (tons/year)		Fuel Consumption[1,2] (million gallons/year)	Carbon Intensity of Fuel[3] (gCO_2e/gal)	Well to Wheel Greenhouse Gas Emissions[4] ($MT\ CO_2e/year$)	Carbon Intensity of Fossil Fuel[3] (gCO_2e/gal)	Well to Wheel Greenhouse Gas Emissions without Renewable Fuel Adoption[5] ($MT\ CO_2e/year$)
				NO_X	PM_{10}					
2000	Diesel	178,113	10,695,696,944	263,005	8,770	1,911	13,508	25,814,265	13,508	25,814,265
	Gasoline	7,276	154,325,260	3,248	3	48	12,048	573,136	12,051	573,265
	Natural Gas	23	705,366	25	0	0.27	11,008	2,946	11,008	2,946
2005	Diesel	217,552	11,822,789,622	253,191	8,016	2,084	13,508	28,146,162	13,508	28,146,162
	Gasoline	4,809	104,190,669	1,321	1	31	11,781	366,246	12,051	374,652
	Natural Gas	421	11,804,714	373	1	4.6	11,008	51,041	11,008	51,041
2010	Diesel	229,437	10,252,779,427	174,506	6,359	1,776	13,508	23,987,931	13,508	23,987,931
	Gasoline	3,677	82,337,543	767	1	25	11,586	284,363	12,051	295,778
	Natural Gas	2,164	45,347,689	454	1	12	11,008	128,554	11,008	128,554
2015	Diesel	262,464	11,160,151,921	103,926	2,325	1,912	12,840	24,546,983	13,508	25,823,657
	Gasoline	870	8,621,180	131	0	2.8	11,509	32,267	12,051	33,785
	Natural Gas	7,179	166,880,843	580	1	35	7,151	251,554	11,008	387,219
2019	Diesel	270,488	12,064,845,187	68,300	1,137	2,087	11,487	23,976,179	13,508	28,194,158
	Gasoline	548	5,599,503	87	0	1.7	11,339	19,579	12,051	20,809
	Natural Gas	11,888	275,265,119	587	1	53	6,096	326,007	11,008	588,641
2020	Diesel	274,445	12,239,392,846	55,523	772	2,116	11,247	23,792,942	13,508	28,575,438
	Gasoline	381	4,017,783	56	0	1.2	11,309	13,440	12,051	14,322
	Natural Gas	13,841	311,373,817	576	1	60	1,125	67,082	11,008	656,314

Conversion Factor:

1,000,000 g/MT

Notes:

[1] Data obtained from Attachment 1. Heavy-heavy duty trucks are represented by the following EMFAC202x vehicle categories: T7 CAIRP Class 8, T7 NNOOS Class 8, T7 NOOS Class 8, T7 Other Port Class 8, T7 POAK Class 8, T7 POLA Class 8, T7 Public Class 8, T7 Single Concrete/Transit Mix Class 8, T7 Single Unit Dump Class 8, T7 Single Unit Other Class 8, T7 SWCV Class 8, T7 Tractor Class 8, T7 Utility Class 8, and T7IS.

[2] Fuel consumption units for natural gas are reported in diesel gallon equivalents (DGE).

[3] Obtained from Tables 3, 4, and 5.

[4] Well to wheel greenhouse gas emissions are estimated as the product of the fuel consumption and carbon intensity for each fuel.

[6] Well to wheel greenhouse gas emissions without renewable fuel adoption are estimated as the product of fuel consumption and carbon intensity of fossil fuel.

Abbreviations:

CAIRP - California International Registration Plan
CARB - California Air Resources Board
CARBOB - California Reformulated Gasoline Blendstock for Oxygenate Blending
CNG - compressed natural gas
CO_2e - carbon dioxide equivalent
EMFAC - EMission FACtors model
g - gram
gal - gallon
LCFS - Low Carbon Fuel Standard
MJ - megajoule
NNOOS - non-neighboring out-of-state
NOOS - neighboring out-of-state
NO_X - oxides of nitrogen
PM_{10} - particulate matter with diameter smaller than or equal to 10 microns
POAK - Port of Oakland
POLA - Port of Los Angeles
SWCV - Solid Waste Collection Vehicle

Table 7. Statewide Criteria Air Pollutant and Greenhouse Gas Emission Inventories for Solid Waste Collection Vehicles
Southern California Gas Company
Los Angeles, California

Calendar Year	Fuel	Vehicle Population[1]	Vehicle Miles Travelled[1] (miles/year)	Tailpipe Emissions[1] (tons/year)		Fuel Consumption[1,2] (million gallons/year)	Carbon Intensity of Fuel[3] (gCO_2e/gal)	Well to Wheel Greenhouse Gas Emissions[4] (MT CO_2e/year)	Carbon Intensity of Fossil Fuel[5] (gCO_2e/gal)	Well to Wheel Greenhouse Gas Emissions without Renewable Fuel Adoption[6] (MT CO_2e/year)
				NO_X	PM_{10}					
2000	Diesel	9,360	282,457,122	6,632	51	116	13,508	1,568,557	13,508	1,568,557
	Natural Gas	23	705,366	25	0.032	0.27	11,008	2,946	11,008	2,946
2005	Diesel	10,770	301,702,701	6,437	43	122	13,508	1,649,983	13,508	1,649,983
	Natural Gas	421	11,804,714	373	0.88	4.6	11,008	51,041	11,008	51,041
2010	Diesel	11,486	236,383,404	4,383	28	95	13,508	1,285,998	13,508	1,285,998
	Natural Gas	1,809	37,016,831	446	1.01	10	11,008	110,507	11,008	110,507
2015	Diesel	10,263	207,174,251	3,444	3.9	84	12,840	1,079,246	13,508	1,135,377
	Natural Gas	4,444	91,414,311	516	0.97	21	7,151	149,804	11,008	230,595
2019	Diesel	9,205	186,103,536	2,797	3.6	75	11,487	857,330	13,508	1,008,155
	Natural Gas	6,922	139,405,413	488	0.83	29	6,096	175,755	11,008	317,344
2020	Diesel	8,381	169,593,149	2,400	3.1	68	11,247	762,178	13,508	915,380
	Natural Gas	7,827	157,335,498	468	0.79	32	1,125	35,516	11,008	347,479

Conversion Factor:

1,000,000 g/MT

Notes:

[1] Data obtained from Attachment 1. Heavy-heavy duty trucks are represented by the T7 SWCV Class 8 EMFAC202x vehicle category.
[2] Fuel consumption units for natural gas are reported in diesel gallon equivalents (DGE).
[3] Obtained from Tables 3, 4, and 5.
[4] Well to wheel greenhouse gas emissions are estimated as the product of the fuel consumption and carbon intensity for each fuel.
[6] Well to wheel greenhouse gas emissions without renewable fuel adoption are estimated as the product of fuel consumption and carbon intensity of fossil fuel.

Abbreviations:

CARB - California Air Resources Board
CARBOB - California Reformulated Gasoline Blendstock for Oxygenate Blending
CNG - compressed natural gas
CO_2e - carbon dioxide equivalent
EMFAC - EMission FACtors model
g - gram
gal - gallon
LCFS - Low Carbon Fuel Standard
MJ - megajoule
NO_X - oxides of nitrogen
PM_{10} - particulate matter with diameter smaller than or equal to 10 microns
SWCV - Solid Waste Collection Vehicle

RAMBOLL

ATTACHMENT A

EMFAC2021 OUTPUT

EMFAC2021 Model Output
Southern California Gas Company
Los Angeles, California

Source: EMFAC2021 (v1.0.2) Emissions Inventory
Region Type: Statewide
Region: California
Calendar Year: 2000, 2005, 2010, 2015, 2019, 2020
Season: Annual
Vehicle Classification: EMFAC202x Categories
Units: miles/day for CVMT and EVMT, trips/day for Trips, kWh/day for Energy Consumption, tons/day for Emissions, 1000 gallons/day for Fuel Consumption

Region	Calendar Year	Vehicle Category	Model Year	Speed	Fuel	Population	Total VMT	NOx_TOTEX	PM10_TOTEX	Fuel Consumption
Statewide Totals	2000	T7 CAIRP Class 8	Aggregate	Aggregate	Diesel	22,060	8,651,953	218.28	7.459	1473.8
Statewide Totals	2000	T7 NNOOS Class 8	Aggregate	Aggregate	Diesel	18,155	10,229,192	258.13	5.484	1716.4
Statewide Totals	2000	T7 NOOS Class 8	Aggregate	Aggregate	Diesel	8,114	3,716,078	94.19	3.403	635.5
Statewide Totals	2000	T7 Other Port Class 8	Aggregate	Aggregate	Diesel	1,338	209,013	5.13	0.243	38.3
Statewide Totals	2000	T7 POAK Class 8	Aggregate	Aggregate	Diesel	1,939	355,851	8.63	0.453	65.5
Statewide Totals	2000	T7 POLA Class 8	Aggregate	Aggregate	Diesel	7,012	1,607,480	36.35	2.240	285.4
Statewide Totals	2000	T7 Public Class 8	Aggregate	Aggregate	Diesel	13,125	909,101	21.53	0.965	177.9
Statewide Totals	2000	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Diesel	4,347	336,896	7.67	0.284	59.4
Statewide Totals	2000	T7 Single Dump Class 8	Aggregate	Aggregate	Diesel	10,656	727,170	16.71	0.634	129.8
Statewide Totals	2000	T7 Single Other Class 8	Aggregate	Aggregate	Diesel	20,480	1,452,170	33.30	1.287	259.2
Statewide Totals	2000	T7 SWCV Class 8	Aggregate	Aggregate	Diesel	9,360	905,311	21.26	0.163	372.2
Statewide Totals	2000	T7 SWCV Class 8	Aggregate	Aggregate	Natural Gas	23	2,261	0.08	0.000	0.9
Statewide Totals	2000	T7 Tractor Class 8	Aggregate	Aggregate	Diesel	60,176	5,109,351	120.13	5.449	898.9
Statewide Totals	2000	T7 Utility Class 8	Aggregate	Aggregate	Diesel	1,351	71,515	1.65	0.045	13.0
Statewide Totals	2000	T7IS	Aggregate	Aggregate	Gasoline	7,276	471,943	9.93	0.008	145.5
Statewide Totals	2005	T7 CAIRP Class 8	Aggregate	Aggregate	Diesel	27,574	9,570,741	228.30	6.246	1621.5
Statewide Totals	2005	T7 NNOOS Class 8	Aggregate	Aggregate	Diesel	24,458	11,315,473	207.42	7.164	1906.0
Statewide Totals	2005	T7 NOOS Class 8	Aggregate	Aggregate	Diesel	10,126	4,110,704	99.32	2.781	699.5
Statewide Totals	2005	T7 Other Port Class 8	Aggregate	Aggregate	Diesel	1,441	231,201	5.48	0.149	40.6
Statewide Totals	2005	T7 POAK Class 8	Aggregate	Aggregate	Diesel	2,561	393,640	9.41	0.282	69.8
Statewide Totals	2005	T7 POLA Class 8	Aggregate	Aggregate	Diesel	10,499	1,779,298	40.69	1.630	307.2
Statewide Totals	2005	T7 Public Class 8	Aggregate	Aggregate	Diesel	17,902	1,005,642	22.22	0.886	194.7
Statewide Totals	2005	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Diesel	5,821	376,477	7.54	0.249	64.1
Statewide Totals	2005	T7 Single Dump Class 8	Aggregate	Aggregate	Diesel	14,270	805,970	16.36	0.553	138.7
Statewide Totals	2005	T7 Single Other Class 8	Aggregate	Aggregate	Diesel	27,286	1,606,370	32.57	1.119	276.6
Statewide Totals	2005	T7 SWCV Class 8	Aggregate	Aggregate	Diesel	10,770	966,996	20.63	0.139	391.5
Statewide Totals	2005	T7 SWCV Class 8	Aggregate	Aggregate	Natural Gas	421	37,836	1.20	0.003	14.9
Statewide Totals	2005	T7 Tractor Class 8	Aggregate	Aggregate	Diesel	63,350	5,651,934	119.99	4.456	954.2
Statewide Totals	2005	T7IS	Aggregate	Aggregate	Gasoline	4,809	318,626	4.04	0.004	95.1
Statewide Totals	2005	T7 Utility Class 8	Aggregate	Aggregate	Diesel	1,494	79,110	1.58	0.040	14.2

Region	Calendar Year	Vehicle Category	Model Year	Speed	Fuel	Population	Total VMT	NOx_TOTEX	PM10_TOTEX	Fuel Consumption
Statewide Totals	2010	T7 CAIRP Class 8	Aggregate	Aggregate	Diesel	30,007	8,328,208	146.58	5.557	1378.4
Statewide Totals	2010	T7 CAIRP Class 8	Aggregate	Aggregate	Natural Gas	1	255	0.00	0.000	0.0
Statewide Totals	2010	T7 NNOOS Class 8	Aggregate	Aggregate	Diesel	26,167	9,846,731	137.33	5.751	1633.9
Statewide Totals	2010	T7 NOOS Class 8	Aggregate	Aggregate	Diesel	11,371	3,577,137	64.70	2.471	593.6
Statewide Totals	2010	T7 Other Port Class 8	Aggregate	Aggregate	Diesel	860	201,163	4.35	0.113	35.3
Statewide Totals	2010	T7 POAK Class 8	Aggregate	Aggregate	Diesel	2,691	342,546	7.84	0.203	61.5
Statewide Totals	2010	T7 POLA Class 8	Aggregate	Aggregate	Diesel	8,911	1,547,026	33.48	1.013	263.8
Statewide Totals	2010	T7 POLA Class 8	Aggregate	Aggregate	Natural Gas	8	1,320	0.00	0.000	0.2
Statewide Totals	2010	T7 Public Class 8	Aggregate	Aggregate	Diesel	20,069	862,919	16.54	0.617	168.4
Statewide Totals	2010	T7 Public Class 8	Aggregate	Aggregate	Natural Gas	196	12,191	0.01	0.000	2.5
Statewide Totals	2010	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Diesel	5,773	324,083	5.33	0.179	54.8
Statewide Totals	2010	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Natural Gas	15	1,371	0.00	0.000	0.3
Statewide Totals	2010	T7 Single Dump Class 8	Aggregate	Aggregate	Diesel	14,144	697,486	11.76	0.399	119.3
Statewide Totals	2010	T7 Single Dump Class 8	Aggregate	Aggregate	Natural Gas	37	3,040	0.00	0.000	0.6
Statewide Totals	2010	T7 Single Other Class 8	Aggregate	Aggregate	Diesel	27,058	1,391,613	23.49	0.807	238.1
Statewide Totals	2010	T7 Single Other Class 8	Aggregate	Aggregate	Natural Gas	70	6,287	0.01	0.000	1.2
Statewide Totals	2010	T7 SWCV Class 8	Aggregate	Aggregate	Diesel	11,486	757,639	14.05	0.091	305.1
Statewide Totals	2010	T7 SWCV Class 8	Aggregate	Aggregate	Natural Gas	1,809	118,644	1.43	0.003	32.2
Statewide Totals	2010	T7 Tractor Class 8	Aggregate	Aggregate	Diesel	69,590	4,916,080	92.94	3.171	827.2
Statewide Totals	2010	T7 Tractor Class 8	Aggregate	Aggregate	Natural Gas	27	2,236	0.00	0.000	0.5
Statewide Totals	2010	T7 Utility Class 8	Aggregate	Aggregate	Diesel	1,309	68,841	0.92	0.009	12.5
Statewide Totals	2010	T7IS	Aggregate	Aggregate	Gasoline	3,677	251,797	2.35	0.002	75.1
Statewide Totals	2015	T7 CAIRP Class 8	Aggregate	Aggregate	Diesel	39,376	9,157,111	81.64	1.765	1515.6
Statewide Totals	2015	T7 CAIRP Class 8	Aggregate	Aggregate	Natural Gas	23	6,466	0.01	0.000	1.1
Statewide Totals	2015	T7 NNOOS Class 8	Aggregate	Aggregate	Diesel	36,687	10,834,084	81.88	2.488	1777.9
Statewide Totals	2015	T7 NOOS Class 8	Aggregate	Aggregate	Diesel	14,654	3,935,825	36.49	0.838	654.4
Statewide Totals	2015	T7 Other Port Class 8	Aggregate	Aggregate	Diesel	1,289	221,281	1.58	0.009	39.4
Statewide Totals	2015	T7 POAK Class 8	Aggregate	Aggregate	Diesel	3,174	376,357	2.86	0.021	68.1
Statewide Totals	2015	T7 POAK Class 8	Aggregate	Aggregate	Natural Gas	4	537	0.00	0.000	0.1
Statewide Totals	2015	T7 POLA Class 8	Aggregate	Aggregate	Diesel	11,506	1,611,840	11.64	0.068	278.3
Statewide Totals	2015	T7 POLA Class 8	Aggregate	Aggregate	Natural Gas	643	91,763	0.07	0.000	17.4
Statewide Totals	2015	T7 Public Class 8	Aggregate	Aggregate	Diesel	23,078	920,784	15.77	0.150	180.8
Statewide Totals	2015	T7 Public Class 8	Aggregate	Aggregate	Natural Gas	797	42,076	0.04	0.000	8.0
Statewide Totals	2015	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Diesel	6,035	347,956	3.71	0.107	58.7

Region	Calendar Year	Vehicle Category	Model Year	Speed	Fuel	Population	Total VMT	NOx_TOTEX	PM10_TOTEX	Fuel Consumption
Statewide Totals	2015	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Natural Gas	76	7,010	0.01	0.000	1.3
Statewide Totals	2015	T7 Single Dump Class 8	Aggregate	Aggregate	Diesel	14,798	755,007	8.52	0.225	129.0
Statewide Totals	2015	T7 Single Dump Class 8	Aggregate	Aggregate	Natural Gas	187	14,248	0.01	0.000	2.6
Statewide Totals	2015	T7 Single Other Class 8	Aggregate	Aggregate	Diesel	28,277	1,509,840	17.31	0.490	257.5
Statewide Totals	2015	T7 Single Other Class 8	Aggregate	Aggregate	Natural Gas	353	28,163	0.02	0.000	5.2
Statewide Totals	2015	T7 SWCV Class 8	Aggregate	Aggregate	Diesel	10,263	664,020	11.04	0.012	269.4
Statewide Totals	2015	T7 SWCV Class 8	Aggregate	Aggregate	Natural Gas	4,444	292,995	1.65	0.003	67.1
Statewide Totals	2015	T7 Tractor Class 8	Aggregate	Aggregate	Diesel	71,795	5,359,870	60.22	1.275	885.4
Statewide Totals	2015	T7 Tractor Class 8	Aggregate	Aggregate	Natural Gas	652	51,616	0.05	0.000	9.9
Statewide Totals	2015	T7 Utility Class 8	Aggregate	Aggregate	Diesel	1,533	75,744	0.45	0.002	13.1
Statewide Totals	2015	T7IS	Aggregate	Aggregate	Gasoline	870	26,364	0.40	0.001	8.6
Statewide Totals	2019	T7 CAIRP Class 8	Aggregate	Aggregate	Diesel	46,527	9,969,747	47.89	0.730	1683.6
Statewide Totals	2019	T7 CAIRP Class 8	Aggregate	Aggregate	Natural Gas	63	14,405	0.01	0.000	2.6
Statewide Totals	2019	T7 NNOOS Class 8	Aggregate	Aggregate	Diesel	42,911	11,804,249	58.73	1.436	1989.9
Statewide Totals	2019	T7 NOOS Class 8	Aggregate	Aggregate	Diesel	17,394	4,288,268	21.54	0.351	728.2
Statewide Totals	2019	T7 Other Port Class 8	Aggregate	Aggregate	Diesel	1,453	241,096	1.31	0.008	42.2
Statewide Totals	2019	T7 POAK Class 8	Aggregate	Aggregate	Diesel	4,218	410,149	2.64	0.019	73.7
Statewide Totals	2019	T7 POAK Class 8	Aggregate	Aggregate	Natural Gas	6	593	0.00	0.000	0.1
Statewide Totals	2019	T7 POLA Class 8	Aggregate	Aggregate	Diesel	13,320	1,772,201	10.29	0.065	302.5
Statewide Totals	2019	T7 POLA Class 8	Aggregate	Aggregate	Natural Gas	631	83,955	0.07	0.000	15.8
Statewide Totals	2019	T7 Public Class 8	Aggregate	Aggregate	Diesel	24,571	985,246	15.04	0.094	192.1
Statewide Totals	2019	T7 Public Class 8	Aggregate	Aggregate	Natural Gas	1,222	63,835	0.05	0.000	11.7
Statewide Totals	2019	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Diesel	5,748	363,190	1.93	0.051	62.2
Statewide Totals	2019	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Natural Gas	232	19,119	0.01	0.000	3.3
Statewide Totals	2019	T7 Single Dump Class 8	Aggregate	Aggregate	Diesel	13,578	801,189	5.09	0.105	137.3
Statewide Totals	2019	T7 Single Dump Class 8	Aggregate	Aggregate	Natural Gas	476	36,770	0.02	0.000	6.6
Statewide Totals	2019	T7 Single Other Class 8	Aggregate	Aggregate	Diesel	27,108	1,604,914	10.25	0.245	275.2
Statewide Totals	2019	T7 Single Other Class 8	Aggregate	Aggregate	Natural Gas	920	70,814	0.05	0.000	12.7
Statewide Totals	2019	T7 SWCV Class 8	Aggregate	Aggregate	Diesel	9,205	596,486	8.96	0.012	239.2
Statewide Totals	2019	T7 SWCV Class 8	Aggregate	Aggregate	Natural Gas	6,922	446,812	1.57	0.003	92.4
Statewide Totals	2019	T7 Tractor Class 8	Aggregate	Aggregate	Diesel	62,845	5,750,114	34.91	0.526	949.7
Statewide Totals	2019	T7 Tractor Class 8	Aggregate	Aggregate	Natural Gas	1,417	145,958	0.11	0.000	26.2
Statewide Totals	2019	T7 Utility Class 8	Aggregate	Aggregate	Diesel	1,609	82,527	0.32	0.001	14.2

Region	Calendar Year	Vehicle Category	Model Year	Speed	Fuel	Population	Total VMT	NOx_TOTEX	PM10_TOTEX	Fuel Consumption
Statewide Totals	2019	T7IS	Aggregate	Aggregate	Gasoline	548	17,124	0.27	0.000	5.3
Statewide Totals	2020	T7 CAIRP Class 8	Aggregate	Aggregate	Diesel	47,849	10,135,704	39.74	0.536	1713.4
Statewide Totals	2020	T7 CAIRP Class 8	Aggregate	Aggregate	Natural Gas	69	15,499	0.01	0.000	2.8
Statewide Totals	2020	T7 NNOOS Class 8	Aggregate	Aggregate	Diesel	44,233	12,001,813	47.19	1.059	2031.6
Statewide Totals	2020	T7 NOOS Class 8	Aggregate	Aggregate	Diesel	17,892	4,360,032	17.69	0.249	741.4
Statewide Totals	2020	T7 Other Port Class 8	Aggregate	Aggregate	Diesel	1,510	251,745	1.26	0.008	43.7
Statewide Totals	2020	T7 POAK Class 8	Aggregate	Aggregate	Diesel	4,353	420,730	2.45	0.015	75.0
Statewide Totals	2020	T7 POAK Class 8	Aggregate	Aggregate	Natural Gas	6	597	0.00	0.000	0.1
Statewide Totals	2020	T7 POLA Class 8	Aggregate	Aggregate	Diesel	14,113	1,855,647	10.38	0.064	315.5
Statewide Totals	2020	T7 POLA Class 8	Aggregate	Aggregate	Natural Gas	664	87,377	0.07	0.000	16.4
Statewide Totals	2020	T7 Public Class 8	Aggregate	Aggregate	Diesel	23,417	972,898	13.00	0.073	187.5
Statewide Totals	2020	T7 Public Class 8	Aggregate	Aggregate	Natural Gas	1,538	81,313	0.05	0.000	14.8
Statewide Totals	2020	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Diesel	5,595	365,253	1.43	0.035	62.7
Statewide Totals	2020	T7 Single Concrete/Transit Mix Class 8	Aggregate	Aggregate	Natural Gas	264	20,798	0.01	0.000	3.6
Statewide Totals	2020	T7 Single Dump Class 8	Aggregate	Aggregate	Diesel	13,041	805,406	3.15	0.038	137.6
Statewide Totals	2020	T7 Single Dump Class 8	Aggregate	Aggregate	Natural Gas	575	40,756	0.03	0.000	7.4
Statewide Totals	2020	T7 Single Other Class 8	Aggregate	Aggregate	Diesel	26,891	1,623,740	6.47	0.087	278.0
Statewide Totals	2020	T7 Single Other Class 8	Aggregate	Aggregate	Natural Gas	1,160	80,394	0.05	0.000	14.7
Statewide Totals	2020	T7 SWCV Class 8	Aggregate	Aggregate	Diesel	8,381	543,568	7.69	0.010	217.2
Statewide Totals	2020	T7 SWCV Class 8	Aggregate	Aggregate	Natural Gas	7,827	504,280	1.50	0.003	101.2
Statewide Totals	2020	T7 Tractor Class 8	Aggregate	Aggregate	Diesel	65,497	5,809,341	27.19	0.296	962.7
Statewide Totals	2020	T7 Tractor Class 8	Aggregate	Aggregate	Natural Gas	1,737	166,979	0.13	0.000	30.2
Statewide Totals	2020	T7 Utility Class 8	Aggregate	Aggregate	Diesel	1,675	82,947	0.32	0.001	14.3
Statewide Totals	2020	T7IS	Aggregate	Aggregate	Gasoline	381	12,287	0.17	0.000	3.6

Abbreviations:

CAIRP - California International Registration Plan
CVMT - combustion vehicle miles traveled
EMFAC - EMission FACtors model
EVMT - electric vehicle miles travelled
NNOOS - non-neighboring out-of-state
NOOS - neighboring out-of-state

NO_X - oxides of nitrogen
PM_{10} - particulate matter with diameter smaller than or equal to 10 microns
POAK - Port of Oakland
POLA - Port of Los Angeles
SWCV - Solid Waste Collection Vehicle