MOBILE SOURCE STRATEGY

APPENDIX A: ECONOMIC IMPACT ANALYSIS

Mobile Source Strategy
Economic Impact Analysis
May 2016

I. Introduction

The economic analysis of the Mobile Source Strategy includes the statewide costs, savings and emission reduction benefits of all proposed measures under State and federal jurisdiction, including passenger vehicles, heavy-duty trucks, locomotives, commercial ships, goods movement, construction and mining equipment, engine exhaust and evaporation, and fuels. The combination of measures are designed to build upon current successful efforts to meet critical air quality and climate goals including attaining federal health-based air quality standards for ozone in 2023 and 2031, fine particulate matter (PM2.5) standards in the next decade, achieving greenhouse gas (GHG) emission reduction targets of 40 percent below 1990 levels by 2030, reducing petroleum use by up to 50 percent by 2030, minimizing health risk from exposure to toxic air contaminants, increasing energy efficiency, and deriving 50 percent of our electricity from renewable sources by 2030. The total statewide costs reflected in this analysis represent cumulative costs incurred through 2031 with individual measures implemented from 2016 through 2031.

The Mobile Source Strategy measures, when adopted as regulatory and programmatic actions, are likely to cause technological changes that could initially increase the production costs for regulated industries as supply chains are built up around new technologies. Increased costs could have an initial contradictory effect on those industries, which in turn could affect other related industries either negatively or positively. The net effect on the California economy of these activities hinges on the extent to which products and services are obtained locally. While costs will be incurred from the regulatory and programmatic actions identified in the Mobile Source Strategy, the majority of the emission reductions will be driven by incentive programs that accelerate technology penetration.

The economic analysis of the Mobile Source Strategy is conducted in accordance with SB 617 that establishes additional regulatory impact assessment standards for regulations exceeding an estimated economic impact of $50 million in a 12-month period after implementation. Software from Regional Economic Models, Inc. (REMI) is used to model the statewide economic impacts including direct, indirect, and induced impacts throughout the California economy through 2031. Modeling results show that the California industries most affected by the proposed measures are those engaged in the production, distribution, sales, and use of cars and trucks, goods movement, off-road equipment and engines, and petroleum production.

In aggregate, the Mobile Source Strategy is estimated to have a negligible impact on the California economy resulting in an average slowing in the growth of gross state product, a common metric used to analyze the California economy, of 0.051 percent from 2023 to 2031. While the cumulative impact of the Mobile Source Strategy is not anticipated to significantly impact the broad California economy, it will incentivize zero- and near-zero emission technology as shown in shifts in employment and output among industrial sectors.

II. Emission Reduction Benefits

The Mobile Source Strategy is anticipated to deliver broad environmental benefits that include an estimated reduction of 206 tons per day (tpd) of NOx, 77 tpd ROG, 2 tpd PM2.5, and 20 million metric tons carbon dioxide equivalent ($MMTCO_2e$). The investments made to deploy cleaner technology vehicles, equipment, and fuels will also provide broad environmental benefits, as well as significant social and health benefits (including fewer illnesses and reduced medical expenses, and fewer lost work and school days) to Californians. These broad benefits, while potentially significant, are not quantified in this analysis.

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

Proposed measures in the Mobile Source Strategy will also result in emission reductions outside of California as vehicles and equipment subject to the proposed measures may also operate outside the State. These emission reductions and any resulting benefits, included those to human and ecosystem health, and are not quantified in this analysis. Social benefits related to the anticipated California emissions reductions, presented in Table A-1, are also not included in the economic modeling of the Mobile Source Strategy. Table A-1 represents the emission reductions that are anticipated to occur through 2031 with full implementation of all proposed measures.

Table A-1: California Emission Reductions Benefits for Mobile Source Strategy Measures

Proposed Measure	2031			
	NOx (tpd)	**ROG** (tpd)	**PM2.5** (tpd)	**GHG** (MMTCO2e)
On-Road Light-Duty				
Advanced Clean Cars 2	2	0.8	<0.1	7
Lower-In-Use Emission Performance Assessment	NYQ	NYQ	NYQ	NYQ
Further Deployment of Cleaner Technologies	5	16	<0.1	5
Total Category Reductions	**7**	**17**	**<0.1**	**12**
On-Road Heavy-Duty				
Lower In-Use Emission Performance Level	NYQ	NYQ	NYQ	NYQ
Low-NOx Engine Standard – California Action	24	--	--	--
Low-NOx Engine Standard – Federal Action	28	--	--	--
Medium Duty Heavy-Duty GHG Phase 2	NYQ	NYQ	NYQ	6
Advanced Clean Transit	0.5	<0.1	<0.1	0.3
Last Mile Delivery	1	<0.1	<0.1	0.4
Innovative Technology Certification Flexibility	NYQ	NYQ	NYQ	NYQ
Zero-Emission Airport Shuttle Buses	NYQ	NYQ	NYQ	NYQ
Incentive Funding to Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles	3	0.4	--	<0.1
Further Deployment of Cleaner Technologies	11	1	--	0.3
Total Category Reductions	**68**	**2**	**<0.1**	**7**
Off-Road Federal and International Sources*				
More Stringent National Locomotive Emission Standards	44	2	0.7	--
Tier 4 Vessel Standards	25	--	--	--
Incentivize Low Emission Efficient Ship Visits	NYQ	NYQ	NYQ	NYQ
At-Berth Regulation Amendments	1	0.1	<0.1	0.1
Further Deployment of Cleaner Technologies	30	0.4	NYQ	NYQ
Total Category Reductions	**100**	**2**	**0.7**	**0.1**
Off-Road Equipment				
Zero-Emission Off-Road Forklift Regulation Phase 1	2	0.2	<0.1	1
Zero-Emission Off-Road Emission Reduction Assessment	NYQ	NYQ	NYQ	NYQ
Zero-Emission Off-Road Worksite Emission Reduction Assessment	NYQ	NYQ	NYQ	NYQ
Zero-Emission Airport Ground Support Equipment	<0.1	<0.1	<0.1	<0.1
Small Off-Road Engines	4	36	<0.1	<0.1
Transport Refrigeration Units Used for Cold Storage	NYQ	NYQ	NYQ	NYQ
Low-Emission Diesel Requirement	8	NYQ	1	NYQ
Further Deployment of Cleaner Technologies	17	20	NYQ	NYQ
Total Category Reductions	**31**	**56**	**1**	**1**
Total Expected Emission Reductions	**206**	**77**	**2**	**20**

III. Methodology

Many measures in the Mobile Source Strategy rely on existing technologies. Other measures, however, encourage the development of new technologies, accelerating reductions of NOx, ROG, PM2.5, and CO_2 across mobile source sectors. Encouraging and incentivizing the development of zero and near zero-emission technologies may change the way vehicles, fuels, mobile equipment, and consumer products are manufactured, distributed and consumed. Proposed measures that accelerate deployment of existing technologies or incentivize new technologies may result in an economic impact as costs and benefits change over time.

Measures outlined in the Mobile Source Strategy include anticipated regulatory actions and possible opportunities for incentive funding. Many of these measures are far from regulatory implementation and, to the extent feasible, ARB has identified an array of potential costs and benefits to best reflect the economic impacts resulting from implementation of the proposed measures. Incentivizing the turnover from conventional technologies to zero- and near-zero emission sources will change the distribution of fleets in the light-duty, heavy-duty and off-road sectors, and will influence the purchasing behavior of both consumers and businesses.

This analysis estimates the cumulative impact of the Mobile Source Strategy on the California economy and includes estimated direct, indirect, and induced impact of the proposed measures. The direct impact is measures as any cost or savings directly related to compliance with a proposed measure, including labor and capital. Indirect impacts result from changes in industries associated with the direct impact. An increase in the demand for diesel particulate filters (DPF) is an indirect impact that could result from a proposed measure that changes filter requirements for heavy-duty vehicles. Induced economic impacts are the estimated changes in the local economy resulting from the direct and indirect impacts. For example, a change in the purchase price of a light-duty vehicle may affect the amount of money households spend on other goods and services in the local economy.

The direct economic impact associated with the proposed measures outlined in the Mobile Source Strategy are estimated using input from ARB, stakeholders, feasibility studies, and academic research. For most proposed measures, direct costs represent the incremental cost of zero and near zero-emission technologies over their conventional counterparts. Changes in operating and maintenance (O&M) costs are also calculated, often generating savings as a result of implementing more fuel-efficient technologies. O&M costs are calculated using estimates of energy consumption, fuel savings, and maintenance costs on an annual basis. For measures in the early stages of development, ARB estimates direct costs by multiplying a cost per ton estimate by the anticipated emission reduction associated with the proposed measure.

Many California industries may also see indirect benefits as a result of the proposed measures. Generally, manufacturers of capital equipment, infrastructure and parts for equipment modifications will see a significant increase in demand for their manufactured goods. Other indirect impacts include demand changes in fuel volumes and types,

generally through the transition from conventional fuels to clean or renewable fuels. The macroeconomic impacts of the proposed measures, including indirect and induced economic impacts, are modeled using the REMI macroeconomic model.

Regional Economic Models, Inc.

Regional Economic Models, Inc. Policy Insight Plus Version 1.7.2 (REMI or REMI PI+) is used to estimate the macroeconomic impacts of the Mobile Source Strategy on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.

REMI PI+ estimates year-by-year estimates of the total impacts (direct, indirect and induced) of the proposed measures outlined in the Mobile Source Strategy. ARB uses the REMI single-region, 160-sector model adjusted for the economic[1] and demographic[2] baseline to reflect the Department of Finance (DOF) Conforming Forecast dated January 2016.

The proposed measures included in the Mobile Source Strategy are simulated in REMI by changing production costs for industries that are expected to replace their fleet equipment with improved technologies defined by individual measures. The change in production cost reflects the estimated direct capital and O&M costs estimated to occur through 2031. Measures directly impacting consumers are simulated in REMI by changing consumer spending. Measures related to zero- or near-zero light-duty vehicles are modeled as a change in consumer spending on motor vehicles and fuels to reflect the direct incremental cost of an advanced technology vehicle and the shift to electricity or low-carbon fuels.

[1] Economic forecasts for California can be accessed at the Department of Finance website at: http://www.dof.ca.gov/html/fs_data/LatestEconData/FS_Forecasts.htm

[2] The Demographic Research Unit at the Department of Finance provides population projections used to adjust the base line in the REMI model. More information on population projections can be found here: http://www.dof.ca.gov/research/demographic/projections/

IV. Measure Impacts

Proposed Mobile Source Strategy measures with quantified emission reductions, as presented in Table A-2, are included in the economic analysis. Many measures are still in development, and may lack the specificity necessary for estimating their economic impact. As these measures develop and move through the regulatory process, ARB will conduct an analysis of the economic impacts associated with each measure, as required by the Administrative Procedure Act (APA).[3] The APA process provides opportunities for public input through out the regulatory process including participation in public workshops where ARB will present the potential costs and benefits of proposed measures on businesses, consumers, and California state agencies. Any regulation with an estimated $50 million impact over a 12-month period after implementation will be subject to an additional macroeconomic analysis performed in the early stages of the regulatory process, as required by SB 617.[4]

A key component in estimating the economic impact of the proposed measures in the Mobile Source Strategy is the change in the composition of the vehicle fleet over time. Vision 2.1, a comprehensive modeling tool for analyzing both upstream and downstream emissions specific to mobile sectors and fuel production activity, is used to estimate turnover such that the emissions profile of the future fleet of light-duty vehicles, heavy-duty vehicles, locomotives, ships, and off-road vehicles will achieve the goals outlined in the Mobile Source Strategy. The most recent version of Vision incorporates updated ARB inventory work, including EMFAC2014[5], and reflects currently adopted policies.

The following section describes the estimated economic impact for each proposed measure and concept with quantified emissions reductions in the Mobile Source Strategy. For each proposed measure, the goal, estimated benefits, and estimated costs are outlined.

Advanced Clean Cars 2

The goal of the Advanced Clean Cars 2 measure concept is to ensure that zero- and near-zero emission technology in light-duty vehicles continues to expand in market share beyond 2025 to ensure further emission reductions are achieved beyond the current Advanced Clean Cars program. An additional goal is to ensure electric drive range improves to address consumer preferences for greater ease of use of the technology. To further reduce new vehicle emissions in the LDV sector, ARB would consider expanding California-specific standards for new light-duty vehicles, building upon the technology and market assessments for advanced technology vehicles. Regulations developed from the measure concept may include lowering fleet emissions further beyond the super-ultra-low-emission vehicle standard for the entire light-duty fleet through at least the 2030 model year, and looking at ways to improve real world emissions through implementation programs. Additionally, new standards would be considered to further increase the sales of non-combustion zero emission vehicles

[3] http://www.oal.ca.gov/administrative_procedure_act.htm
[4] http://dof.ca.gov/research/economic_research_unit/documents/Section%202000%20ISOR%201%20sb_617_bill_20111006_chaptered.pdf
[5] Mobile Source Emissions Inventory: http://www.arb.ca.gov/msei/categories.htm.

(ZEVs) and plug-in hybrid electric vehicles (PHEVs) beyond the levels required in 2025 to ensure future emission reductions, climate, and petroleum targets are met.

Benefits

The proposed Advanced Clean Cars 2 measure concept will result in further emission reductions relative to current regulations, and will likely provide benefits beyond those achieved by complying with the LEV III criteria pollutant standard solely with conventional vehicles. This outcome would primarily be driven by increased electricity and hydrogen use, which would subsequently decrease gasoline production and refinery emissions.

The upstream emissions from the production of hydrogen and electricity represent a small fraction of the combined vehicle and upstream emissions impacts of the fleet, and are far outweighed by the reduction in gasoline production emissions, creating a net emissions benefit. Additionally, a portion of the upstream emissions are in non-urban areas, as compared to the vehicle emission reductions that predominantly occur in urban areas, which may result in improved health outcomes.

The Advanced Clean Cars 2 measure will achieve multiple pollutant benefits including reductions of 2 tpd NOx, 0.8 tpd ROG, <0.1 tpd PM2.5, and 7 MMTCO2e and supports California's air quality, toxics, and climate change goals.

Direct Costs

The GHG emission reductions anticipated in the Advanced Clean Cars 2 measure concept may impact several sectors of the economy. The steps that manufacturers would need to take to comply with the potential GHG fleet standards in the Advanced Clean Cars 2 program are expected to result in price increases for new vehicles, while also leading to reduced operating costs, resulting in both positive and negative impacts on California businesses and individuals. Any vehicle price increase is anticipated to be borne by consumers and may negatively affect businesses. However, the operating cost savings from the use of more efficient vehicles will positively impact both private and commercial vehicle owners. In the original Advanced Clean Cars staff analysis, the net effect of the program on the economy was projected to be small but positive.[6]

During implementation of the Advanced Clean Cars 2 measure concept, the incremental price of a ZEV or PHEV is expected to rapidly decline, but may remain higher than a conventional vehicle for a few years after 2025. However, when considering the cost savings from the offset of gasoline consumption in a conventional vehicle, and the lower average operating cost of plug-in electric vehicles operating on electricity, the period when operating cost savings compensate for higher purchase costs may be short and may also be dependent on other factors. Although ARB is evaluating current advanced vehicle incremental costs as part of the Mid-term Review (MTR), previous cost estimates are used for this analysis until the MTR staff analysis is complete.

[6] [6] 2012 Advanced Clean Cars LEV III ISOR: http://www.arb.ca.gov/regact/2012/leviiighg2012/levisor.pdf

The California businesses impacted by this measure concept are largely impacted indirectly, as affiliated businesses such as gasoline service stations, automobile dealers, and automobile repair shops may see changes in the demand for services and goods. These businesses compete within the State and generally are not subject to competition from out-of-state businesses. Therefore, the potential regulations resulting from this measure concept are not expected to impose significant competitive disadvantages on affiliated businesses.

It is very likely that savings from reduced vehicle operating costs, resulting from the Advanced Clean Cars 2 measure concept, would end up as expenditures for other goods and services. These expenditures would flow through the economy, causing expansion or creation of new businesses in several sectors. The Advanced Clean Cars 2 program would likely increase benefits to companies specializing in ZEVs and ZEV infrastructure. This potential creation or expansion of local business cannot be fully attributed to the Advanced Clean Cars 2 measure concept. Business and job creation from advanced vehicle technologies is part of the clean technology sector, which is currently experiencing higher than average job growth in California and nationally.

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

The goal of this proposed measure is to expand and enhance existing incentive programs for light-duty vehicles to accelerate the replacement of older vehicles with vehicles meeting Low Emission Vehicle Program (LEV III) or better emission levels, while meeting California's air quality, toxics, and climate change goals. The measure would expand the current Enhanced Fleet Modernization Project (EFMP) and EFMP Plus-Up programs by providing funding for an additional 70,000 to 85,000 vehicles per year over a seven-year period increasing the use of advanced technology vehicles in underserved communities and by lower-income consumers. Continued incentive funding post-2023 to further accelerate the deployment of zero-emission vehicles would provide additional reductions for 2031.

In addition to incentive programs, other non-incentive based pathways are expected to contribute to the penetration of zero- and near zero-emission vehicles. SB 375 is helping to transform land use and promote sustainability, while focusing on reducing vehicle miles travelled. Additionally, advances in the development of autonomous and connected vehicles offer the potential to achieve criteria and GHG emission reductions, but could also reduce vehicle miles travelled (VMT) and congestion as well as petroleum usage.

Benefits

Fleet modernization benefits all Californians by providing reductions in air pollution, associated health impacts and in related medical costs. This measure would not require mandatory participation; California businesses would participate only if it is financially beneficial to do so. The types of businesses that would benefit include licensed dismantlers and new or used car dealerships.

Individual owners of light-duty vehicles identified in this measure will benefit from improved safety technology, decreased spending on motor vehicle fuel and vehicle maintenance, and from monetary incentives towards the purchase of charging infrastructure and vehicles in the LEV III program.

Automotive dealerships will experience a boost in vehicle sales as a direct result of the monetary incentive program for vehicles identified in the LEV III program. Automotive dismantlers may experience an increase in revenue resulting from accelerated vehicle turnover, increasing the number of scrapped vehicles.

The Further Deployment of Cleaner Technologies measure in the on-road light-duty source category will achieve multiple pollutant benefits including reductions of 5 tpd NOx, 16 tpd ROG, <0.1 tpd PM2.5, and 5 MMTCO2e and supports California's air quality, toxics, and climate change goals.

Direct Costs

There are no direct costs on individuals as the program provides incentives toward the purchase of cleaner, safer vehicles and does not impose any specific costs on private persons. The measure would not incur direct costs on businesses, including small businesses, as participation would be voluntary and individuals and businesses would not participate unless it is financially beneficial to do so. Based on current programs, there may be minor reporting costs for participants, typically a mileage survey that would be returned annually over a three-year period.

Low-NOx Engine Standard-California Action

The goal of this measure is to introduce near-zero emission engine technologies that will substantially lower NOx emissions from on-road heavy-duty vehicles. Heavy-duty vehicles currently emit approximately one-third of the state's NOx emissions, and therefore measures to reduce emissions from such vehicles are crucial for California. The on-road heavy-duty vehicle sector is diverse in terms of the vehicle types, sizes and usage patterns. The sector includes heavy-duty diesel and natural gas vehicles, urban buses, school buses, motor homes, short haul and long haul combination tractor-trailers, and vocational vehicles such as delivery trucks, garbage trucks, cement mixers, and other work trucks.

ARB will develop a heavy-duty low-NOx engine standard in California, and plans to work with the U.S. Environmental Protection Agency (U.S. EPA) to establish new federal emission standards for heavy-duty engines. ARB will begin developing a new heavy-duty low-NOx emission standard in California in 2017, expected to be presented to the Board for approval in 2019. A California-only low-NOx standard would apply to all heavy-duty engines with gross vehicle weight rating of greater than 10,000 pounds sold In California starting in 2023.

Low-NOx natural gas engine development is more mature than low-NOx diesel engine development. Currently, there is one 8.9 liter natural gas engine certified to the

0.02 grams per brake horsepower hour (g/bhp-hr) optional NOx standard, 90 percent below the currently required NOx standard. Some of the technologies used to meet this standard include advanced three-way catalyst with an additional mid bed temperature sensor, improved engine calibration, and controlling crankcase ventilation. Research on demonstrating low-NOx emissions on other natural gas engine sizes is currently in progress.

Benefits

Emission control system manufacturers may benefit from increased business opportunities created by the need to develop and sell new technology solutions to further reduce NOx emissions. Californians would also benefit from improved health outcomes related to reductions in NOx, specifically in communities in or around freight corridors.

California action on the Low-NOx Engine Standard is anticipated to achieve NOx reductions of 24 tpd, and supports California's air quality goals.

Direct Costs

Research on developing both diesel and natural gas engine and aftertreatment technologies that provide significant NOx reductions from current engines is currently in progress. For diesel engines, the final technology package that provides maximum NOx reductions has not yet been determined. As a result, costs for the low-NOx technology package are currently unknown. However, several technologies, including advanced catalysts and improved engine calibration strategies, are currently being researched to demonstrate the feasibility of significant NOx emission reductions with minimal impact on GHG emissions.

Businesses that may be affected by the low-NOx emission standard include on-road heavy-duty engine and/or vehicle manufacturers (North American Industry Classification System (NAICS) codes 336310, 336111, 336120) and trucking transportation businesses (NAICS code 484). Engine and vehicle manufacturers will incur costs to develop and optimize new low-NOx emission control technologies for maximum emission control effectiveness with minimum negative impacts on engine performance, fuel consumption, greenhouse gas emissions and durability.

Direct costs to engine and vehicle manufacturers will include costs for research and development, incremental hardware costs, assembly costs, and associated markups (e.g., markups to account for increased warranty costs and manufacturer and dealer overhead costs). The incremental cost of the new low-NOx engine will be related to the engine size, as the size of the aftertreatment system is dependent on the engine size. Direct costs are likely to decrease over time as manufacturers gain experience in production and assembly operations, use lower cost materials, reduce the number or complexity of components, and increase sales volume.

Although this proposed measure does not mandate the purchase of low-NOx engines, trucking businesses would incur additional cost when they purchase new heavy-duty

vehicles due to the incremental cost of low-NOx engine technology. The end-user purchasing a heavy-duty vehicle would incur the total incremental cost passed by the manufacturer.

The new emission control technologies are not expected to introduce additional operating costs in the form of increased fuel consumption because engines and vehicles will also have to meet fuel consumption and greenhouse gas emission standards. However, the impacts of the new low-NOx engine on urea consumption of the SCR aftertreatment system are still not known. In the event that the new control technology results in increased urea consumption, trucking businesses would incur additional operating costs. However, ARB staff believes that manufacturers will improve emission control effectiveness and lower operating costs over time.

According to the Truck and Bus rule, a small fleet is defined as a fleet with 3 or fewer heavy-duty vehicles. Although the strategy does not mandate the purchase of low-NOx heavy-duty vehicles, small businesses would be required to pay the increased capital cost when purchasing new heavy-duty vehicles. Additionally, none of the heavy-duty engine and vehicle manufacturers meet the criteria for small businesses[7], and none of them are located in California.

Low NOx Engine Standard-Federal Action

The proposed measure includes a new-NOx standard that would be applied to all new heavy-duty engines sold nationwide starting in 2024 or later through a national standard. This measure concept would ensure that all heavy-duty vehicles traveling within California would eventually be equipped with an engine meeting the low-NOx standard. This proposed measure is necessary to achieve emission reductions from Class 7 and 8 vehicles as many are purchased outside of California. If U.S. EPA begins the regulatory development by 2017, ARB will coordinate its California feet rulemaking efforts with the federal regulation.

[7] Small business classification criteria: http://www.leginfo.ca.gov/cgi-bin/displaycode?section=gov&group=14001-15000&file=14835-14843

Benefits

Federal action is expected to provide maximum health benefits since vehicles purchased out of State that operate in California would have to meet the same emission standards as the California fleet. If uniform standards are adopted nationally, rather than California having a standard stricter than elsewhere in the country, per vehicle compliance costs for manufacturers could be lower due to increased economies of scale and decreased regulatory complexity. Emission control system manufacturers may also benefit from increased business opportunities created by the need to develop and sell new technology solutions nationwide. More discussion on health benefits is provided under Low-NOx Engine Standard-California Action (above).

Federal action on the Low-NOx Engine Standard is anticipated to achieve NOx reductions of 28 tpd and supports California's air quality goals.

Direct Costs

Federal action would affect all heavy-duty vehicles operating in California, including those originating from out of State. Thus, the engine research and development costs necessary to commercialize low-NOx engines would be spread across the national sales volume rather than only California sales. This would result in lower incremental costs per engine for engine and vehicle manufacturers. Although not mandated to purchase low-NOx engines under this measure, trucking businesses would incur additional cost when they purchase new heavy-duty vehicles due to the incremental cost of low-NOx engine technology.

Similar to the California action for the Low-NOx Engine Standard, none of the heavy-duty engine and vehicle manufacturers meet the criteria for small businesses, and none of them are located in California.

Advanced Clean Transit

The goal of this measure concept is to continue the transition of transit fleets to cleaner technologies in support of California's air quality, toxics, and climate change goals. This measure concept will consider a variety of approaches to enhance deployment of advanced clean technology and increase the penetration of the first wave of zero-emission heavy-duty technology into transit applications that are well suited to its use. Transit bus fleets are well suited for introducing zero-emission buses and other advanced technologies because they operate in urban centers, have stop and go driving cycles, and are centrally maintained and fueled. Experience from using advanced technology in buses and demonstrating its viability will benefit the market by allowing the same technologies to be used in other heavy duty vehicle applications.

The Advanced Clean Transit (ACT) concept is a proposed measure with a combination of incentives, and/or other methods that would result in transit fleets purchasing advanced technology buses during normal replacement and using renewable fuels when contracts are renewed. The concept would consider flexibility to allow transit fleets to implement advanced technology in ways that are synergistic with their existing

operation and would potentially recognize factors such as early actions to reduce emissions, utilization of alternative modes of zero emission transportation (e.g., light-rail), and improved efficiencies of the transit system. An important goal would be to ensure the emission benefits are realized in disadvantaged communities within the transit district while maintaining or expanding service and efficiency.

Benefits

The ACT measure primarily affects transit agencies and private entities that are under contract with government agencies that provide passenger transportation services. Renewable diesel and renewable natural gas (RNG) importers and producers also receive Low Carbon Fuel Standard (LCFS) credit for the fuels they sell for transportation so the cost to transit agencies from using renewable diesel or RNG results in a slight savings compared to conventional fuels. California transit agencies could see a costs savings introduced by the fuel efficiency of zero-emission buses, which is higher than that of conventional buses. The average fuel efficiency for battery electric buses is about four times higher than conventional buses (diesel and compressed natural gas (CNG) buses).[8] The average fuel efficiency for fuel cell electric buses is about two times higher than that of conventional buses.[9] Fuel cost savings depends on fuel and electricity costs. Annual maintenance costs for battery electric vehicles are lower than those of conventional buses. The transition from conventional fuels to electricity and hydrogen will be supplemented by the generation of credits in the LCFS program, where transit agencies are able to earn credit revenues through the consumption hydrogen or electricity in zero-emission buses.

There are several zero-emission bus manufacturers with plants located in California, including BYD, ElDorado, Ebus, Gillig, and Greenpower. It is expected that the production of zero-emission buses would increase and the number of jobs related to the bus manufacturing industry will grow. Additional businesses that may benefit from the ACT regulation are those related to the zero-emission bus component supply chain (e.g., fuel cell and electric drivetrain businesses).

The Advanced Clean Transit measure will achieve multiple pollutant benefits including reductions of 0.5 tpd NOx, <0.1 tpd ROG, <0.1 tpd PM2.5, and 0.3 MMTCO2e and supports California's air quality, toxics, and climate change goals.

Direct Costs

Capital costs for zero-emission buses (battery electric and fuel cell electric buses) are higher than costs for diesel and CNG buses, but with the LCFS credits, fuel and maintenance cost savings can offset most of the initial costs during the life of the bus. Several bus manufacturers are offering leasing packages that eliminate the initial capital cost difference that is paid for with annual operational savings. The long-term incremental costs are expected to be decrease further as battery prices continue to

[8] The fuel efficiency for a battery electric bus is about 2kWh/mile (~18.5 mile/diesel gallon equivalent (dge)). The fuel efficiency for a diesel bus and CNG bus is around 4 mile/dge.
[9] National Renewable Energy Laboratory. Fuel Cell Buses in U.S. Transit Fleets: Current Status 2015. http://www.nrel.gov/docs/fy16osti/64974.pdf.

decline, and the production volumes for battery electric buses and fuel cell electric buses increase. Low NOx engines are expected to initially increase the cost of a bus, but these costs should also decline with higher volume production. The average incremental costs for 40' buses with different fuel types or engines are presented in Table A-2.

Table A-2. Incremental costs for 40' buses in 2016[10]

	Average ($2016)
Battery electric over diesel	$270,000- $290,000
Battery electric over CNG	$224,000- $245,000
Fuel Cell Electric over diesel	$755,000
Fuel Cell Electric over CNG	$710,000
Low NOx CNG over CNG	$20,000[11]

For low-NOx CNG, the Manufacturers of Emission Control Association (MECA) estimates that the incremental cost of future advanced technologies needed to achieve NOx levels of 0.02 g/bhp-hr to be approximately $500 per vehicle, averaged over the medium and heavy-duty fleet; however, this estimate does not reflect warranty costs, low production volumes, or other factors that affect the retail price.[12] There will be some costs associated with building charging and fueling infrastructures, in addition to the construction costs of maintenance bays for battery electric and fuel cell electric buses. There may also be an associated cost of training for transit operators and maintenance crews to operate zero-emission buses and to maintain low NOx engines.

The operating and maintenance (O&M) costs of zero-emission buses are lower than conventional buses (diesel and CNG buses) and may offset some or all of the initial capital costs. There will be increased consumption for electricity or hydrogen, but will result in savings from decreased consumption for diesel and natural gas depending on existing and projected fuel prices.

[10] Battery electric and fuel cell bus prices have been declining rapidly in the past few years and are expected to continue to decline.

11 For low NOx CNG, Cumming stated publicly at the ACT workgroup meeting that the incremental cost for engine distributors to achieve NOx levels of 0.02 g/bhp-hr is $15,000 per engine. However, this estimate does not reflect warranty costs, required accessories, or other factors that affect the retail price. In addition, New Floyer, the largest transit bus manufacturers in North America, state that the low NOx engine is larger than the conventional CNG engines and will require additional engineering to be installed. It would be reasonable to assume the net incremental cost for low NOx engines to be $20,000.

[12] MECA Written Statement on the U.S. Environment Protection Agency's Proposal to Revise the NAAQS for Ozone. March 16, 2015. http://www.meca.org/attachments/2560/MECA_EPA_ozone_NAAQS_testimony_031715.pdf.

Last Mile Delivery

The goal of this measure concept is to increase the use of advanced clean technology and to increase the penetration of the first wave of zero-emission heavy-duty technologies in applications that are well suited to its use, in support of California's air quality, toxics, and climate change goals. Last mile delivery trucks operate in local communities with frequent stop-and-go driving, and are centrally maintained and fueled. Last mile delivery trucks are mostly class 3-6 trucks but can include some heavier trucks. Similar to the ACT measure, experience gained from demonstrating the viability of advanced technologies in these fleets will benefit the market and enable the same technologies to be used in other heavy-duty vehicle applications.

Benefits

Last mile delivery businesses, such as parcel, linen and beverage delivery, would see a reduction in the O&M costs of battery electric trucks, compared to the costs of conventional trucks. The O&M costs of fuel cell electric trucks are uncertain as they are still in the prototype demonstration phase. Battery electric trucks are reported to have 35-percent lower total maintenance costs than diesel trucks due to the absence of engine and transmission-related maintenance.[13] One study estimates that an electric truck consumes 28 percent less energy than a diesel truck over its life cycle.[14] Delivery service businesses may also benefit from potential funding opportunities for zero-emission trucks from the State.

The cost of zero-emission trucks has been decreasing, but further cost reduction is still needed for the widespread use of zero-emission technologies. It is expected that the production of zero-emission trucks would increase as a result of the proposed regulation. The increase in production volume could further decrease the cost of zero-emission trucks. Many components used in trucks and buses are the same. The Last Mile Delivery regulation could help expedite the advancement of zero-emission technologies in the heavy-duty sector.

The Last Mile Delivery measure will achieve multiple pollutant benefits including reductions of 1 tpd NOx, <0.1 tpd ROG, <0.1 tpd PM2.5, and 0.4 MMTCO2e, and supports California's air quality, toxics, and climate change goals.

[13] Werber, M., M. Fischer, P.V. Schwartz, Batteries: Lower cost than gasoline? *Energy Policy* 2009, 37(7), 2465-2468; citied by D. Lee, V.M. Thomas, and M.A. Brown, Electric urban delivery trucks: Energy use, greenhouse gas emissions, and cost-effectiveness. *Environmental Science & Technology* 2013, 47, 8022-8030. http://pubs.acs.org/doi/pdf/10.1021/es400179w.

[14] D. Lee, V.M. Thomas, and M.A. Brown, Electric urban delivery trucks: Energy use, greenhouse gas emissions, and cost-effectiveness. *Environmental Science & Technology* 2013, 47, 8022-8030. http://pubs.acs.org/doi/pdf/10.1021/es400179w.

Direct Costs

The capital costs for zero-emission trucks are higher than that of gasoline, diesel, and CNG trucks, but these costs can be offset with operational cost-savings. In the medium and heavy-duty sector, non-bus fuel cell electric vehicles are still in the prototype demonstration phase, and their market prices are not yet known.[15] The incremental cost of a class 5 battery electric truck over a diesel truck is estimated to be $25,000 to $37,000, with a comparable diesel truck price of $60,000.[16] Fleet owners and operators may not have access to a public charging station and may need to build charging or fueling infrastructure and maintenance bays for battery and fuel cell electric trucks. There will be increased consumption for electricity and hydrogen, but decreased consumption for conventional fuels, maintenance, and parts (e.g., engine oil and brake pads).

Some fleet owners and operators could be small businesses; however, it is unclear whether they would be affected by a proposed rule. The number of trucks deployed, supporting infrastructure and fixed costs will determine total costs that may exclude the smallest businesses; however, it is likely that some small businesses would still be affected. Small fleet owners and operators have the same kinds of ongoing costs as the large fleet owners in general.

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

The goal of this measure concept is to provide incentive funding to accelerate the penetration of near-zero emission equipment beyond the rate of natural turnover, while contributing to California's air quality, toxics, and climate change goals. This measure's goal will be achieved through implementation of the technologies developed through other measure concepts identified for on-road heavy-duty vehicles.

Benefits

Providing continued incentives that expedite turnover of South Coast's heavy-duty truck fleet from diesel to low-NOx engines will help drive cost reductions from economies of scale in the production of low-NOx engine technologies and, potentially, expand the market by encouraging production of additional engine sizes and participation by technology manufacturers. Increasing the demand for and availability of low-NOx engine technologies in fleets within the South Coast basin will result in emissions reductions in communities where these technologies are deployed. Over time, incentives that encourage the development and deployment of a variety of low-NOx engine sizes for a variety of heavy-duty applications could help replace many of the diesel trucks operating in South Coast and, as a result, offer multiple benefits to the

[15] ARB Draft Technology Assessment: Medium- and Heavy-duty Fuel Cell Electric Vehicle, November 2015, http://www.arb.ca.gov/msprog/tech/techreport/fc_tech_report.pdf.

[16] D. Lee, V.M. Thomas, and M.A. Brown, Electric urban delivery trucks: Energy use, greenhouse gas emissions, and cost-effectiveness. *Environmental Science & Technology* 2013, 47, 8022-8030. http://pubs.acs.org/doi/pdf/10.1021/es400179w.

communities most affected by heavy-duty vehicle emissions. Requirements that tie the use of renewable natural gas to the low-NOx vehicle incentives will result in GHG emissions reductions on the fuel supply side, as well as improve the business case for developing local renewable natural gas sources.

Incentives for low-NOx trucks will benefit California trucking businesses by covering some or all of the higher capital costs of the clean technology. When combining incentives with lower fuel costs, businesses will experience a shorter payback periods. Increased demand spurred by incentives would also help technology suppliers and vehicle dealers based in California, providing for a larger and predictable market and possibly job growth.

The requirement to use renewable natural gas in low-NOx vehicles that receive Greenhouse Gas Reduction Fund (GGRF) incentive funding will help develop and expand business opportunities for the production and distribution of renewable natural gas. Although certain operational and maintenance costs may be higher, overall operational costs will be lower for natural gas vehicles due to lower fuel costs.

Generally the same capital and operating cost benefits that larger California businesses would experience would also be experienced by small businesses, especially those whose core business and truck vocations lend well to natural gas vehicle technology. A small business' natural gas fleet with localized or defined routes near natural gas fueling infrastructure could experience cost savings compared to conventionally fueled vehicles, which receive no incentives, and considering the price volatility of gasoline and diesel compared to that of natural gas. If proportionately more incentive funding is directed toward small fleets, they may benefit from an even lower cost of ownership.

The Incentive Funding the Achieve Further Emission Reductions from On-Road Heavy-Duty Vehicles measure has multiple pollutant benefits including reductions of 3 tpd NOx, 0.4 tpd ROG, and <0.1 MMTCO2e, and supports California's air quality, toxics, and climate change goals.

Direct Costs

The measure is intended to incentivize businesses into buying cleaner technologies that are more expensive than standard technologies that meet regulations. As is generally true with new technologies, capital costs will be higher until market demand increases and production costs decrease. California businesses will face increased direct costs as a result of the measure but those costs will most likely be recouped over a payback period, depending on usage and fuel costs. Businesses also may pass on capital costs to customers. Without the incentives provided by the measure, capital costs would be higher for businesses seeking to modernize their fleets with cleaner technologies. Considering the cleaner technology that is currently available, targeted businesses will most likely be local or regional trucking services such as those in NAICS codes 48411 and 48422.

Natural gas vehicles generally cost $30,000 - $80,000 more than equivalent diesel trucks depending on their vocation. Ultra-low NOx engines that also meet future GHG

requirements are expected to cost slightly more than low-NOx vehicles that meet current standards. Natural gas vehicles also have higher maintenance or operational costs than diesel-fueled vehicles. The cost increase is estimated as $0.01 - 0.02 per mile because of more frequent oil changes and inspections, as well as high replacement costs for spark plugs and injectors.

Small businesses would bear the same capital cost increases per truck as larger businesses, but costs may take up a higher percentage of their available resources to purchase cleaner technologies. Small businesses that have fewer trucks and use each truck more often may have higher operating and maintenance costs initially, but due to lower fuel prices, may experience a shorter payback period than trucks not used as much.

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

The goal of this measure is to achieve further emission reductions for South Coast attainment in 2023 and 2031 through a suite of additional actions, including early penetration of zero and near-zero technologies, emission benefits associated with increased operational efficiency strategies, and the potential for new driver assist and intelligent transportation systems. The emission reductions will be achieved through a combination of actions to be undertaken by both ARB and the South Coast Air Quality Management District, benefitting California's air quality, toxics, and climate change goals.

Benefits

The main benefit of this measure concept is to achieve further reductions associated with early penetration of cleaner heavy-duty technologies. Businesses and individuals purchasing a new truck or incorporating newer technology into their business will notice an increase in the cost of newer technology compared to conventional technology, but financial incentives are expected to offset these costs. For businesses and individuals who do not qualify for incentive funding, the increased cost of newer technologies will be recouped in the decreased maintenance and fuel costs expected from zero and near-zero technology. Autonomous and connected vehicle systems are expected to provide fuel savings by increasing operational efficiencies and improving transportation logistics for businesses.

The Further Deployment of Cleaner Technologies in the on-road heavy-duty source category will achieve multiple pollutant benefits including reductions of 11 tpd NOx, 1 tpd ROG, and 0.3 MMTCO2e, and supports California's air quality, toxics, and climate change goals.

Direct Costs

The costs associated with this measure concept will mainly be borne by the trucking industry and truck manufacturers as newly manufactured trucks must meet lower emission standards in order to be sold in California. Production costs for truck

manufacturers is expected to increase in the early deployment of cleaner technologies as the newer technology is expected to cost more than conventional diesel technology. Cost information on autonomous technology, telematics, and intelligent transportation systems is still pending as this technology is still in the development phase.

More Stringent National Locomotive Emission Standards

The goal of this measure concept is to reduce NOx, PM, and GHG emissions from locomotives in order to meet California's air quality, toxics, and climate change goals. The current national standard requirement today is Tier 4. This analysis looks at incremental costs and benefits above Tier 4 standards. Under this concept, ARB would petition U.S. EPA to begin the process of developing new Tier 5 locomotive emissions standards for newly manufactured locomotives, and more stringent national requirements for remanufactured locomotives for criteria pollutants, toxics, and GHG emissions by 2018. The More Stringent National Locomotive Emission Standards measure has multiple pollutant benefits including reductions of 44 tpd NOx, 2 tpd ROG, 0.7 tpd PM2.5, and supports California's air quality, toxics, and climate change goals.

Newly Manufactured Locomotives

As envisioned by ARB, the proposed Tier 5 NOx and PM emissions standards (i.e., 0.2 and 0.0075 g/bhp-hr) would be at least 75 percent lower for NOx and 66.7 percent lower for PM than the current Tier 4 emissions standards (i.e., 1.3 and 0.03 g/bhp-hr). The proposed Tier 5 standards would apply to newly-built freight and passenger locomotives beginning in 2025.

The proposed U.S. EPA Tier 5 locomotive regulation would require manufacturers to implement the new emission standard by 2025. It is anticipated that the emissions standards would be met with the use of compact aftertreatment systems such as Selective Catalytic Reduction (SCR) and diesel oxidation catalyst (DOC), renewable diesel or natural gas, hydrogen and electricity.

Benefits

The transition to a larger number of in-use locomotives operating with Tier 5 capabilities would require higher demand for locomotive manufacturers and operators that produce parts and maintain locomotives to meet the new Tier 5 standard. ARB anticipates that the urea manufacturing sector will benefit from the higher demand of urea production and general contractors will benefit from the increased demand to build urea-refueling infrastructure.

The Tier 5 technology would potentially reduce the locomotive fuel use consumption for a small portion of the fleet by 15 percent, given that one technology that could be used to meet the Tier 5 standard is the combination of the compact SCR and DOC aftertreatment system and on-board battery hybrid electric technology. The rail transportation sector could potentially realize cost-savings for operating costs immediately after adopting the combined SCR and DOC aftertreatment system and on-board battery Tier 5 technology.

Direct Costs

For purposes of this analysis, ARB assumes the rail sector would bear the total capital cost for the purchases of locomotives with the compact SCR and DOC aftertreatment system and on-board battery capabilities and for the construction of urea infrastructure required to transition to the Tier 5 standard. Additionally, the rail transportation industry would incur incremental costs related to the operating and maintenance, including those for urea consumption.

Remanufactured Locomotives

As envisioned by ARB, in-use Tier 2+, Tier 3, and Tier 4 locomotive engines would be required to meet Tier 2++, Tier 3+, and Tier 4+ standards, respectively, upon remanufacture. Tier 2++ and Tier 3+ NOx and PM emissions standards would meet or exceed current Tier 4 emissions standards (i.e., 1.3 and 0.03 g/bhp-hr). Tier 4+ NOx and PM emissions standards (i.e., 0.3 and <0.01 g/bhp-hr) would be at least 75 percent lower than the current Tier 4 locomotive engine standard.

It is anticipated that the emissions standards would be met with the use of compact aftertreatment systems such as the SCR and DOC. The proposed standards would apply to in-use freight interstate line haul, medium horsepower, and switch passenger and freight locomotives and could begin as early as 2023.

Benefits

The transition to a larger number of in-use locomotives operating with lower emission technologies would increase demand for locomotive manufacturers and operators that produce parts and maintain locomotives to meet new remanufacture emission standards. The manufacturing sector may benefit from the higher demand of locomotive components and general contractors will likely benefit from the increased demand to build urea-refueling infrastructure, which is required in SCR technology.

Direct Costs

For purposes of this analysis, ARB assumes the rail sector would bear the total capital costs for the transition. The rail transportation sector is anticipated to provide private investments to operate capable remanufactured locomotives retrofitted with the compact SCR and DOC aftertreatment system.

Tier 4 Vessel Standards

The goal of this measure concept is to reduce emissions from ocean going vessels. ARB would advocate with international partners for the International Maritime Organization to establish new Tier 4 NOx and PM standards, plus efficiency targets for existing vessels in Ship Energy Efficiency Management Plans for International Maritime Organization Action. The current international standard requirement is Tier 3. This analysis includes the incremental costs and savings above Tier 3 standards.

Benefits

As envisioned by ARB, the proposed Tier 4 standards (i.e., 3.4 g/kw-hr) would be about 70 percent lower than the current Tier 3 emissions standards (i.e., 1 g/kw-hr). Tier 4 vessels may entail the use of exhaust aftertreatment controls such as Selective Catalytic Reduction (SCR) systems as opposed to the Exhaust Gas Recirculation (EGR) technology used currently for Tier 3 vessels. ARB would advocate for new Tier 4 NOx standards for marine engines on OGVs and vessel efficiency requirements for existing in-use fleets. Manufacturers of Tier 4/SCR components, including catalyst reactors and urea storage tanks, would benefit from greater demand. Fuel consumption may also be lower with the operation of more efficient ships.

Tier 4 Vessel Standards is anticipated to achieve NOx reductions of 25 tpd, and supports California's air quality goals.

Direct Costs

The water transportation sector would bear the costs of the transition to the Tier 4 technology. These costs include the incremental cost above the Tier 3 EGR to the Tier 4 SCR technology.

Maintenance costs may be higher with SCR compared to Tier 3 vessels using EGR technologies due to the SCR's use of urea/ammonia feedstock. There is no mandate to replace existing vessels with Tier 4 technology, just higher engine costs when vessel owners choose to purchase new ships.

At-Berth Regulation Amendments

The proposed Ocean-going Vessel (OGV) At-Berth Regulation Amendments will expand the diesel PM and NOx emission reductions from the regulation by including additional vessel types (and possibly smaller fleet sizes) that are currently not covered under the rule. The amendments will also provide greater flexibility to industry in complying with the regulatory requirements. The reductions in diesel PM and NOx will provide critical public health benefits for communities near seaports, and assist in meeting regional air quality goals.

The current OGV At-Berth Regulation requires fleets to plug in to shore-based electrical power (shore power) rather than running their auxiliary diesel engines when at berth at regulated California seaports, or to use an alternative control technology to reduce emissions of diesel PM and NOx. Regulated fleets are container vessels, and reefer vessels with 25 or more visits at a single regulated California port, and passenger vessels with 5 or more visits at a single regulated California port. The amendments will examine the potential to include other vessel types such as bulk, general cargo, roll-on roll-off (car carrier), and tanker vessels. The amendments may also consider including smaller fleets of vessels (e.g., container vessel fleets smaller than 25 vessels). It is expected that alternative control technologies will primarily be used for the additional vessel types to comply with the amendments rather than shore-based electrical power. These alternative technologies include barge-based control systems that can move to

berthed vessels and connect to the vessel exhaust stacks, routing auxiliary engine exhaust to the barge mounted emission control equipment.

Benefits

The proposed amendments will achieve additional reductions in diesel PM and NOx emissions. Reducing diesel PM will reduce the potential cancer risk and other health impacts for residents living near California's major shipping seaports. Reducing diesel PM and NOx emissions will also assist in meeting regional state and federal ambient air quality standards for PM and ozone. The emission reductions and associated benefits cannot yet be quantified because the vessel types and fleet sizes to be covered by the amendments have not yet been determined. The emission reduction benefits will likely occur on or after 2020.

The proposed amendments would benefit port workers, who would be subject to lower levels of diesel PM. In addition, there may be increased interest in using Prop 1B funding to build new barge-based control systems since this funding can be used for projects that have emission reductions in excess of the regulation requirements. California businesses that own and operate the barge mounted emission control systems that would be expected to be used to comply with the new requirements would benefit from the increase in visits to barge mounted emission control systems. The proposed amendments will also provide greater flexibility to the vessel operators currently subject to the provisions of the regulation, which should reduce their compliance costs. Small business start-ups have already developed alternative technologies for ocean-going vessels, and ARB staff expects this trend to continue.

The At-Berth Regulation Amendments measure has multiple pollutant benefits including reductions of 1 tpd NOx, 0.1 tpd ROG, <0.1 tpd PM2.5, 0.1 MMTCO2e, and supports California's air quality, toxics, and climate change goals.

Direct Costs

The proposed amendments may result in added ongoing costs for the vessel operators subject to the new (yet to be defined) requirements to control their emissions. These vessel operators would most likely need to pay for the services provided by the barge mounted emission control systems, but could also comply by plugging in to shore power or by using other emissions control options that have not been deployed yet.

There could be slightly higher costs for consumers of products delivered by vessel operators if the ongoing costs to the fleet operators under the regulation amendments are passed on to the cargo owners, and ultimately to consumers. The impacts of these costs are expected to be minor when considering the substantial volume of cargo handled. The added costs of the proposed amendments to the regulation would increase costs for fleet operators and potentially for terminal operators. In addition, to the extent that these costs are passed on to the businesses that own the goods shipped to and from California seaports, the added costs are expected to impact the cargo and businesses owners that purchase these goods. The impacts of these costs are expected to be minor when considering the substantial volume of cargo handled at

California seaports. There are costs associated with both the development of new technology and the testing required for approval for use in compliance with the At-Berth Regulation, including source testing and durability testing.

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

The goals of this measure concept are to increase the penetration of cleaner ocean-going vessel, locomotive, and aircraft technologies, and to promote efficiency improvements at the equipment, sector, and systems levels. As envisioned by ARB, the first strategy would be to increase the number of Tier 5 locomotives and Tier 4 vessels servicing California. As this measure concept is early in the development process the estimated benefits and costs are not yet determined but are anticipated to be similar to those for the Tier 5 New Locomotive and Tier 4 Vessel Standards measures and will support California's air quality, toxics, and climate change goals.

The Further Deployment of Cleaner Technologies measure in the off-road federal and international source sector is anticipated to achieve NOx reductions of 30 tpd, and 0.4 tpd of ROG, and supports California's air quality goals.

Zero-Emission Off-Road Forklift Regulation Phase 1

The goal of this measure concept is to accelerate the deployment of zero-emission technologies in off-road equipment types that are primed for zero-emission conversion, and to promote further technology development and electrical and hydrogen infrastructure expansion. ARB would develop a regulation that focuses on forklifts with lift capacities equal to or less than 8,000 pounds.

Benefits

The regulation would result in conversion of an additional 5,800 to 17,500 internal combustion forklifts to zero-emission over the span of the measure. Despite the higher initial capital cost of zero-emission forklifts, the lifetime ownership cost is significantly less than for internal combustion forklifts. Due to the fewer moving parts in electric forklifts, they typically have maintenance costs approximately 25 to 50 percent less than their internal combustion counterparts. In addition, the cost of electricity to power battery-electric forklifts is approximately 20 to 40 percent of the cost of fueling internal combustion forklifts. Electric forklifts also have a useful life that is approximately 50 percent longer than internal combustion forklifts. Altogether, these benefits can lead to a payback time on the higher initial capital cost of as little as one year. The regulation is intended to enhance the strength of the off-road zero-emission market, drive innovation, and to open up possibilities for deployment of zero-emission technology to other applications. For example, by installing electrical charging infrastructure, many fleets converting their forklifts to zero-emission may seek opportunities to convert other off-road equipment types at their facilities to zero-emission. The measure would result in reduced emissions at both the statewide level and in the working environment.

Clean technology manufacturers and suppliers would see higher demand for zero-emission equipment, signaling market stability for zero-emission forklifts. Some fleets may choose to convert to zero-emission hydrogen fuel cell forklifts. This conversion would result in an increased demand for fuel cell technology and would drive sales for fuel cell equipment manufacturers as well as hydrogen suppliers. The regulation would support the green technology market and spur research and development towards applying zero-emission technology to other equipment types.

Many fleets would need to invest in infrastructure upgrades at their facility and will have higher power demands. These changes will benefit utility companies who would experience an increase in demand for electricity and infrastructure as well as contractors that utilities utilize for infrastructure projects. Facilities utilizing fast-charging battery technology or fuel cell technology may see an increase in productivity as recharging and refueling may be quicker and more streamlined than refueling for internal combustion forklifts.

Zero-emission forklifts have fewer moving parts than internal combustion forklifts. As a result, fleets will have reduced labor and parts expenses from equipment maintenance. Battery-electric forklifts have a longer useful life and cost less to power than internal combustion forklifts. Fleets using battery electric forklifts can realize a significant cost savings over the lifetime of the equipment.

The Zero-Emission Off-Road Forklift Regulation Phase 1 measure has multiple pollutant benefits including reductions of 2 tpd NOx, 0.2 tpd ROG, <0.1 tpd PM2.5, 1 MMTCO2e, and supports California's air quality, toxics, and climate change goals.

Direct Costs

A fleet rule would require fleets to replace internal combustion forklifts with zero-emission forklifts. Battery-electric forklifts necessitate the purchase of chargers and batteries, which result in an initial purchase price approximately 50 percent higher than internal combustion forklifts. In addition, fleets that do not have excess electrical supply would need to upgrade their infrastructure. For utility companies, this may require them to invest in upgraded substations upstream of fleets to accommodate increased power demand. Businesses that choose to use battery-swapping rather than fast-charging battery-electric technology would need to dedicate floor space to a battery room and would need to adjust their workflow to accommodate forklift battery charging and swapping. If a fleet chooses to utilize fuel cell technology, it will incur an even higher initial purchase price for equipment along with the need to set up hydrogen infrastructure. For hydrogen suppliers, this would entail installation of infrastructure to support hydrogen delivery or to supply hydrogen on-site.

Typical businesses will incur an incremental cost of purchasing battery-electric or fuel cell forklifts and the associated chargers over costs related to internal combustion forklifts. Some fleets will need to pay to upgrade or install new infrastructure to support either electric charging or hydrogen production or delivery. Suppliers of electricity or hydrogen may need to upgrade their infrastructure upstream of facilities in order to provide sufficient power to fleets. Fleets using lead-acid battery technology may need

to dedicate floor space to a battery room and adjust their day-to-day operations to accommodate battery swapping for depleted batteries.

Zero-Emission Airport Ground Support

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

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

Benefits

The primary benefit will be to businesses that own and operate airport GSE. The costs of electricity for battery electric equipment, when compared to diesel and gasoline fuel prices, are generally more stable. Therefore, increased use of battery electric powered GSE will have the benefit of more predictable and lower fuel costs compared to equipment powered by traditional internal combustion engines. If battery electric airport GSE is collocated with jet bridge power, the GSE can be plugged in overnight or during break periods. This approach allows equipment operators to take advantage of off-peak rates for refueling, thereby increasing equipment fuel savings. Initial infrastructure costs may also be reduced since charging infrastructure costs can be shared with equipment chargers and jet bridge power infrastructure costs.

For some equipment types, the handling, acceleration, and speed of zero-emission GSE may exceed internal combustion engine powered equipment. Additionally, the same equipment is quieter than internal combustion powered equipment. providing a safer and healthier work environment for equipment operators.

A cost savings may be realized through operation and maintenance of the zero-emission GSE. Maintenance costs, including parts and labor for zero-emission GSE, are less than the costs associated with GSE powered by diesel or gasoline engines. Combustion engines are complex machines, with more moving parts which must be serviced on a more frequent schedule than electric equipment. By using zero-emission GSE, the cost of regular maintenance parts (filters, belts, spark plugs, brake pads) can be saved. For instance, regenerative braking reduces brake pad use and wear.

This measure will also encourage and create more business opportunities for businesses that manufacture zero-emission GSE. By introducing more zero-emission equipment into use and by increasing the demand for zero-emission equipment, costs of components such as batteries, motors, fuel cells and controllers will go down over time due to economies of scale. Funding for zero-emission technologies may also be available through programs such as California's Carl Moyer Program and Air Quality Improvement Program, as well as Federal programs such as the Voluntary Airport Low Emissions Program.

Furthermore, a secondary increase in demand will be passed on to businesses within the state that design and construct infrastructure systems supporting zero-emission equipment and businesses that specialize in workforce training in the operation and maintenance of zero-emission equipment.

The Zero-Emission Airport Ground Support Equipment measure has multiple pollutant benefits including reductions of <0.1 tpd NOx, <0.1 tpd ROG, <0.1 tpd PM2.5, <0.1 MMTCO2e, and supports California's air quality, toxics, and climate change goals.

Direct Costs

Costs will be incurred by airport GSE owners and operators. These owners and operators include airports, commercial passenger and air cargo airlines, and airport ground handling companies. While transitioning to zero-emission equipment, equipment operators may also need to ensure additional training is conducted to ensure electric equipment is charged regularly, thereby ready for use when needed. Once electric equipment use is integrated into operational routines, these training costs may be reduced.

Zero-emission GSE have higher initial purchase costs to when compared to diesel and LSI powered GSE. For instance, for the most common battery electric GSE equipment types, equipment cost ranges from 8 percent to 23 percent higher than its conventional fueled counterpart, and can be higher for other types of GSE. These initial capital costs are even higher for fuel cell GSE. However, it is expected that zero-emission equipment costs will decrease as the deployment of this equipment increases.

Zero-emission GSE charging and fueling infrastructure may have initial higher capital costs when compared to conventional-fueled equipment. Battery charging infrastructure and battery charger installation may require large initial capital investment by airport operators particularly if adequate charge capacity is not available. Individual charging stations may cost between $10,000 and $60,000 depending upon existing electric infrastructure, wiring, power demand, capacity and number of chargers purchased. However, the infrastructure may have an overall operating life longer than liquid fuel refueling infrastructure. Additionally, if battery electric airport GSE is collocated with jet bridge power, initial infrastructure costs may be reduced since charging infrastructure costs can be shared with equipment chargers and jet bride power infrastructure costs. Additional costs will also be incurred by businesses that purchase fuel cell GSE due to the installation of hydrogen fuel capacity.

Small Off-Road Engines

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

Benefits

All Californians will receive health benefits from emission reductions of criteria pollutants and toxic air contaminants. The increased safety of zero-emission equipment versus spark-ignited equipment will also benefit all Californians. Commercial equipment operators will likely receive the greatest health and safety benefits because of their extensive use of SORE equipment. The measure will also provide environmental and quality of life benefits by contributing to the attainment of federal ambient air quality standards. Spark-ignited engine manufacturers will benefit from incentives for zero-emission equipment if they take advantage of those incentives. Equipment manufacturers will have flexibility to choose from spark-ignited engines and zero-emission power sources to power their equipment. Manufacturers of emission control systems may see increased demand for their products, and may have to hire additional employees to meet that demand. Zero-emission equipment manufacturers will benefit from increased demand for their equipment, and may have to hire additional employees to meet that demand. All manufacturers whose equipment complies with the emission standards will benefit from enhanced enforcement of the emission standards.

Benefits of tightened emission standards and increased availability of zero-emission SORE equipment to individuals may include fuel savings, lower equipment maintenance costs, and incentives to purchase zero-emission equipment. Equipment that complies with future tightened exhaust and evaporative emission standards may be more fuel efficient than equipment produced today. Fuel savings would be greater for electric zero-emission equipment because gasoline and other fuels would not be used. Zero-emission equipment would also have lower maintenance costs than spark-ignited equipment. Spark-ignited engines using fuel injection would likely have lower maintenance costs than their carbureted equivalents. Lawn mower exchange programs provide participants with discounts on the purchase of zero-emission lawn mowers in return for recycling a spark-ignited lawn mower.

Benefits of tightened emission standards and increased availability of zero-emission SORE equipment to California businesses will likely include higher demand for zero- and low-emission equipment, savings on operations and maintenance, and incentives to produce or purchase zero-emission equipment. Manufacturers of zero-emission equipment and emission control systems may see increased demand for their products from other manufacturers, retailers, and consumers. Businesses that use SORE equipment will save on operating and maintenance costs if they use zero-emission

equipment, and possibly if they use equipment with fuel-injected engines. Zero-emission equipment would not need regular oil changes or tune-ups like spark-ignited equipment.

Manufacturers of zero-emission equipment, whether or not they also produce spark-ignited equipment, will have the opportunity to earn emission reduction credits for zero-emission equipment. Incentives would also help businesses who use SORE equipment to purchase zero-emission equipment.

Benefits of tightened emission standards and increased availability of zero-emission SORE equipment to small businesses will likely include savings on operations and maintenance, and incentives to produce or purchase zero-emission equipment. Small businesses that use SORE equipment will save on operating and maintenance costs if they use zero-emission equipment, and possibly if they use equipment with fuel-injected engines. Small businesses that use zero-emission equipment or equipment using fuel-injected engines may save on fuel costs. Small businesses which produce zero-emission equipment will benefit from the availability of emission reduction credits for zero-emission equipment. Manufacturers and retailers of zero-emission equipment will likely see higher demand for their products as consumers learn about the reduced maintenance costs, lower noise, fuel savings, and health benefits of zero-emission equipment versus spark-ignited equipment.

Small businesses that provide services using SORE, such as landscaping businesses, may have higher demand for their services if they use zero-emission equipment. People who use these services would be attracted to the reduced noise and pollution that would be produced by the landscapers' equipment, and they would also know that they are helping to provide environmental benefits to the state and health benefits to the landscapers.

The Small Off-Road Engines measure has multiple pollutant benefits including reductions of 4 tpd NOx, 36 tpd ROG, <0.1 tpd PM2.5, and <0.1 MMTCO2e and supports California's air quality, toxics, and climate change goals.

Direct Costs

Direct costs on individuals as a result of tightened emission standards and increased availability of zero-emission SORE equipment may include higher electricity costs, hydrogen fuel cost, and higher purchase prices. Spark-ignited equipment do not require electricity, except when a starter battery needs to be charged. Using electric zero-emission equipment would require electricity either for operation (for corded equipment) or for charging batteries (for battery-operated equipment). Using zero-emission equipment powered by a hydrogen fuel cell would require hydrogen fuel. The hydrogen could be purchased from a fueling station, made in a natural gas reformer, or produced using renewable energy. Zero-emission SORE equipment can be operated or charged using existing electrical outlets in homes. Zero-emission equipment may have a higher purchase price than the spark-ignited equipment.

Direct costs on typical businesses as a result of tightened emission standards and increased availability of zero-emission SORE equipment may include higher capital costs for equipment production and higher purchase prices. Manufacturers may have higher initial capital costs if they switch from producing or using spark-ignited engines to zero-emission technology. Zero-emission versions of SORE equipment that meet commercial needs are not currently available for all SORE equipment types, so relative pricing is not yet known. When it does become available, zero-emission equipment may have a higher purchase price than the spark-ignited equivalent. Retailers may have higher capital costs for purchasing zero-emission equipment, but these would presumably be recovered when the equipment are sold to consumers. Operating and maintenance costs are not expected to be higher for zero-emission equipment compared to spark-ignited equipment, as fuel savings are expected, and oil changes and tune-ups would not be required.

Low-Emission Diesel Requirement

The goal of the Low-Emission Diesel Requirement measure is to reduce NOx, diesel PM, and GHG emissions from the portion of the heavy-duty fleet that will continue to operate on internal combustion engines in order to reduce emissions as quickly as possible. The Low-Emission Diesel Requirement measure is expected to be primarily fulfilled using renewable hydrocarbon diesel, also known as renewable diesel, sourced from renewable biomass. Renewable diesel is similar to conventional diesel in chemical and physical properties. This measure concept would put into place standards for low-emission diesel, and would require that diesel fuel providers sell steadily increasing volumes of low-emission diesel until it comprises 50 percent of total diesel sales by 2031. The total diesel sales in California in 2012 were about 3.3 billion gallons. According to the Vision Model, diesel demand in California is projected to grow to 3.9 billion gallons by 2023 (year of Low-Emission Diesel Requirement implementation) and decline to 3.8 billion gallons by 2031 under the Low-Emission Diesel Requirement Measure Concept scenario. The Low-Emission Diesel Requirement is designed to support California's air quality, toxics, and climate change goals.

Benefits

The use of Low-Emission Diesel Requirement in on-road vehicles and off-road equipment will reduce NOx and PM emissions in addition to other criteria pollutants and life cycle GHG emissions. The absolute amounts of NOx and PM reductions will primarily be determined by the level of low-emission diesel penetration in the California diesel market and the relative composition of legacy and newer fleets. Particularly, benefits of PM and NOx emission reductions would be realized from low-emission diesel use in older diesel vehicles and off-road equipment.

Importers and producers of low-emission diesel qualify for Low Carbon Fuel Standard (LCFS) credits under the California LCFS. These credits provide additional sources of revenues for businesses helping them become economically profitable and create additional jobs. By switching to low-emission diesel, businesses regulated under the

cap-and-trade program and LCFS would achieve the GHG reduction targets and lower, or avoid, their compliance costs.

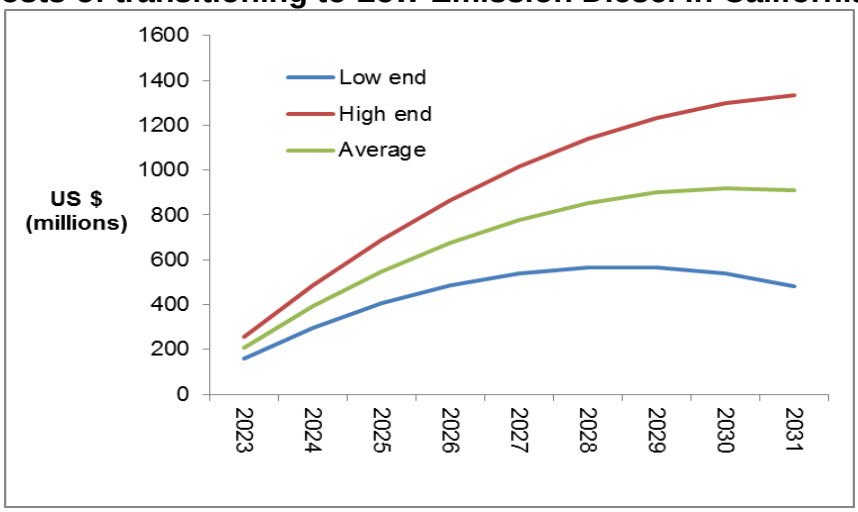
The Low-Emission Diesel Requirement measure has multiple pollutant benefits including reductions of 8 tpd NOx and 1 tpd PM2.5, and supports California's air quality, toxics, and climate change goals.

Direct Costs

Total incremental costs to consumers and businesses in California are calculated by estimating the projected differential costs of production between diesel and renewable diesel and the additional amount of renewable diesel supplied by the Low-Emission Diesel Requirement measure only. The distribution costs and taxes were not included as they would be similar for both fuels and will not contribute to incremental costs. The diesel demand was estimated from the Vision Model assuming the SIP Measure Concept scenario. The production cost forecast for diesel was based on the EIA 2015 Outlook for the retail cost forecasts from 2020 to 2031, which were adjusted to reflect production costs. The projected costs of low-emission diesel were based on literature review of production costs of a variety of biomass-based technologies and biomass feedstock costs. The cost forecast took into account a gradual improvement in technology performances and reduction in costs.

The annual costs are shown in Figure A-1. The average costs to consumers and businesses in California solely due to the Low-Emission Diesel Requirement measure were estimated to be $209 million in 2023 and $908 million in 2031 when 50 percent of diesel demand is met by low-emission diesel.

Figure A-1: **Costs of transitioning to Low-Emission Diesel in California**



Individuals may experience increased fuel costs for diesel fuel. On average, there will be a slight increase in the volumetric consumption of renewable diesel compared to diesel it displaces. Also low-emission diesel is projected to be, on average, costlier than diesel. A lower energy density combined with relatively higher costs would increase fuel expenses for consumers.

Further Deployment of Cleaner Technologies: Off-Road Equipment Sources

The goal of this measure is to achieve further emission reductions for South Coast attainment in 2023 and 2031 through a suite of additional actions, including early penetration of zero and near-zero technologies and emission benefits associated with the potential for worksite integration and efficiency, as well as connected and autonomous vehicle technologies. These emission reductions will be achieved through a combination of actions to be undertaken by both ARB and the South Coast Air Quality Management District.

Benefits

The main benefit of this measure concept is to achieve further reductions associated with early penetration of cleaner technologies in the off-road sector. Affected businesses purchasing newer technology will notice an increase in the cost of newer technology compared to conventional technology, but financial incentives are expected to offset these costs. For business and individuals who do not qualify for incentive funding, the increased cost of newer technology will be recouped in the decreased maintenance and fuel costs expected from zero and near-zero technology. Autonomous and connected vehicle systems will provide fuel savings by increasing operational efficiencies and improving transportation logistics for businesses. The transition to zero and near zero-emission technologies will also reduce vehicle miles traveled which will reduce congestion and fuel usage. Autonomous system technologies are expected to achieve up to a 30 percent improvement in worksite efficiency dependent on various factors, such as duty cycle, vehicle type, worksite conditions, and technology type.

The Further Deployment of Cleaner Technologies measure in the off-road equipment source sector is anticipated to achieve NOx reductions of 17 tpd and 20 tpd of ROG, and supports California's air quality, toxics, and climate change goals.

Direct Costs

The costs associated with this measure concept will mainly be borne by the construction and mining industries as well as airports. Production costs for off-road equipment and airport ground support equipment manufacturers is expected to increase in the early deployment of cleaner technologies as the newer technology is expected to cost more than conventional diesel technology. In addition to equipment, new infrastructure will need to be installed in order to support newer zero and near zero-emission technologies. Transition to zero and near-zero technologies in the Off-Road sector could also lead to an increased consumption of electricity and hydrogen. Individuals and lawn and garden businesses that upgrade to electric equipment would also incur additional costs for batteries and related infrastructure. The costs for autonomous systems technologies is expected to be minimal because many manufacturers are already recognizing the benefits and have started incorporating the technology in some equipment types ahead of any regulatory requirement.

V. Economic Impacts

Methodology for Determining Economic Impacts

To achieve the emission reductions outlined in the Mobile Source Strategy, ARB has estimated the incremental costs of zero- and near zero-emission technologies compared to their conventional counterparts. These incremental costs include capital, fueling infrastructure, and annual O&M unique to each mobile source type. These cost differentials are used to calculate the costs over a vehicle or equipment population generated by ARB's Vision model. Vision is used to estimate turnover such that the emissions profile of the future fleet of light-duty vehicles, heavy-duty vehicles, locomotives, ships, and off-road vehicles will achieve the goals outlined in the Mobile Source Strategy.

Capital Amortization

Capital purchases by industry have been amortized, or spread out, over the lifetime of the equipment assuming a 5 percent interest rate. Amortized capital payments are incurred annually, starting the year of capital purchase, and continue through the useful life of the capital. Additional capital payments are expected to continue beyond 2031, but are not included in this analysis. As measures develop and move through the regulatory process, detailed cost assessments will be performed to account for capital costs throughout the lifetime of the regulation.

Capital purchases by consumers are not amortized, and are assumed to be purchased in full. This includes the incremental cost of zero- and near zero-emission light-duty vehicles and zero-emission home and garden equipment.

Inputs of the Assessment

Two approaches are used in the quantification of costs attributed to the Mobile Source Strategy. The first calculation applies the estimated cost of the measure to affected industries as identified at the 2-4 digit NAICS[17] level.

The second approach is used to calculate the cost of the further deployment measures, currently in the earliest stages of development, and with limited paths to emission reductions outlined in the Mobile Source Strategy. This approach takes average cost-per-ton estimates from related proposed measures with estimated costs and applies them to further deployment measures.

Impacted industries for the further deployment measures are identified as those impacted by related proposed measures in each source category, providing a rough estimation of the affected entities that may result from the further deployment measures. More detail on these cost estimates can be seen in the Modeling Assumptions component of this analysis.

[17] More information on industry categorization using the North American Industry Classification System (NAICS) can be accessed at: https://www.census.gov/eos/www/naics/

Vision 2.1

The economic analysis utilizes the proposed measure implementation dates, fleet turn over, and technology penetration rate assumptions utilized in the Vision 2.1 model in estimating the emission reductions in the Mobile Source Strategy. The Vision 2.1 modeling assumptions are outlined in Table A-3 and Table A-4.

Table A-3: Vision Assumptions for Cleaner Technologies and Fuels

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

Table A-4: Vision Assumptions for Mobile Source Strategy Measures

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

Uncertainty and Limitations

The estimated costs and benefits of the proposed measures in the Mobile Source Strategy likely differ from actual costs and benefits that will result from full implementation of the proposed measures. Technology advancement, equipment modifications and the development of cleaner fuels could change the actual costs and benefits as consumers and businesses adjust their production budget and spending habits. It is also likely that the benefit assessment is underestimated, as health and ecosystem benefits are not included in the macroeconomic modeling.

ARB uses the REMI model to analyze the impacts of the Mobile Source Strategy, and provides estimates for the possible impacts to California employment, output, private investment, personal income, and gross state product (GSP). The impact of the Mobile Source Strategy is estimated as the change in the California economy when the proposed measures are implemented as compared to a forecast of the California economy without the proposed measures. These economic variables provide an estimate of the impact each year of the Mobile Source Strategy, however the realized results may vary based to changes in the California economy, unanticipated technological developments, or shifts in consumer behavior. In addition, the impacts of reduced air pollution could impact the future California economy, as clean air could increase migration to California leading to fundamental shifts in the economy.

Federal and International Measures

Proposed federal and international mobile source measures, which include emission reduction strategies for heavy-duty trucks, locomotives, and ocean-going vessels, are included in the economic analysis. The modeling approach for these measures, however, differs from the measures affecting only California fleets and equipment. The REMI model utilized by ARB focuses solely on the California economy, however it can be modified to account for impacts of changes at the national level. Similar to the methodology utilized by DOF to calibrate to the REMI model to their Statewide economic and demographic projections, ARB adjusts industry variables at the national level to simulate the impact of federal and international measures on the California economy.

In modeling the Mobile Source Strategy, ARB adjusts the production costs incurred by the truck transportation, rail transportation, and water transportation sectors. Changing costs at the national level alters these sectors, and related industries, over time, both with and without the implementation of the California-only proposed measures. For example, the federal heavy-duty low-NOx measure is anticipated to increase the costs of all heavy-duty vehicles nationwide. Therefore, the increased cost is spread across the national sales volume, rather than the fleet of California vehicles. The impact of this proposed measure will change the California economy over time as heavy-duty transportation costs increase – even without the implementation of any other proposed Mobile Source Strategy measures.

REMI Modeling Results

The economic impacts of the Mobile Source Strategy are estimated using the REMI model. The impact of the proposed measures on key economic variables is presented

in the following section. For each variable, the cumulative economic impact of all proposed measures is presented for 2023 and 2031, years in which California must demonstrate SIP compliance. The economic impact is also presented as an annual average from 2023 through 2031 and an a percentage of the estimated growth expected in the variable from 2023 through 2031 if no proposed Mobile Source Measures are implemented (labeled in the following tables as 'Relative to Baseline Growth').

California Employment Impacts

Employment impacts of the proposed measures included in the Mobile Source Strategy are estimated using the REMI model. In total, the implementation of the Mobile Source Strategy is estimated to result in a slight reduction in California employment, approximately 14,000 jobs annually, on average, from 2023 to 2031. This change in employment represents less than 0.1 percent of projected California employment without the implementation of the Mobile Source Strategy.

The Mobile Source Strategy represents a shift away from petroleum-based fuels and conventional vehicles to zero- and near-zero emission fuels and vehicles. This shift is reflected in the changes in employment modeled through 2031. Employment in the mining sector, which represents conventional fuel production, is estimated to decline due to penetration of fuel-efficient technologies and the transition to clean fuels. Employment in the manufacturing and transportation and warehousing sectors, however, are estimated to have steady employment growth as increased costs related to the purchase of zero-and near-zero emission vehicles and equipment is offset by annual fuel savings resulting in steady growth through 2031.

Table A-5 presents the job impacts by industry as a result of implementing the Mobile Source Strategy. The change in the number of jobs by industry (as defined by NAICS code) is presented for 2023 and 2031. This represents the estimated change in employment that results from the full implementation of the Mobile Source Strategy relative to the employment anticipated under the baseline, when no Mobile Source Strategy is implemented.

As shown in Table A-5, the utilities industry is estimated to experience an increase of 200 jobs in 2023 and 250 jobs in 2031, with an average increase in employment of 200 jobs per year during that period. This represents approximately a 0.4 percent increase in employment growth each year from 2023 through 2031 relative to what is projected to occur if no proposed measures are implemented.

Table A-5: Changes in Employment Growth by Sector

Industry	NAICS Code	Jobs		Annual Average	
		2023	2031	Jobs	Relative to Baseline Growth
Forestry, Fishing and Related Activities	113-115	0	0	0	(0.002%)
Mining	21	(100)	(500)	(800)	(0.906%)
Utilities	22	200	250	200	0.388%
Construction	23	2,350	(3,300)	(2,200)	(0.149%)
Manufacturing	31-33	550	1,200	800	0.070%
Wholesale Trade	42	350	(1,000)	(350)	(0.044%)
Retail Trade	44-45	800	(7,200)	(2,550)	(0.126%)
Transportation & Warehousing	48-49	(950)	2,350	900	0.152%
Information	51	0	(250)	(200)	(0.040%)
Finance and Insurance	52	(150)	(1,200)	(950)	(0.091%)
Real Estate, Rental and Leasing	53	200	(1,450)	(900)	(0.070%)
Professional and Technical Services	54	800	(1,550)	(850)	(0.039%)
Management & Support Services of Companies and Enterprises	55	0	0	0	(0.006%)
Administrative and Waste Management Services	56	750	(1,200)	(550)	(0.034%)
Educational Services	61	(150)	(850)	(650)	(0.120%)
Health Care and Social Assistance	62	(450)	(4,350)	(3,100)	(0.103%)
Arts, Entertainment, and Recreation	71	(100)	(650)	(500)	(0.081%)
Accommodation and Food Services	72	200	(2,050)	(1,250)	(0.078%)
Other Services	81	(650)	(3,900)	(2,000)	(0.163%)
Government	92	12,950	(1,700)	650	0.026%
Total		**16,550**	**(27,400)**	**(14,300)**	**(0.063%)**

The values are interpreted as the reference year value less the baseline value. Therefore these values should not be represented as cumulative values, but instead changes year-by-year. The values presented above are rounded to the nearest 50.

Without the implementation of the Mobile Source Strategy, California employment is projected to grow at an average annual rate of 0.12 percent between 2016 and 2031.[18] This analysis estimates a higher rate of employment growth across many industry sectors that benefit from reduced fuel costs resulting from zero-and near-zero emission vehicles, and a negligible slowing of employment growth in other industry sectors that produce high emission goods.

California Business Impacts

As indicated in Table A-6, the modeling results show that the implementation of the Mobile Source Strategy could result in a negligible decrease in aggregate output across

[18] As forecasted in REMI under the baseline in which no proposed Mobile Source Strategy Measures are implemented.

all industrial sectors. Sectors with direct compliance costs attributed to the Mobile Source Strategy may see slight reductions in output growth, which is considered a minor percentage change from their projected output levels. Sectors with slowed growth, such as mining, retail trade and other services, are expected to experience indirect impacts as a result of implementing the proposed Mobile Source Strategy measures as businesses and consumers shift away from petroleum-based fuels and adjust spending to account for higher capital costs for zero-and near-zero technologies.

Output growth persists in the utilities and transportation and warehousing sectors, as the Mobile Source Strategy requires a transition away from conventional fuels and technologies, benefitting industries that generate clean energy and those that gain significant fuel savings through capital turnover. For example, truck transportation, which is an industry nested under the transportation and warehousing sectors, will experience a significant fuel savings throughout the implementation of the Mobile Source Strategy. These savings will lead to an increase in output as a result of lower operating costs.

Table A-6: Changes in Output Growth by Sector (2015 $M)

Industry	NAICS	Output		Annual Average	
		2023	2031	Output	Relative to Baseline Growth
Forestry, Fishing and Related Activities	113-115	0.3	0.0	(0.3)	(0.004%)
Mining	21	(80.3)	(338.9)	(540.8)	(1.123%)
Utilities	22	205.2	364.3	245.1	0.469%
Construction	23	357.2	(560.3)	(341.7)	(0.148%)
Manufacturing	31-33	348.2	(563.3)	45.7	0.006%
Wholesale Trade	42	94.3	(357.0)	(116.3)	(0.044%)
Retail Trade	44-45	92.5	(978.0)	(328.2)	(0.128%)
Transportation & Warehousing	48-49	(190.1)	543.2	208.0	0.166%
Information	51	19.8	(252.4)	(161.5)	(0.048%)
Finance and Insurance	52	(46.2)	(467.7)	(348.2)	(0.101%)
Real Estate, Rental and Leasing	53	63.0	(731.2)	(442.1)	(0.067%)
Professional and Technical Services	54	144.7	(311.0)	(164.2)	(0.039%)
Management & Support Services of Companies and Enterprises	55	7.4	(0.2)	(3.8)	(0.006%)
Administrative and Waste Management Services	56	71.8	(115.7)	(51.9)	(0.038%)
Educational Services	61	(9.0)	(61.3)	(44.1)	(0.122%)
Health Care and Social Assistance	62	(46.5)	(492.6)	(339.0)	(0.113%)
Arts, Entertainment, and Recreation	71	(11.0)	(71.3)	(50.8)	(0.088%)
Accommodation and Food Services	72	10.5	(180.8)	(111.5)	(0.080%)
Other Services	81	(31.3)	(301.9)	(159.1)	(0.189%)
Government	92	2,323.2	(327.1)	110.2	0.022%
Total		**3,324**	**(5,203)**	**(2,595)**	**(0.048%)**

The values are interpreted as the reference year value less the baseline value. Therefore these values should not be represented as cumulative values, but instead changes year-by-year. The values presented above are rounded to the nearest $100,000.

Impacts on Investments in California

As modeled, the Mobile Source Strategy would produce very small impacts on private business investment between 2023 and 2031. Table A-7 shows that the annual change in growth of investments in California is, on average, negative and negligible between 2023 and 2031. The change in these investments can be described as the decreased opportunity for private investment due to the higher production costs affecting many industries operating in California.

Table A-7: Change in Gross Domestic Private Investment Growth (2015 $B)

	Gross Domestic Private Investment Growth		Annual Average	
	2023	2031	Private Investment	Relative to Baseline Growth
Gross Domestic Private Investment	0.3	(1.3)	(0.7)	(0.126%)

The value in each year is interpreted as the reference year value less the baseline value in that same year. Therefore these values should not be represented as cumulative values, but instead changes year-by-year. The values presented above are rounded to the nearest $100M.

Impacts on Individuals in California

The Mobile Source Strategy would produce a negligible change in personal income through 2031. Table A-8 shows that the annual change in the growth of personal income in California does not represent a discernable change from the baseline scenario. The results can be described as an increase in spending by consumers on new motor vehicles attributed to the measures in the on-road light-duty source category, an increase in spending by consumers on home and garden equipment attributed to the Small Off-Road Engine measure, and an increase in consumer price for motor vehicle fuels attributed to the Low-Emission Diesel Requirement measure.

Table A-8: Change in Personal Income Growth (2015 $B)

	Personal Income Growth		Annual Average	
	2023	2031	Personal Income	Relative to Baseline Growth
Personal Income Growth	1.9	(2.3)	(1.0)	(0.033%)

The value in each year is interpreted as the reference year value less the baseline value in that same year. Therefore these values should not be represented as cumulative values, but instead changes year-by-year. The values presented above are rounded to the nearest $100M.

Impacts on Gross State Product (GSP)

As presented in Table A-9, the Mobile Source Strategy is estimated to slightly slow the growth of California GSP from 2023 through 2031. The reduction in growth does not represent a discernable change from baseline GSP growth estimates and the overall impact of the Mobile Source Strategy is small relative to the $2.3 trillion California economy. In 2023, there is an estimated increase in the GSP of $1.8 billion, which is negligible relative to the size of the overall California economy. This increase results from purchases and incentives to meet the 2023 SIP attainment deadline. The highest cost year occurs in 2031 when ARB anticipates the largest fleet turnover from conventional to zero- and near-zero emission mobile sources, translated as higher production costs to industry and increased consumer spending, thus bringing GSP down to its lowest level between 2023 and 2031.

Table A-9: Change in Gross State Product (2015 $B)

			Annual Average	
	2023	2031	Gross State Product	Relative to Baseline Growth
Gross State Product Growth	1.8	(3.0)	(1.7)	(0.051%)

The value in each year is interpreted as the reference year value less the baseline value in that same year. Therefore these values should not be represented as cumulative values, but instead changes year-by-year. The values presented above are rounded to the nearest $100M.

Summary and Interpretation of the Results of the Economic Impact Analysis

The actions outlined in the Mobile Source Strategy are designed to transform California's transportation sector. The combination of proposed measures and incentives will shift California from reliance on petroleum-based fuels and vehicles to zero-and near-zero vehicles and fuels. This shift will be represented by changes in the California economy as industry and individuals shift demand to low-emissions technologies and fuels and away from higher emission vehicles, equipment, and fuels. California's industrial sectors are anticipated to face higher prices for vehicles and equipment that will be largely offset by reductions in fuel costs. Industrial sectors can benefit from the proposed measures in the Mobile Source Strategy and manufacturers and producers of advanced technology vehicles and fuels are estimated to experience steady growth as measures are implemented.

In aggregate, the Mobile Source Strategy is estimated to have a negligible impact on the California economy resulting in an average slowing in GSP growth of 0.051 percent from 2023 to 2031. While the cumulative impact of the Mobile Source Strategy is not anticipated to significantly impact the broad California economy, it will incentivize zero- and near-zero emission technology as shown in shifts in employment and output among industrial sectors.

Appendix: Modeling Assumptions for the Economic Impact Analysis of the Mobile Source Strategy

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On-Road Light-Duty

Advanced Clean Cars 2

Building upon technology and market assessments for advanced technology vehicles, lower fleet emissions for the entire light duty fleet through at least 2030 model year, including increases in the number of zero-emission vehicles on the road.

Direct Manufacturing Costs for Additional ZEVs & PHEVs Above Baseline, 2016-2031, ($2015)

	Affected Groups	Costs (Savings)	
		Capital	O&M
Direct	Consumer Spending on New Motor Vehicles	$17B	
	Consumer Spending on Electricity		$1B
	Consumer Spending on Motor Vehicle Fuels		($8.5B)
	Consumer Spending Fuel Oil and Other Fuels		$890M
	Consumer Spending on Motor Vehicle Maintenance and Repair		$460M

Assumptions:

- Implementation period: 2026-2031 (actual regulatory implementation period has not been defined yet).
- Incremental capital cost:[19]
  - $10,000 per vehicle for 414,002 BEVs in California.
  - $8,000 per vehicle for 272,527 FCVs in California.
  - $9,500 per vehicle for 919,637 PHEVs in California.
- Average annual savings in maintenance of $126 per unit[20]
- Incremental changes in fuel and energy have been estimated in the Vision model:

[19] Costs estimated by ARB Staff using incremental ZEV costs from Table 5.4 in the 2012 Advanced Clean Cars ZEV ISOR: http://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf and netting out a 2025MY conventional vehicle baseline cost (above 2016MY). Vehicle populations provided by Vision from scenarios beyond 2025, and represent vehicles placed into the fleet above what would have occurred in the existing regulations through 2031.

[20] 2012 Advanced Clean Cars ZEV ISOR, adjusted for $2105: http://www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf

Average Annual Change in Fuel and Energy Volumes	
Gasoline, billion gallons	-0.41
Diesel, billion gallons	-0.004
Electricity, billion kwh	1.438
Hydrogen, billion kg	0.025

REMI Policy Variables

The REMI policy variables used for this measure are: Consumer Spending on New Motor Vehicles, Consumer Spending on Motor Vehicle Maintenance and Repair, Consumer Spending on Motor Vehicle Fuels, Consumer Spending on Electricity, Consumer Spending Fuel Oil and Other Fuels (Hydrogen), and Consumption Reallocation.

In-Use Performance Assessment

The goal of this measure concept is to ensure that in-use vehicles continue to operate at their cleanest possible level. This is an ongoing further study measure focused on in-use performance and diagnostic inspection procedures. **No NOx reductions are claimed for this measure.**

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

The goals of this measure concept are to accelerate the penetration of zero and near zero-emission vehicles, and to promote in-use efficiency gains related to vehicle miles travelled (VMT) through use of autonomous vehicles and advanced transportation systems. This measure concept is designed to achieve further emission reductions for South Coast attainment in 2023 and 2031.

	Affected Groups	Costs (Savings)	
		Capital	O&M
Direct	Consumer Spending on New Motor Vehicles	$29B	n/a
	State & Local Spending	$15B[21]	n/a

Assumptions:

- Implementation period: 2016-2031
- 2,000,000 ZEVs/PHEVz in SCAQMD by 2031[22]
- Total cost for each ZEV/PHEV after EFMP & Plus Up: $9,500-14,500 [23]
    - State spending will cover the purchase incentives through 2023

REMI Policy Variables – California Control

The REMI policy variables used for this measure are: Consumer Spending on New Motor Vehicles, Consumption Reallocation, and State & Local Spending.

[21] EFMP sunsets 1/1/2024 and the EFMP Plus Up program currently sunsets in 2020.
[22] Vehicle populations provided by Vision
[23] EFMP incentives by income level: http://www.arb.ca.gov/newsrel/efmp_plus_up.pdf

On-Road Heavy-Duty

Lower In-Use Emission Performance Level

The goals of this measure concept are to ensure that in-use vehicles continue to operate at their cleanest possible level. ARB would develop and propose new, supplemental actions to address in-use compliance and to decrease engine deterioration. No NOx reductions are claimed for this measure.

Low-NOx Engine Standard-California Action

Develop and propose strategies to ensure durability and in-use performance from 2023-2027 including:

- Reduced exhaust opacity limits for PM filer-equipped trucks
- More stringent certification and warranty requirements
- 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
- Developing a new heavy-duty inspection and maintenance program to supplement or replace the current smoke testing programs

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Truck Transportation	484	$650M	-	-
Indirect	Motor Vehicle Manufacturing	3361	-	-	$650M

Assumptions:

- Implementation: 2023-2027
- Per-unit incremental cost of 565,000 new trucks meeting the California action is $1,500
- Vehicle useful life: 15 years
- Capital Recovery Factor (5%, 15 yrs)[24]

[24] The capital recovery factor (CRF) is calculated with the formula $i(1+i)\ n\ /[(1+i)\ n\ -1]$ where i is the discount rate (5-percent in this case) and n is the lifetime of the capital. A real discount rate of 5-percent is chosen so as to match the rate of return on an inflation-adjusted 10-year Treasury security.

REMI Policy Variables

The REMI policy variables used for this measure are: Production Cost for Truck Transportation, and Exogenous Final Demand for Motor Vehicle Manufacturing.

Low-NOx Engine Standard-Federal Action

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

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Truck Transportation	484	$1.2B	-	-
Indirect	Motor Vehicle Manufacturing	3361	-	-	$1.2B

Assumptions:

- Implementation: 2024-2031
- All sales of 1,011,000 new trucks meeting the Federal action, with an incremental cost of $50,000
- Vehicle useful life: 15 years
- Capital Recovery Factor (5%, 15 yrs)
- Federal Control: A national control (which will change variables at the national level) will be used in the REMI model to apply the additional production costs to the Truck Transportation sector at the national level. This step will calibrate the model to reflect the California economy with this federal regulation in place.

REMI Policy Variables

The REMI policy variables used for this measure are: Production Cost for Truck Transportation, and Exogenous Final Demand for Motor Vehicle Manufacturing. All variables will be altered at the national level through the national control.

Medium and Heavy-Duty GHG Phase 2

GHG Phase II will include the next generation of GHG standards to build on Phase I of the GHG regulation. New GHG emissions standards will be adopted in California and nationwide and is expected to take effect with model year 2021 for all new heavy-duty

trucks class 2b-8 sold in the nation and model year 2018 for new trailers. No NOx reductions are claimed for this measure.

Advanced Clean Transit

The goal of this measure concept is to continue the transition of transit fleets to cleaner technologies in support of California's air quality, toxics, and climate change goals. This measure concept will consider a variety of approaches to enhance deployment of advanced clean technology and increase the penetration of the first wave of zero-emission heavy-duty technology into transit applications that are well suited to its use.

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	State Spending[25]	n/a	$788M	($693M)	-
Indirect	Motor Vehicle Manufacturing	3361	-	-	$788M
	Electric Power Generation, Transmission and Distribution	2211	-	-	$144M
	Basic Chemical Manufacturing	325	-	-	$21M
	Oil and Gas Extraction	211	-	-	($315M)
	Natural Gas Distribution	2212	-	-	($71M)
	Repair and Maintenance	8111	-	-	($472M)[26]

Assumptions:

- Implementation: 2018-2040
- Bus purchases are distributed evenly between 2018-2031
- No amortization was used in this analysis, as transit agencies do not currently finance buses.
- Battery Electric (BEV)
  - Population of 3,528 buses with an incremental capital cost of $59,445-$245,000 and one-time cost of $20,000 for charging infrastructure per bus
  - Battery packs have lifetime warranty (no mid-life replacement)
  - Annual savings in maintenance of $10,000 per bus
  - Annual savings from LCFS program credits of $8,000 per bus
- Fuel Cell Buses
  - Population of 364 buses with an incremental capital cost of $225,000 - $775,000
  - Two infrastructure purchases are made between 2018 and 2031, totaling $30M

[25] Representative of public transit agencies in the macroeconomic model

[26] While displayed as repair and maintenance, the value also includes LCFS credits which were not modeled in REMI due to modeling limitations. This represents approximately 50% of the savings of $472M.

- Annual O&M per bus ranges from ($7,000) to $16,000 (where LCFS credit value averages $7,000 per bus)
- Incremental cost of $20,000 for 400 Low NOx Diesel buses
- Incremental cost of $50,000 for 2,050 Low NOx CNG
- All incremental costs are covered by Greenhouse Gas Reduction Fund (GGRF)[27] funding
- Average annual fuel volumes[28]:

Fuel/Energy Type	Change
DSL, bg/year	-0.0017
Gas, bg/year	-0.0058
NG, b scf/year	-0.5137
Elec, b kwh/year	0.0994
H2, b kg/year	0.0003

REMI Policy Variables:

The REMI policy variables used for this measure are: Exogenous Final Demand for Motor Vehicle Manufacturing, Exogenous Final Demand for Electric Transmission & Distribution, Exogenous Final Demand for Oil & Gas Extraction, Exogenous Final Demand for Repair and Maintenance, Exogenous Final Demand for Motor Vehicle Parts Manufacturing, Exogenous Final Demand for Basic Chemical Manufacturing, and State Government Spending.

Last Mile Delivery

The goal of this measure concept is to increase the use of advanced clean technology and to increase the penetration of the first wave of zero-emission heavy-duty technologies in applications that are well suited to its use, in support of California's air quality, toxics, and climate change goals.

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Truck Transportation	484	$425M	-	-
	Couriers and Messengers	492	$425M	-	-
Indirect	Motor Vehicle Manufacturing	3361	-	-	$850M

[27] For more information on climate investments made using GGRF funds, visit http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/auctionproceeds.htm .
[28] Vision has provided annual fuel volumes for the Advanced Clean Transit measure.

Assumptions:

- Implementation: 2020-2050
- Incremental cost of $90,000 for 2,000 FCET electric delivery vehicles, requiring 174 fueling sites at $2M for infrastructure[29]
- Incremental cost of $30,000 for 23,500 BEV delivery vehicle requiring 2,344 charging stations at $20,000 per site.[30]
- Capital Recovery Factor: 5% for 15 years

REMI Policy Variables – California Control

The REMI policy variables used for this measure are: Exogenous Final Demand for Motor Vehicle Manufacturing, Cost of Production Change for Couriers and Messengers, and Cost of Production Change for Truck Transportation.

Innovative Technology Certification Flexibility

The goal of this measure concept is to facilitate the penetration of the first wave of zero-emission heavy-duty technology by providing regulatory certification flexibility for innovative technologies, which will expand the application of zero-emission technologies in heavier applications. ARB would develop and propose an Innovative Technology Certification Flexibility (ITR) regulation that would provide defined, near-term ARB engine and vehicle certification flexibility for medium- and heavy-duty vehicles and engines. No NOx reductions are claimed for this measure.

Zero-Emission Airport Shuttle Buses

The goal of this measure concept is to further support market development of zero-emission technologies in the heavy-duty sector by utilizing incentive support, memorandums of understanding, regulations, or a combination of these actions to initiate deployment of zero-emission airport shuttle busses. No NOx reductions are claimed for this measure.

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

This measure concept will provide incentive funding to accelerate the penetration of zero and near-zero equipment beyond the rate of natural turnover achieved through implementation of the other measure concepts identified for on-road heavy-duty vehicles.

[29] Cost estimates from ARB staff
[30] Cost estimates from ARB staff

Assumptions:

- $7M in funding per year from ARB's Low Carbon Transportation Program and AQIP funds, both a component of GGRF.[31]
- $28M in funding per year of District funds from AB 923 and Carl Moyer funds.[32]
- Funding applied from 2016-2020

REMI Policy Variables

State Government Spending is the only REMI variable used.

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

This measure will accelerate the penetration of zero and near-zero equipment and to promote in-use efficiency gain through use of connected and autonomous vehicles, telematics, and intelligent transportation systems.

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Truck Transportation	484	$4.4B	-	-
	State Spending	n/a	$280M[33]	-	-
Indirect	Motor Vehicle Manufacturing	3361	-	-	$4.7B

Assumptions:

- Implementation: 2016-2031
- Incremental capital cost of $51,000
- Vision population: 120,000
- Two implementation periods: 2016-2020 and 2021-2031
  - Incentive funding from ARB's Low Carbon Transportation Program and Carl Moyer funds applied through 2020
  - No incentive funding available 2021-2031
- Capital Recovery Factor (5%,15 yrs)

[31] Information on AQIP and ARB Low Transportation Funding Plans available at http://www.arb.ca.gov/msprog/aqip/fundplan/fundplan.htm.
[32] Information on the Carl Moyer program available at http://www.arb.ca.gov/msprog/moyer/moyer.htm.
[33] From Incentive Funding to Achieve Further Emission Reductions from Heavy-Duty Vehicles measure.

REMI Policy Variables

The REMI policy variables used for this measure are: Exogenous Final Demand for Motor Vehicle Manufacturing, Cost of Production for Truck Transportation, and State Government Spending.

On-Road Heavy-Duty Fuel Volumes

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Truck Transportation	484	-	($8.5)	-
Indirect	Oil and Gas Extraction	211	-	-	($11.7B)
	Electric Generation, Transmission and Distribution	2211	-	-	$320M
	Natural Gas Distribution	2212	-	-	$2.9B
	Basic Chemical Manufacturing (Hydrogen)	325	-	-	$5.8M

Fuel volumes provided by the Vision model:

Average Annual Change in Fuel and Energy Volumes and Energy Volumes for On-Road Heavy-Duty Sources*	
Gasoline, billion gallons	-0.0115
Diesel, billion gallons	-0.2358
Natural Gas, billion scf	6.6388
Electricity, MWh	221,736
Hydrogen, kg	738,688

*Volumes exclude the proposed Advanced Clean Transit measure

REMI Policy Variables

The REMI policy variables used for this measure are: Exogenous Final Demand for Oil and Gas Extraction, Exogenous Final Demand for Electric Generation, Transmission and Distribution, Exogenous Final Demand for Natural Gas Distribution, Exogenous Final Demand for Basic Chemical Manufacturing (Hydrogen), and Cost of Production for Truck Transportation.

Off-Road Federal and International Sources

Measures for which ARB will petition the U.S. EPA and the International Maritime Organization require ARB staff to calibrate the REMI model to reflect the California economy with these federal and international requirements in place. The national control accounts for the increase in production costs to the rail and water transportation sectors attributed to the source populations that are likely to operate in California. These fleet populations are estimated by ARB staff and the Vision model, providing year-by-year estimates of federal and international source populations that are likely to visit California. All measures in the off-road federal and international source category are included in the national control calibration.

More Stringent National Locomotive Emission Standards

This measure will reduce NOx, PM, and GHG emissions from locomotives in order to meet our air quality and climate change goals. ARB would petition U.S. EPA to begin the process of developing new Tier 5 national locomotive emissions standards for criteria and toxic pollutants, and GHG emissions by 2018. ARB would also work with U.S. EPA to develop and propose a remanufacture requirement for non-new locomotives to maximize the use of Tier 4 or better engines, liquefied natural gas, or zero-emission track miles for in use freight and locomotives in California.

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Rail Transportation	482	$3.7B	($1.1B)[34]	-
Indirect	Railroad Rolling Stock Manufacturing	3365	-	-	$2.5B
	Oil and Gas Extraction	211	-	-	($2.9B)
	Construction	23	-	-	$1.2B

Assumptions:

- Implementation:
  - Remanufacture Populations: 2024+
  - New Tier 5 Populations: 2025+
- Incremental cost per unit:
  - Remanufacture: $250,000 per locomotive
  - New Tier 5: $1M per locomotive[35]

[34] O&M savings represents fuel savings and other incremental operating costs that are split between parts, labor, urea consumption and other operating expenses. ARB staff is unable to determine the breakdown of the O&M costs, minus fuel savings, at this time.

- Annual Populations estimated by ARB staff:

Year	Remanufacture Populations *	Tier 5 Populations **
2024	480	-
2025	960	780
2026	1,440	1,560
2027	1,920	2,340
2028	2,400	3,120
2029	2,880	3,900
2030	3,360	4,680
2031	3,840	5,460

*Assuming about 6,000 Tier 4 line haul locomotives for U.S. Class I Railroads by 2024, and an 8% annual remanufacture rate.

***Regulatory Impact Analysis: Control of Emission of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder,* U.S. EPA (2008)

- Incremental O&M cost per locomotive:
  - Remanufacture: $21,600
  - New Tier 5: $60,000
- National level urea infrastructure: $1.5 billion
- Annual savings for Tier 5 line haul locomotives equipped with on-board batteries: $135,000/locomotive
- Locomotive service life: 15 years
- Capital Recovery Factor: (5%, 15 yrs)
- Federal Control: A national control will be used in the REMI model to apply the additional production costs to the Rail Transportation sector at the national level. This step will calibrate the model to reflect the California economy with this federal regulation in place.

REMI Policy Variables

Production Cost for Rail Transportation is the only REMI policy variable used and it is adjusted at the national level.

[35] This incremental cost includes the Tier 5 line haul on-board battery, estimated at $750,000 per locomotive.

Tier 4 Vessel Standards

This measure will reduce emission from ocean going vessels. ARB would advocate with international partners for the International Maritime Organization to establish new Tier 4 NOx and PM standards, plus efficiency targets for existing vessels in Ship Energy Efficiency Management Plans for International Maritime Organization Action.

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Water Transportation	483	$1B	$340M[36]	-
Indirect	Ship and Boat Building	3366	-	-	$1B
	Pesticide, Fertilizer and Other Agricultural Chemical Manufacturing (Urea)	3253	-	-	$170M

Assumptions:

- Water Transportation will absorb all costs
- Annual incremental cost of O&M include operating expenses and Urea consumption
- Capital Recovery Factor (5%, 20 yrs)
- Federal Control: A national control will be used in the REMI model to apply the additional production costs to the Water Transportation sector at the national level. This step will calibrate the model to reflect the California economy with this federal regulation in place.
- Incremental populations from Vision:

[36] O&M costs represent incremental operating costs that are split between parts, labor, urea consumption and other operating expenses. ARB staff is unable to determine the breakdown of the O&M costs, minus urea demand, at this time.

Year	Tier 4 OGV Incremental Population
2025	72
2026	167
2027	205
2028	197
2029	178
2030	165
2031	184

REMI Policy Variables

Production Cost for Water Transportation is the only REMI policy variable used and it is changed at the national level.

Incentivize Low-Emission Efficient Ship Visits

This measure will achieve early implementation of clean vessel technologies (e.g. liquefied natural gas, Tier 3 standards or better) and incentivize vessels with those technologies in California service. ARB staff would work with California seaports, ocean carriers, and other stakeholders to develop the criteria and to identify the best way to incentivize introduction of Super-Efficient Low Emission Ships into the existing fleet of vessels that visit California seaports. No NOx reductions are claimed for this measure.

At-Berth Regulation Amendments

This measure would further reduce emissions from ships at berth and advance the commercialization of near-zero and zero-emission technologies. ARB staff would develop and propose amendments to the current At-Berth Regulation to include other vessel fleets and types.

Assumptions:

- Water Transportation will absorb all costs
- Annual cost of $6.6-11M[37]
- Capital Recovery Factor (5%, 20 yrs)

[37] No incremental capital unit cost is available for this proposed measure, but ARB staff assumes that the total incremental cost will be a capital cost.

- Federal Control: A national control will be used in the REMI model to apply the additional production costs to the Water Transportation sector at the national level. This step will calibrate the model to reflect the California economy with this federal regulation in place.

REMI Policy Variables

Production Cost for Water Transportation is the only REMI policy variable used and is adjusted at the national level.

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

This measure will increase the penetration of cleaner ocean going vessels, locomotive and aircraft technologies, and promote efficiency improvements at the equipment, sector, and systems levels.

	Affected Industries	NAICS	Costs	
			Capital	O&M
Direct	Rail Transportation	482	$4.1B	-
	Water Transportation	483	$1B	-

Assumptions:

- Costs will be estimated using cost estimates from the More Stringent National Locomotive Emission Standards and Tier 4 Vessel Standards measures– distributing capital costs evenly to obtain a 30 tpd reduction.

Measure	Estimated (Annual) Capital Cost	tpd Reduction
More Stringent National Locomotive Emission Standards	$800M	44
Tier 4 Vessel Standards	$100M	25

- Conversion to 30 tpd for annual measure cost:
  - Average annual capital cost to Rail Transportation multiplied by 0.34[38] to reach 15tpd = $800M x 0.34 = **$272M**
  - Average annual capital cost to Water Transportation multiplied by 0.6[39] to reach 15tpd = $100M x 0.6 = **$60M**

[38] 44tpd x 0.34 = 15tpd

- Federal Control: A national control will be used in the REMI model to apply the additional production costs to the Rail and Water Transportation sectors at the national level. This step will calibrate the model to reflect the California economy with this federal regulation in place.

REMI Policy Variables

The REMI policy variables used for this measure are: Production Cost for Water Transportation and Production Cost for Rail Transportation. Both are adjusted at the national level.

[39] 25tpd x 0.6 = 15tpd

Off-Road Equipment Sources

Zero-Emission Off-Road Forklift Regulation Phase 1

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

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Wholesale Trade	42	$11M	($54M)	-
	Truck Transportation	484	$11M	($54M)	-
	Commercial and Industrial Machinery and Equipment Rental and Leasing	5324	$11M	($54M)	-
	Fruit and Vegetable Preserving and Specialty Food Manufacturing	3114	$11M	($54M)	-
Indirect	Other General Purpose Machinery Manufacturing	3339	-	-	$45M
	Electric Power Generation, Transmission and Distribution	2211	-	-	$34M
	Oil and Gas Extraction	211	-	-	($208M)
	Commercial and Industrial Machinery and Equipment Repair and Maintenance	8113	-	-	($43M)

Assumptions:

- The incremental cost per forklift is $12,700, and by 2030 there will be 6,940 new forklifts statewide.
- Industries with an increase in production cost (% of total cost)[40]:
  - Wholesale Trade 25%
  - Truck Transportation 25%
  - Commercial and Industrial Machinery and Equipment Rental and Leasing 25%
  - Fruit and Vegetable Preserving and Specialty Food Manufacturing 25%
- Fuel savings per forklift are $7,495 annually
- Maintenance savings per forklift are $1,560 annually
- Electricity expenses per forklift are $1,253 per forklift
- Capital Recovery Factor (5%, 10 years)

[40] Estimates from Industrial Truck Association market intelligence data

REMI Policy Variables

The REMI policy variables used for this measure are: Cost of Production Change for Wholesale Trade, Cost of Production Change for Truck Transportation, Cost of Production Change for Commercial and Industrial Machinery and Equipment Rental and Leasing, Cost of Production Change for Fruit and Vegetable Preserving and Specialty Food Manufacturing, Exogenous Final Demand Change for Machinery Manufacturing, Exogenous Final Demand for Utilities, Exogenous Final Demand for Oil & Gas Extraction, Exogenous Final Demand for Commercial and Industrial Machinery and Equipment Repair and Maintenance.

Zero-Emission Off-Road Emission Reduction Assessment

The goal of this measure concept is to expand the use of zero-emission technology in non-freight, off-road applications. This further-study measure concept would be a follow-up to off-road measures implemented in the 2023+ timeframe, such as the Zero-Emission Off-Road Phase 1 Regulation, and through it ARB would identify opportunities to further expand the use of zero and near zero-emission technologies in off-road applications. No NOx reductions are claimed for this measure.

Zero-Emission Off-Road Worksite Emission Reduction Assessment

The goal of this measure concept is to advance ZEV commercialization by increasing the penetration of zero-emission technologies. Through this emission reduction assessment and technology review, ARB would analyze developing worksite integration and efficiency technologies, such as connected vehicle, automation, and fleet management technologies in off-road sectors. ARB would also encourage deployment via incentives or by providing credit in the off-road rule. No NOx reductions are claimed for this measure.

Zero-Emission Airport Ground Support Equipment

The goal of this measure concept is to increase the penetration of the first wave of zero-emission heavy duty technology in applications that are well suited to its use, and will encourage the greater use of zero-emission technologies by demonstrating its viability. ARB would transition diesel and Large Spark Ignition (LSI) airport Ground Support Equipment (GSE) to zero-emission technology through strategies including a combination of natural turnover, existing regulations, and incentive funding.

	Affected Industries	NAICS	Costs (Savings)		Change in Demand
			Capital	O&M	
Direct	Air Transportation	481	$3.2M	($24.7M)	-
Direct	Scenic and Sightseeing Transportation and Support Activities	488	$3.2M	($24.7M)	-
Indirect	Other General Purpose Machinery Manufacturing	3339	-	-	($5.1M)*
Indirect	Electric Power Generation, Transmission and Distribution	2211	-	-	$6.8M
Indirect	Oil and Gas Extraction	211	-	-	($40.7M)
Indirect	Commercial and Industrial Machinery and Equipment Repair and Maintenance	8113	-	-	($7.3M)

*Change in demand includes capital purchases and savings on parts

Assumptions:

- Implementation period: 2023-2031
- The per-unit incremental cost for 610 ground support equipment statewide is $8,000[41]
- Average annual per-unit O&M savings is $9,000.
- Average battery replacements every 5 years exceed the cost of average engine replacement cost by $400[42]
- Ground support equipment useful life: 20 years
- Capital Recovery Factor (5%, 20 yrs)

REMI Policy Variables

The REMI policy variables used for this measure are: Cost of Production Change for Air Transportation, Cost of Production Change for Scenic and Sightseeing Transportation and Support Activities, Exogenous Final Demand Change for Other General Purpose Machinery Manufacturing, Exogenous Final Demand for Electricity Generation and Distribution, Exogenous Final Demand for Oil & Gas Extraction, Exogenous Final Demand for Commercial and Industrial Machinery and Equipment (except automotive and electronic) Repair and Maintenance.

[41] Average incremental cost of baggage tug, belt loader and cargo tractor
[42] Provided by Los Angeles International Airport Feasibility Study (2015)

Small Off-Road Engines

The goal of this measure concept is to reduce emissions from Small Off-Road Equipment (SORE), and to increase the penetration of zero-emission technology. SORE units that are subject to ARB regulations are used in residential and commercial lawn and garden equipment, and other utility applications. ARB would develop and propose tighter emission standards, encourage increased use of zero-emission equipment, and enhance enforcement of current emission standards.

	Affected Groups	Costs (Savings)	
		Capital	O&M
Direct	Consumer Spending on Tools and Equipment for House and Garden	$2.6M	
	Consumer Spending on Electricity		$0.5M
	Consumer Spending on Motor Vehicle Fuels, Lubricants and Fluids		($5.2M)

Assumptions:

- Cost of additional exhaust emission controls are $22 for engines between 80 and 225 cc, and $74 for engines 225 cc + assumed to be passed on to consumers[43]
- Incremental cost for electric mowers: $74
- Incremental cost for electric trimmers: $41
- Annual Fuel Savings per unit: $22
- Annual Electricity Usage per unit: $2

REMI Policy Variables

The REMI policy variables used for this measure are: Consumer Spending on Tool and Equipment for House and Garden, Consumer Spending on Electricity Consumption, Consumer Spending on Motor Vehicle Fuels, Lubricants and Fluids, and Consumption Reallocation.

Transport Refrigeration Units Used for Cold Storage

The goal of this measure concept is to advance zero- and near zero-emission technology commercialization by increasing the early penetration of TRUs used for cold storage, and supporting the needed infrastructure developments. ARB would develop a regulation to reduce NOx, PM, and GHG emissions by prohibiting the use of internal

[43] Estimates in $2003

combustion engine powered transport refrigeration units for cold storage in phases, with incentive support for infrastructure. No NOx reductions are claimed for this measure.

Low-Emission Diesel Requirement

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

Assumptions:

- Increase in demand for
  - NAICS 3112: Starch and Vegetable Fats and Oils Manufacturing
  - NAICS 311613: Rendering and Meat Byproduct Processing
  - NAICS 3219: Other Wood Product Manufacturing
- Annual costs calculated using fuel volumes estimated by ARB staff:

Annual Change in Diesel Fuel Prices (aggregate change in consumer spending)	
2023	$ 469,380,000
2024	$ 531,400,000
2025	$ 580,370,000
2026	$ 616,970,000
2027	$ 640,610,000
2028	$ 651,250,000
2029	$ 650,230,000
2030	$ 636,630,000
2031	$ 607,540,000
Total	**$ 5,384,380,000**

REMI Policy Variables

Consumer Spending on Motor Vehicle Fuels is the only REMI policy variable used.

Further Deployment of Cleaner Technologies: Off-Road Equipment Sources

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

	Affected Industries	NAICS	Costs	
			Capital	O&M
Direct	Wholesale Trade	42	$122.5M	-
	Truck Transportation	484	$122.5M	-
	Commercial and Industrial Machinery Equipment Rental and Leasing	5324	$122.5M	-
	Fruit and Vegetable Preserving and Specialty Food Transportation	3114	$122.5M	-
	Air Transportation	481	$122.5M	-
	Scenic and Sightseeing Transportation and Support Activities	488	$122.5M	-
	Consumer Spending on Tools and Equipment for House and Garden	n/a	$45M	-
	Other General Purpose Machinery Manufacturing	3339	-	$735M

Assumptions:

- Costs will be estimated using capital cost estimates from Zero-Emission Off-Road Forklift Regulation Phase 1, Zero-Emission Ground Support Equipment and Small Off-Road Engines – distributing capital costs evenly to obtain a 17 tpd reduction.

Measure	Estimated (Annual) Capital Cost	tpd Reduction
Zero-Emission Off-Road Forklift Regulation Phase 1	$11M	2
Zero-Emission Airport Ground Support Equipment	$500k	<0.1
Small Off-Road Engines	$1.4M	4

- Conversion to 17 tpd for annual measure cost:
    - Average annual cost to Wholesale Trade, Truck Transportation, Commercial and Industrial Machinery Equipment Rental and

Leasing, Fruit and Vegetable Preserving and Specialty Food Transportation and Scenic and Sightseeing Transportation and Support Activities multiplied by 4.25 to reach 8.5tpd = $11.5M x 4.25 = **$49M**

- Average annual increase in Consumer Spending on Tools and Equipment for House and Garden multiplied by 2.125 to reach 8.5tpd = $1.4M x 2.125 = **$3M**

REMI Policy Variables

The REMI policy variables used for this measure are: Production Cost to Wholesale Trade, Production Cost to Truck Transportation, Production Cost to Commercial and Industrial Machinery Equipment Rental and Leasing, Production Cost to Fruit and Vegetable Preserving and Specialty Food Manufacturing, Production Cost to Air Transportation, Production Cost to Scenic and Sightseeing Transportation and Support Activities, Exogenous Final Demand for Other General Purpose Machinery Manufacturing, Consumer Spending on Tools and Equipment for House and Garden, and Consumption Reallocation.