April 2015

California Air Resources Board

Sustainable Freight

Pathways to Zero and Near-Zero Emissions

DISCUSSION DOCUMENT

CALIFORNIA
SUSTAINABLE FREIGHT INITIATIVE

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Sustainable Freight: Pathways to Zero and Near-Zero Emissions – A Discussion Document –

AIR RESOURCES BOARD (ARB) DISCUSSION

The Board will hear an update and public testimony on development of the Sustainable Freight Strategy, and will discuss this document, at its regular April 23, 2015, meeting at 1001 "I" Street, Sacramento, California, 95814. The Board agenda will be available 10 days prior to the meeting at: http://www.arb.ca.gov/board/ma/2015/ma042315.pdf
Comments can be submitted electronically at:
http://www.arb.ca.gov/lispub/comm/bclist.php

PROGRAM WEBPAGE

For more information on this topic and upcoming meetings,
please see the program website at:
http://www.arb.ca.gov/gmp/sfti/sfti.htm

DOCUMENT AVAILABILITY

Electronic copies of this document and related materials can be found at: http://www.arb.ca.gov/gmp/sfti/sfti.htm . Alternatively, paper copies may be obtained from ARB's Public Information Office, 1001 I Street, 1st Floor, Visitors and Environmental Services Center, Sacramento, California, 95814, (916) 322-2990.

For individuals with sensory disabilities, this document is available in Braille, large print, audiocassette or computer disk. Please contact the Air Resources Board's Disability Coordinator at (916) 323-4916 by voice or through the California Relay Services at 711, to place your request for disability services. If you are a person with limited English and would like to request interpreter services, please contact the Air Resources Board's Bilingual Manager at (916) 323-7053.

QUESTIONS

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California Environmental Protection Agency
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Forward

In 2012, the California Air Resources Board (ARB or Board) directed staff to identify and implement actions to quickly reduce health risk from diesel particulate matter.

The Sustainable Freight Pathways to Zero and Near-Zero Discussion Document (Discussion Document) describes actions that respond to the Board's direction to Identify, prioritize, and recommend specific measures and actions to meet the State's air quality attainment and climate needs. The Board heard an informational update on the Discussion Document, considered testimony, and adopted Resolution 15-22 in April 2015. Board Resolution 15-22, as adopted, is on the following page. The April 2015 Board meeting transcripts and written public comments can be found at the following links:

- *April 23 Board Meeting Transcript.* http://www.arb.ca.gov/board/mt/2015/mt042315.pdf
- *Written public comments on the Discussion Draft.* http://www.arb.ca.gov/lispub/comm/bccommlog.php?listname=freight2015

As part of Resolution 15-22, the Board directed staff to develop a comprehensive, integrated sustainable freight plan, in partnership with other State and local agencies - the California Sustainable Freight Strategy. The Board considers the development of the California Sustainable Freight Strategy a high priority to address localized health impacts, attainment of air quality standards, and achieving climate goals. The Discussion Document describes ARB's initial air quality policy contribution to this effort.

Moving forward, staff will work to incorporate direction received via Board Resolution 15-22 and anticipates coming back to the Board with an update in late 2015.

In addition, the following clarifications were made to the draft version of the Discussion Document:

- Table numbering (throughout the document)
- Updates to the following text:
  - Freight-dependent industries accounted for over $~~650~~ 700 billion or 32 percent of the California economy in 2013, and over 5 million or 33 percent of California jobs. (pg. 10)
  - However, freight-related sulfate formation is expected ~~and~~ to be relatively low because of the successful implementation of low-sulfur fuels throughout the California freight transport system. (pg. 15)
  - Additionally, such studies, along with baseline incidence rates ~~promote the ability to develop~~ allow the calculation of quantitative health risk estimates. (pg. 16)
  - The ~~costs~~ economic valuation associated with health impacts discussed here ~~are~~ is high. (pg. 16)
  - Develop an ocean-going vessel renewable biofuels market through proposal of an amendment ~~allowing~~ that allows renewable biofuels suppliers to opt-in

~~the option of~~ ~~such fuels in~~to the Low Carbon Fuel Standard if ~~it is~~ the amendment is adopted, or inclusion in Cap and Trade (pg. 37).

State of California
AIR RESOURCES BOARD

Update on Sustainable Freight Strategy

Resolution 15-22

April 23, 2015

Agenda Item No.: 15-3-4

WHEREAS, section 39003 of the Health and Safety Code charges the Air Resources Board (ARB or Board) with coordinating efforts to attain and maintain ambient air quality standards, to conduct research into the causes of and solution to air pollution, and to systematically attack the serious problem caused by motor vehicles;

WHEREAS, sections 39600 and 39601 of the Health and Safety Code authorize the Board to adopt standards, rules, and regulations and to do such acts as may be necessary for the proper execution of the powers and duties granted to and imposed upon the Board by law;

WHEREAS, sections 39666 and 39667 of the Health and Safety Code authorize the Board to regulate emissions of toxic air contaminants from non-vehicular and vehicular sources;

WHEREAS, sections 39666 and 39667 of the Health and Safety Code require an airborne toxic control measure for an existing source for which the Board has not specified a threshold exposure level, including a mobile source, be based on application or utilization of the best available control technologies or more effective control methods, unless the Board determines, based on an assessment of risk, that an alternative level of emission reduction is adequate or necessary to prevent an endangerment of public health;

WHEREAS, on August 27, 1998, the Board identified diesel particulate matter (PM) as a toxic air contaminant pursuant to article 1 (commencing with section 39650), chapter 3.5, part 2, division 26 of the Health and Safety Code;

WHEREAS, the trucks, ships, locomotives, aircraft, harbor craft, and equipment that move freight in California currently contribute about half of the total statewide diesel PM emissions;

WHEREAS, sections 43013 and 43018 of the Health and Safety Code authorize the Board to adopt and implement regulations, to control air pollution from motor vehicles and off-road or non-vehicle engine categories, which the Board has found to be necessary, cost-effective, and technologically feasible;

WHEREAS, the federal Clean Air Act requires the Board and local air districts to prepare State Implementation Plans (SIPs) demonstrating how each nonattainment region will attain the national 8-hour ozone and fine particulate matter (PM2.5) standards, with plans due in 2016;

WHEREAS, freight equipment currently accounts for 45 percent of the statewide oxides of nitrogen (NOx) emissions that react in the atmosphere to form ozone and PM2.5;

WHEREAS, the California Global Warming Solutions Act of 2006 (Assembly Bill 32; Chapter 488 Statutes of 2006; Health & Safety Code section 38500 et seq.) declares that global warming poses a serious threat to the economic well-being, public health, natural resources, and environment of California; it granted ARB the authority to monitor and regulate greenhouse gas emissions from all sources, and provided initial direction on creating a comprehensive multi-year program to reduce California's greenhouse gas emissions to 1990 levels by 2020, maintain and continue reductions beyond 2020, and initiate the transformations required to achieve the State's long range climate goals;

WHEREAS, Executive Order S-3-05 established a California greenhouse gas emission reduction target of 80 percent below 1990 levels by 2050; this target was reaffirmed in Executive Order B-16-2012, which established a California target for the reduction of greenhouse gas emissions from the transportation sector of 80 percent below 1990 levels by 2050;

WHEREAS, Assembly Bill 32 added section 38501 to the Health and Safety Code, which expresses the Legislature's intent that ARB coordinate with State agencies and consult with the environmental justice community, industry sectors, business groups, academic institutions, environmental organizations, and other stakeholders in implementing AB 32, and that ARB design emissions reduction measures in a manner that minimizes costs and maximizes benefits for California's economy, maximizes additional environmental and economic co-benefits for California, and complements the State's efforts to improve air quality;

WHEREAS, section 38560 of the Health and Safety Code directs the Board to adopt rules and regulations in an open public process to achieve the maximum technologically feasible and cost-effective greenhouse gas emissions reductions from sources or categories of sources;

WHEREAS, freight equipment is a substantial contributor to black carbon emissions, a potent short-lived climate pollutant, and currently accounts for 6 percent of the statewide greenhouse gas emissions with growth projected in future years;

WHEREAS, local air districts, ports, transportation and energy agencies, cargo owners, trucking firms, railroads, shipping lines, and terminal operators are initiating or continuing activities to reduce freight-related emissions; these actions are integral to the success of California's air quality and climate programs;

WHEREAS, Resolution 14-2 directs staff to work with stakeholders to identify and implement near-term actions to reduce localized risk in communities near freight facilities, identify and prioritize actions to move California towards a sustainable freight

transport system, and evaluate and implement opportunities to prioritize transformative zero and near-zero emission technologies;

WHEREAS, implementation of a sustainable freight transport system that relies on zero and near-zero emission equipment powered by renewable energy sources needs to meet multiple goals, including: enhancing the economic competitiveness and efficiency of California's ports and logistics industries, creating jobs, and increasing the safety and livability of freight corridors;

WHEREAS, State environmental, energy, and transportation agencies, together with the business development office, will be working with local partners and stakeholders to develop a proposed comprehensive, integrated sustainable freight plan– the California Sustainable Freight Strategy—that will include actions and milestones to transition California to a sustainable freight transport system;

WHEREAS, on April 3, 2015, ARB staff released a document entitled "Sustainable Freight: Pathways to Zero and Near-Zero Emissions, Discussion Draft" (Discussion Draft) to seek input from the public and the Board; and

WHEREAS, the Board finds that the Discussion Draft advances the objectives identified in Resolution 14-2 and:

1. The Discussion Draft sets out ARB's vision of a clean freight system and immediate and potential near-term ARB actions that staff will develop for future Board consideration or Executive Officer implementation, as appropriate under State law, to address localized health impacts, attainment of air quality standards, and climate goals.

2. The Discussion Draft outlines the immediate steps ARB intends to pursue, and potential near-term actions ARB will consider, to advance California towards a zero and near-zero emission freight transportation system.

3. As described in the Discussion Draft, and consistent with the objectives outlined in Resolution 14-2, staff has initiated efforts to develop a proposed California Sustainable Freight Strategy for future consideration by the Board, in partnership with the California Transportation Agency, the California Environmental Protection Agency, the Office of Business and Economic Development, the California Department of Transportation, and the California Energy Commission.

4. The Discussion Draft provides ARB's initial proposed air quality policy contribution to the broader California Sustainable Freight Strategy effort.

NOW, THEREFORE, BE IT RESOLVED that the Board directs staff to:

1. Pursue development of the potential near-term actions described in the Discussion Draft for Board consideration or Executive Officer implementation, as appropriate under State law, as quickly as possible to meet public health and climate change needs.

2. Evaluate the potential ARB levers described in the "Vision for the Future" section of the Discussion Draft for inclusion in future planning documents that address federal and State air quality and climate change goals.

3. Evaluate and consider both the potential ARB levers and the broad-based approaches for freight facilities and systems described in the Discussion Draft, especially the range of system efficiency improvements that depend on industry participation and leadership, as part of the development of a proposed California Sustainable Freight Strategy.

4. Work closely with local air districts in the preparation of the 2016 State Implementation Plan, and give strong consideration to actions identified in the Sustainable Freight Strategy in the development of that State Implementation Plan.

BE IT FURTHER RESOLVED that the Board considers the development of a comprehensive California Sustainable Freight Strategy to be a high priority for the agency and directs staff to:

1. Continue engaging cargo owners; the logistics industry; labor; ports and airports; utilities; business leaders; environmental and community groups; environmental justice groups; academics; air districts; metropolitan planning organizations; federal government agencies; and other interested stakeholders on development of a proposed California Sustainable Freight Strategy.

2. Continue working with the identified State agencies, in addition to the California Department of Food and Agriculture, and other affected Boards and Commissions to develop a proposed California Sustainable Freight Strategy for consideration that addresses the State's air quality, climate, energy, transportation, and economic objectives.

3. Explore revenue opportunities to provide funding to the measures in a proposed California Sustainable Freight Strategy.

BE IT FURTHER RESOLVED that the Board directs staff to incorporate revisions identified by the Board into the Discussion Draft, return to the Board in late 2015 with an informational update on the immediate actions and potential near-term actions described in the Discussion Draft, and continue efforts to contribute to development of a proposed California Sustainable Freight Strategy.

I hereby certify that the above is a true and correct copy of Resolution 15-22 as adopted by the Air Resources Board.

Tracy Jensen

Tracy Jensen, Clerk of the Board

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Executive Summary

To achieve its healthy air quality, climate, and sustainability goals, California must take effective, well-coordinated actions to transition to a zero emission transportation system for both passengers and freight.

The freight transport system is a major economic engine for our State, but also accounts for about half of toxic diesel particulate matter (diesel PM), 45 percent of the emissions of nitrogen oxides (NOx) that form ozone and fine particulate matter in the atmosphere, and six percent of the greenhouse gas (GHG) emissions in California. These statistics include emissions from trucks, ships, locomotives, aircraft, harborcraft, and all types of equipment used to move freight at seaports, airports, railyards, warehouses and distribution centers.

It is clear that in order to meet our public health mandates, climate goals, and economic needs, the transition to a less-polluting, more efficient, modern freight transport system is a preeminent policy objective for the State of California – and will continue to be so for several decades to come. It will require us to make steady and continual progress in moving both domestic and international cargo in California more efficiently, with zero emissions everywhere feasible, and near-zero emissions with 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. Many of the needed steps have happened already. Others must happen over the coming years. In some cases, the move to zero emission technology can happen immediately. In other cases, the technology needs to be further developed, and intermediate steps to ever-cleaner technologies will take us toward the ultimate goal of zero emissions.

California's freight system is part of the vast interconnected national and global system. As the global system changes in response to economic forces, California's system will also evolve. This evolution presents a tremendous opportunity to make increased system efficiency and zero emission technology mutually reinforcing. Computerized logistics systems and technologies to physically move containers and trucks more efficiently will reduce emissions, but can also benefit from the performance characteristics and operation of modem zero emission drive systems. Approached this way, California can move more goods, with less energy, and less pollution.

A more efficient, zero and near-zero emission freight system will demand not only new equipment and fuels, but also new transportation infrastructure, communications, and industry operating practices. We will need workers trained to build, maintain, and operate this advanced equipment and communications systems. To help fund these efforts, California's logistics industry must remain profitable in the face of increasing competition from other North American seaports and supply chains. The ability to readily adapt to changing trends and expand operations is key to improving the

competitiveness of the system. Community acceptance of industry expansion often depends on the prospects for new local jobs, clean air, and safe operations.

The California Air Resources Board (ARB or Board) is working with the State's transportation and energy agencies, as well as its economic development office, local partners, and stakeholders to develop a comprehensive, integrated plan—the California Sustainable Freight Strategy. A sustainable freight system is one that meets California's environmental, energy, mobility, safety, and economic needs by: enhancing system efficiency; deploying zero and near-zero emission freight equipment powered by renewable energy sources; providing reliable velocity while increasing safety, mobility and capacity; and improving the competitiveness of our logistics system.

To inform that effort, this report sets out ARB's vision of a clean freight system, together with the immediate and near-term steps that ARB will take to support use of zero and near-zero emission technology.

Need to Accelerate Progress

Together with our local and federal government partners, we have motivated and required extensive changes across the State. Truck owners, ocean carriers, terminal operators, and railroads have made substantial investments to transition their diesel-fueled freight equipment to cleaner models, while refineries retooled to produce cleaner diesel fuels. We are seeing the real-world benefits of those investments—measurably cleaner air in communities near seaports, railyards, and freeways over the last decade. For example, these combined actions have cut toxic diesel PM at the State's largest ports by 80 percent over the last decade.

However, the need to accelerate air quality progress for public health is urgent and the scope of emission reductions required to meet our mandates is vast. California must pursue immediate actions to reduce the unacceptably high risk from freight sources, and re-orient our freight system to meet our State Implementation Plan, and ultimately reshape the freight system to meet our long-term climate goals. This presents California with some notable challenges:

- **Health risks**: Despite substantial progress over the last decade, the remaining localized risks of cancer and other adverse effects near major freight hubs is not acceptable and must be significantly reduced. New health science tells us that infants and children are 1.5 to three times more sensitive to the harmful effects of exposure to air toxics, like those emitted from freight equipment, than we previously understood, which heightens the need for further risk reduction.

- **More protective air quality standards**: Current control programs will reduce NOx and PM2.5 emissions over 50 percent by 2030, but the next State Implementation Plans required by federal law to demonstrate our path to attain ozone and diesel PM air quality standards will compel significant additional emission reductions in the South Coast and San Joaquin Valley.

- **Climate change goals**: New efforts in response to climate change are ramping up the pressure for further progress in the 2030 and 2050 timeframes to reduce GHG and short-lived climate pollutants, like black carbon from diesel equipment.

Actions to Further Reduce Emissions from Freight Operations

At two meetings in 2014, the Board directed ARB staff to identify and implement actions to quickly reduce the health risk from diesel PM in the most impacted communities around freight hubs. This report describes near-term actions that respond to the Board's direction, as well as the potential new measures and other approaches we are evaluating to meet all of our air quality and climate goals. These actions build on the conclusions of a companion document entitled *Draft Heavy-Duty Technology and Fuels Assessment Overview, April 2015,* developed by ARB staff with agency partners.

Immediate ARB Actions. ARB staff is initiating actions now to enhance enforcement and deploy incentives to deliver new emission reductions and further reduce health risks in impacted communities in 2015.

- We are expanding enforcement at or near freight hubs through several mechanisms:
  - First, ARB is reassigning existing personnel to assist with these focused enforcement efforts and continuing to seek additional air district and port partners that can enforce ARB regulations in their jurisdictions.
  - Second, staff will maximize compliance and enforcement efforts at freight hubs by: conducting over 50 percent of heavy-duty diesel truck inspections at seaports, intermodal railyards, and distribution centers in or near disadvantaged communities.
  - Third, to increase the efficiency of our enforcement of the Statewide Truck and Bus Rule, we are focusing on larger truck fleets and brokers first.
  - And fourth, staff is developing a pilot program to use remote imaging and sensing to identify non-compliant trucks and target them for compliance assistance.

- Through the State-funded incentive programs administered by ARB and the local air districts, we expect that 1,500-1,700 new trucks and other freight equipment will be put into service in 2015. These include zero emission and hybrid trucks, as well as diesel and natural gas trucks, locomotives, and marine vessels that are replacing older, higher-emitting models.

Near-Term ARB Measures. ARB staff has identified a range of measures that we intend to begin developing in 2015-2016 for Board consideration within the next few years (or near-term implementation for steps that do not require Board action). These focus on both cleaner combustion technologies and introduction of zero emission equipment.

Summary of Near-Term ARB Measures

Near-Term ARB Measures	ARB Action	ARB Implemen-tation
Cleaner Combustion		
Trucks		
Trucks Action 1: Develop and propose strategies to ensure durability and in-use performance. Such strategies may include: • Reduced exhaust opacity limits for PM filter-equipped trucks. • New certification and warranty requirements for low in-use emissions. • Strengthen existing emission warranty information reporting and enable corrective action based on high warranty repair rates. • Clarification on the State's authority to inspect heavy-duty warranty repair facilities to ensure proper emission warranty repairs are being conducted.	2015-2017	2017+
Trucks Action 2: Develop and propose increasing flexibility for manufacturers to certify advanced innovative truck engine and vehicle systems in heavy-duty applications. Enables accelerated introduction of new technologies to market.	2015	2016
Trucks Action 3: Develop and propose new, stringent California Phase 2 GHG requirements to reduce emissions from trucks and trailers, and provide fuel savings.	2016-2017	2018+
Trucks Action 4: Petition U.S. EPA to develop lower NOx standards for new heavy-duty truck engines for rulemaking in 2018.	2015	--
Trucks Action 5: (if U.S. EPA does not complete Trucks Action 4): Develop and propose California specific standards for new heavy-duty truck engines to provide benefits above national standards.	2018	2023+
Ocean-Going Vessels		
Ocean-Going Vessels Action 1: Advocate with international partners for new International Maritime Organization Tier 4 NOx/PM standards, and efficiency targets for existing vessels in Ship Energy Efficiency Management Plans for International Maritime Organization action 2018-2020.	2015	--
Ocean-Going Vessels Action 2: Define criteria for "Super Low Emission Efficient Ship" and achieve early implementation of clean technologies (liquefied natural gas, Tier 3, or better) for newer vessels via existing and enhanced seaport incentive programs (e.g. Green Ship, Ship Index, etc.).	2016	2018
Ocean-Going Vessels Action 3: Develop and propose amendments to the At-Berth Regulation to include other vessel fleets and types to achieve additional emission reductions.	2016	2020+

Summary of Near-Term ARB Measures, continued

Near-Term ARB Measures	ARB Action	ARB Implemen-tation
Locomotives		
Locomotives Action 1: Petition U.S. EPA to develop a Tier 5 national locomotive emissions standard for criteria pollutants and GHG (based on aftertreatment, liquefied natural gas, and/or zero emission track miles) for rulemaking in 2018 and introduction in 2025 and beyond.	2015	--
Locomotives Action 2: Petition U.S. EPA to amend its regulations that define a preempted "new" locomotive engine for rulemaking in 2017. The desired outcome is to limit federal preemption to the initial useful life (typically seven to ten years) of the locomotive engine.	2015	--
Locomotives Action 3 (contingent on Locomotives Action 2): Develop and propose a regulation applicable to all non-new locomotives to maximize the use of Tier 4 engines, liquefied natural gas, or better line-haul, medium horsepower, and switch locomotives (provide credit for zero emission track miles and zero emission locomotives).	2018	2020-2030
All sectors/freight hubs		
All sectors/freight hubs: Collect data (such as facility location, equipment, activity, and proximity to sensitive receptors) from seaports, airports, railyards, warehouse and distribution centers, truck stops, etc. to identify and support proposal of facility-based approach and/or sector-specific actions to reduce emissions and health risk, as well as efficiency improvements.	2015	2015-2016
Zero Emissions		
Delivery Vans/Small Trucks: Develop proposal to accelerate penetration of zero emission trucks in last mile freight delivery applications, with potential incentive support.	2017	2020
Large Spark-Ignition Equipment (forklifts, etc): Develop proposal to establish purchase requirements to support broad scale deployment of zero emissions equipment.	2016-2018	2020
Transit Buses: Develop proposal to deploy commercially available zero emission buses in transit, and other applications, beginning with incentives for pilot programs and expanding purchase requirements, as appropriate, to further support market development of zero emission technologies in the heavy-duty sector with potential incentive support.	2016	2018
Airport Shuttles: Develop proposal to deploy zero emission airport shuttles to further support market development of zero emission technologies in the heavy-duty sector, with potential incentive support.	2017-2018	2020
Transport Refrigeration Units: Develop and propose a regulatory requirement to prohibit the use of fossil-fueled transport refrigeration units for cold storage in phases, with incentive support for infrastructure.	2016	2020+
Incentive programs: Develop modifications to existing incentive programs to increase the emphasis on and support for zero and near-zero equipment used in freight operations, including introduction of truck engines certified to optional low-NOx standards.	2015-2016	2016-2020

Vision for the Future

Although the time horizon to commercialize and introduce zero emission technology may be long-term for some equipment categories and applications, the potential levers that ARB could exercise to accelerate that introduction cover the time spectrum from 2015 through the next several decades. They also include actions to achieve interim progress through use of near-zero emission technologies powered by low-carbon energy sources.

The report includes summary tables that describe the prospects to accelerate progress toward zero emissions for trucks, ocean-going vessels, locomotives, transport refrigeration units, cargo/industrial/ground service equipment, commercial harbor craft, and aircraft. These tables reflect ARB staff's current vision for each equipment category, list key challenges to the development and widespread deployment of zero and near-zero emission technologies, and identify potential levers available to ARB.

After the April 2015 Board meeting, ARB staff will further evaluate and develop, as appropriate, a subset of the potential levers identified in this section in partnership with other agencies and in consultation with stakeholders. These may become additional near-term measures, or new mid-term measures, that support the State Implementation Plan, the Climate Change Scoping Plan, and other efforts.

Additional Approaches to Support System Transformation and Efficiency

In addition to the specific ARB levers and actions discussed above, the report discusses other approaches for the freight industry to reduce emissions, through a facility-based emissions cap, use of land use and transportation planning mechanisms, and systemwide efficiency improvements.

Next Steps

This report is an outline of the initial steps ARB intends to take to achieve a zero and near-zero emissions freight system. We will be working with our State, local, and federal agency partners on the Sustainable Freight Strategy, in consultation with all interested stakeholders over the next year. ARB staff expects to bring a proposal to the Board for consideration in the first half of 2016 that includes the strategies, as well as the required environmental and economic analyses.

Work is also underway on the development of State Implementation Plans and the Climate Change Scoping Plan that will draw from the immediate actions and near-term measures described in this report, as well as additional measures (regulatory or voluntary) and partnerships to be identified in the Sustainable Freight Strategy. This document and the Sustainable Freight Strategy are part of a comprehensive step-wise planning and implementation effort to meet the State's multiple environmental and public heath goals.

Following public comment and Board direction at its April 23, 2015 meeting, staff will finalize this report and focus on the integrated Sustainable Freight Strategy. The full Strategy will include additional measures to reduce emissions to meet the State Implementation Plan and Climate Change Scoping Plan needs as well as other objectives. We expect to provide an update to the Board in late 2015 on both the near-term ARB actions and planning underway. Staff anticipates bringing a proposed Sustainable Freight Strategy to the Board for consideration in the first half of 2016.

I. Background

This section provides background on the framework of the freight system, air pollutant emissions and health impacts, and our air quality and climate goals.

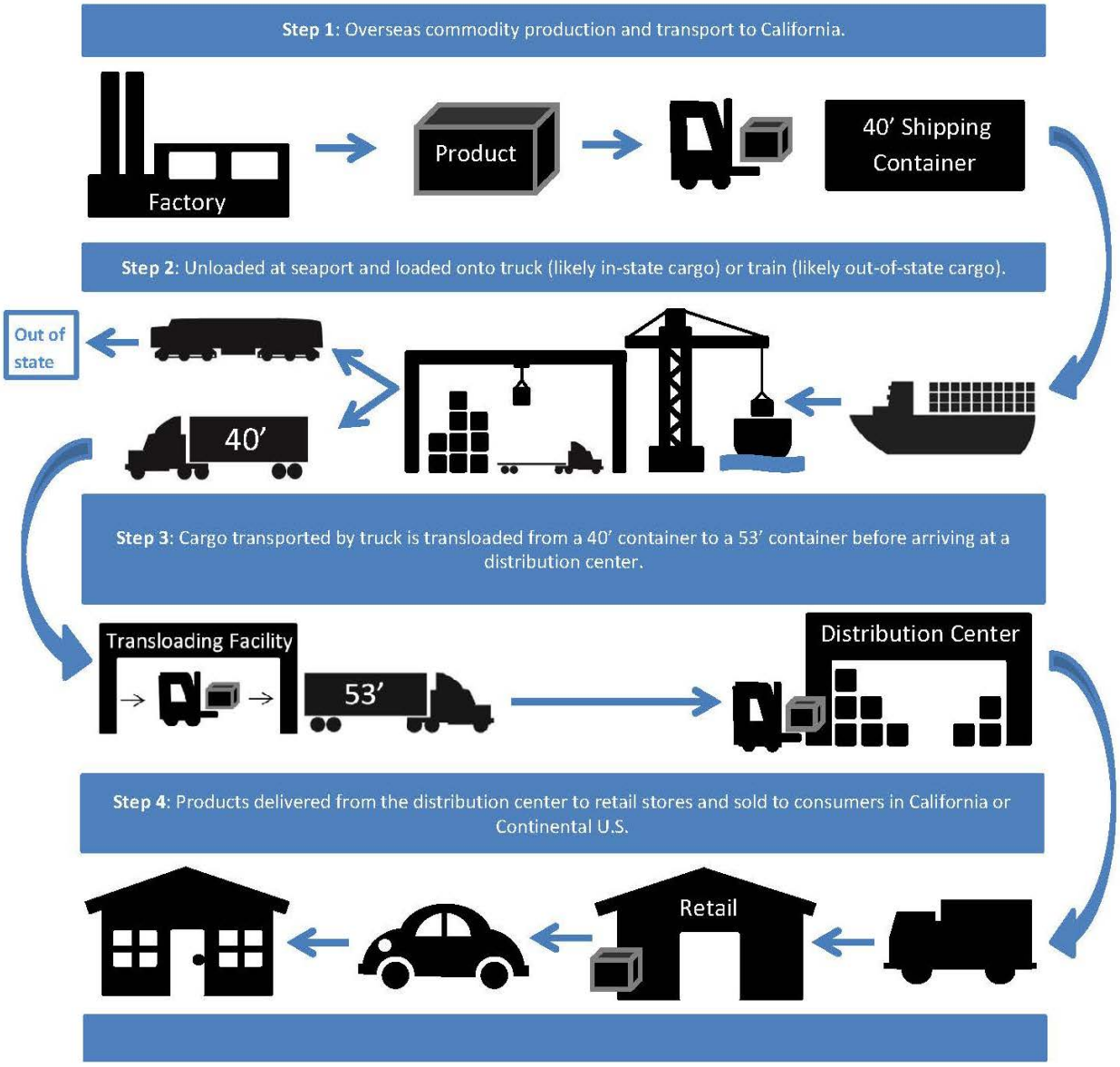
A. Freight Transport System

The smooth functioning of California's freight transport system depends on the interactions between equipment, infrastructure, and facilities. The vehicles and equipment that move freight range from aircraft and ocean-going vessels for international transport, to locomotives and trucks for interstate transport, and smaller trucks/vans and harborcraft for in-state operations. A wide variety of cargo handling, industrial, and ground service equipment is used at freight hubs like seaports, railyards, airports, distribution centers, warehouses, and truck stops. Also, moving perishable products requires transport refrigeration units to provide the necessary cooling.

We consider all of the freight hubs to be freight facilities, along with the network of roads, land ports of entry (border crossings), railways, and waterways that provide the transportation infrastructure.

For illustrative purposes, Figure 1 shows the key steps in one example of an import supply chain for an international product purchased at a retail location by a consumer. It is a simplistic depiction of the transport modes, equipment, and facilities often used to move imports from the manufacturer to the destination market, whether in California or elsewhere in the U.S.

FIGURE 1: Import Supply Chain Example



California's economy is supported by commerce and trade-related activities that rely on a complex freight transport system. In 2013, California's $2.2 trillion economy was the world's eighth largest, as measured by gross domestic product, the value of all goods and services produced in the State. California also accounted for 13 percent of the nation's gross domestic product ($16.8 trillion) in 2013, while accounting for 12 percent of the population.[1,2,3] California's diverse economy and prosperity are tied to the export

[1] United States Department of Commerce, Bureau of Economic Analysis, "Current-Dollar and 'Real' Gross Domestic Product," January 2015, <http://bea.gov/national/xls/gdplev.xls>, accessed March 17, 2015.
[2] United States Department of Commerce, Bureau of Economic Analysis, "Widespread but Slower Growth in 2013: Advance 2013 and Revised 1997–2012 Statistics of GDP

and import of freight moving throughout the State, and are dependent on an integrated freight transport system.

Freight-dependent industries are defined in this report as those industries where freight transport is of high-level importance to their operations. These industries rely heavily on the transport of raw materials, intermediate goods, and finished products. They also typically include transportation, warehousing and utilities, wholesale and retail trade, manufacturing, agriculture, and mining. Freight-dependent industries accounted for over $700 billion or 32 percent of the California economy in 2013, and over 5 million or 33 percent of California jobs.

Job metrics are frequently used to measure the economic impacts of transportation. Determining the number of freight-transportation related jobs requires identifying industries that are interlinked with the freight transport system; a narrow application would only include jobs that are directly affected by freight. However, considering the extensive supply-chain activities that the freight transport system connects, it is reasonable to include industries that are freight-dependent in job calculations. This approach is consistent with recent reports prepared for California agencies.

Throughout the freight transport system, jobs are created in the manufacturing, retailing, wholesaling, construction, transportation, and warehousing sectors. The freight transport system is also interlinked with regional and national economies. Understanding the relationships between the freight transport system, economic indicators (including employment, number of establishments, and gross state product), and funding needs is critical.

B. Emissions

The engines that move freight in California contribute to our primary air pollutants. In response, ARB and its partners have motivated and required extensive changes across the State focused on the use of cleaner technologies. Industry has made substantial investments to transition its mostly diesel-fueled freight equipment to cleaner models, while refineries retooled to produce cleaner fuels.

ARB has adopted and implemented over a dozen regulations, as well as agreements with industry and incentive programs, to reduce freight emissions. We are seeing the real-world benefits of those investments—measurably cleaner air in communities near seaports, railyards, and freeways. Since 2005, the Port of Los Angeles and Port of Long Beach have achieved an 80 percent reduction in diesel PM emissions based on

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by State," June 11, 2014, <http://bea.gov/newsreleases/regional/gdp_state/2014/pdf/gsp0614.pdf.>, accessed March 18, 2015.

[3] The World Bank, "GDP (current US$)," 2015, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?order=wbapi_data_value_2012+wbapi_data_value&sort=desc, accessed March 18, 2015.

ARB rules and port initiatives. Figures 2-5 show how these regulations and investments have cut statewide freight emissions of NOx, sulfur oxides (SOx), particulate matter 2.5 microns or less in diameter (PM2.5), GHG, and the expected future reductions.

FIGURE 2: Statewide NOx Emissions from Freight Sources
(tons per day)

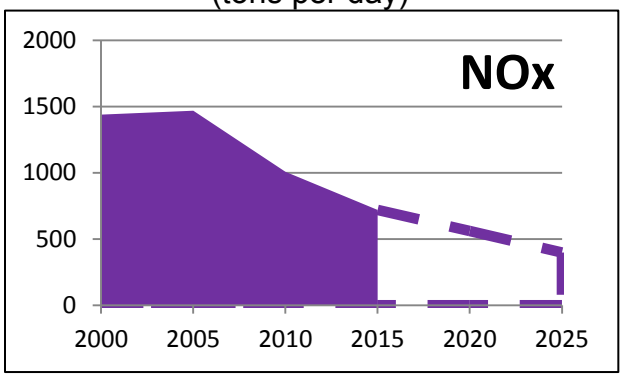


FIGURE 3: Statewide SOx Emissions from Freight Sources
(tons per day)

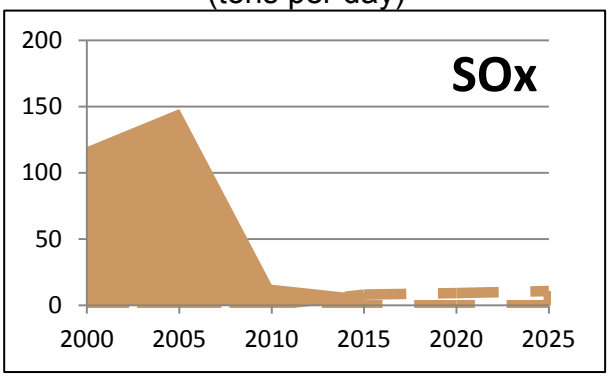


FIGURE 4: Statewide PM2.5 Emissions from Freight Sources
(tons per day)

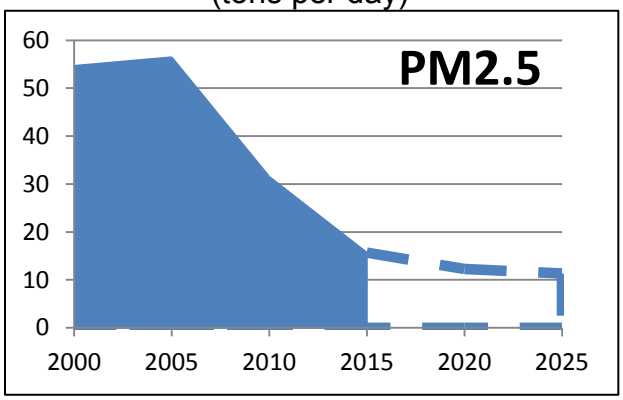
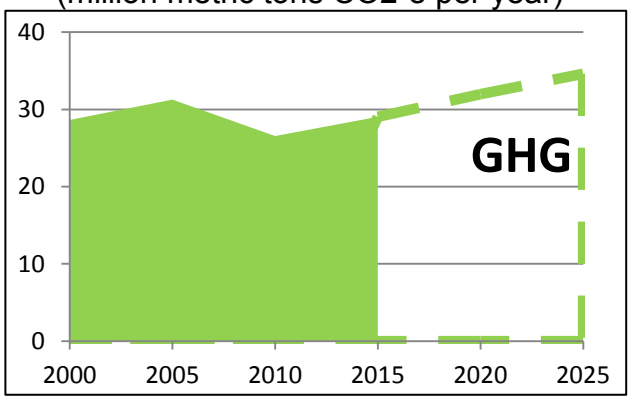


FIGURE 5: Statewide GHG Emissions from Freight Sources
(million metric tons CO2-e per year)

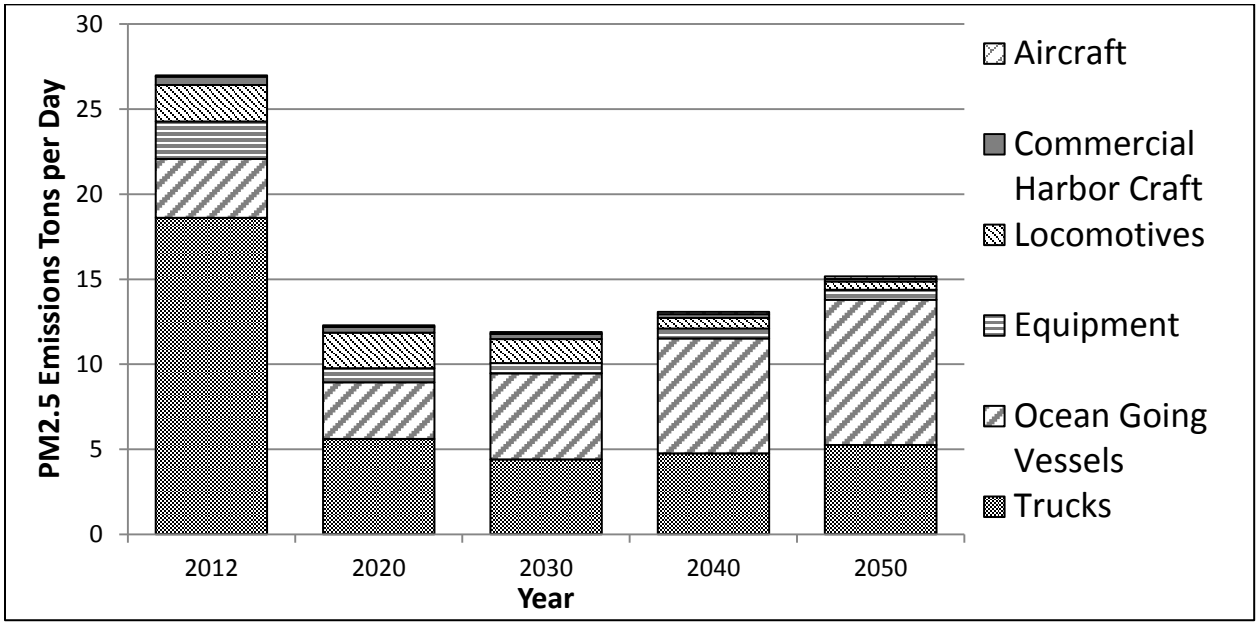


Despite the progress made, freight transport emissions remain a large contributor to air pollution. Freight equipment currently accounts for about half of the statewide diesel PM emissions, which are both a toxic air contaminant and a contributor to black carbon, a powerful short-lived climate pollutant. Freight operations also account for approximately 45 percent of the statewide NOx emissions and six percent of the statewide GHG emissions.

Looking ahead, emissions from some categories, like trucks, continue to decline over the next decade as adopted controls are fully implemented, then begin to increase as growth in activity overcomes the benefits of the existing controls. For other categories like ships and aircraft, that are subject to fewer controls, the emissions continue to steadily grow. Appendix A provides additional information regarding emissions and growth assumptions.

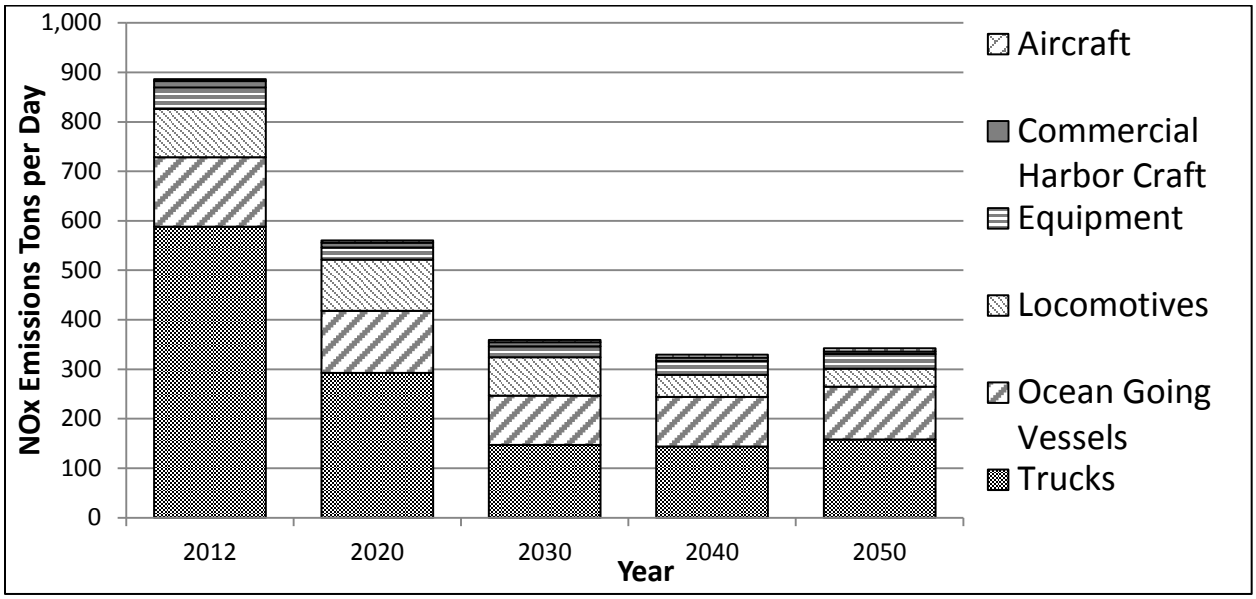
Figures 6 and 7 show projected statewide PM2.5 and NOx emissions by sector from 2012 through 2050. Projected emissions reflect anticipated increases in cargo activity, along with the benefits of existing control programs. Eventually, growth in freight activity overcomes the benefits of adopted controls. The single largest contributor in 2012 is the trucking sector. In later years after implementation of the existing truck regulations is complete, the ocean-going vessel sector replaces it as the largest contributor.

FIGURE 6: Statewide PM2.5 Emissions from Freight Sources with Existing Control Program*



*Ocean-going vessels out to 24 nautical miles. Aircraft up to 3,000 feet.

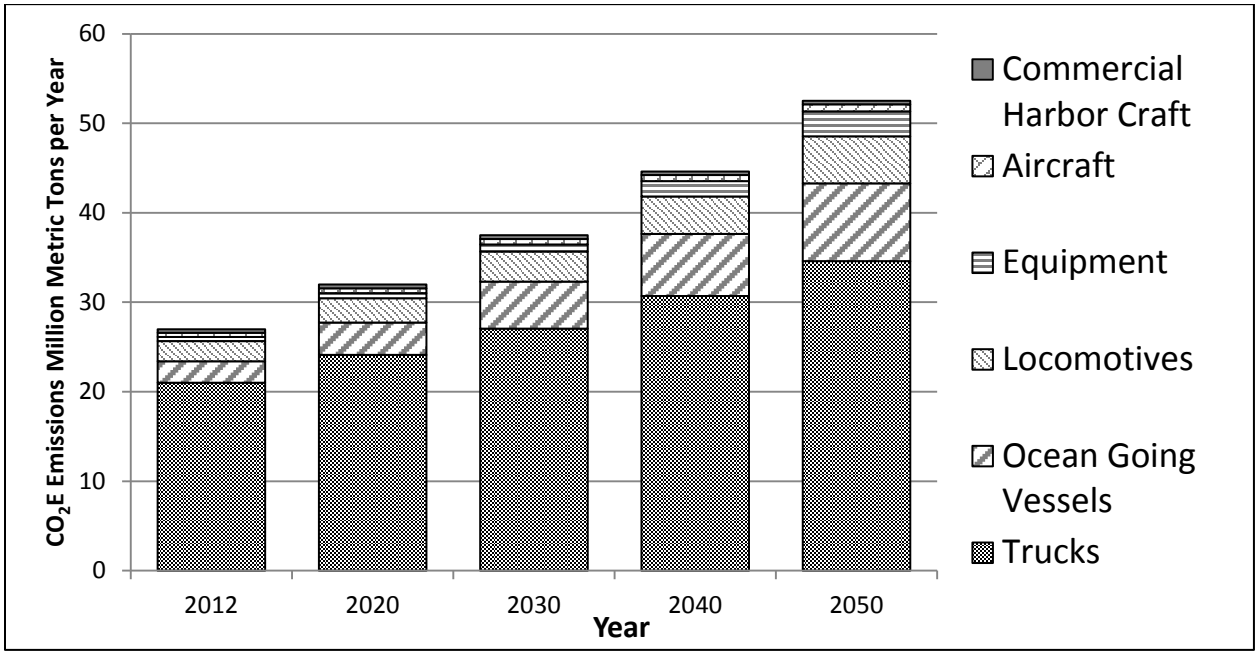
FIGURE 7: Statewide NOx Emissions from Freight Sources with Existing Control Program*



*Ocean-going vessels out to 24 nautical miles. Aircraft up to 3,000 feet.

Figure 8 reflects increasing GHG emissions by sector through 2050. Unlike other pollutants, total freight GHG emissions continually increase because existing control strategies for this industry have primarily focused on reducing toxic and criteria pollutants. The largest contributors are the trucks, ocean-going vessels, and locomotives sectors. Existing programs targeted at reducing GHG from the trucking sector include the federal Phase I rule for trucks and ARB's Tractor-Trailer GHG Reduction Regulation. Development of federal and California-specific Phase 2 GHG rules are underway; both aim to achieve further reductions after 2018. ARB's shorepower regulation for ships at berth is eliminating GHGs and other pollutants through the use of grid-based electrical power.

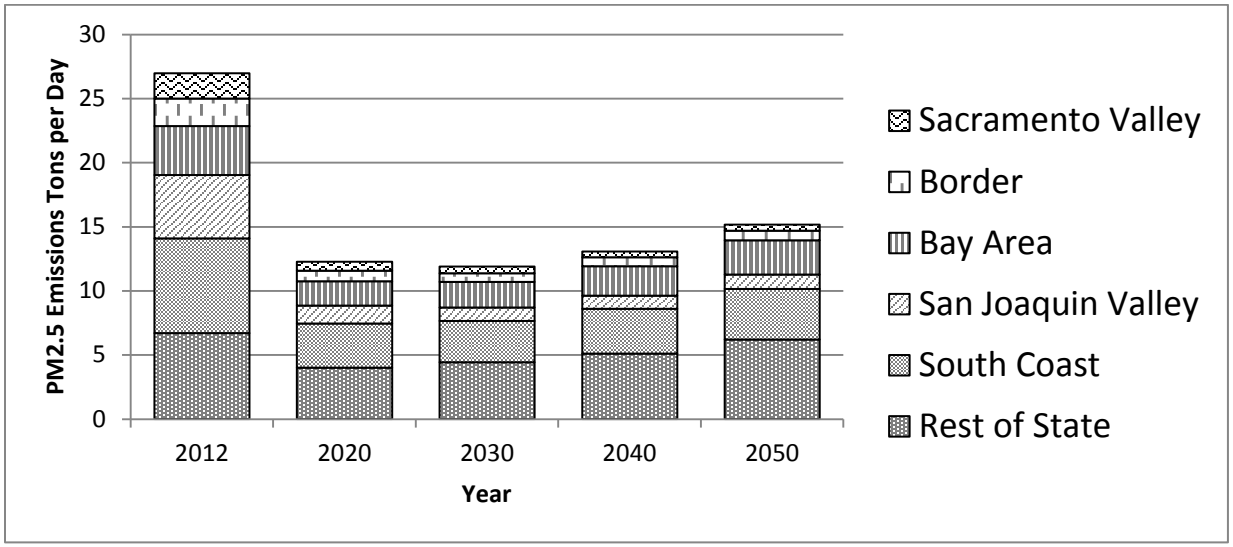
FIGURE 8: Statewide GHG Emissions from Freight Sources with Existing Control Program*



*Ocean-going vessels out to 24 nautical miles.

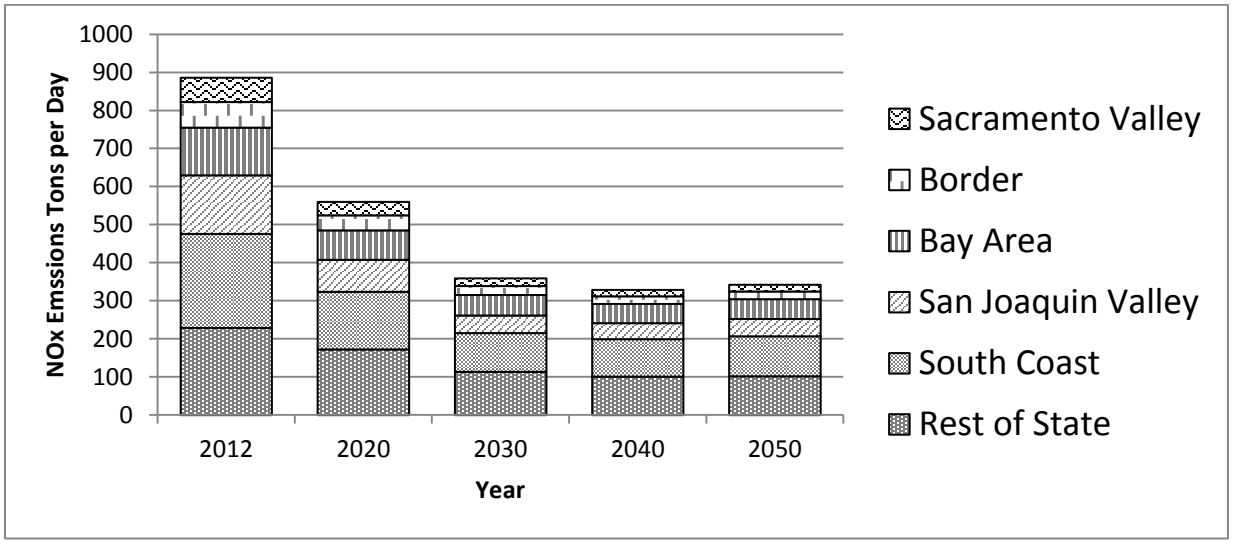
Figures 9 and 10 show PM2.5 and NOx emissions for major freight corridors. Both pollutants show dramatic near-term reductions with longer-term increases as growth in cargo activity overcomes the benefits of adopted controls. All areas of California experience benefits from reduced PM2.5 emissions and the associated health risk. Current control programs will reduce NOx and PM2.5emissions by over 50 percent by 2030. However, meeting federal ozone and PM2.5 standards in the South Coast and San Joaquin Valley will require significant further reductions over the next fifteen years. This includes meeting the 80 parts per billion 8-hour ozone standard by 2023, and the 75 parts per billion 8-hour ozone standard by 2031, as well as the 12 micrograms per cubic meter annual PM2.5 standard by 2021 to 2025. Efforts to achieve further near-term emission reductions are essential in meeting these air quality standards.

FIGURE 9: Regional PM2.5 Emissions from Freight Sources with Existing Control Program*



*Ocean-going vessels out to 24 nautical miles. Aircraft up to 3,000 feet.

FIGURE 10: Regional NOx Emissions from Freight Sources with Existing Control Program*



*Ocean-going vessels out to 24 nautical miles. Aircraft up to 3,000 feet.

C. Health Impacts

The emissions from the heavy equipment that transports freight within and through California contributes to both elevated ambient levels of criteria pollutants such as PM2.5 and ozone, as well as localized impacts near freight hubs and facilities. This section summarizes our current understanding of the effect of freight emissions on both the statewide health effects and valuation due to ambient PM2.5 levels, as well as the excess cancer risk from near-source exposure to PM2.5.

1. Statewide Health Impacts

The estimation of premature deaths, hospitalizations, and emergency room visits related to PM2.5 exposure presented below is based on a peer-reviewed methodology developed by the U.S. Environmental Protection Agency (U.S. EPA), updated with observed relationships between emissions and exposure, and California-specific demographic and baseline health incidence rate data.[4] Table 2 shows the premature deaths, hospitalizations, and emergency room visits associated with freight emissions of both primary PM2.5 and secondary PM2.5 (particle nitrates formed from photochemical reactions of the precursor NOx).

ARB staff updated its estimates of the health impacts from ambient PM2.5 pollution attributable to direct PM and NOx emissions from freight sources in each region of California. These estimates do not include the health impacts of ozone pollution from freight emissions, or the component of PM2.5 due to secondary sulfate from freight emissions.

Freight emissions also contribute to ozone formation in California. Because ozone formation is a complex, non-linear process, photochemical modeling of freight-related emissions is needed in order to estimate the health impacts associated with ozone exposure. This modeling is planned for the summer of 2015, and the health impacts of freight-related ozone exposure will be estimated at that time. Ozone-related premature deaths are likely to be relatively small compared to those associated with freight-related PM2.5 exposures because of the approximately order of magnitude lower concentration-response function for ozone, while hospitalizations are expected to be higher.

Emissions for SOx from freight sources are another contributor to secondary PM2.5 (particle sulfates). However, freight-related sulfate formation is expected to be relatively low because of the successful implementation of low-sulfur fuels throughout the California freight transport system. It was not possible to establish a relationship between SOx emissions and sulfate formation because of the relatively high contribution of poorly quantified non-local sources such as intercontinental transport and biogenic formation.

The health endpoints selected are the same as those used by the U.S. EPA Quantitative Risk Assessment for Particulate Matter as part of the National Ambient Air Quality Standard setting process.[5] U.S. EPA chose premature deaths, hospitalizations, and asthma and respiratory emergency room visits as endpoints. These endpoints were chosen because the U.S. EPA has determined that a variety of studies have

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[4] ARB, "Initial Statement of Reasons, Appendix J, Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants from In-Use Heavy-Duty Diesel-Fueled Vehicles," 2010.

[5] U.S. EPA, "Quantitative Health Risk Assessment for Particulate Matter - Final Report Publication No. EPA-452/R-10-005," 2010.

shown evidence that there is a causal relationship between these end points and PM2.5. Additionally, such studies, along with baseline incidence rates allow the calculation of quantitative health risk estimates.

ARB staff used a methodology that relates the observed association between emissions and pollutant concentrations to quantify health benefits. This method is similar in concept to the methodology developed by the U.S. EPA for health benefit estimation with the addition of California-specific population and health incidence rates.[6] Details of ARB's methodology can be found in *Appendix J of the Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and other Criteria Pollutants from In-Use Heavy-Duty Diesel-Fueled Vehicles*.[7]

a. Economic Valuation of Health Impacts

The economic valuation associated with health impacts discussed here is high. Over 99 percent of the economic impact is from premature death. U.S. EPA established the value of mortality risk reduction as $7.4 million in 2006 dollars. Adjusted for real income and inflation, the value of mortality risk reduction is equivalent to $8.9 million in 2013 dollars. Table 3 lists the economic value of avoiding the adverse health impacts associated with freight emissions in 2013 dollars. The value of mortality risk reduction is based on contingent valuation and wage-risk studies, which examine the willingness to pay for a minor decrease in the risk of premature death. As real income increases, people are willing to pay more to reduce their risk of premature death.

The economic values of respiratory and cardiovascular hospitalizations were drawn from Chestnut, et al. (2006).[8] The authors of this study estimated the value of reducing hospitalizations based on cost of illness and willingness to pay. The economic value of emergency room visits for asthma was drawn from the U.S. EPA's 2011 Regulatory Impact Assessment for Ozone and PM2.5.[9] The values were adjusted for inflation to 2013 dollars using the U.S. Bureau of Labor Statistics Consumer Price Index for medical care.

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[6] Neal Fann, Charles M. Fulcher, and Bryan J. Hubbell. "The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution," *Air Quality, Atmosphere and Health,* Vol 2, 2009, pp. 169–176.
[7] ARB, "Initial Statement of Reasons, Appendix J, Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants from In-Use Heavy-Duty Diesel-Fueled Vehicles," 2010.
[8] Lauraine G. Chestnut, Mark A. Thayer, Jeffery K. Lazo, ad Stephen K. Van Den Eeden, "The Economic Value of Preventing Respiratory and Cardiovascular Hospitalizations," *Contemporary Economic Policy*, Vol. 24, 2006, pp. 127–143.
[9] U.S. EPA, "Regulatory Impact Analysis for the Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone in 27 States; Correction of SIP Approvals for 22 States Publication No. EPA-HQ-OAR-2009-0491," 2011.

TABLE 1: Statewide Health Effects and Valuation (2013 $) Associated with Freight Emissions Contributing to PM2.5—Midpoint Projections

	2012	2030	2050
Mortality	2,200	980	1,100
Hospitalizations*	330	150	160
ER Visits†	950	420	450
Valuation (billions)	$20	$9	$10

* Include respiratory and cardiovascular hospitalizations
† Includes asthma and cardiovascular emergency room visits

TABLE 2: Statewide Health Effects and Valuation (2013 $) Associated with Freight Emissions Contributing to PM2.5—Uncertainty Ranges**

PM2.5 and NOx	2012	2030	2050
Mortality	1,700-2,700	770-1,200	830-1,300
Hospitalizations*	43-770	19-340	20-370
ER Visits†	600-1,300	260-570	280-620
Valuation (billions)	$16-$24	$7-$11	$7-$12

* Include respiratory and cardiovascular hospitalizations
**Uncertainty ranges only reflect uncertainty in the concentration-response function, and do not reflect uncertainty in emission projections, spatial interpolation, and aggregation.
† Includes asthma and cardiovascular emergency room visits

2. Localized Cancer Risks near Freight Hubs

The diesel equipment operating in and around freight hubs, such as seaports, railyards, and warehouse and distribution centers, is a significant source of diesel PM, a toxic air contaminant that can cause cancer and other health problems, including respiratory illnesses, increased risk of heart disease, and premature death. Exposure to diesel PM is a health hazard, particularly to children whose lungs are still developing and the elderly, who may have other serious health problems.

The diesel PM emissions from freight operations impact communities located adjacent to those operations, as well as residents living miles away. Between 2004 and 2008, ARB staff conducted health risk assessments of 18 major railyards throughout the State,[10] the Ports of Los Angeles and Long Beach,[11] and West Oakland.[12] The railyard health risk assessments examined the increased cancer risk zones due to diesel PM emissions from locomotives, cranes, and yard equipment within facility boundaries as

[10] ARB, Railyard Health Risk Assessments and Mitigation Measures, 2004-2009, <http://www.arb.ca.gov/railyard/hra/hra.htm>.
[11] ARB, "Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach," 2006, <http://www.arb.ca.gov/ports/marinevess/documents/portstudy0406.pdf>.
[12] ARB, "Diesel Particulate Matter Health Risk Assessment for the West Oakland Community," 2008, <http://www.arb.ca.gov/ch/communities/ra/westoakland/documents/westoaklandreport.pdf>.

well as on/off site emissions from heavy-duty diesel trucks. The port assessments analyzed at berth and in transit emissions from marine vessels and harbor craft, on-site equipment, and trucks and locomotives serving the ports. The ports and railroads provided extensive data on their activities, and the Bay Area Air Quality Management District partnered with ARB on the West Oakland assessment.

These risk assessments were based on emissions that existed as of 2000 (for the Roseville Railyard), 2002 (for the Ports of Los Angeles and Long Beach), or 2005 (for all other facilities) using the 2003 State guidance on health risk assessments developed by the Office of Environmental Health Hazard Assessment. The results summarized below do not represent the much lower emission levels present today after implementation of extensive regulatory and incentive programs, as well as port and railroad initiatives.

a. Port of Los Angeles and Port of Long Beach

In 2002, diesel PM emissions from activities associated with the Ports of Los Angeles and Long Beach resulted in elevated cancer risk levels over the entire 20-mile by 20-mile study area. In neighborhoods near the Ports' boundaries, potential cancer risk levels exceeded 500 in a million in 2002. Further away, the potential cancer risk levels decreased but continued to exceed 50 in a million for more than 15 miles. Ships and drayage trucks operating in communities near the Ports were the largest contributors to cancer risk.

Based on implementation of ARB and Port requirements for drayage trucks, ships, cargo equipment, harbor craft, and locomotives, we expect that the emission reductions achieved since the original ARB risk assessment for 2002 would result in a 50-75 percent reduction in cancer risk by 2020. The Ports publish updates of their emission inventories on an annual basis which show an 80 percent reduction in diesel PM from 2005 levels.[13,14]

b. 18 Major Railyards

For the 18 major railyards, the potential maximum individual cancer risk a decade ago was estimated to range between 40-2,500 chances per million for residents living nearby. The greatest risks were associated with the BNSF San Bernardino Railyard because of its high levels of locomotive and truck activity and the many densely populated neighborhoods that surround the Railyard. The cluster of four railyards (Union Pacific Commerce, BNSF Hobart, BNSF Mechanical Sheila, and BNSF Commerce Eastern) operating in the densely populated Commerce area also resulted in high combined cancer risks.

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[13] Starcrest Consulting Group LLC., "Port of Los Angeles Inventory of Air Emissions – 2013," 2014, <http://www.portoflosangeles.org/pdf/2013_Air_Emissions_Inventory_Full_Report.pdf>.
[14] Starcrest Consulting Group, LLC, "Port of Long Beach Air Emissions Inventory – 2013," 2014, <http://www.polb.com/civica/filebank/blobdload.asp?BlobID=12238>.

In July 2011, ARB published updated cancer risk estimates for the four highest risk railyards in Southern California – BNSF San Bernardino, Union Pacific Intermodal Container Terminal Facility/Dolores, BNSF Hobart, and Union Pacific Commerce.[15] In that report, we used updated emissions and activity data to estimate the change in cancer risk from 2005 to 2010. All four yards showed a substantial drop in risk, from 40 to over 70 percent due to the introduction of much cleaner trucks, locomotives, equipment, and fuel in this period. These changes resulted from the combination of ARB regulations, two enforceable agreements between the Class I railroads (BNSF and Union Pacific) and ARB, and incentives.

International cargo activity was lower in 2010 than in 2005 at the BNSF San Bernardino, BSNF Hobart, and Union Pacific Intermodal Container Terminal Facility/Dolores railyards due to the recession, enhancing the significant risk reductions of 60-70 percent. However, Union Pacific Commerce experienced a steady increase in domestic cargo activity from 2005 through 2010, but still achieved a net 40 percent reduction in cancer risk.

c. Community of West Oakland

The health risk assessment for West Oakland was the most complex and provides information about how a neighborhood experiences pollution from multiple freight facilities and operations. It included the broadest scope of facilities and sources—the Port of Oakland, two railyards and four surrounding freeways. Residents of West Oakland experienced elevated levels of cancer risk estimated at 10-1,200 per million in 2005. High diesel truck traffic from the freeways was the dominant source of risk, followed by the activities at the Port.

Based on changes in emissions attributable to compliance with ARB regulations for drayage trucks, ships, cargo equipment, and harbor craft, we would expect that the contribution from the Port of Oakland has decreased by roughly 70 percent.[16] Diesel PM emissions from trucks on the surrounding freeways are dropping steadily as the statewide Truck and Bus Regulation results in use of diesel particulate filters throughout the fleet.

[15] ARB, "Supplement to the June 2010 Staff Report on Proposed Actions to Further Reduce Diesel Particulate Matter at High-Priority California Railyards," 2011, <http://www.arb.ca.gov/railyard/commitments/suppcomceqa070511.pdf>.
[16] Environ International, "Port of Oakland 2012 Seaport Air Emissions Inventory," 2013, <http://www.portofoakland.com/pdf/environment/maqip_emissions_inventory.pdf>.

3. Changes in Methodology to Estimate Localized Health Risks

In March 2015, the Office of Environmental Health Hazard Assessment released an update to its recommended methodology for conducting health risk assessments in California.[17] In the last decade, advances in science have shown that early-life exposures to air toxics contribute to an increased lifetime risk of developing cancer, or other adverse health effects, compared to exposures that occur in adulthood. The new risk assessment methodology addresses this greater sensitivity and incorporates the most recent data on childhood and adult exposure to air toxics.

In addition, the new methodology relies on U.S. EPA's current air dispersion model (AERMOD) to estimate the concentration of the modeled pollutant at a specific location. In 2006, AERMOD replaced the Industrial Source Complex Model.

For many facilities, use of the new risk assessment methodology and air dispersion model will result in higher pollutant concentrations, higher exposures, and higher estimated potential cancer risks than would have been calculated with the prior (2003) methodology—for the same level of emissions. The potential inhalation cancer risk using the new methodology may be 1.5 to three times (or more) higher than was estimated using the 2003 methodology.

ARB has not yet conducted health risk assessments for freight facilities using the new methodology, but will use the new methodologies for future health risk assessments.

D. Air Quality and Climate Goals

California's efforts to reduce the air quality and climate impacts from freight transport must help address a number of challenges throughout the State:

Reducing exposure to air toxics:

- Minimizing near-source exposure and health risk from identified toxic air contaminants, including diesel PM and other toxics produced by fuel combustion in freight-related vehicles and equipment pursuant to the Toxic Air Contaminant Identification and Control Act (AB 1807, Tanner, Chapter 1047, Statutes of 1983).
- New information on the sensitivity of children to air toxics exposure early in life further heightens this need to further reduce the exposure and health risk from freight operations.

[17] Office of Environmental Health Hazard Assessment, "Air Toxics Hot Spot Program: Risk Assessment Guidelines, Guidance Manual for Preparation of Health Risk Assessments," 2015, <http://www.oehha.ca.gov/air/hot_spots/2015/2015GuidanceManual.pdf>.

Federal and California air quality standards:

- Attaining the National Ambient Air Quality Standards for ozone and particulate matter in all regions of California, as required by the Federal Clean Air Act:

    - Current control programs will reduce NOx and PM2.5 emissions over 50 percent by 2030. However, meeting federal ozone and PM2.5 standards in the South Coast and San Joaquin Valley will require significant further reductions over the next fifteen years. This includes meeting the 80 parts per billion (ppb) 8-hour ozone standard by 2023, and the 75 ppb 8-hour ozone standard by 2031, and the 12 micrograms per cubic meter annual PM2.5 standard by 2021 to 2025. Further near-term emission reductions are essential in meeting these air quality standards.
    - Meeting the newly proposed federal ozone standard will be even more challenging to attain than the 2031 standard.

- California's own ambient air quality standards set by ARB are generally more stringent than the current federal standards; many areas of the State do not attain these standards.

Climate goals:

- Meeting the State's greenhouse gas reduction targets and related climate goals:

    - Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), which requires California to cut GHG emissions back to 1990 levels by 2020, and continue and maintain reductions post-2020.
    - Governor Brown's Executive Order B-16-2012, which requires transportation GHG emissions to be reduced 80 percent below 1990 levels by 2050.
    - Governor Brown's energy goals outlined in his 2015 inaugural address, which include reducing petroleum use by cars and trucks by up to 50 percent.
    - State statute that requires ARB to develop and implement a plan to reduce emissions of short-lived climate pollutants, including black carbon (Senate Bill 605 (Lara, Chapter 523, Statutes of 2014).

II. ARB Strategies

Achieving our State's air quality, climate, and sustainability goals requires a broad-based effort to more efficiently move both domestic and international cargo in California with zero emissions everywhere possible, and near-zero emissions with renewable fuels everywhere else. A zero emission freight transport system will demand not only new equipment and fuels, but also new transportation infrastructure, communications, and industry operating practices. We will need workers trained to build, maintain, and operate the advanced equipment and communications systems. To help fund the whole effort, California's logistics industry must remain profitable in the face of increasing competition from other North American seaports and supply chains. The ability to readily adapt to changing trends and expand operations is key to improving the competitiveness of the system. Community acceptance of industry expansion often depends on the prospects for new local jobs, clean air, and safe operations.

The scale of transformation needed to fulfill our mission is beyond the reach of ARB and our air quality partners alone to accomplish. We must continue to build a coalition to effect change beyond our sphere of influence. It is clear to us that the environmental, transportation, energy, and economic objectives of transforming the freight transport system are interdependent; the success of one depends on the success of all.

ARB has consulted a broad group of stakeholders including, but not limited to: cargo owners, the logistics industry, labor, seaports, utilities, business leaders, environmental and community groups, agencies at all levels, and other interested stakeholders. In addition to public forums and workshops, ARB staff used smaller focus groups, individual meetings, and conference calls to discuss the need for and approaches to achieve a sustainable freight transport system, as well as other stakeholder concerns and recommendations. Over 220 stakeholder organizations participated in these discussions during the course of over 180 meetings and conference calls. We also asked stakeholders to provide concepts to move California towards a sustainable freight transport system and received more than 100 ideas. Appendix B lists the organizations we consulted in 2014.

Industry leaders remind us that global freight transport is not a single system, but rather a "system of systems," all interconnected. Examples of systems include: (a) a supply chain to move one product from manufacture or harvest to its ultimate destination, (b) a large facility like a seaport that has multiple ocean carriers and terminal operators with a wide variety of vessels and onsite cargo equipment handled by organized labor, and served by logistics providers like railroads and trucking fleets for offsite transport, and (c) the trucking sector itself with a myriad of vehicle types to move raw materials and finished products across town or across the country, as well as the chassis and containers to carry them. There is no analytical tool available to us today that captures the complex interactions, or the time, cost, energy, and environmental impacts, of all these systems transporting cargo to, from, and within California.

ARB's freight expertise is built on the equipment and fuels that move cargo, as well as health risk assessments, plans, regulations, and incentive programs to characterize and reduce the air quality impacts. Stakeholders from seaports, airports, rail, trucking, ocean shipping, warehousing and distribution, and cargo owners have generously shared their time and opened their facilities to help us better understand both their operations and the systems within which they operate. We continue to learn from them and seek similar insight on supply chain economics, which has been more difficult to access, as the industry uses proprietary data and business models. This insight will be critical to making progress on system efficiency strategies that offer the prospect of industry time/cost savings and near-term air quality gains. Similarly, our partners at the State's transportation and energy agencies, as well as economic and workforce development offices, will bring essential experience and perspective to the integrated sustainable freight planning process this year.

This chapter builds on the 2014 stakeholder engagement and technology assessment efforts summarized in the work in progress entitled *Draft Heavy-Duty Technology and Fuels Assessment Overview*. The objective is to share our current thinking on what actions ARB can and should take now, what else staff is considering in the near-term, and what we believe will be possible in the future. Actions and policies outlined in this chapter would help accelerate the development and deployment of zero and near-zero emission technologies in each equipment category. We expect that these actions and policies will also contribute to ARB's section of the 2016 State Implementation Plans, which will follow a separate public development process.

A. Moving Towards Zero Emissions

The heavy-duty sector is diverse, and there are many different technologies and approaches that can achieve substantial emissions reductions. Over the past decade, heavy-duty fleets have made significant investments to introduce modern, lower-emitting vehicles and equipment. Building on this success to further reduce combustion emissions from engines and vehicles, near-zero emission technologies are under development that provide ultra-low NOx emissions and operate on renewable fuels. Substantial emission reductions can be achieved through improvements to conventional technologies such as advanced combustion, aerodynamics, hybridization, and connected vehicle technologies. Renewable fuels can provide deep GHG reductions. Development and use of these technologies and fuels can provide nearer term emission reductions in applications where zero emissions are not yet feasible.

The development of heavy-duty zero emission technologies is also well underway. Today, zero emission vehicles are commercially available in battery and fuel cell forklifts, certain types of cargo handling equipment, and airport ground support equipment. Battery electric and fuel cell buses are in the early commercialization phase, with many transit agencies deploying a growing number of vehicles. Demonstrations are in progress across the State in a wide array of heavy-duty applications, including drayage trucks, delivery trucks, school buses, and some types of off-road equipment. Over 300 medium-duty battery electric trucks are currently in

service in California. State incentives are in place that are encouraging the development and adoption of these technologies, increasing production volumes, fostering innovation, and reducing costs.

In developing and deploying these technologies for freight, the need for an integrated approach—focusing on vehicles and equipment, renewable fuel production and storage, fueling infrastructure and the electrical grid—is clear. Zero and near-zero emission technologies require coordinated deployment with different types of fueling infrastructure that those vehicles and equipment will require to operate.

In addition, vehicle-grid integration and power to gas technologies suggest a potentially synergistic relationship between renewable electricity on the grid, electricity supply/demand management, and zero and near-zero emission technologies in freight operations. The goal of vehicle-grid integration is to create a mutually beneficial relationship between battery powered vehicles and the electrical grid. It is based on a two way power flow that allows vehicles to accept a charge from the grid, and to supply a charge to the grid when necessary to maintain balance between electricity supply and demand. In this way, vehicle batteries could store excess electricity generated by renewable sources (like solar) for return to the grid when those renewable sources are off line.

Achieving the successful transition to cleaner zero and near-zero emission technologies will be challenging and may take time to realize. Successful approaches and strategies must acknowledge economic realities and begin to build an environmental and business case that encourages and supports adoption of zero and near-zero emission technologies. Significant public and private investment will be critical.

By focusing on the ultimate technology endpoint (zero emissions) that satisfies all of our air quality goals and supporting needed engineering advances, we can provide the certainty businesses need for long-term planning. By looking several decades ahead, we can seek approaches that allow equipment owners who have recently purchased cleaner equipment in response to air quality regulations to recoup the value of those investments and get the useful life out of their equipment. By supporting near-term efficiency improvements, businesses can realize a benefit while cutting both localized health risk and regional air pollution. By capturing the benefits of emerging technologies like information systems and vehicle-to-roadway integration, we can cut travel time and fueling costs, plus increase the capacity of the system to transport more cargo within the existing transportation infrastructure.

B. Accelerating Technology Development and Deployment

Government policies can encourage the introduction of new, cleaner, and more efficient technologies through investment in research and development, technology demonstration and deployment help to support industry investment, and incentives to consumers and fleets to drive demand for those new technologies. A policy package that accelerates the use of new, cleaner, and more efficient technologies can also include adopting policies that collect data on operation, maintenance, cost, and benefits

associated with the use of new technologies, and developing escalating purchase requirements to support increasing sales volumes.

Zero emission technologies developed in one sector often can have cross-over benefits to other sectors. For example, California's Zero Emission Vehicle mandate continues to foster technology improvements in fuel cell-electric and battery-electric vehicles in the light-duty sector, which has led to technology advancements benefitting the heavy-duty sector. Demonstrations conducted in urban transit bus fleets, for example, confirmed the viability of both battery and fuel cell electric buses in public transit and related applications like shuttles to the point that such technologies are in commercial service today. In turn, the purchase of fuel cell buses helps to build markets for fuel cells, related components (such as power electronics), and hydrogen fueling infrastructure for light-duty vehicles. These purchases can help reduce manufacturing, capital, operations, and maintenance costs across vehicle classes as well as support development of needed fueling infrastructure that serves multiple vehicle types.

To accelerate development and deployment of zero emission technologies, ARB can employ a combination of policies that include vehicle requirements and emission performance standards, as well as incentives for vehicles and low-carbon fuels and fueling infrastructure. We can also help create conditions for greater operational and system wide efficiencies that allow new technologies to achieve higher performance levels, and seek opportunities to promote technology innovations with cross-sector benefits (e.g., battery storage, fuel cells).

Although this document focuses on what ARB can do to move California towards zero and near-zero emission technologies in the freight transport system, other entities also have a major role. Public entities like the Port of Long Beach and Port of Los Angeles have been proactive in establishing policies, like emission-based fees for trucks, and incentives that accelerate introduction of cleaner technology. The local air districts have active programs to both incentivize the purchase of cleaner vehicles and spur advancements in zero and near-zero emission technologies. Logistics providers are investing in developing and promoting new technologies.[18] For example:

- Siemens, the South Coast Air Quality Management District, and other partners are developing a catenary demonstration project for hybrid trucks in the 2016 timeframe.
- United Parcel Service and FedEx have invested in electric and hybrid electric vehicles as part of their fleets, helping to advance the state of the electric and hybrid vehicle market.
- Boeing has invested in developing an experimental unmanned aircraft, propelled by a liquid-hydrogen propulsion system, thus helping to advance the state of zero carbon technologies in the aircraft sector.
- Corporations such as WalMart have invested in fleets of fuel cell forklifts.

[18] The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

C. Near-Term NOx Reductions from Trucks

Extensive certification and in-use testing demonstrates that today's heavy-duty diesel and natural gas truck engines are the cleanest ever built. Through the use of after-treatment devices like diesel PM filters, selective catalytic reduction devices for diesel NOx control and three-way catalysts for natural gas NOx control, on-road trucks certified to current standards for 2010 and later model year engines emit at levels that are more than 90 percent lower for PM and NOx than trucks built just ten years ago.

Building on the opportunities provided by these cleaner technologies, ARB has adopted several in-use fleet requirements, such as the Statewide Truck and Bus Regulation, which require the turnover of pre-2010 model truck engines operating in California to engines that meet the 2010 NOx emission standard by 2023. In addition, incentive programs such as Carl Moyer and the Proposition 1B Goods Movement Emission Reduction Programs have invested hundreds of millions of dollars in cleaner vehicle replacements. All told, these programs collectively are accelerating the deployment of the cleanest conventional technologies available today and providing substantial localized risk and air quality benefits throughout the State.

To further reduce NOx emissions from new engines, California has established optional heavy-duty low-NOx engine standards that can reduce certified NOx emissions by up to an additional 90 percent relative to 2010 model year levels. Both the State and the local air districts are investing in bringing these technologies to the marketplace on an expedited schedule, and ARB staff expect new natural gas engines that meet one of the optional low NOx standards to become commercially available early as early as 2015.

However, despite this tremendous progress, significant additional reductions from heavy-duty trucks are needed to meet ambient air quality standards and to further reduce the localized risk impacts associated with exposure to toxic diesel PM. Adding to the challenge, as discussed in ARB's technology assessment document, not all on-road heavy-duty engine components are as high-quality or as durable as once thought, resulting in elevated levels of in-use emissions from some trucks. In addition, on-road diesel engines appear to be generating higher than expected in-use NOx emissions during low temperature, low load operations that characterize some vocational driving cycles such as those seen in many freight applications (e.g., local delivery and drayage).

To address these issues, and provide the substantial additional emission reductions needed from heavy-duty trucks operating in California, ARB has identified a suite of strategies. These strategies will both address the in-use performance issues seen with today's heavy-duty engines, as well as build the market for even cleaner heavy-duty trucks by:

- Incentivizing the accelerated deployment of trucks with engines meeting California's current optional heavy-duty low-NOx standards.
- Improving durability, warranty, and certification requirements.

- Enhancing inspection programs and improving maintenance practices.
- Developing new future mandatory lower NOx standards.

Taken together, these strategies, along with the use of renewable fuels, are expected to deliver near-zero emission trucks that provide up to a 90 percent reduction in in-use NOx emissions from today's trucks operating in California.

D. Immediate ARB Actions to Reduce Health Risk

To reduce emissions and health risk in impacted communities near freight hubs, ARB staff has identified two types of immediate actions for 2015. Enforcement efforts will place additional emphasis on freight facilities and the fleets that serve those facilities to achieve the full benefits of adopted regulations. As part of this effort, we will enhance our enforcement capacity by shifting existing personnel as well as pursuing opportunities for additional enforcement partnerships. ARB-funded incentive programs, many administered by the local air districts, will also achieve significant new reductions in 2015 through the introduction of cleaner freight vehicles and equipment. See Appendix C for further description of each immediate action. Table 3 describes each of these immediate actions and the pollutants they target.

TABLE 3: Immediate ARB Actions to Reduce Localized Health Risk

Immediate ARB Action	Pollutants Targeted for Reduction		
	Diesel PM	NOx	GHG
Enforcement: Expand Enforcement Presence. Existing ARB personnel are being reassigned to assist with these focused enforcement efforts at or near freight hubs. In addition, staff continues to look for opportunities to leverage resources and expand enforcement throughout the State by utilizing agreements with local air districts and seaports.	✓	✓	
Enforcement: Focus on Freight Hubs. Staff will maximize enforcement efforts at freight hubs by: conducting over 50 percent of heavy-duty diesel truck inspections at seaports, intermodal railyards, and distribution centers in or near disadvantaged communities, working with program staff to identify fleets and companies in each program that are least likely to be in compliance, and following up with field inspections and/or fleet investigations and appropriate enforcement actions, and working cooperatively with other State and local agencies to minimize the impacts of State-funded construction projects on disadvantaged communities.	✓	✓	✓
Enforcement: Increase Efficiency of Statewide Truck and Bus Rule Enforcement. ARB staff's proposed strategy going forward will be to focus on sizable fleets and brokers first, and to use those enforcement efforts to help encourage small fleets to come into compliance through a combination of broker/contractor compliance and ARB compliance assistance.	✓	✓	

TABLE 3: Immediate ARB Actions to Reduce Localized Health Risk, continued

Immediate ARB Action	Pollutants Targeted for Reduction		
	Diesel PM	NOx	GHG
Enforcement: Leverage Technology. Staff is working on a pilot program to develop and deploy a remote imaging / sensing program in 2015 for heavy-duty trucks with the potential for expansion later on. Portable remote imaging (capturing truck data remotely through transponders, cameras, etc.) and sensing (characterizing NOx and diesel PM emissions) can be used to identify noncompliant or mal-performing trucks and target them for compliance assistance, enforcement, and/or engine and after-treatment repair.	✓	✓	
Incentives: Proposition 1B. Freight equipment upgrades funded by Proposition 1B include large-fleet trucks and locomotives. Projects that will be newly in operation in 2015 include an estimated 855 to 1,060 older trucks, which will be scrapped and replaced with the same number of cleaner trucks, and six locomotives with cleaner engines will be operating in Southern California. The projects are estimated to achieve emission reductions of 31 to 36 tons of PM2.5 and 6,470 to 8,060 tons of NOx over the life of the grant contracts.	✓	✓	✓
Incentives: Carl Moyer. This program provides funding opportunities for truck fleets with three or fewer vehicles to replace or retrofit their older heavy-duty diesel vehicles. Freight related projects include trucks, marine vessels and locomotives. In 2015, staff estimates that about 230 new engines will be funded; benefits related to these engines are approximately 13 tons of PM2.5, 29 tons of reactive organic gases, and 732 tons of NOx, over the lifetime of the vehicles.	✓	✓	
Incentives: Hybrid and Zero Emission Truck and Bus Voucher Incentive Project. This program is designed to offset the incremental additional cost of eligible hybrid and battery-electric medium- and heavy-duty vehicles through a purchase voucher. In 2015, staff estimates that about 420 vehicles will be funded. Benefits beyond those otherwise achieved with conventional 2015 engines, are approximately 11 tons of PM2.5, 4 tons of reactive organic gases, and 37 tons of NOx, over the lifetime of the vehicles.	✓	✓	✓

E. Near-Term ARB Measures

ARB staff anticipates beginning development of the near-term measures listed in Table 4 in 2015-2016 for Board consideration (where applicable) or implementation within the next few years. For the items listed in Table 4 that require Board consideration and approval, ARB staff will develop each regulatory proposal through the required process. These ARB measures would work to promote cleaner combustion, including the introduction of near-zero emission technology, and to accelerate use of zero emission technologies. See Appendix D for a further description of each measure.

TABLE 4: Near-Term ARB Measures

Near-Term ARB Measures	ARB Action	ARB Implementation	Type of Action	Pollutants Targeted for Reduction		
				Diesel PM	NOx	GHG
Cleaner Combustion						
Trucks Action 1: Develop and propose strategies to ensure durability and in-use performance. Such strategies may include: • Develop enhanced truck inspection programs by reducing exhaust opacity limits for diesel PM filter-equipped trucks. • Develop and implement new certification and warranty requirements and maintenance practices to better ensure vehicle reliability and low in-use emissions in new trucks certified to existing heavy-duty engine NOx standard. • Revise existing emission warranty information reporting regulations to strengthen current program enabling implementing corrective action based on high warranty repair rates. • Seek clarification on the State's authority to enter and inspect heavy-duty warranty repair facilities to ensure proper emission warranty repairs are being conducted.	2015-2017	2017+	ARB Regulation, Potential State Legislative Action	✓	✓	✓

TABLE 4: Near-Term ARB Measures, continued

Near-Term ARB Measures	ARB Action	ARB Implementation	Type of Action	Pollutants Targeted for Reduction		
				Diesel PM	NOx	GHG
Trucks Action 2: Develop and propose increasing flexibility for manufacturers to certify advanced innovative truck engine and vehicle systems in heavy-duty applications. Enables accelerated introduction of new technologies to market.	2015	2016	ARB Regulation			
Trucks Action 3: Develop and propose new, stringent California Phase 2 GHG requirements to reduce emissions from trucks and trailers, and provide fuel savings.	2016-2017	2018+	ARB Regulation	✓	✓	✓
Trucks Action 4: Petition U.S. EPA to develop lower NOx standards for new heavy-duty truck engines for rulemaking in 2018.	2015	--	ARB Petition, U.S. EPA Regulation			
Trucks Action 5: (if U.S. EPA does not complete Action 4): Develop and propose California specific standards for new heavy-duty truck engines to provide benefits above national standards, with potential incentive support.	2018	2023+	ARB Regulation and Incentive		✓	
Ocean-Going Vessels Action 1: Advocate with international partners for new International Maritime Organization Tier 4 NOx/PM standards and efficiency targets for existing vessels in Ship Energy Efficiency Management Plans for International Maritime Organization action 2018-2020.	2015	--	ARB Advocacy			
Ocean-Going Vessels Action 2: Define criteria for "Super Low Emission Efficient Ship" and achieve early implementation of clean technologies (liquefied natural gas, Tier 3, or better) for newer vessels via existing and enhanced seaport incentive programs (e.g. Green Ship, Ship Index).	2016	2018	Incentive	✓	✓	✓

TABLE 4: Near-Term ARB Measures, continued

Near-Term ARB Measures	ARB Action	ARB Implementation	Type of Action	Pollutants Targeted for Reduction		
				Diesel PM	NOx	GHG
Ocean-Going Vessels Action 3: Develop and propose amendments to the At-Berth Regulation to include other vessel fleets and types to achieve additional emission reductions.	2016	2020+	ARB Regulation	✓	✓	✓
Locomotives Action 1: Petition U.S. EPA to develop a Tier 5 national locomotive emissions standard for criteria pollutants and GHG (based on aftertreatment, liquefied natural gas, and/or zero emission track miles) for rulemaking in 2018 and introduction in 2025 and beyond.	2015	--	ARB Petition, U.S. EPA Regulation	✓	✓	✓
Locomotives Action 2: Petition U.S. EPA to amend its regulations that define a preempted "new" locomotive engine for rulemaking in 2017. The desired outcome is to limit federal preemption to the initial useful life (typically seven to ten years) of the locomotive engine.	2015	--	ARB Petition, U.S. EPA Regulatory Amendment	✓	✓	✓
Locomotives Action 3 (contingent on Locomotives Action 2): Develop and propose a regulation applicable to all non-new locomotives to maximize the use of Tier 4 engines, liquefied natural gas, or better line-haul, medium horsepower, and switch locomotives (provide credit for zero emission track miles and zero emission locomotives).	2018	2020-2030	ARB Regulation and Incentive	✓	✓	✓
All sectors/freight hubs: Collect data (such as facility location, equipment, activity, and proximity to sensitive receptors) from seaports, airports, railyards, warehouse and distribution centers, truck stops, etc. to identify and support proposal of facility-based approach and/or sector-specific actions to reduce emissions and health risk, as well as efficiency improvements.	2015	2015-2016	Data Collection			

TABLE 4: Near-Term ARB Measures, continued

Near-Term ARB Measures	ARB Action	ARB Implementation	Type of Action	Pollutants Targeted for Reduction		
				Diesel PM	NOx	GHG
Zero Emission						
Delivery Vans/Small Trucks: Develop proposal to accelerate penetration of zero emission trucks in last mile freight delivery applications, with potential incentive support.	2017	2020	ARB Regulation and Incentive	✓	✓	✓
Large Spark-Ignition Equipment (forklifts, etc): Develop proposal to establish purchase requirements to support broad scale deployment of zero emissions equipment.	2016-2018	2020	ARB Regulation and Incentive	✓	✓	✓
Transit Buses: Develop proposal to deploy commercially available zero emission buses in transit, and other applications, beginning with incentives for pilot programs and expanding purchase requirements, as appropriate, to further support market development of zero emission technologies in the heavy-duty sector with potential incentive support.	2016	2018	ARB Regulation and Incentive	✓	✓	✓
Airport Shuttles: Develop proposal to deploy zero emission airport shuttles to further support market development of zero emission technologies in the heavy-duty sector, with potential incentive support.	2017-2018	2020	ARB Regulation and Incentive	✓	✓	✓
Transport Refrigeration Units: Develop and propose a regulatory requirement to prohibit the use of fossil-fueled transport refrigeration units for cold storage in phases, with incentive support for infrastructure.	2016	2020+	ARB Regulation and Incentive	✓	✓	✓

TABLE 4: Near-Term ARB Measures, continued

Near-Term ARB Measures	ARB Action	ARB Implementation	Type of Action	Pollutants Targeted for Reduction		
				Diesel PM	NOx	GHG
Expand/Enhance Existing Incentive Programs: Develop modifications to increase the emphasis on and support for zero and near-zero equipment used in freight operations, including introduction of truck engines certified to optional low-NOx standards. • Support Carl Moyer Program statutory revisions to enable local air districts to provide funding for advanced technologies and to recognize GHG co-benefits. • Propose changes to Proposition 1B to offer higher funding for zero and near-zero equipment. • Propose Air Quality Improvement Program/Low Carbon Transportation Funding Plan to accelerate and expand adoption of certified zero and near-zero emissions vehicles and equipment. • Coordinate with the California Air Pollution Control Officers Association on investment of local funding towards higher priority freight projects. • Include maintenance, best practices, etc. requirements beyond manufacturers' recommendations in future incentive contracts for truck operators of plug-in hybrids, hybrids, transformational technologies, etc.	2015 - 2016	2016-2020	State Legislation and Incentive	✓	✓	✓

F. Vision for the Future

The following discussion describes the prospects to accelerate progress toward zero emissions for trucks, ocean-going vessels, locomotives, transport refrigeration units, cargo/industrial/ground service equipment, commercial harbor craft, and aircraft. The tables contain ARB staff's current vision for each equipment category, challenges to the development and widespread deployment of zero and near-zero emission technologies, and potential levers available to ARB now through the next several decades.

Generally, ARB levers include: regulations, partnerships, incentives, and demonstration programs. Often, these levers could accelerate progress in one category, and support technology transfer to other equipment types. The concepts described here are informed by the Boardwide technology assessment work in progress, but go beyond the preliminary findings of that work. We approached the question of "zero?" working back from the ultimate goal (can we envision zero emission equipment, or technology capable of zero emission operation) rather than the forward approach used for the technology assessments (where is technology today and what developments are foreseeable in the near-term?). The next step will be to reconcile the two approaches and identify when we can expect to see both near-zero and zero emission technology demonstrated in some or all applications for that equipment category to start feasible clocks for deployment.

ARB will need to fully evaluate the feasibility of bringing the technologies in each equipment category to zero or near-zero emissions, the cost/economics of widespread deployment of those technologies and the associated fueling infrastructure, and the potential impacts on the supply chain and the environment. ARB will also need to prioritize its resources and actions based on the potential for emissions and risk reduction, as well as the potential for technology development in one equipment category to spur or support advances in other categories. We expect to begin these evaluations with our State and local agency partners in May 2015.

In all cases, additional technology development and demonstration is needed to advance zero emission technologies to meet the duty cycle requirements in higher horsepower applications. Success will depend on the gains made in significantly increasing the capacity and durability of batteries and fuel cells in harsh environments, while decreasing size, weight, and cost. The sectors with equipment that moves cargo over a distance will also depend on design and/or operational changes to improve efficiency. In addition to technological advancements, deployment of these technologies will also rely on ARB partnerships with State agencies and others to provide the alternative fuels and energy infrastructure.

From a technology perspective, the equipment categories with the greatest potential for zero emission technology and/or zero emission operation include trucks, locomotives, transport refrigeration units, equipment, commercial harbor craft, and airport ground service equipment. For ocean-going vessels and aircraft, we anticipate that near-zero

emission technologies and efficiencies will be capable of achieving a 90 percent reduction in NOx emissions and a 50 to 80 percent reduction in GHG emissions.

Vision: Trucks

Long-term Vision: Based on currently foreseeable technology, there are opportunities to move this sector to zero emission technologies, with near-zero emissions feasible for many applications in the near-term. Early applicability of zero emission technologies will vary depending on how different truck types are operated. The progression for zero emission technologies is expected to occur first in urban bus and last mile applications and later be adopted in other heavy-duty applications as the technology progresses and supply chains are developed for the components. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals.

Relative contribution of category to emissions: Near-source toxics – Medium, Criteria pollutants – High, GHG – High

Technology: Fuel cell**,** battery electric for zero emission vehicles, renewable natural gas/diesel, and biofuels as near-zero options.

Challenges	Potential ARB Levers
Technical: • Zero emission technologies will require a significant change nationally and internationally before energy storage needs meet all the requirements for use across all truck types. Long haul applications face a tradeoff between space and fuel storage. • Need for development of near-zero technologies that achieve a 90 percent reduction in in-use emissions. • Drayage trips between seaports and near-dock rail are a target area for demonstrations. **Economic:** • Cost recovery issues from compliance with existing regulations. **Data Needs:** • Development of cost curve expectations to track technology diffusion. • Where to invest, when, what is the right order, and how to achieve economies of scale?	**All Trucks:** • Develop and propose strategies to ensure durability and in-use performance. • Petition U.S. EPA for lower national NOx standards, and develop a California proposal if U.S. EPA does not act. • Encourage use of renewable natural gas and biofuels. • Petition U.S. EPA to prohibit high-global warming potential refrigerants in truck air conditioning systems, and develop a proposed California proposal if U.S. EPA does not act. • Develop and propose new, stringent California Phase 2 GHG requirements to reduce emissions from trucks and trailers, and provide fuel savings. • Explore with transportation partners the development of preferential access/pricing strategies that encourage zero emission truck travel. • Develop a renewable natural gas standard. • Support an electric corridor demonstration project. • Develop and propose increasing flexibility for manufacturers to certify advanced truck engine and vehicle systems in heavy-duty applications. • Develop an emissions cap for freight facilities. • Expand and enhance existing incentive programs to increase support for zero and near-zero truck deployment, including introduction of trucks certified to optional low-NOx standards. **Urban delivery—Medium Duty:** • Develop proposed efficiency standards to accelerate zero emission vehicle demonstration projects. • Consider Zero Emission Vehicle requirements based on fleet volume and vehicle size, beginning with last mile delivery, with complementary incentives. **Long haul—Heavy Duty:** • Develop pilot projects for zero emission travel and idling in impacted communities. **Short haul—Heavy Duty (e.g. Drayage):** • Provide incentives to demonstrate viability of zero emission technology and hybrids capable of zero emission miles. • Develop a proposed regulation that provides mandatory or strong incentives for zero emission trucks or trucks capable of zero emission operation that builds upon complementary incentives for vehicles and infrastructure. **Transfer Trucks (Trucks carrying recyclables from transfer stations):** • Develop proposed efficiency standards to accelerate zero emission vehicle demonstration projects, including anti-idling measures. • Consider a Zero Emission Vehicle purchase mandate, with complementary incentive support.

Vision: Ocean-Going Vessels

Long-term Vision: Based on currently foreseeable technology, opportunities exist to move this sector toward a 90 percent reduction in NOx and a 50 percent reduction in greenhouse gas emissions. In particular, some liquefied natural gas engines, Selective Catalytic Reduction, and design efficiencies can be employed to achieve reductions in criteria and greenhouse gas emissions. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals.

Relative contribution of category to emissions Near-source toxics – Medium,
Criteria pollutants – Medium to High (depending on geographic boundary), GHG – Medium

Technology: NOx/ diesel PM : greater use of at-berth technologies (more plug-ins, fuel cells, and emissions capture and control systems), Selective Catalytic Reduction, and engine design.
GHG: vessel design, certain liquefied natural gas engines, energy systems optimization, operational improvements, enhanced maintenance, logistics, scheduling, and zero emissions at berth.

Challenges	Potential ARB Levers
Technical: • Safety and technical issues regarding retrofit applications. • Zero emission technology is not currently available for commercial vessels operating at sea and is limited to nuclear military vessels. • Lack of fueling infrastructure for vessels operating on liquefied natural gas. • Only some liquefied natural gas engines in ocean-going vessels provide significant GHG emissions benefits that are dependent on engine design and the carbon intensity of the fuel. **Economic:** • Long vessel lifespan.	**Partnerships:** • Collaborate with the U.S. EPA and U.S. Coast Guard to advocate for more stringent federal and international engine emissions, and engine and vessel efficiency standards. • Learn from Department of Defense / U.S. Navy activities on biofuels and propulsion technology. • Work with the Pacific Coast Collaborative on greening west coast seaports. • Work with national and subnational jurisdictions through Memorandums of Understanding and the United Nation's Green Freight Action Plan to advocate for marine-related actions. • Working with shipping companies to develop standards for renewable biofuels. • Work with partners to develop robust liquefied natural gas fueling infrastructure. • Advocate with international partners for new International Maritime Organization Tier 4 NOx/PM standards, and efficiency targets for existing vessels in Ship Energy Efficiency Management Plans. **Potential Research & Demonstrations:** • NOx retrofit technology for in-use vessels and boilers. • Effects of emission reduction technologies on black carbon emissions. • Seek federal dollars from U.S. Maritime Administration and U.S. Department of Energy for technology and fuel demonstration projects. **Potential Incentives:** • Develop incentives to attract cleaner more efficient ships to California seaports by leveraging port and air agency funds. **Potential ARB Regulations & Incentives:** • Develop an ocean-going vessel renewable biofuels market through proposal of an amendment that allows renewable biofuels suppliers to opt-in to the Low Carbon Fuel Standard if the amendment is adopted, or inclusion in Cap and Trade. • Develop an emissions cap for freight facilities. • Define criteria for "Super Low Emission Efficient Ship" and achieve early implementation of clean technologies (liquefied natural gas, Tier 3, or better) for newer vessels via existing and enhanced seaport incentive programs (e.g. Green Ship, Ship Index, etc.). • Develop and propose amendments to the At-Berth Regulation to include other vessel fleets and types to achieve additional emission reductions.

Vision: Locomotives

Long-term Vision: Based on currently foreseeable technology, opportunities exist to move the locomotive sector toward zero emission track miles for interstate locomotives, particularly as battery and fuel cell technologies advance. Early demonstration and adoption of zero emission switchers and short hauls may pave the way for technology advancements needed for widespread adoption. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals.

Relative contribution of category to emissions: Near-source toxics – High**,**
Criteria pollutants – Medium**,** GHG – Medium

Technology: Battery or fuel cell tenders to create hybrids capable of zero emission miles and renewable LNG-fueled hybrid for potential near-zero emissions technology.

Challenges	Potential ARB Levers
Technical: • The direct transfer of technology from trucks will not fully address category-specific demands such as duty cycle, power, reliability, operating, environment, and infrastructure. • Will need results of demonstration projects to determine which zero emission tender will be appropriate (battery tender versus a fuel cell tender). • Class I railroads typically run a national fleet, with about 10% of annual locomotive operations in California. **Economic:** • Locomotives and engines have a long useful life. • Limited demonstration projects are available due to high cost.	**Partnerships:** • Petition U.S. EPA to amend the definition of a "new" locomotive. • Petition U.S. EPA to develop a Tier 5 national emissions standard for new locomotives. • Partner with the U.S. Department of Energy, U.S. Department of Defense, and Federal Railroad Administration on other battery and fuel cell research, development, and demonstration efforts. **Potential Research & Demonstrations:** • Investigate the viability of battery and fuel cell tenders through demonstration projects, beginning with switcher applications, and then expand to interstate line haul operating within parts or all of California. **Potential ARB Regulations & Initiatives:** • Develop a California regulation for non-new locomotives operating in the State. • Consider adopting a California regulation for intrastate engines to accelerate a transition to cleaner technology. • Maximize the use of renewable natural gas and biofuels in locomotive fleet and railroads' national fuel distribution network through the Low Carbon Fuel Standard and Cap and Trade programs. • Develop an emissions cap for freight facilities.

Vision: Transport Refrigeration Units

Long-term Vision: Based on currently foreseeable technology, there are opportunities to move this sector to zero emission technologies. Cryogenic refrigeration system pilot programs and hydrogen fuel cell demonstrations are underway. In the interim, provision of charging infrastructure at warehouse and distribution centers can help ensure the use of existing plug-in capabilities of transport refrigeration units. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals.

Relative contribution of category to emissions: Near-source toxics – High, Criteria pollutants – Medium**,** GHG – Low

Technology: All-electric plug-in with range extender technology, van and refrigeration system efficiency, cryogenic refrigeration systems, and fuel cell.

Challenges	Potential ARB Levers
Technical: • Limited charging infrastructure available for all-electric battery and fuel cell. • Retrofitting and conversion options are limited. • May need additional time to verify and certify zero emission vehicle technologies. • Demonstrations must address reliability to ensure food safety. • Need to address equipment from the entire U.S. that will support the interstate nature of transport refrigerants. **Economic:** • Cost recovery issues from compliance with existing Transport Refrigeration Unit regulation. • Cost-effectiveness of mandating, verifying, and certifying technologies and equipment that may be ultimately adopted. • Cost to move to zero emission technology such as charging/fueling infrastructure.	**Partnerships:** • Enhance partnerships with U.S. EPA (e.g. SmartWay) and Department of Energy to regulate insulation and refrigeration standards. • Petition U.S. EPA to prohibit high-global warming potential refrigerants in transport refrigeration units, and prohibit high-global warming potential in refrigerated shipping containers. **Potential Research & Demonstration Projects:** • Demonstration projects for equipment and infrastructure, such as partnering with a demonstration facility to go to completely zero emission, and applying lessons learned to future regulatory proposals. **Potential ARB Regulations & Initiatives:** • Propose regulations to prohibit cold storage, with incentives to support infrastructure installation (for example, plug-in charging capability) and demonstration projects. • Develop a proposed amendment to the existing rule to set equipment standards for van insulation and refrigeration systems. • Consider requiring operational efficiency metrics to include electric standby power capabilities on all equipment. • Provide incentives to demonstrate hydrogen fuel cells, all-electric battery/plug-in technologies, and cryogenic technologies which are already in use in Europe. • Develop an emissions cap for freight facilities.

Vision: Cargo Handling, Industrial, and Ground Service Equipment

Long-term Vision: Based on currently foreseeable technology, there are opportunities to move this sector to zero emission technologies. Battery electric and fuel cell technologies are currently being used in warehouse and distribution centers. Electric cargo handling equipment for container movement at seaports is already in use in California. As cargo handling equipment technology develops, zero emission technologies will become technically feasible for use in bulk handling applications. The industry is also looking into the feasibility of fuel cells in ground support engines. Widespread use of zero emission technologies and development of associated infrastructure will provide overlapping benefits with other sectors with similar charging needs. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals.

Relative contribution of category to emissions: Near-source toxics – Low**,** Criteria pollutants – Low**,** GHG – Low

Technology: Container handling: grid, battery electric system, potential for fuel cell systems as technology matures; Bulk handling: Battery electric, potential for selected automated electric systems and fuel cell as technology matures.

Challenges	Potential ARB Levers
Technical: • Data Needs: The current and future projection of activity in warehouses and distribution centers. • Viable electric yard trucks are not commercially available even though there has been progress in developmental efforts. • Need for systems-level demonstration of fuel cell and battery terminal operations. **Economic:** • Cost-effectiveness of mandating, verifying, and certifying technologies and equipment that may ultimately be adopted. • Need to deploy charging/fueling infrastructure for zero emission technology.	**Industrial Equipment:** • Develop proposal to establish purchase requirements to support broad scale deployment of zero emissions equipment. • Develop an emissions cap for freight facilities. **Cargo Handling Equipment:** • Develop Memorandums of Understanding with seaports, airports, and railroads. • Support programs for technology demonstrations including battery electric, fuel cell, and pathway hybrids. • Potentially focus on battery-electric vehicle, fuel cell, and grid electric technologies, which are currently further along in the development and demonstration phase. • Support automated zero emission technology for all new facilities. • Support favorable electricity rate structure for freight facilities, including expansions. • Develop a proposed amendment to the Cargo Handling Equipment regulation requiring a phase-in approach to zero emission equipment. • Develop an emissions cap for freight facilities. **Airport Ground Support Equipment:** • Support research and demonstrations of zero emission aircraft taxi systems. • Develop proposed regulations to accelerate penetration of zero emission equipment and vehicles, many of which are currently subject to the Large Spark Ignition and Off-road Compression-Ignition regulations. • Develop a proposed zero emission aircraft taxi regulation. • Develop an emissions cap for freight facilities.

Vision: Commercial Harbor Craft	
Long-term Vision: Based on currently foreseeable technology, opportunities exist to move this sector towards employing zero and near-zero emission technologies. In particular, harbor craft operated within the seaport and close to shore are candidates for zero emission technology or hybrid technologies with zero emission range. There are a number of near-zero and other technologies now available to reduce emissions, including Tier 3 engines. Several fuel cell demonstrations are underway. Fuel cell and battery electric technologies need to be tested for performance, range, and cost. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals. **Relative contribution of category to emissions:** Near-source toxics – Low**,** Criteria pollutants – Low**,** GHG – Low **Technology:** Renewable biofuel; hydrogen hybrid, and selective catalytic reduction technologies.	
Challenges	**Potential ARB Levers**
Technical: • The interaction between zero emission vehicle technologies and the marine environment is unknown. • May need to use renewable biofuel or hydrogen hybrid technologies as a stepping stone before commercial harbor craft can reach zero. • Data Needs: Have tug-specific data from hybrid tug boat demonstrations. Need data for other vessel categories. **Economic:** • Cost recovery issues from compliance with the existing commercial harbor craft rule.	**Potential Research & Demonstrations:** • Potential focus on data collection from hybrid tug boat demonstration projects and additional demonstrations in other vessel categories to ensure success in future regulations. **Potential ARB Regulations & Initiatives:** • Develop a proposed amendment to harbor craft regulation to require selective catalytic reduction on engines where feasible and/or require new builds operating in California in select operating categories to be hybrids. • Develop an emissions cap for freight facilities.

Vision: Aircraft

Long-term Vision: Based on currently foreseeable technology, opportunities exist to move this sector toward a 90 percent reduction in NOx and an 80 percent reduction in GHG emissions. In the foreseeable future, application of renewable biofuels and aircraft and engine design can provide reduced emissions from aircraft operations and partnering with airports could result in increased building efficiencies from onsite operations. This table represents possible ARB levers to meet near-term, mid-term, and long-term air quality and climate goals.

Relative contribution of category to emissions: Near-source toxics – Medium**,** Criteria pollutants – Low**,** GHG – Low

Technology: Renewable biofuels for near-term deployment; liquid hydrogen as combustion fuel for propulsion may be possible in the future.

Challenges	Potential ARB Levers
Technical: • Zero carbon technologies may be theoretically feasible; no real-world demonstration projects exist for commercial aircraft. Challenges include related fueling, production, and storage.	**Partnerships :** • Work with potential partners to advocate to increase the stringency of aircraft emission standards and to set international goals. • Learn from Department of Defense / U.S. Air Force activities on biofuels and propulsion technology. • Partner with airports to incentivize cleaner aircrafts to come to California. • Work with major airlines to leverage existing programs and build coalitions for applying biofuels in pipeline connections. • Work with airports through a memorandum of understanding to demonstrate zero emission technologies (e.g. “Advanced Clean Airports” partnership) to develop and achieve emission reductions. • Partner with international engine manufacturers to encourage production of efficient engines. **Potential Research & Demonstrations:** • Support aircraft research and development of aircraft-engine design, improved aerodynamics, auxiliary power units, lightweighting, and increased use of renewable biofuels. **Potential ARB Regulations & Initiatives:** • Establish an aviation biofuels market. • Develop an emissions cap for freight facilities.

III. Expanding Our Focus to Freight Facilities and Systems

Both State and national regulations to reduce air pollution from the freight system have focused on the fuels and vehicles/equipment that transport cargo. ARB has established comprehensive fuel specifications, emission standards for many types of new engines, multiple in-use rules to accelerate the retrofit and turnover of the diesel fleet to cleaner models, truck efficiency standards, and operational limits on idling. These equipment-specific approaches have been effective in reducing emissions statewide from the sectors where ARB has direct regulatory authority.

Within a complex multi-modal freight hub like a seaport, railyard, airport, or distribution center, there are multiple types of equipment subject to many different air pollution control regulations. ARB adopted its regulations to meet California's needs, and other agencies set standards to meet less rigorous national requirements or international consensus. Specifically, the national standards for interstate trucks and line-haul locomotives, and the international standards for ocean-going vessels and aircraft are not sufficiently stringent to meet California's air quality and climate targets.

To make further gains through widespread introduction of zero and near-zero emission equipment, we can consider amendments to ARB's existing equipment-specific regulations, as well as approach the need to further reduce emissions and exposure from a facility perspective.

From a climate change perspective, California's requirements for more efficient trucks and trailers, lower-carbon fuels, and fuels in the Cap-and-Trade program are reducing the carbon footprint of land-based freight operations involving trucks and cargo equipment, but not interstate locomotives, marine vessels or aircraft. More efficient zero or near-zero emission equipment and lower carbon fuels can cut the climate impact of these freight operations. But, there is inefficiency in the structure and operations of the freight transport system that offers a very attractive target because of the opportunity to simultaneously achieve climate and air quality gains, cost savings, and the ability to increase the capacity of the transportation system without increasing its footprint. Efficiency improvements can be tied to a type of equipment, a sector, a facility, a company, or the entire system.

A. Facility Based Approach to Facilitate Transformation

In addition to pursuing sector-specific control strategies, we are evaluating a facility-based cap approach for all types of major freight hubs and facilities. This facility perspective offers several possibilities:

- For air agencies – to prioritize requirements for further near-term actions at the freight hubs posing the greatest health risk to communities, including the risk associated with emissions from national/international sources.
- For owners and operators of equipment at freight hubs – to have the flexibility to choose which elements of their operation are best suited to transition to zero and near-zero emissions in the near-term.

Our first priority is to cut the community health risk through reductions in emissions and exposure. We also need to support the transition of the freight transport system to zero and near-zero emissions. A facility cap approach could accelerate near-term emission reductions for attainment of air quality standards, as well as spur introduction of new technologies and more efficient operations. Implementing emission reduction targets for an entire facility could provide both compliance flexibility and synergies in facility fueling infrastructure. For example, if a distribution center moves to fuel cell or electric forklifts, the hydrogen fueling or electric charging infrastructure is then available to on-road trucks and transportation refrigeration units serving that facility.

There may be opportunities for complementary State and local air district actions designed to function as a single program. For example, ARB and an air district could work together to establish facility emission caps within that region. Or ARB could develop and adopt a statewide regulation and partner with multiple air district(s) to implement and enforce the requirements. There is also the potential to develop a cap approach that could be implemented with a mix of incentives, enforceable agreements, and regulatory elements to achieve the needed results.

Below are some of the potential approaches to structure a facility cap and considerations to evaluate and resolve if ARB decides to proceed with this concept.

1. Threshold to Determine Covered Facilities

The proposed near-term ARB actions include a reporting element to gather data on facility location, equipment type and activity levels, and proximity to residences and other sensitive receptors. This information would support a facility emissions cap or further sector-specific rulemakings.

The intent of the cap would be to address the major freight hubs and facilities in the State that pose the highest health risks. We expect that straightforward activity indicators could be the metric to determine the applicability of the regulation; these indicators would ideally be data that facility owners/operators already collect or could readily collect. The distance to the nearest receptor may also play a role in identifying

covered facilities. ARB staff would develop activity and distance thresholds based on typical correlations to health risks and contributions to regional pollution levels. Other factors that might be considered to prioritize facilities for inclusion would be higher regional air toxics health risks and/or higher regional ozone and fine particulate matter levels.

2. Cap Based on Facility Emissions

This approach would be to set caps on the total emissions from all sources operating at the hub or facility (including vehicles and equipment accessing the facility within a defined radius). For a smaller facility with one operator and only a few types of equipment, this could be simple. However, for a major seaport or airport serving many carriers the approach is more complex and a key question would be how to define the activities subject to the cap? Would a single cap apply to the entire hub or facility, or would a cap apply to each terminal/carrier within the facility? The challenge would be how to best align the responsibility for compliance with the regulated entity's ability to control the equipment and operations.

We would also need to assess how to set the cap(s) for multiple types of hubs and facilities. As an absolute level of emissions or a percent reduction from a baseline? A different cap for each facility type or the same cap across all facility types? A cap proportional to current activity and operations levels or a cap that considers the technology status (i.e., facilities with higher proportions of the cleanest operations have the least stringent requirements)? There are many options and combinations that could be considered.

An absolute cap on emissions based on facility type would provide a clear limit and could relate to health risk, but would not account for differences between the largest and smallest facilities in an industry. A percent reduction could reflect these differences, but may not appropriately advantage a facility that has already invested in cleaner, more efficient operations compared to its competitors.

3. Cap Based on Facility Emissions per Unit of Freight Activity

This approach would be to establish caps on the total emissions from all sources operating at the hub or facility (including vehicles and equipment accessing the facility within a defined radius) per unit of freight activity. Freight activity could include metrics such as: tons of freight handled for bulk cargo operations, number of twenty-foot equivalent units or lifts for containerized cargo operations, number of truck trips for warehouse/distribution centers or land ports of entry (border crossings), and number of take-offs and landings or cargo value for airports. This approach would offer the strongest incentive for both efficiency gains and cleaner technology, but would not result in a defined limit on the pollution from each facility.

Many of the issues raised above in the discussion of a facility emissions cap would also be relevant with an activity-based approach.

4. Cap Based on Facility Cancer Risk

This approach could involve setting an absolute cancer risk level that each facility must achieve or a percent reduction in the baseline cancer risk. This approach has the benefit of directly addressing the need to reduce health risk, but it would require very significant resource investments from the affected facilities and ARB staff to evaluate the existing health risks. It also sets up a system where facilities that can afford consultants are advantaged compared to smaller or less profitable facilities that cannot. The result would be considerable industry dollars spent on risk assessments that could instead be invested in cleaner technologies and efficiency strategies. Similarly, ARB's resources would be consumed for several years in developing methodologies for the risk assessments and reviewing them, establishing baselines, and repeating the exercise to monitor facility progress.

5. Other Considerations

Under any of the cap approaches, we would seek ways to incentivize use of zero emission technology through extra credit, time extensions, or other means. We would also evaluate the innate tradeoffs between the complexity of a cap system and the flexibility it could provide for businesses versus the cost to businesses and the ability to enforce a complex cap. For example, it might be possible to construct and offer a "best practices" option for small facilities that would be simpler to implement and require less recordkeeping as an alternative to a quantitative cap approach that involves more attention to collecting and reporting data on equipment and activity.

B. Land Use and Transportation Infrastructure Considerations

Optimized land use is critical to minimize community exposure to freight pollution and maximize freight efficiency. Leveraging partnerships between State, regional and local planning entities to develop a coordinated approach to freight transportation and land use can improve our ability to achieve both objectives. Ideally, these partnerships will lead to more efficient freight movement by locating freight facilities closer to their customers and suppliers, creation of system wide efficiencies through implementation of distance-based fees or time-of-day based fees to minimize peak periods of congestion. The following land use and transportation strategies merit further investigation.

1. Urban Distribution Centers

Urban distribution centers have the potential to reduce emissions from the last mile of delivery for freight. Urban distribution centers are facilities located in urban areas that consolidate deliveries near the final cargo destination to reduce unnecessary vehicle miles travelled. Urban distribution centers incorporate several efficiency measures such as real-time traffic management, smart information technology solutions, automation, and social media integration, which can optimize the last mile delivery and reduce

emissions. To align health and efficiency needs, these urban facilities and the trucks that serve them would need to operate with zero emissions.

2. Regional Planning

Similar to the concepts behind Senate Bill 375 (Steinberg, Chapter 728, Statutes of 2008), bringing together local and regional planning entities to facilitate better land use and freight transportation infrastructure can lead to system wide benefits. Senate Bill 375 directed metropolitan planning organizations and regional transportation planning agencies to develop sustainable community strategies that integrate development patterns and transportation networks in a way that reduces GHG emissions from cars and light-duty trucks. Utilizing a similar strategy to incorporate freight-related goals and metrics, such as emission limits or fuel consumption goals, could promote the optimization of land use, and encourage increased system efficiency.

3. Freight Land Use Handbook

A freight land use handbook could be developed that identifies best practices for the siting, design, and operation of freight facilities that result in minimizing exposure to air toxics and maximizing the capacity of the transportation infrastructure. This handbook could also identify and recommend the use of the cleanest available engine and equipment technologies for the construction and maintenance of freight facilities, as well as assist in determining associated infrastructure needs and recommended air quality mitigation measures for new freight infrastructure and facility projects.

C. System Efficiency and Transformation

In addition to positive air quality impacts, system efficiency improvements can produce a business benefit. By implementing one or more efficiency strategies, businesses may be able to cut travel time, decrease fuel costs and increase the capacity of the system to transport more freight within the existing footprint. Additionally, efficiency improvements have the potential to support multi-agency environmental, energy, mobility, safety and economic goals.

Many of these opportunities fall outside of the purview of ARB. Industry leadership is key in the development and implementation of freight efficiency solutions. Facilitating additional systemwide efficiencies will require coordination among industry, technology developers, and public and private stakeholders to maximize benefits and minimize any disruption of the current system. Challenges facing the development and implementation of such strategies include obtaining necessary information and identifying specific partnership opportunities.

The freight industry has already made progress in implementing efficiencies in cargo movement. Container standardization and the implementation of Radio Frequency Identification systems are two such advances that increased the efficiency of freight transport. Containerization drastically reduced shipping costs and time, decreased

storage needs, and reduced congestion. It also led to the introduction of intermodal transport, allowing containerized cargo to move seamlessly between ships, trucks, and locomotives. Radio Frequency Identification systems increased efficiency with improved tracking of containers and increased security and truck traffic flow by electronically reading tags to allow for automated truck entry at California's seaports. These improvements decreased congestion, resulting in fuel savings, lower shipping costs, and air quality benefits.

While there are many efficiency opportunities, ARB staff suggests that the following merit discussion and exploration with other agencies and industry stakeholders.

- Establishing a freight efficiency metric and targets to monitor progress.
- Extending seaport hours.
- Implementing free-flow, a cargo handling process at marine terminals.
- Reducing container dwell time at seaports and railyards.
- Using automation as an opportunity to build zero emission markets.
- Expanding use of Information Technology software.
- Implementing logistics planning software.
- Making use of virtual container yards.
- Implementing collaborative logistics.
- Implementing eco-driving.
- Implementing cooperative delivery systems.

1. Efficiency Metric

ARB staff is evaluating an efficiency metric that reflects the pollutant intensity of moving cargo throughout all transportation sectors. Staff conducted a literature review and found numerous metrics, each designed to measure specific parameters. One such metric is emissions per ton-mile. Currently used by most freight sectors, the ton-mile activity component of the metric may support cross-sector comparison.

Staff is analyzing the option of using a performance metric to create a baseline that defines the state of the current freight transport system and to set goals. This could also be used to track the State's progress in reducing freight emissions by evaluating the impacts of shifting from one mode of freight transportation to another and to assess and compare concepts developed for the Sustainable Freight Strategy at regional and statewide levels.

2. Operational Efficiencies

Operational efficiencies are changes to business models that have the potential to increase freight flow and capacity in the freight transport system. These strategies include expanded operational hours and increased availability of transport modes to maximize the use of infrastructure while increasing capacity and decreasing peak time congestion.

a. Extended Hours

Expanding freight transport operating hours can be effective to reduce congestion during peak hours by rescheduling freight movement to off peak hours. For example, an off peak incentive program called PierPass was created at the Ports of Los Angeles and Long Beach in 2005 to move cargo during non-peak hours at night and on the weekends. This program reduced truck traffic and pollution during the daytime by distributing traffic across more hours of operation and improved overall turn times for trucks.[19] The PierPass program currently redirects almost 55 percent of daily truck traffic at the Ports of Los Angeles and Long Beach.[20] Expanding operational hours to other freight transport facilities has the potential to increase capacity and improve velocity and reliability while mitigating traffic congestion. This approach can expand the capacity of the system, but its applicability to other freight facilities must be sensitive to the community impacts from 24-hours a day operation, particularly noise and light impacts.

b. Free-Flow

Free-flow is a cargo handling practice that streamlines container pickup at marine terminals. This practice groups large retailer container cargo in a separate stack to be picked up by a single owner, trucking company or logistics company. Once grouped, the owner or company then sends a fleet of trucks through a special lane to pick up the containers with each truck taking the next container in the stack rather than a specific container. This reduces unproductive re-stacking of containers, truck idling and waiting compared to conventional container pickups that match a single truck to a specific container. PierPass recently launched a free-flow demonstration project at the Port of Los Angeles to reduce the time it takes participating trucks to pick up containers at marine terminals. Eventually, PierPass expects free-flow operations to account for nearly 30 percent of cargo moves at the terminals.[21]

c. Reducing Container Dwell Time

Container dwell time refers to the amount of time containers spend at the seaport. Major customers can influence ship schedules, rates, and cargo handling. For example, marine terminal operators offer special pickup times or shorter dwell times for containers for preferred customers. There is opportunity for marine terminals to take a

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[19] PierPass, "Off-Peak Information," <http://www.pierpass.org/offpeak-information/>, accessed March 17, 2015.

[20] PierPass, "PierPass Diverts 30 Millionth Truck Trip from Los Angeles, Long Beach Traffic," August 2014, <http://www.pierpass.org/wp-content/uploads/2014/08/30-million-trucks-release_final_8-28-14.pdf>, accessed March 17, 2015.

[21] PierPass, "PierPass Announces Free-Flow Program to Speed Cargo Through Ports of Los Angeles and Long Beach," September 2014, <http://www.pierpass.org/news/pierpass-announces-free-flow-program-to-speed-cargo-through-ports-of-los-angeles-and-long-beach/>, accessed March 17, 2015.

more active approach to decrease dwell times. In 2005, the Port of Los Angeles reduced free dwell time for imports and exports by one day in order to incentivize freight movement and increase terminal capacity.[22] Possible operational changes that could shorten container storage times at the seaports or other freight facilities are imposing dwell time charges or incentivizing quick pick up.

3. Automation

As automation is increasingly occurring at seaports, warehouses, and distribution centers, ARB would like to see those applications help build a market for zero emission technologies. As existing facilities consider expansion or automation, there is potential to incorporate zero emission equipment and technologies. If automation continues to increase, there is also a need to include robust preparations for workforce training to ensure that the California workforce is ready to meet the more complex computer and engineering demands of the associated jobs.

4. Information Technology Software

Information Technology Software systems provide software solutions that improve efficiency through better informed and coordinated cargo movement. This section will focus on several opportunities for deployment of Information Technology applications. These include advanced scheduling systems for seaport and intermodal operations, virtual container yards to minimize empty container moves and collaborative logistics to reduce empty backhauls for cargo traveling over the road.

a. Logistics Planning Systems

Logistic planning technologies provide coordination and access to advanced scheduling systems that can improve communication, appointments, routing, container tracking, productivity, and congestion. Advanced scheduling Information Technology programs have the potential to distribute container pick-up times at seaports reducing truck queues and idling times, coordinating routing and logistic connections at distribution centers. Currently, the U.S. Department of Transportation's Intelligent Transportation Systems Office is leading efforts to provide innovative Information Technology projects and funding to improve operational efficiency within the freight network. The Port of Los Angeles is currently demonstrating the Freight Advanced Travel Information System (FRATIS) through 2015.

[22] Rodrigue Notteboom, “The Terminalization of Supply Chains: reassessing the role of terminals in ports/hinterland logistical relationships,” International Association of Maritime Economists, Dalian, China, 2008.

Case Study: Freight Advanced Travel Information System (FRATIS)

The Freight Advanced Traveler Information System (FRATIS) is an Intelligent Transportation System designed to enable the development of specific freight-related (real-time) travel information applications for the freight community. This software planning prototype is currently being deployed and monitored to improve freight flow at the Port of Los Angeles, Central Florida, Miami and Texas to determine site specific implementation benefits. The applications include freight-specific dynamic route guidance and coordinated load/empty optimized management applications. The FRATIS applications focus on:

- Improving communications and sharing intermodal logistics information between the truck drayage industry and seaport terminals to reduce congestion during peak hours.
- Integration of data including wait times at intermodal facilities, traffic incident alerts, road closures, work zones, truck parking, and routing restrictions (hazmat, oversize/overweight) giving the trucking community real time truck specific routing information to improve safety and efficiency.

Source: Randy Butler, "Using Freight Advanced Traveler Information Systems to Promote Urban Freight Mobility," U.S. Department of Transportation, May 13, 2014.

b. Virtual Container Yards

Virtual container yards reduce empty container moves by matching export needs to containers before returning to the seaport. Current business practices create significant empty containers traffic to the seaports. Some of these containers are subsequently picked up, transferred off seaport grounds, loaded with cargo, and then delivered back to the seaport. These unproductive trips are due to most shipping contracts requiring shipping containers be returned to the seaport container yard before they are called out again to be loaded with goods for export. This practice results in unnecessary 'empty miles' near the seaport which results in increased congestion and emissions.

c. Collaborative Logistics (Cutting Empty Backhauls)

Collaborative logistics refers to the practice of two or more parties collaborating to reduce empty backhauls by matching or sharing loads. This can improve over-the-road truck efficiency by reducing empty backhauls. Approximately 16 percent of current trailer loads on the road are running "empty miles" that contribute to unnecessary traffic congestion and air pollution.[23] This practice offsets costs for fleet owners by improving overall operational efficiencies that decrease fuel consumption and emissions.

[23] Michael Taptich, et al., "Goods Movement Calculator," [Computer Software], University of California, Berkeley, 2012.

The changing economy and demands on carriers require a shift in logistic operations toward a collaborative logistics model. Most collaborative logistics scenarios involve a network of partnering companies that work through a web based IT system. Recent research found that freight collaboration could lead to cost savings between 13 and 28 percent for participating companies.[24]

Case Study: Macy's and Schneider National:
Filling Empty Miles for Sustainability and Savings

Macy's and Schneider National joined forces to increase operational efficiency and revenue by reducing empty miles through utilization of an IT application. Reportedly, this resulted in decreased operating costs due to eliminations of 11 percent of its empty miles and moving 22 percent more backhaul freight with member shippers. At the same time, Macy's experienced an increase of 30 backhaul loads per week, or a projected 1,500 loads per year, at competitive market rates.

Source: Voluntary Interindustry Commerce Solutions,"Case Study: Macy's and Schneider National,", September 2009, <http://macysgreenliving.com/media/_CustomMedia/EmptyMiles_cs_092809.pdf>.

5. Engine and Vehicle Efficiencies

The transition of the California freight transport system to zero and near-zero emissions will require a combined approach that maximizes technological advancements through higher efficiency and engine standards, and operational efficiencies through implementation of intelligent transportation systems that utilize connected vehicle technologies (e.g. truck platooning). To support engine and equipment efficiencies, staff is developing an assessment of technologies for each sector.

- Stop-start technologies which conserve energy by shutting off the engine when the vehicle is at rest, such as at a traffic light, and automatically re-starting it.
- Advanced transmissions that utilize various technologies in order to optimize the performance of the transmission and improve fuel efficiency.
- Engine down-speeding, where the engine runs at low speeds and with high torques, which results in higher efficiency and reduced fuel consumption.
- Innovative fuel injection techniques that allow for fast and clean combustion and increased fuel efficiency.
- Waste heat recovery, using technology such as thermoelectric generators, that can directly convert energy from the hot engine exhaust into electricity that can power vehicle auxiliary loads and accessories.

[24] Lotte Verdonck, "Collaborative Logistics from the Perspective of Road Transportation," *Transport Reviews*, Vol. 33, No. 6, November 2013.

- Cylinder deactivation, which keeps the intake and exhaust valves closed through all cycles for a particular set of cylinders in the engine, improving combustion chamber pressure, which in turn, improves fuel efficiency.
- Hybridization in select applications where the duty cycle maximizes the benefits of the hybrid's regenerative braking.
- Vehicle improvements such as light-weighting, aerodynamics, low-rolling resistance tires, automatic tire inflation systems, speed limiters, axle efficiency improvements, idle reduction and more efficient accessories.

6. Eco-Driving

Eco-driving is a strategy that assists truck drivers in the freight transport system to drive more efficiently and economically by providing training to drivers with practical tips about fuel-saving techniques, fuel usage and the associated unnecessary tailpipe emissions. Fuel efficiency techniques include trip planning, use of cruise control, and avoidance of sudden acceleration and deceleration by monitoring traffic flow through route planning. Fleet managers can reduce fuel costs by teaching drivers eco-driving techniques and providing incentives for implementing efficient driving practices.

7. Cooperative Delivery

Cooperative delivery is when a co-op of similar businesses combine efforts, typically sharing a delivery vehicle, to minimize costs on last mile delivery. Cooperative delivery is an efficiency measure implemented to reduce vehicle miles travelled and optimize delivery routes emphasizing sustainability to reduce overall emissions. The potential efficiency is highly dependent on the delivery vehicle. This measure is feasible for similar urban businesses with overlapping delivery areas. Using a cooperative delivery network combined with hybrid or electric vehicles can reduce traffic congestion as well as the associated unnecessary emissions.

8. Emerging Technology

Emerging technologies have the potential to shift to more efficient manufacturing and delivery modes. For example, three-dimensional printing is an in-house manufacturing process that creates a three dimensional object from a digital file. This would decrease the amount of freight moving through the system and therefore increase efficiency. Battery powered drones and internet ordering could promote more efficient delivery methods by reducing last mile delivery emissions. Both three-dimensional printing and drone delivery are emerging technologies, which require further development and consumer acceptance, but both strategies have the potential to reduce vehicle miles travelled.

IV. Next Steps

This section describes the next steps to finalize this stand-alone document, as well as to develop the full Sustainable Freight Strategy in an integrated State planning process over the next year.

A. Sustainable Freight: Path to Zero/Near-Zero Emissions

ARB staff will continue to meet with stakeholders and provide an informational update on the Discussion Draft to the Board at its April 2015 meeting. Following that meeting, we will finalize this document to reflect any direction from the Board and appropriate changes in response to public comment.

In addition to pursuing the immediate and near-term actions identified in this document, and continuing the technical evaluation of other potential levers, ARB staff will provide components of this document as input to the development of other planning efforts. The 2016 State Implementation Plans, the next update of the Scoping Plan, and the 2016 Short-lived Climate Pollutant Strategy are examples of ARB efforts that will leverage the actions and measures identified here. These actions will also serve to inform ARB's contribution to the integrated statewide planning effort for the Sustainable Freight Strategy described in the next section.

Staff also expects to return to the Board in late 2015 with a more comprehensive update on the status of the work associated with this document and integration efforts.

B. California Sustainable Freight Strategy

Collectively, the State has agencies that are involved in nearly every aspect of the freight system, from transportation and energy infrastructure, to financial incentive programs, to advanced information technology and research, to economic development, to air quality and public health. However, individual transportation infrastructure projects, incentive programs, economic development efforts, or advanced technology applications are not enough to spur the rapid and transformative improvements needed to make the freight transport system sustainable.

Therefore, the State's environmental, energy, and transportation agencies, together with the business development office, will be working with local partners and stakeholders to develop a comprehensive, integrated plan – the California Sustainable Freight Strategy. The State agencies will develop this plan through a public process that will utilize the existing California Freight Advisory Committee as a sounding board, as well as discussions with all of the interested stakeholders such as industry, environmental groups, and community groups.

This planning effort has already begun. The California Freight Mobility Plan and California Transportation Plan 2014, released by California State Transportation Agency and California Department of Transportation outlines the State's transportation vision. The California Energy Commission released the Updated Integrated Energy Policy

Report, which discusses the State's energy needs. This Sustainable Freight Pathways document articulates the air quality needs and vision for the future. Together, these documents provide a foundation for the California Sustainable Freight Strategy and will help determine how to achieve a sustainable freight transport system.

1. Objectives

The Sustainable Freight Strategy will include specific actions and milestones to help achieve the goal of a sustainable freight transportation system in California that supports environmental, energy, transportation, and economic objectives. ARB's priority is a more efficient system that utilizes zero emission technology wherever possible and near-zero emission technology with renewable fuels everywhere else. This integrated effort responds to goals already established by California as described below.

Environmental Objectives:

- Reduce freight-related emissions to help meet federal ambient ozone and PM air quality standards, which requires significant further reductions over the next 15 years to meet ozone and diesel PM standards in the South Coast and San Joaquin Valley.
- Minimize near-source exposure to diesel particulate matter and associated health risks near railyards, seaports, airports, warehouse/distribution centers, and other freight facilities near impacted communities.
- Lower the carbon intensity of the freight sector with improved efficiency and the use of zero and near-zero emissions vehicles and equipment using renewable fuels to achieve an 80 percent reduction in GHG emissions from the transportation sector from 1990 levels by 2050 and to achieve up to a 50 percent reduction in fossil fuel use by cars and trucks by 2030.

Transportation Objectives:

- Increase freight movement efficiencies on California's highway, railroad, airport and seaport networks to support the State's international trade economy.
- Identify dedicated funding for freight improvements to succeed the Proposition 1B Highway Safety, Traffic Reduction, Air Quality and Port Security Bond Act of 2006 Trade Corridor Improvement Fund program.
- Use fix-it-first investments, including cleaner truck and locomotive engines and the provision of technologically supportive corridor infrastructure to contribute to improved efficiencies in freight velocity with fewer externalities.
- Improve freight system efficiency through new technology, and smart logistics and infrastructure investment.

Economic Objectives:

- Enhance the economic competitiveness of California's logistics system.
- Continue to advance California's position as a leader of green markets in domestic commerce and international trade.
- Establish a policy framework to attract industry and create clean-energy investments (e.g., manufacturing zero-emission trucks and freight equipment), which generate green and high-value jobs, create business certainty, assure long-term industry stability, and attract business establishments to California.
- Reduce congestion related costs by increasing freight-corridor capacity and increasing productivity of under-used transportation infrastructures.

2. Ensuring Measurable Outcomes

Transformation of the freight transportation system and projects to support that transformation can take years, if not decades, and are only accomplished if several key components are successfully completed. To ensure progress towards a sustainable freight transportation system, State agencies must pursue projects integrated with each other that reflect the same levels of priority and timing.

One such project could be to transform last mile delivery of freight in California. Another example could be to increase the efficiency of a major freight route; the most important starting point is to identify the specific route as a priority for each agency to address. The State agencies can also work together to improve a freight hub or facility.

The initial success of an integrated effort comes down to a statewide prioritization that is able to focus limited resources on accomplishing specific freight projects and implementing specific freight policies within the same general timeframe.

3. Plan Completion

Staff anticipates completion of an integrated plan in mid-2016, after conducting an analysis of potential environmental impacts under the California Environmental Quality Act if necessary. The public will have the opportunity to participate fully in the California Environmental Quality Act process conducted. Any potential regulatory actions developed in response to the plan will undergo any required economic and environmental assessments as appropriate. We will seek assistance from our public and private sector partners on ways to implement these actions. New ideas that emerge during the public process will be evaluated for inclusion in the draft set of recommendations.

APPENDICES

Appendix A: Emissions

A. Emission Tables

TABLE 5: Statewide Diesel PM Emissions from Freight Sources (tons per day)

	2012	2020	2030	2040	2050
Trucks	18.61	5.60	4.40	4.76	5.24
Ocean-Going Vessels	3.46	3.34	5.06	6.75	8.56
Equipment					
Transportation Refrigeration Unit	1.31	0.19	0.12	0.12	0.14
Industrial	0.58	0.49	0.39	0.39	0.38
Airport Ground Service	0.18	0.10	0.05	0.05	0.04
Cargo Handling	0.12	0.03	0.04	0.04	0.01
Locomotives	2.15	2.08	1.42	0.62	0.49
Commercial Harbor Craft	0.48	0.34	0.29	0.21	0.15
Aircraft	0.08	0.10	0.11	0.13	0.15
Total	**26.97**	**12.27**	**11.88**	**13.07**	**15.16**

TABLE 6: Statewide NOx Emissions from Freight Sources (tons per day)

	2012	2020	2030	2040	2050
Trucks	587.99	292.85	146.93	143.99	158.00
Ocean-Going Vessels	140.59	125.55	100.05	99.90	106.57
Locomotives	97.52	103.48	77.47	44.57	36.68
Equipment					
Transportation Refrigeration Unit	17.72	11.91	14.09	15.49	17.11
Industrial	15.61	7.58	4.77	9.97	10.10
Airport Ground Service	5.18	2.38	1.00	1.19	1.19
Cargo Handling	5.19	2.48	1.77	1.73	1.29
Commercial Harbor Craft	12.97	9.66	8.41	6.69	4.89
Aircraft	3.65	4.31	4.99	5.84	6.60
Total	**886.42**	**560.21**	**359.48**	**329.37**	**342.43**

TABLE 7: Statewide GHG Emissions from Freight Sources (million metric tons of CO2e per year)

	2012	2020	2030	2040	2050
Trucks	21.01	24.12	27.04	30.71	34.59
Ocean-Going Vessels	2.38	3.60	5.28	6.93	8.71
Locomotives	2.28	2.71	3.34	4.18	5.24
Equipment	0.45	0.59	0.79	1.70	2.79
Aircraft	0.45	0.54	0.62	0.70	0.80
Commercial Harbor Craft	0.40	0.41	0.41	0.40	0.39
Total	**26.97**	**31.97**	**37.48**	**44.62**	**52.52**

TABLE 8: Regional Diesel PM Emissions (tons per day)

	2012	2020	2030	2040	2050
South Coast	7.40	3.46	3.23	3.49	3.93
Rest of State	6.69	4.00	4.42	5.11	6.21
San Joaquin Valley	4.93	1.38	1.04	1.03	1.12
Bay Area	3.82	1.91	2.00	2.30	2.69
Border	2.15	0.82	0.69	0.68	0.73
Sacramento Valley	1.98	0.70	0.50	0.46	0.48
Total	**26.97**	**12.27**	**11.88**	**13.07**	**15.16**

TABLE 9: Regional NOx Emissions (tons per day)

	2012	2020	2030	2040	2050
South Coast	247.02	151.47	101.43	98.19	105.46
Rest of State	228.87	172.75	114.19	101.17	101.94
San Joaquin Valley	153.83	83.44	46.29	42.19	44.69
Bay Area	125.38	77.99	53.24	50.11	52.27
Border	67.35	38.85	23.71	20.45	20.38
Sacramento Valley	63.97	35.71	20.62	17.26	17.69
Total	**886.42**	**560.21**	**359.48**	**329.37**	**342.43**

B. Growth Assumptions

The growth assumptions used to forecast diesel PM, NOx, and GHG emissions are described below. Projected emissions do not explicitly account for changes in the split of freight between sectors, they are grown from the current activity split.

1. Trucks

The trucking sector criteria inventory growth projections are derived as part of EMFAC2014 using an array of parameters to calculate a base-year as well as projected emissions.

ARB staff estimates the base year population for trucks using information from the 2000 to 2012 California Department of Motor Vehicles registration database, the 2012 International Registration Plan Clearinghouse, and vehicle miles traveled based on historical taxable fuel sales from the Board of Equalization. Projections of emission growth is based on the impact of regulations, vehicle retention rates, as well as projected vehicle miles traveled and new vehicle sales using socio-economic regression models. With this information, staff's initial estimates show that the heavy-duty truck population will increase by 90 percent by 2050.

2. Ocean-Going Vessels

Staff updated the ocean-going vessel inventory in September 2013. These updates included new information regarding long-term growth factors for container ships, auto ships, and tankers. The growth factor updates are specific to each California seaport represented in the ocean-going vessel model. For container ships, auto ships and

tankers, the growth factor updates are from forecasted freight tonnage derived from the Federal Highway Administration Freight Analysis Framework model.

Staff's initial estimates show that the ocean-going vessel equipment activity will increase over 200 percent by 2050.

For more detailed information:
http://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf and
http://www.arb.ca.gov/msei/msab_oct_workshop_10_07_2013_final.pdf

3. Locomotives

In 2014, staff developed a revised inventory for Class I line-haul locomotive activity in California. The rail lines reported line haul activity directly to ARB for the majority of the California network in calendar year 2011. Staff estimates the 2011 fuel consumption per unit of activity, based upon data regarding duty cycle, and the emissions per unit of fuel consumption based upon the tier distribution, and the emission factors defined by the U.S. EPA for each tier.

Activity growth, fuel efficiency increases, and projected turnover define emissions forecast for locomotives. Activity for premium, or intermodal locomotives is projected to grow at a rate equivalent to ocean-going vessels, whereas activity for all other locomotives is projected to grow in proportion to truck activity. Fuel efficiency improvements forecasts will follow Federal Railroad Association projections (one percent per year improvement). This results in forecasted locomotive fuel consumption more than doubling by 2050.

For more detailed information:
http://www.arb.ca.gov/msei/goods_movement_emission_inventory_line_haul_octworkshop_v3.pdf

4. Transport Refrigeration Units

Staff updated the inventory for this category in 2011 as part of the amendments to the regulation. Staff used new information obtained for population, activity, engine load, turnover practices, and emission factors to calculate the inventory. Staff estimates that the transport refrigeration units equipment population will increase by 58 percent by 2050.

For more detailed information: http://www.arb.ca.gov/regact/2011/tru2011/truisor.pdf

5. Commercial Harbor Craft

Since there is no one available data set that covers all commercial harbor craft operating in California, vessel population data were collected from various sources, including the U.S. Coast Guard documentation data, the California Department of Fish

and Game registration data, ARB's 2004 Harbor Craft Survey, and information from recent emission inventory estimates generated for the Port of Los Angeles. Staff estimated statewide emissions by multiplying number of engines in each engine category within each region by average emissions per engine. Staff used local air districts' fleet growth rates to project commercial harbor craft equipment will remain flat through 2050.

For more detailed information:
http://www.arb.ca.gov/regact/2008/fuelogv08/appdfuel.pdf and
http://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf

6. Cargo Handling, Industrial, and Airport Ground Support Equipment

In 2011, staff updated the cargo handling equipment inventory to accompany amendments to the regulation. Staff updated inventory inputs such as population, age distribution, and growth and activity information to calculate the new inventory. This update indicates projected cargo handling equipment population increasing 146 percent by 2050.

Based on current information, growth in the industrial sector mirrors growth in the construction industry. Data from the 1990-2009 California construction gross domestic product and 1970-1989 U.S. construction from the Bureau of Economic Analysis gross domestic product are the foundation for long-term growth rates for the construction sector. The long-term annual growth is over 1.5 percent per year and results in the population of industrial equipment growing almost 50 percent by 2050.

For airport ground support equipment U.S. airline fuel consumption from the Bureau of Transportation Statistics for 1977-2009 was used to project long-term growth in the sector. A growth rate of approximately two percent per year was estimated and results in ground support equipment population growing 37 percent by 2050.

For more detailed information:
http://www.arb.ca.gov/regact/2010/offroadlsi10/offroadappd.pdf
http://www.arb.ca.gov/regact/2011/cargo11/cargoappb.pdf and
http://www.arb.ca.gov/msei/msab_oct_workshop_10_07_2013_final.pdf

7. Aircraft

The growth surrogates for the aviation sector are a combination of growth surrogates provided by the local air districts (Bay Area, South Coast, and Ventura County) and statewide defaults developed by ARB for the rest of the State.

Staff uses Federal Aviation Administration flight operations data (landings and takeoffs) to determine aircraft growth at commercial airports while civil aircraft growth is linked to population. Since none of the existing growth profiles extended all the way out to 2050,

ARB estimates that value by straight-line extrapolation through the last ten years of available data for each profile.

8. GHG Emissions – All Sectors

ARB's GHG emission inventories are based on statewide fuel use, process, and activity data to estimate emissions. These estimates use the actual amount of all fuels used in the State, which accounts for over 85 percent of the GHG emissions within California.

Growth factors from 2012 to 2020 are sector-specific and derived from several sources, including:

- The energy demand models generated by California Energy Commission for their biennial Integrated Energy Policy Report.
- Business economic growth data developed for ARB's criteria pollutant forecast system.
- Population growth data from the California Department of Finance.
- Projections of vehicle miles traveled from ARB's on-road mobile source emissions model.

The 2012 to 2020 emissions projection in this document is consistent with the analysis conducted for the 2014 Update to the AB 32 Scoping Plan.

Staff developed the 2030 to 2050 emissions from the 2020 emissions levels using projections of future fuel use trends consistent with the assumptions and methods described in the previous sub-sections, including:

- ARB's EMFAC 2014 model for on-road truck emission sources.
- The Off-Road Emission Inventory Models for Ships, harbor craft, cargo handling equipment, rail, and transport refrigeration units.

Fuel use for aircraft-based freight relies on jet fuel forecasts for freight flights assuming 13 percent of flights were freight-related and included only intrastate flights. Growth estimates for fuel use come from various sources such as the Energy Information Agency's Annual Energy Outlook and studies showing the particular growth of freight as a function of increasing population and associated demand for goods.

Appendix B: Stakeholder Engagement

ARB staff has engaged with the following organizations and\or members of these organizations to discuss the Sustainable Freight Initiative:

Alameda County Transportation Commission
American Lung Association
American Trucking Association
Apostolic Faith Church
Association of American Railroads
Association of Bay Area Governments
Association of Monterey Bay Area Governments
Bay Area Air Quality Management District
Bay Conservation and Development Commission
BNSF Railway
Business for Social Responsibility
California Air Pollution Control Officers Association
California Association of Councils of Governments
California Association of Port Authorities
California Business Investment Services
California Clean Energy Committee
California Cleaner Freight Coalition
California Community Colleges
California Construction Trucking Association
California Cotton Ginners and Growers Association
California Department of Transportation
California Electric Transportation Coalition
California Energy Commission
California Transportation Commission
California Trucking Association
California Environmental Protection Agency
California Farm Bureau Federation
California Freight Advisory Committee
California Independent System Operator
California Kids Indoor Air Quality
California Labor & Workforce Development Agency
California Manufacturers & Technology Association
California Marine and Intermodal Transportation System Advisory Council
California Natural Gas Vehicle Coalition
California Office of Technology
California Public Utilities Commission
California Refuse Recycling Council
California Retailers Association
California Rice Commission
California State Association of Counties
California State Transportation Agency
California State University Long Beach
California Trade Business Network
California Transit Association
CalSTART
CalTrans Policy Advisory Committee
Center for Community Action and Environmental Justice
Center for Sustainable Energy
Center for Transportation and the Environment
Chemical Industry Council of California
Coalition for a Safe Environment
Coalition for America's Gateway and Trade Corridors
Coalition for Clean Air
Coalition for Responsible Transportation
Coalition on Sustainable Freight
Comite Civico de Valle
Commercial Real Estate Development Association
Communities for a Better Environment
Community Dreams
EarthJustice
East Yard Communities for Environmental Justice
End Oil/Communities for Clean Ports
Environmental Defense Fund
Environmental Health Coalition
FuturePorts

Gateway Cities Council of Governments
Greenaction for Environmental Health and Justice
Industrial Environmental Association
Inland Empire Economic Partnership
Inland Empire Transportation Coalition
International Council on Clean Transportation
International Council on Sustainable Infrastructure
International Warehouse Logistics Association
Jobs 1st Alliance
Kern Council of Governments
Logistics in Wallonia
Long Beach Area Chamber of Commerce
Los Angeles Area Chamber of Commerce
Los Angeles County Business Federation
Los Angeles County Economic Development Corporation
Los Angeles Department of Water and Power
Los Angeles World Airports
Los Angeles Unified School District
Metropolitan Transportation Commission
National Association of Industrial and Office Properties
National Center for Sustainable Transportation
National Freight Advisory Committee
Natural Resources Defense Council
Nisei Farmers League
Orange County Business Council
Pacific Gas & Electric
Pacific Merchant Shipping Association
Port of Hueneme
Port of Long Beach
Port of Los Angeles
Port of Oakland
Port of San Diego
Port of Stockton
Port of West Sacramento
Regional Asthma Management & Prevention
Riverside Chamber of Commerce
Sacramento Area Council of Governments
Sacramento Metro Chamber of Commerce
Sacramento Metropolitan Air Quality Management District
Sacramento Municipal Utility District
San Bernardino Association of Governments
San Diego Air Pollution Control District
San Diego Association of Governments
San Diego International Airport
San Francisco Bay Conservation and Development Commission
San Francisco International Airport
San Gabriel Valley Economic Partnership
San Joaquin Valley Air Pollution Control District
San Joaquin Council of Governments
Sierra Club
South Coast Air Quality Management District
Southern California Association of Governments
Southern California Edison
Southern California Gas Company
Southern California Environmental Health Sciences
Southern California Leadership Council
State Lands Commission
U.S. Department of Transportation
U.S. Environmental Protection Agency
Union of Concerned Scientists
Union Pacific Railroad
University of California Davis
University of California Los Angeles
University of Southern California
Valley Improvement Project
Valley Industry & Commerce Association
West Coast Collaborative
West Coast Lumber & Building Materials
Western Agricultural Processors Association
Western Growers Association
Western States Petroleum Association
Western Trucking Alliance
Western Wood Preservers Institute

Throughout the engagement process, ARB staff posed the following questions:

- What is a sustainable freight transport system?
- From the business perspective, what issues and concerns do you feel must be addressed if a sustainable freight transport system is to be achieved?
- What actions do you think government should take to encourage both the general business community and supply chain businesses, in particular, to help meet sustainable goals?
- What actions would you recommend as next steps to achieving a sustainable freight transport system?
- What hurdles exist within the existing freight transport system that if removed could provide better efficiency and a more sustainable system?
- What are areas of potential unintended consequences?
- Strategies to foster a sustainable freight transport system, in part, rely on emerging technologies to meet greenhouse gas and criteria emissions goals. What should both the public and private sector do to ensure needed technologies are advanced and are commercially available in time to meet milestone deadlines?
- What are the issues/concerns with emerging technologies?
- What other issues is the group facing that we should be aware of?
- How does the California freight transport system become more efficient so it can expand, be competitive, and reduce emissions?
- Do you have suggestions regarding potential funding and market mechanisms to support the transformation of freight-related infrastructure, vehicles, equipment and operations?
- What actions could ARB support with business communities where air quality is not the primary or identified benefit (e.g. fuel efficiency, waste diversion, rebates or tax credits)?
- What is the best way to engage additional stakeholders?

Staff participated in various tours of freight facilities and support operations including airports, cargo handling operations, container terminals, a rail facility, a warehouse, and a distribution center. ARB staff held and webcast a public forum on May 5, 2014, which included breakout sessions, tabletop discussion, and silent brainstorming. The purpose of the forum was to provide an opportunity for open, interactive discussions between staff and attendees. Staff also held five public workshops in September 2014 to seek public comment on a draft list of stakeholder concepts to achieve the objectives of a sustainable freight transport system.

Appendix C: Immediate ARB Actions

A. Enforcement

Enforcement efforts will prioritize freight facilities to achieve the full benefits of adopted regulations. In addition, we will enhance our enforcement capacity by shifting existing personnel toward these targeted efforts, as well as pursing opportunities for additional enforcement partnerships.

1. Expand Enforcement Presence

Existing ARB personnel are being reassigned to assist with these focused enforcement efforts at or near freight hubs. ARB's heavy-duty diesel inspection team provides training to other agencies that have entered into agreements to help enforce ARB's diesel regulations. These include: Port Authority (Port of Los Angeles), Bay Area Air Quality Management District (Port of Oakland), San Diego Air Pollution Control District (Mexican border), and U.S. EPA Region 9 (large out-of-state fleet investigations). In addition, staff continues to look for opportunities to leverage resources and expand enforcement throughout the State by utilizing agreements with local air districts and seaports.

2. Focus on Freight Hubs

In 2015, staff will maximize enforcement efforts at freight hubs by: conducting over 50 percent of heavy-duty diesel truck inspections at seaports, intermodal railyards, and distribution centers in or near disadvantaged communities, working with program staff to identify fleets and companies in each program that are least likely to be in compliance, and following up with field inspections and/or fleet investigations and appropriate enforcement actions, and working cooperatively with other State and local agencies to minimize the impacts of State-funded construction projects on disadvantaged communities.

3. Increase Efficiency of Statewide Truck and Bus Rule Enforcement

Enforcing the Statewide Truck and Bus Rule is a major challenge because of the large number of trucks, truckers, fleets, small fleets, and brokers subject to the Rule. ARB staff's proposed strategy going forward will be to focus on sizable fleets and brokers first, and to use those enforcement efforts to help encourage small fleets to come into compliance through a combination of broker/contractor compliance and ARB compliance assistance. Highlights include: improved targeting of noncompliant fleets for audit through data mining; prioritizing investigations of companies that submit suspect documentation in an effort to claim "good faith effort," economic hardship, or to otherwise present the fleet as compliant; streamlined citations processing through utilization of new information technology; additional focus on large non-California

registered trucking fleets through partnership with U.S. EPA Region 9; and providing assistance to smaller fleets to achieve compliance.

4. Leverage Technology

Staff is working on a pilot program to develop and deploy a remote imaging/sensing program in 2015 for heavy-duty trucks with the potential for expansion later on. Portable remote imaging (capturing truck data remotely through transponders, cameras, etc.) and sensing (characterizing NOx and diesel PM emissions) can be used to identify noncompliant or mal-performing trucks and target them for compliance assistance, enforcement, and/or engine and after-treatment repair. Such a program could augment or potentially replace current roadside inspections, while providing additional information critical to enforcement and public health protection.

B. Incentives

ARB-funded incentive programs, many administered by the local air districts will also achieve significant new reductions in 2015 through the introduction of cleaner freight vehicles and equipment. ARB's primary freight-related incentive programs include the Proposition 1B: Goods Movement Emission Reduction Program, the Carl Moyer Program, and the Air Quality Improvement Program.

The Proposition 1B: Goods Movement Emission Reduction Program provides funds to reduce freight emission in the four priority trade corridors (Los Angeles/Inland Empire, Central Valley, Bay Area, and San Diego/Boarder). Proposition 1B funds supplement regulatory actions by upgrading to cleaner technology ahead of compliance deadlines or supporting cleaner than required equipment. Grants are awarded to local agencies (like air districts and seaports) who in turn provide incentives to equipment owners to upgrade trucks, locomotives, shore side electrical power for ships, cargo handling equipment and commercial harbor craft. Freight equipment upgrades funded by Proposition 1B include trucks, locomotives, shore side electrical power for ships, and harbor craft.

Freight equipment upgrades funded by Proposition 1B include large-fleet trucks and locomotives. Projects that will be newly in operation in 2015 include an estimated 855 to 1,060 older trucks, which will be scrapped and replaced with the same number of cleaner trucks, and six locomotives with cleaner engines will be operating in Southern California. The projects are estimated to achieve emission reductions of 31 to 36 tons of PM2.5 and 6,470 to 8,060 tons of NOx over the life of the grant contracts. The reductions by trade corridor are shown in Table 10.

The Carl Moyer Program provides funding opportunities for truck fleets with three or fewer vehicles to replace or retrofit their older heavy-duty diesel vehicles. In 2015, staff estimates that about 230 new engines will be funded; benefits related to these engines are approximately 13 tons of PM2.5, 29 tons of reactive organic gases, and 732 tons of NOx over the lifetime of the vehicles.

TABLE 10: Emissions Reductions by Trade Corridor

Trade Corridor	PM2.5 (tons)		NOx (tons)		# Trucks		#Locom-otives
	Low	High	Low	High	Low	High	
Los Angeles/Inland Empire	24	27	3,960	4,910	515	640	6
Central Valley	4	5	1,340	1,680	180	225	-
Bay Area	2	3	780	980	105	130	-
San Diego/Border	1	1	390	490	55	65	-

The Air Quality Improvement Program's Hybrid and Zero Emission Truck and Bus Voucher Incentive Project is designed to offset the incremental additional cost of eligible hybrid and battery-electric medium- and heavy-duty vehicles through a purchase voucher. The Air Quality Improvement Program is also the source for low carbon transportation pilot and demonstration projects that are being planned with a particular emphasis on bridging the current technology gap to further California's trajectory towards a sustainable freight transport system. In 2015, staff estimates that about 420 vehicles will be funded. Benefits beyond those otherwise achieved with conventional 2015 engines, are approximately 11 tons of PM2.5, 4 tons of reactive organic gases, and 37 tons of NOx, over the lifetime of the vehicles (15 years).

Appendix D: Near-Term ARB Actions

A. Cleaner Combustion

1. Trucks Action 1

Action Description: Develop and propose strategies to ensure durability and in-use performance. Such strategies may include:

- Develop enhanced truck inspection programs by reducing exhaust opacity limits for diesel PM filter-equipped trucks.
- Develop and implement new certification and warranty requirements and maintenance practices to better ensure vehicle reliability and low in-use emissions in new trucks certified to existing heavy-duty engine NOx standard.
- Revise existing emission warranty information reporting regulations to strengthen current program and enabling implementing corrective action based on high warranty repair rates.
- Seek clarification on the State's authority to enter and inspect heavy-duty warranty repair facilities to ensure proper emission warranty repairs are being conducted.

ARB Action: 2015-2017

ARB Implementation: 2017+

Type of Action: ARB Regulation; Potential State Legislative Action

Overview: Staff is proposing to take several actions to help ensure durability and in-use performance of heavy-duty trucks. These strategies will be focused in four areas: reducing opacity levels to require repair of damaged PM filters, developing documentation and training describing best preventive maintenance practices for heavy-duty engines and vehicles, lengthening warranty periods to cover a longer portion of the useful life of heavy-duty trucks, and holding manufacturers accountable for high warranty claims.

a. Reduce Opacity Limits for Diesel PM Filter Equipped Vehicles

Vehicles with a gross vehicle weight rating above 14,000 pounds having a properly functioning diesel particulate filter routinely measure at opacity levels at or near zero percent, while vehicles with damaged diesel particulate filters typically measure at opacities many times higher. Damaged diesel particulate filters are likely the result of internal engine problems, and lead to higher in-use emissions. Research suggests that a large amount of diesel PM emissions, about 70 percent, emitted from the on-road heavy-duty vehicle sector are from a small portion of the fleet having damaged diesel particulate filters.

The current allowable opacity limit of 40 percent for heavy-duty vehicles is no longer sufficient to identify vehicles having a damaged diesel particulate filter that is in need of repair. A significantly lower opacity limit will help ensure that the emission benefits from 2007 and subsequent model year heavy-duty diesel engine standards and the Truck and Bus Regulation are obtained by promoting improved engine maintenance and detection of malfunctioning or damaged diesel particulate filters. A lower opacity limit will require owners of these high-emitting vehicles to repair and replace damaged engine and aftertreatment parts resulting in better assurance of expected diesel PM emission benefits. It is anticipated that the Board will consider a proposal to lower the opacity in March 2016, with implementation in 2017.

b. Best Practices for Preventive Maintenance

ARB has established a working group, comprised of staff and outside stakeholders, including the California Trucking Association, the Truck and Engine Manufacturers Association, the Manufacturers of Emission Control Association, and retrofit devices installers, to define best practices for preventive maintenance of heavy-duty vehicles. At this time, this working group is in the process of conducting surveys of vehicle owners. Although an exact timeframe is not yet determined, these best practices will be available to vehicle owners through outreach, training, and other media avenues. This information and training would help inform vehicle owners on the importance of preventative maintenance in order to better assure their emission performance level, while reducing avoidable repair costs. This will reduce the incidence of engine issues, associated vehicle downtime, and impacts to diesel particulate filters.

c. Expanding Emissions Warranty Requirements

The current on-road heavy-duty manufacturer's warranty coverage period for emission-related parts is five years/100,000 miles/3,000 hours, whichever occurs first. Because heavy-duty trucks can operate for a million miles or more, and can operate for 20 years or longer, the current warranty period covers a very small fraction of total vehicle operation. Expanding warranty protections for a longer portion of a heavy-duty truck's useful life would provide additional protections to truck owners, and help ensure emissions control over the full life of the vehicle. Additional actions may provide access to heavy-duty vehicle warranty and repair records at repair facilities to evaluate manufacturer compliance with warranty reporting requirements.

d. Emission Warranty Information Reporting

ARB will revise the existing Emission Warranty Information Reporting regulations to enable corrective actions based on high warranty claims. By holding manufacturers accountable for high warranty claims on emission control equipment (for example, parts that exceed a ten percent or higher claim rate), a greater degree of assurance of heavy-duty engine durability would be achieved, along with the expected diesel PM and NOx emission benefits, while reducing the owners' burdens resulting from extensive vehicle

repair costs. The Board will consider the Emission Warranty Information Reporting regulatory proposal in late 2016, with an implementation in 2018.

2. Trucks Action 2

Action Description: Develop and propose increasing flexibility for manufacturers to certify advanced innovative truck engine and vehicle systems in heavy-duty applications. Enables accelerated introduction of new technologies to market.

ARB Action: 2015

ARB Implementation: 2016

Type of Action: ARB Regulation

Overview: Staff is currently developing a proposed Innovative Technology Regulation, which is intended to provide defined, near-term ARB certification and aftermarket part approval flexibility to help facilitate market launch of the next generation of medium- and heavy-duty engine and vehicle technologies that California needs to meet its long-term air quality and climate goals. ARB's existing certification and on-board diagnostics requirements provide a critical and effective mechanism for ensuring a vehicle's expected emission benefits are achieved. However, ARB's new engine and vehicle approval paradigm, geared towards higher volume, traditional technologies, may deter some manufacturers from developing promising new technologies that are uncertain to achieve market acceptance. Similarly, ARB's aftermarket part approval protocol also poses challenges for some advanced technologies, especially those that reduce engine operation, such as hybrid drivelines.

Staff is developing the Innovative Technology Regulation to address these issues by providing targeted flexibility at market launch and early technology deployment stages, while requiring full ARB certification approval once the technology achieves a market foothold. Specific certification and on-board diagnostics flexibility provisions should provide manufacturers with a defined, predictable, and practical ARB approval pathway, while preserving ARB's overarching objective to ensure expected emission benefits are achieved in-use. Targeted technologies include hybrid drivelines, with an emphasis on those achieving significant zero emission operation, and new technologies that can achieve lower NOx emissions from heavy-duty engines.

3. Trucks Action 3

Action Description: Develop and propose new, stringent California Phase 2 GHG requirements to reduce emissions from trucks and trailers, and provide fuel savings.

ARB Action: 2016-2017

ARB Implementation: 2018+

Type of Action: ARB Regulation

Overview: In 2011, U.S. EPA and National Highway Traffic Safety Administration adopted the first national standards for GHG emissions from heavy-duty trucks, called the Phase 1 standards. These standards, apply to all trucks over 8,500 pounds gross vehicle weight, including vocational trucks, Class 2b/3 vans and pickups, Class 7 and 8 tractors, took effect with model year 2014 and increased in stringency through model year 2017. Currently, the U.S. EPA and National Highway Traffic Safety Administration are working on a next generation of GHG standards to build on Phase 1, called Phase 2.

We expect Phase 2 to encourage the use of technologies such as aerodynamic features on trucks and tractors, waste heat recovery, hybridization, and engine and transmission improvements. An effective Phase 2 program, combined with the existing Phase 1 standards, could reduce heavy-duty truck GHG emissions by approximately 40 percent from a 2010 baseline.

The U.S. EPA and National Highway Traffic Safety Administration are expected to propose the Phase 2 standards in May of 2015 and to finalize them in spring of 2016. Staff anticipates bringing a Phase 2 proposal to the Board in late 2016 or early 2017. California's Phase 2 proposal will likely harmonize with parts of the federal Phase 2 proposal, but – if necessary – may also include California-only measures such as more stringent GHG standards for vehicles that generally do not cross state lines, aerodynamic controls for trailer types not covered in Phase 2, etc. California-only action could lead the way for later nationwide progress, as has occurred with California's Tractor Trailer GHG Regulation.

4. Trucks Action 4

Action Description: Petition U.S. EPA to develop lower NOx standards for new heavy-duty truck engines for rulemaking in 2018.

ARB Action: 2015

ARB Implementation: --

Type of Action: ARB Petition, U.S. EPA Regulation

Overview: To further reduce NOx emissions from new engines, California has established optional heavy-duty low-NOx engine standards that can reduce certified NOx emissions by up to an additional 90 percent relative to 2010 model year levels. Both the State and the local air districts are investing in bringing these technologies to the marketplace on an expedited schedule, and ARB staff expect new natural gas engines that meet one of the optional low NOx standards to become commercially available as early as 2015.

Despite this progress, significant additional reductions from heavy-duty trucks are needed to meet ambient air quality standards and to further reduce the localized risk impacts associated with exposure to toxic diesel PM. Adding to the challenge, not all on-road heavy-duty engine components are as high-quality or as durable as once expected, resulting in elevated levels of in-use emissions from some trucks. In addition, on-road diesel engines appear to be generating higher than expected in-use NOx emissions during low temperature, low load operations that characterize some vocational driving cycles such as those seen in many freight applications (e.g., local delivery and drayage).

To address these issues, and provide substantial additional emission reductions needed from heavy-duty trucks operating in California, ARB has identified a suite of strategies, including petitioning the U.S. EPA to develop lower NOx standards for new heavy-duty truck engines nationwide. A national standard would benefit California, as a majority of heavy-duty trucks operating in California are purchased elsewhere and may be operated as part of a nationwide fleet.

5. Trucks Action 5 (If U.S. EPA does not complete Trucks Action 4)

Action Description: Develop and propose California specific standards for new heavy-duty truck engines to provide benefits above national standards, with potential incentive support.

ARB Action: 2018

ARB Implementation: 2023+

Type of Action: ARB Regulation and Incentive

Overview: As described in Trucks Action 4, due to the impact of the national market on California's heavy-duty truck fleet, developing lower NOx standards for new heavy-duty truck engines at the national level would be best. However, if the U.S. EPA is unable to proceed, ARB will develop and propose California specific standards for new heavy-duty truck engines to provide benefits above national standards, with potential incentive support.

6. Ocean-Going Vessels Action 1

Action Description: Advocate with international partners for new International Maritime Organization Tier 4 NOx/PM standards and efficiency targets for existing vessels in Ship Energy Efficiency Management Plans for International Maritime Organization Action 2018-2020.

ARB Action: 2015

ARB Implementation: --

Type of Action: ARB Advocacy

Overview: Under this Action, ARB would work with the U.S. EPA and international partners to urge the International Maritime Organization to adopt more stringent emission standards for new ocean-going vessels. Specifically, ARB would advocate for a diesel PM and Tier 4 NOx/PM 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 International Maritime Organization 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 International Maritime Organization 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.

7. Ocean-Going Vessels Action 2

Action Description: Define criteria for "Super Low Emission Efficient Ship" and achieve early implementation of clean technologies (liquefied natural gas, Tier 3, or better) for newer vessels via existing and enhanced seaport incentive programs (e.g. Green Ship, Ship Index, etc.).

ARB Action: 2016

ARB Implementation: 2018

Type of Action: Incentive

Overview: 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 Action, criteria for a "Super- Low Emission Efficient Ship" would be developed targeting GHG, sulfur oxides, NOx, and diesel PM emissions. ARB staff would work with California seaports and other stakeholders to develop the criteria and to identify the best way to incentivize introduction of Super-Efficient Low Emission Ships into the existing fleet of vessels that visit California seaports. This will 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.

8. Ocean-Going Vessels Action 3

Action Description: Develop and propose amendments to the At-Berth Regulation to include other vessel fleets and types to achieve additional emission reductions.

ARB Action: 2016

ARB Implementation: 2020+

Type of Action: ARB Regulation

Overview: In December 2007, ARB approved the "Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port" Regulation (At-Berth Regulation) to reduce emissions from diesel auxiliary engines on container ships, passenger ships, and refrigerated-cargo ships while at berth at a California seaport. There are two companies working on portable systems to reduce emissions from vessels at-berth that may qualify as an alternative control technique under the Regulation. If one or both of these systems successfully demonstrate that they can provide durable performance and operational feasibility, they may offer additional compliance flexibility in the future to vessel fleet operators under the existing Regulation. If the systems become commercially available and are cost-effective, the technology could help support an ARB staff proposal to expand the scope of the At Berth Regulation to include other vessel fleets and types.

9. Locomotives Action 1

Action Description: Petition U.S. EPA to develop a Tier 5 national locomotive emissions standard for criteria pollutants and GHG (based on aftertreatment, liquefied natural gas, and/or zero emission track miles) for rulemaking in 2018 and introduction in 2025 and beyond.

ARB Action: 2015

ARB Implementation: --

Type of Action: ARB Petition, U.S. EPA Regulation

Overview: In 2015, ARB could petition U.S. EPA to begin the process of developing new Tier 5 national locomotive emissions standards for criteria pollutants and GHG by 2018. ARB staff estimates that the U.S. EPA could develop the new locomotive emission regulations as early as 2018 and require introduction of new Tier 5 locomotives by as early as 2025. Based on the historic rate of locomotive fleet turnover the new Tier 5 locomotive emissions regulations could be fully implemented nationally by 2055.

The proposed U.S. EPA locomotive regulations could further reduce emission from existing Tier 4 locomotive baseline over 70 percent with the use of proven locomotive

aftertreatment systems, renewable natural gas, or other alternative fuels. U.S. EPA could also include provisions with incentives for locomotive manufacturers and railroads to develop and operate locomotives with zero emission track miles for specific nonattainment areas in the country (e.g., South Coast Air Basin, Kansas City, Dallas Fort Worth, Chicago, New York, and Boston) that could provide additional criteria and GHG reductions.

10. Locomotives Action 2

Action Description: In 2015, ARB could petition U.S. EPA to amend its regulations that define a preempted "new" locomotive engine for rulemaking in 2017. The desired outcome is to limit federal preemption to the initial useful life (typically seven to ten years) of the locomotive engine. It is important that U.S. EPA maintain its existing requirements for remanufactured engines to provide national benefits. Redefining a "new" engine would allow California the option to regulate the universe of non-new locomotives operating in the State, beyond U.S. EPA's current remanufacture requirements, to provide NOx reductions to meet federal air quality standards and to cut the health risk from interstate line-haul locomotives.

ARB Action: 2015

ARB Implementation: --

Type of Action: ARB Petition, U.S. EPA Regulatory Amendment

Overview: Petition U.S. EPA to amend its locomotive emissions regulations. The petition would request that U.S. EPA amend federal emissions regulations to limit the preemption from state regulation to new or "freshly" manufactured locomotives, or until the end of a locomotive's first useful life (i.e., typically about seven to ten years). ARB estimates U.S. EPA would need about two years to amend the national locomotive regulations, or to complete the revisions by 2017.

The proposed U.S. EPA regulatory amendment could expand ARB's authority to regulate non-new interstate, regional, and switch (yard) locomotives operating in California.

11. Locomotives Action 3—contingent on Locomotives Action 2

Action Description: Develop and propose regulation applicable to all non-new locomotives to maximize the use of Tier 4 engines, liquefied natural gas, or better line-haul, medium horsepower, and switch locomotives (provide credit for zero emission track miles and zero emission locomotives).

ARB Action: 2018

ARB Implementation: 2020-2030

Type of Action: ARB Regulation and Incentive

Overview: With a U.S. EPA regulatory amendment to limit federal preemption to new locomotives by 2017, ARB staff could develop a California regulation to require non-new locomotives to meet Tier 4 or better emission levels between 2020 and 2030. This regulation could represent up to an 85 percent reduction or more in non-new locomotive NOx and diesel PM emissions statewide, and could be designed to provide emission credits for near-zero and zero emission advanced technology locomotives similar to the 1998 Locomotive NOx Fleet Average Agreement. The latter could potentially provide significant GHG reductions.

12. All sectors/freight hubs

Action Description: Collect data (such as facility location, equipment, activity, and proximity to sensitive receptors) from seaports, airports, railyards, warehouse and distribution centers, truck stops, etc. to identify and support proposal of facility-based approach and/or sector-specific actions to reduce emissions and health risk, as well as efficiency improvements.

ARB Action: 2015

ARB Implementation: 2015-2016

Type of Action: Data Collection

Overview: Implement a program to request data on facility location, equipment type and activity levels, and proximity to residences and other sensitive receptors. This information would support a future facility emissions cap, source sector-specific rulemakings, or other approaches to further reduce emissions and increase efficiency.

B. Zero Emission Requirements

1. Delivery vans/small trucks

Action Description: Develop proposal to accelerate penetration of zero emission trucks in last mile freight delivery applications, with potential incentive support.

ARB Action: 2017

ARB Implementation: 2020

Type of Action: ARB Regulation and Incentive

Overview: Delivery vans and trucks used in urban areas to deliver freight from warehouses and distribution centers to its final point of sale or use (last mile delivery) typically operate at low average driving speeds with frequent stop-and-go drive cycles

that are well suited for vehicles able to provide zero emission operation. Zero emission vehicles used in last mile delivery applications are nearing early commercialization, as they are currently being piloted in a number of current demonstration and early deployment programs. Early demonstrations have already shown that fuel and maintenance cost savings can offset the higher vehicle upfront costs with efficiencies that can be 50 percent higher than conventional vehicles.[25]

Regulations, along with financial and other incentives, are a key step in the overall strategy to accelerate the broad deployment of zero emission technologies in the heavy-duty sector. Incentives can motivate the early commercialization of zero emission vehicles and can offset some of the initial incremental capital costs, thereby expanding the market share of zero emission vehicles. Coordinated regulatory and incentive funding policies also establish long-term drivers for zero emission vehicle deployments, providing manufacturers and fleet owners with more certainty of the existing and future market potential. An expanding market will foster lower capital and operating costs which will support additional improvements in technology and will accelerate the market potential for other heavy-duty applications.

2. Large Spark-Ignition Equipment (forklifts, etc)

Action Description: Develop proposal to establish purchase requirements to support broad scale deployment of zero emissions equipment.

ARB Action: 2016-2018

ARB Implementation: 2020

Type of Action: ARB Regulation and Incentive

Overview: Off-road large spark-ignition engines of 25 horsepower (19 kilowatt) or greater are most commonly found in forklifts, scrubbers and sweepers, specialty vehicles, portable generators, large turf care equipment, irrigation pumps, welders, air compressors, airport ground support equipment, and a wide array of other agricultural, construction and general industrial equipment and fueled by gasoline, propane, or compressed natural gas. The Large Spark-Ignition Fleet Regulation was originally adopted by ARB in 2006 and later amended in 2010 as part of a comprehensive rulemaking that also established new engine performance requirements and verification procedures for large spark-ignition engines and emission control equipment. The Large Spark-Ignition Fleet Regulation, in particular, established emission level performance requirements for in-use medium (4-25 pieces of equipment) and large (26+ pieces of equipment) spark-ignition fleets that became more stringent over time for forklifts, sweepers/scrubbers, industrial tugs (tow tractors), and ground support equipment. The

[25] Dong-Yeon Lee, Valerie M. Thomas, and Marilyn A. Brown, "Electric Urban Delivery Trucks: Energy Use, Greenhouse Gas Emissions, and Cost-Effectiveness," *Environ. Sci. Technol*, Vol. 47, 2013, pp. 8022−8030.

final performance milestone of January 1, 2013, has come to pass and the final fleet recordkeeping requirements sunset on June 30, 2016.

Zero emission technologies are commercially available, already in use in some of these equipment types, especially forklifts, and ground support equipment, while many other large spark-ignition equipment types operate in duty cycles where zero emission technologies may be viable. A combination of incentives and regulatory approaches will be proposed to expand the deployment of zero emission technologies in the large-spark ignition sector. The first step in this process will begin in early 2016, where staff will introduce a proposal to amend the Large Spark-Ignition Fleet Regulation to align with the reporting and labeling requirements of the existing In-Use Off-Road Diesel Vehicle Regulation. Through reporting of equipment used in large-spark ignition applications, staff will gain a greater understanding of both compliance with the current Large Spark-Ignition Fleet Regulation, as well as better understand applications where zero emission technologies are being used or could potentially be used. The second step in this process will be to evaluate and implement approaches to expand the deployment of zero emission technology into large spark-ignition fleet applications. These efforts will help zero emission technologies mature for potential application to other off-road sectors in the future.

3. Transit Buses

Action Description: Develop proposal to deploy commercially available zero emission buses in transit, and other applications, beginning with incentives for pilot programs and expanding purchase requirements as appropriate to further support market development of zero emission technologies in the heavy-duty sector, with potential incentive support.

ARB Action: 2016

ARB Implementation: 2018

Type of Action: ARB Regulation and Incentive

Overview: Zero emission buses are commercially available today, already being purchased in small numbers in transit and shuttle fleets across the State, and capable of serving most passenger routes. In addition, financial incentives are available at the State and Federal level to support zero emission vehicle purchases. Importantly, zero emission buses represent the first opportunity to achieve significant zero emission vehicle volumes in the heavy-duty sector.

Staff's upcoming Advanced Clean Transit proposal is designed to promote economies of scale in zero emission technologies in the heavy-duty sector by accelerating an initial deployment of zero emission technologies in the transit sector.

4. Airport Shuttles

Action Description: Develop proposal to deploy zero emission airport shuttles to further support market development of zero emission technologies in the heavy-duty sector, with potential incentive support.

ARB Action: 2017-2018

ARB Implementation: 2020

Type of Action: ARB Regulation and Incentive

Overview: Airport passenger shuttles that frequent the airport (including rental car, hotel, and parking lot shuttles) typically operate fixed short routes coupled with stop-and-go operation and low average speeds. The current successes from zero emission transit buses can be translated to zero emission airport shuttle buses because of the significant similarities. A near-term strategy to encourage airports and other fleets to begin purchasing zero emission shuttle buses (either by regulation, memorandum of understanding, incentives, or a combination of these) would accelerate the use of these buses into the marketplace, with the potential to result in entire zero emission shuttle bus fleets in the future. Like transit buses, the inclusion of zero emission airport shuttles in the near-term strategy will serve as a stepping-stone to encourage broader deployment of zero emission technologies in the on-road sector.

5. Transport Refrigeration Units

Action Description: Develop and propose a regulatory requirement to prohibit the use of fossil-fueled transport refrigeration units for cold storage in phases, with incentive support for infrastructure.

ARB Action: 2016

ARB Implementation: 2020+

Type of Action: ARB Regulation and Incentive

Overview: Transport refrigeration units are refrigeration systems that are powered by integral internal combustion engines designed to control the environment of temperature-sensitive products that are transported in trucks, trailers, railcars and shipping containers. They may be capable of cooling or heating. Products include, but are not limited to food, pharmaceuticals, plants, medicines, blood, chemicals, photographic film, art work, satellites, and explosives.

This regulation would address several transport refrigeration unit uses that result in excessive criteria pollutant and GHG emissions, such as:

- Use of transport refrigeration unit-equipped trailers at distribution centers and retail delivery points (e.g. grocery stores) for cold storage during the weeks before holidays and major events (e.g. Super Bowl) when the facility runs out of cold storage space.
- Operation of transport refrigeration units in distribution centers yards and outside the distribution centers gates while waiting for an available loading dock space, for manpower to be available to unload goods, or for dispatch or driver pick-up. Such operations can go on for several days (e.g. load up on Friday for dispatch on Monday).

The initial concepts of the proposed regulation would limit the amount of time that a transport refrigeration system powered by a fossil-fueled internal combustion engine can operate at any facility. The time limit decreases over time.

- Phase I: 24 hours, effective January 1, 2020
- Phase II: 1 hours, effective January 1, 2022
- Phase III: 5 minutes, effective January 1, 2025

Use of zero emission all-electric plug-in transport refrigeration systems, hydrogen fuel cell transport refrigeration, and cryogenic transport refrigeration would be encouraged, as well as adequately-sized cold storage facilities, and more efficient appointment scheduling.

6. Expand/Enhance Existing Incentive Programs

Action Description: Develop modifications to the Carl Moyer, Proposition 1B, Air Quality Improvement, Low Carbon Transportation programs to increase the emphasis on and support for zero and near-zero equipment used in freight operations, including introduction of truck engines certified to optional low-NOx standards.

1. Support Carl Moyer Program statutory revisions to enable local air districts to provide funding for advanced technologies and to recognize GHG benefits.
2. Propose changes to Proposition 1B to offer higher funding for zero and near-zero equipment.
3. Propose Air Quality Improvement Program/Low Carbon Transportation Funding Plan to accelerate and expand adoption of certified zero and near-zero emissions vehicles and equipment.
4. Coordinate with the California Air Pollution Control Officers Association on investment of local funding towards higher priority freight projects.
5. Include maintenance, best practices, etc. requirements beyond manufacturers' recommendations in future incentive contracts for truck operators of plug-in hybrids, hybrids, transformational technologies, etc.

ARB Action: 2015-2016

ARB Implementation: 2016-2020

Type of Action: State Legislation and Incentive

Overview: 2015 marks the introduction of three new freight related ARB incentive programs funded by proceeds from the Cap-and-Trade Program to reduce greenhouse gas emissions. The Low Carbon Transportation program projects include Zero Emission Drayage Trucks and Multi-Source Facility demonstration projects and the Zero Emission Truck and Bus Pilot Projects in Disadvantaged Communities. Implementation of the Low Carbon Transportation Program is within ARB's Air Quality Improvement Program. The emphasis of these projects in on bridging the current technology gap to accelerate and expand adoption of zero and near-zero emissions vehicles and equipment. The Board will have an opportunity to adjust and update the Air Quality Improvement Program Funding Plan, which includes these low carbon transportation projects in summer 2015.

In addition to these new projects, staff is exploring opportunities to further transition ARB's existing incentive portfolio towards one that better aligns with a zero and near-zero future. Achieving a transition from current technologies to zero and near-zero technologies will be challenging, and early investments through incentive programs will be critical to help bridge the increased incremental costs of advanced technologies by:

- Increasing production volumes to drive down manufacturing costs.
- Demonstrating projects to foster consumer acceptance of new technologies and highlight their potential to lower operating and maintenance costs.
- Sending a strong signal to manufacturers and private investors that these technologies will be supported.

The Air Quality Improvement Program Hybrid and Zero Emission Truck and Bus Voucher Incentive Project currently provide funds for hybrid and zero emission equipment. The Carl Moyer Program and Proposition 1B Program have generally focused funds on turning over the State's legacy fleet to cleaner, commercially available technologies ahead of regulatory deadlines. However, each of these programs has technology advancement elements, which are under analysis for further opportunities to target a greater range of zero and near-zero projects. Below is a brief description of each incentive measure and anticipated emission reductions from California's investments.

a. Support Carl Moyer Program Statutory Revisions to More Effectively Fund Advanced Technology Projects.

The Carl Moyer Program provides funds to reduce air pollution throughout California. Grants are awarded to local air districts, which in turn, provide incentives to equipment owners to deploy cleaner on-road, off-road, marine, locomotive, and agricultural equipment, as well as to retire older, higher polluting light-duty vehicles. The Carl Moyer Program achieves surplus emission reductions to complement regulatory

requirements. NOx and diesel PM emission reductions achieved by the Carl Moyer Program are creditable toward the State Implementation Plan.

In a December 2014 report to the Board, staff identified areas of the Carl Moyer Program that could be improved and expanded to better accomplish local and State air quality and climate objectives. These improvements, which require legislative changes to current statutes governing the Carl Moyer Program, would position the Program to better incentive the deployment of advanced technologies and newly recognize potential GHG benefits. These include the ability for the Carl Moyer Program to leverage funds from separate programs that accomplish multiple goals, including programs that fund GHG reductions, as well as the ability of the Carl Moyer Program to fund necessary supporting infrastructure projects. The changes would also include the ability for the Carl Moyer Program to recognize ancillary benefits of funded projects, including GHG emission benefits, reducing public exposure, and providing projects in environmental justice communities. If the statute is modified as described above in 2015, the Carl Moyer Guidelines would then be revised accordingly, with the resulting changes implemented in the 2017-2018 timeframe.

b. Propose changes to Proposition 1B to Offer Higher Funding for Zero and Near-Zero Equipment

The Proposition 1B: Goods Movement Program provides funds to reduce air pollution throughout California's trade corridors. Grants are awarded to local agencies, which in turn, provide incentives to equipment owners to replace higher polluting equipment. The Program achieves early or extra emission reductions to complement regulatory requirements.

Staff will be proposing updated Program Guidelines to the Board later in 2015. The Guideline updates, which require Board approval, would position the Program to incentivize zero and near-zero equipment by potentially increasing grant amounts. Staff is planning to include funding recommendations for freight technologies such as heavy-duty trucks, locomotives, cargo handling equipment, and harbor craft.

c. Provide Funding for Zero and Near-Zero Emissions Projects through Low Carbon Transportation and Air Quality Improvement Programs

The Funding Plan for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments is designed to support development and commercialization of advanced technologies that are necessary to meet California's long-term air quality and climate goals. Air Quality Improvement Program provides about $25 million each year primarily from smog impact fees. The Governor's January proposed 2015-16 budget includes $200 million for Low Carbon Transportation Greenhouse Gas Reduction Fund. These funds continue the Administration's commitment to develop and deploy advanced technology vehicles into the transportation sector, including a strong focus on freight activities.

Staff is currently developing the Funding Plan for fiscal year 2015-16, which will include project-specific funding allocations to support technology advancement in a comprehensive range of on-road vehicle and off-road equipment sources. The Funding Plan will also describe ARB's longer-term vision for the role of incentives to support technology advancement and transformation of the California fleet, with a focus on providing benefits to disadvantaged communities. Scheduled for approval at the June 2015 Board meeting, the plan will identify funding for ongoing deployment projects such as the Clean Vehicle Rebate Project and the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project, as well as pilot projects that provide benefits to disadvantaged communities. Staff is also planning to include funding for pre-commercial demonstrations of heavy-duty advanced freight technologies such as locomotive battery tenders, off-road freight equipment, advanced truck engines and power locomotives, and connected truck systems, all of which will support continued investments to reduce freight emissions and support a more sustainable freight transport system.

d. Coordinate with the California Air Pollution Control Officers Association to Fund Priority Freight Projects

While local air districts have traditionally funded many successful clean freight projects, ARB will work with the districts and the California Air Pollution Control Officers Association to identify opportunities to increase incentive funding for freight-related projects. While ARB does not directly control which projects selected by the districts when they are investing local funds, ARB can work with the California Air Pollution Control Officers Association to encourage that a greater percentage of Carl Moyer Program incentives and local funds, such as those under AB 923, are directed toward freight.

ARB can also ensure that a greater emphasis is on freight-related projects when establishing priorities for multi-district funding. For example, Carl Moyer Program funding for freight-related projects was approximately $14.7 million for the most recent year in which all funds have been expended (fiscal year 2013-14). This total represents almost 21 percent of the year's Moyer funds and resulted in the reduction of roughly 170 tons of ozone precursor (reactive organic gases and NOx) emissions and 3 tons of particulate matter. Increasing funding for freight-related projects by 20 percent (i.e., to a total of 25 percent of the annual funding) could provide an additional 34 tons of ozone precursor emission reductions and over half a ton of particulate matter per year from this sector. Because the Carl Moyer Program funding is limited, funding for other types of vehicle and equipment projects would decrease.

e. Develop Incentive Contracts for Truck Operators To Maintain Vehicles Beyond Manufacturers' Recommendations

ARB will consider incorporating requirements for fleets to undertake regular and preventive maintenance on all trucks funded by ARB incentive programs including the Carl Moyer Program, the Proposition 1B Program, and Air Quality Improvement

Program/Low-Carbon Transportation funding programs. By providing fleets basic, low cost, additional preventive maintenance procedures that they should take in addition to requiring them to follow suggested manufacturer maintenance procedures will help better ensure proper vehicle and after-treatment function, this will reduce the incidence of engine issues, associated vehicle downtime, and impacts to diesel particulate filters.