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Mobile Source Strategy

California Environmental Protection Agency

Air Resources Board

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Preface

In September 2015, ARB staff published the Mobile Source Strategy Discussion Draft, which introduced a comprehensive strategy to reduce emissions from mobile sources to meet critical air quality and climate goals over the next fifteen years. The discussion draft provided a coordinated framework supporting multiple planning efforts currently underway.

Subsequent to publication, ARB staff held a public workshop and provided the Board an informational briefing on the strategy. Both the workshop and the Board meeting provided the public opportunities to comment on the strategy and proposed measures.[1] The public process for individual planning efforts has also continued over the last six months. Workshops for the Scoping Plan Update were initiated in October 2015, and ARB expects to release a concept paper in May 2016. In early 2016, staff updated the Board on the planning efforts of several State agencies to develop a California Sustainable Freight Action Plan, with a draft published on May 3, 2016.[2] A revised Short Lived Climate Pollutant Strategy was published on April 11, 2016.[3] Additionally, on May 17, 2016 staff released the Proposed 2016 Strategy for the State Implementation Plan (State SIP Strategy)[4]. While each of the individual planning efforts incorporate and expand upon various elements of the mobile source strategy, ARB has updated the strategy to continue to provide an integrated planning perspective and common vision for transforming the mobile sector.

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[1] Public comments are available at: http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_ddcomments.pdf
[2] May 2016 Draft California Sustainable Freight Action Plan available at: http://www.casustainablefreight.org/files/managed/Document/175/CSFAP_Main%20Document_DRAFT_050216%20v2.pdf
[3] Proposed Short Lived Climate Pollutant Reduction Strategy available at: http://www.arb.ca.gov/cc/shortlived/meetings/04112016/proposedstrategy.pdf
[4] State SIP Strategy available at: http://www.arb.ca.gov/planning/sip/2016sip/2016sip.htm

Progress on these planning efforts has continued to shape staff's approach on the scope of actions and appropriate policy and programmatic mechanisms needed to implement the overall strategy. ARB has also continued to work closely with state agencies, air districts, including the South Coast and San Joaquin Valley, and other stakeholders. As part of this update, ARB staff has developed the initial measure concepts into full measure descriptions, incorporated air quality modeling and inventory data which have been updated as part of the SIP development process, and included an assessment of the costs and economic impacts of the strategy. Other specific updates include:

- Refinements to assumptions regarding the use of natural gas and diesel fuel in heavy-duty trucks, based on availability and infrastructure requirements in various truck vocations and vehicle classes.

- Expanded discussion of the role slowing growth in passenger vehicle miles travelled plays in meeting California's goals.

- Expanded analysis and discussion of the role of zero-emission technologies in the heavy-duty on-road sector.

- Revisions to the Advanced Clean Transit measure to reflect a broader programmatic approach to continue to transition transit fleets to cleaner technologies.

- Refinements to the phase-in assumptions for the Last Mile Delivery measure to better reflect timing for introduction of zero-emission technology.

- Revisions to the proposed approach for achieving further reductions from new and re-manufactured locomotives, the potential for zero-emission technologies, and enhanced control effectiveness.

Executive Summary

Over the next fifteen years, California will need to build upon its successful efforts to meet critical air quality and climate goals. These include:

- Attaining federal health-based air quality standards for ozone in 2023 and 2031 in the South Coast and San Joaquin Valley, and fine particulate matter (PM2.5) standards in the next decade;
- Achieving greenhouse gas (GHG) emission reduction targets of 40 percent below 1990 levels by 2030, with continued progress towards an 80 percent reduction by 2050;
- Minimizing health risk from exposure to toxic air contaminants;
- Reducing our petroleum use by up to 50 percent by 2030; and
- Increasing energy efficiency and deriving 50 percent of our electricity from renewable sources by 2030.

Achieving these complementary goals will provide much needed public health protection for the millions of Californians that still breathe unhealthy air, and reduce exposure to air toxics in disadvantaged communities, especially in light of new information regarding the sensitivity of children to toxic emissions early in life. Meeting California's GHG emission reduction targets is an essential part of the global action needed to slow global warming and achieve climate stabilization. Finally, actions to meet California's public health and climate goals will reduce our dependence on petroleum and establish a more secure energy future.

Mobile sources—cars, trucks, and a myriad of off-road equipment—and the fossil fuels that power them are the largest contributors to the formation of ozone, PM2.5, diesel particulate matter, and GHG emissions in California. They are responsible for approximately 80 percent of smog-forming nitrogen oxide (NOx) emissions, 90 percent of diesel particulate matter emissions, and nearly 50 percent of GHG emissions. Given this contribution, significant cuts in pollution from these sources are needed.

In this report, ARB staff is outlining a mobile source strategy that simultaneously meets air quality standards, achieves GHG emission reduction targets, decreases toxics health risk, and reduces petroleum consumption from transportation emissions over the next fifteen years. The integrated approach to planning described in this report allows

consideration of the multi-pollutant benefits, identifies interactions between measures, and maximizes program effectiveness.

ARB staff developed this strategy using a multi-pollutant scenario planning tool that quantifies changes in ozone and PM2.5 precursor emissions, GHG emissions, diesel toxics emissions, and petroleum usage as various technologies become widespread in vehicle and equipment fleets. This tool, Vision 2.1, is the next generation of ARB's first Vision scenario planning tool used for ARB's *Draft Vision for Clean Air: A Framework for Air Quality and Climate Planning* published in 2012 [5]. Staff evaluated scenarios with varying assumptions about potential technology and fuel mixes, and explored different rates at which those technologies could become widely used.

The analysis illustrates a scenario for meeting the State's public health, climate, and petroleum reduction goals with a strategy consisting of cleaner vehicle technologies, energy sources, and fuels. Technologies, energy sources, fuels, and the best policy tools will vary by sector based on the status of technology development in various applications, the multi-pollutant benefits, and the interactions between measures. The approaches for each sector will continue to be refined as the planning process for implementing specific actions moves forward. However the scenario analysis provides a foundation for establishing the types of technologies, fuels, and energy sources that will be necessary, and identifying a core suite of measures to be implemented.

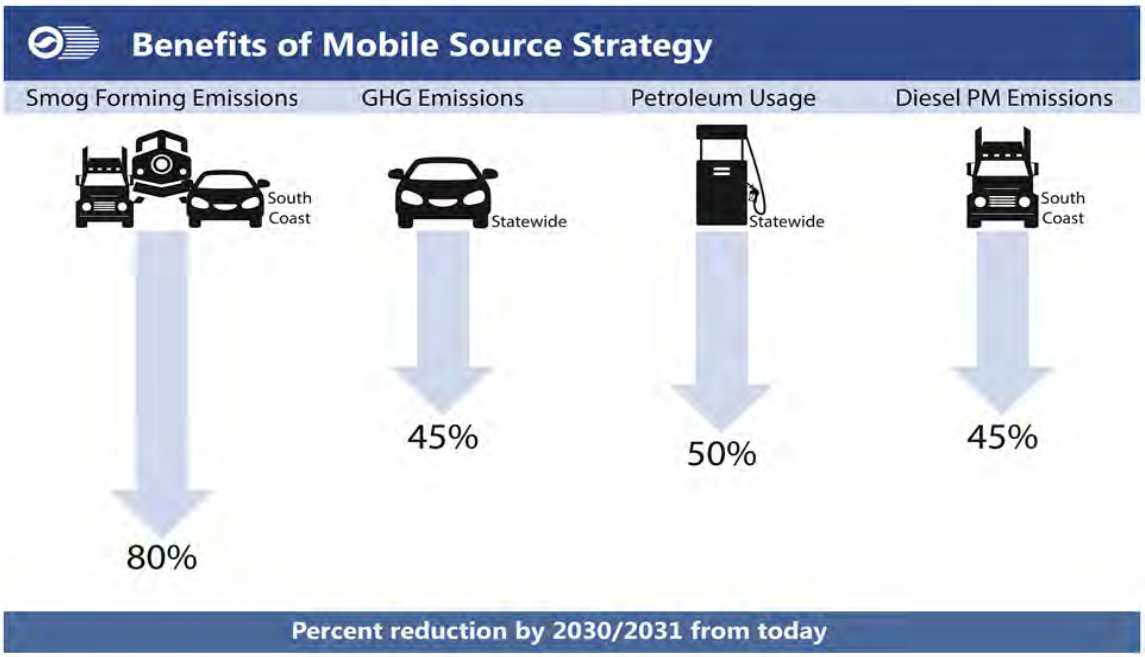
Table 1 highlights the scope of actions across all mobile sectors that are included as part of the proposed mobile source strategy. These actions would establish regulatory requirements for cleaner technologies (both zero and near-zero), deploy these technologies into the fleet, require cleaner fuels, and ensure in-use performance. Actions to accelerate the deployment of cleaner technologies through incentives, system efficiency improvements in moving people and freight, and support for the use of advanced transportation technologies, such as intelligent transportation systems and autonomous and connected vehicles are also needed. Taken together, the actions in Table 1 would provide the reductions necessary from mobile sources to achieve federal health-based air quality standards for ozone in 2023 and 2031, reduce GHG emissions from on-road vehicles by over 40 percent below 1990 levels by 2030, decrease regional and near-source health-risk from exposure to toxic air contaminants, and reduce our transportation-related petroleum use by up to 50 percent by 2030.

The estimated benefits of the strategy in reducing emissions from mobile sources are shown in Figure 1. This includes an 80 percent reduction of smog-forming emissions, and a 45 percent reduction in diesel particulate matter emissions in the South Coast from today's levels. Statewide, the strategy would also result in a 45 percent reduction of GHG emissions and a 50 percent reduction in the consumption of petroleum-based fuels.

Actions to deploy both zero-emission and cleaner combustion technologies will be essential to meet multiple goals. Near-term focused electrification and progress

[5] Vision Scenario Planning http://www.arb.ca.gov/planning/vision/vision.htm

Figure 1: A Mobile Source Strategy for Achieving Multiple Goals



towards zero-emission technologies is critical to continue to reduce near-source exposure to air toxics, especially around freight hubs such as ports, rail yards, and distribution centers. These zero-emission technologies must play a growing role in reducing GHG emissions and petroleum use, particularly as these strategies are adopted by more jurisdictions. The strategy therefore includes actions to deploy zero-emission technologies across a broad spectrum of sources, including passenger vehicles, targeted truck and bus applications, forklifts, transport refrigeration units, and airport ground support equipment. At the same time, the cleaner combustion technologies now being demonstrated for sectors such as heavy-duty trucks, locomotives, and ocean going vessels will provide the bulk of the smog-forming NOx reductions needed to meet air quality standards by 2031.

For passenger vehicles, the strategy calls for increasing the penetration of plug-in hybrid electric vehicles (PHEV) and non-combustion zero-emission vehicles (ZEV) including battery-electric (BEV) and hydrogen fuel cell electric vehicles (FCEV) by over 50 percent compared to current programs. The electrical grid and hydrogen supply supporting these electric vehicles will need to represent 50 percent renewable energy generation. A large portion of the liquid fuels for combustion engine vehicles will also need to be sourced from renewable feedstock.

For heavy-duty vehicles, California is laying the groundwork for reducing emissions from the heavy-duty truck sector on multiple fronts: cleaner internal combustion engines, renewable fuels, and zero-emission technology. The strategy calls for internal combustion engine technology that is effectively 90 percent cleaner than today's current standards, with clean, renewable fuels comprising half the fuels burned. Cleaner

engine standards will be especially important for interstate trucks given the status of technology development and infrastructure requirements. These efforts will be complemented by introduction of zero-emission technologies in heavy-duty applications that are suited to early adoption of ZEV technologies. Applications such as last mile delivery, transit and shuttle buses, and other small vocational trucks offer the potential for increasing use of ZEV technologies. Actions to promote ZEVs in these heavy-duty applications are underway and are important to further reduce regional and near-source toxics exposure as well as foster the development of these technologies so they become suitable for broader use in the future. Off-road equipment will need to reflect this same type of transformation to a mix of zero and near-zero technologies operating on renewable fuels.

Along with the widespread use of cleaner technologies and fuels, the strategy calls for ongoing improvements in community design and efficiency improvements to the freight transport system. These efforts will make our communities and cities more sustainable and enhance the benefits of investments in cleaner technologies by reducing growth in vehicle miles travelled (VMT). In the longer-term, advanced transportation systems and technologies, such as intelligent transportation systems and autonomous and connected vehicles, have the potential to be a transformative element of a cleaner, safer, and more efficient transportation system. The strategy also relies on the increased use of renewable fuels to ensure that GHG reductions are achieved while meeting the ongoing demand for liquid and gaseous fuels in applications where combustion technologies remain, including in heavy-duty trucks and equipment and light-duty hybrid vehicles.

This transformation and integration of technology, systems, and fuels has already begun. New vehicle technologies are being rolled out to the public at an increasing pace. Longer range battery electric vehicles are coming to market, and battery costs are declining at faster rates than projected a few years ago. Fuel cell electric vehicles are now for sale in California. Autonomous and connected vehicle technologies are being introduced on an increasing number of new car models. This technology has the potential to deliver enormous gains in safety, while also reducing traffic congestion and improving fuel efficiency. A growing network of retail hydrogen stations is now available in California, and California is the first in the world to certify a station for retail hydrogen fuel sales to the public. DC fast charging stations are expanding in California, and we are seeing increasing volumes of renewable fuels. Finally, systems are becoming more efficient. Examples include automated shipping terminals, such as Middle Harbor at the Port of Long Beach and TraPac at the Port of Los Angeles, as well as smart logistics which are transforming freight movement in California. In the light-duty sector, more transportation choices are available than ever before. The option to share a car, use on-demand mobility services, take transit, ride a bike or walk, is resulting in new choices in personal mobility. These expanded travel choices are being incorporated into sustainable communities strategies.

Significant investments will be needed to continue the transformation of California's transportation sector. The strategy in this report is an integrated approach to meeting multiple goals, and the investments necessary to implement the strategy will deliver

broad environmental and public health benefits, as well as support much needed efforts to modernize and upgrade transportation infrastructure, enhance system-wide efficiency and mobility options, and promote clean economic growth in the mobile sector.

Meeting our multiple goals will require sustained action, and the major plans coming out this year will build from the mobile source strategy by taking measures contained in the strategy to draw specific roadmaps for meeting climate and air quality targets. These include State Implementation Plans (SIPs) required under the Clean Air Act to meet federal air quality standards; California's Scoping Plan Update to meet GHG reduction goals; the California Sustainable State Action Plan to establish clear targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of California's freight system, and the Short-Lived Climate Pollutant Plan to reduce potent short-lived climate forcers.

Although each plan focuses on individual mandates, the integrated planning process and overall strategy outlined in Chapters 1 through 4 continue to provide a coordinated framework to support agency-wide planning efforts.

Chapters 6 through 10 outline a coordinated suite of proposed measures to implement the technology aspects of the strategy. These measures also represent the regulatory and programmatic mechanisms necessary to meet Clean Air Act requirements required as part of SIPs. ARB staff has been working closely with both the South Coast and the San Joaquin Valley on regional SIPs. Under State law, ARB has responsibility to develop SIP strategies for mobile sources and fuels, while local air districts are primarily responsible for controlling emissions from stationary sources. As part of this effort, in May 2016, ARB released the Proposed 2016 State Strategy for the State Implementation Plan (State SIP Strategy)[6]. The State SIP Strategy includes those measures in the mobile source strategy necessary to meet air quality standards. The State SIP Strategy also includes the legal commitment required under the Clean Air Act to develop and implement the measures. SIPs outlining local measures for stationary sources coupled with measures contained in the State SIP Strategy are considered for approval at the regional level. The Board then considers approval of the regional SIPs before submitting the plans to the United States Environmental Protection Agency (U.S. EPA). Board action on the State SIP Strategy is planned for September 2016

Planning efforts are also underway for the Scoping Plan Update, with ongoing public workshops, and a concept paper anticipated in May 2016. The GHG reduction measures in the mobile source strategy will be further refined in that process as well as expanding upon and evaluating potential additional actions and policies that will be required, including efforts to increase the use of renewable fuels and provide further improvements in freight transport and community design. Adoption of the final Scoping Plan Update is targeted for March 2017. Finally, staff updated the Board in early 2016 on the progress being made by multiple State agencies on the California Sustainable Freight Action Plan as well as progress made on implementing ARB's *Sustainable Freight: Pathways to Zero and Near-Zero Emissions Discussion Document* that was

[6] State SIP Strategy available at: http://www.arb.ca.gov/planning/sip/2016sip/2016sip.htm

released earlier in 2015. The draft California Sustainable Freight Action Plan was released for public review and comment on May 3, 2016. The measures in the mobile source strategy and subsequently incorporated into the SIP provide an implementation mechanism for near-term ARB regulatory and programmatic actions identified in the Sustainable Freight Action Plan.

Table 1: Mobile Source Strategy*

On Road Light Duty
• More stringent engine performance standards and increased fuel efficiency
• Requirements to ensure durability of passenger vehicle technologies
• Incentive funding to achieve further ZEV deployment beyond vehicle regulations
• Increased use of renewable fuels
On Road Heavy Duty
• More stringent engine performance standards reflecting technology 90 percent cleaner than today's standards and increased fuel efficiency
• Deployment of near-zero and zero-emission technologies into focused heavy-duty applications such as transit buses and last mile delivery
• Requirements to ensure durability of heavy-duty vehicle technologies
• Incentive funding to achieve further deployment of cleanest engine technologies
• Increased freight transport system efficiencies and use of intelligent transportation systems
• Increased use of renewable fuels
Off Road Federal and International Sources
• Call for federal and international action to set more stringent standards for ocean going vessels, locomotives, and aircraft, as well as cleaner technologies for older locomotives
• Decreased emissions from ocean going vessels at berth
• Increased freight transport system efficiencies
• Incentive funding to achieve further deployment of cleanest engine technologies
• Increased use of renewable fuels
Off Road Equipment Sources
• Deployment of ZEV technologies into targeted equipment categories such as forklifts and airport ground support equipment
• Cleaner engine technology transfer from on-road to off-road applications
• Incentive funding to achieve further deployment of cleanest engine technologies
• Increased worksite efficiencies
• Increased use of renewable fuels

* Chapters 6 - 10 provide further details regarding the strategy concepts described in this table.

1. Blueprint for Mobile Source Transformation

ARB's current mobile source programs, coupled with efforts at the local and federal level, have achieved tremendous success in reducing emissions, resulting in significantly cleaner vehicles and equipment in operation today. Current control programs will reduce NOx emissions in 2030 by over 50 percent from today's levels, position California to meet our 2020 GHG target, and provide approximately half the petroleum reductions needed by 2030. These programs provide a significant down payment on the needed emission reductions. Nonetheless, meeting all of our air quality and climate goals will require large reductions beyond those occurring under existing programs.

The success of California's longstanding mobile program provides a blueprint for how to effectively implement a vision for the mobile source sector to meet mid-term goals by 2030 and 2031, as well as to position California for continued progress in addressing longer-term needs. The blueprint is a portfolio approach that combines technology-forcing fleet average standards for new vehicles, cleaner-burning fuels, durability requirements and inspection programs to ensure clean in-use performance, sales requirements for advanced technologies, pilot programs to demonstrate technologies, and incentive programs and other actions to accelerate technology deployment.

Using the light-duty sector as an example, this portfolio approach has resulted in significant progress in encouraging and deploying clean passenger vehicle technologies while setting the stage to transition to zero-emission vehicles, which afford both air quality and climate benefits. ARB's Low Emission Vehicle (LEV) fleet emission standards have driven the ongoing clean-up of combustion technology. The Smog

Check program has ensured clean in-use performance, and the continued lower in-use performance assessment will do so even more effectively in the future. California's reformulated gasoline standard requires fuel producers to meet increasingly stringent standards, which has reduced emissions of NOx, reactive organic gasses, and toxic pollutants from gasoline. ARB's technology-forcing ZEV regulation continues to drive technology development needed for the long-term transformation of the passenger vehicle fleet. The success of these programs is evident: California is the world's largest market for ZEVs, with over 21 models available today, and a wide variety are now available at lower price points, attracting new consumers. As of January 2015, Californians drive 40 percent of all ZEVs on the road in the United States, while the U.S. makes up about half of the world market.

Looking forward, ARB will continue California's leadership role to accelerate the market for ZEVs in order to meet the milestone of 1.5 million ZEVs in California by 2025, as laid out in Governor Brown's ZEV Action Plan.[7] Since the 2013 ZEV Action Plan, which is currently being revised, additional priorities have emerged that focus on ensuring that ZEVs are accessible to a broad range of Californians, scaling-up ZEV technologies so they are suitable for use in medium and heavy-duty applications, and accelerating market growth beyond California. The multi-state ZEV Memorandum of Understanding and efforts to establish an International ZEV Alliance aim to foster continued national and international growth in the ZEV market. Finally, partnerships with automotive manufacturers, energy providers and government and non-governmental organizations, like the California Plug-in Electric Vehicle Collaborative and the California Fuel Cell Partnership, have been key to addressing market barriers, infrastructure, and other gaps to further foster the commercialization of ZEVs and PHEVs.

California's portfolio of programs to reduce emissions from the heavy-duty on-road sector has also resulted in substantially cleaner fleets. These efforts include requirements for increasingly tighter new engine standards, vehicle idling, in-use performance systems, and in-use fleet standards. In addition, California's low sulfur diesel fuel program has established stringent standards for diesel fuel sold in the State. In planning for the expansion of ZEVs beyond light-duty vehicles, the portfolio of passenger vehicles policies can serve as a model for next steps in the heavy-duty

[7] Governor's Interagency Working Group on Zero-Emission Vehicles April 2015 ZEV Action Plan http://gov.ca.gov/docs/DRAFT_2015_ZEV_Action_Plan_042415.pdf

sector. Just as the continued tightening of tailpipe emission standards for light-duty vehicles was integral to successfully reducing emissions while zero-emission technology was developed and commercialized, policies to continue to increase the stringency of tailpipe emission standards for heavy-duty applications while ZEV technologies suitable for certain heavy-duty applications are developed will be essential. Developments in light-duty ZEV technology and California's ZEV mandate continue to foster technology improvements in FCEV and BEVs, which have led to technology advancements benefitting the heavy-duty sector. Specific off-road categories can also benefit from these technology advancements. Knowledge and technological innovation, economies of scale, and efficiency improvements gained by producing generations of lighter application technologies can reduce costs and accelerate commercialization of heavier technologies for both on- and off-road applications.

With the success of California's existing control programs for light- and heavy-duty vehicles, sources primarily regulated by the federal government, including locomotives, aircraft, and ocean going vessels, represent an increasing portion of emissions in California. Although ARB has established a number of requirements to reduce emissions from these sources where possible, such as requiring cleaner fuels to be used in ocean going vessels and auxiliary engines near ports, and accelerating the introduction of cleaner locomotives, further emission reductions from these sources are necessary to meet our goals. Measures to reduce emissions from interstate sources depend on the federal government developing more stringent emission standards, and implementing those standards as soon as possible. For international sources such as ocean going vessels, the federal government must act on California's behalf to encourage cleaner requirements. While the need for federal and international action is critical, the strategy also identifies a suite of actions that ARB is committed to undertake to reduce emissions from these sources, underscoring California's leadership role and ensuring continued momentum towards cleaner technologies in all mobile sectors.

In addition, a continued emphasis on development of cleaner renewable fuels and energy sources will be critical for decarbonizing the transportation system and reducing our reliance on fossil fuels. Renewable energy sources will be necessary to support the growing use of ZEVs and the associated growth in electricity demand. Parallel efforts will also be needed to develop the necessary charging and refueling infrastructure, and to integrate this infrastructure with the electricity grid. The Low Carbon Fuel Standard (LCFS) is an essential tool for reducing the carbon intensity of our fuel mix and reducing petroleum dependence. Transportation fuels are also covered under California's Cap-and-Trade program which, together with the LCFS, provides strong market incentives for fuel suppliers to develop cleaner fuels and sell them in California. Further strengthening of the LCFS standards post-2020 will continue this transition to greater use of renewable fuels. A cleaner diesel standard can also build on ARB's existing fuels framework by requiring that conventional diesel is blended with increasing amounts of qualifying renewable fuels that reduce carbon intensity and criteria pollutant emissions.

Applying this blueprint will take time, and will require a comprehensive suite of policy tools to be further refined, as well as new ones to be developed through a stakeholder

process. These efforts will be predicated on early and sustained action. Regulatory approaches will help drive the introduction of cleaner technologies, fuels, and fueling infrastructure. Due to the magnitude of emission reductions needed to meet our air quality and climate goals, the natural fleet turnover rate and the current pace of market development for zero and near-zero technologies will not be sufficient to meet California's needs. Therefore, additional funding mechanisms, partnerships, research and demonstration projects, and other innovative strategies will be needed to incentivize accelerated deployment.

Successful approaches and strategies must consider the economics of individual sectors and begin to build an environmental and business case that encourages and supports adoption of these technologies and mechanisms. It will also require partnerships with the private sector and across all levels of government to secure the needed funding and resources, put enabling policies in place, and continue to spur technology innovation as ARB continues to build on California's successful legacy of innovative environmental and public health policies.

Advanced Transportation Technologies and Efficiency Improvements

Beyond the approaches described above, other technology innovations and policies provide opportunities for further transformation. Additional gains in passenger transportation efficiencies can be achieved by developing sustainable communities that feature a range of mobility choices, including easy and equitable access to public transit, active transportation, and improved public transit and rail service utilizing zero and near-zero emission technologies. SB 375[8], the Sustainable Communities and Climate Protection Act, is one key mechanism to move toward more efficient land use and to promote alternative modes of transportation. Local actions and leadership in planning and building more sustainable and livable communities will be critical.

Autonomous and connected vehicles and new approaches to personal mobility also represent an opportunity to fundamentally transform the transportation system and, if done correctly, substantially reduce emissions. Many new vehicles are now equipped with automated features for certain driving conditions, such as parking assist, adaptive cruise control, and automatic braking technology. The technology is maturing rapidly and several automakers are planning on the capability of a fully autonomous vehicle for sale by 2020. Part of this effort includes development of "vehicle-to-vehicle" or "connected vehicle" technology and software systems to communicate vehicle data and conditions of the surrounding driving environment. The potential for improvements in both speed and efficiency, from fewer stop-start cycles to more free-flowing traffic, as well as incorporating zero and near-zero emission technologies could be significant, and the heavy-duty truck and freight facility applications for these technologies also show great promise. Automated vehicles are a natural platform for zero-emission technologies. ARB has initiated efforts to understand what policies and programs are

[8] Sustainable Communities http://www.arb.ca.gov/cc/sb375/sb375.htm

needed to ensure that the transformation to autonomous technologies is also a transition to cleaner technologies.

The integrated approach in the California Sustainable Freight Action Plan will serve to coordinate State agency priorities and timing on actions to influence freight transportation and energy infrastructure, vehicle and equipment technologies, and facility and operations efficiency, rather than the traditional and separate planning efforts for transportation, environment and energy. Improvements in the efficiency of the freight transport system can be achieved through new technology, operational efficiencies, and smart logistics. Operational efficiencies include changes to business models that have the potential to increase freight flow and capacity in the transportation system. Logistics planning technologies can provide coordination and access to advanced scheduling systems that can improve routing, container tracking, productivity and congestion throughout the transportation system.

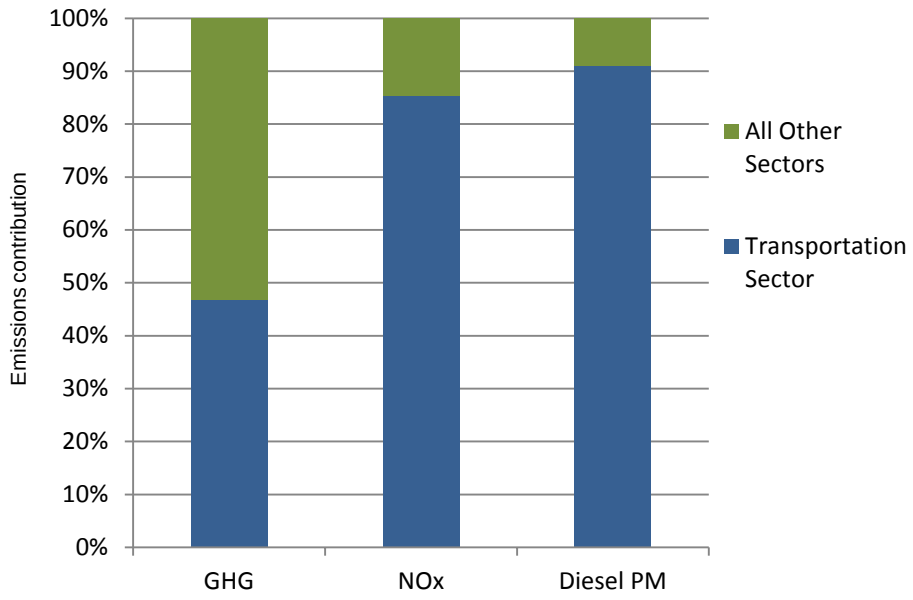
As these advanced technologies emerge and sustainable community strategies are implemented, the transportation sector will require a broader systems-based planning approach. This will require greater coordination among policymakers and stakeholders, and it will naturally lead to synergies between all elements of the transportation system to maximize potential benefits. These actions will work in concert to set California on the path for 2050 climate change goals, while achieving the necessary level of transformation to meet interim air quality and climate goals.

2. Defining Needs to Meet California's Goals

Scope of the Challenge

Over the next fifteen years, California will need to meet a number of critical air quality and climate goals. In response to new science demonstrating health impacts at lower and lower levels of pollution, U.S. EPA has progressively strengthened federal air quality standards. In 2008, U.S. EPA revised the 8-hour ozone standard to 75 parts per billion (ppb), and the annual PM2.5 standard to 12 micrograms per cubic meter (µg/m^3) in 2012. Exposure to PM2.5 and ozone are associated with premature death, increased hospitalizations and emergency room visits due to

Figure 2: Emission Contribution from Mobile Sources

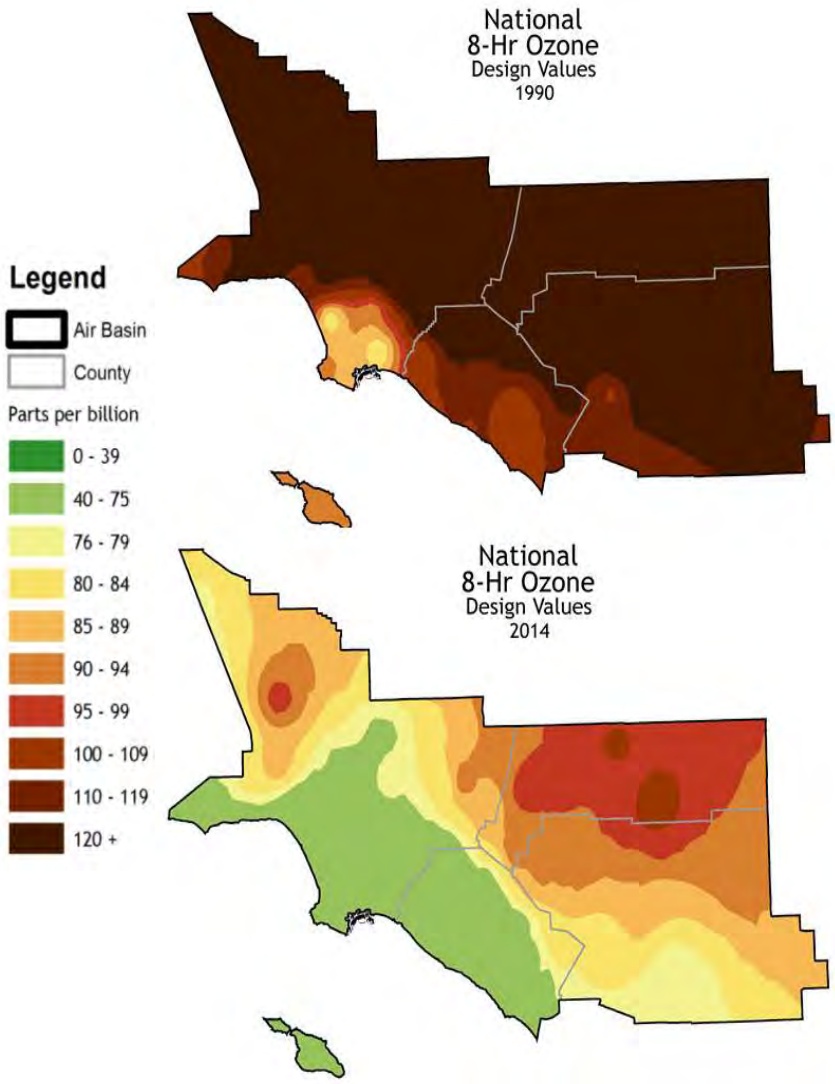


exacerbation of chronic heart and lung diseases, and other serious health impacts. Governor Brown has also set ambitious climate change goals that include GHG emission reduction targets of 40 percent below 1990 levels by 2030 and reducing petroleum use up to 50 percent by 2030. At the same time, we must continue efforts to minimize near-source risk and exposure to toxic air contaminants. As illustrated in Figure 2, mobile sources and the fuels that power them contribute over 80 percent of smog forming NOx emissions, over 90 percent of the diesel PM emissions, and nearly 50 percent of Statewide GHG emissions. Efforts to reduce pollution and fossil fuel use in mobile sources will therefore be essential in creating a future transportation system that provides the foundation for meeting California's goals.

Air Quality Standards

California has made significant progress in improving air quality through existing State and local air district control programs. Figure 3 illustrates the progress that has occurred since 1990 in the South Coast, the region with the highest ozone levels in the State. Twenty-five years ago the entire South Coast region violated the current 8-hour ozone standard of 75 ppb. Today, concentrations have declined 45 percent, and 40 percent of the population lives in communities that meet the standard. Nonetheless, the South Coast still has the highest ozone levels in the nation while the San Joaquin Valley has the greatest PM2.5 challenge.

Figure 3: South Coast Ozone Progress since 1990



Statewide, about 12 million Californians live in communities that exceed the federal ozone and PM2.5 standards. The health and economic impacts of exposure to elevated levels of ozone and PM2.5 in California are considerable; meeting air quality standards will pay substantial dividends in terms of reducing costs associated with emergency room visits and hospitalization, lost work and school days, and most critically, premature mortality.

Statewide Air Quality Needs

Sixteen areas in California are designated as nonattainment for the 75 ppb 8-hour ozone standard. Six areas that were originally designated nonattainment now meet the standard, with several additional areas poised to reach the standard within the next several years. Ozone nonattainment areas are classified according to the severity of their air pollution problem, and areas with higher pollution levels are given more time to meet the standard (attainment date). The South Coast and San Joaquin Valley are the only two extreme areas in the nation, with an attainment deadline of 2031. SIPs for meeting the 75 ppb ozone standard are due to U.S. EPA in 2016.

Four areas in California are designated as nonattainment for the 12 $\mu g/m^3$ annual PM2.5 standard. These areas include the South Coast and the San Joaquin Valley, as well as the border region of Imperial County and the City of Portola in Plumas County. While the PM2.5 challenges in the South Coast and the San Joaquin Valley are regional in nature, the Imperial County and Portola nonattainment areas reflect unique local conditions related to cross-border transport and wood smoke impacts, respectively. Separate, tailored control programs will be necessary for these two areas. SIPs for the 12 $\mu g/m^3$ annual PM2.5 standard are due in October 2016, and attainment dates range from 2021 to 2025.

Additionally, the South Coast and San Joaquin Valley must also continue to address progress towards attainment of earlier standards that they have not yet achieved, including the 8-hour ozone standard of 80 ppb, and the 24-hour PM2.5 standard of 35 $\mu g/m^3$.

Most recently, U.S. EPA finalized a more stringent 70 ppb ozone standard in October 2015. This more protective ozone standard will result in a number of additional nonattainment areas in the more rural regions of California, as well as require further emission reductions in California's existing nonattainment areas. SIPs for this standard will be due in 2021, with attainment dates through 2037. The progression of greater health protection in federal standards underscores the ongoing need for continuing transformation in the transportation sector.

Air quality modeling is used to define the extent of emission reductions required to meet a standard by the attainment deadline. Based on this modeling, the existing control program will provide the reductions needed to bring almost all areas of the State into attainment of the ozone and PM2.5 standards. The key remaining challenges are meeting ozone standards in the South Coast, and PM2.5 standards in the San Joaquin Valley. The scope and timing of emission reductions required to meet air quality

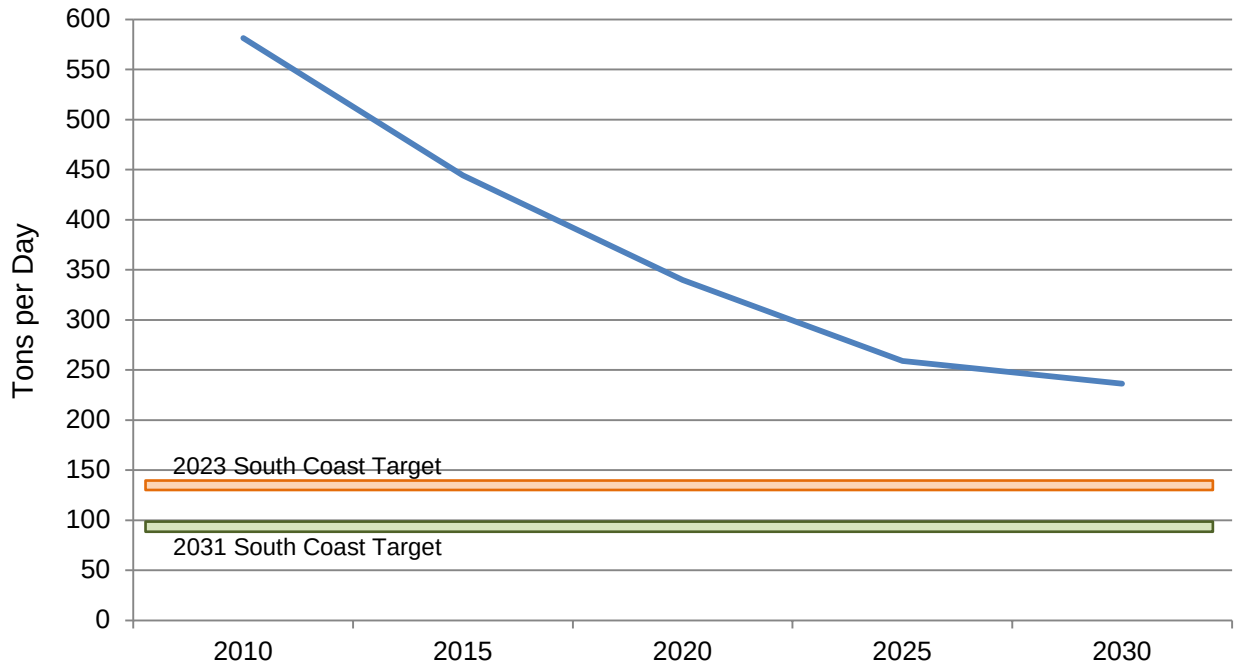
standards in these two regions are therefore key drivers for the development of the mobile source strategy.

South Coast Attainment Needs

Figure 4 illustrates the NOx emission levels in the South Coast over time, and shows that existing ARB and district control programs are projected to reduce NOx emissions by over 50 percent between 2015 and 2031. These programs will also result in significant reductions in PM2.5, as well as diesel particulate matter (diesel PM). ARB and the South Coast have been collaborating on modeling to provide estimates of the reductions necessary to meet the ozone and PM2.5 standards. Similar to ozone, PM2.5 air quality has been showing steady improvement. Annual average concentrations have been cut in half since 2001, and the region met the prior annual standard of 15 ug/m3 in 2013. Ongoing NOx reductions to reduce regional PM2.5 concentrations, coupled with targeted controls focused on the remaining area of nonattainment in Riverside are expected to bring the entire South Coast region into attainment by 2025.

Meeting the ozone standards will therefore drive overall emission reduction needs, and substantial reductions beyond those being achieved with the current control program will be needed to meet standards in 2023 and 2031. Current modeling indicates NOx emissions will need to decline to approximately 130 tons per day (tpd) in 2023, and 90 tpd in 2031 to provide for attainment in the remaining portions of the South Coast Air Basin that do not yet meet the standards. Reaching these levels will require an approximate 70 percent reduction from today's levels by 2023, and an overall 80 percent reduction by 2031. Achieving this magnitude of reductions will require

Figure 4: South Coast NOx Emission Trends



comprehensive efforts to address emissions from both mobile and stationary sources in the region.

NOx reductions will also provide benefits for meeting the PM2.5 standards, by reducing ammonium nitrate formed from interactions between NOx and ammonia. Current health studies indicate the largest share of air pollution-related health impacts occur from exposure to PM2.5. Thus ongoing reductions in NOx will provide significant regional health benefits, coupled with reductions in diesel PM to reduce near-source exposure.

San Joaquin Valley Attainment Needs

Ozone levels in the San Joaquin Valley have also shown continuing improvement over the last twenty five years. While there was relatively modest progress in the early years, over the last decade ozone levels have shown significant improvement in response to accelerated NOx reductions. Current control programs will continue the pace of NOx reductions, with a further 50 percent reduction by 2031. Air quality modeling indicates these substantial reductions are sufficient to provide for attainment of both the 80 ppb ozone standard by 2023, and the 75 ppb ozone standard in 2031. Additional NOx reductions from the measures in the mobile source strategy will further enhance ozone progress.

Meeting PM2.5 standards presents the greater air quality challenge. Modeling efforts are underway to evaluate the magnitude of reductions needed for attainment of the 12 ug/m3 annual PM2.5 standard, and further region specific strategies will be defined through this process. The PM2.5 attainment strategy for the Valley will need to consider the diversity of sources that contribute to PM2.5, as well as the specific timeframes of meeting both the annual and 24-hour standards. Initial assessments indicate that, given the earlier attainment dates for PM2.5 compared to ozone, accelerating the pace of NOx reductions will be necessary. Ongoing mobile source NOx reductions will provide for significant regional improvement, but strategic use of incentive funding will be essential to achieve earlier penetration of cleaner technologies. Additional reductions from sources of directly emitted PM2.5 under local district control will also be critical given their contribution to ambient PM2.5 levels in the Valley.

Climate and Other Goals

In conjunction with meeting air quality standards, the State's climate, petroleum use, and risk reduction goals will drive the need for transformation of the mobile sector and necessitate a coordinated mobile source strategy.

Greenhouse Gas Targets

The Global Warming Solutions Act of 2006 (AB 32) established a 2020 reduction target to return to 1990 levels of GHG emissions, with a further reduction target of 80 percent below these levels by 2050 specified through Executive Order[9]. In April 2015, Governor Brown signed an Executive Order[10] that established a 2030 target of a 40 percent GHG reduction below 1990 levels. Reducing GHG emissions this amount by 2030 ensures that California will continue its efforts to reduce carbon and stay on the trajectory to help stabilize global temperatures.

Governor Brown further identified key climate change strategy pillars for California in his January 2015 inaugural address to help achieve the 2030 target and establish a model for other states and nations to follow. These strategy pillars include:

- up to a 50 percent reduction in petroleum use;
- increasing the amount of electricity derived from renewable sources to 50 percent;
- doubling the efficiency savings achieved at existing buildings;
- reducing emissions of short-lived climate pollutants;
- managing natural and working lands so they can store carbon; and
- safeguarding California through climate adaptation strategies.

ARB initiated a public process in October 2015 and is working closely with other State agencies to update the State's Climate Change Scoping Plan to address the actions that will be necessary to meet these new targets. The Scoping Plan process, which is required to be updated at least every five years, builds upon the long-term goals and vision laid out in the First Update to the Scoping Plan,[11] and sets targets to inform mid-term goals in the 2030 timeframe while ensuring that each sector is on the trajectory to achieve longer-term, post-2030 goals. The Scoping Plan Update focuses on areas within the pillars framework, including energy, transportation, industry, and natural and working lands, while maximizing synergies among sectors. Public workshops have been ongoing since late 2015, and will continue throughout the year. A Scoping Plan concept paper is scheduled to be released in May 2016, followed by a full

[9] Executive Order S-3-05, http://gov.ca.gov/news.php?id=1861
[10] Executive Order B-30-15, http://gov.ca.gov/news.php?id=18938
[11] Proposed First Update to the Climate Change Scoping Plan: Building on the Framework (2014) available at: http://www.arb.ca.gov/cc/scopingplan/2013_update/draft_proposed_first_update.pdf

Figure 5: California Climate Strategy

draft Scoping Plan including CEQA and economic analyses in late summer 2016, and consideration by ARB's Board for approval in March 2017.

Short-Lived Climate Pollutants

While California must continue to steadily reduce CO_2 emissions for long-term climate stability, we also need a global commitment and near-term actions to dramatically reduce short-lived climate pollutant emissions over the next 10 to 15 years. In 2014, Governor Brown signed Senate Bill 605 (SB 605) (Lara, Chapter 523, Statutes of 2014), directing ARB to develop a comprehensive short-lived climate pollutant strategy by January 1, 2016.

Short-lived climate pollutants, including black carbon (soot), methane, and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs) are powerful climate forcers and dangerous air pollutants that remain in the atmosphere for a much shorter period of time than longer-lived climate pollutants, such as CO_2. Short-lived climate pollutants are estimated to be responsible for about 40 percent of current net climate forcing.

ARB released a Short-Lived Climate Pollutant Reduction Strategy Discussion Draft[12] for public review in September 2015, with a draft strategy released in April 2016. The strategy proposes targets to reduce emissions of methane and HFCs by 40 percent below 2013 levels by 2030, and anthropogenic (i.e. non-forest) black carbon emissions by 50 percent below 2013 levels by 2030. Strategies include a range of options to accelerate reductions, including incentivizing early reduction actions, market-supporting

[12] Reducing Short Lived Climate Pollutants in California http://www.arb.ca.gov/cc/shortlived/shortlived.htm

activities, and regulatory actions. California has already made tremendous progress reducing emissions of black carbon, with more than a 90 percent reduction since the 1960s. The actions proposed in the mobile source strategy provide opportunities for further reductions as part of meeting the 50 percent reduction goal for black carbon.

Sustainable Freight

In July of 2015, Governor Brown released an Executive Order[13] that directs the California State Transportation Agency, California Environmental Protection Agency, Natural Resources Agency, California Air Resources Board, California Department of Transportation, California Energy Commission, and Governor's Office of Business and Economic Development to develop a California Sustainable freight Action Plan by July 2016. The agencies released the Action Plan in May 2016[14]. This Action Plan is intended to integrate investments, policies, and programs across several State agencies to help realize a singular vision for California's freight transport system. The freight transport system (which includes trucks, ships, locomotives, aircraft, harborcraft, and all types of equipment used to move freight at seaports, airports, railyards, warehouses and distribution centers, and along highway and rail corridors) is a major economic engine for California, which also accounts for about half of diesel PM, 45 percent of NOx and PM2.5, and six percent of the GHG emissions in California.

A transition to a less-polluting, more efficient, modern freight transport system is needed, which will require utilizing a partnership of federal, State, regional, local and industry stakeholders, environmental and community groups, -to move freight in California on a modern, safe integrated, and resilient system that continues to support California's economy and livability. It will also require transporting freight reliably and efficiently by zero-emission equipment everywhere feasible, and near-zero emission equipment powered by clean renewable fuels everywhere else. The transition to this modern freight system will rely on public and private funds invested in infrastructure projects, vehicle and equipment purchases, technology applications, and system management approaches. It will also require regulatory and other programs to spur zero-emission and other clean technology development and deployment. To inform that effort, the *Sustainable Freight: Pathways to Zero and Near-Zero Emissions Discussion Document*[15] sets out ARB's vision of a clean freight transport system, together with the immediate and near-term steps that ARB will take to support use of zero and near-zero emission technology. ARB staff provided an update to the Board on the development of the California Sustainable Freight Action Plan and implementation of the actions in the *Sustainable Freight: Pathways to Zero and Near-Zero Emissions Discussion Document* in January 2016, and will return to the Board in May 2016 with an informational update on the draft California Sustainable Freight Action Plan.

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[13] Executive Order B-32-15 https://www.gov.ca.gov/news.php?id=19046
[14] California Sustainable Freight Action Plan http://www.casustainablefreight.org/app_pages/view/154
[15] Sustainable Freight Pathways to Zero and Near-Zero Emissions Discussion Document http://www.arb.ca.gov/gmp/sfti/sustainable-freight-pathways-to-zero-and-near-zero-emissions-discussion-document.pdf

Diesel Risk Reduction

In 2000, the Board adopted the Diesel Risk Reduction Plan, following an extensive 10-year scientific assessment process that identified particulate matter from diesel-fueled engines as a toxic air contaminant (TAC). Compared to other air toxics, diesel PM emissions are estimated to be responsible for about 70 percent of the total ambient air toxics risk. The Diesel Risk Reduction Plan recommended many control measures to reduce the risks associated with diesel particulate matter in order to achieve a goal of 85 percent PM reduction by 2020. The need for risk reduction is heightened further by new health science indicating that infants and children are 1.5 to 3 times more sensitive to the harmful effects of exposure to air toxics, such as those emitted from diesel engines and vehicles, than previously understood.

3. Assessing Coordinated Planning Needs

As outlined in Chapter 2, meeting California's air quality and climate goals will require substantial reductions in mobile source emissions from today's levels over the next fifteen years. This includes:

- 80 percent reduction in NOx emissions in the South Coast
- 45 percent reduction in GHG emissions
- 50 percent reduction in petroleum consumption
- Ongoing reduction in toxic air contaminants, including diesel PM

Defining the scope of actions necessary to implement a strategic vision for meeting these goals relies upon a coordinated planning process. Given the interconnected nature of California's goals, this type of planning effort is essential to address the interplay between pollutants and sources, and consider the benefits of different technologies and energy sources. Development of this integrated strategy relies on three elements. First, ongoing implementation of current programs provides significant reductions. Second, detailed technology assessments evaluate the capabilities of technologies and fuels that are becoming available today, and advancements that are expected to occur in the near future. Finally, scenario analysis provides the framework for coordinated assessment by analyzing the types of technologies, fuels and energy sources that will ultimately need to make up our vehicle and equipment fleets by the end of the next decade. In turn, these efforts define the scope, types, and timing of further improvements that will be needed and the policy and regulatory framework necessary.

Technology Assessments

ARB has developed a series of technology assessments for heavy-duty applications

and the fuels necessary to power them[16], along with ongoing review of advanced vehicle technologies for the light-duty sector in collaboration with U.S. EPA and the National Highway Traffic Safety Administration. The South Coast Air Quality Management District has also prepared white papers describing available technologies and recommendations for approaches to achieve reductions in key source sectors[17]. These assessments have identified the types of technologies that will be needed as part of a cleaner, more efficient transportation system. While the status of technology availability varies by sector, meeting combined air quality and climate goals while continuing to reduce exposure to toxic air contaminants will require a portfolio of both substantially cleaner combustion and zero-emission technologies. Key findings from these technology assessments are highlighted below:

Key Technology Assessment Findings

In the light-duty sector, conventional hybrid electric vehicles have gained significant market share, and ZEV commercialization is well underway, with increasing numbers of BEV, PHEV and FCEV vehicles available for sale.

In the heavy-duty sector, near-zero combustion technologies that provide ultra-low NOx emissions and operate on renewable fuels are beginning to enter the market. Low-NOx natural gas engines in some sizes, certified to an optional 0.02 g/bhp-hr standard are now becoming available, with low-NOx diesel engines certified to the optional standard of either 0.05 or 0.1 g/bhp-hr available thereafter.

The development of heavy-duty zero emission technologies is also underway. Zero-emission vehicles are already available in a number of applications such as forklifts and airport ground support equipment. Battery electric and fuel cell buses are in the early commercialization phase and demonstration projects are underway in additional applications such as zero-emission drayage and last mile delivery trucks, certain types of off-road equipment, and at distribution centers, warehouses and intermodal facilities.

Further emission reductions beyond current engine standards for locomotives and ocean going vessels are feasible with the use of aftertreatment technologies such as oxidation or three-way catalysts, diesel particulate filters, or selective catalytic reduction.

Renewable fuels can provide significant GHG and petroleum reductions, as well as NOx and PM reductions in applications where combustion technologies will continue to operate. Vehicle grid integration and power to gas technologies can also help support a high renewable portfolio electrical grid.

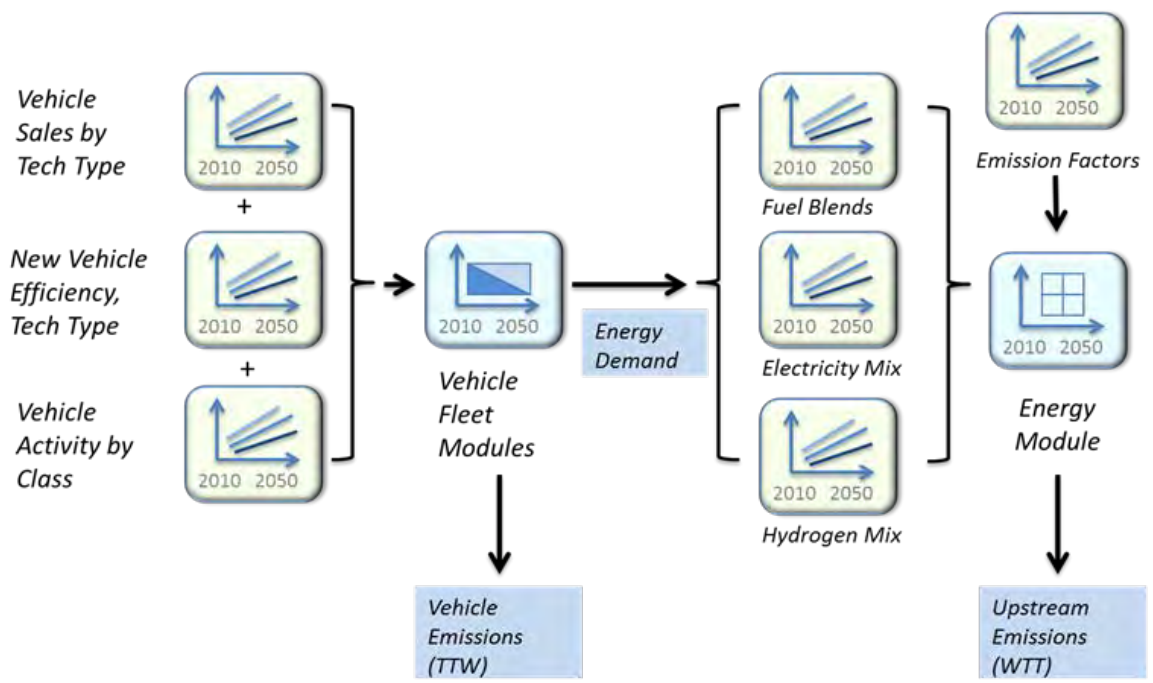
[16] Technology and Fuel Assessments http://www.arb.ca.gov/msprog/tech/tech.htm
[17] 2016 AQMP White Papers http://www.aqmd.gov/home/about/groups-committees/aqmp-advisory-group/2016-aqmp-white-papers

Vision Scenario Planning Process

Recognizing the mobile source strategy must include actions to deploy all of these technologies into California's fleet, ARB's Vision planning model[18] provides a framework for examining the magnitude of technology penetration necessary and how quickly technologies need to be introduced, as well as the necessary infrastructure to support them. This coordinated assessment includes not only technology deployment, but also interactions with needed energy sources and efficiency improvements. The Vision modeling system was used to identify emission reductions associated with the existing mobile source control program, as well as to explore different combinations of further advancements in technologies, fuels, and transportation system efficiencies. This type of assessment provides insights on multi-pollutant impacts of policy choices, including technology synergies and tradeoffs, availability of renewable fuel stocks, and distribution of reductions across sectors. The Vision tool is described in detail, along with the specific scenario assumptions, in Chapter 10. The Vision 2.1 model is available on ARB's website[19], reflecting scenario assumptions and baseline input data.

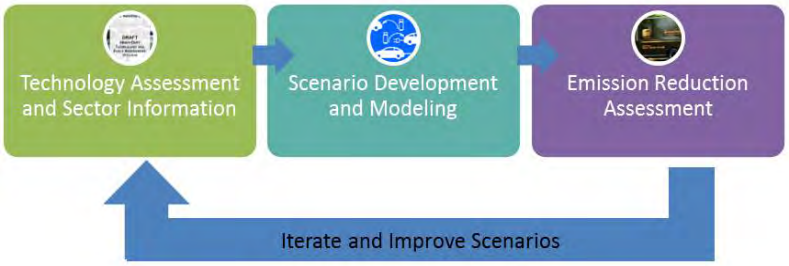
As shown in Figures 6 and 7, Vision scenario modeling is an iterative process to reflect different combinations of technology, energy, and efficiency assumptions that change over time, building from the benefits of existing programs. These assumptions are informed by foundational technical work and the technology assessments. Results from

Figure 6: Vision Model Framework



[18] Vision Scenario Planning http://www.arb.ca.gov/planning/vision/workshops.htm#vision2
[19] Vision Scenario Planning http://www.arb.ca.gov/planning/vision/vision.htm

Figure 7: Vision Scenario Development



initial scenarios provide feedback to understand the interactions between strategies and their impact on criteria pollutant and GHG emission reductions. Through this process, the Vision model provides an means to understand the intertwined nature of different policies. For example, strategies such as greater deployment of light-duty BEV technologies provides benefits across all pollutants, decreases petroleum use, and allows renewable fuels to be focused in other sectors where combustion technologies will continue to play a significant role. At the same time, the associated increase in electricity demand must be coupled with greater use of renewable energy generation to meet climate goals. Similarly, deployment of cleaner combustion technologies for heavy-duty trucks provides significant NOx reductions, but requires use of renewable fuels to achieve GHG and petroleum reductions. Understanding these interactions informs further scenario analysis to determine how strategies to meet both air quality and climate goals can best complement each other.

The scenario planning process provides key insights that serve as the foundation for the mobile source strategy presented in this document. While the penetration of different technologies and the appropriate regulatory and policy mechanisms will vary by sector, the scenarios demonstrate significant additional progress is needed on all technology fronts, and multiple potential combinations of technology mixes that can allow us to realize needed reductions.

Progress Due to Existing Policies

As described in Chapter 1, ARB's success in reducing emissions from mobile sources has relied on a multi-pronged suite of policy and regulatory mechanisms that includes establishing emissions and performance standards for new vehicles and fuels, setting mandates and sales requirements for advanced technologies, developing pilot programs, and implementing incentive and other programs to accelerate technology deployment. Together, these approaches are designed to achieve progressively cleaner in-use fleet emission levels.

Figure 8 highlights the progress in reducing in-use NOx emissions through currently adopted control programs for both the light and heavy-duty on-road sectors in the South Coast. In-use emissions represent emissions from all vehicles operating, not just new vehicle sales. The reductions are substantial, however significant efforts associated with implementation and enforcement will continue to be required to ensure the benefits of these current programs. The graphs also depict in-use emission rate performance targets that reflect a 70 percent reduction by 2023, and an overall 80 percent reduction

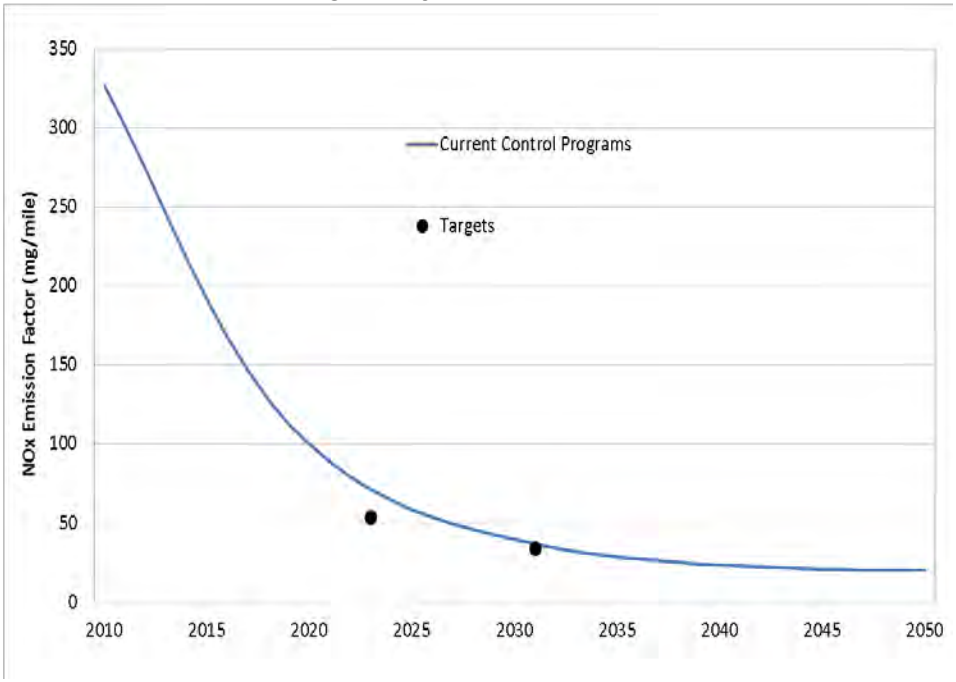
by 2031, relative to today's emissions. The targets shown represent an equal share reduction toward meeting South Coast attainment needs.

In the light-duty sector, the maturity of advanced technologies required under currently adopted programs results in in-use fleet average NOx emission rates that are projected to be reduced by almost 80 percent between 2015 and 2031. This progress is the result of new engine standards that have significantly reduced emissions from conventionally fueled vehicles. Alongside these programs, ZEV technologies have achieved commercial status, and sales mandates are increasing ZEV penetration. Together these

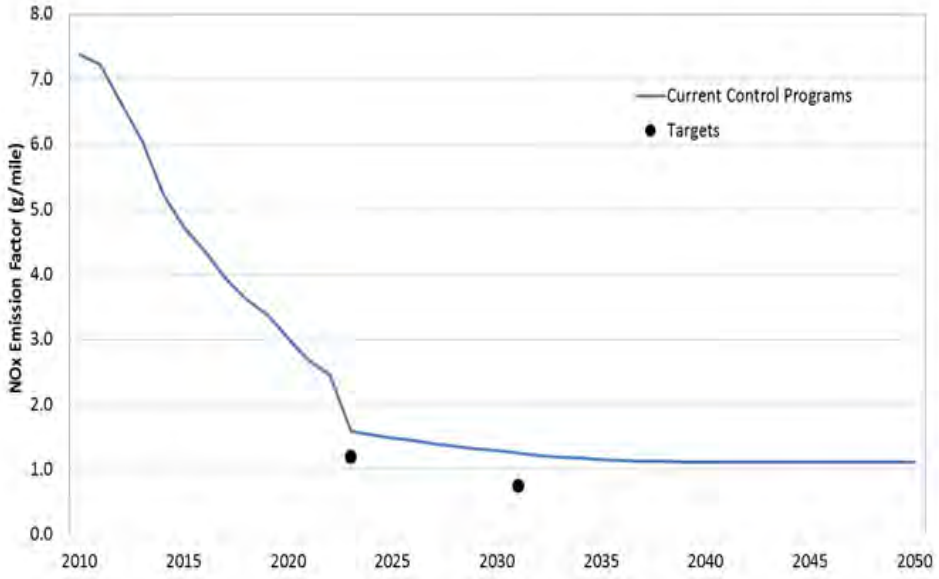
Figure 8: In-Use Fleet Average NOx Emission Rate Trends in South Coast

Under Current Control Programs

Light-Duty Vehicle Fleet



Heavy-Duty Vehicle Fleet*



* Weighted by vehicle class and vehicle miles traveled.

programs provide a trajectory that would meet the in-use NOx targets over time.

For heavy-duty trucks, current programs reduce in-use NOx emission rates by nearly 70 percent by 2031. The significant drop in emission rates through 2023 reflects new engine standards, implementation of the Truck and Bus Regulation, and incentive funding to further accelerate turnover. However, the pace of emission reductions from existing control programs in the heavy-duty sector flattens after 2023, and is never projected to reach the 2031 target. This demonstrates that although current programs achieve substantial reductions, in-use fleet emissions must continue to decrease and at a more rapid pace in order to meet ozone attainment needs. To achieve the incremental reduction between in-use emissions and the target requires a substantially cleaner technology introduced early enough to have sufficient time to penetrate the fleet. Analysis shows that a path to achieving these reductions will require establishing a low-NOx performance level that is 90 percent cleaner than today's technology.

While not pictured, NOx emissions from off-road sources such as construction and industrial equipment are projected to decrease approximately 45 percent by 2031 as a result of ARB programs to establish more stringent engine standards, in-use fleet rules, idling limits, and increasing electrification of smaller equipment. However, although engine standards have become more stringent over time, overall NOx emissions from sources that are primarily regulated by the federal government, such as ocean going vessels, aircraft, and locomotives, have not kept pace with reductions in other sectors, and are only projected to decrease by approximately 20 percent. Thus significant further progress is needed to reach similar emission reduction targets as those for on-road sources.

As shown in Figure 9, diesel PM emissions also continue to decrease significantly as a result of regulations associated with implementation of ARB's Diesel Risk Reduction Program. These efforts are reducing both regional and near-source risk. However, additional reductions are needed to reach the target established in the risk reduction plan.

The existing suite of clean vehicle, fuel and transportation policies that comprise current control programs are also anticipated to put California on track to meet the 2020 GHG target, with a further 20 percent reduction in on-road mobile source GHG emissions between 2020 and 2030, as illustrated in Figure 10. However, further reductions are needed to meet the 2030 GHG reduction target. In addition, beyond 2035, on-road GHG emissions begin to increase without adoption of additional policies as growth in VMT outpaces vehicle fuel efficiency improvements

Figure 9: Diesel PM Emission Trends in South Coast

Under Current Control Programs

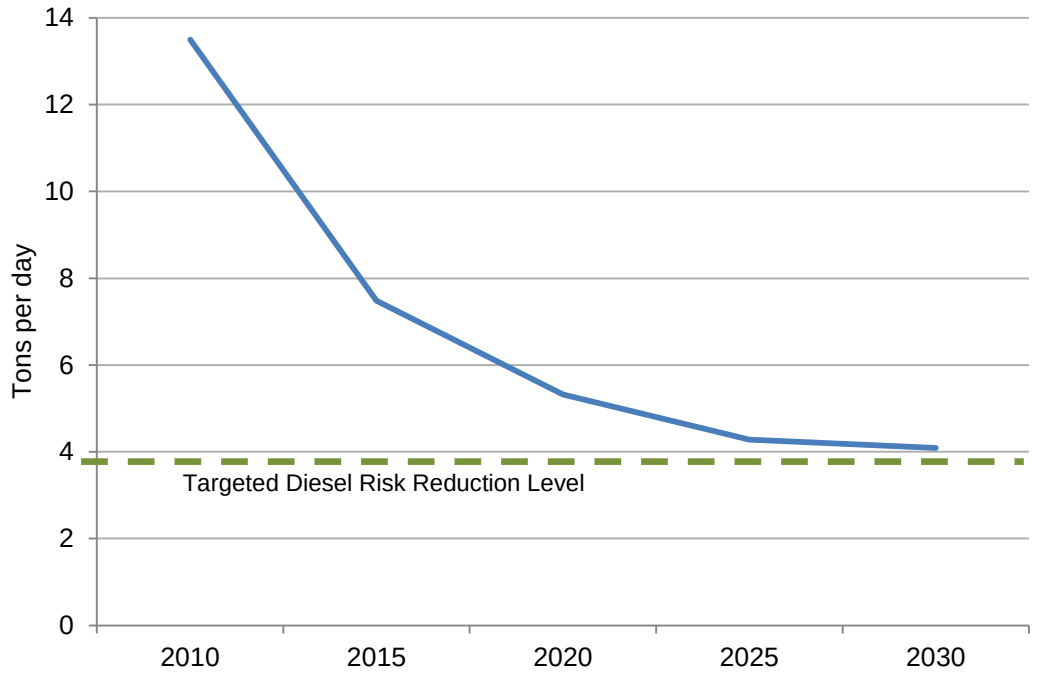
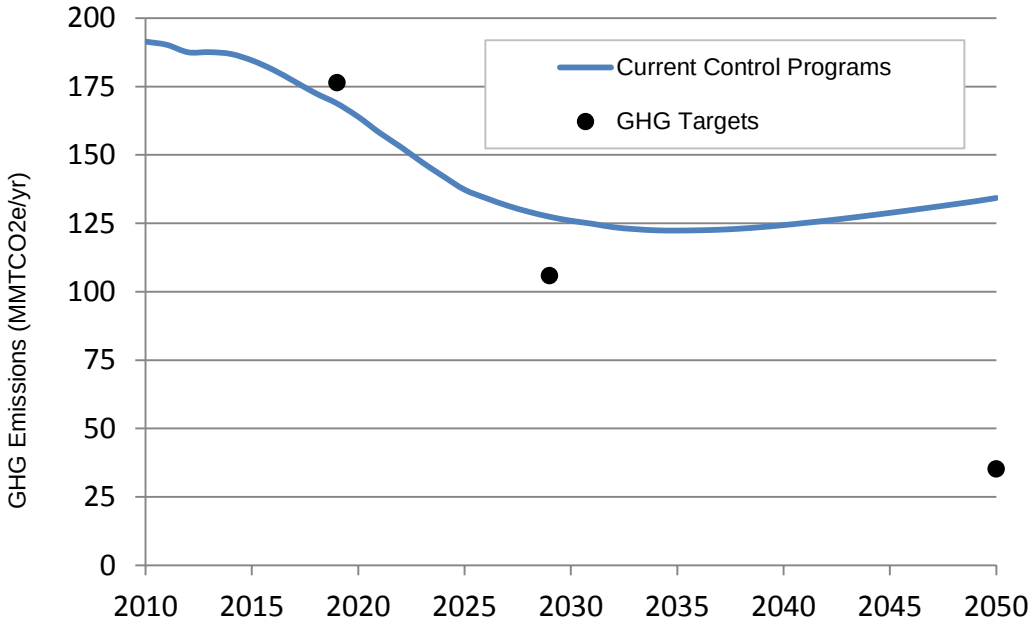


Figure 10: On-Road California GHG Emission Trends

Under Current Control Programs



Progress in reducing GHG emissions is the result of multiple policies, including the Advanced Clean Cars program for light-duty cars and trucks, designed to cut GHG emissions from new passenger vehicles in half by 2025, the ZEV mandate, and Phase 1 GHG emission standards for heavy-duty trucks. Additional efforts include the LCFS, which requires a reduction in the carbon content of transportation fuels by 2020, along with sustainable community strategies (SCS) developed pursuant to SB 375 to reduce per capita GHG emissions from passenger vehicles by 2020 and 2035.

These programs will also achieve approximately half of the reductions needed to meet the 2030 petroleum reduction goal.

Introduction of Cleaner Technologies and Fuels Scenario

Building on the progress achieved through existing programs, ARB developed a scenario through the Vision modeling process to evaluate further emission and petroleum reduction benefits that would result from deploying the cleaner vehicle technologies and fuels identified in the technology assessments. This evaluation, called the *Cleaner Technologies and Fuels* scenario, examined the benefits of new technologies that would replace older vehicles in the fleet under what is predominately a natural turnover rate, coupled with increasing percentages of renewable fuels and energy sources, and slower growth of VMT. The scenario focused on the on-road sector, which comprises the largest share of mobile source NOx and GHG emissions. It is important to note that this is one scenario, and depending on technology development and deployment, other scenarios could examine a different mix of vehicle technologies and fuels.

Scenario Assumptions

Light-Duty Sector

In the light-duty sector, the scenario examined post-2025 technology approaches that would extend beyond current requirements in the Advanced Clean Cars regulation and the ZEV mandate to achieve further NOx, GHG, toxics, and petroleum reductions. These actions included increasing the sales for ZEVs and PHEVs to 40 percent by 2030 to enhance market penetration, as well as setting more stringent vehicle NOx emission standards and new fleet standards for GHG emissions. Post-2030 it was assumed that combined car and light trucks sales of ZEVs and PHEVs will reach 100 percent by 2050, and fuel efficiency will continue to increase. The scenario also assumed an increasing penetration of renewable fuels for the remaining combustion vehicles in the fleet.

While the majority of GHG reductions are assumed from new vehicle technologies and low carbon fuels, the scenario also included slower growth of light-duty VMT. VMT reductions not only reduce emissions, but also have co-benefits that include more walkable, energy, and water efficient communities and preservation of natural and working lands. Further reductions in VMT could be achieved through continued land use changes, synergies with emerging technologies such as autonomous vehicles, transportation system improvements that offer more mobility options, and emerging

changes in travel behavior, especially amongst millennials. The scenario assumed a 15 percent reduction in total light-duty VMT in 2050, compared to baseline 2050 levels. This would translate into light-duty VMT growth of only five percent by 2030, compared to current growth rates of approximately 11 percent.

Heavy-Duty Sector

For heavy-duty trucks, the *Cleaner Technologies and Fuels* scenario focused on cleaner traditional combustion technologies coupled with renewable fuels for the heaviest vehicles, and ZEV and PHEV technologies in targeted vocational applications. For traditional combustion technologies the scenario assumed low-NOx performance standards by California and U.S. EPA implemented in 2024 (representing a 90 percent reduction in overall emissions) that would continue through 2030 and beyond. The scenario also included efficiency improvements from a national Phase 2 GHG standard with implementation starting in 2018, and an approximate blend level of 50 percent biofuels by 2030 to provide petroleum and GHG emission reductions.

Although ZEV and PHEV technologies are not as mature for heavy-duty trucks, Class 3 - 7 delivery trucks and urban buses provide opportunities for introducing ZEV technologies. The scenario therefore explored gradual introduction of zero-emission technologies in transit buses and last mile delivery applications beginning in 2018 to 2020. These initial deployments provide a foundation for subsequent migration of zero-emission technology to other heavier platforms. ARB is optimistic that the potential for zero-emission technologies can continue to expand in the long term, especially in certain vocational classes and fleets that are under California regulatory authority. Continued growth in heavy-duty zero-emission vehicles can also provide greater flexibility for use of renewable fuels in other applications. Additional discussion on the role of ZEVs in heavy-duty truck applications is provided in Chapter 7.

The scenario also examined potential fuel sources for heavy-duty trucks. The ultimate distribution between diesel and natural gas trucks will depend upon a number of factors including the availability and suitability of engines across different weight classes and vocations, requirements for fueling infrastructure, and the incremental cost of each technology. For example, the penetration of low-NOx natural gas engines will likely cluster around vocational, return-to-base operations in the near term, although this is expected to expand as more low-NOx natural gas engines and fueling stations become available. However, diesel technologies are likely to remain dominant in class 8 interstate truck fleets due to fueling infrastructure needs.

Therefore, based on information from the technology assessments and corresponding infrastructure requirements, the scenario assumed for combustion technologies diesel fuel would continue to be used for 100 percent of interstate truck new sales, 90 percent of heavy-duty class 8 truck new sales, and 80 percent for all remaining heavy-duty truck below class 8 new sales. However, as a result of South Coast District fleet rules, incentives, and efforts by other organizations, the scenario assumed a greater penetration of natural gas trucks in certain weight classes and vocations in the South Coast. This included 50 percent natural gas for port trucks, and 50 percent natural gas for heavy-duty trucks below class 8.

Results of Cleaner Technologies and Fuels Scenario

The *Cleaner Technologies and Fuels* scenario highlights actions that would provide for significant progress towards reaching California's air quality and climate goals. These actions would achieve a 45 percent reduction in on-road GHG emissions by 2030, and reduce on-road petroleum demand by approximately 50 percent, and would therefore meet both climate targets. The scenario would also significantly further reduce NOx emissions and regional diesel PM and other mobile source toxic air contaminants, but does not achieve the full complement of NOx reductions needed to attain the ozone standard in 2031.

Figure 11 illustrates the South Coast in-use fleet average NOx emission rate trajectories for the on-road fleet, and Figure 12 illustrates the Statewide GHG emissions (using a well-to-wheel[20] emissions analysis). The greatest NOx reductions result from actions associated with the turnover of heavy-duty vehicles to cleaner technologies, while the greatest GHG reductions are in the light-duty sector.

For light-duty vehicles, this transition occurs through enhanced sales assumptions as the penetration of PHEVs and pure ZEVs increases by over 50 percent, and the oldest, conventionally fueled vehicles are retired from the fleet. By 2030, there would be nearly 1.8 million pure ZEVs operating Statewide, and 2.4 million PHEVs. This technology transition is also coupled with a doubling of fuel efficiency, an increase in clean renewable energy generation, and slower growth of VMT from light-duty vehicles that would result from continued advances in the development of more sustainable communities.

The trajectory for heavy-duty vehicles reflects substantial penetration of trucks meeting the Phase 2 GHG standards, as well as those meeting a new low-NOx standard operating on fuels with 50 percent renewable content. The number of zero-emission heavy-duty vehicles although small in 2030, would continue to expand through 2050 with continued penetration of ZEV technologies in vocational operations such as transit buses and last mile delivery. Altogether, by 2031 nearly two-thirds of the heavy-duty truck fleet operating in the State would consist of vehicles meeting Phase 2 or low-NOx standards, with similar proportions in the South Coast. However, further reductions from heavy-duty trucks are still needed beyond what is achieved through the scenario to meet ozone attainment targets in the South Coast. Achieving the incremental reduction between what the scenarios achieve and the targets will require enhanced deployment of either low-NOx or ZEV trucks. The next section addresses the magnitude of this enhanced deployment.

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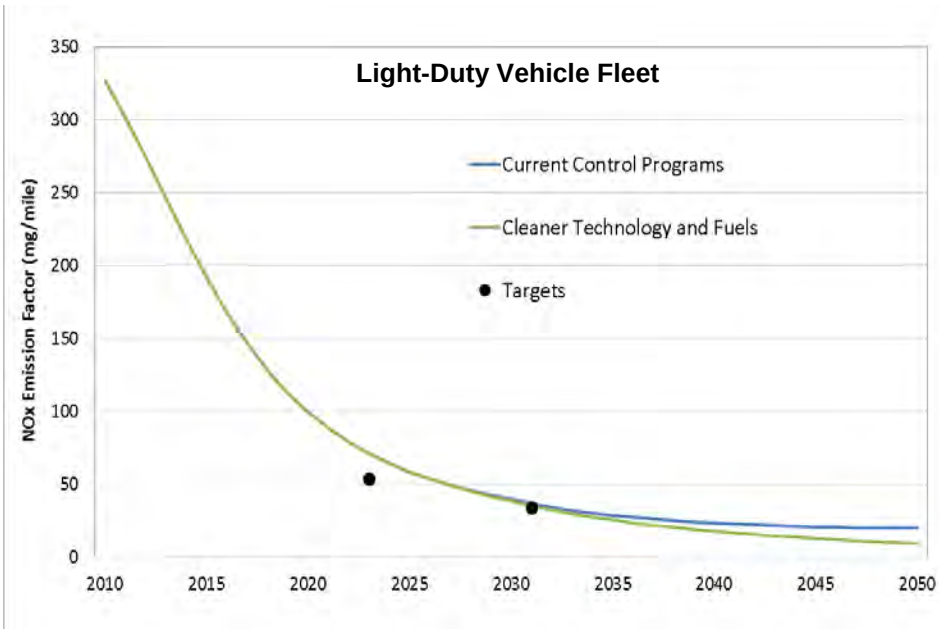
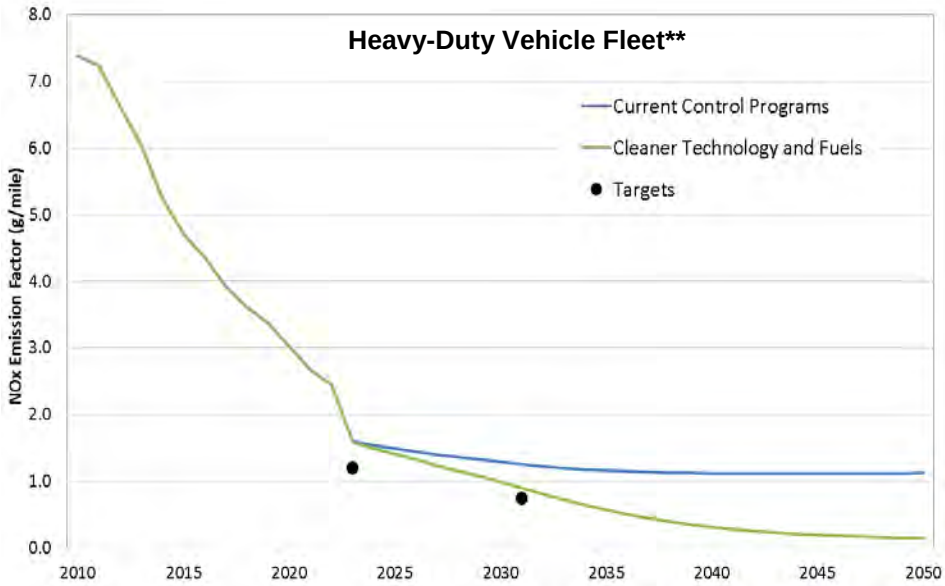
[20] Well to wheel (WTW) emissions analysis is a form of life cycle analysis that considers the energy or emissions intensity of all stages of fuel production and final use of a fuel in a vehicle (i.e. the production, transport, and consumption of fuels in a vehicle). A WTW analysis slightly differs from a broader life cycle analysis in that it is not a cradle-to-grave approach, i.e., it does not capture the energy or emissions associated with vehicle production and/or vehicle recycling phases.

Figure 11: In-Use Fleet Average NOx Emission Rate* Trends in South Coast

Under Cleaner Technologies and Fuels Scenario





*In-use fleet average NOx emissions reflect natural turnover rates for light and heavy-duty vehicles.
** Heavy-duty vehicle fleet weighted by vehicle class and vehicle miles traveled.

Figure 12 shows the GHG emission reductions anticipated from the on-road fleet under current control programs, as well as the *Cleaner Technologies and Fuels* scenario; Figure 13 shows the corresponding reductions in petroleum consumption throughout the State. The projected fuel mix reflects two important trends in California's fuel portfolio over time: decreasing consumption of petroleum-based gasoline and diesel; and increasing use of cleaner energy sources, including renewable fuels, electricity, natural gas and hydrogen. While many passenger vehicles transition to battery electric or other zero-emission options in future years, many heavier applications are anticipated to continue operating on near-zero internal combustion technologies powered by fuels blended with increasing levels of clean, renewable fuels. As such, heavy-duty diesel vehicles drive the majority of renewable fuel demand in future years.

This mix also represents an increasing share of renewable and more sustainable feedstock sources over time. This is true for liquid transportation fuels, natural gas and electricity, as renewable fuels displace increasing volumes of petroleum, and as the Renewable Portfolio Standard drives the California grid mix toward an increasing share of energy procured from renewable sources.

Figure 12: On-Road Statewide GHG Emission Trends

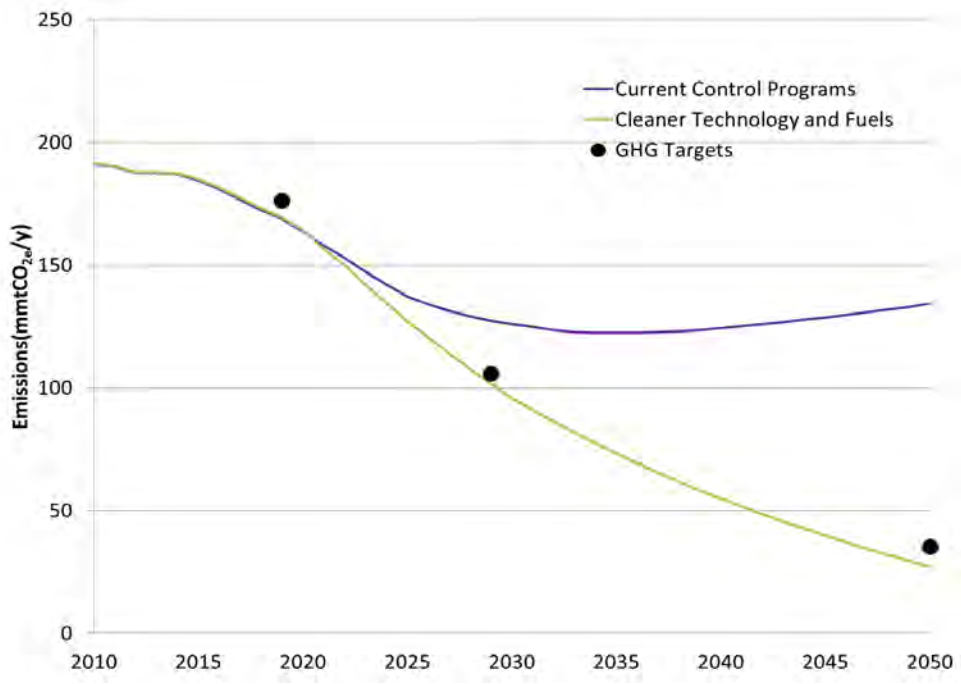


Figure 13: On-Road Statewide Petroleum Reduction Trends

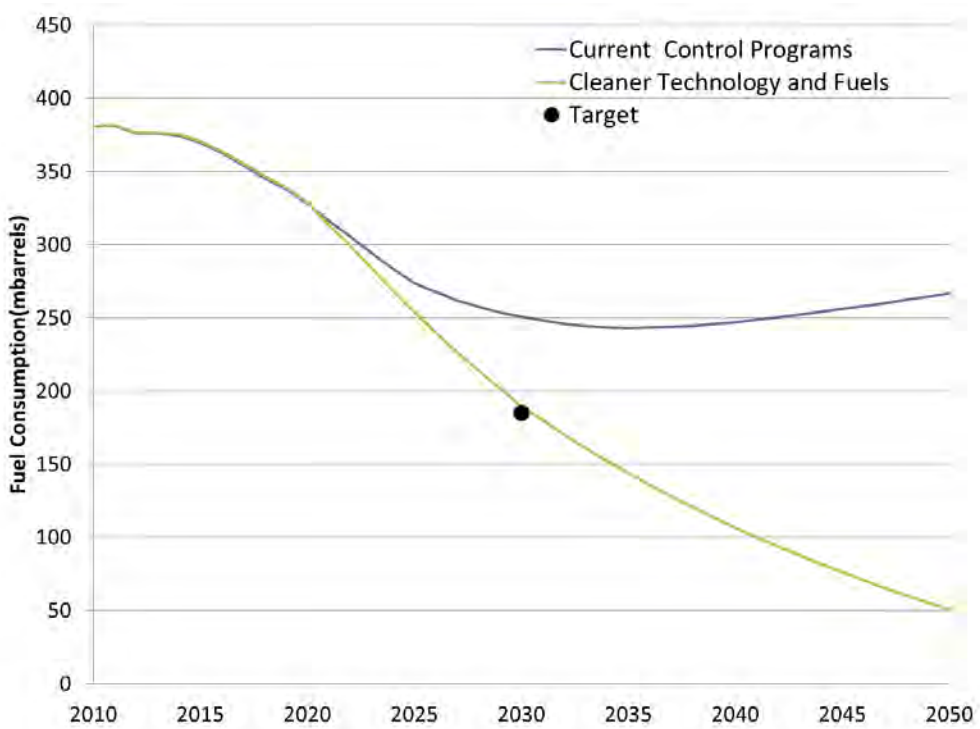


Table 2 summarizes the Statewide changes in passenger and truck fleets that would result under this scenario between today and 2030.

Table 2: On-Road Fleet Transformation
Statewide under Cleaner Technology and Fuels Scenario

	Today		2030
Passenger Fleet	~200k	ZEV/PHEV population	4.2 Million
	27%	Renewable energy generation	50%
	24 mpg	Fuel Efficiency	49 mpg
	11%	Improved system to reduce VMT growth (VMT growth between today and 2030)	5%
Truck Fleet	Demos	Low-NOx truck population	900,000
	~ 300	ZEV last-mile delivery truck population	23,000
	8%	Renewable Fuels	50%
	6.5 mpg	Fuel Efficiency*	8.9 mpg

*Fuel efficiency for class 8 trucks

It's important to note, that while this scenario is not intended to be a specific forecast of the future, the *Cleaner Technologies and Fuels* scenario highlights a mix of cleaner technologies, low-carbon fuels, and passenger vehicle efficiencies that promote the much needed transformation of California's transportation system. Altogether, a broad range of actions are examined that collectively provide a path towards meeting climate and petroleum reduction goals and achieve significant progress towards providing necessary NOx reductions and in reducing risk.

Further Deployment of Cleaner Technologies and Pathways to Attain Air Quality Standards

While the *Cleaner Technologies and Fuels* scenario is projected to achieve significant reductions, enhanced deployment of both cleaner on-road and off-road technologies will be needed to ensure that the mobile source strategy comprehensively meets all goals,

especially the critical public health needs associated with attaining the federal 80 ppb and 75 ppb ozone standards by 2023 and 2031 in the South Coast. Additional targeted actions will also be needed to continue to reduce local exposure, especially in communities living near freight hubs such as seaports, railyards, and distribution centers. These targeted actions will be part of the California Sustainable Freight Action Plan.

ARB staff therefore examined further deployment of the same core technologies included in the *Cleaner Technologies and Fuels* scenario as part of a pathway to meet attainment needs in the South Coast. The additional deployment of these cleaner vehicles and equipment will also provide further benefits in reducing GHG emissions and petroleum demand, and continue to support trajectories for meeting these goals. As part of this effort, ARB worked with South Coast staff to assess the penetration of these cleaner technologies that would be required by 2023 and 2031 to meet the ozone standards.

The mix of technologies and the emissions performance levels for meeting the 80 ppb and the 75 ppb ozone standards are similar, as evidenced by the results of the *Cleaner Technologies and Fuels* scenario. Thus, appropriate actions to deploy cleaner technologies to meet the 80 ppb standard will carry forward towards meeting the 75 ppb standard. As a result, these investments in early deployment of cleaner technologies will not require that vehicles and equipment be replaced twice. Nevertheless, the 2023 deadline to meet the 80 ppb standard will require significantly earlier penetration of the cleanest technologies. Given the timing and the overlay of current regulatory programs, technology deployment by 2023 must come primarily through incentive mechanisms. At the same time, it will be necessary to establish more stringent emissions standards, ramp up the use of renewable fuels, and require further ZEV penetration to meet all goals by 2030 and 2031.

While many factors will influence the ultimate combination of technologies that will be necessary, including further engineering advances, the results of pilot demonstrations, and consumer acceptance and commercialization, this analysis represents staff's assessment of a likely mix of technologies based on the current status of technology readiness and market penetration. Based on this assessment, on-road sectors offer the greatest opportunities for further reductions.

Light-duty ZEV technologies continue to enter the market at an increasing pace. Therefore, for light-duty vehicles, the assessment focused on continued expansion of the pure ZEV fleet (both BEVs and FCEVs) to achieve greater NOx reductions. Equally important, policies to increase light-duty ZEV penetration through 2030 and beyond are also a critical driver for addressing the State's climate change targets. By 2031, the population of pure ZEVs in the South Coast would reach approximately 2.9 million vehicles, while maintaining a PHEV population of approximately 1.2 million vehicles. Of this population, approximately 0.9 million would come from natural turnover explored in the *Cleaner Technology and Fuel Scenario*, with an additional 2 million from enhanced deployment focused within the South Coast to meet the region's ozone attainment needs. While PHEVs could also achieve needed NOx reductions, the scenario relies on assumptions that PHEV electric mile range remains high throughout the lifespan of the

vehicle and may not achieve equivalent reductions in petroleum use over the longer-term. Near-zero technologies such as PHEVs can play an important role in reducing NOx and GHG emissions. However, with the majority of renewable fuels going to on-road and off-road heavy-duty applications in order to meet GHG reductions from those sectors, PHEVs operating on conventional gasoline with a more limited proportion of renewable gasoline are not sufficient for meeting longer-term goals beyond 2030.

The timing of availability of low-NOx engines across multiple weight classes is still evolving. However, regulatory requirements outlined in this strategy, greater certification flexibility, incentive funding, and demonstration project assistance are all sending strong market signals to foster development and certification of these engines prior to 2023. Thus staff's analysis included a focus on enhanced penetration of cleaner light- and heavy-duty vehicle technologies.

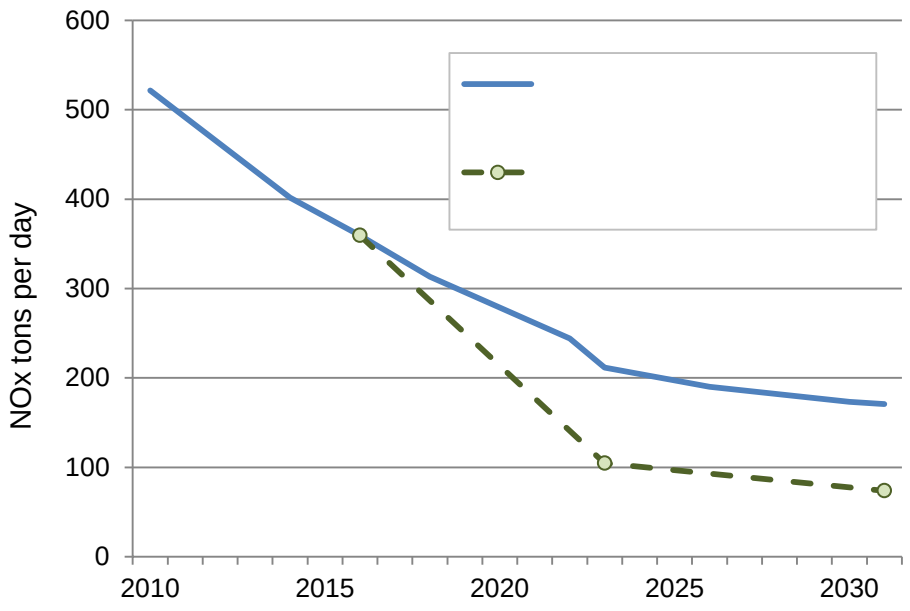
In the case of heavy-duty vehicles, combustion is likely to remain a dominant technology through 2031 based on the maturity of current technologies. Thus, the assessment focused on expanded deployment of low-NOx trucks. Under this approach, the population of trucks meeting a low-NOx standard in the South Coast would increase by approximately 150,000, totaling over 430,000 trucks by 2031. These technologies are anticipated to be available, but will require substantial incentive funding to achieve this additional level of enhanced deployment. Commercial applications of technologies capable of zero-emission or zero-emission miles in targeted applications will play a role, and demonstration and expansion of zero-emission technologies into new applications will continue to occur. However, heavy-duty zero-emission vehicles need to be able to demonstrate the capability to handle the duty cycle of a larger portion of the heavy-duty duty cycle in order to play a dominant role. Enhanced deployment of ZEV technologies over time will continue to be important in near-source risk reduction efforts, particularly in communities near freight hubs.

At the same time, further reductions will also be needed from off-road sources to achieve the aggregate reductions needed for attainment. ARB and South Coast staff therefore also examined mechanisms and opportunities to further advance technologies in off-road sectors. This included increased electrification of small equipment such as forklifts, transportation refrigeration units, and airport ground support equipment, as well as bringing the construction fleet up to current Tier 4 standards. As noted earlier, sources such as ocean going vessels, locomotives, and aircraft represent an increasing share of emissions in the South Coast, and emission reductions have not kept pace with those from on-road and other off-road equipment sources. Thus, strong action by the federal government and international agencies will be essential in developing effective solutions for these sources. Continued partnerships with the federal government to conduct research and demonstration projects of new zero and near-zero technologies will also be needed.

Additional details regarding the scope of needed technology penetration within the 2023 and 2031 timeframes are provided in Chapters 6 through 10 for individual sectors, along with recommended mechanisms and actions for achieving these reductions.

Figure 14 shows the NOx benefits of the *Cleaner Technology and Fuels* scenario with the additional overlay of reductions from the further deployment of cleaner technologies for both on-road and off-road mobile sectors. Combined, this scope of technology penetration achieves a 70 percent reduction in NOx emissions by 2023, and an 80 percent reduction by 2031 in the South Coast to meet ozone attainment needs, as well as meets California's 2030 climate and petroleum reduction goals.

Figure 14: NOx Emissions in the South Coast from Mobile Sources



Strategy Conclusions

California's existing control policy framework, technology assessments, and scenario evaluations demonstrate combinations of technologies and fuels that together can transform the transportation sector and achieve air quality and climate goals over the next decade and a half. These pathways will require a mix of both near-zero and zero-emission technologies, increased use of renewable fuels, and enhanced efficiencies in moving people and freight throughout the State. The balance between different technologies and fuels will vary by sector depending upon current fleet characteristics and the pace of future technology development. Appropriate regulatory and programmatic mechanisms to achieve further penetration of cleaner technologies will also reflect the nature of each sector. Key policy conclusions include:

- Policy levers to significantly increase the penetration of pure ZEVs into the light-duty fleet are necessary, particularly for achieving GHG reductions in 2030 and beyond. This must be coupled with increased all electric vehicle range for PHEVs and continued development of FCEVs to expand the attractiveness of ZEVs to a broader market, along with deployment of fueling infrastructure, and increase use of renewable electricity generation.

- Given the role that combustion technologies will continue to play in the heavy-duty sector, more stringent emission and efficiency standards will need to be developed, as well as measures to ensure that technologies remain durable over the long lifetimes of these vehicles.

- The need for timely action by U.S. EPA to establish more stringent engine performance standards in collaboration with California efforts is essential. About 60 percent of total heavy-duty truck VMT in the South Coast on any given day is accrued by trucks purchased outside of California, and are exempt from California standards. U.S. EPA action to establish a federal low-NOx standard for trucks is critical. Delays in federal action on heavy-duty truck standards would result in a significant loss of emission benefits that cannot be made up by California acting alone.

- Deployment of zero-emission technologies in targeted heavy-duty applications is critical both for near-term reduction of risk and sustainable longer term GHG reductions. State support for zero-emission technology deployment will be an important factor in the deployment of this technology.

- Federal action is also necessary for many off-road sources such as locomotives, aircraft, and ocean going vessels where U.S. EPA has primary regulatory authority. As sources covered by the State and Districts become increasingly cleaner, sources that fall under Federal and international authority will comprise an increasing portion of emissions in the South Coast unless the federal government takes parallel actions. Regulatory mechanisms and policies to introduce zero-emission technologies into select on and off-road heavy-duty applications provide a foundation for accelerating commercialization into additional platforms. At the same time, continued investments in research and development, especially in off-road applications, will be needed to facilitate demonstration projects and the commercialization of new technologies.

- Substantial expansion in the use of renewable fuels and energy sources can reduce petroleum demand and GHG emissions. Renewable fuels can also provide NOx reductions and will represent an important alternative fuel source for heavy-duty trucks that will continue to rely on combustion technologies. A clean diesel fuel program that requires increasing use of fuels such as renewable diesel, NOx-mitigated biodiesel, and/or renewable natural gas from biomethane also provides an effective control approach by reducing emissions from all the vehicles and equipment using those fuels, especially from off-road vehicles and equipment, marine vessels, locomotives, and interstate trucks operating on California fuels. Concurrent investments by other agencies will also be essential to help fund charging infrastructures, as well as low carbon and renewable fuels.

- Although establishing cleaner engine and fuel standards will provide ongoing reductions, actions to further accelerate penetration of the cleanest technologies by 2023 will be needed. This will require strategic investments and development of a comprehensive funding plan to identify funding needs and financing and

incentive options will be a necessary first step. Acquiring the requisite level of funding will be an incremental process, but will provide ongoing progress in achieving the fleet transition needed.

- Greater system efficiencies, particularly in the freight sector, provide opportunities for emission reductions, including as a means to help mitigate potential growth in freight activity in the State and to supplement needed federal and international actions on new performance standards.

- Innovations in intelligent transportation systems and zero and near-zero emission autonomous and connected vehicles also show promise. The potential for emission reductions from these broad system changes must be closely followed, with ongoing coordination among local, State and federal agencies to position California to take advantage of these emerging technologies.

- Coordinated regional planning can improve California's land use patterns and transportation policy in a way that reduces transportation-related emissions by reducing growth in VMT. The SB 375 process provides one mechanism to pursue these reductions through the development of sustainable community strategies meeting per capita GHG reduction targets for passenger vehicles, however additional policies to further incentive land use changes and promote communities that are designed to foster use of ZEVs and new modes of personal mobility will also be needed.

4.
Mobile Source Strategy Proposed Measures

ARB's existing policies, and the new reductions that will continue to accrue from ongoing implementation, establish a substantial down payment on the actions necessary to meet California's goals. Based on the conclusions outlined in Chapter 3 summarizing strategic approaches to further strengthen and expand upon existing policies, ARB staff has developed proposed measures to implement the technology aspects of the strategy. These core measures represent a combination of actions that support ARB's multiple planning efforts to meet air quality standards, achieve GHG reduction targets, decrease near-source risk, and reduce petroleum consumption. These measures also represent the regulatory and programmatic mechanisms necessary to meet Clean Air Act requirements.

The measures described in Chapters 6 through 10 include actions to:

- Establish more stringent engine performance standards for cleaner combustion technologies;
- Ensure that emissions control systems remain durable over the lifetime of the vehicle;
- Increase the penetration of the zero-emission technology across a broad range of applications;
- Expand the requirements for cleaner low carbon diesel fuels;
- Conduct pilot studies to demonstrate new technologies; and
- Incentivize the turnover of equipment and fleets to the cleanest technologies.

Measures in each sector reflect the maturity of current control programs as well as the nature of further technology deployment needed. For light-duty vehicles, the need to significantly increase the penetration of current ZEV technology and encourage advancements in battery range, hydrogen technology and fueling infrastructure will be implemented through the Advanced Clean Cars 2 measure, along with an ongoing in-use performance assessment and incentive funding to expand the deployment of cleaner vehicles.

In the heavy-duty sector, while ARB's current Truck and Bus Regulation is ensuring that the fleet consists of the cleanest engines currently available, the scenario analysis demonstrated that combined ARB and federal action to develop a more stringent low-NOx engine standard will be necessary to move towards even cleaner combustion technologies. Parallel measures will require deployment of zero-emission and cleaner combustion technologies in initial applications such as last mile delivery and urban transit buses. Finally, given the long lifetime of heavy-duty trucks, further incentive funding will be critical to achieve greater fleet turnover, especially within the 2023 time frame.

Similar actions will be necessary in the off-road sector, with a focus on further federal and international actions to reduce emissions from these sources which, without further action, become an increasing portion of the emission inventory. Measures include a petition for new national Tier 5 emissions standards and cleaner remanufacture requirements for locomotives, as well as advocacy for international Tier 4 vessel standards. The remaining off-road equipment categories provide an opportunity to introduce zero and near-zero advanced emission technologies, with measures to initially deploy zero-emission technologies for sources such as forklifts, transport refrigeration units, and airport ground support equipment, with continued evaluation of technology transfer of cleaner on-road technologies to heavier off-road categories.

Coupled with these efforts is a measure to adopt a low-emission diesel requirement to ensure further reductions from vehicles and equipment still using combustion technologies.

Due to the severity of the South Coast's ozone challenge, each source sector also includes a measure that reflects the further deployment of cleaner technologies described in Chapter 3 needed for ozone attainment. The specific combination of approaches to achieve reductions under the further deployment measures will vary by source sector and the timing of needed reductions. ARB and South Coast staff have collaborated on developing an illustrative pathway for each sector, outlining the scope of cleaner technology required as well as a suite of implementation tools and recommended actions to be implemented by ARB, the South Coast, and U.S. EPA. These pathways are described as part of the measure write-ups contained in Chapters 6 through 10. These measures will also facilitate the broader transformation to cleaner technologies throughout the State.

Table 3 summarizes the core set of measures that will drive technology development and deployment, as well as provide the reductions necessary for ozone attainment in the South Coast. The table includes the implementing agency, the date by which

actions will be proposed (i.e. propose a regulation to the Board, disperse funding, or petition U.S. EPA for action), and the expected first year of implementation.

The approaches for each sector will continue to be refined as the planning process for implementing specific actions moves forward. Specific actions associated with additional aspects of the mobile source strategy, such as continued strengthening of renewable fuel programs and further development of efficiency measures, are being specified through individual planning documents, including the Scoping Plan Update, and the California Sustainable Freight Action Plan. The Scoping Plan Update[21] will examine post-2020 targets for fuels under Cap-and-Trade, as well as efforts to continue to reduce the carbon content of transportation fuels as part of further refinements to LCFS. Parallel efforts will also be required to expand the renewable portfolio standard to ensure the increasing numbers of ZEVs in California's fleets are powered by clean, renewable energy sources.

In addition, SB 375 requires Metropolitan Planning Organizations (MPOs) to adopt Sustainable Communities Strategies that integrate land use and transportation planning to achieve passenger vehicle GHG emission reductions. Per capita GHG emission reduction targets for each MPO are established by ARB. The 15 percent reduction in light-duty VMT in 2050 included in the *Cleaner Technology and Fuels* scenario provides a top-down framework for how transportation efficiencies can put California on a trajectory to meet climate goals. ARB and the MPOs will be working on a comprehensive bottom-up process to update SB 375 targets. MPO recommendations will be considered as part of the SB 375 target setting process, along with broader policy recommendations to achieve the overall VMT reductions identified in the scenario as part of the Scoping Plan Update.

Finally, as part of the California Sustainable Freight Action Plan[22], ARB and other State agencies are providing a recommendation on a high level vision, targets, and broad direction to the Governor to consider for State agencies to utilize when developing specific investments, policies, and programs related to the freight transport system that serves our State's transportation, environment, and economic interests.

[21] Scoping Plan http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm
[22] Sustainable Freight Transport Initiative http://www.arb.ca.gov/gmp/sfti/sfti.htm

Table 3: Proposed Measures and Implementation Schedule

Measures	Agency	Action	Implementation Begins
On-Road Light-Duty			
Advanced Clean Cars 2	ARB	2020	2026
Lower In-Use Performance Assessment	ARB / BAR	n/a	ongoing
Further Deployment of Cleaner Technologies	ARB / SCAQMD / U.S. EPA	ongoing	2016
On-Road Heavy-Duty			
Lower In-Use Emission Performance Level	ARB	2016	2017
Low-NOx Engine Standard – California Action	ARB	2017 - 2019	2023
Low-NOx Engine Standard – Federal Action	U.S. EPA	2017 - 2019	2024
Medium and Heavy-Duty GHG Phase 2	ARB / U.S. EPA	2016 - 2019	2018
Advanced Clean Transit	ARB	2017	2018
Last Mile Delivery	ARB	2018	2020
Innovative Technology Certification Flexibility	ARB	2016	2016
Zero-Emission Airport Shuttle Buses	ARB	2018	2023
Incentive Funding to Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles	ARB / SCAQMD	ongoing	2016
Further Deployment of Cleaner Technologies	ARB / SCAQMD / U.S. EPA	ongoing	2016
Off-Road Federal and International Sources			
More Stringent National Locomotive Emission Standards	U.S. EPA	2016	2023
Tier 4 Vessel Standards	ARB / IMO	2015 - 2018	2025
Incentivize Low-Emission Efficient Ship Visits	ARB	2017 - 2018	2018
At-Berth Regulation Amendments	ARB	2017 - 2018	2022
Further Deployment of Cleaner Technologies	ARB / SCAQMD / U.S. EPA	ongoing	2016
Off-Road Equipment Sources			
Zero-Emission Off-Road Forklift Regulation Phase 1	ARB	2020	2023
Zero-Emission Off-Road Emission Reduction Assessment	ARB	2025	--
Zero-Emission Off-Road Worksite Emission Reduction Assessment	ARB	tbd	--
Zero-Emission Airport Ground Support Equipment	ARB	2018	2023
Small Off-Road Engines	ARB	2018	2022
Transport Refrigeration Units Used for Cold Storage	ARB	2017 - 2018	2020
Low-Emission Diesel Requirement	ARB	by 2020	2023
Further Deployment of Cleaner Technologies	ARB / SCAQMD / U.S. EPA	ongoing	2016

Statewide Emission Reductions from Proposed Measures

Table 4 shows the Statewide benefits of the proposed measures for both criteria pollutants and GHG emissions. The existing control program, and reductions that will occur as implementation continues, will provide a significant portion of the necessary reductions. Key new actions across all pollutants include the Advanced Clean Cars 2 regulation requiring increasing ZEV penetration, the next generation in heavy-duty truck standards for both NOx and GHGs, and the introduction of zero-emission technologies in targeted on- and off-road applications, particularly those for last mile delivery and forklifts.

In aggregate, the combination of existing programs and proposed new measures will reduce NOx emissions by over 950 tpd Statewide by 2031. The majority of new NOx reductions accrue from the heavy-duty fleet through the low-NOx engine standard, and from more stringent engine standards established for federal and international sources such as locomotives and ocean going vessels. The measures will also contribute to further PM2.5 reductions, predominately in the off-road vehicle and equipment fleet. New PM2.5 reductions also result from the low-emission diesel measure that reduces emissions of diesel PM through the displacement of petroleum-based diesel with renewable clean diesel fuels. In addition, the measures reduce emissions of reactive organic gases (ROG), which come predominately from increased penetration of ZEV technologies for light-duty vehicles, and off-road equipment such as lawn and garden equipment.

The measures are also projected to reduce mobile source GHG emissions statewide by 20 million metric tons of carbon dioxide equivalency (MMTCO2e) in 2030. Key actions include the Advanced Clean Cars 2 regulation for light-duty vehicles, and implementation of the Phase 2 GHG regulation for heavy-duty trucks. These technology measures provide the majority of the reductions needed to meet the 2030 GHG reduction goal. The remaining reductions would be achieved through expansion of renewable fuel requirements and actions to reduce growth in VMT. The benefits of the technology measures will also continue to grow significantly through 2050 as the penetration of cleaner technologies increases over time.

Table 4: Statewide Expected Emission Reductions

Criteria emission reductions in tons per day (tpd) from current levels
GHG emission reductions in million metric tons of carbon dioxide equivalent (MMTCO2e) from current levels

Proposed Measure	2031			
	NOx	ROG	PM2.5	GHG
On-Road Light-Duty				
Reductions from Current Control Program	160	165	-1	NYQ
Advanced Clean Cars 2	2	0.8	<0.1	7
Lower In-Use Emission Performance Assessment	NYQ	NYQ	NYQ	NYQ
Further Deployment of Cleaner Technologies	5	16	0.1	5
Total Category Reductions	**167**	**182**	**-1**	**12**
On-Road Heavy-Duty				
Reductions from Current Control Program	338	30	6	NYQ
Lower In-Use Emission Performance Level	NYQ	NYQ	NYQ	NYQ
Low-NOx Engine Standard – California Action	24	--	--	--
Low-NOx Engine Standard – Federal Action	28	--	--	--
Medium and Heavy-Duty GHG Phase 2	NYQ	NYQ	NYQ	6
Advanced Clean Transit	0.5	<0.1	<0.1	0.3
Last Mile Delivery	1	<0.1	<0.1	0.4
Innovative Technology Certification Flexibility	NYQ	NYQ	NYQ	NYQ
Zero-Emission Airport Shuttle Buses	NYQ	NYQ	NYQ	NYQ
Incentive Funding to Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles	3	0.3	--	<0.1
Further Deployment of Cleaner Technologies	11	1	--	0.3
Total Category Reductions	**406**	**32**	**6**	**7**
Off-Road Federal and International Sources*				
Reductions from Current Control Program	92	-4	-4	NYQ
More Stringent National Locomotive Emission Standards	44	2	0.7	NYQ
Tier 4 Vessel Standards	25	--	--	--
Incentivize Low-Emission Efficient Ship Visits	NYQ	NYQ	NYQ	NYQ
At-Berth Regulation Amendments	1	0.1	<0.1	0.1
Further Deployment of Cleaner Technologies	30	0.4	NYQ	NYQ
Total Category Reductions	**191**	**-2**	**-3**	**0.1**
Off-Road Equipment				
Reductions from Current Control Program	161	69	10	NYQ
Zero-Emission Off-Road Forklift Regulation Phase 1	2	0.2	<0.1	1
Zero-Emission Off-Road Emission Reduction Assessment	NYQ	NYQ	NYQ	NYQ
Zero-Emission Off-Road Worksite Emission Reduction Assessment	NYQ	NYQ	NYQ	NYQ
Zero-Emission Airport Ground Support Equipment	<0.1	<0.1	<0.1	<0.1
Small Off-Road Engines	4	36	<0.1	<0.1
Transport Refrigeration Units Used for Cold Storage	NYQ	NYQ	NYQ	NYQ
Low-Emission Diesel Requirement	8	NYQ	1	NYQ
Further Deployment of Cleaner Technologies	17	20	NYQ	NYQ
Total Category Reductions	**192**	**125**	**11**	**1**
Total Expected Emission Reductions	**956**	**337**	**13**	**20**

* Quantification of emission reductions are based on current growth forecasts, which are undergoing review.
"NYQ" denotes emission reductions are Not Yet Quantified; "—" denotes no anticipated reductions

Regional Emission Reductions from Proposed Measures

In addition to providing significant benefits Statewide, Tables 5 and 6 show the regional reductions of criteria pollutants that will be incorporated into local attainment plans for the South Coast and the San Joaquin Valley. The emission reduction commitments for these two areas are further described in the State SIP Strategy.

South Coast Emission Reductions

The measures included for the South Coast, in conjunction with the existing control program, identify all of the reductions needed to achieve a 70 percent reduction in NOx emissions from mobile sources by 2023, and an 80 percent reduction by 2031. Approximately 80 percent of the reductions needed to meet the ozone standard in 2031 will come from regulatory actions associated with ongoing implementation of the existing control program and incentive programs, combined with new regulatory measures identified in the mobile source strategy. The remaining 20 percent will come from additional actions to enhance the deployment of these cleaner technologies through new incentive funding, efficiency improvements in moving people and freight, and support for the use of advanced transportation technologies such as intelligent transportation systems and autonomous vehicles. Together with the existing program, the actions called for in the strategy are designed to achieve 305 tons per day of NOx reductions by 2031. These measures also provide PM2.5 and ROG reductions. The anticipated emission reductions in the South Coast from the proposed strategy measures are summarized in Table 5.

San Joaquin Valley Emission Reductions

Air quality modeling has demonstrated that the substantial reductions from implementation of the existing mobile source control program will provide for attainment of both the 80 ppb ozone standard in 2023, and the 75 ppb ozone standard in 2031. These programs will reduce NOx emissions in the Valley by 134 tpd between 2015 and 2031. The new measures identified in this document will provide additional NOx reductions to enhance air quality progress. The anticipated NOx emission reductions in the Valley from the proposed strategy measures are summarized in Table 6.

Table 5: South Coast Expected Emission Reductions
Emission reductions in tons per day (tpd) from current levels

Proposed Measure	2031			2023
	NOx	ROG	PM2.5	NOx
On-Road Light-Duty				
Reductions from Current Control Program	62	65	0.3	48
Advanced Clean Cars 2	0.6	0.3	<0.1	--
Lower In-Use Emission Performance Assessment	NYQ	NYQ	NYQ	NYQ
Further Deployment of Cleaner Technologies	5	16	0.1	7
Total Category Reductions	**68**	**81**	**0.4**	**55**
On-Road Heavy-Duty				
Reductions from Current Control Program	94	8	1	86
Lower In-Use Emission Performance Level	NYQ	NYQ	NYQ	NYQ
Low-NOx Engine Standard – California Action	5	--	--	--
Low-NOx Engine Standard – Federal Action	7	--	--	--
Medium and Heavy-Duty GHG Phase 2	NYQ	NYQ	NYQ	NYQ
Advanced Clean Transit	0.1	<0.1	<0.1	<0.1
Last Mile Delivery	0.4	<0.1	<0.1	<0.1
Innovative Technology Certification Flexibility	NYQ	NYQ	NYQ	NYQ
Zero-Emission Airport Shuttle Buses	NYQ	NYQ	NYQ	NYQ
Incentive Funding to Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles	3	0.4	--	3
Further Deployment of Cleaner Technologies	11	1	--	34
Total Category Reductions	**121**	**10**	**1**	**123**
Off-Road Federal and International Sources*				
Reductions from Current Control Program	12	-3	-0.6	7
More Stringent National Locomotive Emission Standards	8	0.3	0.1	0.7
Tier 4 Vessel Standards	4	--	--	--
Incentivize Low-Emission Efficient Ship Visits	NYQ	NYQ	NYQ	NYQ
At-Berth Regulation Amendments	1	<0.1	<0.1	0.3
Further Deployment of Cleaner Technologies	30	0.4	NYQ	40
Total Category Reductions	**56**	**-3**	**-0.5**	**48**
Off-Road Equipment				
Reductions from Current Control Program	40	24	2	27
Zero-Emission Off-Road Forklift Regulation Phase 1	1	0.1	<0.1	--
Zero-Emission Off-Road Emission Reduction Assessment	NYQ	NYQ	NYQ	NYQ
Zero-Emission Off-Road Worksite Emission Reduction Assessment	NYQ	NYQ	NYQ	NYQ
Zero-Emission Airport Ground Support Equipment	<0.1	<0.1	<0.1	<0.1
Small Off-Road Engines	2	16	<0.1	0.7
Transport Refrigeration Units Used for Cold Storage	NYQ	NYQ	NYQ	NYQ
Low-Emission Diesel Requirement	2	NYQ	0.2	0.6
Further Deployment of Cleaner Technologies	17	20	NYQ	21
Total Category Reductions	**61**	**60**	**3**	**50**
	305	**148**	**4**	**275**

* Quantification of emission reductions are based on current growth forecasts, which are undergoing review.
"NYQ" denotes emission reductions are Not Yet Quantified
"—" denotes no anticipated reductions

Table 6: San Joaquin Valley Expected Emission Reductions
Emission reductions in tons per day (tpd) from current levels

Proposed Measure	2031		
	NOx	ROG	PM2.5
On-Road Light-Duty			
Reductions from Current Control Program	17	18	-0.5
Advanced Clean Cars 2	0.2	<0.1	<0.1
Lower In-Use Emission Performance Assessment	NYQ	NYQ	NYQ
Total Category Reductions	**17**	**18**	**-0.5**
On-Road Heavy-Duty			
Reductions from Current Control Program	72	5	1
Lower In-Use Emission Performance Level	NYQ	NYQ	NYQ
Low-NOx Engine Standard – California Action	7	--	--
Low-NOx Engine Standard – Federal Action	8	--	--
Advanced Clean Transit	<0.1	<0.1	<0.1
Last Mile Delivery	0.2	<0.1	<0.1
Innovative Technology Certification Flexibility	NYQ	NYQ	NYQ
Zero-Emission Airport Shuttle Buses	<0.1	<0.1	<0.1
Total Category Reductions	**88**	**5**	**1**
Off-Road Federal and International Sources*			
Reductions from Current Control Program	2	-0.6	-0.3
More Stringent National Locomotive Emission Standards	5	0.2	<0.1
Total Category Reductions	**7**	**-0.4**	**-0.3**
Off-Road Equipment			
Reductions from Current Control Program	43	11	2
Zero-Emission Off-Road Forklift Regulation Phase 1	<0.1	<0.1	<0.1
Zero-Emission Airport Ground Support Equipment	<0.1	<0.1	<0.1
Small Off-Road Engines	0.3	3	<0.1
Transport Refrigeration Units Used for Cold Storage	NYQ	NYQ	NYQ
Low-Emission Diesel Requirement	1	NYQ	0.2
Total Category Reductions	**45**	**13**	**2**
Total Expected Emission Reductions	**157**	**36**	**3**

* Quantification of emission reductions are based on current growth forecasts, which are undergoing review.
"NYQ" denotes emission reductions are Not Yet Quantified
"—" denotes no anticipated reductions

5. Economic Assessment

The actions outlined in the Mobile Source Strategy are designed to transform California's transportation sector. The combination of proposed measures and incentives will shift California from reliance on petroleum-based to zero and near-zero emission vehicles and fuels. This shift will be represented by changes in the California economy as industry and individuals shift demand to low-emissions technologies and fuels and away from higher emission vehicles, equipment, and fuels.

The economic analysis of the Mobile Source Strategy includes the statewide costs, savings and emission reduction benefits of all proposed measures with quantified emission reductions under State and federal jurisdiction, including passenger vehicles, heavy-duty trucks, locomotives, commercial ships, goods movement, construction and mining equipment, engine exhaust and evaporation, and fuels. To achieve the emission reductions outlined in the Mobile Source Strategy, ARB has estimated the incremental costs of zero and near-zero emission technologies compared to their conventional counterparts. These incremental costs include capital, fueling infrastructure, and annual operations and maintenance (O&M) costs unique to each mobile source type. These cost differentials are used to calculate the costs over a vehicle or equipment population generated by ARB's Vision model.

The Mobile Source Strategy measures, when adopted as regulatory and programmatic actions, are likely to cause technological changes that could increase the production costs for regulated industries. Increased costs could have an initial contradictory effect on those industries, which in turn could affect other related industries either negatively or positively. The net effect on the California economy of these activities hinges on the extent to which products and services are obtained locally.

Benefits

The measures contained in the Mobile Source Strategy are anticipated to deliver broad environmental benefits that include an estimated reduction of 206 tons per day (tpd) of NOx, 87 tpd ROG, 2 tpd PM2.5, and 20 MMT carbon dioxide (CO_2) equivalent. The investments made to deploy cleaner technology vehicles, equipment, and fuels will also provide broad environmental benefits, as well as significant social and health benefits (including fewer illnesses and reduced medical expenses, and fewer lost work and school days) to Californians. These broad benefits, while potentially significant, are not quantified in this analysis.

The benefits achieved through the Mobile Source Strategy are part of California's comprehensive strategy to achieve lasting emission reductions in the mobile source sector. ARB's strategic vision for the sector is based on the principle that economic prosperity and environmental sustainability can be achieved together. Undertaking the transformative actions outlined in the Mobile Source Strategy will continue California's long and successful legacy of building a world-class economy in concert with innovative and effective environmental and public health policies. Innovations in clean vehicles, fuels, and equipment provide an opportunity for California to continue to leverage its position as a leader in the high-tech, green economy resulting in deep emission reductions across the State.

Proposed measures in the Mobile Source Strategy will also result in emission reductions outside of California as vehicles and equipment subject to the proposed measures may also operate outside the State. These emission reductions and any resulting benefits, included those to human and ecosystem health, and are not quantified in this analysis. Social benefits related to the anticipated California emissions reductions are also not included in the economic modeling of the Mobile Source Strategy.

Costs

As modeled in *Appendix A: Economic Analysis of the Mobile Source Strategy*, the Mobile Source Strategy is estimated to have a negligible impact on the California economy resulting in an average slowing of Gross State Product (GSP) growth of 0.051 percent per year from 2023 to 2031. This slight reduction in growth does not represent a discernable change from the baseline GSP growth estimates and the overall impact of the Mobile Source Strategy is small relative to the $2.3 trillion California economy.

While the cumulative impact of the Mobile Source Strategy is not anticipated to significantly impact the broad California economy, it will incentivize zero-and near-zero emission technology as shown in shifts in employment and output among industrial sectors. The implementation of the Mobile Source Strategy is estimated to result in accelerated employment growth across many industry sectors as a result of reduced fuel costs resulting from use of zero and near-zero emission vehicles, and a negligible

slowing of employment growth in other industry sectors that produce high emission goods.

Similarly, California businesses are anticipated to see a negligible decrease in output across the majority of industrial sectors, with the exception of industries that generate clean energy and those that gain significant fuel savings through capital turnover to zero-and near-zero technologies. At the consumer level, there is an estimated decline in personal income growth as consumers increase spending on cleaner fuels and technologies as the proposed measures are implemented.

6.
On-Road Light-Duty Sector

The light-duty transportation sector includes light-duty vehicles (LDVs) such as passenger cars, minivans, most sport utility vehicles and pickup trucks, and motorcycles. Since the 1960s, the Board has been successfully reducing emissions from the light-duty transportation sector through technology forcing emission standards. As a result, LDVs are now 99 percent cleaner than their uncontrolled counterparts. Board action has also successfully brought to market ZEVs and PHEVs. Due to the success of ARB regulations, light-duty vehicle NOx emissions are projected to decrease by nearly 80 percent from 2015 to 2031 in the South Coast Air Basin.

Current Suite of Programs

In 2012, the Board adopted the Advanced Clean Cars (ACC) rulemaking, which is a suite of regulations that ensure emission reductions from the State's LDV fleet. The ACC brought together three major regulations that were previously separate. Two of these regulations, the LEV III GHG and LEV III criteria emission rules, are fleet average performance standards for new vehicles that provide for continued annual emission reductions as the stringency increases through 2025. These programs apply to the entire light-duty fleet by setting an average emissions requirement across all new vehicles that creates inherent market flexibility for compliance. The third program, the ZEV Regulation, focuses on advanced technology development and fleet penetration of ZEVs and PHEVs. The ZEV regulation ensures that advanced electric drive technology is commercialized and brought to production scale for cost reductions by 2025.

Also in 2012, the Board found federal GHG vehicle standards to be equivalent with California standards, and therefore allowed manufacturers the option to comply with federal standards or with California standards. The Board also agreed to participate in

a joint-agency review of the 2022 through 2025 model year standards, commonly referred to as the midterm review, with the National Highway and Traffic Safety Administration and U.S. EPA. In addition to participation in the joint-agency review of the GHG standards, the Board directed staff to review the feasibility of accelerating the LEV III regulation's 1 milligram per mile particulate matter standards. Staff will present the findings of the midterm review to the Board in 2016, and will conduct a subsequent rulemaking to modify the standards if necessary. The midterm review provides the Board an opportunity to reaffirm the importance of the ZEV program with sufficient lead time that any necessary adjustments, including the possibility of increasing the standards, will be possible by the 2022 model year. The findings of the midterm review will also play a role in informing future light-duty vehicle standards beyond 2025.

It can take decades for a new propulsion system to capture a large fraction of the LDV fleet because new technologies require time for vehicle manufacturers to incorporate them into numerous vehicle models with consumer acceptance. Once new technologies are widely available, it can take over 15 years for these new vehicle models to fully replace existing vehicles in the fleet with natural turnover. Further, ZEV technology consumer acceptance is also a function of vehicle range, access to widespread infrastructure throughout the operating life of the vehicle, and driver behavior to charge the vehicle.

Therefore, incentive programs have been essential in facilitating the light-duty fleet transition to zero and near-zero emission technologies. ARB's Air Quality Improvement Program (AQIP), is a voluntary incentive program to fund clean vehicle and equipment projects. Started in 2009, the Clean Vehicle Rebate Project is one of the current projects under AQIP, and is designed to accelerate widespread commercialization of ZEVs and plug-in hybrid electric vehicles by providing consumer rebates to partially offset the higher cost of these advanced technologies. Similarly, the Enhanced Fleet Modernization Program (EFMP) and EFMP Plus-Up programs provide funding to low-income consumers to remove older light-duty vehicles from the fleet and replace them with cleaner alternatives. Federal incentives also exist to provide additional financial assistance.

In addition to vehicle policies and programs that expand ZEV sales, emission reductions from ZEVs are influenced by fuel-related government actions, including fuel supply policies that require a reduction in carbon intensity and/or use of renewable feedstock. Complementary policies such as ARB's Low Carbon Fuel Standard and the Public Utilities Commission's (PUC) Renewable Portfolio Standard play a critical role in ensuring that total emissions from ZEVs remain substantially cleaner than conventional vehicles. Public incentives and planning support have also been instrumental in developing and expanding advanced renewable fuel distribution networks throughout the State, including electric charging equipment and hydrogen stations.

To further foster the commercialization of ZEVs and PHEVs, automotive manufacturers have partnered with energy providers, government, and non-governmental organizations to jointly address market barriers and gaps through public-private partnerships such as the California Plug-in Electric Vehicle Collaborative and the

California Fuel Cell Partnership. Collaboration between members has resulted in the development of infrastructure best practices, local government guidance and support, public messaging and outreach, and collective engagement with standards setting organizations.

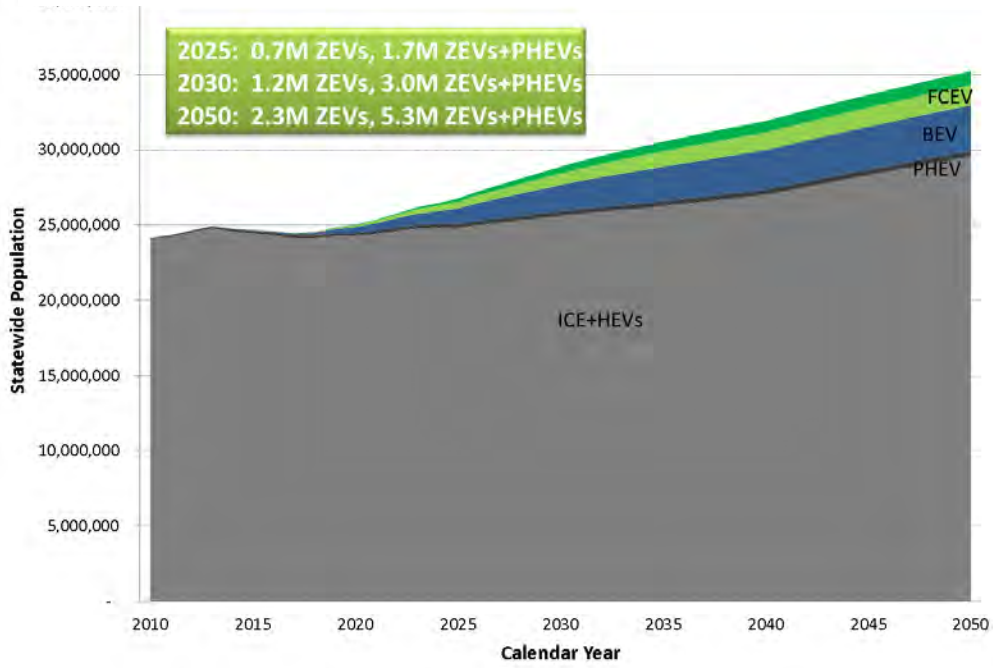
The Importance of ZEVs

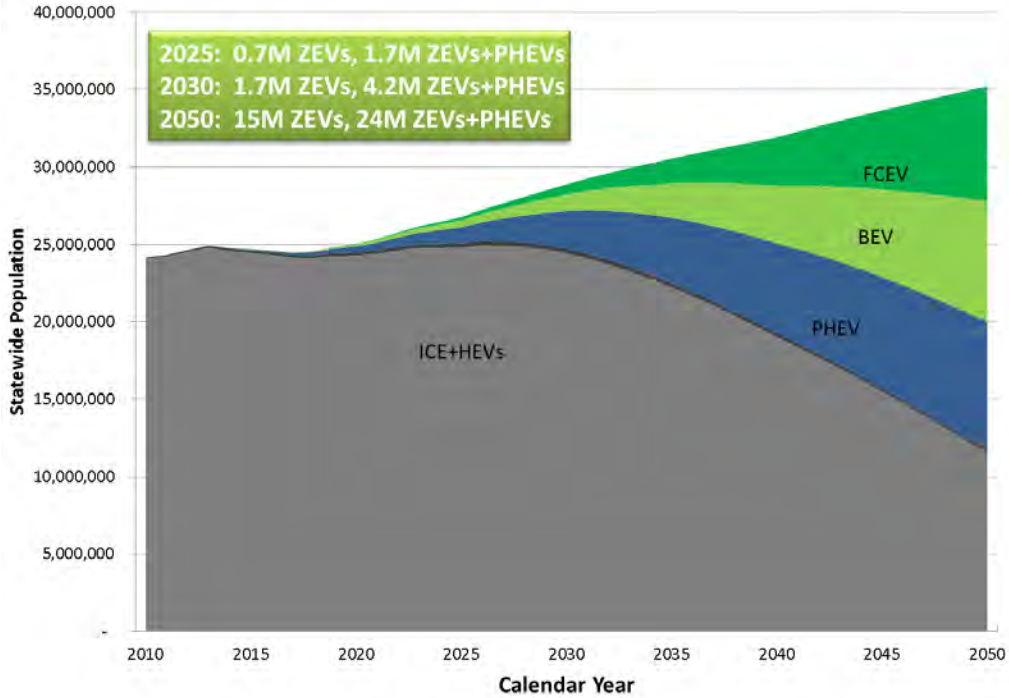
The updated Vision analysis shows the vast majority of the on-road fleet must be ZEVs and PHEVs by 2050 in order to meet GHG targets, requiring sales to achieve nearly 100 percent ZEVs (BEVs, FCVs, and PHEVs combined) by that point. All scenario iterations explored by ARB show this consistent trend, though the mix of electric vehicle technology types may vary. Pure ZEV technology will be necessary well beyond the ZEV regulation levels in 2025. Plug-in hybrid electric vehicles could also comprise a large fraction of the fleet so long as the fraction of their mileage that is electric remains high throughout their lifespan.

The *Cleaner Technology and Fuels* scenario described in Chapter 3 was developed with a few key themes in mind: the need for zero-emission technology development, the limit on renewable fuels available to meet GHG targets, and the current state of technology development in the light duty sector. Given these themes, staff's *Cleaner Technology and Fuels* scenario focused on the deployment of ZEV technologies over near-zero emission technologies. As shown in Figure 15, the Advanced Clean Car Regulation will result in 3.0 million combined ZEVs and PHEVs Statewide in 2030, and increasing to 5.3 million in 2050.

As ZEV and PHEV sales increase, emission benefits associated with those vehicles are included as part of the fleet-wide performance standards. For this reason, it is important to continue to maintain a strong ZEV regulation in order to commercialize the technology, and couple that with fleet performance standards to ensure sufficient levels of penetration of vehicles operating on the new technology.

Figure 15: Projected Statewide Light Duty Vehicle Technology Mix





*Vehicle populations in the *Cleaner Technologies and Fuel Scenario* does not include the additional ZEVs from Further Deployment measures

Proposed Measures: On-Road Light-Duty Vehicles

Passenger cars and light trucks (up to 8,500 lbs.), otherwise called light-duty vehicles, are a major contributor to smog-forming and GHG emissions in California. The State's 39 million residents collectively own about 25 million passenger vehicles and drive more than most other Americans. Over ten million of these vehicles are in the South Coast. The vast majority of these vehicles have internal combustion engines and use gasoline. A small portion is powered by diesel compression ignition engines, and a smaller portion still has electric powertrains. The light-duty vehicle sector is projected to grow to approximately 30 million vehicles statewide by 2031 and will increasingly rely on electric drive vehicles of varying types (e.g. battery electric, plug-in hybrid, or fuel cell electric vehicles).

These measures contained in the mobile source strategy reflect the current status of the light-duty fleet, and recognize that much of the necessary zero-emission technology has been developed and is currently commercially available for light-duty vehicles. Multiple car manufacturers offer passenger BEVs, FCEVs, and PHEVs with a large portion operating in an "all-electric range" that provide NOx and GHG emission reductions compared with conventional internal combustion vehicles.

Measures include requirements for further emission reductions from advanced gasoline vehicles and requirements to accelerate the deployment of ZEVs and PHEVs to encourage more widespread penetration. Measures also focus on supporting penetration of these vehicle technologies through incentive programs, which help to ensure that ZEVs and PHEVs are priced competitively relative to conventional vehicles. Other aspects address non-financial considerations, such as consumer preference for greater range and expanded refueling infrastructure to increase the convenience of refueling ZEVs and PHEVs. Finally, the on-board diagnostics assessment measures will help to ensure that vehicles are operating at intended emission levels throughout their useful life

Advanced Clean Cars 2

Overview:

The goal of this proposed measure is to make sure that zero and near-zero emission technology options continue to be commercially available, with electric driving range improvements to address consumer preferences and to maximize electric vehicle miles traveled (eVMT). ARB would consider expanded California-specific standards for new light-duty vehicles to increase the number of new ZEVs and PHEVs sold in California and increased stringency of fleet-wide emission standards.

Background / Regulatory History:

Since setting the nation's first motor vehicle exhaust emission standards in 1966 that led to the first pollution controls, California has dramatically tightened emission standards for light-duty vehicles. Through ARB regulations, today's new cars pollute 99 percent less than their predecessors did thirty years ago. In 1970, ARB required auto manufacturers to meet the first standards to control NOx emissions along with hydrocarbon emissions, which together form smog. The simultaneous control of emissions from motor vehicles and fuels led to the use of cleaner-burning gasoline that has removed the emissions equivalent of 3.5 million vehicles from California's roads. Since ARB first adopted it in 1990, the Low Emission Vehicle Program (LEV 1 and LEV 2) and Zero-Emission Vehicle (ZEV) Programs have resulted in the production and sales of hundreds of thousands of zero-emission vehicles (ZEVs) in California. More recently, there is a focus on reducing GHGs from motor vehicles. Transportation is California's largest source of carbon dioxide, with passenger vehicles and light-duty trucks creating more than 30 percent of total climate change emissions. ARB adopted the first GHG emission standards for new passenger vehicles in the United States, effective with the 2009 model years.

Proposed Actions:

For this proposed measure, ARB staff would develop a regulation based on the technology and market assessments for advanced technology vehicles that would increase the number of new ZEVs and PHEVs sold in California. The regulation may include lowering fleet emissions further beyond the super-ultra-low-emission vehicle (SULEV) standard for the entire light-duty fleet through at least the 2030 model year, and look at ways to improve real world emissions through implementation programs. Additionally, new standards would be considered to further increase the sales of ZEVs and PHEVs in 2026 (and later years) beyond the levels required to ensure future emission reduction, climate, and petroleum targets are met.

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.11[23] model to estimate the emission reductions associated with this proposed measure. Baseline projections include emissions from light- and medium-duty passenger car, trucks, and sport utility vehicles. Baseline emissions reflect projected benefits from the LEV III criteria emission vehicle fleet standards which have increasing stringency for new vehicles through the model year 2025. Emission reductions projected beyond baseline are calculated assuming new vehicles continue to become cleaner through the year 2031. ARB staff assumed a combined passenger vehicle (LDA/LDT2) ZEV/PHEV sales increase from 18 percent to 40 percent between 2025 and 2030, medium-duty trucks (MDV) ZEV/PHEV sales beginning 2026, ramping up to 10 percent by 2030, with 100 percent sales of super-ultra-low-emission vehicles certified to the SULEV 20 exhaust emission standards by 2030 for gasoline light-duty automobiles (LDAs). ARB staff also modeled increased fuel efficiency (at approximately 2.9 percent per year) between 2025 and 2035 for gasoline vehicles.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
2	0.8	<0.1	7

Timing:

Proposed ARB Board adoption: By 2020
Implementation schedule: 2026 – 2030

[23] Vision Scenario Planning http://www.arb.ca.gov/planning/vision/vision.htm

Lower In-Use Emission Performance Assessment

Overview:

The goal of this proposed measure is to ensure that in-use vehicles continue to operate at their cleanest possible level. This joint ARB and Bureau of Automotive Repair (BAR) assessment is an ongoing further study measure focused on in-use performance and diagnostic inspection procedures.

Description of Source Category:

This evaluation will apply to all On-Board Diagnostic (OBD) II equipped vehicles that are subject to the Smog Check program. OBD II is the second generation of requirements for on-board, self-diagnostic equipment that monitors a vehicle's control components to ensure they are functioning correctly. Light- and medium-duty vehicles are major contributors of air pollutants in the South Coast. While VMT increased more than 50 percent over the last 20 years, vehicle emissions have dropped threefold due to increasingly stringent vehicle emission standards. Yet, the light- and medium-duty vehicle fleet continues to contribute significantly to the NOx emissions in the State. Studies show that the highest emitting 20 percent of the light-duty fleet contribute well over 50 percent of the fleet's total emissions, emphasizing the need to identify and repair these high emitting vehicles.

Background / Regulatory History:

<u>OBD II</u>

California's first OBD regulation required manufacturers to monitor some of the emission control components on vehicles starting with the 1988 model year. In 1989, ARB adopted OBD II, which required 1996 and subsequent model year passenger cars, light-duty trucks, and medium-duty vehicles and engines to be equipped with second generation OBD systems. OBD systems are designed to identify when a vehicle's emission control systems or other emission-related computer-controlled components are malfunctioning, causing emissions to be elevated above the vehicle manufacturer's specifications. ARB subsequently strengthened OBD II requirements and added OBD II specific enforcement requirements for 2004 and subsequent model year passenger cars, light-duty trucks, and medium-duty vehicles and engines. In 2005, the Board adopted regulations that required OBD systems in heavy-duty engines (HD OBD) beginning in the 2010 model year and that established HD OBD-specific enforcement requirements.

<u>Smog Check</u>

BAR is the state agency charged with administration and implementation of the Smog Check Program. The Smog Check Program is designed to reduce air pollution from California registered light-duty vehicles by requiring periodic inspections for emission-control system problems, and by requiring repairs for any problems found.

Prior to 2015, Smog Check stations relied on the BAR-97 Emissions Inspection System (EIS) to test tailpipe emissions with either a Two-Speed Idle (TSI) or Acceleration Simulation Mode (ASM) test depending on the program area. For instance, vehicles registered in urbanized areas or "Enhanced Areas," received an ASM test, while vehicles in rural areas or "Basic Areas" received a TSI test.

Assembly Bill (AB) 2289 (Eng, Chapter 258, Statutes of 2010) required BAR to implement a new protocol for testing 2000 and newer model-year vehicles. This new test, which relies primarily on the vehicle's OBD system, provides for a faster and more cost effective inspection compared to tailpipe testing. The BAR-97 EIS utilized OBD test equipment; however, this equipment was outdated and incapable of collecting complete OBD information for all vehicles. To facilitate state-of-the-art OBD-based testing, BAR developed equipment specifications for a new OBD communications device, referred to as the Data Acquisition Device (DAD), which is a component of the new OBD Inspection System (OIS) that replaces the EIS. These changes are aimed at providing for quicker and potentially less costly Smog Check inspections for consumers, and lower Smog Check station operating costs, all while preserving, or even enhancing the emission benefits associated with the Smog Check Program. However, because the OBD inspection procedure does not provide for direct measurement of vehicle emission levels, ARB believes it is prudent to monitor the effectiveness of the new procedure in identifying vehicles in need of emission repairs, and to implement changes necessary to address any issues that are uncovered.

Proposed Actions:

ARB and BAR staff would perform a comprehensive evaluation of California's in-use performance-focused inspection procedures and, if necessary, make improvements to further the Smog Check Program's effectiveness. ARB will conduct a study to further evaluate California's in-use performance inspection procedures through analysis of the Smog Check database and vehicle sampling obtained through BAR's Random Roadside Inspection Program. Comparison of test results from the fleet at the time Smog Check inspections take place with the results of roadside inspections conducted at random times in between Smog Check inspections will allow for analysis of Smog Check station performance, repair durability, the real-world performance of OBD II systems in detecting emission-related problems, and other factors that impact the emission benefits provided by the program. Further investigation and analysis of in-use vehicles at the ARB Haagen-Smit Laboratory will be conducted as needed based on the preliminary findings of the roadside data. Results from the study can be used to improve inspection test procedures, address program fraud, improve the effectiveness and durability of emission-related repair work, and to improve the regulations governing the design of in-use performance systems on motor vehicles to the extent necessary.

Estimated Emission Reductions:

As this proposed measure is a study to further evaluate the California's in-use performance and vehicle inspection and maintenance program, anticipated emission reductions are not identified at this time. This measure may provide emission reduction;

should the evaluation identify necessary program improvements, the emission reduction potential and cost effectiveness of such enhancements will be identified at that time.

Timing:

Proposed ARB Board adoption:	n/a
Implementation schedule:	ongoing

Further Deployment of Cleaner Technologies: On-Road Light-Duty Vehicles

The goals of this proposed measure are to accelerate the penetration of zero and near-zero emission vehicles and to promote in-use efficiency gains related to vehicle miles travelled (VMT), and through use of autonomous vehicles and advanced transportation systems.

Background / Regulatory History:

ARB's mobile source regulatory program is complemented by additional efforts that reduce emissions. These include incentive programs and implementation of SB 375. Incentive Programs are intended to accelerate the introduction of advanced technology vehicles, accelerate the turnover of the oldest, highest emitting vehicles, and increase access to clean vehicles and transportation in disadvantaged communities and lower-income households. The three programs established by Assembly Bill (AB) 118 (Núñez, Chapter 750, Statutes of 2007) and reauthorized by AB 8 (Perea, Chapter 401, Statutes of 2013) provide funding for light-duty vehicle incentives. These include are ARB's Air Quality Improvement Program (AQIP), California's Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program, and the ARB / Bureau of Automotive Repair's (BAR) Enhanced Fleet Modernization Program (EFMP). More recently, Cap-and-Trade auction proceeds have greatly expanded the scale of light-duty vehicle incentive funding. Local air district incentive programs complement these statewide efforts. The State's light-duty incentive strategy includes:

- *ZEV Deployment and Infrastructure:* ARB's Clean Vehicle Rebate Project (CVRP) provides consumer rebates for the purchase of zero-emission and plug-in hybrid passenger vehicles in order to increase the number of ZEVs on California's roadways and help achieve the large scale transformation of the fleet. The Energy Commission's electric vehicle charging and hydrogen fueling infrastructure investments complement ARB's vehicle deployment incentives.

- *Disadvantaged Community Programs:* CVRP is complemented by incentives aimed at increasing access to these clean vehicles in disadvantaged communities and lower-income households. These include car sharing and other mobility improvement programs and financing assistance, among others.

- *Car Scrap:* EFMP provides incentives to lower-income vehicle owners to retire older, higher emitting vehicles. EFMP includes pilot programs run by the South Coast and San Joaquin Valley air districts that provide additional incentives for lower-income vehicle owners who replace their scrapped vehicles with cleaner, more fuel-efficient vehicles, and the EFMP Plus-Up pilot provides an even greater incentive for ZEV, hybrid, or plug-in hybrid replacement vehicles in underserved communities.

Proposed Actions:

This proposed measure is designed to achieve further emission reductions for South Coast attainment in 2023 and 2031 through a suite of additional actions, including early penetration of zero and near-zero technologies, and emission benefits associated with increased transportation efficiencies, as well as the potential for autonomous vehicles and advanced transportation systems. The emission reductions will be achieved through a combination of actions to be undertaken by both ARB and the South Coast. These actions reflect an initial assessment of a pathway, recognizing that as funding is allocated and advanced technologies further develop, the balance amongst approaches will necessarily adjust.

<u>Scope of Technology Penetration and Mechanisms to Achieve Reductions:</u>
The Advanced Clean Cars regulation brings together a suite of regulations, including the LEV III standards and the ZEV regulation. To achieve the further reductions associated with early penetration of the zero and near-zero vehicle technologies established under the ZEV regulation, ARB and South Coast staff estimate that approximately 500,000 to 600,000 of the oldest passenger cars and trucks would need to be turned over to model year vehicles meeting the currently applicable LEV III emission standard or advanced hybrid or zero-emission technology by 2023. The following mechanisms provide a pathway for achieving this scale of technology deployment:

- Expand and enhance existing incentive and other innovative funding programs for light-duty vehicles in order to accelerate the replacement of older vehicles with vehicles meeting a LEV III or better emissions level. Assuming incentive funding is the primary mechanism to achieve the scope of further technology deployment described above, funding would be required for approximately 70,000 to 85,000 vehicles per year over a seven year period. The incentive funding required for this effort would go beyond the amount currently authorized for existing programs through 2023. This effort could expand upon the current EFMP and EFMP Plus-Up programs, and include increasing the use of these vehicles in underserved communities and by lower-income consumers. Continued incentive funding post-2023 to further accelerate the deployment of zero-emission vehicles would provide additional reductions for 2031.

  Determination of the needed resources will be based on assessment of the incremental cost of technologies and the type of funding mechanism employed. Funding needs and mechanisms will be identified working in collaboration with the South Coast and other State agencies over the next several months.

- Continue to support infrastructure investment programs with the California Energy Commission (CEC) to maximize the use of electric vehicles through expanding charging and hydrogen networks.

Additional mechanisms reflect reductions achieved through reducing growth in VMT as well as through intelligent transportation systems. While these approaches have the greatest potential to provide further reductions post-2023, early advances in these areas could offset some of the reductions required through incentive funding. These additional pathway mechanisms include:

- Reducing growth in passenger vehicle VMT. Local planning jurisdictions are implementing strategies to create more sustainable communities and integrate transportation and land use planning. These efforts to increase mobility choices and focus growth within existing urban boundaries provide a more efficient passenger transportation system that reduces VMT. The SB 375 Sustainable Communities and Climate Protection Act serves as a mechanism for implementation of efforts to reduce growth in passenger vehicle VMT.

- Advances in the development of autonomous and connected vehicles. These changes in how the on-road light-duty sector would operate offer the potential to achieve criteria and GHG emission reductions, but could also reduce VMT and congestion as well as petroleum usage. These concepts are based on emerging technologies and will require significant exploration and demonstration, but also offer synergies in a continued transition to zero-emission vehicle technologies.

Additional mechanisms may be developed to achieve additional reductions from vehicles in this category, including on-road motorcycles.

Estimated Emission Reductions:

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
5	16	0.1	5

Timing:

Proposed ARB Board adoption: n/a
Implementation schedule: 2017 - 2031

Implementation Milestones and Schedule		
Proposed Strategy	**Implementation Steps**	**Date**
Identify and secure funding for incentive based and other innovative funding programs for accelerated turn-over of zero and near-zero passenger cars and trucks	*Phase 1*: Identify funding needs and potential sources	2016+ (annually)
	Phase 2: Pursue actions to secure funding	
	Phase 3: Implement funding/incentive programs	
Evaluate potential emission benefits from VMT reductions and autonomous vehicles and quantify and develop mechanisms to provide SIP reductions as appropriate	*Phase 1:* Evaluation of approaches and potential for emission reductions	2016 - 2023
	Phase 2: Demonstration of systems	2017 – 2026
	Phase 3: Quantification of emission reductions and mechanisms for incorporating into SIP	2023 – 2027

7.
On-Road Heavy-Duty Sector

The on-road heavy-duty vehicles category includes heavy-duty gas and diesel trucks, urban and school buses, and motorhomes. The heavy-duty sector is diverse, with many different technologies and approaches that can achieve substantial emission reductions. Heavy-duty trucks that operate in California can travel long distances with about one-third of the trucks originating from out of state. Some trucks, however, are part of captive fleets that operate shorter distances.

Current Suite of Programs

Through ongoing efforts, California has developed the most stringent and successful heavy-duty vehicle emission control program in the world. These regulatory programs include not only requirements for increasingly tighter new engine standards, but also address vehicle idling, certification procedures, on-board diagnostics, and emission control device verification. Stringent fuel requirements further ensure that diesel engines are operating as cleanly as possible. ARB has also adopted in-use requirements that provide substantial further reductions. Most recently, ARB adopted optional low-NOx emission standards that establish a certification pathway for a new generation of requirements for heavy-duty engines that meet standards between 50 percent and 90 percent lower than current model year 2010 engine standards. As a result, California's heavy-duty fleets have made substantial investments over the past decade to adopt modern, lower-emitting vehicles and equipment.

The success of ARB regulations is projected to reduce heavy-duty vehicle NOx emissions by nearly 70 percent from 2015 to 2031. Key regulations include the Truck and Bus Regulation, the Heavy-Duty Tractor-Trailer Greenhouse Gas Regulation, and the Drayage Regulation. Adopted in 2008, the Truck and Bus Regulation impacts approximately one million inter- and intra-state vehicles, and requires privately and

federally owned diesel fueled trucks and buses and privately and publicly owned school buses to fully upgrade to newer, cleaner engines by 2023. The Heavy-Duty Tractor-Trailer Greenhouse Gas Regulation was adopted in 2008 to reduce greenhouse gas emissions by improving fuel efficiency of heavy-duty tractors that pull 53-foot or longer box-type trailers. An increase in fuel efficiency is achieved through improvements in tractor and trailer aerodynamics and the use of low rolling resistance tires. In addition to emission reductions, the Tractor-Trailer Greenhouse Gas Regulation has resulted in a reduction in fuel consumption and cost savings for truckers and trucking companies. Additionally, in 2007 ARB adopted the Drayage Truck Regulation in order to accelerate PM and NOx emission reductions and the associated community health risk from diesel fueled engines involved in moving goods into and out of California's ports and railyards.

Incentive programs promote the purchase of cleaner vehicles and equipment, assist truck owners with the cost of upgrading their vehicles, and increase development and deployment of cleaner and advanced zero-emission technologies. These programs include the Carl Moyer Program, the Low Carbon Transportation and AQIP, the Loan Incentives Program, and the Proposition 1B Program. The Carl Moyer Program provides about $60 million in grant funding annually through local air districts for cleaner-than-required engines and equipment. The Low Carbon Transportation and AQIP provide incentive funding to reduce greenhouse gas emissions, criteria pollutants, and air toxics from mobile sources through the development and use of advanced technology and clean transportation. The Governor's proposed Fiscal Year 2015-16 State Budget includes $350 million for Low Carbon Transportation investments. Considered separately from Low Carbon Transportation investments, the Legislature has already appropriated $23 million for AQIP projects in the Fiscal Year 2015-16 State Budget. The Loan Incentives Program was given a one-time appropriation of approximately $35 million in Fiscal Year 2008-09 to implement a heavy-duty loan program that assists on-road fleets affected by the Truck and Bus Regulation and the Heavy-Duty Tractor-Trailer Greenhouse Gas Regulation. In addition to these programs, the Proposition 1B: Goods Movement Emission Reduction Program provides incentives to owners of equipment used in freight movement to upgrade to cleaner technologies sooner than required by law or regulation. Voters approved $1 billion in total funding for the air quality element of the Proposition 1B program to complement $2 billion in freight infrastructure funding under the same ballot initiative. ARB has awarded all of the funds with local air districts implementing the final increment over the next three to four years.

In order to meet our air quality goals and GHG emission and petroleum use reduction targets, the on-road heavy-duty sector must transition to low-NOx emission technology coupled with advanced renewable fuels and zero emission vehicles and equipment where possible.

Advancing On-Road Low-NOx and Zero-Emission Technology

Moving forward, California is laying the groundwork for reducing emissions from the

on-road heavy-duty sector on multiple fronts: cleaner internal combustion engines, renewable fuels, and advanced technology. A low-NOx natural gas engine, the Cummins 8.9 liter natural gas engine, has already been certified to the optional 0.02 g/bhp-hr standard which is 90 percent below the current NOx standard. In addition, the Cummins 6.7 liter natural gas engine has been certified to the optional 0.10 g/bhp-hr NOx standard, which is 50 percent below the current standard. Both engines are expected to be commercially available in 2016. Cummins was able to achieve high levels of NOx emission reductions while simultaneously meeting the 2017 heavy-duty GHG standards with improved catalysts, improved air/fuel ratio controls, and closed crankcase ventilation system, demonstrating the technological ability of the industry to simultaneously achieve significant reductions in both NOx and GHG emissions. Other engine sizes meeting the optional NOx standards are expected within the next several years.

The optional NOx standard is paving the way for future mandatory requirements for California and federal trucks that have 90-percent lower NOx emissions in-use than today's required engines. Assuming the Low-NOx Engine Standard measure begins phase-in in 2024, 45 percent of the annual heavy-duty truck population in 2031 would be trucks meeting the new low-NOx engine standard, equating to approximately one million trucks statewide. A low-NOx pathway will provide broad health benefits at both the regional and community level. Exposure to PM2.5 and ozone are associated with premature death, increased hospitalizations and emergency room visits for exacerbation of chronic heart and lung diseases, and other serious health impacts. The available evidence indicates that PM2.5 is responsible for the largest share of the air pollution-related health burden and that all PM2.5 sources—both those that directly emit PM and those that lead to the formation of secondary constituents such as nitrates, sulfates, and organics—have similar potency on a mass basis. Nitrates formed from NOx emissions are the largest constituent of PM2.5, representing about half of the total particle mass. Therefore, large-scale deployment over the next 15 years of low-NOx heavy-duty engines for ozone and PM2.5 attainment, combined with particulate filters to reduce direct particle emissions, will provide the largest health benefit of any single new strategy.

To meet the 2030 GHG emissions and petroleum reductions targets statewide, low-NOx trucks will need to use renewable fuels. Low Carbon Fuel Standard (LCFS) credits, together with federal Renewable Fuels Standard RIN credits, are helping incentivize the use of renewable natural gas and renewable diesel. At the same time, near-term focused electrification and progress toward zero emission is critical to address the remaining localized risks of cancer and other adverse effects near major freight hubs, and must also play a growing role in reducing GHG emissions and petroleum use.

The Last Mile Delivery and Advanced Clean Transit measures included in the Mobile Source Strategy provide the foundation for initial deployment of zero emission vehicles in the heavy-duty truck sector. ARB is optimistic that the potential for zero emission technologies can continue to expand in the long term, especially in certain vocational classes and fleets that are under California regulatory authority. Continued growth in heavy-duty zero emission vehicles can also provide greater flexibility for use of

renewable fuels in other applications. ARB therefore examined an additional scenario with zero emission sales assumptions for heavy-duty trucks that went beyond those included in the *Cleaner Technologies and Fuels* scenario described in Chapter 3. This scenario reflected expansion of zero emission technologies to light heavy-duty trucks, use of zero emission technologies in drayage trucks, as well as continued growth in last mile delivery sales post-2030. While continued technology development is needed for the largest class 7 and 8 trucks, and infrastructure requirements will limit applicability for interstate fleets, the scenario also assumed a small amount of zero emission vehicle deployment for in-state class 7 and 8 trucks beginning in 2030.

The sales assumptions for California fleets in the expanded zero emission scenario are shown in Tables 7 through 9. For last mile delivery and other light truck applications the scenario assumes zero emission vehicles would comprise 12 to 15 percent of sales by 2030, and reach approximately one third of all sales by 2050. Introduction of zero emission technology in the heavier class 7 and 8 vehicles would begin first with transit buses and port trucks. Today's zero emission port truck demonstration fleet would grow to approximately 3,000 vehicles by 2033, with continued growth through 2050. From 2030 on, sales of zero emission vehicles in other class 7 and 8 applications would begin, growing to 10 percent of sales by 2050.

California efforts to establish requirements for these key vocational applications would result in a growing population of zero emission trucks in the State. As shown in Figures 16 and 17, by 2030, approximately 38,000 lighter duty class 2B and last mile delivery zero emission trucks would be on the road, increasing to 260,000 by 2050. This would represent approximately 20 percent of the in-state light truck fleet in 2050. While the population of larger class 7 and 8 zero-emission trucks would remain small, their population would reach over 20,000 by 2050. These efforts would provide strong market signals for further development, and establish a framework for other jurisdictions to follow.

Achieving expanded deployment of zero emission vehicles fueled with renewable electricity or renewable hydrogen will require continued investments in technology development and demonstration. ARB is working with federal, State and local partners to foster these efforts. The development of heavy-duty zero emission technologies also yields dividends in improved performance at lower costs. Today, battery electric and fuel cell buses are in the early commercialization phase, with transit agencies deploying a growing number of buses. Currently there are 80 zero-emission buses in service in California, with more than 100 additional zero-emission buses on order. Commercial deployment and demonstrations are in progress across the State in an array of additional heavy-duty applications, including drayage trucks, delivery trucks, and school buses. Over 300 light-heavy-duty battery electric trucks are currently in service in California (with gross vehicle weight between 8,501 and 14,000 pounds). State incentives are in place that are encouraging the development and adoption of these technologies, increasing production volumes, fostering innovation, and reducing costs. For example, ARB recently provided a $24 million grant to the South Coast Air Quality Management District for a statewide demonstration project for zero-emission drayage trucks.

Figure 16: Population of In-State Class 2B and Last Mile Delivery Trucks

Under *Expanded Zero-Emission* Scenario

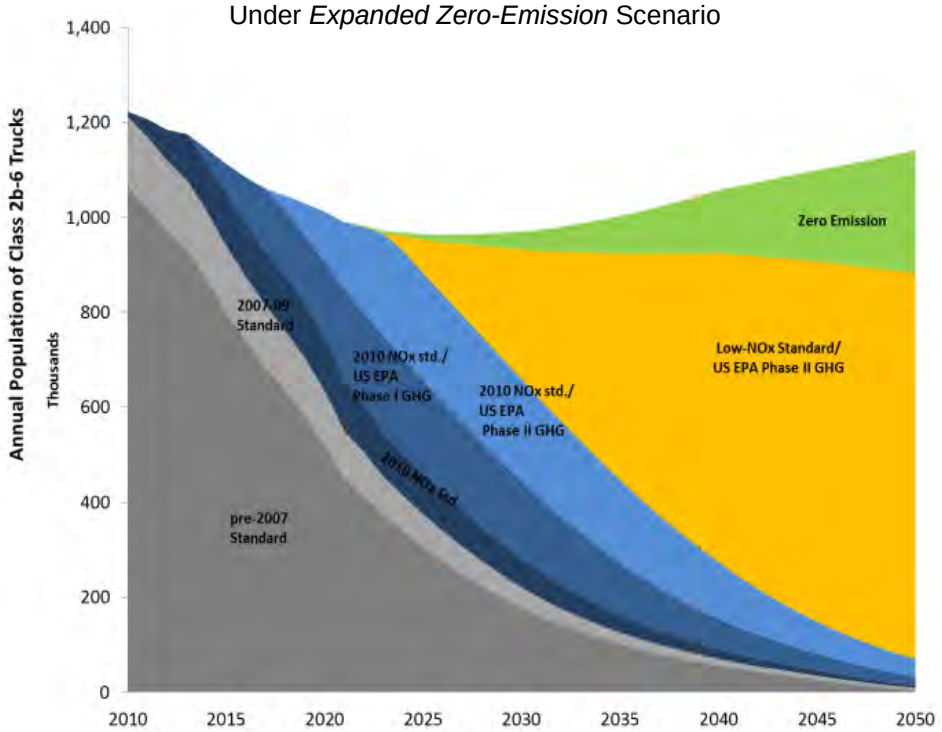


Figure 17: Population of In-State Class 7 and 8 Heavy-Duty Trucks

Under *Expanded Zero-Emission* Scenario

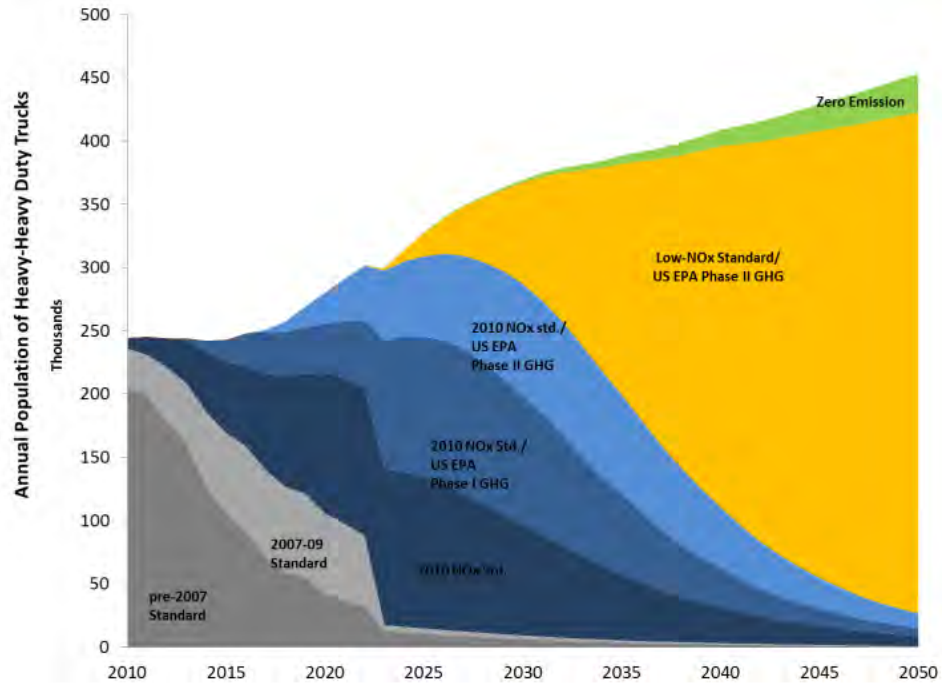


Table 7: Sales Assumptions for Last Mile Delivery Trucks
Under *Expanded Zero-Emission* Scenario

Model Year	Percent ZEV	FCEV/BEV
2020&21	2.5%	10/90
2022	7%	10/90
2023	8.5%	10/90
2024	9%	10/90
2025	10%	10/90
2030	15%	10/90
2035	20%	20/80
2040	25%	30/70
2045	30%	40/60
2050	35%	50/50

Table 8: Sales Assumptions for In-State Class 2B Light Trucks
Under *Expanded Zero-Emission* Scenario

Model Year	Percent ZEV	FCEV/BEV
2023&24	2.5%	10/90
2025	7%	10/90
2026	8.5%	10/90
2027	9%	10/90
2028	10%	10/90
2030	12%	10/90
2035	17%	20/80
2040	22%	30/70
2045	27%	40/60
2050	32%	50/50

Table 9: Sales Assumptions for In-state Class 7 and 8 Trucks
Under *Expanded Zero-Emission* Scenario

Model Year	Percent ZEV
2030	2.5%
2040	5%
2050	10%

The Importance of the Federal Low-NOx Standard

Because out-of-state heavy-duty vehicles operating in South Coast are not covered by California new engine emission standards, timely federal action to implement a national low-NOx performance standard is necessary to achieve an in-use fleet average that provides the emission reductions from heavy-duty trucks needed for ozone attainment. If U.S. EPA does not act at all, a California-only new engine emission standard would reduce NOx emissions, but not sufficiently enough to attain federal air quality standards.

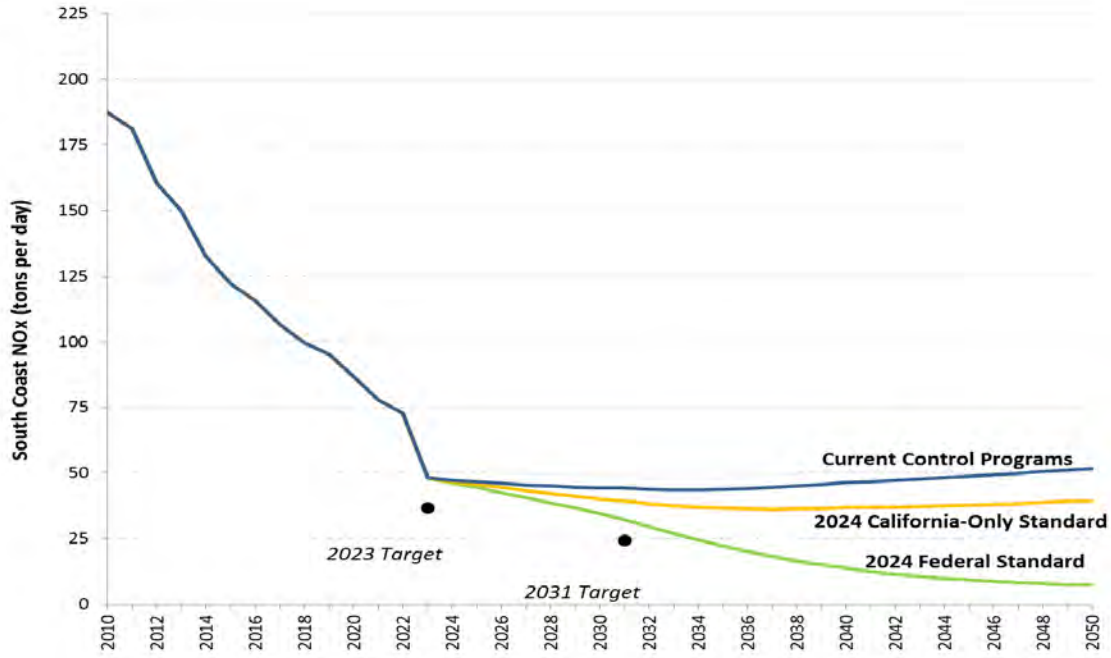
ARB's Truck and Bus Regulation will ensure that nearly every heavy-duty vehicle operated in California by 2023 will meet 2010 heavy-duty engine emission standards, but even a highly aggressive full-fleet penetration of 2010-compliant engines would not provide sufficient NOx reductions to attain the federal ozone standard in the timeframe required. This drives the need for progressively more stringent heavy-duty engine NOx emission standards. The measures outlined in this document call for U.S. EPA to develop a national low-NOx standard. Due to the preponderance of interstate trucking's contribution to in-state VMT, federal action would be far more effective at reducing in-state emissions than a California-only standard. However, California is prepared to develop a California-only standard, if needed, to meet federal attainment targets. Timely action is also important. While the *Cleaner Technology and Fuels* scenario discussed in Chapter 3 assumed U.S. EPA action by 2024, delaying implementation until 2027 would result in a significant loss in overall emission benefits.

U.S. EPA has also promulgated a lower 8-hour ozone standard of 70 ppb in October of 2015. Non-attainment areas will continue to need strategies that reduce NOx emissions in order to meet attainment deadlines for this more health protective standard. California has the authority to set emission standards as long as the standards meet or exceed any federal emissions regulations and U.S. EPA grants a waiver for California to implement the standards. In addition, Section 177 of the Clean Air Act allows other states to adopt California's standards in lieu of federal standards without U.S. EPA approval. This would allow other states to adopt a lower California NOx standard ahead of federal implementation if U.S. EPA does not act in a timely manner, or in lieu of the current standards if U.S. EPA fails to act, in order to meet attainment deadlines.

There have been past successes with other states adopting California emission standards in order to meet their specific air quality needs. During ARB's California Phase 2 Symposium held on April 22, 2015, Paul Miller, from the Northeast States for Coordinated Air Use Management (NESCAUM), presented on other states' positive experience adopting California's mobile source programs[24]. According to NESCAUM, it is evident that there is a continued need for cleaner heavy-duty vehicles in other states in order for GHG and NOx standards to be met. NESCAUM believes that some states

[24] Miller, Paul J. "States' Experience and Perspectives with CA Mobile Source Programs". Northeast States for Coordinated Air Use Management (NESCAUM). South Coast Air Quality Management District Headquarters, Diamond Bar, CA. 22 April 2015. Symposium Presentation.

Figure 18: The Importance of Federal Standards for Heavy-Duty Vehicles*



*The scenarios illustrated in this figure reflect natural turnover rates.

may consider adopting California's optional low-NOx engine standards if future federal action is insufficient to meet their air quality needs. Given past trends and successes, there is a strong possibility that other states would follow California's lead and adopt lower heavy-duty engine emission standards. This could result in emission reductions from a portion of out-of-state vehicles operating in California if new lower national NOx standards are not in place.

Figure 18 demonstrates the need for federal action and shows the benefits associated with federal action in 2024, as assumed in the *Cleaner Technology and Fuels* case in green, versus the benefits of a California only measure, shown in yellow.

Proposed Measures: On-Road Heavy-Duty Vehicles

Heavy-duty trucks over 8,500 pounds are currently the fastest growing transportation sector in the United States, responsible for about 33 percent of total statewide NOx emissions, approximately 26 percent of total statewide diesel PM emissions, and a significant source of GHG emissions. Most of the NOx emissions from heavy-duty engines come from diesel-cycle engines, especially in the higher weight classes. Gasoline and natural gas Otto-cycle spark-ignited engines are also used in heavy-duty trucks, to a lesser extent, and primarily in the lower weight classification vehicles.

Measures presented in the mobile source strategy will build on past successes to further reduce combustion emissions from engines and vehicles, and to quickly deploy currently available near-zero emission technologies, including low-NOx engines powered with renewable fuels. As vehicles purchased out-of-state account for a majority of the heavy-duty vehicle miles travelled in the South Coast on any given day, ARB will develop new heavy-duty diesel engine emission standards and, if necessary, petition U.S. EPA to establish a national standard, in order to achieve emission reductions from vehicles operating in California that were purchased in a different state. A lower NOx standard that reduces emissions from all trucks operating in California is critical to meeting 2031 air quality goals. Substantial future emission reductions can also be achieved through system and operational efficiency improvements to conventional technologies through measures supporting advanced combustion, aerodynamics, hybridization, and connected vehicle technologies.

To keep pace with achieving long-term, zero emission goals, measures will focus on expanding the use of ZEV technologies in lighter heavy-duty trucks and in applications where commercial products are feasible and commercially available, such as last mile delivery. Transit buses are one of the first heavy-duty applications where zero emission technologies have been demonstrated and are commercially available. Zero emission transit buses are primed to be one of the first heavy-duty vehicle types to achieve significant zero-emission vehicle sales volumes, leading and supporting technology development in the heavy-duty sector as a whole. While the development of heavy-duty zero emission technologies is well underway, it lags ZEV development in the light-duty sector; thus the heavy-duty sector has further to go to increase the penetration of zero-emission technologies. Nonetheless, ZEV technologies in heavier applications will benefit from technology migration and cost reductions achieved through economies of scale, technological innovation, and learning gained along the path to commercialization.

Early investments and incentives that accelerate deployment of zero and near-zero technologies in the heavy-duty sector are essential. Incentive programs have played a vital role in transitioning on-road heavy-duty vehicles and equipment to cleaner technology and they will continue to play a critical role in the success of transitioning the heavy-duty sector to cleaner technology. Incentives will not only encourage increased development and deployment of zero and near-zero emission technologies in heavy-duty applications, they will also help encourage acceptance of new technology with consumers. The vehicles and equipment in heavy-duty sectors have long lifetimes, and many of the engines sold today may still be operating in 2030. Investments that bring the cleanest technologies to market as quickly as possible are essential for achieving near-term criteria pollutant reductions to our air quality and climate goals.

Lower In-Use Emission Performance Level

Overview:

The goals of this proposed measure are to ensure that in-use heavy-duty vehicles continue to operate at their cleanest possible level. ARB staff would develop and propose new, supplemental actions to address in-use emissions and compliance and to decrease engine deterioration.

Background / Regulatory History:

Since 1982, both U.S. EPA and ARB have required manufacturers to submit emissions data showing that their engines and vehicles meet applicable emission standards to qualify for a federal “Certificate of Conformity” and/or a California “Executive Order” in order to be sold. The data are generated using specific test procedures for measuring emission levels and assessing durability. The number and types of these tests vary according to the engine/vehicle being tested. The Federal Test Procedure (FTP) is used for regulatory emissions testing of on-road heavy-duty engines. While the FTP was developed to assess emissions performance of an engine under representative operating conditions, it does not assess emissions under all driving conditions, such as high-speed freeway driving and hard accelerations, such as acceleration on an entrance ramp to a freeway.

In the late 1990s, many heavy-duty engine manufacturers were accused of deliberately calibrating their engines to run extremely lean during high-speed freeway driving, which improved fuel economy but increased NOx emissions. U.S. EPA and ARB deemed this strategy to be a defeat device deliberately designed to delay or deactivate emissions controls, which prompted both agencies to seek remedial action and penalties against the offending manufacturers. As part of a related settlement agreement, all affected parties were directed to work together to further develop the Not To Exceed (NTE) test protocol. The development effort was successful, and the NTE requirement is in effect today.

In addition to complying with the FTP and NTE requirements, compliance with OBD, anti-tampering, fuel tank fill-pipe and openings, crankcase emissions, and other requirements, as applicable, must also be demonstrated as part of the existing certification protocol. Manufacturers must also provide a warranty for the emissions control systems of their certified engines and vehicles for a specified durability period and identify them with emissions control labels. Also, these engines and vehicles are subject to compliance testing and are required to report warranty-related repair rates to both U.S. EPA and ARB.

Additionally, all heavy-duty vehicles in California are subject to in-use inspections in order to control excessive smoke emissions and tampering. These programs are described below:

- The Heavy-Duty Vehicle Inspection Program, adopted in 1988, requires heavy-duty vehicles to be inspected for smoke opacity (i.e., excessive smoke), tampering, and engine certification label compliance. Any heavy-duty vehicle operating in California, including vehicles registered in other states and foreign countries, may be inspected. Inspections are performed by ARB inspection teams at border crossings, California Highway Patrol weigh stations, fleet facilities, and randomly selected roadside locations.

- The Periodic Smoke Inspection Program, also adopted in 1988, requires heavy-duty vehicle fleet owners to conduct annual smoke opacity inspections of their vehicles, and have them repaired if excessive smoke emissions are observed. In addition, ARB has the authority to randomly audit these fleets, by reviewing the owners' maintenance and inspection records, and conducting opacity inspections on a representative sample of the vehicles.

- The Emissions Control Label Inspection Program requires all vehicles operating in California be equipped with engines that meet California and/or U.S. EPA emission standards. The engine must have an emissions control label which is legible, displayed as originally installed by the engine manufacturer, and must match the engine serial number stamped on the engine. Owners of applicable vehicles not meeting the emissions control label requirements are subject to a penalty.

Currently, there is no regular, mandatory in-use screening for NOx or any emissions other than visible smoke.

Proposed Actions:

For this proposed measure, ARB staff would develop new, supplemental actions, in the form of regulatory amendments or new regulations, to address in-use compliance and to decrease engine deterioration. This suite of actions includes:

- Amendments to ARB's existing Periodic Smoke Inspection and Heavy-Duty Vehicle Inspection Programs to revise the current opacity limit and make other program improvements;
- Amendments to warranty and useful life provisions;
- Amendments to the durability demonstration provisions within the certification requirements for heavy-duty engines;
- Amendments to the NTE supplemental test procedures for heavy-duty diesel engines; and
- Adoption of comprehensive heavy-duty vehicle inspection and maintenance program.

Estimated Emission Reductions:

As this proposed measure is a study to further evaluate the California's in-use performance and vehicle inspection and maintenance program, anticipated emission

reductions are not identified at this time. This measure may provide emission reductions; should the evaluation identify necessary program improvements, the emission reduction potential and cost effectiveness of such enhancements will be identified at that time.

Timing:

Proposed ARB Board adoption: 2016 – 2020[25]
Implementation schedule: 2017 – 2026

[25] This proposed measure will be implemented via amendment and adoption of multiple regulations. Staff anticipates bringing several of the items to the Board between 2016 and 2020, but some elements may be brought to the Board later.

Low-NOx Engine Standard

Overview:

The goal of this proposed measure is to introduce near-zero emission engine technologies that will substantially lower NOx emissions from on-road heavy-duty vehicles. ARB will develop a heavy-duty low-NOx engine standard in California, and, if necessary, petition U.S. EPA to establish new federal low-NOx emission standards for heavy-duty engines.

Background / Regulatory History:

California is the only state with the authority to adopt and enforce emission standards for new motor vehicle engines that differ from the federal emission standards. Since 1990, heavy-duty engine NOx emission standards have become dramatically more stringent, dropping from six grams per brake horsepower-hour (g/bhp-hr) in 1990 down to the current 0.2 g/bhp-hr standard, which took effect in 2010. In addition to mandatory NOx standards, there have been several generations of optional lower NOx standards put in place over the past 15 years. From 1998 to 2003, optional NOx standards ranged from 0.5 g/bhp-hr to 2.5 g/bhp-hr, at 0.5 g/bhp-hr increments, which was much lower than the mandatory 4 g/bhp-hr limit. Starting in 2004, engine manufacturers could choose to certify to optional NOx + non-methane hydrocarbon (NMHC) standards ranging from 0.3 g/bhp-hr to 1.8 g/bhp-hr, at 0.3 g/bhp-hr increments, which was significantly below the mandatory 2.4 g/bhp-hr NOx+NMHC standard. Starting in 2015, engine manufacturers could certify to three optional NOx emission standards of 0.1 g/bhp-hr, 0.05 g/bhp-hr, and 0.02 g/bhp-hr (i.e., 50 percent, 75 percent, and 90 percent lower than the current mandatory standard of 0.2 g/bhp-hr). The optional standards allow local air districts and ARB to preferentially provide incentive funding to buyers of cleaner trucks, which encourages the development of cleaner engines.

Proposed Actions:

This proposed measure would establish low-NOx engine standards for new on-road heavy-duty engines used in medium and heavy-duty trucks.

<u>California Action</u>

ARB will begin development of new heavy-duty low-NOx emission standards in 2017 with Board action expected in 2019. ARB may also petition U.S. EPA in 2016 to establish new federal heavy-duty engine emission standards. If U.S. EPA fails to initiate its own rule development process for a federal standard by 2017, ARB would continue with its development and implementation efforts to establish a California-only lower NOx standard. If U.S. EPA begins the regulatory development process for a new federal heavy-duty emission standard by 2017, ARB will coordinate its regulatory development efforts with the federal regulation.

A California-only lower NOx standard would apply to vehicles with new heavy-duty engines sold in California starting in 2023. However, the dynamics of the heavy-duty market means that this approach would not achieve the full benefit of the emission reductions that could be realized through a federal program. In order to achieve the maximum emission reductions from this proposed measure, a federal standard is necessary.

Federal Action

Federal lower NOx standards could apply to all new heavy-duty trucks sold nationwide starting in 2024 or later. This will ensure that all trucks traveling within California would eventually be equipped with an engine meeting the lower NOx standard. Without federal action to implement this emission standard, emission reductions would come mostly from Class 4-6 vehicles (as most Class 7 and 8 vehicles operating in California were originally purchased outside the State) as a result of California-only ARB regulations.

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate the emission reductions associated with this proposed measure. Both the Federal and California-only low-NOx standards were assumed to provide 90 percent overall NOx emission reductions from the current engine and emission control technologies. This reduction, in part, reflects assumptions on decreasing engine deterioration due to Lower In-Use Emission Performance Level Measure. For Federal low-NOx standards, NOx reductions were applied to all heavy-duty trucks starting in model year 2024, regardless of vocation and registration.

In addition to trucks coming from out-of-state, many California heavy-duty truck owners also purchase used trucks from out-of-state. Therefore, a California-only low-NOx standard would only impact a fraction of the heavy-duty activity and emissions in California. Staff assumed an aggregated fraction to estimate emission reduction based on survival rates derived from multiple years of EMFAC baseline data.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
California Action			
24	--	--	--
Federal Action			
28	--	--	--

Timing:

ARB petition to U.S. EPA:	2016
U.S. EPA Rulemaking:	2017-2019
ARB Rulemaking:	2017-2019
Proposed ARB Board adoption:	2019
Implementation schedule:	California regulation implementation would be starting in 2023; If U.S. EPA establishes a similarly stringent federal low-NOx standard, federal implementation should align with California. Under such a scenario, to ensure regulatory consistency, ARB would harmonize with U.S. EPA's program.

Medium and Heavy-Duty GHG Phase 2

Overview:

The goal of this proposed measure is to advance fuel efficiency improvements and achieve greater GHG emission reductions through the introduction of the next generation of integrated engine, powertrain, vehicle and trailer technologies designed to reduce climate emissions and fuel use. This new round of medium and heavy-duty vehicle and engine GHG emission standards, known as Phase 2, will build upon the Phase 1 standards adopted federally in 2011 and in California in 2013.

Background / Regulatory History:

The California Global Warming Solutions Act of 2006, Assembly Bill 32 (AB 32), established requirements for a comprehensive program of regulatory and market mechanisms to reduce GHG emissions in California. AB 32 also required ARB to develop and approve a Scoping Plan that describes California's approach to reducing GHG emissions to 1990 levels by 2020. The Scoping Plan was first approved by the Board in 2008 and updated for the first time in 2014.

The Tractor-Trailer GHG Regulation was an early action measure from the 2008 Scoping Plan. First approved by the Board in late 2008 and later amended in 2010, this regulation required improved aerodynamics and tires for 53-foot and longer long-haul tractors and trailers operating on California's roads.

The Phase 1 GHG standards, based on off-the-shelf technologies and applicable to 2014 and later model year medium- and heavy-duty engines and vehicles, were adopted by U.S. EPA in 2011 and by the Board in 2013. The Phase 1 standards took effect with the 2014 model year and are projected to reduce CO2 by about 12.5 percent by 2035.

Proposed Actions:

In summer 2016, U.S. EPA expects to finalize the federal Phase 2 standards. The new standards, which push technology improvements beyond what is currently in widespread commercial use, are expected to take effect with model year 2021 for all new class 2b-8 medium- and heavy-duty trucks sold in the nation and in model year 2018 for new trailers, and to be fully phased in by model year 2027. This proposed measure would establish Phase 2 GHG standards for all new class 2b-8 medium- and heavy-duty trucks starting in 2021, and for certain classes of new trailers, starting in 2018. At the federal level, GHG emission reduction requirements would apply to certain box-type trailers for the first time.

ARB staff plans to present a California Phase 2 proposal for the Board's consideration in 2017. In addition to harmonizing with the federal Phase 2 standards where applicable, ARB staff's proposal may include some more stringent, California-only provisions that are necessary to meet California's unique air quality challenges. For

example, the California Phase 2 proposal may layer additional requirements for vocational vehicle aerodynamics onto the federal Phase 2 program.

ARB staff also plans to present amendments to the Tractor-Trailer GHG regulation in 2019 to harmonize with the federal Phase 2 trailer requirements that also include requirements for trailer categories not included in the federal Phase 2 program in order to further reduce GHG emissions in California. In California, GHG emission reduction requirements for certain 53-foot and longer box-type trailers have been in place since 2008 under ARB's Tractor-Trailer GHG Regulation. Amendments to this regulation, separate from the Board's adoption of the Phase 2 standards for medium- and heavy-duty engines and vehicles, would align with the federal Phase 2 trailer requirements for box-type trailers and also include GHG emission reduction requirements for other trailer categories not covered by the federal Phase 2 standards, potentially including flatbed, tanker, container, and curtain side trailers, thus providing additional GHG reductions in California. California is the only state with the authority to adopt and enforce emission standards for new motor vehicles and engines that differ from the federal emission standards.

Estimated Emission Reductions:

While criteria emission reductions have not been identified at this time, ARB will quantify any emission reductions from this measure during the SIP measure development process.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
NYQ	NYQ	NYQ	6

Timing:

Proposed ARB Board adoption: 2016 - 2019

Implementation schedule: Implementation will begin with model year 2021 for all new heavy-duty trucks class 2b-8 sold in the nation and model year 2018 for new trailers, and will be fully implemented by model year 2027.

Advanced Clean Transit

Overview:

The goal of this proposed measure is to continue the transition of transit fleets to cleaner technologies to support NOx and GHG emission reduction goals. The measure will consider a variety of approaches to enhance the deployment of advanced clean technology and increase the penetration of the first wave of zero-emission heavy-duty technology into transit applications that are well suited to its use. The measures will rely on a suite of actions that together will achieve benefits in disadvantaged communities, maintain or expand service, while deploying advanced technologies. Low-NOx engines are available today for many transit agencies which are using compressed natural gas. Transit bus fleets are also well suited for introducing zero-emission technology because they operate in urban centers, have stop and go driving cycles and are centrally maintained and fueled. Experience from using advanced technology in buses and demonstrating its viability will benefit the market for the same technologies to be used in other heavy-duty vehicle applications.

Description of Source Category:

There are around 11,000 buses operated by transit agencies and by private companies under contract with through state administered funds to provide connecting bus to rail and ferries services. These buses operate primarily on diesel or natural gas.

Background / Regulatory History:

Adopted in 2000, the Fleet Rule for Transit Agencies required reductions in diesel particulate matter and oxides of nitrogen emissions from urban buses and transit fleet vehicles, and required future zero-emission bus purchases. Urban bus fleets were required to select either the diesel path or the alternative-fuel path. Transit agencies on the diesel path needed to demonstrate zero-emission buses, and to meet the zero-emission bus purchase requirements sooner, while agencies on the alternative-fuel path had to ensure that 85 percent of urban bus purchases were alternative fueled without a demonstration requirement.

The Transit Fleet Rule was amended in 2004, and again in 2006. The 2006 amendments temporarily postponed the zero-emission bus purchase requirement (until 2011 and 2012, depending on the compliance path) and expanded the initial demonstration with a subsequent advanced technology demonstration phase.

In 2009, ARB staff provided a technology update to the Board on the commercial readiness of zero-emission buses. At that time, the extended demonstration was behind schedule due to delays in funding and vehicle production. ARB staff recommended a postponement of the purchase requirements, and proposed to establish technology performance metrics that could be used to assess commercial readiness of zero-emission buses. The Board, through Resolution 09-49, directed ARB staff to delay the purchase requirement, research and develop commercial-readiness

metrics to be used as criteria to initiate the zero-emission bus purchase requirement, and to conduct a technology assessment on the readiness of zero-emission bus technologies.

Proposed Actions:

ARB would develop and propose an Advanced Clean Transit (ACT) measure with a combination with incentives, and/or other methods that would result in transit fleets purchasing advanced technology buses during normal replacement and using renewable fuels when contracts are renewed. The concept would consider flexibility to allow transit fleets to implement advanced technology in ways that are synergistic with their operation and potentially recognize factors such as early actions to reduce emissions, utilization of alternative modes of zero emission transportation (e.g., light-rail), and improved efficiencies of the transit system. An important goal would be to ensure the emissions benefits are realized in disadvantaged communities within the transit district while maintaining or expanding service and efficiency. The measure will also be consistent with and complementary to both SB 375 and LCFS.

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate the emission reductions associated with this proposed measure. As a bounding exercise to estimate the potential emissions benefits, ARB staff modelled 20 percent of the new urban buses purchased by transit agencies beginning in 2018 will be zero-emission buses with the penetration of zero-emission technology ramped up to 100 percent of new sales in 2030. The emission reductions themselves may come from a combination of new purchase requirements, incentives, or alternative performance standards. ARB staff also assumed any new natural gas buses, starting in 2018, and diesel buses, starting in 2020, would meet the optional heavy-duty low-NOx standard. The low-NOx standard was assumed to provide 90 percent overall NOx emission reductions from the current engine and emission control technologies.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
0.5	<0.1	<0.1	0.3

Timing:

Proposed ARB Board hearing: 2017
Implementation schedule: 2018-2040

Last Mile Delivery

Overview:

The goal of this proposed measure is to achieve NOx and GHG emission reductions goals through advanced clean technology, and to increase the penetration of the first wave of zero-emission heavy-duty technology into applications that are well suited to its use. Last mile delivery fleets are well suited for introducing zero-emission technology because they operate in urban centers, have stop and go driving cycles and are centrally maintained and fueled. Experience gained from demonstrating the viability of advanced technologies in these fleets will benefit the market and enable the same technologies to be used in other heavy-duty vehicle applications.

Description of Source Category:

The source category includes Classes 3-7 heavy-duty delivery trucks operated within California that are used in last mile freight delivery applications. Most of the last mile delivery trucks are within vehicle classes 3-6 (10,000 -26,000 lbs.) and some are in the vehicle class 7 (26,001-33,000 lbs.) Last mile delivery fleets are predominately used in urban areas to deliver freight from warehouses and distribution centers to its final point of sale or use (last mile delivery). Their duty cycle is favorable for accelerated penetration of zero-emission technology because they typically operate at low average driving speeds with frequent stop-and-go drive cycles, and are centrally maintained and fueled at an urban distribution center.

Background / Regulatory History:

The Last Mile Delivery is a newly proposed measure to support the SIP, Sustainable Freight Action Plan, SB 350, AB 32, and the Diesel Risk Reduction Plan. This proposed measure would require the use of low-NOx engines and the purchase of zero-emission trucks for class 3-7 last mile delivery trucks in California. Although there have not been previous regulations specific to last mile delivery trucks, ARB has controlled these sources through other regulations such as the Truck and Bus Regulation. All privately and federally owned diesel trucks with a GVWR of 14,0001 pounds and greater (Class 4 and above) that operate in California are subject to the requirements of the Truck and Bus Regulation, which include meeting particulate matter (PM) filter requirements and upgrading to 2010 or newer model year engines.

Proposed Actions:

ARB would develop and propose a regulation that would require the use of low-NOx engines and the purchase of zero-emission trucks for class 3-7 last mile delivery trucks in California. This proposed measure will require certain fleets that operate last mile delivery trucks to purchase low-NOx engines if available and phase-in zero-emission trucks starting 2020, with a low fraction initially and ramping up to a higher percentage of the fleet gradually at time of normal replacement. The initial ramp up of zero

emission trucks will consider the ability of the new technology to meet the operational needs of the users. ARB staff is evaluating options for purchase requirements.

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate conservative emission reductions associated with this proposed measure. The benefits were estimated assuming that zero-emission vehicles comprise 2.5 percent of new Class 3-7 trucks sales in local fleets starting 2020. The penetration rate increases to 10 percent in 2025, and is assumed to remain flat through 2030.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
1	<0.1	<0.1	0.4

Timing:

Proposed ARB Board hearing: 2018
Implementation schedule: 2020-2050

Innovative Technology Certification Flexibility

Overview:

The goal of this proposed measure is to encourage early deployment of the next generation of truck and bus technologies through defined, near-term ARB certification and OBD compliance flexibility for medium- and heavy-duty vehicles. This regulation is intended to balance the need to provide key, promising technologies with a predictable, and practical ARB-certification pathway, while preserving ARB's overarching objective to ensure expected emission benefits of advanced truck and bus technologies are achieved in-use. This regulation would provide the greatest flexibility for potentially transformational engine and vehicle technologies, such as robust hybrids and heavy-duty engines meeting the current optional low-NOx standard.

The deployment of robust hybrids (including those with zero-emission capability) is expected to both yield near-term emission benefits and facilitate the battery innovation needed to expand the application of zero-emission technology. By enabling early deployment of electric drivelines, low-NOx engines, and other key truck and bus technologies, this regulation would also help lay the foundation for the future technology-advancing regulation(s) needed to meet air quality and climate goals.

Background / Regulatory History:

In December 2013, ARB adopted Optional Reduced Emission Standards for Heavy-Duty Engine to further reduce emissions from the heavy-duty vehicle sector. These optional low-NOx emission standards set targets of 0.10, 0.05, and 0.02 g/bhp-hr NOx, which are 50 percent, 75 percent, and 90 percent, respectively, below the current 2010 emission standard. As of November 1, 2015, only one heavy-duty engine has been certified to an optional low-NOx standard – a Cummins ISL 8.9 liter alternative-fueled engine meeting the 0.02 g/bhp-hr NOx standard.

California law requires new motor vehicles and engines to be certified by ARB for emission compliance before they are legal for sale, use, or registration in California. Light- and medium- duty vehicle emissions are typically evaluated on a *chassis dynamometer* as part of the vehicle certification process. Heavy-duty vehicles (greater than 14,000 lbs.) are not required to be ARB-certified as a complete vehicle; instead, an engine must be ARB-certified for use in a heavy-duty vehicle.[26] Heavy-duty engine emissions are certified using an engine dynamometer, in part due to challenges in chassis testing heavier vehicles, and the impracticality of chassis certifying the diversity of potential truck and bus configurations in which a heavy-duty engine could be installed. However, dynamometer testing of heavy-duty engines does not quantify the potential emission impact of innovative non-engine technologies, such as hybrid drivelines.

[26] Hybrid heavy-duty vehicles have the option for complete full vehicle certification, utilizing ARB's Heavy-Duty Hybrid-Electric Vehicles Certification Procedures (December, 2013)

ARB certification requirements mandate that manufacturers demonstrate that their new engines or vehicles comply with applicable exhaust and evaporative emission standards over their useful life, and comply with other requirements, such as labeling and emissions warranty requirements.

OBD is an important emission control program that is critical for California to achieve its air quality goals. OBD consists mostly of added software in the relevant powertrain control modules that monitor critical components of the engine and aftertreatment. The OBD system monitors virtually every component that can cause an emission increase, including but not limited to all emission controls and all electronic components (such as sensors and actuators) that affect emissions or are used to monitor other emission controls. To function properly, OBD monitors must run with a specified minimum frequency in-use. The OBD system alerts the driver if something is wrong via the dashboard “check engine” (or malfunction indicator) light, and stores information pinpointing the likely root cause of a potential malfunction to assist repair technicians.

Light- and medium-duty vehicles have met OBD requirements beginning in 1996. Heavy-duty gasoline and diesel engine OBD requirements phased-in with the 2013 model year, while alternative fuel heavy-duty engines must begin OBD compliance in the 2018 model year due in part to their limited production volumes.

Proposed Actions:

ARB’s existing medium- and heavy-duty vehicle certification and OBD requirements provide a critical and effective mechanism for ensuring a vehicle’s expected emission benefits are achieved in-use. However, ARB’s engine and vehicle approval paradigm, geared towards traditional technologies, may deter some manufacturers from developing promising new truck and bus technologies that are uncertain to achieve market acceptance.

Hybrid truck and bus technology, in particular plug-in technology, has potential to achieve near-term emission benefits and provide a technology bridge to zero-emission solutions. Hybrid truck and bus technology can support battery innovation in higher demand zero-emission applications, and help build supply chains for zero-emission components like controllers, motors, and electricity converters. Plug-in hybrids with a robust electric drive can also foster fleet acceptance of zero-emission technology and drivetrains. However, California demand for hybrid trucks and the number of manufacturers offering hybrid truck technology in California has declined significantly in recent years. Part of this decline in hybrid truck manufacturers may be attributed to reduced demand from initial large, early adopter fleets as well as challenges meeting California heavy-duty OBD requirements.

Initial Innovative Technology Regulation concepts discussed with stakeholders would provide tiered ARB certification and OBD requirements for an innovative heavy-duty engine or vehicle technology, providing targeted flexibility at market launch and early technology deployment stages, and reverting back to full ARB approval requirements

once the technology achieves a market foothold. Initial draft flexibility provisions for hybrid trucks are geared towards encouraging manufacturers to enter the market, and address OBD compliance challenges encountered by what are typically non-vertically integrated engine, driveline and vehicle manufacturers. Hybrid flexibility provisions discussed with stakeholders thus far are structured to preferentially encourage hybrids capable of achieving at least 35 miles of zero-emission range. Initial Innovative Technology Regulation concepts for low-NOx engines are geared towards encouraging manufacturers to accelerate development and market launch of a diversity of alternative-fuel and diesel low-NOx engine families.

Estimated Emission Reductions:

As this measure is a modification to a test procedure that is intended to enable key technology-advancing heavy-duty vehicle regulations and incentive programs identified in this SIP, it does not have associated emission reductions.

Timing:

Proposed ARB Board adoption:	2016
Implementation schedule:	2016-2031

Zero-Emission Airport Shuttle Buses

Overview:

The goal of this proposed measure is to achieve NOx and GHG emission reductions goals through advanced clean technology, and to increase the penetration of the first wave of zero-emission heavy-duty technology into applications that are well suited to its use.

Description of Source Category:

Airport shuttle buses include buses that transport passengers to and from car parking lots and airport terminals as well as those that transport passengers to airport car rental facilities. The emissions in this source category are expected to increase with the projected increase in passenger aviation activities.

Background / Regulatory History:

Diesel airport shuttle buses with a gross vehicle weight rating (GVWR) greater than 14,000 pounds that are owned or operated by a municipality are regulated under California's Diesel Particulate Matter Control Measure for Municipality or Utility On-Road Heavy-Duty Diesel Fueled Vehicles (Public Agency and Utility Regulation). This regulation requires a municipality or utility that owns, leases or operates on-road diesel fueled vehicles with engine model year 1960 or newer and GVWR greater than 14,000 pounds to reduce its engine's PM2.5 emissions to 0.01 g/bhp-hr. This can be done by repowering, retrofitting, or retiring the vehicle. Implementation of the rule started in 2007, with a compliance schedule based on the engine model year. Airport shuttle buses owned by a municipality that are less than 14,000 pounds GVWR are not subject to the Public Agency and Utility Regulation.

Private contractors that operate diesel airport shuttles are regulated under the Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants from In-Use Heavy-Duty Diesel-Fueled Vehicles (Truck and Bus Regulation). The regulation requires airport shuttle buses with engines older than 2010 to eventually be replaced with engines that meet the 2010 emission standard of 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM2.5. As a result, by 2023, nearly all shuttle buses should be compliant with this regulation. However, similar to the Public Agency and Utility Regulation, this regulation does not apply to shuttle buses with GVWR less than 14,000 pounds.

Diesel and alternative-fueled shuttles less than 14,000 GVWR are subject to new engine emission standards of 0.20 g/bhp-hr NOx and 0.01 g/bhp-hr PM.

There are additional regulatory requirements for airport shuttle fleets that operate in the South Coast District's jurisdiction, as specified in Rule 1194. This rule requires public and private fleets of 15 or more vehicles that provide passenger pickup services at commercial airports to acquire cleaner burning (certified to ARB's ultra-low emission

vehicle, super-ultra-low emission vehicle, or zero-emission vehicle emission standards) or alternative-fueled vehicles when procuring their vehicles.

Non-diesel airport shuttles are not subject to ARB in-use fleet regulations.

Proposed Actions:

ARB would develop and propose a regulation or other measures to deploy zero-emission airport shuttles in order to further support market development of zero-emission technologies in the heavy-duty sector. Airport passenger shuttles that frequent the airport such as rental car and parking lot shuttles typically operate fixed short routes coupled with stop-and-go operation and low average speeds. As seen in past zero-emission bus demonstrations, vehicles that operate on fixed routes, have stop-and-go operation, and maintain low average speeds are ideal candidates for zero-emission electric technologies.

The current successes of zero-emission transit buses can reasonably be translated to airport shuttle buses due to the similarities between these two vehicle types. A near-term strategy to encourage airports to begin purchasing zero-emission shuttle buses would introduce these buses into the marketplace, which may result in entire zero-emission shuttle bus fleets in the future. Like transit buses, the inclusion of zero-emission airport shuttles would serve as a stepping stone to encourage broader deployment of zero-emission technologies in the on-road sector. Initially, incentive funding could be used to help defer the higher incremental cost of zero-emission airport shuttles as compared to traditionally-fueled shuttles. As the capital costs for zero-emission technologies decrease due to higher sales volume, implementation of the near-term strategy could occur either by regulation or a memorandum of understanding, or a combination thereof.

Estimated Emission Reductions:

While emission reductions have not been identified at this time, ARB will quantify any emission reductions from this measure during the SIP measure development process.

Timing:

Proposed ARB Board adoption: 2018
Implementation schedule: 2023

Incentive Funding to Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles

Overview:

The goal of this proposed measure is to provide incentive funding to accelerate the penetration of zero and near-zero equipment beyond the rate of natural turnover achieved through implementation of the other proposed measures identified for on-road heavy-duty vehicles.

Background / Regulatory History:

Several State and local incentive funding pools have been used historically -- and remain available -- to fund the accelerated turnover of on-road heavy-duty vehicles. Since 1998, the Carl Moyer Program (Moyer Program) has provided funding for replacement, new purchase, repower and retrofit of trucks in the South Coast. Beginning in 2008, the Goods Movement Emission Reduction Program funded by Proposition 1B has funded cleaner trucks for the region's transportation corridors; the final increment of funds will implement projects in South Coast through 2020.

The Air Quality Improvement Program has funded the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) since 2010, and continued South Coast participation is expected. ARB has also administered a Truck Loan Assistance Program since 2009. Beyond these statewide programs, the District receives local funds to improve air quality through vehicle registration fees authorized by AB 923, AB 2766, and SB 1928.

Proposed Actions:

This proposed measure would use existing incentive and other innovative funding programs to help increase the penetration of zero and near-zero heavy-duty trucks. Funding mechanisms would target technologies that meet or exceed an optional low-NOx standard through 2023, when implementation of a new Federal low-NOx standard will begin and part of the current round of Moyer Program funding ends.

Implementation will require commitment of at least $28 million of the current State and South Coast District incentive funds described above to truck replacement projects in the 2015 to 2020 timeframe. In addition, pending annual appropriation by the Legislature and approval by the Board, ARB's Low Carbon Transportation and AQIP funds can be apportioned from 2015 through 2020, with approximately $7 million per year allocated for low-NOx trucks using renewable fuels in South Coast.

It is important to note that funds under the control of the South Coast District may also be used for other applications, including off-road vehicles. Identifying the most effective use of funds in order to maximize emission reductions will depend on the incremental cost of technologies, cost effectiveness, and the type of financing mechanism

employed. Accordingly, the use of these funds to maximize emission reductions for 2023 may be further refined.

Estimated Emission Reductions:

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
3	0.4	--	<0.1

Timing:

Proposed ARB Board adoption: 2016 and annually thereafter
Implementation schedule: 2016-2023

Further Deployment of Cleaner Technologies: On-Road Heavy-Duty Vehicles

Overview:

The goal of this proposed measure is to identify concepts that will further reduce NOx emissions. These concepts will include additional incentive funding and developing technologies to accelerate the penetration of zero and near-zero equipment beyond the rate of natural turnover achieved through implementation of the other proposed measures identified for on-road heavy-duty vehicles.

Background / Regulatory History:

A number of existing measures will achieve NOx reductions from heavy-duty trucks, and could be expanded to provide additional reductions. In addition, new technologies, along with regulations, could potentially provide additional NOx reductions.

Incentives:

Several State and local incentive funding pools have been used historically -- and remain available -- to fund the accelerated turnover of on-road heavy-duty vehicles in the South Coast. Since 1998, the Carl Moyer Program has provided funding for replacement, new purchase, repower and retrofit of trucks in the basin. Beginning in 2008 the Goods Movement Emission Reduction Program funded by Proposition 1B has funded cleaner trucks for the region's transportation corridors. The Air Quality Improvement Program has funded the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) since 2010. In addition, new Low Carbon Transportation incentives funded by the Greenhouse Gas Reduction Fund are available for zero-emission and cleaner combustion truck projects that achieve GHG benefits, and these projects may often provide criteria pollutant reduction co-benefits. However, to achieve additional reductions in this category, new sources of funding will be pursued.

Advanced Technologies Such as Connected and Autonomous Vehicles/Systems:

Advanced technologies are expected to be introduced into the market and could replace or supplement the need to solely rely on additional funding pools. Examples of these strategies include autonomous and connected vehicle systems, greater fleet and system operational efficiencies, and improvements in transportation logistics. Some of these strategies are currently in the early stages of development and are expected to bring not only emission reductions, but cost savings to the industry once deployed. Many of these technologies will ultimately bring cost saving to the freight movement sector. It is likely that this deployment can be accelerated if necessary using by incentive funding and regulations.

Proposed Actions:

This proposed measure is designed to achieve further emission reductions for South Coast attainment in 2023 and 2031 through a suite of additional actions, including early penetration of zero and near-zero technologies, emission benefits associated with increased operational efficiency strategies, and the potential for new driver assist and intelligent transportation systems. The emission reductions will be achieved through a combination of industry actions, motivated by both ARB and the South Coast. These actions reflect an initial assessment of a pathway, recognizing that as funding is allocated and advanced technologies further develop, the balance amongst approaches will necessarily adjust.

<u>Scope of Technology Penetration and Mechanisms to Achieve Reductions:</u>

Under current ARB regulations, nearly all heavy-duty trucks operating in the South Coast must meet today's 2010 engine standards by 2023, with the exception of very low mileage fleets and public fleets regulated under earlier fleet rule requirements. A key component of the mobile source strategy for heavy-duty vehicles is the adoption of a more stringent engine performance standard reflecting technology that is effectively 90 percent cleaner than today's standards. To achieve the further reductions associated with early penetration of these cleaner heavy-duty technologies, ARB and South Coast staff estimate that by 2023, approximately 100,000 to 150,000 trucks would need to have engine technologies that meet or exceed a 0.02 g/bhp-hr low-NOx standard. The following mechanisms provide a pathway for achieving this scale of technology deployment:

- Identify and develop regulatory mechanisms that encourage the development of near-zero and zero-emission heavy-duty truck deployment. Similar actions have been done previously in the South Coast, including local regulations and the San Pedro Bay Ports Clean Truck Program. The South Coast will include local measures in its Air Quality Management Plan to address the accelerated deployment of heavy-duty vehicles.

- Expand and enhance existing incentive and other innovative funding programs for heavy-duty vehicles to increase the emphasis on and support for purchase of zero and near-zero equipment. Funding mechanisms would target technologies that meet either lower NOx standards, or are hybrid/zero-emission technologies. If incentive funding is the primary mechanism to achieve the scope of further technology deployment described above, funding would be required for approximately 15,000 to 20,000 trucks per year over a seven year period, depending upon the availability of zero-emission vehicles and engines certified to ARB's optional low-NOx standards of 0.05 g/bhp-hr and 0.02 g/bhp-hr or other advanced hybrid/zero-emission technologies. The incentive funding required for this effort would go beyond the amount currently authorized for existing programs through 2023. Continued incentive funding post-2023 to further accelerate the deployment of trucks meeting or exceeding a 0.02 g/bhp-hr standard would provide additional reductions for 2031.

Determination of the needed resources will be based on assessment of the incremental cost of technologies, cost effectiveness, and the type of financing mechanism employed. Funding needs and mechanisms will be identified working in collaboration with the District and other State agencies over the next several months.

Additional mechanisms reflect continued penetration of zero-emission technologies, as well as reductions achieved through intelligent transportation systems and operational efficiencies. While these approaches have the greatest potential to provide further reductions post 2023, early advances in these areas could offset some of the reductions required through incentive funding or regulations. These additional pathway mechanisms include:

- Several individual proposed measures focus on deploying zero-emission vehicles in heavier applications that are currently well-suited for broad market development, such as transit buses, airport shuttles, and last mile delivery. Depending upon the success of these applications, and ongoing technology assessment, regulatory mechanisms to require zero-emission vehicles in additional applications may be feasible. The greatest opportunities exist for fleets that are captive to the South Coast, and drive shorter distances. This technology assessment is already underway.

- Advances in the development of autonomous and connected vehicle systems, particularly if based on zero-emission technologies, as well as greater operational efficiencies, and improvements in transportation logistics. These changes in how the heavy-duty truck sector would operate offer the potential to achieve criteria, toxic, and GHG emission reductions, but also reduce VMT and congestion as well as petroleum usage. These concepts are based on emerging technologies, and will require significant exploration and demonstration prior to becoming concepts with quantified emission reductions. To promote initial demonstration of these concepts, the FY 16/17 Low Carbon Transportation Funding Plan will include eligibility for demonstration projects related to intelligent transportation systems and connected vehicles.

Estimated Emission Reductions:

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
11	1	--	0.3

Timing:

Proposed ARB Board adoption: n/a
Implementation schedule: 2016 – 2031

Implementation Milestones and Schedule		
Proposed Strategy	**Implementation Steps**	**Date**
Identify and secure funding for incentive based and other innovative funding programs for accelerated deployment of zero and near-zero heavy-duty vehicles	*Phase 1*: Identify funding needs and potential sources	2016 + (annually)
	Phase 2: Pursue actions to secure funding	
	Phase 3: Implement funding/incentive programs	
Develop regulatory strategies for deployment of zero-emission technologies in additional heavy-duty vehicle applications as appropriate	*Phase 1:* Evaluation of technology and prototype demonstrations. Regulatory strategies brought to ARB Board for approval.	2016 – 2023
	Phase 2: Development of regulatory strategies	2020 - 2023
	Phase 3: Measure implementation	2025 – 2031
Evaluate potential for emission benefits from operational efficiencies and intelligent transportation systems and quantify and develop mechanisms to provide SIP reductions as appropriate	*Phase 1:* Evaluation of approaches and potential for emission reductions	2016 – 2023
	Phase 2: Demonstration of systems	2020 – 2024
	Phase 3: Quantification of emission reductions and mechanisms for incorporating into SIP	2024 – 2027

8.
Off-Road Federal and International Sources

For the purposes of this document, sources in the off-road sector have been grouped into two categories. The federal and international sources category includes emissions associated with ships, locomotives, and aircraft.

Locomotives operating at railyards and traveling through California are a significant source of emissions of diesel PM (which ARB has identified as a toxic air contaminant), NOx, and GHGs. These emissions often occur in or near densely populated areas and neighborhoods, exposing residents to unhealthy levels of toxic diesel PM, plus regional ozone and fine particulates that form in the atmosphere.

Union Pacific Railroad (UP) and BNSF Railway (BSNF) are the two Class I, or major, freight railroads operating in California. There are also seven intrastate passenger commuter operators and up to 26 freight shortline railroads currently operating in California. UP and BNSF, however, generate the vast majority (90 percent) of locomotive emissions within the State, with most attributable to interstate line haul locomotives.

UP and BNSF operate three major categories of freight locomotives, both nationally and in California. The first category is interstate line haul locomotives, which are primarily ~4,400 horsepower (HP). The second category is made up of medium-horsepower (MHP) locomotives, as defined by ARB staff as typically between 2,301 and 3,999 HP. MHP locomotives are typically older line haul locomotives that have been cascaded down from interstate service. And lastly, there are switch (yard) locomotives, specifically defined by U.S. EPA as between 1,006 and 2,300 HP.

Ocean-Going Vessels (OGVs) are very large vessels designed for deep water navigation. OGVs include large cargo vessels such as container vessels, tankers, bulk carriers, and car carriers, as well as passenger cruise vessels. These vessels transport containerized cargo; bulk items such as vehicles, cement, and coke; liquids such as oil and petrochemicals; and passengers. Ocean-going vessels travel internationally and may be registered by the U.S. Coast Guard (U.S.-flagged), or under the flag of another country (foreign-flagged). The majority of vessels that visit California ports are foreign-flagged vessels.

Current Suite of Programs

Ocean going vessels, locomotives, and aircraft are sources that are primarily regulated by the federal government and international organizations. In contrast to the significant NOx emission reductions in the on-road mobile sector, emission sources in this category are only forecasted to decrease by about 20 percent by 2031. ARB programs contributing to these reductions include efforts focusing on cleaner fuel requirements and use of cleaner locomotives and vessel shore power. For example, in 2007, ARB adopted a regulation to reduce emissions from diesel auxiliary engines while ships were berthing at a California port. ARB also adopted regulations requiring cleaner fuels for ocean going vessels within 24 nautical miles and cleaner diesel fuel requirements for intrastate locomotives. Finally, ARB and the Class I railroads have been implementing a memorandum of understanding to accelerate the introduction of cleaner locomotives in the South Coast since 1998.

The Importance of More Stringent Federal Standards

While more stringent engine standards have been established for new aircraft, locomotives, and ocean-going vessel engines and equipment, existing equipment in this category tend to remain in operation for long periods of time. In addition, these sources are primarily regulated by the federal government and international organizations. As a result, emissions from these categories have not decreased at the same pace as those for other mobile sources. Achieving the magnitude of emission reductions necessary from this category is therefore more difficult, and will require strong action at the federal and international level, coupled with State and local advocacy and action to facilitate these efforts. It is critical to continue to reduce emissions from in-use equipment through new national emission standards for newly manufactured and remanufactured locomotives, adoption of more stringent emission standards for new ocean-going vessels and efficiency requirements for existing vessels, and by spurring the early implementation of clean technologies via mechanisms to incentivize the use of those technologies in California. This includes partnerships with ports and engine manufacturers to incentivize the use of cleaner technologies in California and to encourage the production of cleaner, more efficient engine technologies.

Proposed Measures: Off-Road Federal and International Sources

ARB has identified a number of actions to achieve further emission reductions from these sources. These include ARB petitions to U.S. EPA to adopt more stringent criteria pollutant and GHG performance standards for locomotives, and more stringent requirements for non-new locomotives. ARB would also advocate with international partners for new International Maritime Organization Tier 4 standards and efficiency targets. Other measures for ocean going vessels include development of criteria for and mechanisms to incentivize introduction of low-emisison efficient ship visits, as well as amendments to ARB's At-Berth regulation to further reduce emissions from vessels at berth. In addition to the measure descriptions provided in this Chapter, further detail can be found in the *Sustainable Freight: Pathways to Zero and Near-Zero Discussion Document*.[27]

[27] *Sustainable Freight: Pathways to Zero and Near-Zero Discussion Document* http://www.arb.ca.gov/gmp/sfti/sustainable-freight-pathways-to-zero-and-near-zero-emissions-discussion-document.pdf

More Stringent National Locomotive Emission Standards

Overview:

The goal of this proposed measure is to reduce emissions from locomotives in order to meet air quality and climate change goals. Under the proposed measure, ARB will petition U.S. EPA to promulgate by 2020 both Tier 5 national emission standards for newly manufactured locomotives, and more stringent national requirements for remanufactured locomotives, to reduce criteria and toxic pollutants, fuel consumption, and GHG emissions.

Background/Regulatory History:

Under the Clean Air Act (CAA), U.S. EPA has the sole authority to establish emissions standards for new locomotives. (42 United States Code (U.S.C.) §7547, (a)(5)) By regulation, U.S. EPA has defined “new” locomotives to include both those newly manufactured and those existing locomotives that are remanufactured or rebuilt.

U.S. EPA has previously promulgated two sets of national locomotive emission regulations (1998 and 2008). In 1998, U.S. EPA approved national regulations that primarily emphasized NOx reductions through Tier 0, 1, and 2 emission standards. Tier 2 NOx emission standards reduced older uncontrolled locomotive NOx emissions by up to 60 percent, from 13.2 to 5.5 g/bhp-hr.

In 2008, U.S. EPA approved a second set of national locomotive regulations. Older locomotives, upon remanufacture, are required to meet more stringent particulate matter (PM) emission standards, which are about 50 percent cleaner than Tier 0-2 PM emission standards. U.S. EPA refers to the PM locomotive remanufacture emission standards as Tier 0+, Tier 1+, and Tier 2+. The new Tier 3 PM emission standard (0.1 g/bhp-hr), for model years 2012-2014, is the same as the Tier 2+ remanufacture PM emission standard. The 2008 regulations also included new Tier 4 (2015 and later model years) locomotive NOx and PM emission standards. U.S. EPA Tier 4 NOx and PM emission standards further reduced emissions by approximately 90 percent from uncontrolled levels.

Proposed Actions:

ARB would petition U.S. EPA for new national locomotive emission standards for significant additional reductions in criteria and toxic pollutants, and GHG emissions from existing and future locomotives. ARB staff estimates that U.S. EPA could require manufacturers to implement the new locomotive emission regulations by as early as 2023 for remanufactures and 2025 for newly manufactured locomotives.

This measure describes the emissions levels that ARB staff believes would be achievable with a new generation of national emissions standards for locomotives, including both newly manufactured and remanufactured units. The description focuses

on technology that could be employed to reach the lower emission levels to address local, regional, and global air pollution concerns in California, and in other states with high levels of railyard activity or rail traffic.

As documented in the Draft Technology Assessment for Freight Locomotives,[28] ARB staff believes the most technologically feasible advanced technology for near-term deployment is the installation of a compact aftertreatment system (e.g., combination of selective catalytic reduction (SCR) and diesel oxidation catalyst (DOC) onto new and remanufactured diesel-electric freight interstate line haul locomotives. Newly manufactured locomotives can also be augmented with on-board batteries to provide an additional 10-25 percent reduction in diesel fuel consumption and GHG emissions to achieve the Tier 5 emission levels shown in the table below. For purposes of this document, ARB staff assumes a 15 percent reduction in fuel use for locomotives equipped with this battery technology. On-board batteries could also provide zero-emission track mile capabilities in and around railyards to further reduce diesel PM and the associated health risks.

Newly Manufactured Locomotives

Emission Levels	**NOx** (g/bhp-hr)	**PM** (g/bhp-hr)	**GHG Reductions** (relative to Tier 4)
Existing Tier 4 Standard	**1.3**	**0.03**	0%
– In-Use	1.0	0.015	N/A
Potential Tier 5 Standard	**0.2**	**0.0075**	10-25%
– In-Use	0.15	0.006	10-25%

A new federal standard could also facilitate development and deployment of zero-emission track mile locomotives and zero-emission locomotives by building incentives for those technologies into the regulatory structure.

The compact SCR and DOC aftertreatment system could also be retrofitted to existing Tier 4 locomotives to be able to achieve a Tier 4+ emissions standard, when Tier 4 locomotives are scheduled for remanufacture (every seven to ten years). Based on the typical remanufacture schedule, all Tier 4 locomotives could potentially be retrofitted with aftertreatment between 2025 and 2037. Existing locomotives originally manufactured to meet Tier 2 or Tier 3 standards could also be upgraded with the same compact aftertreatment system upon remanufacture to achieve emissions equal to Tier 4 levels.

[28] Draft Technology Assessment for Freight Locomotives available at: http://www.arb.ca.gov/msprog/tech/techreport/freight_locomotives_tech_report.pdf

The result would be remanufactured locomotives meeting the emissions levels shown in the table below.

Remanufactured Locomotives

Tier 2+/3	5.5	0.1	Retrofit to Tier 4	1.3	0.03
Tier 4	1.3	0.03	Retrofit to Tier 4+ (with aftertreatment)	0.3	<0.01

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate the emission reductions associated with this proposed measure.

Newly manufactured locomotives:

The Tier 5 emissions standard was modeled as a new tier of locomotives to be introduced in 2025. Tier 5 is defined by the same emission standards as Tier 4 for all pollutants except NOx, PM, and GHG, which would be at the levels shown in the table above. This was represented in the model by increasing the Tier 5 locomotive population in the total tier distribution by ~4.0 percent per year over the baseline population with an equal reduction in the Tier 4 distribution.

Remanufactured locomotives:

The locomotive fleet meeting the remanufacture emissions levels is modeled such that 95 percent of line-haul locomotive activity is represented by Tier 4 locomotives by 2031, with phase-in of Tier 4+ starting in 2023. For modeling purposes, this is represented by increasing the Tier 4 locomotive population in the total tier distribution by ~8 percent per year over the baseline with an equal total reduction in the lower tier populations to account for the increase in Tier 4.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
44	2	0.7	--

Timing:

ARB petition to U.S. EPA	2016
U.S. EPA rulemaking date:	2020
Implementation schedule:	2023 for remanufactured locomotives
	2025 for newly manufactured locomotives

Tier 4 Vessel Standards

Overview:

The goal of this proposed measure is to reduce emissions from ocean-going vessels (OGVs). ARB would advocate with international partners for the International Maritime Organization (IMO) to establish new Tier 4 NOx and PM standards, plus efficiency targets for existing vessels, and new vessel categories not covered by IMO efficiency standards.

Background/Regulatory History:

The IMO, under Annex VI ("Regulations for the Prevention of Air Pollution from Ships"), specifies new engine NOx standards and sets fuel sulfur limits. Tier 2 IMO NOx standards have applied to new vessels since 2011, and in 2016, Tier 3 NOx standards will apply within NOx Emission Control Areas (ECAs) such as the North American ECA. However, the Tier 3 NOx limits are relatively high compared to the standards that apply to landside diesel engines. Annex VI regulations also do not limit PM exhaust emissions from new engines. The fuel sulfur limit in the North American ECA is 0.1 percent sulfur, the same as the ARB regulation discussed below. However, there are some differences between the regulations. The California regulation specifies the use of cleaner "distillate" grades of fuel, rather than just a sulfur limit, and the federal ECA provides exemptions for many vessels that are not exempted by the California rule.

The IMO also established amendments to Annex VI in 2011 that set in place efficiency standards for new ships. Beginning in 2013, the regulations establish energy efficiency design index (EEDI) standards that become progressively more stringent over time. The EEDI requires a minimum energy efficiency level per capacity mile (e.g., tonne-mile) for different ship types and size segments. The categories of ships covered include oil and gas tankers, bulk carriers, general cargo ships, refrigerated cargo carriers and container ships. Together, these vessel categories account for over 70 percent of the carbon dioxide emissions from the new-build fleet. The regulations do not cover passenger vessels, mixed-use vessels, other specialty vessels, and vessels below 400 gross tons. For vessel types not covered, EEDI formulas are expected to be developed in the future.

The IMO also requires operators of both new and existing vessels to develop and maintain a Ship Energy Efficiency Management Plan (SEEMP). The SEEMP, a complement to the EEDI, provides a mechanism to improve the energy efficiency of a ship. A vessel's SEEMP document is expected to change over time, and many companies already use a similar plan to reduce fuel costs. The SEEMP regulations only require that ships have plan, but an approval of the plan, and tracking of the vessel's progress by the flag state administration is not required.

California regulations include the Ocean-going Vessel Fuel Regulation and the At-Berth (Shore-power) Regulation. The OGV Fuel Regulation was designed to reduce diesel PM, NOx, and SOx emissions. This regulation was implemented in 2009, and required that vessels use lower sulfur distillate fuels. The current fuel sulfur limit of 0.1 percent was implemented in 2014, a year before the ECA set this same sulfur standard. The At-Berth Regulation was designed to limit emissions of diesel PM and NOx from vessels at dockside. The regulation requires that vessels turn off their auxiliary diesel engines and plug in to shore-based grid electrical power, or utilize alternative technologies to achieve comparable emission reductions.

California has the authority to regulate marine vessels, including foreign-flagged vessels, when they visit our ports, to the extent such regulation is not preempted by federal law. The California OGV Fuel Regulation was adopted as two essentially identical regulations under our authority to regulate both airborne toxicants and criteria pollutants.

Proposed Actions:

Under this Action, ARB would work with U.S. EPA, U.S. Coast Guard, and international partners to urge the IMO to adopt more stringent emission standards for new ocean-going vessels and efficiency requirements for existing vessels. Specifically, ARB would advocate for a Tier 4 NOx standard for new marine engines on ocean-going vessels and vessel efficiency requirements for the existing in-use fleet.

Additional regulations are necessary because the existing IMO marine engine regulations do not include a PM standard, and the Tier III 2016 NOx standard is higher than the NOx standards for other diesel equipment categories. In addition, the IMO efficiency standards for existing vessels only require that vessels have a “Ship Energy Efficiency Management Plan.” These regulations do not require approval of the plan, tracking of the vessel’s progress, or actual improvement in energy efficiency.

Estimated Emission Reductions:

ARB staff used ARB’s Vision 2.1 model to estimate the emission reductions associated with this proposed measure. The measure would require that 100 percent of new vessels meet Tier 4 NOx emissions standards which are 70 percent lower than existing Tier 3 standards, starting in the calendar year 2025. The new standards would be allowed to enter the fleet using natural turnover and would not be accelerated by additional rules or incentives.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
25	--	--	

Timing:

ARB advocacy:	2015 - 2018
IMO action, ratification, and implementation:	2020 - 2025

Incentivize Low-Emission Efficient Ship Visits

Overview:

The goal of this proposed measure is to achieve early implementation of clean vessel technologies such as liquefied natural gas, Tier 3 standards or better, and incentivize vessels with those technologies in California service. ARB staff would work with California seaports, ocean carriers, and other stakeholders to develop the criteria and to identify the best way to incentivize introduction of Super-Low Emission Efficient Ships into the existing fleet of vessels that visit California seaports.

Background/Regulatory History:

In addition to the traditional regulations outlined in the previous proposed measure, Port authorities in California have developed a number of measures for OGVs which are typically implemented through incentive programs or lease agreements.

The Ports of Los Angeles and Long Beach (San Pedro Bay Ports) have the most comprehensive program. The San Pedro Bay Ports Clean Air Action Plan (CAAP) is designed to reduce the emissions from a variety of port sources, including OGVs. The plan includes reductions from Port ordinances, regulations, green lease agreements, environmental mitigation requirements, and voluntary and incentive efforts such as the "Green Ship Incentive Program" and “Vessel Speed Reduction Incentive Program” (VSR). In addition, the Ports of Los Angeles, Long Beach, Oakland, San Diego, San Francisco, and Hueneme have installed shoreside infrastructure for vessels to plug in at berth, and some have provisions in leases to require use of the infrastructure beyond the requirements of ARB’s statewide At-Berth regulation. Prior to the implementation of a statewide clean fuel regulation for OGVs, the San Pedro Bay Ports also developed a clean fuel incentive program which covered the cost differential between dirty heavy fuel oil and cleaner burning low sulfur distillate fuel.

The Port of Los Angeles’ Voluntary Environmental Ship Index Program (ESI) rewards vessel operators for reducing NOx, SOx, and CO2 from OGVs. When an operator goes beyond what is required for compliance by bringing their newest and cleanest vessels to the Port and demonstrating technologies onboard their vessels, they are rewarded with incentives via lower dockage fees. It also encourages use of cleaner technology and practices in advance of regulations.

Proposed Actions:

Numerous technologies are available that can reduce emissions from ships and improve the efficiency of a vessel. Incentive programs can be leveraged to encourage vessel owners and operators to implement technologies that exceed current regulatory requirements. Under this proposed measure, ARB staff would work with California seaports and other stakeholders to develop criteria for a Low-Emission Efficient Ship, targeting NOx, diesel PM, GHG, and sulfur oxide emissions. ARB would also pursue

partnerships with other ports along the Pacific shipping corridor to develop a “green lane” concept with multiple small incentives for cleaner vessels that add up to sufficient financial benefit to change the decisions of vessel operators about which vessels are deployed on which routes. Incentives to encourage visits from ships meeting the criteria would involve identification of funding sources and implementation mechanisms such as development of new programs, enhancement of existing programs such as the Port of Long Beach Green Flag program and the Port of Los Angeles Environmental Ship Index Incentive Program, or incorporation into existing statewide incentive programs.

Estimated Emission Reductions:

While emission reductions have not been identified at this time, ARB will quantify any emission reductions from this measure during the SIP measure development process.

Timing:

ARB Action date:	2017 - 2018
Implementation schedule:	2018 +

At-Berth Regulation Amendments

Overview:

The goal of this proposed measure is to further reduce emissions from ships auxiliary engines at berth. ARB staff would develop and propose amendments to the current At-Berth Regulation and look for additional reductions from additional vessel fleets or types.

Description of Source Category:

Auxiliary engines are diesel engines on ocean-going vessels that provide power for uses other than propulsion. They are generally four-stroke diesel engines that are smaller than the main engines. Most ocean-going vessels have more than one auxiliary engine. Auxiliary engines are usually coupled to generators used to produce electrical power. On cargo vessels, most auxiliary engines are used to provide ship-board electricity for lighting, navigation equipment, refrigeration of cargo, and other equipment. Oil tankers typically use on-board boilers to pump product to shore.

Passenger cruise vessels use a different engine configuration that is referred to as "diesel-electric." These vessels use large diesel generator sets to provide electrical power for both propulsion and ship-board electricity. For the purpose of the regulation, these large diesel generator sets are included in the definition of "auxiliary engines" because they are physically similar to auxiliary engines.

Background/Regulatory History:

In December 2007, ARB approved the Airborne Toxic Control Measure (ACTM) for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port Regulation (At-Berth Regulation). ARB has broad authority to regulate ocean-going vessel emissions, including the emissions from diesel auxiliary engines on ocean-going vessels docked at California ports.

The At-Berth Regulation was designed to reduce emissions from diesel auxiliary engines on container ships, passenger ships, and refrigerated cargo ships while at berth at California's major seaports, and is limited to fleets of 25 or more vessels (five or more for passenger ships). The At-Berth regulation also requires that vessels turn off their auxiliary diesel engines and plug in to shore-based grid electrical power, or utilize alternative technologies to achieve comparable emission reductions.

ARB staff has begun developing proposed amendments to the Regulation. These amendments will be designed to both address current implementation issues while preserving the intended air quality benefits, and to expand the scope of the Regulation to achieve additional emission reductions.

Proposed Actions:

ARB would evaluate how the Regulation can be amended to achieve further emission reductions by including smaller fleets and/or additional vessel types (including roll-on/roll-off vehicle carriers, bulk cargo carriers, and tankers). In addition, there are two companies with portable emissions capture and control systems that have successfully demonstrated performance and may now be used for compliance with the Regulation on certain container vessels. If one or both systems prove to be feasible and cost-effective on additional vessel types, the technology could help support an ARB staff proposal to expand the scope of the Regulation to include additional vessel types and/or smaller fleets.

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate the emission reductions associated with this proposed measure. The amendments would require additional vessels to reduce emissions at berth, with the primary compliance options likely to be the use of shore power or the emissions capture and control systems. For this calculation, staff assumed that additional vessels (i.e., auto carriers, bulk cargo, general cargo, roll-on roll-off carriers, and tankers) would connect to shore power rather than run auxiliary engines. For modeling purposes, the amendments were limited to the ports that are currently offering shore power and implementation was assumed to start in 2022 at 10 percent fleet compliance and to increase to 50 percent fleet compliance by 2032. This compliance rate was converted into the number of ships impacted, and then multiplied by the average time spent at berth. As the current regulation allows between three to five hours of auxiliary engine operation for each affected visit, four hours was used as the average time spent at berth using auxiliary engines. The results from above were then combined to find the total hours of auxiliary engine use at berth that would be reduced by the amendments.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
1	0.1	<0.1	0.1

Timing:

ARB Board adoption date: 2017 - 2018
Implementation schedule: 2022 - 2032

Further Deployment of Cleaner Technologies: Off-Road Federal and International Sources

Overview:

The goals of this proposed measure are to increase the penetration of cleaner ocean-going vessel, locomotive, and aircraft technologies, and to promote efficiency improvements at the equipment, sector, and systems levels.

Background/Regulatory History:

This category includes a variety of sources that travel both nationally and internationally, including ocean going vessels, locomotives, and aircraft. Under current requirements, new locomotive engines must meet a Tier 4 engine emission standard. Beginning in 2016, new ocean going vessels must meet a Tier 3 standard if the vessel will be calling at marine ports located in an Emissions Control Area such as the North American Emission Control Area. Finally, new certificated aircraft engines must meet Tier 8 (CAEP/8) standards.

Proposed Actions:

This proposed measure is designed to achieve further emission reductions for South Coast attainment in 2023 and 2031 through a suite of additional actions, including early penetration of cleaner technologies and emission benefits associated with increased efficiencies.

While more stringent engine standards have been established for new equipment, existing equipment tends to remain in operation for a long period of time. In addition, these sources are primarily regulated by the federal government and international organizations. As a result, emissions from these categories have not decreased at the same pace as those for other mobile sources. By 2023, ocean going vessel NOx emissions in the South Coast are projected to grow to 23 tons per day. Locomotive emissions will also grow to 23 tons per day, and aircraft emissions will grow to almost 17 tpd. Achieving the magnitude of emission reductions necessary from this category is therefore more difficult, and will require strong action at the federal and international level, coupled with State and local advocacy and action to facilitate these efforts.

ARB and South Coast staff have estimated a scope of technology development and penetration as one example pathway of what would be necessary by 2023 and 2031 to achieve equal share reductions from this sector. Achieving equal share reductions would represent a significant expansion of cleaner technology deployment. The time frame to accomplish this is short, the development of cleaner technologies lags behind those for other sectors, and the scope of State and local authority is limited. These issues will need to be considered as the proposed measures are further developed for this SIP. For 2023, this would require: 1) all locomotives operating in the South Coast meeting the Tier 4 standard, 2) all aircraft meeting today's Tier 8 emission levels, and 3)

ocean going vessels achieving emission levels significantly cleaner than today's requirements. An equal share pathway for this sector post-2023 would require deployment of locomotives meeting a more stringent Tier 5 standard. More stringent Tier 4 ocean going vessel standards would also be necessary. Finally, operational efficiency strategies would be needed to provide an additional mechanism for further reductions as a complement to deployment of cleaner technologies.

A series of actions that would be taken at the State and local level to achieve further reductions are outlined below:

- Expand and enhance existing incentive and innovative funding programs to increase the emphasis on and support for deployment of cleaner technologies in these sectors. Air quality incentives and transit funding programs, for example, will be effective in transforming the passenger rail system in the South Coast, with nearly all Metrolink trains expected to reach a Tier 4 level by 2023.

  The incentive funding required will go well beyond the amount currently authorized under existing programs through 2023. Funding needs and mechanisms will be identified working in collaboration with the District over the next several months.

- Partner with airports to incentivize cleaner aircraft to come to California airports, along with partnerships with international engine manufacturers to encourage production of cleaner, more efficient engines.
- Seek continued funding for and partnerships with federal agencies such as the U.S. Department of Energy, U.S. EPA, Federal Aviation Administration (FAA), U.S. Maritime Administration, and Federal Railroad Administration for new technology and fuel demonstration projects. This would include efforts on development of hybrid, battery and fuel cell technologies for locomotives, the FAA's CLEEN program, and retrofit technologies for in-use vessels and boilers.
- Encourage efficiency improvements, including industry based initiatives (like the San Pedro Bay Ports' Supply Chain Optimization effort to increase port competitiveness), as well as concepts being developed as part of the California Sustainable Freight Action Plan. These improvements may include approaches such as reducing unproductive moves, use of marine vessel sharing agreements that result in maximum use of cargo space, and increased reliance on logistics planning and operations software.

Estimated Emission Reductions:

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
30	0.4	NYQ	NYQ

Timing:

Implementation schedule: 2016 – 2031

Implementation Milestones and Schedule		
Proposed Strategy	**Implementation Steps**	**Date**
Identify and secure incentives, including funding, for accelerated deployment of cleaner ocean going vessels, locomotives, and aircraft in California service	*Phase 1*: Identify incentives, including funding needs and potential sources *Phase 2*: Pursue actions to secure funding *Phase 3*: Implement funding/incentive programs	2016 + (annually)
Work with federal and international agencies to advocate for increased stringency of emission standards and efficiency requirements, demonstration of new technologies, and incentives to attract the cleanest technologies to California	*Ongoing*	2016 - 2031
Evaluate, quantify and encourage efficiency improvements with the potential to result in lower emissions per unit of cargo transported, including changes in cargo and equipment activity that are typically reflected in SIP emission inventories	*Phase 1:* Retrospective and prospective evaluation of approaches with potential for lower systemwide emissions per unit of cargo transported	2016 – 2023
	Phase 2: Demonstration of system efficiency improvements and support for expanded private and public efforts	2018 – 2027
	Phase 3: Ongoing quantification of the effect of efficiency improvements on freight activity and emissions for incorporation into SIP	2020 – 2031

9.
Off-Road Equipment

The Off-Road Equipment category includes lawn and garden equipment, transport refrigeration units, vehicles and equipment used in construction and mining, forklifts, cargo handling equipment, commercial harbor craft, and other industrial equipment. Given the diversity of equipment and duty cycles that comprises this category, each measure includes a more detailed description of the specific source.

Current Suite of Programs

The off-road equipment category includes lawn and garden equipment, transport refrigeration units, vehicles and equipment used in construction and mining, forklifts, cargo handling equipment, commercial harbor craft, and other industrial equipment. Due to the success of ARB regulations, NOx emissions from off-road equipment are projected to decrease about 40 percent by 2031. These types of sources require a long-term, comprehensive approach to transition to the cleanest possible technologies. ARB has developed a number of regulatory and incentive-based approaches to ensure an ongoing transition to cleaner technologies.

In 2004, ARB adopted a fourth tier of increasingly stringent advanced aftertreatment based PM and NOx standards for new off-road compression-ignition engines. These "Tier 4" standards were phased-in across product lines from 2008 through 2015 and reduced exhaust emission levels by up to 95 percent compared to previous control strategies. In 2007, ARB first approved the Off-Road Regulation that requires off-road fleets to reduce their emission by retiring, replacing or repowering older engines. This regulation expanded the penetration of existing clean technology to ensure that the engines and vehicles used today are as clean as possible.

Advancing Low-Emission and ZEV Technologies for Off-Road Equipment

Off-road equipment provides an opportunity to introduce ZEV technologies in heavier applications with duty cycles well-suited for the first wave of heavy-duty ZEV technologies, such as forklifts, transport refrigeration units, and airport ground support equipment. ARB is currently investigating the need for even cleaner new off-road compression ignition engine standards and related requirements. For instance, certain smaller engines do not meet stringent advanced aftertreatment NOx and PM standards. These smaller diesel engines comprise a significant portion of both the new off-road CI engine population and emissions inventory, and more stringent standards may be appropriate if effective emission controls can be demonstrated to be both feasible and cost-effective. ARB is also considering the need to further lower NOx standards for the larger new off-road CI engines similar to the voluntary low-NOx standards recently adopted for on-road CI engines. Another area that warrants consideration is mandatory requirements for the use of diesel particulate filters (DPFs) in off-road engines. Currently, a growing number of off-road engines that were expected to be certified with DPFs are meeting the current standard without them. These engines may have higher in-use PM emissions and elevated emissions of ultrafine particles relative to CI engines that incorporate a DPF.

ARB will continue to review and analyze the status of technologies in order to better understand technology, emission reduction, and pathway options, and use that information to strategically invest and support advanced technology demonstration opportunities to expand and advance the marketplace. In addition, ARB will support the development and deployment of emerging worksite integration and efficiencies, vehicle automation, and fleet management technologies. These measures include incentives for pilot programs and expanding purchase requirements as appropriate to further support market development of zero-emission technologies.

Proposed Measures: Off-Road Equipment

Measures for these sources will focus on deploying zero-emission technologies in applications such as battery and fuel cell electric forklifts, where the technology is commercially available. ARB will also continue to review and analyze the status of technologies in order to better understand technology and pathways options, and to integrate emerging worksite efficiencies, vehicle automation, and fleet management technologies. These emission reduction assessments will inform future actions focused on expanding the application of ZEV technologies by identifying equipment where zero-emission options are commercially feasible, such as forklifts. These measures include purchase requirements as well as incentives for technology demonstration and deployment to further support market development of zero-emission technologies in other off-road applications.

Zero-Emission Off-Road Forklift Regulation Phase 1

Overview:

The goal of this proposed measure is to accelerate the deployment of zero-emission technologies in off-road equipment types that are already primed for the technologies that exist today and facilitate further technology development and infrastructure expansion by demonstrating its viability. ARB would develop a regulation that focuses on forklifts with lift capacities equal to or less than 8,000 pounds.

Description of Source Category:

Forklifts operate in many different industry sectors but are most prevalent in manufacturing and at locations such as warehouses, distribution centers, and ports. There are approximately 100,000 forklifts operating in California, most of which are battery-electric, propane, diesel, or gasoline-fueled. Although battery-electric forklifts offer reduced maintenance requirements, lifetime cost savings, and cleaner tailpipe emissions, electric forklift usage has not changed significantly relative to internal combustion forklift usage over the past 20 years. While the equipment population of this source category has seen limited growth, without ARB actions, the transition to zero-emission may remain very gradual.

Background/Regulatory History:

Manufacturers of forklift engines are subject to new engine standards for both diesel and Large Spark Ignition (LSI) engines. Off-road diesel engines were first subject to engine standards and durability requirements in 1996 while the most recent Tier 4 Final emission standards were phased in starting in 2013. Tier 4 emission standards are based on the use of advanced after-treatment technologies such as diesel particulate filters and selective catalytic reduction. LSI engines have been subject to new engine standards that include both criteria pollutant and durability requirements since 2001 with the cleanest requirements phased-in starting in 2010.

Forklift fleets can be subject to either the LSI fleet regulation, if fueled by gasoline or propane, or the off-road diesel fleet regulation. Both regulations require fleets to retire, repower, or replace higher-emitting equipment in order to maintain fleet average standards. The off-road diesel regulation was adopted by the Board in 2007 with implementation beginning in 2010. It is applicable to all diesel-fueled, self-propelled off-road equipment with at least 25 HP. Forklifts are included in the fleet average along with other equipment. The LSI fleet regulation was originally adopted in 2007 with requirements beginning in 2009. While the LSI fleet regulation applies to forklifts, tow tractors, sweeper/scrubbers, and airport ground support equipment, it maintains a separate fleet average requirement specifically for forklifts. The LSI fleet regulation requires fleets with four or more LSI forklifts to meet fleet average emission standards.

The Clean Air Act preempts states, including California, from adopting requirements for new off-road engines less than 175 HP used in farm or construction equipment. California may adopt emission standards for in-use off-road engines pursuant to Section 209(e)(2), but must receive authorization from U.S. EPA before it may enforce the adopted standards.

Proposed Actions:

ARB staff would develop and propose a regulation to increase penetration of ZEVs in off-road applications, with specific focus on forklifts with lift capacities equal to or less than 8,000 pounds for which zero-emission technologies have already gained appreciable customer acceptance and market penetration. This regulation would send a market signal to technology manufacturers and investors that zero-emission technologies will be strongly supported moving forward. This proposed measure would advance ZEV commercialization by increasing the penetration of zero-emission technologies. Experience gained from demonstrating the viability of advanced technologies in heavier-duty applications will spur market development and enable the technologies to be transferred to larger, higher power-demand off-road equipment types, such as high lift-capacity forklifts and other equipment types in the construction, industrial, and mining sectors. The regulation could also include requirements that result in the deployment of zero-emission technologies in heavier equipment fleets that remain at a particular location for extended periods of time or other similar provisions that would spur further technology innovation.

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate the emission reductions associated with this proposed measure. This measure requires electrification of diesel and LSI forklifts with horsepower ratings less than 65 HP in the industrial and airport ground support sectors. Electrification would be accomplished through incentives as well as natural and accelerated turnover. To model the emission reductions, ARB staff reviewed the reporting data and found that approximately 73 percent of forklifts in California were in medium or large fleets and would be subject to the regulation. Additionally, it was assumed that 90 percent of qualifying forklifts (overall 65.7 percent of the total) could reasonably be targeted for electrification by 2035 with a proposed starting year of 2028. A linear penetration of replaced equipment from 2028 to 2035 was applied to the emissions data from the official in-use off-road model.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
2	0.2	<0.1	1

Timing:

ARB Board adoption date:	2020
Implementation schedule:	2023 - 2035

Zero-Emission Off-Road Emission Reduction Assessment

Overview:

The goal of this proposed measure is to expand the use of zero-emission technology in non-freight, off-road applications. This further-study proposed measure would be a follow-up to off-road measures implemented in the 2023+ timeframe, such as the Zero-Emission Off-Road Forklift Regulation Phase 1, and through it ARB would identify opportunities to further expand the use of zero and near-zero emission technologies in off-road applications.

Description of Source Category:

Equipment in these sectors is typically high power and utilizes diesel powertrains. While it is expected that these sectors will be heavily reliant on diesel for the foreseeable future, diesel-electric and hybrid powertrains significantly reduce fuel consumption and are in the early stages of commercialization. As battery technology develops, it may open up opportunities to apply these advanced technologies to more applications as well as develop all-electric versions of equipment. While new engine and fleet standards continue to reduce emissions from heavy-duty off-road equipment, it is important that ARB continue to look for ways to continue to apply advanced technology to further increase the sustainability of the off-road sector.

Background/Regulatory History:

Fleets with diesel equipment are subject to the off-road diesel fleet regulation. This regulation requires fleets to retire, repower, or replace higher-emitting equipment in order to maintain fleet average standards. The off-road diesel regulation was adopted by the Board in 2007 with implementation beginning in 2010. It is applicable to all diesel-fueled, self-propelled off-road equipment with at least 25 HP. Manufacturers of diesel engines are subject to new engine standards. Off-road diesel engines were first subject to engine standards and durability requirements in 1996 while the most recent Tier 4 Final emission standards were phased in starting in 2013. Tier 4 emission standards are based on the use of advanced after-treatment technologies such as diesel particulate filters and selective catalytic reduction.

Proposed Actions:

ARB staff would conduct an assessment and provide the Board with an informational update regarding the status of ZEVs in off-road applications, once the Phase I Forklift Regulation is in place. The update would be the result of a technology assessment, and would identify opportunities to further expand their use. The focus of this proposed measure is on transferring zero and near-zero emission technologies to heavier pieces of off-road equipment, such as high lift-capacity forklifts or other equipment in the construction, industrial, and mining sectors, with the intent of expanding their application as technology matures and infrastructure grows. This evaluation would focus primarily on the scalability and transferability of zero-emission technologies from smaller

applications to larger, higher power-demand equipment types and would be used to inform the development of the Phase 2 regulation. The information obtained from this technology review would be used to inform the development of Phase 2 of the Zero-Emission Off-Road Regulation. The Zero-Emission Off-Road Phase 2 Regulation would build upon the Phase 1 regulation and focus primarily on larger, higher power-demand equipment types, such as large forklifts, construction equipment, etc. The scope and timeframe of the Phase 2 regulation would depend upon advancements in technology and information obtained through the Zero-Emission Off-Road Emission Reduction Assessment.

Estimated Emission Reductions:

As this proposed measure is a study to further evaluate the status of ZEVs in off-road applications and to identify opportunities to further expand their use, anticipated emission reductions are not identified at this time. This measure may provide emission reduction; should the evaluation identify necessary program improvements, the emission reduction potential and cost effectiveness of such enhancements will be identified at that time.

Timing:

ARB Board date:	2025+
Implementation schedule:	--

Zero-Emission Off-Road Worksite Emission Reduction Assessment

Overview:

The goal of this proposed measure is to advance ZEV commercialization by increasing the penetration of zero-emission technologies. Through this emission reduction assessment and technology review, ARB would analyze developing worksite integration and efficiency technologies, such as connected vehicle, automation, and fleet management technologies in off-road sectors. ARB would also encourage deployment via incentives or by providing credit in the off-road rule.

Description of Source Category:

This assessment will focus on technologies and strategies that increase worksite efficiency, such as automation, connected vehicles, and fleet management. These technologies are already being applied to the construction industry in a variety of equipment types, including graders, excavators, and tractors. Examples include grading assisted technologies that can use on-board sensors and GPS to accurately grade to a desired depth and slope thus reducing the number of passes needed. Fleet management technologies allow a fleet manager to monitor parameters such as fuel usage and productivity to optimize equipment utilization on the job site. Technologies such as these have the potential to achieve significant fuel-savings if applied across the industry and could yield emission reductions beyond what is achieved through engine and fleet regulations.

Background/Regulatory History:

Currently, there is no regulatory program that considers worksite efficiency technologies. One of the goals of the assessment will be to consider potential metrics in order to compare fuel efficiency, work productivity, and emission reductions and develop ways to award either regulatory credits or credits or incentives for usage of these technologies.

Fleets with diesel equipment are subject to the off-road diesel fleet regulation. This regulation requires fleets to retire, repower, or replace higher-emitting equipment in order to maintain fleet average standards. The off-road diesel regulation was adopted by the Board in 2007 with implementation beginning in 2010. It is applicable to all diesel-fueled, self-propelled off-road equipment with at least 25 HP. Manufacturers of diesel engines are subject to new engine standards. Off-road diesel engines were first subject to engine standards and durability requirements in 1996 while the most recent Tier 4 Final emission standards were phased in starting in 2013. Tier 4 emission standards are based on the use of advanced after-treatment technologies such as diesel particulate filters and selective catalytic reduction.

Proposed Actions:

Staff would conduct an assessment and provide the Board regarding the technologies and/or strategies that increase worksite efficiency, such as connected vehicles, automation, and fleet management technologies. While there is not yet a consensus on how to quantify the benefits of such technologies, advanced machine control and worksite integration technologies that are commercially available today reportedly hold the potential for fuel savings of up to 30 percent or more, depending on worksite conditions. Some of these products are available today from new equipment manufacturers, as well as aftermarket suppliers, and can be adapted or retrofitted to much of the existing legacy fleet. The scalability of these systems is wide ranging and such systems can be applied to a single piece of off-road equipment on a small project or on many vehicles at the largest, most complex worksites. While there is significant promise in these types of technologies, more work has to be done to ensure the development of a robust worksite efficiency program that is cost-effective and achieves emission reductions that are real and quantifiable. This proposed measure would evaluate business return on investment, sustainability of the system, and ancillary benefits such as improved safety and work consistency. There would also be potential testing comparing fuel efficiency, work productivity, and emission reductions via portable emission measurement system (PEMS).

Estimated Emission Reductions:

As this proposed measure is an assessment of the technologies and/or strategies to increase worksite efficiency, anticipated emission reductions are not identified at this time. This measure may provide emission reduction; should the evaluation identify necessary program improvements, the emission reduction potential and cost effectiveness of such enhancements will be identified at that time.

Timing:

ARB Board date: tbd
Implementation schedule: --

Zero-Emission Airport Ground Support Equipment

Overview:

The goal of this proposed measure is to increase the penetration of the first wave of zero-emission heavy-duty technology in applications that are well suited to its use, and to facilitate further technology development and infrastructure expansion. ARB staff would develop a regulation to accelerate the transition of diesel and LSI Airport Ground Support Equipment (GSE) to zero-emission technology.

Description of Source Category:

Airport GSE are used in airport operations and perform a wide variety of functions including providing power to aircraft, transporting cargo, baggage, and passengers to and from aircraft, and providing aircraft maintenance and fueling. The most common equipment types include belt loaders, baggage tugs, cargo tractors, cargo loaders, forklifts, and aircraft tugs. GSE are fueled by gasoline, liquefied petroleum gas (LPG), compressed natural gas (CNG) and diesel fuel. Battery-electric GSE are the most common zero-emission alternative technology equipment commercially available today. The current California population estimate of internal combustion powered GSE is greater than 10,000. This includes approximately 4,000 compression ignition engine powered equipment and approximately 6,000 large spark-ignited engine powered equipment. Aircraft activity is expected to increase significantly by 2050. This increase will likely necessitate an increase in GSE population as well.

Background/Regulatory History:

California has adopted regulations limiting emissions from new engines used in GSE as well as emissions from existing GSE in-use.

Engines used in newly manufactured GSE operating on gasoline, LPG, and CNG are required to meet California's new engine emission standards for LSI. The LSI engine standard for engines greater than 1.0 liter (typical for GSE) is 0.6 g/bhp-hr of hydrocarbons (HC) and NOx. Engines meeting this standard are 70 percent cleaner than LSI engines produced as recent as 2009. Additionally, fleets operating LSI GSE must meet the in-use LSI engine fleet requirements. Adopted in 2006, the LS3I fleet rule requires GSE fleets to maintain an average emission level of no more than 2.5 g/bhp-hr HC+NOx, starting January 1, 2013.

Diesel engines in newly manufactured GSE must meet the Tier 4 emission standards applicable to off-road compression-ignition engines. These standards vary by horsepower and are more than 90 percent cleaner than the emissions levels of engines produced twenty years ago. Additionally, in 2007, California adopted the In-Use Off-Road Diesel-Fueled Fleets regulation which requires fleets operating in-use diesel equipment to meet an annual fleet average emissions target that decreases over time. For example, for equipment over 175 and under 750 HP, the final 2023 NOx fleet average target is 1.5 g/bhp-hr, which is equivalent to the interim Tier 4 NOx standard for

newly produced engines. Fleets that do not meet the required annual fleet average must meet the best available control technology (BACT) requirements that require turnover, repower or retrofit of a specific percent of a fleet's total HP. These requirements are currently being phased-in.

Lastly, non-mobile GSE such as portable air-start units, ground power units and air conditioners may be subject to the Portable Diesel-Engines Air Toxic Control Measure (ATCM). The ATCM reduces PM emissions by requiring engine replacement in a schedule based on a fleet's weighted PM emission average.

Proposed Actions:

ARB would develop and propose a regulation to transition diesel and LSI GSE to zero-emission technology. The current commercial availability of several GSE equipment types indicates the feasibility of this transition. Battery-electric GSE are the most common type of zero-emission GSE, and are available for several high-population equipment types. Many large air carriers which operate diesel GSE have already begun moving towards electric equipment. The added introduction of zero-emission GSE will act as a catalyst to further zero-emission equipment penetration in the off-road equipment sector and other heavier duty-cycle and longer range applications.

A conservative strategy would rely on incentives and natural turnover, along with current in-use requirements, to replace equipment in which electric replacements are readily available, such as belt loaders, baggage tractors and cargo tractors. A more aggressive turnover and implementation strategy could utilize a memorandum of understanding, regulation, or a combination thereof, along with incentives for demonstration, to ensure 60 percent of existing diesel equipment in these categories would be replaced with zero-emission equipment by 2032, along with 50 percent of narrow body aircraft tugs and 30 percent existing wide-body aircraft tugs. Incentive funds would be targeted to demonstrating the feasibility of zero-emission technologies in the high-power equipment applications (e.g., wide-body aircraft tugs).

Estimated Emission Reductions:

ARB staff used ARB's Vision 2.1 model to estimate the emission reductions associated with this proposed measure. This proposed measure requires electrification of certain diesel airport ground support equipment (belt loaders, baggage tugs, and cargo tractors) through incentives and natural turnover. To model emission reductions, ARB staff used the turnover inherent in the official in-use off-road model, and assumed all new vehicles of the applicable types would be electric starting in 2023. For modeling purposes, new electric GSE vehicles would replace older vehicles using the natural turnover rate for this sector, which is the historical rate that equipment has been replaced, with no acceleration of purchasing habits.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
<0.1	<0.1	<0.1	<0.1

Timing:

ARB Board adoption date: 2018
Implementation schedule: 2023

Small Off-Road Engines

Overview:

The goal of this proposed measure is to reduce emissions from Small Off-Road Engines (SORE) and to increase the penetration of zero-emission technology. Small off-road engines that are subject to ARB regulations are used in residential and commercial lawn and garden equipment, and other utility applications. ARB staff will propose tighter exhaust and evaporative emission standards, encourage increased use of zero-emission equipment, and enhance enforcement of current emission standards for SORE.

Description of Source Category:

SORE are spark-ignited engines rated at or below 19 kilowatts. They are used in applications such as lawn and garden, industrial, construction and mining, logging, airport ground support, commercial utility, and farm equipment, golf carts, and specialty vehicles. It is estimated that there are approximately 16 million pieces of SORE equipment in California in 2015. In the absence of tighter emission standards for SORE, emissions of the ozone precursors ROG and NOx are expected to increase beginning in the late-2020s.

Background/Regulatory History:

The Board first approved regulations to control exhaust emissions from SORE in December 1990. ARB adopted amendments to the 1990 regulations to further control exhaust emissions in 1998 and 2003. These regulations were implemented through three tiers of progressively more stringent exhaust emission standards that were phased in between 1995 and 2008. Evaporative emissions from SORE were uncontrolled prior to the adoption of standards by the Board in 2003, which were implemented from 2006-2013. As a result of these regulations, the sum of exhaust and evaporative ROG emissions from SORE in the South Coast have been reduced by 60 percent in 2015, compared to 1990 levels, and NOx emissions from SORE in the South Coast have been reduced by two percent in 2015, compared to 1990 levels.

Proposed Actions:

ARB will develop and propose a regulation to tighten exhaust and evaporative emission standards for small off-road engines, including incentives for manufacturers to produce zero-emission equipment. High failure rates have been observed in evaporative emissions testing of SORE, preventing previously-claimed emission reductions from being realized. Exhaust and evaporative emissions from of SORE would be reduced through enhanced enforcement of the current emission standards, adoption of tighter exhaust and evaporative emission standards, and increased use of zero-emission equipment. Strategies will be developed for transitioning to zero-emission technologies from of SORE, including phased emission standards and incentives for zero-emission equipment. A conservative strategy would use incentives and natural turnover to

replace existing spark-ignited small off-road engines and equipment representing 25 percent of statewide ROG and NOx emissions with zero-emission equipment by 2030, while other spark-ignited equipment would meet exhaust and evaporative emission standards that are approximately 90 percent tighter than today's by 2030. The greatest emission reductions from incentives would be realized by the early turnover of commercial lawn and garden equipment to zero-emission equipment, which accounts for a disproportionate amount of SORE emissions.

Estimated Emission Reductions:

ARB staff estimated the emission reductions associated with this proposed measure by applying a NOx and hydrocarbon emission factor reduction by model year, beginning in 2022 with a reduction of 50 to 75 percent, and increasing in stringency to 2031 with reductions of 80 to 90 percent. The reductions apply to running and evaporative emissions (though each has its own reduction factor), and manufacturers are assumed to meet the required reductions with engine controls and by increasing sales of battery or electric powered equipment to replace traditional small gasoline engines.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
4	36	<0.1	<0.1

Timing:

ARB enhanced enforcement:	2016
Proposed ARB Board adoption date:	2018
Implementation schedule:	2022 – 2030

Transport Refrigeration Units Used for Cold Storage

Overview:

The goal of this proposed measure is to advance zero and near-zero emission technology commercialization by increasing the early penetration of hybrid electric and electric standby-equipped Transport Refrigeration Units (TRU) used for cold storage, and supporting the needed infrastructure developments. ARB would develop a regulation to reduce NOx, PM, and GHG emissions by reducing the amount of time that TRUs operate using internal combustion engine while refrigerated trucks, trailers, and shipping containers are parked (stationary) at certain California facilities and other locations.

Description of Source Category:

TRUs are refrigeration systems powered by an internal combustion engine (inside the unit housing), designed to control the environment of temperature-sensitive products that are transported in refrigerated trucks, trailers, railcars, and shipping containers. Examples of the products hauled are food, beverages, pharmaceuticals, flowers, medical products, industrial chemicals, and explosives. TRUs may be capable of both cooling and heating. TRUs operate in large numbers at distribution centers, food manufacturing facilities, packing houses, truck stops, and intermodal facilities. They deliver perishable goods to retail outlets, such as grocery stores, restaurants, cafeterias, convenience stores, etc. The growth rate of TRUs is tied to population, since food is the main product type that is hauled.

Background/Regulatory History:

The Board identified diesel PM as a TAC and in October 2000, ARB published a "*Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-fueled Engines and Vehicles*." In the Diesel Risk Reduction Plan, ARB identified TRU PM emissions associated with refrigerated warehouse distribution centers as creating potential cancer risks and included TRU engines in the plan to reduce diesel PM emissions 85 percent by 2020.

ARB adopted its ATCM for In-Use Diesel-Fueled TRUs and TRU Generator Sets in 2004. This regulation requires TRU diesel engines to meet in-use diesel PM emission standards by the end of the seventh year after manufacture. Implementation of the TRU ATCM began in 2009. The TRU ATCM was amended in 2010 and 2011.

Proposed Actions:

The initial concepts of the proposed regulation would limit the amount of stationary operating time that a transport refrigeration system powered by an internal combustion engine can operate at certain facilities. The time limit would decrease on a phased compliance schedule. Compliance options include the use of commercially available

hybrid electric TRUs, TRUs equipped with electric standby motors, and cryogenic transport refrigeration systems. Hybrid electric and electric standby-equipped TRUs would plug into electric power plugs while stationary and use diesel engine power while on the road. Cryogenic transport refrigerators use liquid nitrogen and liquid carbon dioxide to provide cooling. Development and use of zero-emission technologies, such as all-electric plug-in / advanced battery transport refrigeration systems would be encouraged, as well as adequately-sized cold storage facilities, and more efficient inbound delivery appointment and outbound dispatch scheduling.

Estimated Emission Reductions:

While emission reductions have not been identified at this time, ARB will quantify any emission reductions from this measure during the SIP measure development process.

Timing:

ARB Board adoption date:	2017 - 2018
Implementation schedule:	2020+

Further Deployment of Cleaner Technologies: Off-Road Equipment

Overview:

The goals of this proposed measure are to accelerate the penetration of zero and near-zero equipment and to promote in-use efficiency gains through use of connected and autonomous vehicles, and worksite efficiencies.

Background/Regulatory History:

Incentive Funding

Several State and local incentive funding pools have been used historically – and remain available – to fund the accelerated turnover of off-road heavy-duty vehicles in the South Coast. Since 1998 the Carl Moyer Program has provided funding for replacement, new purchase, repower and retrofit of engines in the South Coast. However, to achieve additional reductions in this category, new sources of funding will be pursued.

Low-Emission Technologies and Efficiency Improvements

In addition to developing new funding sources, alternative strategies may exist to replace or supplement additional funding pools. While new engine and fleet standards continue to reduce emissions from heavy-duty off-road equipment, it is important that ARB continue to look for ways to apply advanced technology to further increase the sustainability of the off-road sector such as automation, connected vehicles, and fleet management. These technologies are already being applied to the construction industry in a variety of equipment types, including graders, excavators, and tractors. Examples include grading assisted technologies that can use on-board sensors and GPS to accurately grade to a desired depth and slope thus reducing the number of passes needed. Fleet management technologies allow a fleet manager to monitor parameters such as fuel usage and productivity to optimize equipment utilization on the job site. Technologies such as these have the potential to achieve significant fuel-savings if applied across the industry and will yield emission reductions beyond what is achieved through engine and fleet regulations.

Proposed Actions:

This proposed measure is designed to achieve further emission reductions through a suite of additional actions, including early penetration of zero and near-zero technologies, and emission benefits associated with the potential for worksite integration and efficiency, as well as connected and autonomous vehicle technologies. These emission reductions will be achieved through a combination of actions to be undertaken by both ARB and the District.

Scope of Technology Penetration and Mechanisms to Achieve Reductions:

Under current requirements, most new equipment is required to meet Tier 4 emission standards, and many smaller engines are converting to use of zero-emission technologies. To achieve the further reductions associated with early penetration of the cleanest technologies across each sector, ARB and South Coast staff estimated the scope of penetration that would be required by 2023. This would include:
1) electrification of small engine forklifts less than 65 HP; 2) cleaner zero and near-zero technologies for TRUs; 3) electrification of ground support equipment such as baggage tugs, belt loaders, cargo tractors, and aircraft tugs; 4) electrification of certain types of lawn and garden equipment such as mowers, leaf blowers, and edgers; and
5) replacement of construction, mining, and industrial equipment with engines that are below Tier 4 with Tier 4 final equipment.

The following mechanisms provide a pathway for achieving this scale of technology deployment: Identify and develop mechanisms to incentivize deployment of construction and mining equipment meeting Tier 4 final standards such as the South Coast's SOON program for the clean-up of off-road diesel equipment. Such programs have allowed affected fleets to meet requirements through public funding assistance. This could achieve further reductions from the approximately 7,000 pieces of equipment that would still have engines that are Tier 2 and below in 2023. The South Coast will include local measures to address certain types of heavy-duty equipment in their AQMP.

- Develop requirements for cleaner zero and near-zero technologies for TRUs. Emission reductions associated with Transport Refrigeration Units Used for Cold Storage measure have not yet been quantified. This proposed measure reflects concepts to limit the amount of stationary operating time that a TRU powered by an internal combustion engine could operate at certain facilities. Development and use of zero-emission technologies would be encouraged. This proposed measure will need to motivate distribution and other facilities to install the infrastructure needed to support zero and near-zero emission technologies, encourage the development and demonstration of zero and near-zero emission technologies, and cause refrigerated fleets to evaluate and invest in zero and near-zero technologies.
- Expand and enhance existing incentive and other innovative funding programs for off-road equipment to increase the emphasis on and support for zero-emission capable equipment. Assuming incentive funding is the primary mechanism to achieve early deployment of zero-emission capable technologies for forklifts, airport ground support equipment, and TRUs by 2023, funding would be required for at least 4,000 pieces of equipment per year over a seven year period. This early deployment through enhanced incentive funding would provide a down payment towards meeting requirements that would be established through the subsequent regulatory mechanisms identified for these categories. The population of lawn and garden equipment in the South Coast is very large; thus funding programs

would target the types of lawn and garden equipment with the greatest emissions, such as mowers, leaf blowers, and edgers. Use of zero-emission technologies would also provide near-source risk reduction for operators of the equipment. The incentive funding required for these efforts would go beyond the amount currently authorized through 2023.

Determination of the needed resources will be based on assessment of the incremental cost of technologies, cost effectiveness, and the type of financing mechanism employed. Funding needs and mechanisms will be identified working in collaboration with the District and other State agencies over the next several months.

Additional mechanisms reflect continued penetration of near-zero and zero-emission technologies, as well as reductions achieved through worksite efficiencies. Reductions from other equipment types within this category will also be considered, including motorcycles, watercraft, aftermarket parts, and additional enforcement initiatives. While these approaches have the greatest potential to provide further reductions post 2023, early advances in these areas could offset some of the reductions required through incentive funding. These additional pathway mechanisms include:

- Further advanced technology deployment. Based on on-going technology assessment, regulatory mechanisms to expand zero-emission technologies into heavier pieces of off-road equipment such as high lift-capacity forklifts and other equipment in the construction, mining, and industrial sectors may be feasible. The greatest opportunities exist for engines that have a duty cycle to accommodate battery electric or fuel cell electric technologies.
- Advances in the development of autonomous systems, particularly if based on zero-emission technologies, as well as greater worksite integration, efficiency and fleet management technologies. These changes in how the off-road equipment sector would operate offer the potential to achieve criteria, toxic, and GHG emission reductions as well as reduce petroleum usage. These concepts are based on emerging technologies, and will require exploration and demonstration prior to quantifying emission reductions.

Estimated Emission Reductions:

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
17	20	NYQ	NYQ

Timing:

Implementation schedule: 2016 – 2031

Implementation Milestones and Schedule:		
Proposed Strategy	**Implementation Steps**	**Date**
Identify and secure funding for incentive based and other innovative funding programs for accelerated deployment of zero and near-zero off-road equipment	*Phase 1*: Identify funding needs and potential sources	2016 + (annually)
	Phase 2: Pursue actions to secure funding	
	Phase 3: Implement funding/incentive programs	
Develop regulatory strategies for deployment of zero-emission technologies in off-road equipment applications as appropriate	*Phase 1:* Evaluation of technology and prototype demonstrations	2016 – 2023
	Phase 2: Development of regulatory strategies	2022 – 2025
	Phase 3: Measure implementation	2027 – 2031
Evaluate potential for emission benefits from operational efficiencies, and intelligent transportation systems and quantify and develop mechanisms to provide SIP reductions as appropriate	*Phase 1:* Evaluation of approaches and potential for emission reductions	2016 – 2023
	Phase 2: Demonstration of systems	2020 – 2025
	Phase 3: Quantification of emission reductions and mechanisms for incorporating into SIP	2025 – 2031

10. Fuels

The total diesel sales in California in 2012 were about 3.3 billion gallons.[29] Based on the California Energy Commission analysis, it is expected that the total diesel demand may remain more or less the same or slightly decline by 2030.[30] The use of Low-Emission Diesel in on- and off-road vehicles and off-road equipment will reduce NOx and PM emissions in addition to other criteria pollutants and life cycle GHG emissions. Studies carried out to date on Low-Emission Diesel, particularly hydrotreated vegetable oil (HVO), have reported NOx emission reductions of six percent to 25 percent and PM emission reductions of 28 percent to 46 percent, depending on the types of fuels and diesel engines used. The absolute amounts of NOx and PM reductions will primarily be determined by the level of Low-Emission Diesel penetration in the California diesel market.

Current Suite of Programs

ARB has a long history of achieving emission reductions via setting fuel standards. Cleaner fuel has an immediate impact in reducing emissions from the mobile source sector and has had a significant impact in reducing reactive organic compounds and sulfur oxide emissions. More recently, ARB developed the Low Carbon Fuel Standard to reduce the carbon intensity of transportation fuels, which will reduce our dependence on petroleum, and incentivizes increased production and use of renewable, low-carbon fuels.

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[29] California Energy Commission. Retrieved from http://energyalmanac.ca.gov/gasoline/piira_retail_survey.html

[30] Gene Strecker, 2015. Overview of Preliminary Transportation Energy Demand Forecast. Retrieved from http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-10/TN205135_20150623T151914_Overview_of_Preliminary_Transportation_Energy_Demand_Forecast.ppt.

California's stringent air quality programs treat motor vehicles and their fuels holistically (as a system, rather than as separate components). As a result, ARB's fuels programs achieve significant reductions in criteria and toxic air pollution from motor vehicles used in California. Relative to federal gasoline, ARB's reformulated gasoline program reduces smog forming emissions by 15 percent and toxic air contaminants by 50 percent. Similarly, ARB's ultralow sulfur diesel program reduces emissions significantly relative to federal diesel, about seven percent reduction in NOx and 25 percent in diesel PM. Further, in combination with other state and federal GHG-reduction programs (the State Advanced Clean Cars and Pavley Vehicle Standards programs; the U.S. EPA's Renewable Fuel Standard 2 and Corporate Average Fuel Economy programs), implementation of the recently re-adopted LCFS and adopted new Alternative Diesel Fuel (ADF) regulations is anticipated to result in environmental benefits that include an estimated reduction in GHG emissions of more than 60 million MMTCO2e from transportation fuels used in California from 2016 through 2020. On its own, the LCFS is estimated to reduce transportation-related GHG emissions by 35 MMT during those years.

Importance of Renewable Fuels

In 2015, Governor Brown set a goal to reduce petroleum use by up to 50 percent by 2030. One of the opportunities to help meet this goal is for fuel providers to sell diesel with incrementally higher blends of advanced renewable fuels, which will support the Low Carbon Fuel Standard and ensure sufficient volumes of advanced renewable fuels are available. Because the mobile sector will continue operating on internal combustion engines for some time, it is critical that the fuels consumed in these vehicles contribute to the emission reductions needed to meet our 2031 air quality and 2030 climate and petroleum reduction goals. The Vision scenarios illustrate that, since diesel vehicles will comprise a large portion of the fleet still operating with combustion engines, a Low-Emission Diesel Requirement would reduce NOx, diesel PM, and GHG emissions. Furthermore, a Low-Emission Diesel Requirement would provide the flexibility to target the most cost-effective emission reductions, for example by requiring higher blend levels in South Coast than in the rest of the State.

Proposed Measures: Fuels

The proposed measure for a new Low-Emission Diesel Requirement would complement existing ARB programs that incentivize increased use of renewable fuels as substitutes for conventional gasoline and diesel fuels, and will focus on more completely transitioning the fuel mix away from petroleum-based diesel to a cleaner, renewable mix of diesel substitute fuels such as renewable diesel from biomass, NOx-mitigated biodiesel, renewable natural gas from biomethane, gas to liquid diesel from biomethane, renewable hydrocarbon diesel, and/or co-processed renewable hydrocarbon diesel. The measure is anticipated to diversify the fuel pool, as it will incentivize increased production of low-emission diesel fuels. This measure would require incremental progress toward a goal of Low-Emission Diesel comprising 50 percent of the on-and off-road diesel sold in State by 2030.

Low-Emission Diesel Requirement

Overview:

The goal of this proposed measure is to reduce emissions from the portion of the heavy-duty fleet that will continue to operate on internal combustion engines in order to reduce emissions as quickly as possible. This proposed measure would put into place standards for Low-Emission Diesel, and would require that diesel fuel providers sell steadily increasing volumes of Low-Emission Diesel until it comprises 50 percent of total diesel sales by 2031.

Description of Source Category:

The total diesel sales in California in 2012 were about 3.3 billion gallons.[31] Based on the California Energy Commission analysis, it is expected that the total diesel demand may remain more or less the same or slightly decline by 2030.[32] The use of Low-Emission Diesel in on-road vehicles and off-road equipment will reduce NOx and PM emissions in addition to other criteria pollutants and life cycle GHG emissions. Studies carried out to date on Low-Emission Diesel, particularly hydrotreated vegetable oil (HVO), have reported NOx emission reductions of six percent to 25 percent and PM emission reductions of 28 percent to 46 percent, depending on the types of fuels and diesel engines used. The absolute amounts of NOx and PM reductions will primarily be determined by the level of Low-Emission Diesel penetration in the California diesel market.

Proposed Actions:

ARB would bring to the Board a proposed measure that would require Low-Emission Diesel comprise a steadily increasing percent of the ARB diesel pool. Due to the magnitude of needed NOx reductions in the South Coast and the large volumes of Low-Emission Diesel needed for full statewide implementation, the proposed measure would be phased-in with a gradual implementation strategy that starts in the South Coast, and subsequently expands statewide.

This standard is flexible and enables multiple fuel types to meet this standard. The specifications of Low-Emission Diesel would require less than one percent aromatics, virtually no sulfur, and a blendstock carbon intensity maximum of 30-60 gCO2e/MJ. This standard is anticipated to increase consumption of Low-Emission Diesel fuels, including: renewable diesel from biomass, NOx-mitigated biodiesel, renewable natural gas from biomethane, gas to liquid diesel from biomethane, renewable hydrocarbon diesel, and/or co-processed renewable hydrocarbon diesel. This proposed measure

[31] California Energy Commission. Retrieved from http://energyalmanac.ca.gov/gasoline/piira_retail_survey.html
[32] Gene Strecker, 2015. Overview of Preliminary Transportation Energy Demand Forecast. Retrieved from http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-10/TN205135_20150623T151914_Overview_of_Preliminary_Transportation_Energy_Demand_Forecast.ppt.

would provide NOx benefits predominately from legacy (pre-2010) on-road heavy-duty vehicles, off-road engines, stationary engines, portable engines, marine vessels and locomotives, as well as NOx and Diesel PM benefits in potentially all model year off-road engines, stationary engines, portable engines, marine vessels and locomotives. Interstate vehicles, even those registered out-of-state but operating on ARB diesel blended with Low-Emission Diesel, are also anticipated to provide emission reduction benefits.

This standard would complement existing ARB programs that incentivize increased use of renewable fuels as substitutes for conventional gasoline and diesel fuels, and will focus on more completely transitioning the fuel mix away from petroleum based diesel to a cleaner, renewable mix of diesel substitute fuels. Potential diesel substitutes that may be considered include renewable diesel from biomass, NOx mitigated biodiesel, renewable natural gas from biomethane, gas to liquid diesel from biomethane, renewable hydrocarbon diesel, and/or co-processed renewable hydrocarbon diesel. The proposed measure is anticipated to diversify the fuel pool, as it will incentivize increased production of Low-Emission Diesel fuels. This proposed measure would require incremental progress toward a goal of Low-Emission Diesel comprising 50 percent of the on and off-road diesel sold in State by 2031.

Estimated Emission Reductions:

To calculate the emission reductions for this requirement, ARB staff used ARB's official emissions inventory coupled with the reductions associated with the aforementioned measures. Under this requirement, emissions for NOx and PM2.5 would be reduced by 9 percent to 18 percent and 24 percent to 34 percent, respectively. Furthermore, the requirement would only affect non-SCR engines, 50 percent of the diesel pool, and it would assume that 50 percent of the fuel for locomotives and OGV is from in-state. For modeling purposes, the total emissions associated with the locomotive and OGV were reduced by 50 percent (in-state fuel), while the rest of the off-road inventory emissions were reduced to include only those emissions associated with non-SCR engines. The total emissions were then calculated (locomotive, OGV, and the rest of the off-road inventory) and this number was reduced by the sum of the measure reductions, multiplied by 50 percent (diesel pool), and multiplied by 13 percent or 29 percent (average NOx or PM2.5 reductions) to determine the total reductions in NOx and PM2.5 for this requirement.

Emission Reductions in 2031 (Statewide)			
NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (mmtCO2e)
8	NYQ	1	NYQ

Timing:

Proposed ARB Board adoption:	by 2020
Implementation schedule:	2023-2031

11. Vision Tools

Background

The Vision model was first developed in 2012 to enhance ARB's ability to conduct transportation system-wide, multi-pollutant, analysis to inform policy development. It allows for the evaluation of technology, fuel, and efficiency interactions across many source sectors and multiple pollutants. Measuring and analyzing the system-wide emissions impacts that stem from strategies in individual sectors requires a comprehensive approach that reflects real-world linkages. Initially much of the ARB Vision methodology was based on the Argonne National Laboratory national Vision model that included only on-road vehicle GHG emissions, leveraging the Argonne GREET lifecycle emission factors.

Over time, ARB staff revised the national Vision model platform with additional California-specific data and methodologies, and expanded the ability to analyze both GHG and criteria pollutants. This first public version of the model, Vision 1.0[33], was released publically in 2012 on the ARB website with a coinciding public workshop[34].

Based on this work, ARB staff developed Vision 2.0 in 2014 and gave a detailed overview of the model at a public workshop[35] in 2015. Vision 2.0 models were made available in October, 2015 on ARB's Vision web page[36].

[33] Vision 1.0 Model http://www.arb.ca.gov/planning/vision/downloads.htm
[34] Vision 1.0 Workshop http://www.arb.ca.gov/planning/vision/workshops.htm
[35] Vision 2.0 Workshop http://www.arb.ca.gov/planning/vision/workshops.htm
[36] Vision 2.0 available at http://www.arb.ca.gov/planning/vision/downloads.htm

Building upon Vision 1.0 framework, staff enhanced and broadened the scopes of on-road, off-road and stationary sources energy demand modules and developed a separate energy module to aggregate energy consumption and multi-pollutant emissions associated with fuel demand. As a result, Vision 2.0 is a comprehensive modeling tool that provides the ability to analyze both upstream and downstream emissions.

Vision 2.0 is unique in that was designed to focus on California specific policy questions and metrics by incorporating ARB's most recent inventory work such as EMFAC2014 and reflects all adopted policies. In addition, it is one of the few scenario tools that integrate greenhouse gas and criteria emissions to inform how air quality, climate, and petroleum reduction goals can be met. The modules also have the most detailed breakdowns of each sector by vocation, technology type, and emissions process, and go further by providing that detail at an enhanced spatial resolution that can be merged with roadway network models. The output from the modules can also be merged with information about the cost of technologies and infrastructure for an economic assessment of a policy.

Vision scenario modeling is an iterative process. Information on the current and potential future state of technology is synthesized into a scenario that reflects a combination of technology, fuel, and efficiency assumptions. These assumptions are revised as new information becomes available. The base assumptions are informed by foundational technical work and ongoing technology assessments by ARB[37] and other organizations. Results from scenarios are used to evaluate progress towards climate and air quality goals and inform policy making decisions.

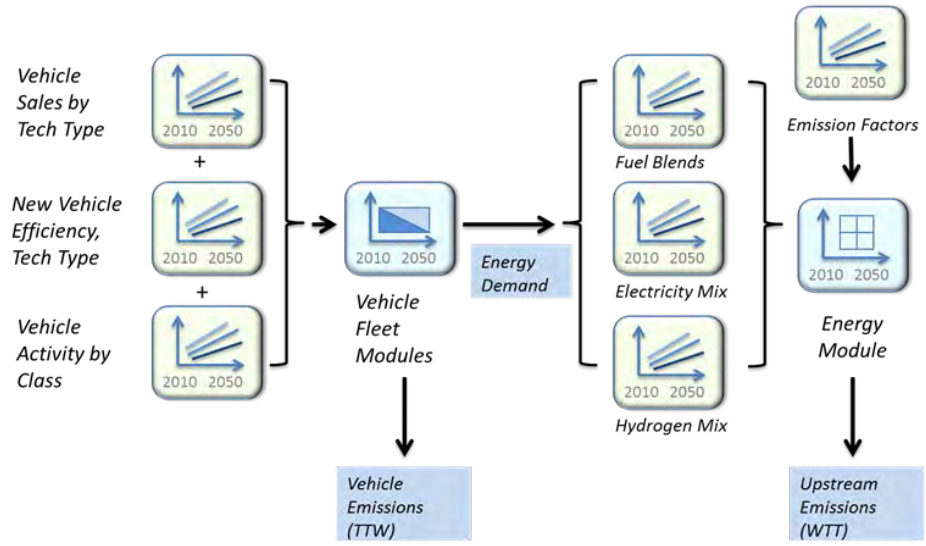
ARB staff reviewed Vision's inputs and assumptions after the October release. An updated Vision, Vision 2.1, which has the same modeling structure as Vision 2.0 but reflects the latest planning inventory and assessments, is used for the analyses presented in this document. Vision 2.1 and companion documentations will be released and posted on Vision website in late Spring, 2016.

Vision Methodology

The Vision tools incorporate detailed data from ARB's standard inventories, which include EMFAC, locomotives, ships, and OFFROAD, into separate modules where comprehensive scenarios can be run. These results are then aggregated into a central module that allocates fuels and energy and outputs emissions, as shown in Figure 19. For example, information about changing technology sales, how clean those technologies are, and any changes in the transportation system efficiency are defined inputs to the vehicle fleet module. The model then evaluates the impact of this scenario on tank-to-wheel (TTW) emission and the associated energy demand. This energy demand, plus input assumptions about the mix of fuels is input to the energy module where upstream well-to-tank (WTT) emissions are calculated.

[37] Technology and Fuels Assessments http://www.arb.ca.gov/msprog/tech/tech.htm

Figure 19: Framework of the Vision Model



The baseline data in Vision incorporates all of the following state and national adopted policies and regulations:

On-Road Mobile

- EMFAC2014 planning inventory updates with VMT based on 2015 FSTIP (Federal Statewide Transportation Improvement Program) for all 17 MPOs and for SCAG it is based on draft 2016 RTP/SCS. For non-MPO regions, it is based on default EMFAC2014.
- Light-duty vehicles (LDV): Advanced Clean Cars and SB 375
- Heavy-duty vehicles (HDV): Phase 1 GHG, Truck & Bus Regulation, Drayage Regulation and South Coast AQMD's Rule 1193

Off-Road Mobile

- Ocean Going Vessel: At-Berth Regulation, Fuel Rule
- Locomotives: South Coast MOU and Statewide Rail Yard Agreement

Fuels

- LCFS: Assumes 2020 compliance
- Grid: RPS 33 percent renewables by 2020
- Hydrogen: SB 1505 33 percent renewables, expected by 2020
- Biomethane: Landfill methane and waste diversion for biogas

Baseline Demand Model Inputs

On-Road Vehicle Modules

The Vision 2.1 On-Road Vehicle Modules, Passenger and Heavy-Duty Vehicle Modules, forecast population, vehicle sales, fuel efficiency, turnover, and VMT, energy demand and emissions (NOx, PM2.5, reactive organic gases, and tailpipe GHGs) for various vehicle types in California under given scenarios. The Passenger Vehicle Module covers light-duty vehicles with GVWR up to 8,500 lbs and all types of buses while the Heavy-Duty Vehicle Module includes trucks with GVWR above 8,500 lbs. All scenario analyses are provided out to calendar year 2050 for the vehicle categories found in the EMFAC2014[38] model. For light-duty and heavy-duty vehicles, the categorizations are as shown in Table 10.

[38] Mobile Source Emissions Inventory http://www.arb.ca.gov/msei/categories.htm

Table 10: Vision Vehicle Categories

EMFAC Vehicle ID	Description
LDA	Light-Duty Automobiles (i.e. Passenger Cars)
LDT1	Light-Duty Trucks (0-3,750 lbs GVWR)
LDT2	Light-Duty Trucks (3,751-5,750 lbs GVWR)
MDV	Medium-Duty Trucks (5,751-8,500 lbs GVWR)
UBUS	Urban Buses
SBUS	School Buses
OBUS	Other Buses
LHD1	Light-Heavy-Duty Trucks (GVWR 8501-10000 lbs)
LHD2	Light-Heavy-Duty Trucks (GVWR 10001-14000 lbs)
T6 Ag	Medium-Heavy Duty Diesel Agriculture Truck
T6 CAIRP heavy	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR>26000 lbs
T6 CAIRP small	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR<=26000 lbs
T6 instate	Medium-Heavy Duty Diesel instate construction Truck with GVWR>26000 lbs
T6 instate	Medium-Heavy Duty Diesel instate construction Truck with GVWR<=26000 lbs
T6 instate heavy	Medium-Heavy Duty Diesel instate Truck with GVWR>26000 lbs
T6 instate small	Medium-Heavy Duty Diesel instate Truck with GVWR<=26000 lbs
T6 OOS heavy	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR>26000 lbs
T6 OOS small	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR<=26000 lbs
T6 Public	Medium-Heavy Duty Diesel Public Fleet Truck
T6 utility	Medium-Heavy Duty Diesel Utility Fleet Truck
T6TS	Medium-Heavy Duty Gasoline Truck
T7 Ag	Heavy-Heavy Duty Diesel Agriculture Truck
T7 CAIRP	Heavy-Heavy Duty Diesel CA International Registration Plan Truck
T7 CAIRP	Heavy-Heavy Duty Diesel CA International Registration Plan Construction Truck
T7 NNOOS	Heavy-Heavy Duty Diesel Non-Neighboring Out-of-state Truck
T7 NOOS	Heavy-Heavy Duty Diesel Neighboring Out-of-state Truck
T7 other port	Heavy-Heavy Duty Diesel Drayage Truck at Other Facilities
T7 POAK	Heavy-Heavy Duty Diesel Drayage Truck in Bay Area
T7 POLA	Heavy-Heavy Duty Diesel Drayage Truck near South Coast
T7 Public	Heavy-Heavy Duty Diesel Public Fleet Truck
T7 Single	Heavy-Heavy Duty Diesel Single Unit Truck
T7 single	Heavy-Heavy Duty Diesel Single Unit Construction Truck
T7 SWCV	Heavy-Heavy Duty Diesel Solid Waste Collection Truck
T7 tractor	Heavy-Heavy Duty Diesel Tractor Truck
T7 tractor	Heavy-Heavy Duty Diesel Tractor Construction Truck
T7 utility	Heavy-Heavy Duty Diesel Utility Fleet Truck
T7IS	Heavy-Heavy Duty Gasoline Truck
PTO	Power Take Off

The vehicle types are further split into the following technology categories:

Table 11: Vision Vehicle Technology Categories

Technology ID	Description
GAS	Gasoline Fueled Vehicles
DSL	Diesel Fueled Vehicles
ELE	Electric Power Vehicles
E85	Ethanol Fueled Vehicles
CNG	Compressed Natural Gas Fueled Vehicles
LNG	Liquefied Natural Gas Fueled Vehicles
HYD	Hydrogen Power Vehicles (i.e. Fuel Cells)
PHEV	Plug-in Hybrid Vehicles

EMFAC2014 provides output for gasoline and diesel technologies for all vehicle types, and natural gas and electric technologies for selected vehicle types[39]. To reflect and refine the underlining assumptions of Advanced Clean Cars in EMFAC and to account for upstream energy and fuel demands, additional modifications were made to EMFAC2014 output. The modifications to ZEV and PHEV for light-duty vehicles are described in Draft Vision 2.0 Model Documentation[40]. The technology categories represented in Vision:

Table 12: Vision Vehicle Technology Categories

Technology ID	Description
GAS	Gasoline Fueled Vehicles
DSL	Diesel Fueled Vehicles
ELE	Electric Power Vehicles
E85	Ethanol Fueled Vehicles
CNG	Compressed Natural Gas Fueled Vehicles
LNG	Liquefied Natural Gas Fueled Vehicles
HYD	Hydrogen Power Vehicles (i.e. Fuel Cells)
PHEV	Plug-in Hybrid Vehicles

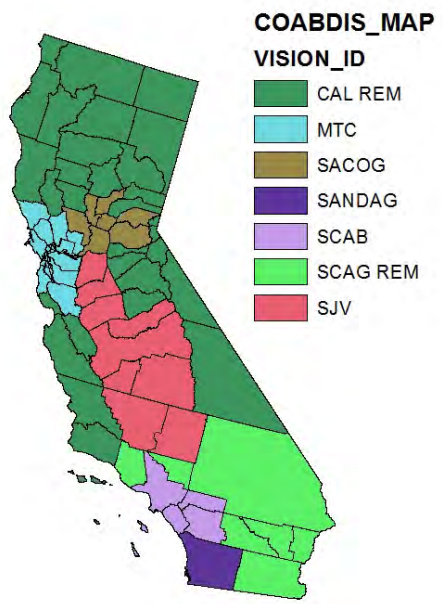
The model output is also output to seven geographic areas. These areas are aggregations of geographic areas found in the EMFAC2014 model. Each of the 69 geographic areas in the EMFAC2014 model is identified by county, air basin, and air district (COABDIS). The seven aggregated areas in the model represent areas where it

[39] EMFAC2014 Technical Documentation http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol3-technical-documentation-052015.pdf
[40] Draft Vision 2.0 Modeling System General Model Documentation http://www.arb.ca.gov/planning/vision/docs/vision2.0lr_model_documentation.pdf

would be relevant for specific SIP or climate related policies. The seven geographic areas are described below and displayed in Figure 20.

- **South Coast Air Basin (SCAB):** those counties and geographic areas defined by California law as the South Coast Air Basin. Includes non-attainment areas for the 1997 and 2008 ozone air quality standards as well as the 1997 and 2006 PM2.5 air quality standards.

Figure 20: Vision Geographic Areas



- **Southern California Association of Governments (SCAG REM):** those remaining counties and geographic areas under the jurisdiction of the Southern California Association of Governments not included in the SCAB. Includes non-attainment areas for the 1997 and 2008 ozone air quality standards as well as the 1997 and 2006 PM2.5 air quality standards.

- **San Diego Association of Governments (SANDAG):** the geographic area confined by San Diego County. Includes non-attainment areas for the 1997 and 2008 ozone air quality standards.

- **San Joaquin Valley (SJV):** those counties and geographic areas defined by California law as the San Joaquin Valley Air Basin plus the eastern portion of Kern County not included in the San Joaquin Valley Air Basin. Includes non-attainment areas for the 1997 and 2008 ozone air quality standards as well as the 1997 and 2006 PM2.5 air quality standards.

- **Sacramento Area Council of Governments (SACOG):** those counties and geographic areas under the jurisdiction of the Sacramento Council of Governments. Includes non-attainment areas for the 1997 and 2008 ozone air quality standards as well as the 2006 PM2.5 air quality standards.

- **Metropolitan Transportation Commission (MTC):** those counties and geographic areas under the jurisdiction of the Metropolitan Transportation Commission. Includes non-attainment areas for the 1997 and 2008 ozone air quality standards as well as the 2006 PM2.5 air quality standards.

- **California Remaining Areas (CAL REM):** All remaining counties in California not in one the regions defined above. Some of the counties within this area are non-attainment for the ozone and/or PM2.5 air quality standards.

Off-Road Vision Modules

Although Vision Model covers off-road sectors extensively, only the sectors impacted by measures outlined in this document are discussed here:

Table 13: Descriptions of Off-Road Vision Modules

Module	Sources	Geographic Areas	Forecast
Off-Road, Forklifts & GSE	OFFROAD2007, 2010 In-Use Off-Road Emissions Inventory, Off-road Simulation Model[41]	South Coast & San Joaquin Air Basins and Statewide	Up to 2050
Locomotives	Updated locomotive inventory[42]	County, Air Basin and Air District	Up to 2050
Ocean Going Vessels	Marine Emissions Model v2.3L[43]	South Coast & San Joaquin Air Basins and Statewide	Up to 2031

Baseline Energy Module Inputs

The Vision 2.1 energy module is used to evaluate the liquid fuels, electric power, hydrogen and natural gas required to supply the demands of the vehicle fleet models. Additionally, the energy module calculates the upstream WTT emissions associated with transportation fuel consumption and total WTW greenhouse gases based on the composition of the fuels used in the scenario. The module processes data inputs from the vehicle fleet modules in the form of demands, blending assumptions, supply capacities, emissions and emission factors. The module then outputs consumed quantities of finished fuels, feedstocks, electricity, and other supplies required to meet vehicle fleet module demands and their associated emissions. Data for the module was acquired from a number of different sources. Facility emission rates and well-to-wheel GHG emission rate inputs are obtained from facility reports[44], statewide emissions inventories[45], and CA GREET v2[46]. The California Energy Commission (CEC), the U.S. Energy Information Administration (U.S. EIA), and the Low Carbon Fuel Standard (LCFS) Program provide data on blending input assumptions. Finally, supply capacities

[41] Off-Road Mobile Source Emissions Inventory http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles
[42] Locomotive Inventory Update http://www.arb.ca.gov/msei/goods_movement_emission_inventory_line_haul_octworkshop_v3.pdf
[43] Off-Road Mobile Source Emissions Inventory http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles
[44] Facility Emissions Data available at http://www.arb.ca.gov/ei/disclaim.htm
[45] Emissions Inventories available at http://www.arb.ca.gov/aqmis2/aqdselect.php
[46] California GREET Model available at http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm

are derived from the CEC, the Department of Energy's Billion Ton Study[47], and the LCFS Program.

The energy module contains a number of different fuels and blendstocks, including:

Table 14: Vision Fuels and Blendstocks

Demand	Blendstocks
Gasoline	CARBOB, Ethanol, Renewable Gasoline
Diesel	ULSD, Bio-diesel, Renewable diesel
Electricity	Coal, Natural Gas, Nuclear, Hydro, Wind, Solar,
Natural gas	Fossil, Landfill, AD Gas
Hydrogen	Reformed Natural Gas, Biomass, Wind, Solar
Jet Fuel	Petroleum, Bio-Jet, Renewable Jet

The module can vary blendstocks for the various demands so that it is able to optimize blends to utilize low-CI supplies. Supply mix choices can be varied for electricity and hydrogen (i.e. by varying the percent of electricity supplied by coal, nuclear, or solar power). Finally, the module allows for global, statewide, and regional boundaries to account for where emissions occur.

Scenario Assumptions

The scenarios outlined earlier in this document include a *Current Control Program* scenario, and a *Cleaner Technology and Fuels* scenario. The baseline *Current Control Programs* scenario reflects all adopted policies as discussed above. The *Cleaner Technology and Fuels* scenario explored a pathway to getting deeper NOx reductions and meeting climate and petroleum reduction goals. Lastly, *SIP Measures* represents the assumptions used in estimating the South Coast NOx reductions associated with the proposed measures identified in Chapter 4.

The scenario concepts are translated into assumptions which can be used in the Vision 2.1 model. These assumptions, when run through the Vision modules, provide the emission reductions associated with each scenario or concept. Some of the measure concepts are more complex than the current emission inventory and Vision could fully reflect, staff strove to develop assumptions that are consistent with the intent of proposed actions. During the regulatory process, regulatory-specific inventories will be compiled based on detailed fleet information collected through the outreach process including the most up-to-date data. Tables 15 and 16 display the measure on the left, and the translated Vision modeling assumptions on the right. These assumptions reflect the reductions that could be achieved from the concept, but do not necessarily

[47] US Department of Energy (DOE) Billion Tons Study https://bioenergykdf.net/content/billiontonupdate

represent what would ultimately be developed through the more rigorous regulatory or policy development process.

The assumptions used in the *Cleaner Technologies and Fuels* Scenario are shown in Table 15:

Table 15: Vision Assumptions for *Cleaner Technologies and Fuels* Scenario

Measure	Assumptions
On-Road Heavy-Duty	
Federal Low-NOx Engine Standards	Assumed National Standard starting in 2024 that is 90 percent lower NOx than 2010 Std trucks
California Low-NOx Engine Standards	Assumed California Standard starting in 2024 that is 90 percent lower NOx than 2010 Std trucks
Medium and Heavy-Duty GHG Phase 2	Assumed benefits phase in from 2018 to 2027. Efficiency improvements from 5 to 25 percent depending on vocation
Advanced Clean Transit	Assumed Urban Bus ZEV sales, both battery and fuel cell technologies, begin in 2018 and increase to 100 percent of all sales in 2030. Assumed 100 percent purchases of Low-NOx standard starting model years 2018 and 2020 for natural gas and diesel buses, respectively.
Last Mile Delivery	Assumed 2.5 percent of Class 3-7 new sales in local fleets to be ZEV, both battery and fuel cell technologies, starting 2020. The penetration rate ramp up to 10 percent in 2025.
On-Road Light-Duty	
Advanced Clean Cars 2	Assumed combined LDA/LDT2 ZEV/PHEV sales increase from 18 percent to 40 percent between 2025 and 2030, and reach 100 percent by 2050. Assumed MDV ZEV/PHEV sales beginning in 2025, ramping up to 10 percent by 2030, and reach 50 percent by 2050. Assumed increased fuel efficiency (~2.9 percent per year) for gasoline vehicles starting 2025. Assumed new SULEV NOx standard phased in between 2025 and 2030 for gasoline LDAs. 100 percent SULEV20 sales by 2030. Assumed VMT reductions ramping up to 15 percent below 2050 baseline VMT in 2050. Assumed extended electric range for PHEVs after 2025 from 40 percent to 60 percent eVMT by 2050.

Finally, Table 16 provides the *SIP Measures Scenario* assumptions:

Table 16: Vision Assumptions for SIP Measures Scenario

Measure	Assumptions
On-Road Heavy-Duty	
Same as Cleaner Technologies and Fuels	
On-Road Light-Duty	
Advanced Clean Cars 2	Assumed combined LDA/LDT2 ZEV/PHEV sales increase from 18percent to 40 percent between 2025 and 2030. Assumed MDV ZEV/PHEV sales beginning in 2025, ramping up to 10 percent by 2030. Assumed increased fuel efficiency (~2.9 percent per year) 2025 to 2035 for gasoline vehicles. Assumed new SULEV NOx standard phased in between 2025 and 2030 for gasoline LDAs. 100 percent SULEV20 sales by 2030
Off-Road Equipment	
Zero-Emission Off-Road Forklift Regulation Phase 1	Assumed electrification of diesel and LSI forklifts less than 65HP starts in 2028 through natural and accelerated turnover and nearly 2/3 of the targeted population will be electrified by 2035.
Zero-Emission Airport Ground Support Equipment	Assumed all new sales of belt loaders, baggage tugs, and cargo tractors are electric-powered starting 2023.
Fuel	
Low-Emission Diesel Requirement	Assumed 50 percent of the diesel pool is renewable by 2030. Assumed NOx and PM benefits for non-SCR equipped vehicles -13 percent NOx reduction and 25 percent PM reduction. Also assumes an overall ~14 percent reduction in diesel carbon intensity.
Off-Road Federal and International Category	
More Stringent National Locomotive Emission Standards	Assumed remanufacturing of the locomotive fleet such that 95 percent of line-haul locomotive activity is represented by Tier 4 and Tier 5 locomotives by 2031 with phase-in starting in 2023. The Tier 5 emission standard was represented in the model by increasing the Tier 5 locomotive distribution in the total tier distribution by ~4.0 percent per year over the baseline distribution starting in 2025 with an equal reduction in the Tier 4 distribution.
Tier 4 Vessel Standards	Assumed new main and auxiliary engines will achieve a 70 percent reduction in NOx starting with calendar year 2025. No reductions to PM were assumed.
At-Berth Regulation Amendments	Assumed At-Berth Regulation expanded to include some of the following vessel types: auto, bulk cargo, general cargo, roro and tankers. Reductions start in 2022 at 10 percent compliance and ramp up to 50 percent by 2032.

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Air Resources Board

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