

CLEAN TRUCK TECHNOLOGY COMPARATIVE REPORT 3

Projected Changes to Technology Mix from Existing and Proposed Regulations, and Resulting Benefits to Air Quality and Public Health

METRO GOODS MOVEMENT PLANNING



Metro

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Nomenclature

AB	Assembly Bill
ACF	Advanced Clean Fleets
ACT	Advanced Clean Trucks
AQMD	Air Quality Management District
AQMP	Air Quality Management Plan
BEV	Battery-Electric Vehicle
CAIRP	California Registered International Registration Plan
CARB	California Air Resources Board
CERP	Community Emissions Reduction Plan
DPM	Diesel Particulate Matter
EMFAC	EMission FACtor
EPA	Environmental Protection Agency
ER	Emergency Room
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
HD I&M	Heavy-Duty Inspection and Maintenance
HD Omnibus	Heavy-Duty Engine and Vehicle Omnibus Regulation
ISOR	Initial Statement of Reasons
IWG	Interagency Working Group
MATES V	Multiple Air Toxics Exposure Study
NAAQS	National Air Ambient Air Quality Standards
NOx	Nitrogen Oxides
NZE	Near-Zero Emission
SB	Senate Bill
SC-CO2	Social Cost of Carbon Dioxide
SRIA	Standardized Regulatory Impact Assessment
SSP	Sustainability Strategic Plan
VOC	Volatile Organic Compounds
ZE	Zero-Emission
ZEV	Zero-Emission Vehicle

1 Background and Overview

The purpose of this report is to conduct Class 8 heavy-duty truck fleet modeling to determine the mix of zero-emission (ZE) and near-zero emission (NZE) technologies needed for LA County to meet its local public health, regional air quality, and climate goals. This report utilizes a set of NO_x, diesel particulate matter (DPM), and greenhouse gas (GHG) emission reduction targets to determine the pace of technology adoption and penetration of ZE and NZE vehicles needed to achieve air quality and climate objectives. The proposed technology mix also takes into consideration the effect of current and proposed state policies, such as the Heavy-Duty Engine and Vehicle Omnibus Regulation (HD Omnibus Regulation), Advanced Clean Truck (ACT) Regulation, Heavy-Duty Inspection and Maintenance Program (HD I&M), and Advanced Clean Fleet (ACF) Regulation to be considered by CARB's Board in October 2022. Many of these policies are driven by Governor Newsom's Executive Order N-79-20, which calls for all drayage trucks operating in California to be ZE by 2035 and all other heavy-duty trucks to be ZE by 2045. More detailed discussion on pertinent heavy-duty vehicle policies, as well as incentive programs and air quality planning efforts, will be covered in Report 6.

This report opens by defining key air quality needs for LA County, consistent with LA Metro's 2020 Sustainability Strategic Plan (SSP), as well as South Coast AQMD's Community Emissions Reduction Plans (CERP) for its AB 617 communities and 2022 Air Quality Management Plan (AQMP) being released in October 2022. These plans define the required emission reductions to achieve its national ambient air quality standards (NAAQS). The baseline Class 8 heavy-duty truck emissions data from Report 1 are used to develop a new technology mix that would meet NO_x, DPM, and GHG emission targets. New to this report are additional overviews provided on the HD I&M and proposed ACF regulation.

Projected Class 8 heavy-duty truck populations and emissions are compiled for years 2020 through 2040 to visualize the impact of proposed technology mixes on the overall criteria pollutant and GHG emissions. The contents of this report aim to provide the necessary information to assess fueling and charging infrastructure needed for the upcoming wave of ZE and NZE Class 8 trucks.

2 Emission Reduction Targets and Supporting Regulation

This section of the report outlines the air quality and climate goals for the proposed Class 8 truck technology mixes. These emission reduction targets include:

- a) **DPM Emission Reduction Target:** The DPM emission reduction target in this report is consistent with LA Metro's 2020 SSP, which set a target for 62% DPM emissions reduction by 2030 from their 2018 baseline¹. The Metro SSP expects to chart a path towards reducing total DPM emissions by replacing older engines with ultra-low NO_x NZE (0.02g/bhp-hr) engines, as well as transitioning to battery-electric vehicles (BEV) and fuel cell electric vehicles (FCEV). Additionally, the Metro SSP references the approved 710 Clean Truck Program, which aims at reducing pollutant emissions near goods movement corridors and the San Pedro Bay Ports.

To supplement the Metro SSP goal, this report also looks to the South Coast AQMD 2019 CERP, a community emission reduction plan directed at air quality and public health concerns in AB 617 communities including Wilmington/West Long Beach/Carson². The 2019 CERP follows the advent of AB 617, requiring air districts to engage in community-focused action for specially designated disadvantaged communities. There are other communities identified by AB 617, such as East LA, Boyle Heights, West Commerce, and South LA, with their own CERPs that focus on these same priorities. This report intends to assess the

¹ [LA Metro Sustainability Strategic Plan 2020 \(dot.gov\)](https://dot.gov)

² [Annual Progress Report for AB 617 Community Emissions Reduction Plans \(aqmd.gov\)](https://aqmd.gov)

South Coast region where feasible; to this end, the South Coast AQMD's 2019 CERP for the Wilmington/West Long Beach/Carson community calls for 10% in DPM emission reductions in 2024 from the 2017 baseline.

- b) **NOx Emission Reduction Target:** The NOx emission reduction target in this report follows that of the South Coast AQMD 2022 AQMP, in which South Coast AQMD staff segment three milestones to achieve air quality goals for the region. As previously explored in Report 1, achieving U.S. EPA ozone standards will come primarily from reducing NOx emissions. According to draft analysis conducted by South Coast AQMD, meeting the NAAQS for ozone in the South Coast Air Basin would require NOx emission reductions of 45% by 2023, 55% by 2031, and 73% by 2037³. Assuming a fair share reduction across all sectors, the project team uses these emission reduction targets for determining the technology mixes for Class 8 trucks.
- c) **GHG Emission Reduction Target:** The GHG emission reduction target in this report aligns with those adopted by the state through SB 32 and Governor Brown's Executive Order B-55-18. The policies seek to reduce GHG emissions to 40% below 1990 levels by 2030 and achieve carbon neutrality no later than 2045, respectively. For consistency across the report, the 40% below 1990 levels by 2030 goal is what will be assessed to draw parallels across each emission category.

The three emission reduction targets identified in this report are pursued in accordance with data provided by EMFAC2021 and CARB's own regulatory scenario analyses. However, some of these targets are more difficult to achieve than others. In Report 1, the project team's assessment of baseline emissions highlighted that LA County's ozone chemistry is more sensitive to changes in NOx than changes in VOC; the project team determined that pursuing NOx emissions will also lead to greater DPM emission reductions (i.e., a more aggressive transition to ZE and NZE technologies are needed to achieve NOx emission reduction targets). Consequently, this report will consider NOx emission reductions as the primary guidepost for the final technology mix. Setting this air quality objective in developing the technology mix will ensure the greatest public health benefits for LA County if regulation is implemented successfully. Of course, DPM and GHG reductions are not disregarded in this work. In Report 5, DPM health effects are evaluated against potential emissions benefits; in Report 6, the impact of renewables through the LCFS is discussed to qualify GHG benefits.

To achieve these emission reduction targets, the California Air Resources Board (CARB) has recently adopted the HD I&M program to significantly reduce in-use emissions from trucks above 14,000 pounds by identifying malfunctioning emission control systems and prompting vehicle owners to repair them. Additionally, CARB anticipates the adoption of the ACF regulation, which will fully transition drayage, public, as well as federal and high-priority fleets to zero emission over the next two decades. Although Report 3 focuses on the (prospective) impacts of the ACT and proposed ACF regulations, Report 6 will delineate other incentives and policies that will accelerate ZE truck adoption.

2.1 Heavy-Duty Inspection and Maintenance Regulation

In September 2019, Governor Gavin Newsom signed SB 210 (Leyva, Chapter 5.5, Statutes of 2019) into law which directed CARB to develop a new, comprehensive HD I&M program to control emissions more effectively from non-gasoline (diesel) on-road heavy-duty vehicles with a gross vehicle weight rating greater than 14,000 pounds operating in California. The HD I&M program, adopted in December 2021, requires affected heavy-duty vehicles to perform periodic emission testing to ensure and demonstrate that their emission control systems are operating properly.

³ <http://www.aqmd.gov/docs/default-source/Agendas/Mobile-Source/msc-agenda-021822.pdf?sfvrsn=23>

The HD I&M regulation (expected to begin in 2023) is projected to be one of CARB's grandest efforts in relieving air quality burdens for disadvantaged communities. By requiring quarterly inspections, of heavy-duty vehicle emission control systems, CARB estimates that the HD I&M regulation will prevent 65% of DPM emissions and 47% of NOx emissions due to deteriorated systems⁴. Cumulative emission reduction benefits for the South Coast Air Basin after total implementation are expected to be 22.1 tons per day of NOx and 0.171 tons per day of DPM by 2037. The expected NOx and DPM emission reductions for the South Coast and San Joaquin Valley Air Basins in the immediate- through long-term are taken from CARB's emission inventory methodology report and shown in **Error! Not a valid bookmark self-reference..** For baseline data on South Coast and San Joaquin Valley Air Basins, see results from CARB's emission inventory in Appendix A.

Table 1 – Emissions Reductions Benefits from Proposed HD I&M Regulation

	Statewide	Statewide	South Coast	South Coast	San Joaquin Valley	San Joaquin Valley
Year	NOx (tpd)	DPM (tpd)	NOx (tpd)	DPM (tpd)	NOx (tpd)	DPM (tpd)
2023	6.4	0.072	2.1	0.023	2.7	0.030
2024	30.3	0.324	8.4	0.083	8.6	0.089
2025	54.5	0.604	14.5	0.149	14.3	0.152
2031	71.6	0.658	19.5	0.165	18.7	0.169
2037	81.3	0.698	22.1	0.171	21.5	0.184

Of course, this bears significant public health prospects, primarily reductions in hospitalizations due to cardiovascular illness⁵. Initial public health benefit estimates in CARB's 2021 Initial Statement of Reasons (ISOR) on the HD I&M regulation present cumulative regional and statewide avoided health incidents⁶. CARB's ISOR for the HD I&M uses an incidence per ton (IPT) methodology to estimate avoided health benefits by assigning dollar-values per health incident, as described in Table 2. For the South Coast Air Basin, the cumulative avoided regional health incidents from 2023 through 2050 under the HD I&M regulation are shown in Table 3.

Table 2 – Valuation per Incident for Avoided Health Outcomes

Outcome	Value per Incident (2021\$)
Avoided Premature Cardiopulmonary Mortality	\$10,453,897
Avoided Cardiovascular Hospitalizations	\$61,750
Avoided Acute Respiratory Hospitalizations	\$53,862
Avoided ER Visits	\$848

⁴ [06. HD I-M App D – Emissions Inventory Method and Results \(ca.gov\)](#)

⁵ [Appendix E – Further Details on Health Benefit Modeling Methodology \(ca.gov\)](#)

⁶ [02. HD I-M ISOR \(ca.gov\)](#)

Table 3 – South Coast Avoided Health Incidents from 2023 through 2050 Under the HD I&M*

Air Basin	Cardiopulmonary Mortality	Hospitalizations for Cardiovascular Illness	Hospitalizations for Respiratory Illness	Emergency Room Visits
South Coast	4,278	723	863	2,171

*Since CARB uses the incidence per ton method to estimate avoided health incidents, they did not have to calculate the baseline health impacts.

Though CARB admits that the full scope of health benefits is underestimated in the ISOR⁷, the HD I&M as implemented would result in significant health benefits. For the South Coast Air Basin, nearly 4,300 avoided premature deaths and \$44.8 billion in monetary health benefits overall are achieved between 2023 through 2050; statewide, nearly 8,000 avoided premature deaths and \$75.8 billion in monetary health benefits are achieved from 2023 to 2050.

2.2 Advanced Clean Fleets (ACF) Regulation

In addition to the HD I&M which seeks to reduce emissions from existing diesel and natural gas vehicles, CARB is also pursuing the ACF regulation where fleets would be required to transition to zero emission vehicles (ZEVs). ACF would focus on setting ZEV purchase requirements for public, drayage, and high priority private and federal fleets⁸. Beginning 2024, a large fraction of heavy-duty vehicles operating in California would be subject to the following requirements:

- State and Local Government Fleets:** This piece of the ACF regulation targets Class 2b through 8 public vehicles. In calendar years 2024 through 2026, at least 50% of new public vehicles must be ZEVs, with a 100% purchase requirement starting in 2027.
- Drayage Fleets:** This portion of the ACF regulation looks towards transitioning drayage trucks to ZE at the seaports (i.e., POLA and POLB) and intermodal railyards. Beginning in calendar year 2024, new drayage trucks added to Port registries must be ZE, and all drayage trucks must be ZE by 2035. The ACF regulation notes that legacy drayage trucks (i.e., diesel and natural gas drayage trucks) may enter the Port registry prior to 2024 and operate to the extent of their useful life. These legacy drayage trucks would be required to have model year (MY) 2010 or newer engines, and if entering the San Pedro Bay Ports for the first time, need MY 2014 or newer engines. Regardless, all drayage trucks must be ZE by 2035 – legacy trucks will not be allowed to renew their registration even if they have not reached useful life.
- High Priority and Federal Fleets:** This section of the ACF regulation focuses on large private and federal fleets operating in California. This measure would apply similar drayage fleet requirements to high-priority fleets in California. California heavy-duty truck fleets are considered high-priority if: 1) fleet has 50 or more vehicles, or 2) fleet procures \$50 million in gross annual revenue. Note that trucks part of the International Registration Plan would also be subject to the proposed ACF regulation if they operate in California. The most recent data on the percentage of heavy-duty trucks from high-priority and small and medium fleets by EMFAC2021 category are shown in
- Table 4. Similar to drayage trucks, we assumed that Class 8 trucks reach their useful life within 15 years. This is a conservative assumption, as some of the Class 8 trucks, especially single

⁷ An expansion of emissions inputs and an assessment for other health outcomes, including, but not limited to, additional cardiovascular and respiratory illnesses, nonfatal/fatal cancers, nervous system diseases, and lost workdays would provide a more complete picture of the benefits from reduced exposure to air pollution.

⁸ [draft2022aqmp.pdf \(aqmd.gov\)](#)

unit trucks, may have a useful life of 18 years (up to the 800,000 mileage limit allowed by CARB).

*Table 4 – Total HDT Population by High-Priority and Small and Medium Fleets**

EMFAC2021 Vehicle Category	High-Priority Fleet	Small and Medium Fleet
T7 CAIRP Class 8	43%	57%
T7 NNOOS Class 8	87%	13%
T7 NOOS Class 8	66%	34%
T7 Single Concrete/Transit Mix Class 8	91%	9%
T7 Single Dump Class 8	29%	71%
T7 Single Other Class 8	53%	47%
T7 Tractor Class 8	55%	45%
T7 Utility Class 8	100%	0%
T7IS	36%	64%

* "T7" is an EMFAC2007 vehicle code, the "T" is short for Truck Class. It is a naming convention carried through EMFAC2021.

* CAIRP = California Registered International Registration Plan

* NNOOS = Non-Neighboring Out of State (i.e., a truck from Washington); NOOS = Neighboring Out of State (i.e., a truck from Nevada)

* IS does not stand for anything, it is a "catch-all" for vehicles EMFAC202x describes as "Heavy-Heavy Duty Truck"

The potential of the ACF regulation to help California meet the NAAQS may be understated. This rule is a culmination of efforts to deploy zero-emission trucks everywhere feasible. It is California's prerogative to do what had been done for light-duty vehicles for heavy-duty trucks. However, the acceleration of ZE technology additions in heavy-duty truck fleets will require statewide strategies that get original equipment manufacturers (OEMs), commercial fleet owner-operators, and stakeholders to support each other in the immediate- through long-term. Moreover, the resultant technology mix is a means of addressing California's greatest air quality challenges. Without this kind of major change in heavy-duty truck acquisitions, millions of LA County residents risk living in areas with elevated levels of air pollution (e.g., ozone and DPM), and attainment of upcoming NAAQS in 2031 and 2037 would not be possible⁹. Routine maintenance of diesel-powered trucks by the HD I&M only ensures that trucks do not significantly increase their emissions over time. Thus, policy as fast-paced as the ACF regulation best ensures that critical public and community health needs are met.

CARB has acknowledged that the HD I&M program alone is not sufficient to maximize emission reductions from conventional heavy-duty trucks. As with the HD I&M regulation, initial public health benefit estimates are developed in CARB's Standardized Regulatory Impact Assessment (SRIA) of the ACF regulation, in which cumulative regional and statewide avoided mortality and morbidity incidents are assessed from 2024 through 2050. CARB uses the same IPT methodology used in the HD I&M ISOR for the ACF SRIA, so the dollar-value per health incidents is the same as those in Table 2. In Table 5, cumulative avoided mortality and morbidity incidents for the South Coast Air Basin are summarized from 2024 through 2050. According to CARB's SRIA, the South Coast Air Basin could expect nearly 3,500 avoided mortalities and \$35.9 billion in monetary health benefits between 2023 through 2050; statewide, the ACF regulation would result in nearly 6,000 avoided mortalities and \$61.6 billion monetary health benefits between 2023 through 2050.

⁹ [Executive Officer Memo Regarding Accelerating California's Transition to Zero-Emission Trucks](#)

Table 5 – South Coast Air Basin Avoided Mortality and Morbidity Incidents from 2024 through 2050

Air Basin	Cardiopulmonary Mortality	Hospitalizations for Cardiovascular Illness	Hospitalizations for Respiratory Illness	Emergency Room Visits
South Coast	3,429	592	707	1,721

The proposed ACF regulation will accelerate ZEV adoption in different ways compared to current policies, namely the ACT regulation. The primary element of the ACT regulation requires manufacturers to make phased-in percentages of trucks and buses sold be ZE. The ACT regulation applies to vehicles with a GVWR greater than 8,500 lbs. (Classes 2b through 8) and manufacturers with greater than 500 annual California sales. Increasing the percentage of trucks and buses sold be ZE supports ZEV adoption from the supply side of the market, enabling fleets greater accessibility to increase their ZEV penetration. EMFAC2021 has already been configured to reflect the impact the ACT regulation will have on vehicle populations and emissions, as well as policies such as HD Omnibus and Truck and Bus rule. Whereas the ACT regulation accelerates ZEV adoption through supply, the proposed ACF regulation would accelerate ZEV adoption through the demand side of the market. The proposed ACF regulation would require fleets to introduce more ZEVs onto the roads than the ACT regulation would have done on its own. The proposed ACF regulation language can be applied to EMFAC2021 via conditional formatting to determine changes in ZEV vehicle populations and emissions benefits, as will be described in the following section.

3 Class 8 Heavy-Duty Truck Clean Technology Mix

In order to develop a technology mix consistent with the ACF regulation and assess whether emission reductions can be met, LA County vehicle population and vehicle emissions data from EMFAC2021 are used as baseline fleet conditions, and used to compare against a scenario in which the proposed ACF regulation is applied. Note again that EMFAC2021's baseline conditions reflect the ACT regulation, HD Low NOx Omnibus, Phase 1 and 2 GHG standards, and the Truck and Bus Rule. As such, the results presented in this report reflect the maximum benefits anticipated by existing rules and regulations, as well as the proposed ACF regulation.

To remain consistent with the regulatory language and requirements, EMFAC2021 vehicle categories are mapped to ACF Classifications. Note that EMFAC2021 groups BEVs and FCEVs into a homogenous "Electricity" fuel type. For the infrastructure assessment in Report 4, it is critical to separate battery-electric from hydrogen fuel technologies. **Error! Not a valid bookmark self-reference.** provides ICF's assumptions that are applied to EMFAC2021 baseline data to a) map EMFAC2021 categories to the Classification used in ACF and in this report, and b) separate battery electric from hydrogen fuel cell trucks. These assumptions are largely based on where the project team likely will see hydrogen to be deployed. Recall that state and local government, drayage, and priority fleets each have unique purchase and registration requirements (see Section 2.2). This analysis applies the ACF regulation to an EMFAC2021 run for LA County through conditional formatting to produce the baseline and ACF scenario charts in subsequent sections.

Table 6 – Alignment of EMFAC2021 Vehicle Categories to ACF Classification

EMFAC2021 Vehicle Category	ACF Vehicle Class	ACF Classification	Battery	H2
T7 CAIRP Class 8	CAIRP Interstate	Priority / Federal	50%	50%
T7 NNOOS Class 8	Out of State	Priority / Federal	50%	50%
T7 NOOS Class 8	Out of State	Priority / Federal	50%	50%
T7 POAK Class 8	Drayage	Drayage	90%	10%
T7 POLA Class 8	Drayage	Drayage	90%	10%
T7 Public Class 8	Single Unit	State and Local	100%	0%
T7 Single Concrete/Transit Mix Class 8	Single Unit	Priority / Federal	100%	0%
T7 Single Dump Class 8	Single Unit	Priority / Federal	100%	0%
T7 Single Other Class 8	Single Unit	Priority / Federal	100%	0%
T7 SWCV Class 8	Single Unit	State and Local	100%	0%
T7 Tractor Class 8	CAIRP Intrastate	Priority / Federal	90%	10%
T7 Utility Class 8	Single Unit	State and Local	100%	0%
T7IS	Single Unit	State and Local	100%	0%

3.1 Drayage Fleet Technology Mix

The baseline EMFAC2021 drayage fleet population in LA County by fuel type is shown in Figure 1, showing that nearly all drayage trucks in the Ports and intermodal railyards operate on diesel fuel, though by 2040 the projected electric (BEV and FCEV combined in EMFAC2021) drayage truck population reaches 11% of total drayage trucks in LA County because of the ACT regulation.

As expected, the ACF regulation would dramatically alter the technology mix, as shown in Figure 2. Note that the “Electricity” category now allocates a 90% battery and 10% hydrogen mix when new vehicles are added (as shown in In order to develop a technology mix consistent with the ACF regulation and assess whether emission reductions can be met, LA County vehicle population and vehicle emissions data from EMFAC2021 are used as baseline fleet conditions, and used to compare against a scenario in which the proposed ACF regulation is applied. Note again that EMFAC2021’s baseline conditions reflect the ACT regulation, HD Low NOx Omnibus, Phase 1 and 2 GHG standards, and the Truck and Bus Rule. As such, the results presented in this report reflect the maximum benefits anticipated by existing rules and regulations, as well as the proposed ACF regulation.

To remain consistent with the regulatory language and requirements, EMFAC2021 vehicle categories are mapped to ACF Classifications. Note that EMFAC2021 groups BEVs and FCEVs into a homogenous “Electricity” fuel type. For the infrastructure assessment in Report 4, it is critical to separate battery-electric from hydrogen fuel technologies. **Error! Not a valid bookmark self-reference.** provides ICF’s assumptions that are applied to EMFAC2021 baseline data to a) map EMFAC2021 categories to the Classification used in ACF and in this report, and b) separate battery electric from hydrogen fuel cell trucks. These assumptions are largely based on where the project team likely will see hydrogen to be deployed. Recall that state and local government, drayage, and priority fleets each have unique purchase and registration requirements (see Section 2.2). This analysis applies the ACF regulation to an EMFAC2021 run for LA County through conditional formatting to produce the baseline and ACF scenario charts in subsequent sections.

Table 6). Acquisition of diesel and natural gas trucks begin to taper off at the start of 2024, but any conventional drayage trucks registered at the Ports will be allowed to operate to useful life or until 2035 when all non-ZEV trucks will be removed from the CARB Drayage Truck Registry.

Figure 1 – Baseline Drayage Fleet Population

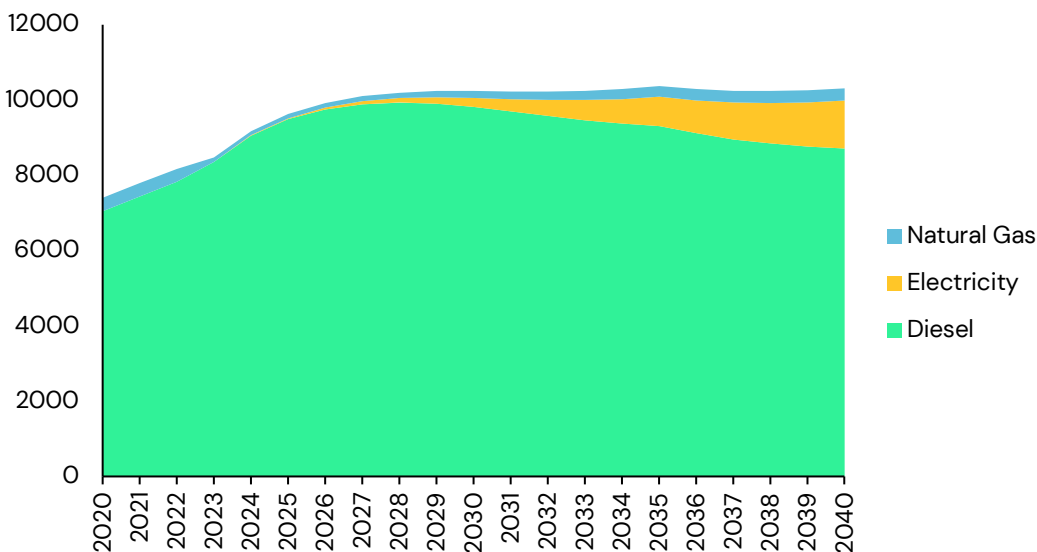
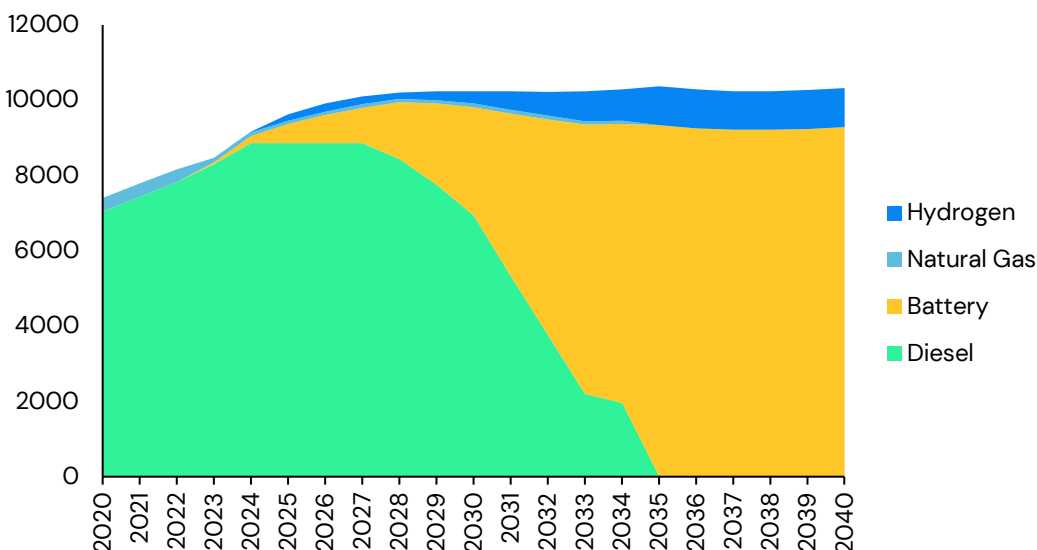


Figure 2 – Drayage Fleet Population with ACF



3.2 State and Local Fleet Technology Mix

The baseline state and local public fleet population by fuel type is shown in Figure 3. For state and local public fleets, it is projected that 48% and 27% of vehicles will be natural gas and electricity (BEV and FCEV combined in EMFAC2021), compared to 24% diesel in 2040. The high fraction of natural gas trucks in public fleets in LA County is due to South Coast AQMD's Rule 1196, which requires public fleets operating heavy-duty vehicles in the South Coast AQMD's jurisdiction to acquire alternative-fuel, dual-fuel, or dedicated gasoline heavy-duty vehicles when procuring or leasing vehicles for use within the jurisdiction. As a result, most public fleets in LA County already shifted to natural gas trucks. The impact of the ACF regulation on public fleets is charted in Figure 4, where the BEV population

balloons to 57% of the total state and local fleet population. Of course, this would mean that new BEV additions cut into new diesel and natural-gas additions. Note that the ACF regulation does not accelerate turnover of conventional diesel or natural-gas vehicles within public fleets.

Figure 3 – Baseline State and Local Fleet Population

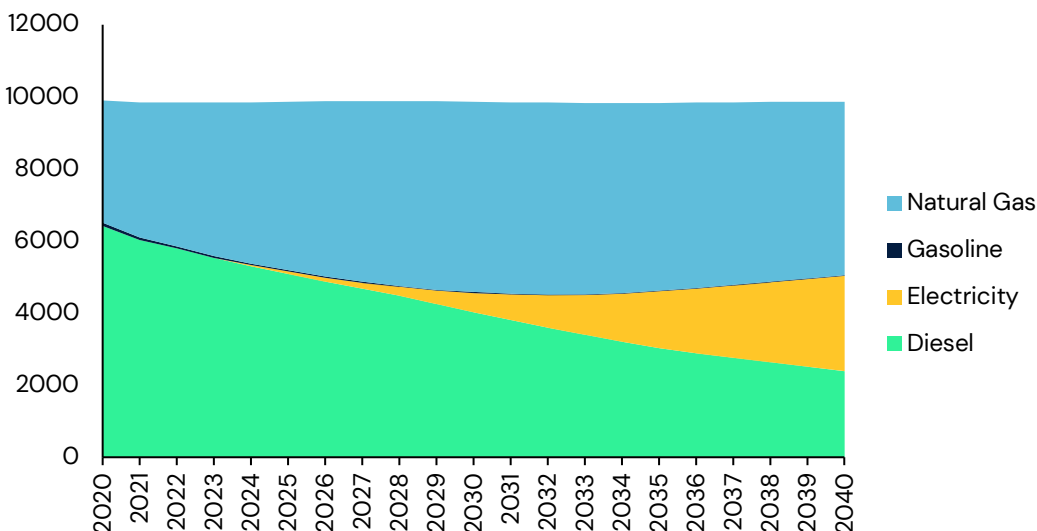
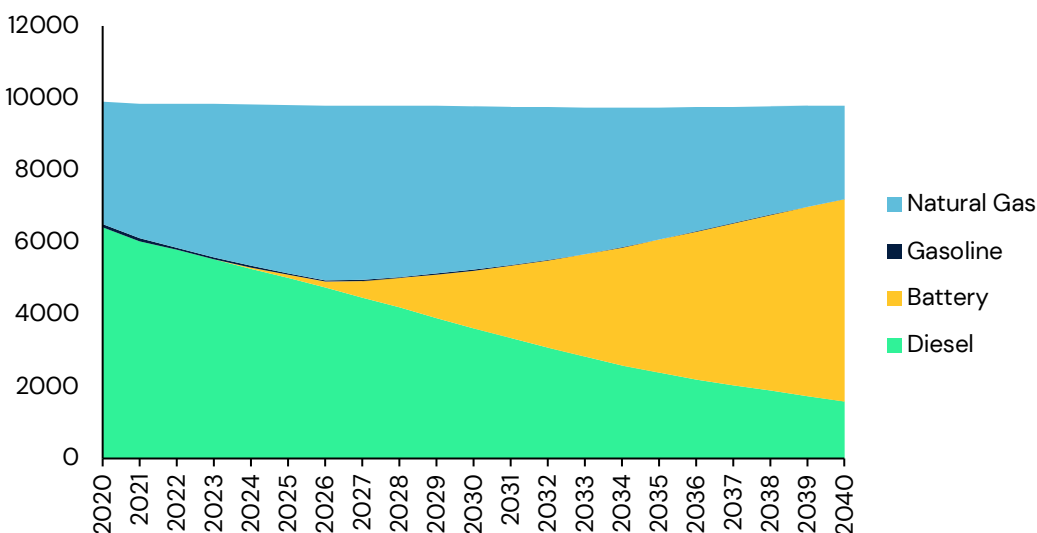


Figure 4 – State and Local Fleet Population with ACF



3.3 High-Priority and Federal Fleet Technology Mix

3.3.1 High-Priority/Federal Fleets

The baseline high-priority/federal (as defined on Page 8) truck fleet population is assessed separately from the small and medium truck fleet population. Figure 5 showcases high-priority/federal truck fleets by fuel type. As a result of the ACT regulation, EMFAC2021 projects that 14% of the high-priority/federal truck fleet population would be ZE by 2040. This shift is much more pronounced in the wake of the ACF regulation, as shown in Figure 7. Per the ACF regulation, the operation of diesel trucks begins to sunset in 2024 (i.e., no further additions of diesel or natural gas trucks), to make way for nearly 30,000 battery-electric and 9,000 hydrogen fuel cell local and long-haul trucks in LA County.

Figure 5 – Baseline High-Priority/Federal Fleet Population

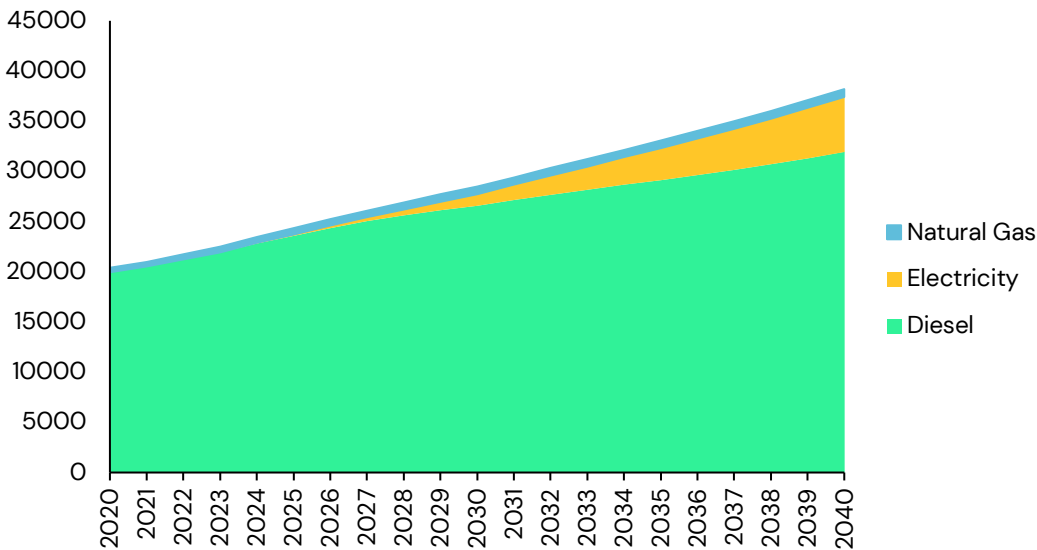
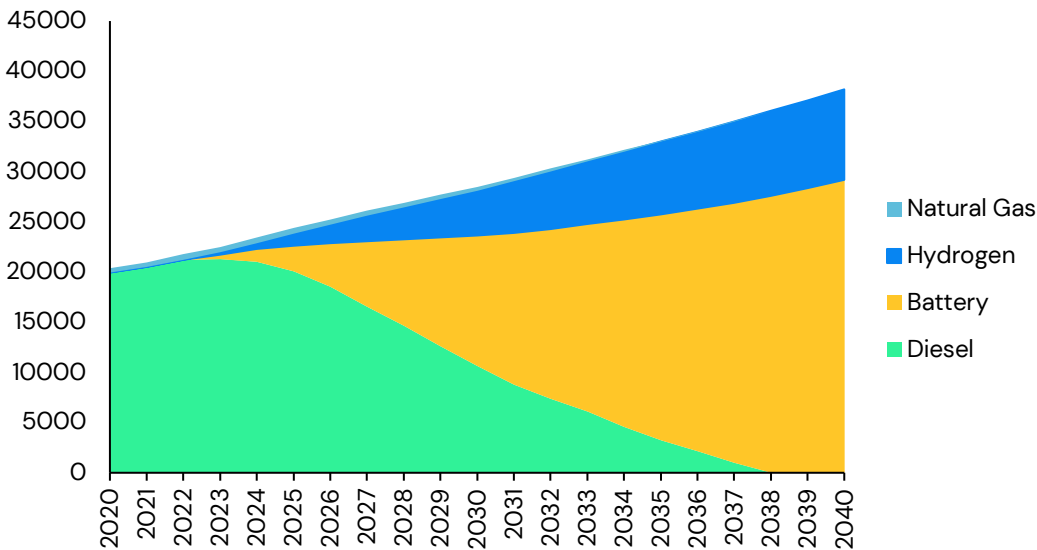


Figure 6 – High-Priority/Federal Fleet Population with ACF



3.3.2 Small & Medium Fleets

e) Based on the data provided in

Table 4, a separate assessment was performed for the remaining small and medium size fleets that do not fall under the ACF regulation, as visualized in Figure 7. With some of the small and medium fleets being excluded from the ACF regulation, their transition to ZETs will be solely bounded by the sales requirements from the ACT regulation. To maximize the DPM reduction, we considered a scenario where pre-2024 MY diesel trucks within small and medium fleets will be transitioning to low NOx natural gas trucks as they reach their useful life. This analysis proposes that beginning in 2024, pre-2024 MY diesel trucks 15 years and older shall be replaced with ultra-low NOx natural gas trucks powered by renewable natural gas (RNG), accelerate turnover of older diesel truck technology (i.e., MY 2010 certified diesel engines) and replace diesel trucks with commercially available clean trucks for some LA County independent fleet owner-operators.

Figure 8 shows the resultant small and medium fleet population after introducing low-NOx natural gas replacements for end-of-life diesel trucks is shown. While there are no regulatory actions to require such transition, state and local incentive programs (e.g., Carl Moyer, AB 617, Community Air Protection Program) as well as upcoming South Coast AQMD WAIRE Program will encourage small fleets (i.e., small and medium) to take advantage of available funding and contribute to near term emission reductions in LA County.

Figure 7 – Baseline Small and Medium Fleet Population

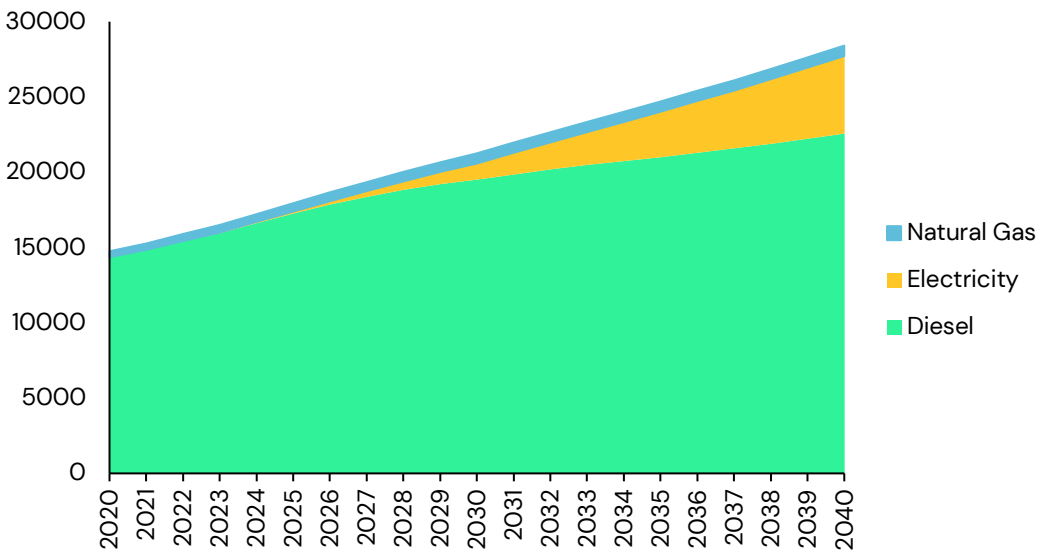
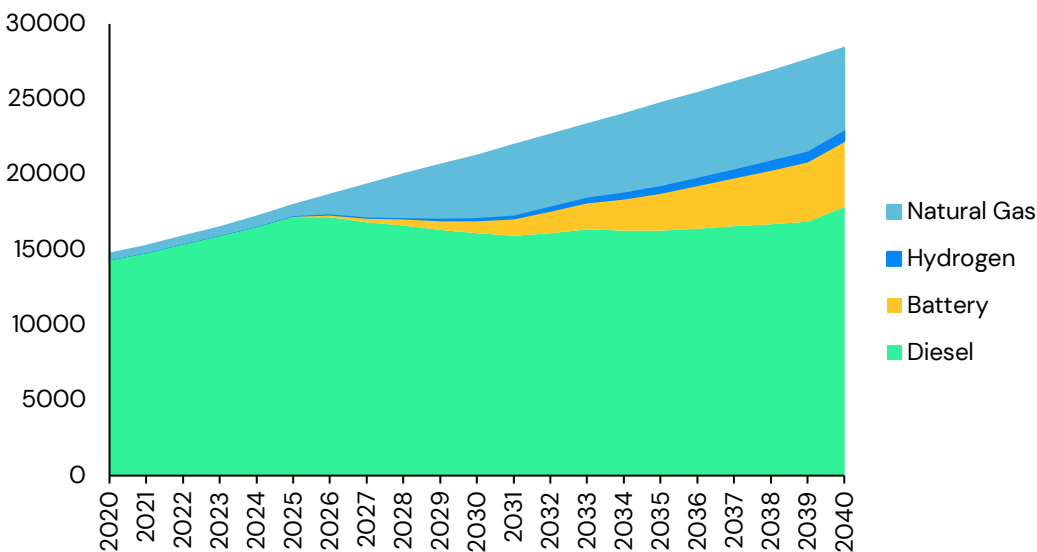


Figure 8 – Small and Medium Fleet Population with Low NOx RNG Truck Scenario



3.4 Overall Mix

The analysis performed in this report aligns EMFAC2021 vehicle categories with vehicle classifications identified in the ACF regulation, as shown in In order to develop a technology mix consistent with the ACF regulation and assess whether emission reductions can be met, LA County vehicle population and vehicle emissions data from EMFAC2021 are used as baseline fleet conditions, and used to compare against a scenario in which the proposed ACF regulation is applied. Note again that EMFAC2021's

baseline conditions reflect the ACT regulation, HD Low NOx Omnibus, Phase 1 and 2 GHG standards, and the Truck and Bus Rule. As such, the results presented in this report reflect the maximum benefits anticipated by existing rules and regulations, as well as the proposed ACF regulation.

To remain consistent with the regulatory language and requirements, EMFAC2021 vehicle categories are mapped to ACF Classifications. Note that EMFAC2021 groups BEVs and FCEVs into a homogenous “Electricity” fuel type. For the infrastructure assessment in Report 4, it is critical to separate battery-electric from hydrogen fuel technologies. **Error! Not a valid bookmark self-reference.** provides ICF’s assumptions that are applied to EMFAC2021 baseline data to a) map EMFAC2021 categories to the Classification used in ACF and in this report, and b) separate battery electric from hydrogen fuel cell trucks. These assumptions are largely based on where the project team likely will see hydrogen to be deployed. Recall that state and local government, drayage, and priority fleets each have unique purchase and registration requirements (see Section 2.2). This analysis applies the ACF regulation to an EMFAC2021 run for LA County through conditional formatting to produce the baseline and ACF scenario charts in subsequent sections.

Table 6. However, to better align this work's results with language used in Reports 1 and 4, additional graphic visualizations describing Single Unit, CAIRP Interstate, CAIRP Intrastate, and Out of State truck populations have been included in Appendix¹⁰. For a high-level assessment of all truck categories combined, the total baseline and ACF scenario populations are shown in Figure 9 and Figure 10, respectively.

Figure 9 – Baseline Class 8 Truck Population in LA County

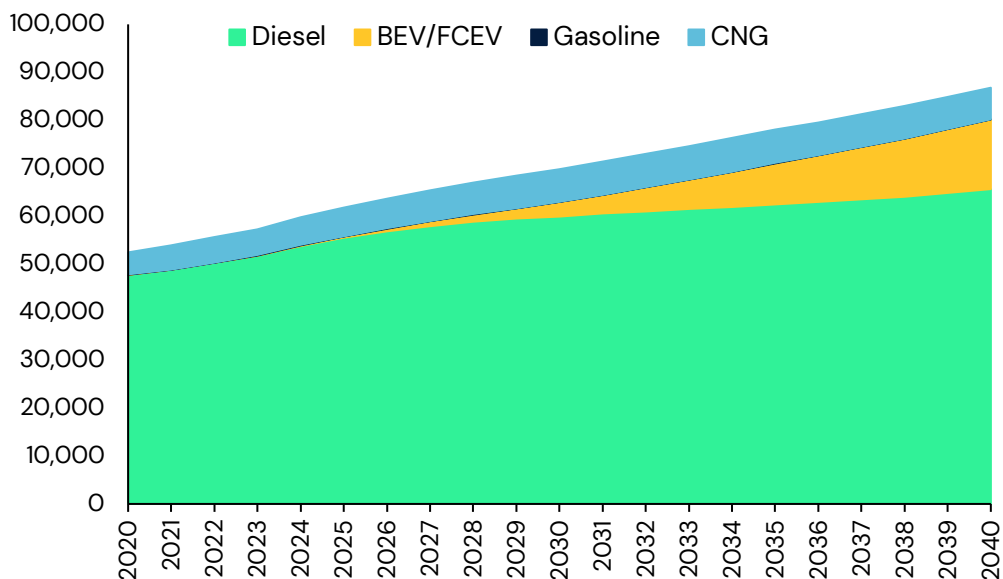
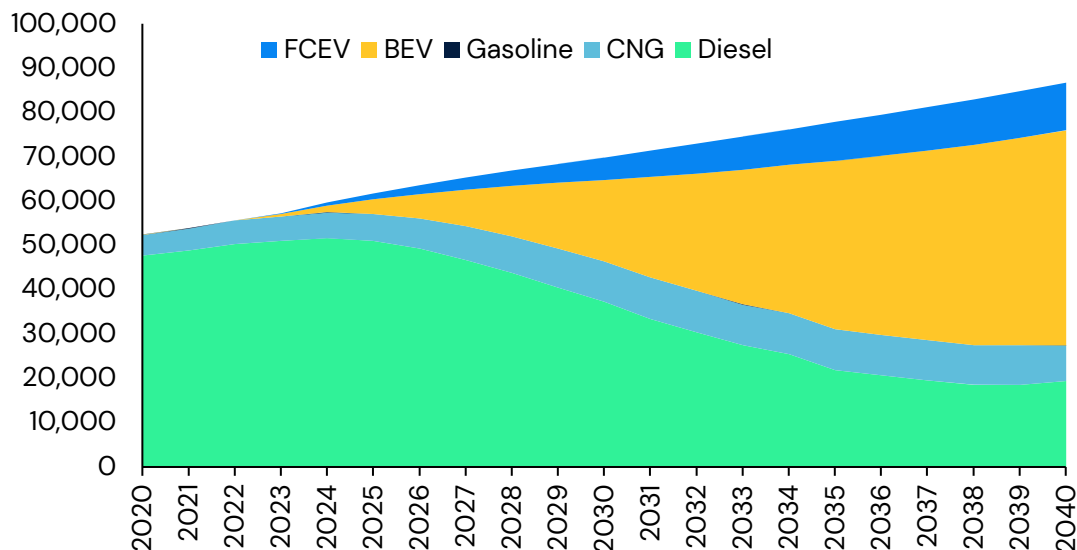


Figure 10 – Class 8 Truck Population with ACF Regulation



¹⁰ A chart for drayage trucks is not produced in this section because it would be identical to Figure 2.

Table 7 – Summary of Overall Technology Mix

Scenario	Fuel Technology	2022	2025	2030	2035	2040
Baseline	Diesel	50253	55408	59893	62463	65592
	CNG	5310	5978	6842	6938	6596
	Gasoline	63	38	20	14	12
	“Electricity”	-	360	3013	8539	14545
with ACF	Diesel	50246	51040	37241	21892	19408
	CNG	5310	6000	9078	9179	7997
	Gasoline	63	38	18	10	6
	BEV	6	3259	18331	37988	48477
	FCEV	1	1386	5006	8793	10777

*Note: EMFAC2021 uses the “Electricity” category to lump BEVs and FCEVs together. The project team defines BEV and FCEV percent allocations for the ACF regulation scenario in Table 5.

4 Modeling Emissions Reductions

With the technology mix resulting from the ACF regulation as well as adjustments to small and medium fleets, ICF modeled emission reductions to determine whether proposed state policies will be enough to meet air quality and climate needs. The assessment focuses on the prospective impacts of the HD I&M and ACF regulation as well as accelerated turnover of small and medium fleets to ultra-low NOx natural gas and compares adjusted emissions trajectories to the baseline from EMFAC2021.

The HD I&M regulation is written to facilitate NOx and DPM emission reductions through physical emission inspections. To best capture the impact of the HD I&M, the scenario is prepared using the most recent analysis from CARB. In CARB’s analysis, NOx and DPM emissions for heavy-duty diesel trucks in LA County are simulated in alignment with the public hearing scenario from December 2021¹¹. The ratio of total NOx and DPM exhaust emissions post-HD I&M regulation to the baseline exhaust emissions are calculated to create scaling factors used in for modeling emission reductions in this project.

Next, emission reductions due to the proposed ACF regulation are calculated. This analysis follows CARB’s consensus that the ACF regulation will fill in the gaps of the HD I&M regulation. Thus, emission reductions from the ACF regulation are calculated on top of those from the HD I&M regulation, so as not to draw the comparison to the original baseline emissions. In this work, emission reductions are assumed proportional to decreases in the diesel truck population.

Finally, emission reduction targets consistent with the LA Metro SSP, South Coast AQMD CERP and South Coast AQMD AQMP are calculated and tacked onto emission projections between 2020

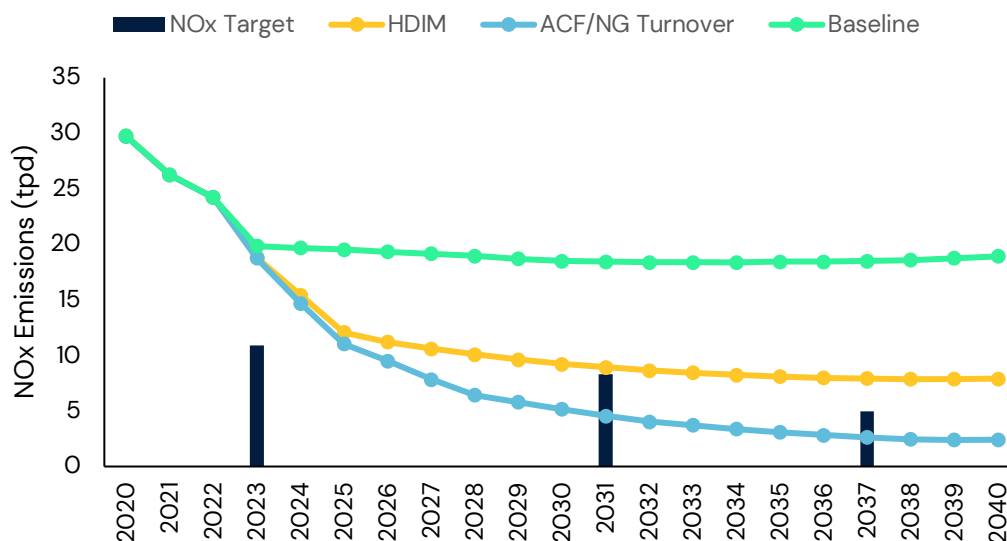
¹¹ These results are subject to change as of May 23, 2022.

through 2040, to indicate how close the HD I&M and ACF regulations bring LA County into attainment of NAAQS.

4.1 Resultant NOx Emissions in Regulatory Scenarios

The baseline and scenario NOx emission projections developed in this analysis are presented in Figure 11. The results in the immediate term are sobering. It is not possible to meet NOx reductions needed by 2023. Even considering the aggressive approach of the ACF regulation, an immediate 45% reduction in NOx emissions would be required to reach the levels needed in 2023. Considering that 2023 is just a year ahead, it would be unrealistic to assume any significant technology transformation that would result in 45% NOx emission reductions.

Figure 11 – Comparison of Baseline NOx Emissions to Regulatory Scenarios and NOx Targets

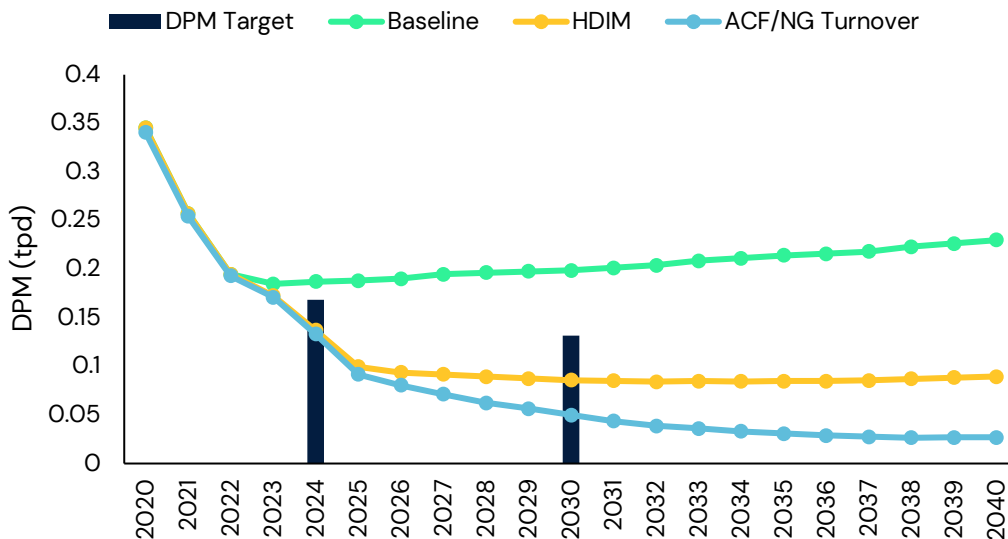


This shortcoming in the 2023 NOx emission reduction target should not dissuade air quality agencies or stakeholders, but rather embolden them for greater changes in the mid- through long-term. According to our assessment, the HD I&M regulation will result in 51% reductions in 2031 and 57% reductions in 2037. The ACF regulation and accelerated turnover of small and medium fleets result in 76% reductions from the 2031 baseline and 87% reductions from the 2037 baseline. By calendar year 2040, NOx emissions from Class 8 trucks in LA County would be as low as 2.5 tons per day, nearly 10 times smaller than baseline emissions in the same year.

4.2 Resultant DPM Emissions in Regulatory Scenarios

The baseline and scenario DPM emission projections developed in this analysis are presented in Figure 12. Unlike the results on NOx emission reductions in the immediate term, both the HD I&M and ACF regulations are expected to exceed DPM targets in 2024 and 2030.

Figure 12 – Comparison of Baseline DPM Emissions to Regulatory Scenarios and DPM Targets



In 2024, The HD I&M and ACF regulations are expected to reduce DPM emissions by 26% and 29% from baseline conditions, respectively. The trajectories of the HD I&M and ACF for DPM emission reductions begin to diverge after 2025. By 2030, the HD I&M and ACF regulations exceed the LA Metro SSP DPM emission reduction target of 62% from 2018 baseline, decreasing baseline emissions by 75% and 85%, respectively. From thereon, DPM emissions are expected to continue decreasing under ACF.

4.3 Resultant GHG Emissions

Although HD I&M program only impacts the criteria pollutants, the penetration of ZE technology resulting from the ACF regulation as well as the ICF's assumptions for accelerated turnover of small and medium fleets to RNG trucks will provide significant GHG reductions¹², as illustrated in Figure 13.

¹² When substituting old diesel trucks for ultra-low NOx natural gas trucks, the same CO₂ emissions as their diesel counterpart are included in the GHGs calculations. Thus, these GHG emissions are representative of tailpipe emissions and do not consider upstream emissions.

Figure 13 – Comparison of Baseline GHGs to Regulatory Scenario

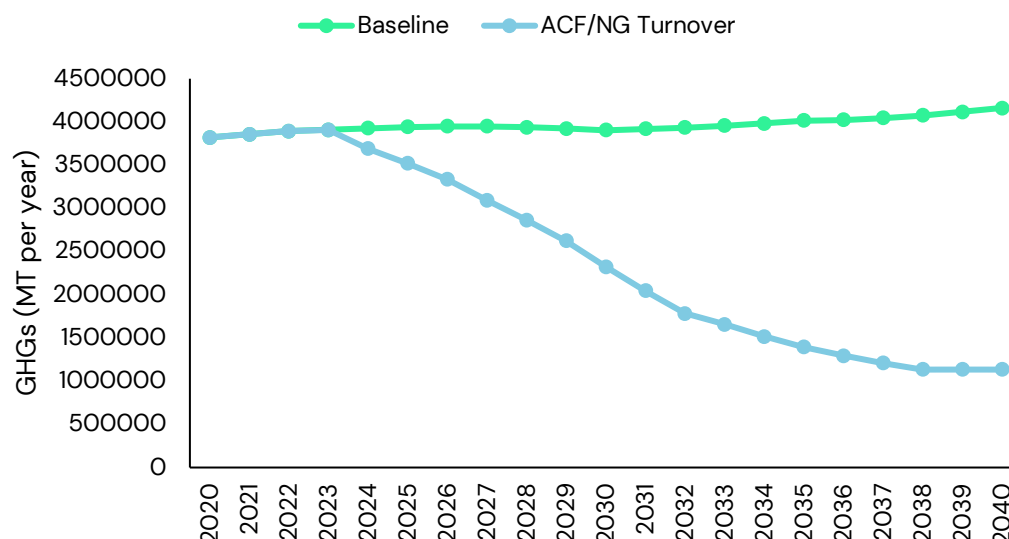


Figure 13 shows the resultant GHG emissions with the ACF regulation. As shown, by 2030, the ACF regulation is projected to decrease GHG emissions by 39% from 2020 levels, close to California’s GHG target established under SB 32.

The social benefits of reducing CO₂ can be estimated using the Social Cost of CO₂ (SC-CO₂), which provides a dollar valuation of the damages caused by one ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future. CARB’s ACF SRIA develops an estimate for statewide GHG emissions reductions benefits using the SC-CO₂¹³. The valuation comes from avoided damages – those damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO₂ emissions today will affect economic outcomes throughout the next several centuries¹⁴. The SC-CO₂ is year-specific and highly sensitive to the discount rate used to discount the value of the damages in the future due to CO₂. In their analysis, CARB uses the same SC-CO₂ values used by the Interagency Working Group (IWG). CARB adjusts the IWG SC-CO₂ values using the California consumer price index better account for the social costs of actions taken to reduce GHG emissions in California. The SC-CO₂ increases over time as systems become more stressed from the aggregate impacts of climate change and as future emissions cause incrementally larger damages. In CARB’s SRIA for the ACF regulation, avoided SC-CO₂ are estimated statewide using discount rates between 2.5% through 5% to represent varying valuation of future damages.

To estimate the SC-CO₂ for LA County based on GHG reductions from the ACF regulation and natural gas truck turnover, scaling factors are derived from CARB’s SRIA avoided SC-CO₂ analysis. These scaling factors are annual dollars per metric ton of GHGs between 2024 through 2050, so that multiplying by cumulative GHG reductions in LA County from 2024 through 2050 yields the avoided SC-CO₂. In Table 8, ICF calculated the avoided SC-CO₂ depending on the chosen discount rate based on GHG reductions for LA County. Figure 14 shows the avoided SC-CO₂ to emphasize the difference between varying valuations of future damages.

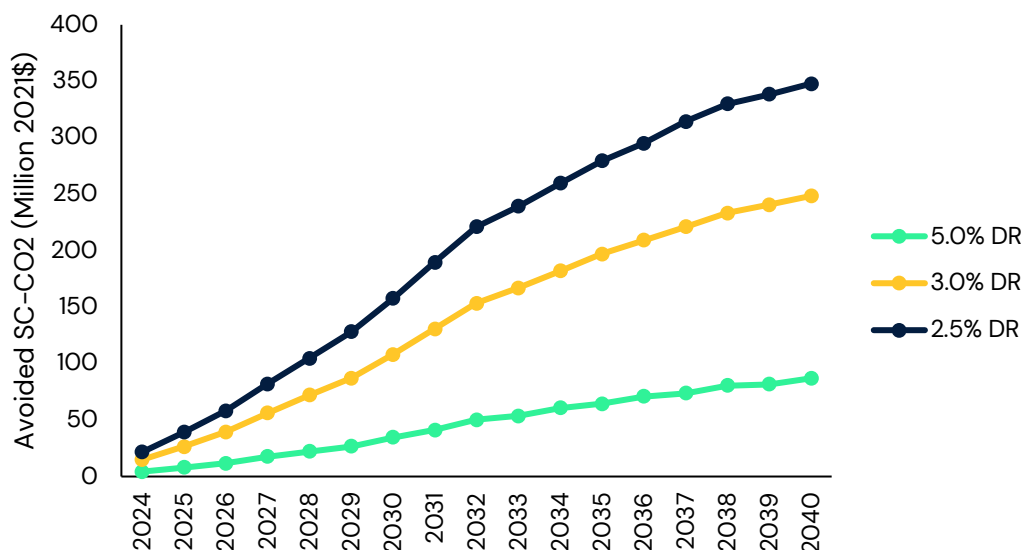
¹³ https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/ARB-ACF-SRIA_2022-05-18.pdf

¹⁴ National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of Carbon Dioxide, 2017 (web link: <http://www.nap.edu/24651>)

Table 8 – Avoided SC-CO2 for LA County (Million 2021\$)

Year	GHG Reductions (MMT per year)	Avoided SC-CO2 5.0% Discount Rate	Avoided SC-CO2 3.0% Discount Rate	Avoided SC-CO2 2.5% Discount Rate
2024	0.2	4.3	14.8	21.5
2025	0.4	8.0	26.5	39.1
2026	0.6	11.8	39.5	58.0
2027	0.9	17.5	56.2	81.9
2028	1.1	22.1	72.0	104.4
2029	1.3	26.7	87.1	128.0
2030	1.6	34.6	108.0	157.6
2031	1.9	41.0	130.6	189.5
2032	2.2	50.1	153.2	220.9
2033	2.3	53.5	166.7	239.1
2034	2.5	60.7	182.0	259.5
2035	2.6	64.5	197.0	279.4
2036	2.7	70.9	208.9	294.8
2037	2.8	73.7	221.0	314.1
2038	2.9	80.4	233.3	329.8
2039	3.0	81.5	240.5	338.3
2040	3.0	86.9	248.3	347.7
Total	32.0	788.0	2385.5	3403.5

Figure 14 – Avoided SC-CO₂ for LA County (Million 2021\$)



For LA County, the benefits of GHG reductions as a result of applying the ACF regulation and natural gas truck turnover range from approximately \$788 million to \$3.4 billion through 2040, depending on the chosen discount rate (see Table 8 or Figure 14). It is important to note that the SC-CO₂, while intended to be a comprehensive estimate of the damage caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. The SC-CO₂ values used here and in CARB’s SRIA are likely underestimated due to the omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts. Even so, the prospective avoided SC-CO₂ from the ACF regulation as proposed is noteworthy and will be explored further in subsequent reports.

5 Summary

This report presented the changes to Class 8 heavy-duty truck fleet mix in the South Coast Air Basin due to existing and proposed regulations, and broadly discussed resulting benefits on regional air quality, local public health and climate goals. Heavy-duty truck fleet modeling is conducted using EMFAC2021 data, as well as upcoming policies, to determine the technology mix required to meet NO_x, DPM, and GHG targets. These air quality and climate targets are in accordance with statewide air quality plans and written law, such as the 2022 South Coast AQMD AQMP and the California Global Warming Solutions Act. In this report, the HD I&M and ACF regulations are discussed at length with special interest, the former to begin in 2024 and the latter soon-to-be adopted regulation to begin in the same year. Each of these regulations seek to take inventory of active heavy-duty truck fleet populations, and approach emission control strategies in different ways. Whereas the HD I&M regulation is adopting physical inspection to ensure proper maintenance and operation of emission control systems, the ACF regulation seeks to make sweeping changes through aggressive ZE truck penetration requirements, completely changing truck demographics and energy requirements within the next two decades. This report focuses on modeling these ZEV requirements due to the ACF regulation and assesses the resultant emission reductions following successful implementations of the HD I&M and ACF regulation. The results indicate that ZEV requirements set by the ACF meet nearly all emission reductions targets, and in some cases, significantly exceed the targets. In the next report, the project team will shed light on charging and fueling infrastructure needs to support these ZEVs.

Key Take Aways

- Significant NOx emission reductions through ZE and NZE technologies will also substantially reduce DPM and GHG emissions.
- The HD I&M and ACF are important considerations in the development of heavy-duty truck fleet technology mixes. These two regulations will ensure that critical public and community health needs are met for millions in LA County. According to CARB's health benefit assessment, these two regulations combined will result in reduction of more than 7,700 cardiopulmonary mortalities, 1,300 hospitalizations for cardiovascular illness, 1,570 hospitalizations for respiratory illness, and 3,900 ER visits in the South Coast Air Basin¹⁵.
- The overall heavy-duty truck technology mix resulting from the adoption of ACF will substitute tens of thousands of diesel-fuel vehicles for battery-electric and hydrogen fuel cell electric vehicles between 2024 and 2040. By 2040, over 68% of the active Class 8 heavy-duty truck population on LA County's roads will be ZE. This corresponds to approximately 48,000 battery-electric trucks and 11,000 hydrogen fuel cell electric trucks that will need adequate infrastructure to sustain goods movement, without harmful tailpipe emissions.
- The projected technology mix will not bring LA County into attainment of the 2023 NOx emission reduction target, however, the HDI&M and ACF regulations will meet subsequent NOx and DPM emission reduction targets upon successful implementation.
- While the ACF and HD I&M will establish requirements for fleets operating in California to maintain their diesel fleet and transition them to ZE technology, successful adoption of this regulation will rely on the buildout of ZE infrastructure (e.g., charging and hydrogen fueling infrastructure) as well as financial assistance to fleets that cannot bear the cost of repairing their fleets (to meet HD I&M) or transitioning to ZE technologies. This year, the state has allocated significant amount of funding toward ZETs and infrastructure. While these funds will serve as a catalyst early in the market adoption of these trucks, funding assistance at a local level will be necessary to keep the truckers in business and help transition to cleaner and more sustainable technologies.

¹⁵ https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/ARB-ACF-SRIA_2022-05-18.pdf

Appendix A

Figure A-1 – Single Unit Truck Population with ACF (State and Local, and Priority/Federal)

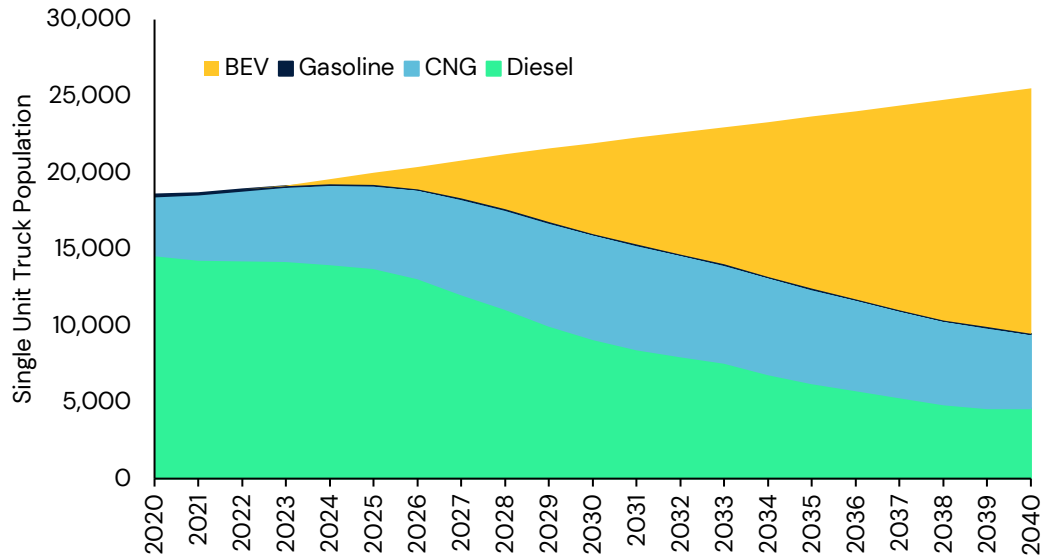


Figure A-2 – CAIRP Intrastate Truck Population with ACF (Priority/Federal)

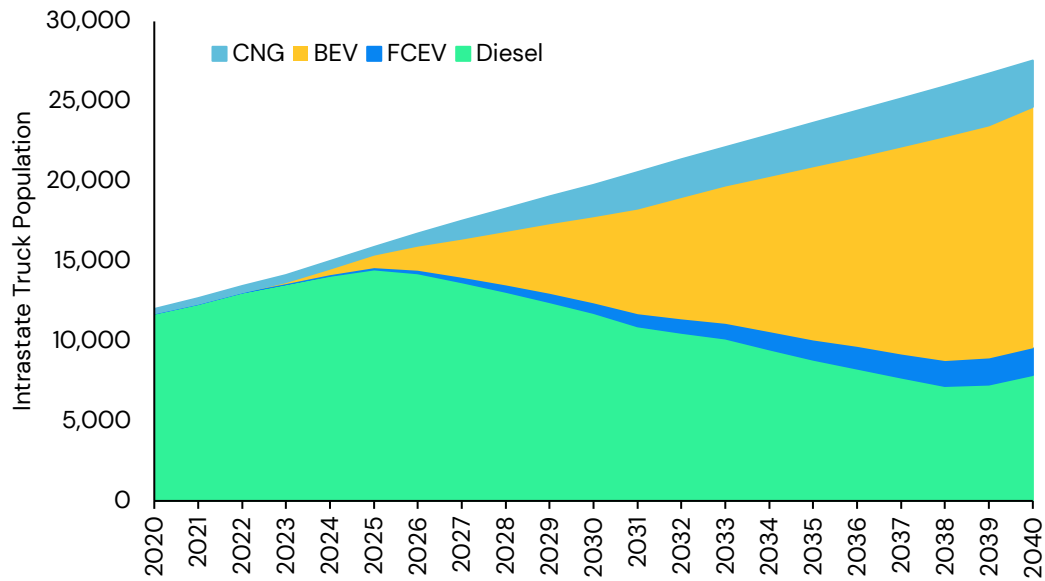


Figure A-3 – CAIRP Interstate Truck Population with ACF (Priority/Federal)

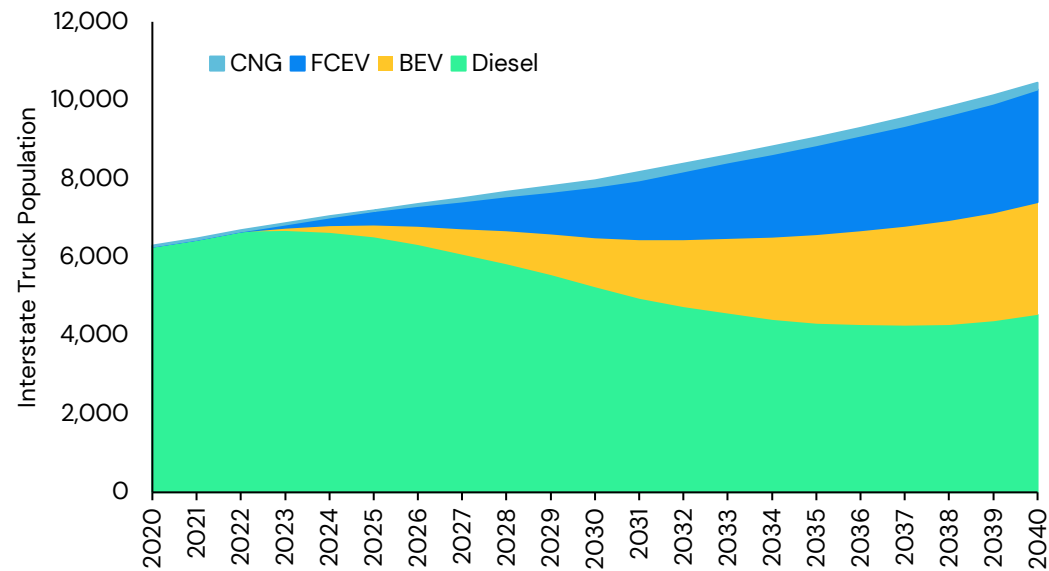


Figure A-4 – Out of State Truck Population with ACF (Priority/Federal)

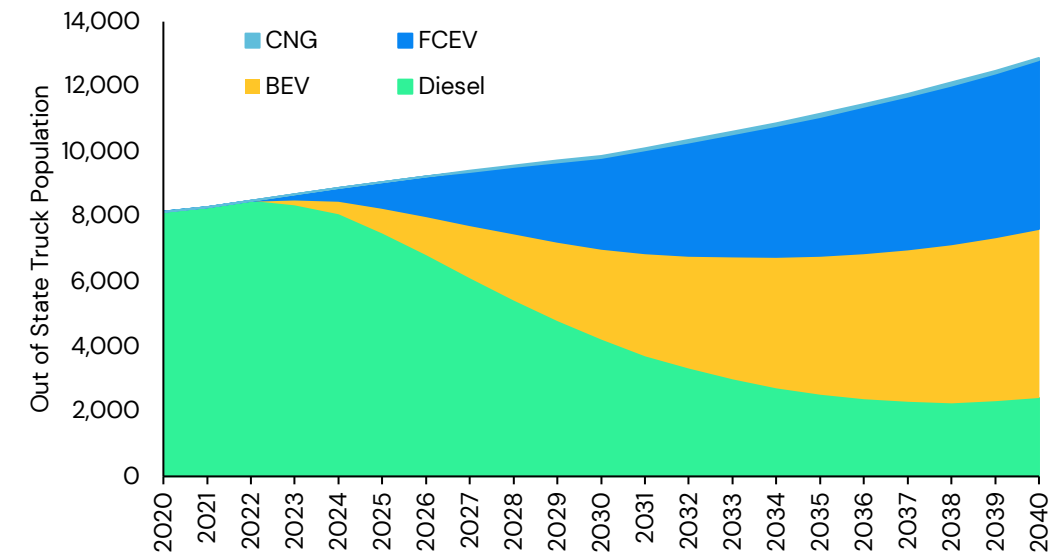


Figure B-5 – NO_x and PM Emissions (tpd) in SC Air Basin under the Legal Baseline, Proposed Regulation, and Alternatives⁴

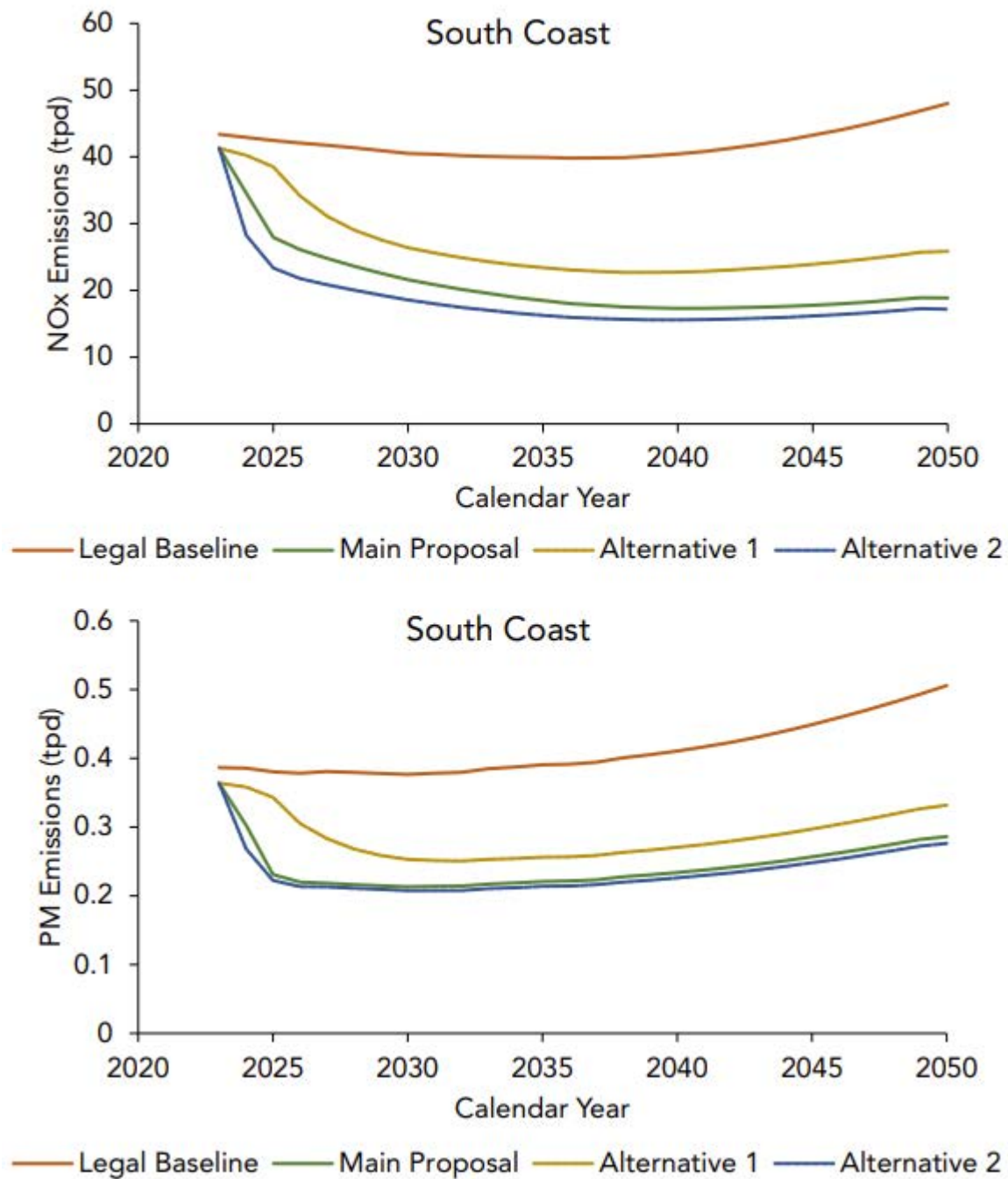


Figure C-6 – NO_x and PM Emissions (tpd) in SJV Air Basin under the Legal Baseline, Proposed Regulation, and Alternatives⁴

