SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

South Coast AQMD

Preliminary Draft Socioeconomic Report

2016 AIR QUALITY MANAGEMENT PLAN

August 2016

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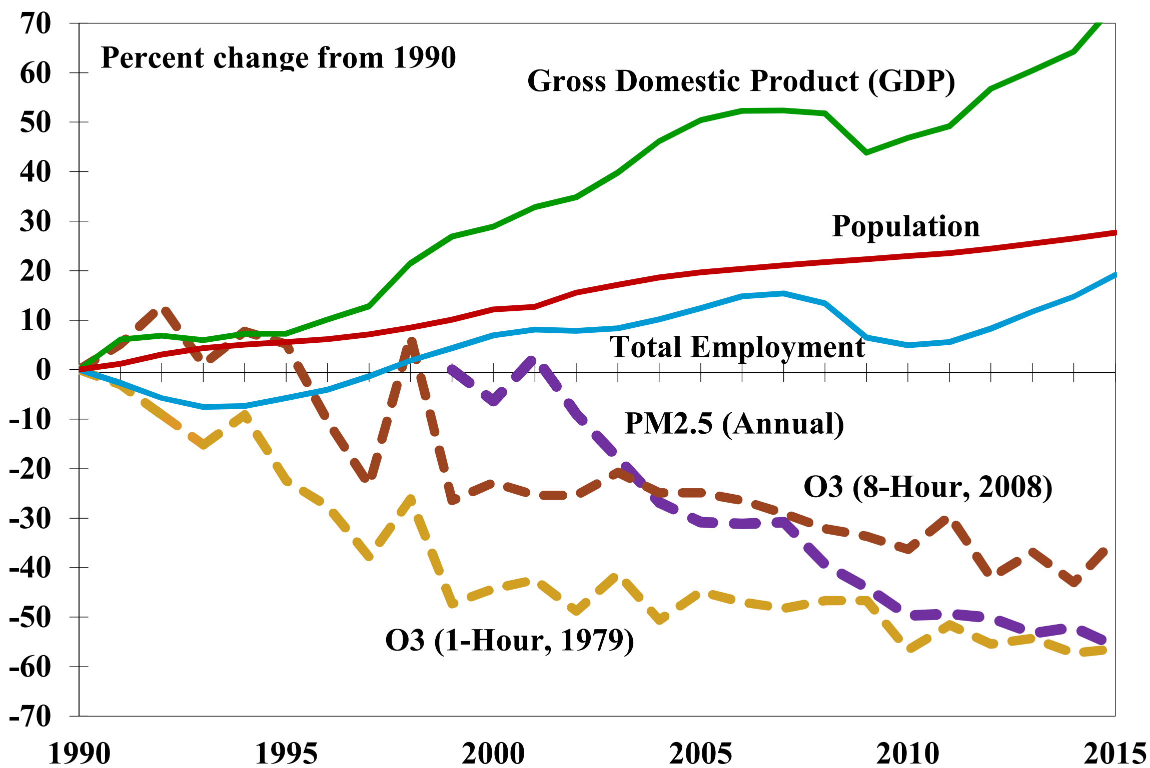
Chapter 1: Introduction

Air quality in the South Coast Air Basin (Basin) has improved significantly over the years, and air quality control programs at the local, state and federal levels have played an important role. These improvements are demonstrated in Figure 1-1, which shows the air quality trends since 1990, including percent changes in the 8-hour ozone concentrations, the 1-hour ozone concentrations, and the annual average concentrations of fine particulate matter (PM2.5) since measurements began in 1999.

Concurrent economic trends, including percent changes in regional gross domestic product, total employment and population, are also depicted in Figure 1-1. The 2007-2009 economic recession, precipitated by the housing market collapse and ensuing worldwide financial crisis, dealt a severe blow to the regional economy and employment. Since then, the slow pace of economic recovery in the nation amid global headwinds continues to cast uncertainties on the sustainability of this recovery. Despite these issues, California has been one of the nation's silver linings in recent years, and the economy of the four-county region—Los Angeles, Orange, Riverside and San Bernardino—is expanding again, with clearly rebounding employment and output numbers that have exceeded pre-recession peaks.

Figure 1-1: Air quality has improved amid population increases and rise in economic activity (SCAQMD Four-County Region, 1990-2015)



Data Sources: SCAQMD, California Department of Finance, California Employment Development Department, U.S. Bureau of Economic Analysis, and REMI.

Economic growth and other human activities generally result in increased air pollutant emissions (i.e., anthropogenic emissions). However, the increased utilization of low-emitting and more energy efficient technologies have nonetheless resulted in decreased ozone and PM levels. Thus, advances in technology demonstrate that it is possible to maintain a healthy economy while improving public health through air quality improvements. This reality has been demonstrated in the past, and with concerted efforts by all stakeholders, can continue into the future.

Challenges to Attain Air Quality Standards

While substantial progress and improvements in air quality have been made, the region still does not meet all federal and state air quality standards set to protect public health. The Draft 2016 Air Quality Management Plan (AQMP) is designed to provide a path to clean air targets and address federal Clean Air Act (CAA) requirements for ozone and PM2.5 standards.

The CAA requires areas not attaining the national ambient air quality standards (NAAQS) to develop and implement an emission reduction strategy that will bring the area into attainment in a timely manner. For ozone and PM2.5, the area is given a classification that describes the degree of nonattainment. This classification dictates specific planning requirements under the CAA, including the time provided to attain the standard. The CAA requires attainment of the standard to be achieved as "expeditiously as practicable", but no later than the attainment years listed in Table 1-1 below**.**

Table 1-1: Air Quality Standards and Latest Attainment Year

<table>
<tr><th>Standard</th><th>Concentration</th><th>Classification</th><th>Latest Attainment Year</th></tr>
<tr><td>2008 8-Hour Ozone</td><td>75 ppb</td><td>Extreme</td><td>2031</td></tr>
<tr><td rowspan="2">2012 Annual PM2.5</td><td rowspan="2">12.0 µg/m³</td><td>Moderate</td><td>2021</td></tr>
<tr><td>Serious</td><td>2025</td></tr>
<tr><td>2006 24-Hour PM2.5</td><td>35 µg/m³</td><td>Serious</td><td>2019</td></tr>
<tr><td>1997 8-Hour Ozone</td><td>80 ppb</td><td>Extreme</td><td>2023</td></tr>
<tr><td>1979 1-Hour Ozone</td><td>120 ppb</td><td>Extreme</td><td>2022</td></tr>
</table>

Note: "ppb" stands for parts per billion and "$\mu g/m^3$" stands for microgram per cubic meter.

The most significant air quality challenge in the Basin is to reduce nitrogen oxide (NOx) emissions sufficiently to meet the upcoming ozone standard deadlines. Although the existing air regulations and programs will continue to lower NOx emissions in the region, an additional 43 percent of NOx emission reductions in the year 2023 and an additional 55 percent in the year 2031 are necessary to attain the 8-hour ozone standards.[1] Since NOx emissions also lead to the formation of PM2.5, the NOx reductions needed to meet the ozone standards will likewise lead to significant improvement of PM2.5 levels and attainment of PM2.5 standards.

Latest Scientific Evidence Relating Ozone and PM2.5 Exposure to Public Health

Ambient air pollution is a major public health concern. Ozone and PM2.5 are the two pollutants being targeted to meet federal air quality standards in the Draft 2016 AQMP and they continue to be linked to increases in illness (morbidity) and increases in death rates (mortality).[2]

In 2013, the U.S. Environmental Protection Agency (U.S. EPA) released the latest Integrated Scientific Assessment (ISA) of ozone and related photochemical oxidants (U.S. EPA 2013). It was concluded in the assessment that there was a causal relationship between short-term ozone exposure and respiratory effects, and a likely causal relationship between long-term ozone exposure and respiratory effects. Short-term ozone exposure was also determined to have likely causal relationships with mortality and cardiovascular effects. U.S. EPA additionally identified groups with increased risk from ozone exposure such as outdoor workers, individuals with asthma, children, elderly adults, and people with certain vitamin deficiencies. As a result of these findings, in 2015, the U.S. EPA revised the 8-hour ozone standard to 70 ppb from 75 ppb. While the Basin needs to attain the 2008 standard of 75 ppb in 2031, the attainment deadline of the 2015 standard of 70 ppb is anticipated to be 2037 if the Basin retains the designation as an extreme nonattainment area.

With regard to particulate matter, the 2009 ISA[3] released by the U.S. EPA concluded that both mortality and cardiovascular effects had a causal relationship with both short- and long-term PM2.5 exposures (U.S. EPA 2009). Respiratory effects were also likely to have a causal relationship with short and long-term exposure to PM2.5. Numerous studies showing the causal relationship between PM2.5 and negative health effects have been closely scrutinized with the data being reanalyzed by additional investigators. The re-analyses confirmed original findings, and there were additional studies reviewed in the 2009 ISA that confirmed and extended the range of the adverse health effects of PM2.5 exposures. As a result, in 2012, the U.S. EPA revised the PM2.5 annual average standard to 12.0 μg/m^3, which the Basin needs to attain in 2025 as a serious nonattainment area.

In a systematic literature review commissioned by the South Coast Air Quality Management District (SCAQMD), Industrial Economics, Inc. (IEc) found 27 studies published since 2012 that

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[1] Estimates are based on the inventory and modeling results and are relative to the baseline emission levels for each attainment year (see Draft 2016 AQMP for detailed discussion).

[2] See Appendix 1 of the Draft 2016 AQMP for a discussion of these studies.

[3] The 2009 PM ISA is currently being updated, with draft materials being circulated for public input.

assessed the relationship between mortality and PM2.5 exposure that were conducted in the U.S. or Canada. Four studies focused on effects of PM2.5 exposures on populations within California or within the Los Angeles metropolitan area specifically. Collectively, these newer studies provided additional evidence to support the U.S. EPA's determination of a causal association between PM2.5 exposure and mortality due to both short- and long-term exposure. (Industrial Economics, Inc. 2016a)

Legal Requirements for Socioeconomic Analysis

Both the SCAQMD Governing Board and the California Health & Safety Code require preparation of a socioeconomic analysis whenever the SCAQMD adopts or amends emission reduction rules or regulations. Although these requirements do not apply to preparation of the AQMP, the SCAQMD nonetheless elects to perform a separate socioeconomic analysis of the AQMP in order to further inform public discussions and the decision-making process associated with adoption of the Plan.

In so doing, SCAQMD staff is guided by a Governing Board Resolution adopted in 1989. That resolution directed staff to prepare an economic analysis of all emissions reduction rules proposed for adoption or amendment. The analysis was to include the following elements: identification of affected industries, cost effectiveness of control, and public health benefits in any such analysis.

Staff is additionally guided by the California Health & Safety Code requirements for socioeconomic analyses prepared during the rulemaking process. In particular, Health and Safety Code Section 40440.8 lists relevant impacts to be considered in a socioeconomic analysis. These impacts include:

(1) The type of industries affected by the rule or regulation.
(2) The impact of the rule or regulation on employment and the economy in the Basin.
(3) The range of probable costs, including costs to industry, of the rule or regulation.
(4) The availability and cost-effectiveness of alternatives to the rule or regulation.
(5) The emission reduction potential of the rule or regulation.
(6) The necessity of adopting, amending, or repealing the rule or regulation in order to attain state and federal ambient air standards.

Health and Safety Code Section 40728.5 identifies similar impacts to be discussed in a socioeconomic analysis and additionally states that efforts shall be made to minimize any adverse impacts.

Finally, staff may also consider Health and Safety Code Sections 39616 and 40920.6 during its preparation of the socioeconomic analysis. Section 39616 requires the SCAQMD to ensure that any market-based incentive strategy it adopts results in equivalent or greater emission reductions at equivalent or less cost and overall job impacts – i.e., no greater job losses or significant shifts from high-paying to low-paying jobs – when compared to command-and-control regulations. Section 40920.6, requires that incremental cost effectiveness – i.e., the difference in costs divided by difference in emission reductions – be performed whenever more than one control option is feasible to meet control requirements.

Economic Outlook for the Potentially Affected Industries by the Draft 2016 AQMP

Nearly 18 million people currently reside in the counties of Los Angeles, Orange, Riverside and San Bernardino. The four-county regional economy generates more than one trillion dollars of gross domestic product and employs 8.2 million workers, with a five to seven percent unemployment rate among the four counties.[4,5,6] Total employment in the region is forecast to grow at an annualized rate of 1.4 percent between 2012 and 2022,[7] according to the long-term projections by the California Economic Development Department (EDD). To date, regional employment growth has far outpaced the projected rate: between July 2012 and July 2016, total employment in the region has increased at an annualized rate of nearly 2.5 percent.[8]

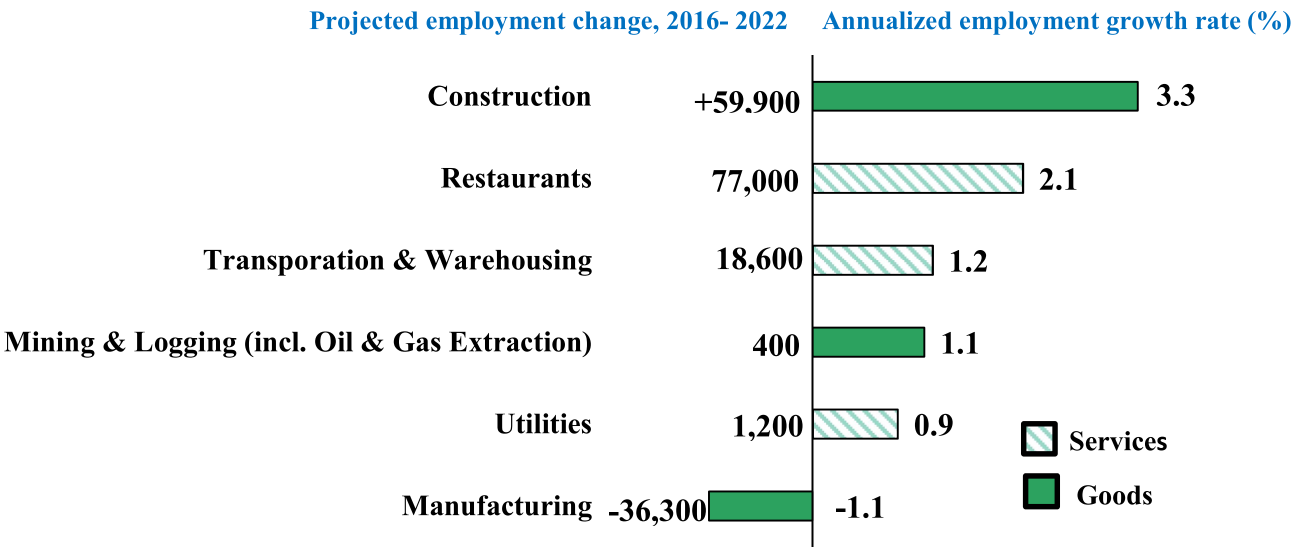
The Draft 2016 AQMP includes control strategies for emission reductions from both stationary sources and local strategies for mobile sources, as well as broader mobile source control measures proposed by the California Air Resources Board (CARB) that would contribute to further emission reductions and help the region attain upcoming NAAQS. These strategies are comprised of both command-and-control regulations and incentive programs, as well as further deployment of advanced clean technologies. These proposed control strategies could potentially affect both public and private sectors, but are expected to mainly impact the nine private sector industries as listed below:

- Oil & Gas Extraction
- Utilities
- Construction
- Manufacturing
- Nurseries, Wholesale Garden
- Transportation & Warehousing
- Equipment Leasing and Rental
- Waste Management
- Restaurants

[4] California Department of Finance, State/County Population Estimates as of January 1, 2016.
[5] U.S. Bureau of Economic Analysis, 2014 GDP estimates for Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino-Ontario metros.
[6] California Economic Development Department (EDD), preliminary estimates as of July 2016, civilian employment only. A five-percent unemployment rate is generally considered as "full employment" by the Federal Reserve.
[7] Total employment represents the total job count which includes all workers who are primarily self-employed and wage and salary workers who hold a secondary job as a self-employed worker.
[8] EDD, Current Employment Statistics (CES), July 2012 and July 2016.

Figure 1-2 shows the regional employment outlook between 2016 and 2022 for the potentially affected industries, based on EDD projections.

Figure 1-2: Construction leads projected employment growth while manufacturing declines



Note: 1) Job changes are rounded to nearest '00 and growth is rounded to the 1st place decimal.
2) Employment projections are not available for the affected industries of nurseries and wholesale garden, equipment leasing and rental, and waste management.
Source: Staff analysis of the EDD Long-Term (10 years) Industry Employment Projections for 2012-2022.

Both SCAQMD and CARB's mobile source strategies would primarily affect passenger transportation and the "goods movement" sector, the core of which constitutes freight transportation and warehousing. The goods movement sector plays a pivotal part in the regional economy. It provides the critical service of delivering goods between the region's seaports and airports and businesses across the nation. It also serves the fast-growing consumer demand for retail products purchased online.[9] The strong dollar and demand for imports, coupled with increases in e-commerce and the competition among the retailers to shorten delivery time, especially to large urban markets, puts a growing number of high-cube distribution centers in the Inland Empire at a strategic economic advantage. The transportation and warehousing sector

[9] According to the 2013 market research by eMarketer, online retail in the U.S. grew by 16.4 percent from 2012 to 2013 and totaled $262.3 billion in sales; by 2017, it was expected to reach $440 billion (Jones 2013).

currently provides 282,000 jobs in the region.[10] Over the next six years, the sector as a whole is expected to grow at an annualized rate of 1.2 percent, adding 18,600 jobs to the region between 2016 and 2022.[11] Much of this job growth will be concentrated in the Inland Empire. Currently, average pay in this sector ranges from $38,000 in Riverside County to $56,000 in Los Angeles County, which are respectively seven percent below the average wage in Riverside County and about the average wage in Los Angeles County.[12]

The manufacturing sector would be affected by stationary source measures targeting NOx and VOC emissions, which include both command-and-control regulations and incentive programs to accelerate facility modernization. In the meantime, transportation equipment manufacturers in the region and nationwide would benefit from the incentive programs proposed to accelerate the deployment of zero and near-zero emission technologies, as part of the mobile source control strategies. The manufacturing sector in the region currently provides 613,000 jobs; however, the sector's total employment level is expected to mirror the nationwide trend and continue its long-term decline (see Figure 1-3). Manufacturing employment is projected to decrease by approximately 36,000 jobs between 2016 and 2022, or at an annualized rate of one percent. Over 80 percent of the projected manufacturing job losses would occur in Los Angeles County where the industry is concentrated.

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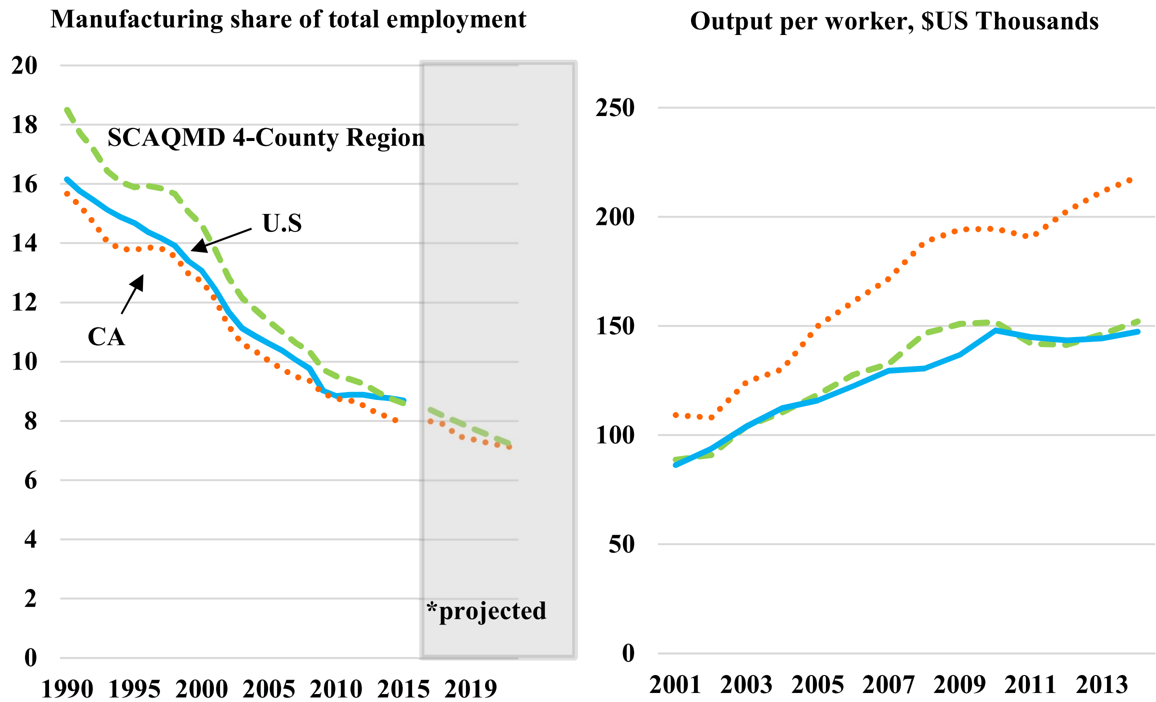
[10] Based on EDD's CES for July 2016. All current employment numbers listed below are from this source unless otherwise noted.

[11] Based on EDD Long-Term (10 years) Industry Employment Projections for 2012-2022. All employment projections discussed below are from this source: http://www.labormarketinfo.edd.ca.gov/data/employment-projections.html

[12] Historical wage data from California Employment Development Department's Quarter Census of Employment and Wage (QCEW) database for 2015 Q3 wages. All the wage data in this section is from this source unless otherwise noted and is reported for the county with the lowest average annual wage in a specific industry and the county with the highest. The average wage represents the average of all industries covered by QCEW in both private and public sectors. According to EDD, the average annual pay is affected by the ratio of full-time to part-time workers; the number of workers who worked for the full year; and the number of individuals in high-paying and low-paying occupations. When comparing average pay levels between geographic areas and industries, these factors should be taken into consideration. For example, industries characterized by high proportions of part-time workers will show average wage levels appreciably less than the pay levels of regular full-time employees in these industries. The opposite effect characterizes industries with low proportions of part-time workers, or industries that typically schedule heavy weekend and overtime work. Average wage data also may be influenced by work stoppages, labor turnover, retroactive payments, seasonal factors, bonus payments, and so on.

Figure 1-3: Output per worker increases despite steady decline in manufacturing



Data sources: U.S. Bureau of Labor Statistics and U.S. Bureau of Economic Analysis.

Despite the industry's shrinking workforce, its output per worker has increased over time, rising from $89,000 to $152,000 (in 2015 dollars) over the 2001 to 2014 time period (see Figure 1-3).[13] Currently, the average pay in the sector ranges from $50,000 in Riverside County to $69,000 in Orange County, paying about a quarter more than the average wages in these counties. Both chemical manufacturers and refineries are expected to be impacted by stationary source measures. Chemical manufacturing pays slightly higher with average pay ranging from $58,000 in Riverside County to $70,000 in Orange County. Petroleum manufacturing pays substantially higher, ranging from $75,000 in Riverside County to $117,000 in Los Angeles County.

Transportation equipment manufacturing and its related industries will be key partners in the joint effort to reduce mobile source emissions, as it plays a pivotal role in the research, development and deployment (RD&D) of advanced clean transportation technologies, whether they apply to light-duty passenger cars or heavy-duty commercial trucks. Funding programs can help lower the upfront financial barriers for deploying cleaner technologies and realize long-term benefits such as fuel-savings. Long-term cost-savings can potentially become greater over time as the sector shifts towards producing not only the hardware but the software that will be needed to help increase fuel efficiency. Past funding programs have incentivized several truck engine manufacturers to develop and demonstrate that ultra-low NOx technologies (0.02 g/bhp-hr) are technically feasible.

[13] Output from the U.S Bureau of Economic Analysis and employment data from the U.S. Bureau of Labor Statistics.

These technologies have provided the basis for CARB's Low-NOx Engine Standard control measure for heavy-duty vehicles, proposed as part of the State Implementation Plan (SIP). Currently, the transportation equipment manufacturing industry provides 62,000 jobs in coastal counties and is projected to decline about one percent annually from 2016 to 2022. The average wage in this sector ranges from $41,000 Riverside County to $88,000 in Los Angeles County, which is about the overall average wage in Riverside County and nearly 60 percent higher than the average wage in Los Angeles County.

Restaurants would be affected by a NOx measure that proposes the installation of cleaner cooking equipment. Restaurants are one of the region's major small business employers with nearly all establishments employing fewer than 100 people.[14] It currently provides 591,000 jobs and accounts for about eight percent of overall employment in the region. Between 2016 and 2022, restaurant employment is projected to grow by two percent annually, adding 77,000 jobs in total over this time period. Growth in this industry is expected to be fairly similar across all counties. However, restaurants typically offer lower paying jobs—the recent annual compensation is on average about $17,000 in Riverside County to $20,000 in Los Angeles County, more than 60 percent below the average wages in these counties.

Energy producers, who are broadly considered to include the oil and gas industry and the utilities sector, would also be affected by the proposed control measures. Oil and gas extraction is a highly capital intensive industry. While the industry's total output was as high as $1.4 billion in 2012,[15] it provides only a few thousand jobs[16] in the region and pays on average six-figure wages that are similar to or higher than in the petroleum manufacturing industry. The industry sector of utilities currently provides 21,000 jobs in the region. It offers high paying jobs in all counties with average pay ranging from $90,000 in San Bernardino to $101,000 in Orange County, which is 130 and 80 percent higher than the average wage in the respective counties. The employment level for energy producers is projected to remain relatively flat between 2016 and 2022.

Additionally, the industry of waste management and remediation service would be impacted by a VOC/PM2.5 measure. The industry currently provides 18,000 jobs[17] and average pay ranges from $54,000 in San Bernardino County to $61,000 in Orange County, which is about 30 and eight percent more than the average wage in their respective counties. Construction, the fastest growing industry in the Basin, is expected to be directly affected by mobile source strategies incentivizing the conversion to cleaner equipment and a stationary source strategy regulating the VOC content of coatings, solvents, adhesives, and sealants. In the meantime, however, construction could

[14] Based on the establishment-by-size data for the four counties from the U.S. Census Bureau's 2014 County Business Patterns Database.

[15] Bureau of Economic Analysis.

[16] CES data do not provide employment estimates for the oil and gas extraction industry; however, this industry belongs to the broader sector of mining and logging, with current employment estimated at about 5,000. Moreover, the QCEW data indicated that, in Los Angeles County alone, the oil and gas extraction industry supplied approximately 2,000 jobs in the third quarter of 2015.

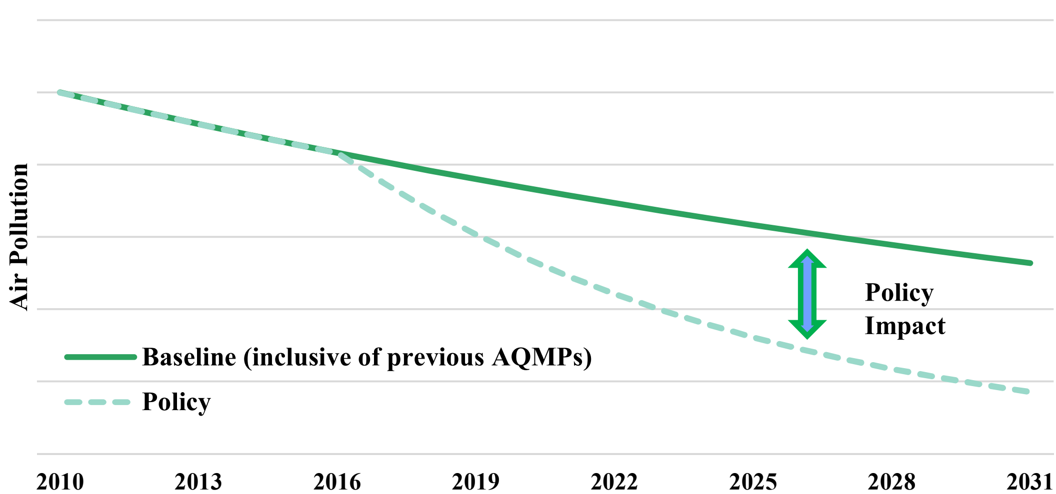
[17] Unlike other current employment estimates, this figure is based on the QCEW 2015 third quarter data.

potentially benefit from additional revenues from installing control equipment. Currently, the construction industry provides 322,000 jobs in the region, and the industry's employment is projected to grow at an annualized rate of 3.3 percent, adding 59,900 jobs between 2016 and 2022. The average pay in the sector ranges from $50,000 in Riverside to $63,000 in Orange County, about 25 and 15 percent higher than the average job in the respective counties. Finally, the proposed control measures would also affect segments of the retail and wholesale trades (e.g., nurseries and wholesale garden suppliers), as well as commercial and industrial machinery and equipment rental and leasing.

Baseline Definition for Socioeconomic Assessment

A fundamental component in the practice of socioeconomic analysis is the definition of the baseline for analysis. The "baseline" is often referred to as the business-as-usual scenario, to which an alternative scenario with a project or plan implemented is compared (i.e., the "policy" scenario). The difference between the baseline and policy scenario is the policy impact (an example of this is illustrated in Table 1-4).

Figure 1-4: Illustrative Example of Baseline and Policy Scenarios



For the purpose of this socioeconomic analysis, the impacts of the Draft 2016 AQMP, which is implemented in the policy scenario,[18] are evaluated with respect to the baseline scenario, which

[18] "Policy scenario" is used interchangeably with "control scenario" throughout the report, particularly in the discussion of regional air quality modeling as an input to the quantification of public health benefits.

is a projection of the regional economy *without* the implementation of the control measures described in Draft 2016 AQMP.[19] The baseline scenario is inclusive of any effects that have not yet occurred but are projected to occur as a result of all existing plans, regulations, and policies, including those adopted and implemented pursuant to previous AQMPs. Specifically, all SCAQMD rules adopted as of December 2015 and all CARB rules adopted by November 2015, are incorporated into the baseline, while rules after these dates are not (for more information see Draft 2016 AQMP Appendix 3-B).[20]

The baseline scenario analyzed in this report is derived from the 2016 Growth Forecast, which is a long-term demographic and employment forecast developed by the Southern California Association of Governments (SCAG 2016). SCAG's growth forecast was used to guide the development of its 2016 Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS), and it was also used by the SCAQMD to develop the baseline emissions inventory for the Draft 2016 AQMP and thus for air quality model projections. This growth forecast assumes that the four-county region would continue receiving federal highway funding to make the necessary infrastructure investments for implementing the 2016 RTP/SCS to keep the region competitive nationally and globally. For this reason, the baseline scenario for both emission inventory and socioeconomic analysis purposes includes implementation of the 2016 RTP/SCS.

The socioeconomic analysis herein attempts to address any deviations from the baseline as the Draft 2016 AQMP is fully implemented in terms of benefits of cleaner air, incremental costs of control strategies, and spillover impacts of direct benefits and costs. These deviations represent the socioeconomic impact of the Draft 2016 AQMP, and they do not overlap with any cost, benefit, and macroeconomic impacts analyzed for the 2016 RTP/SCS. The impacts of the 2016 RTP/SCS are separately summarized and discussed in Appendix 4-C of the Draft 2016 AQMP. Similarly, the air quality improvements projected in the Draft 2016 AQMP do not overlap with any emission reductions attributable to the 2016 RTP/SCS or any of its components such as the Transportation Control Measures (TCMs). TCMs are included in the Draft 2016 AQMP for air quality conformity purposes (for more information see Chapter 4 and Appendix 4-C of the Draft 2016 AQMP).

This baseline definition is employed consistently throughout the socioeconomic analysis both for quantifying costs and benefits, and for determining regional macroeconomic impacts from implementation of Draft 2016 AQMP control strategies. The costs evaluated in this socioeconomic analysis are the total incremental cost expected to be incurred due to Draft 2016 AQMP control strategies. Any costs associated with TCMs and TCM-type projects included in SCAG's 2016 RTP/SCS are excluded from this analysis. Public health benefits reflect air quality improvements attributable to the Draft 2016 AQMP control measures. Any benefits associated with TCMs and TCM-type projects included in SCAG's 2016 RTP/SCS are excluded from this analysis. The

[19] These "without" (baseline) and "with" (policy) scenarios are different than "before" and "after" scenarios, because they control for changes over time.

[20] This includes the reduction in RECLAIM trading credits (RTCs) by 12 tpd by year 2022, which was adopted by the SCAQMD Governing Board in December 2015.

regional macroeconomic impact model, REMI PI+ v1.7, baseline forecast is updated with employment and population forecast from SCAG (2016), ensuring that the baseline used for costs and benefits analyses is consistent with that used for macroeconomic modeling (for more information see Appendix 4 of this report).

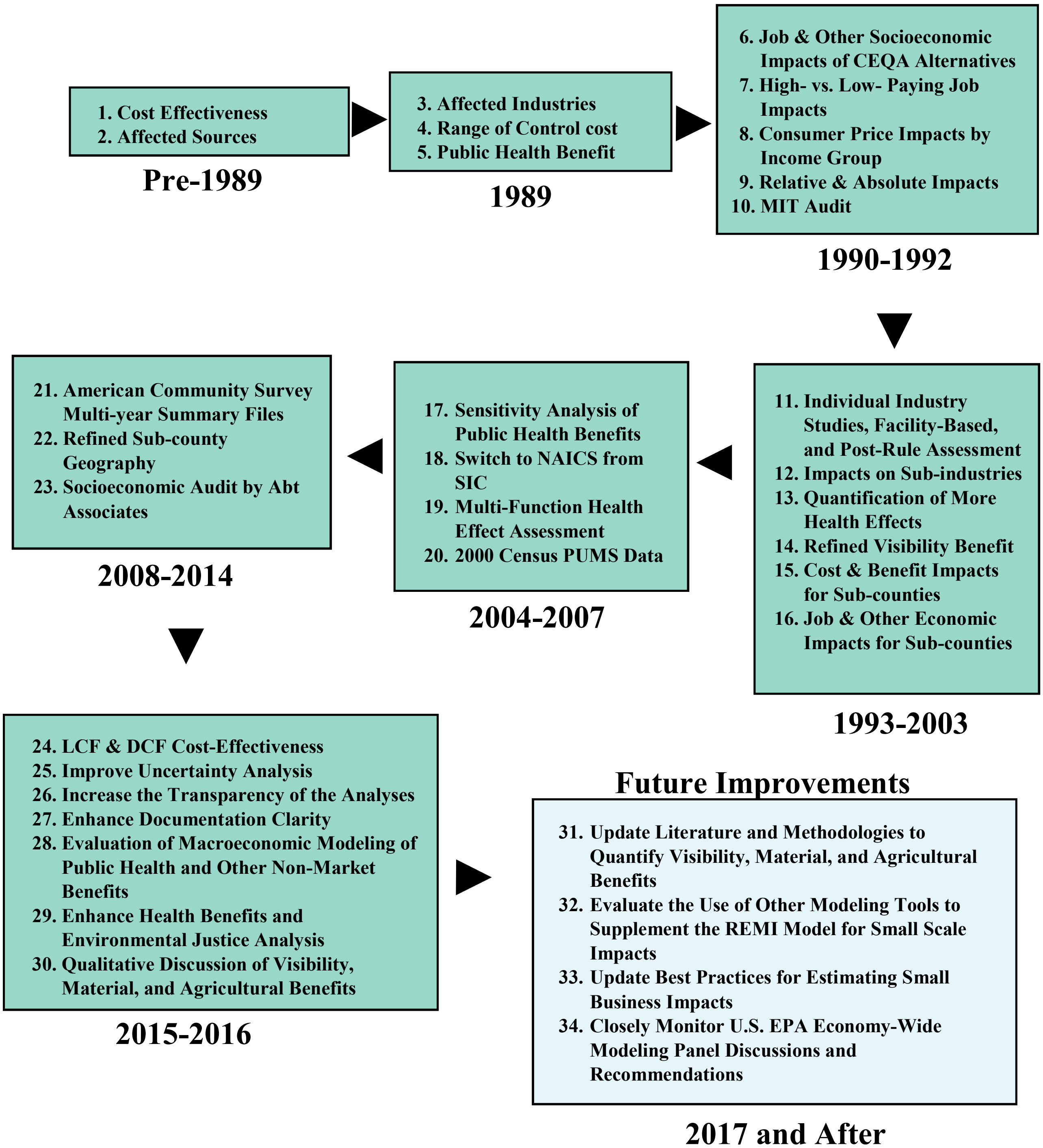
The socioeconomic analysis horizon is from 2016 to 2031, where 2016 is expected to be the year when the 2016 AQMP is adopted and 2031 is the last year of the planning horizon, at which time the federal 8-hour ozone standard will need to be attained (see the Draft 2016 AQMP for the attainment demonstration). SCAG forecasts employment and population in the four-county region to grow by 16 percent and 11 percent, respectively, from 2016 to 2031. The County of Riverside is projected to grow at the fastest pace: its employment is projected to increase by 36 percent and population by 22 percent over the period of 2016 to 2031.

It should be noted that the receipt of federal highway funding for transportation investment in the region hinges on adopting an appropriate plan to achieve the federal air quality standards (i.e., the highway sanction clause in the CAA). Ultimately, failure to attain these standards could have undesirable economic consequences for the region if it results in the inability to have an approvable plan or results in a failure to implement the plan. However, this outcome is not incorporated into the baseline as the purpose of this socioeconomic analysis is to evaluate the impact of the Draft 2016 AQMP, not the impacts of a scenario where the region is penalized for failure to attain NAAQSs.

Current Socioeconomic Analysis Program

SCAQMD staff continually seeks to improve its analysis of socioeconomic impacts by expanding the scope of analysis, as well as the methods and tools utilized. Over the years, the SCAQMD socioeconomic analyses have evolved as shown in Figure 1-5. The evolution has been informed by two major reviews of the socioeconomic assessment procedures and guided by the Scientific, Technical and Modeling Peer Review (STMPR) Advisory Group members, who are economists from academia, other government agencies (SCAG, CARB, and U.S. EPA), the Center for Continuing Study of California Economy (CCSCE), and other economic research and consulting firms. The first comprehensive review was conducted by the Massachusetts Institute of Technology (MIT) in 1992 (Polenske, et. al 1992). This review found that the SCAQMD surpassed most other agencies in analytical methods and recommended further enhancements, which included using alternative approaches in certain areas and working with the regulated community and socioeconomic experts to refine its socioeconomic assessment.

Figure 1-5: Evolution of Socioeconomic Analysis



In 2014, Abt Associates, Inc. (Abt) conducted the second comprehensive review of the SCAQMD's socioeconomic assessments (Abt Associates 2014). This review found that the SCAQMD socioeconomic assessment is more comprehensive in both breadth and depth relative to those conducted by the majority of other agencies considered in Abt's evaluation effort. Abt also found that SCAQMD staff uses sound methodologies to analyze costs, health benefits, and economic impacts. For further enhancements, Abt provided a list of major and minor recommendations.

The key recommendations concerned multiple areas. First, Abt recommended that SCAQMD clearly define the baseline and policy scenarios, specifically, whether SCAG's TCMs and their associated benefits and costs are considered as part of the AQMP policy scenario. Second, while Abt supported the continued use of REMI for economic impact analysis, it recommended that SCAQMD staff: 1) use other modeling tools and analysis for small industry sectors and small businesses; 2) improve the REMI amenity inputs; and 3) keep abreast of the U.S. EPA's development of methods for applying benefits in economy-wide models. In addition, Abt advised that SCAQMD improve the uncertainty analyses, expand the environmental justice (EJ) analysis, and institute a systematic process to review and update recent literature in specific areas. Finally, in the interest of transparency, Abt recommended that the SCAQMD: 1) involve the scientific advisory group; 2) increase public outreach; 3) make the peer review process clearer; and 4) enhance documentation and clarity to consider different types of audiences.

Between the two reviews, there have been a number of major enhancements to the SCAQMD socioeconomic assessment. In 2000, towards the goal of expanding its analysis tools, SCAQMD staff commissioned BBC Research and Consulting to examine approaches to assess impacts of proposed regulations on a spectrum of facilities and to evaluate impacts of rules after their adoption. The study results indicated the need to employ a variety of external data sources, construct internal time series data, and explore data sharing opportunities with other governmental agencies.

Beginning in 2000, published economic statistics at the industry level have moved away from the Standard Industrial Classification (SIC) system to the North American Industrial Classification System (NAICS) to include new and emerging industries such as information technologies, among others. In 2006, all the potentially affected point source facilities in the 2002 emission inventory were re-designated with appropriate NAICS codes. The American Community Survey (ACS) continuously samples population to provide up-to-date demographic statistics to supplement information not provided by decennial censuses. There are ACS one-year, three-year, and five-year estimates for various purposes. The 2006 to 2008 estimate was used to expand the four-county geography to 21 sub-regions from the previous 19 regions.

Since 2007, SCAQMD staff has used the Environmental Benefits Mapping and Analysis Program (BenMAP) to assess health benefits associated with reductions in exposure to criteria pollutants. BenMAP is currently maintained and used by the U.S. EPA to assess health benefits of federal rules. It is a geographic information system (GIS) application which integrates epidemiological studies with air quality and demographic data, as well as economic valuation methodologies to quantify health effects associated with pollutant concentration and economic values associated with these effects.

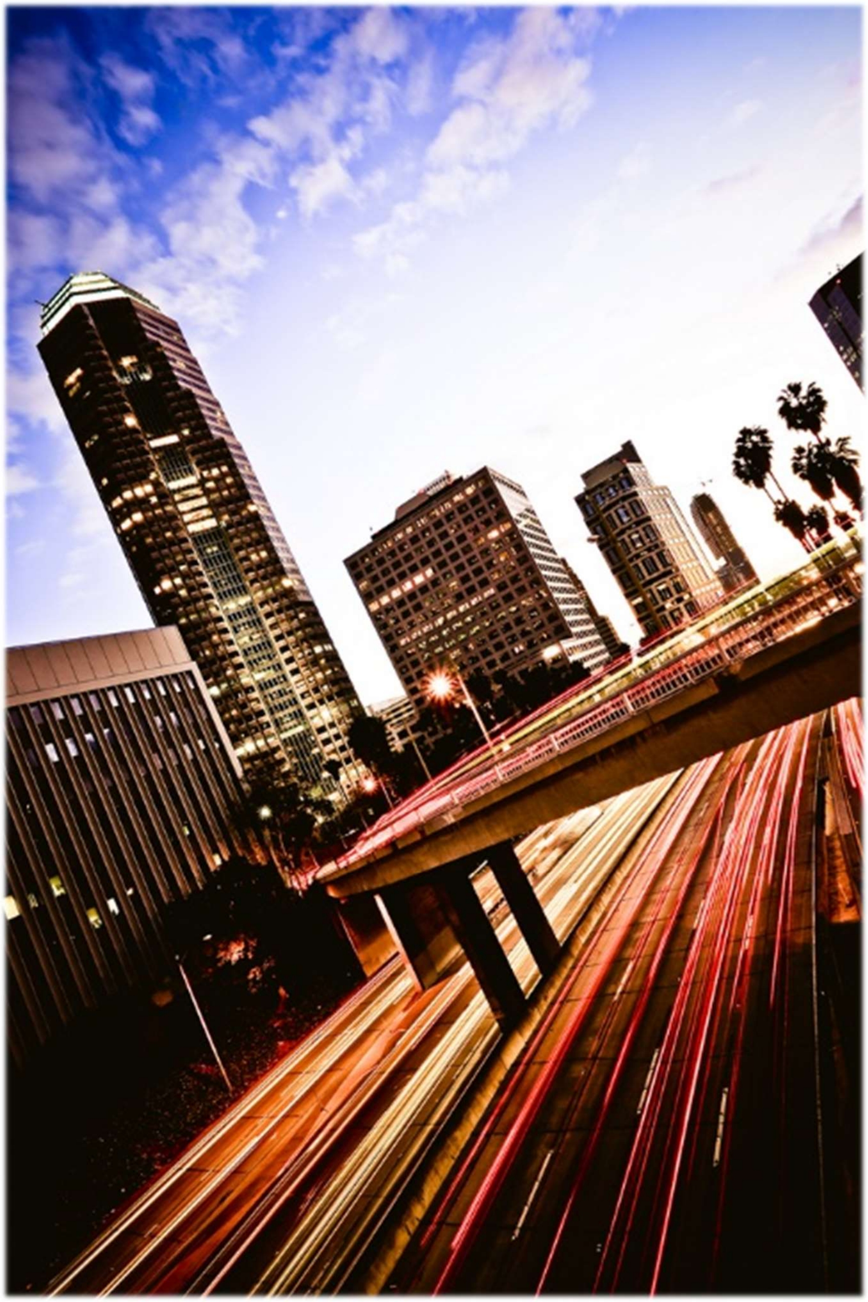
In preparation for development of the socioeconomic assessment of the Draft 2016 AQMP, SCAQMD staff has consulted with the AQMP Advisory Group, the STMPR Advisory Group, SCAG, CARB, California Department of Finance, and U.S. EPA staff, as well as independent consultants to discuss possible and future refinements to data collection, modeling, and other aspects of socioeconomic of analyses. In 2015, SCAQMD staff continued to refine its socioeconomic analysis as recommended by Abt. During 2015, staff held multiple study sessions with SCAG staff and consultants and came to consensus on the most suitable approach to define the baseline for the socioeconomic analyses. Three Requests for Proposals were issued relative to analysis of health benefits, environmental justice, and small scale economic impacts. A contract was issued for a third-party evaluation of macroeconomic modeling of public health and other non-market benefits. Based on a stakeholder request that was documented in the Abt report, but not recommended in the Abt report, another contract was issued for analysis of the health impacts of unemployment in the SCAQMD region. The findings of the latter two contracts were published and made available to the public (Lahr 2016; Tekin 2015).[21]

In addition, an Ad Hoc Governing Board Committee on Large Compliance Investments and Regulatory Uncertainty was formed in 2015 to evaluate recent concerns raised by the business community regarding investing in pollution control technologies only to have them become stranded assets as a result of later rule amendments. In 2016, the 2016 AQMP--Socioeconomic Assessment EJ Working Group was formed to further engage stakeholders to help staff enhance the impact analyses on EJ communities.

In addition to enhancements made to the costs, benefits, macroeconomic impact, and EJ analyses, other Abt recommendations are also implemented throughout this report. They include improving the uncertainty analyses, increasing the transparency of the analyses, increasing public outreach, making the peer review process more transparent, and enhancing documentation and clarity to consider different types of audiences. The implementation of the Abt recommendations will be discussed in detail in the ensuing chapters and summarized in the closing chapter.

[21] The Evaluation of Macroeconomic Impacts of Non-Market Benefits can be found here: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/lahr_evalmacroeconimpacts_041716.pdf?sfvrsn=2
The Final Report on Unemployment and Health can be found here: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/unemploymentandhealth_dec2015_012616.pdf?sfvrsn=2

Chapter 2: Incremental Costs



Preface

Incremental costs for SCAQMD control measures estimated herein are based on preliminary cost data and assumptions and are subject to revision. For example, revisions to control measures are underway based on the receipt of public comments. Those revisions could, and likely will change this analysis. Revisions may be also necessary for a number of control measures where the total cost of equipment may have been considered as an incremental cost.

Incremental costs for CARB mobile source control strategies utilized data and assumptions provided by CARB staff and are consistent with the underlying data for CARB's Mobile Source Strategy, Appendix A: Economic Impact Analysis. In consultation with CARB staff, alternative incentive funding scenarios are currently being explored. These scenarios may be incorporated into the subsequent revisions of the Socioeconomic Report.

The Draft 2016 AQMP control strategies will seek emission reductions from stationary and mobile sources through command-and-control regulations and incentives to help accelerate the deployment of cleaner equipment. The cost analysis herein quantifies the incremental cost associated with the additional actions needed to achieve sufficient emission reductions for attaining the federal ozone and PM2.5 standards.

What is Quantified in the Preliminary Costs of Draft 2016 AQMP Measures?

Costs associated with the Draft 2016 AQMP are characterized as incremental costs, not as the total cost of a particular control equipment or program. Specifically, they represent the cost difference between a "business as usual" path and an alternative path as proposed by the Draft 2016 AQMP to reach the attainment targets. As an illustrative example, if a piece of low-emission replacement equipment costs $5,000, and without the proposed actions identified in the control strategies, it can be reasonably expected that an affected facility would normally purchase a conventional model as a replacement for $2,000, then the *total incremental cost* associated with purchasing the low-emission model would be $3,000 ($5,000-$2,000=$3,000). Suppose a $1,500 cash rebate is available, then the affected facility will not incur the total incremental costs, but the *remaining incremental cost* of $1,500 ($3,000 price difference between models - $1,500 rebate=$1,500).[22]

Present Value (PV) of Total Incremental Costs
= PV of Remaining Incremental Costs + PV of Incentives

[22] These do not represent market prices and are for illustrative purposes only.

Note that only the remaining incremental costs will be incurred by the affected entities, including businesses and consumers, and it is assumed that federal, state, or local governments will be responsible for financing the entire incentive amount. Total incremental costs are calculated as the sum of incremental capital costs (e.g., equipment purchases and installation costs) and future incremental recurring costs over the equipment's expected lifetime that are associated with operation and maintenance (e.g., filter replacement and fuel costs/savings).[23] The present value, or interchangeably present worth value (PWV), of incremental capital costs is calculated by multiplying the unit cost of equipment by the number of affected units and discounting them from the year of capital spending back to 2017, or when a number of control strategies are expected to begin implementation.[24] The present value of incremental recurring costs are calculated by multiplying recurring costs or savings over the lifetime of the equipment by the number of affected units and discounting back to 2017. The present value of incentives are also discounted back from the year of capital spending to 2017. All present worth values are expressed in 2015 dollars. More details about the assumptions of cost estimates for each control measure can be found in Appendix 2-A.

Similar to previous AQMPs, the 2016 Draft AQMP contains control strategies with quantified emission reductions, as well as control measures with to-be-determined (TBD) emission reductions. It is important to note that NAAQS are expected to be attained with the quantified emission reductions alone. For the cost analysis in this report, incremental costs are estimated for the control strategies with quantified emission reductions only. Some of the control strategies with TBD emission reductions may serve as contingency measures to make up for any unexpected emission reductions shortfall. However, many of these control strategies include emergent technologies. Therefore, their emission-reducing potential may still need to be evaluated and their cost-effectiveness, and in some cases their costs too, remain highly uncertain or unknown for the time being. Nonetheless, the inclusion of these TBD control strategies can provide strategic flexibility in the future. For example, as cleaner technologies develop, they can potentially become more cost-effective than the proposed control strategies with quantified emission reductions. As a result, the SCAQMD may consider the more cost-effective option first at the time of rule or program implementation.

Currently available but limited cost information regarding the TBD control strategies has been provided in Appendix 2-A. In addition, measures that recognize co-benefit ozone emission reductions from other programs will not have incremental costs and include ECC-01, ECC-02, and ECC-04 which recognize co-benefit credits from other *existing* programs that aim to promote energy efficiency and greenhouse gas reductions. Similarly, the costs associated with the *existing* Carl Moyer projects (part of MOB-14) will not be considered as part of the incremental cost of

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[23] CTS-01 (Coatings, Solvents, Adhesives, and Lubricants) has a reformulation cost associated with Rule 1168—Adhesive and Sealant Applications and is calculated by multiplying the price difference between compliant/non-compliant products and the annual sales of the product (in tons).

[24] A discount rate of four percent is used in the Preliminary Draft Socioeconomic Report. See Appendix 2-A for more discussion on the discount rate.

Draft 2016 AQMP. These existing Carl Moyer projects are included for the purpose of recognizing their associated emission reductions for the SIP submittal. These emission reductions are included in the baseline emission inventory. Therefore, they do not count toward the quantified public health benefits that will be discussed in Chapter 3.

Preliminary Cost Summary of Draft 2016 AQMP Measures

As seen in Table 2-1, the total present worth value is estimated to be $38.2 billion for the total incremental costs associated with the Draft 2016 AQMP control strategies, and the amortized annual average is $2.5 billion between 2017 and 2031.[25] It should be noted that the amortization was performed for the upfront costs, mainly for expenditures related to capital outlay, over the equipment lifetime. However, many categories of equipment have an expected lifetime that will extend well beyond 2031. Therefore, the amortized annual average between 2017 and 2031 does not reflect the entire present worth value of the total incremental costs. The amortized annual average can be considered as the expected spending per year between 2017 and 2031, if the affected entities would be able to finance their upfront costs and pay off the loan over the equipment lifetime with an equal amount of annual installments.

[25] These numbers are slightly different than what was presented at the Scientific, Technical, and Modeling Peer Advisory Group Meeting on July 28, 2016 due to minor revisions.

Table 2-1: Preliminary Cost Summary of Draft 2016 AQMP Measures

	Implementation Period for Cost Analysis	Present Value of Remaining Incremental Cost (Millions, 2015$)		Present Value of Incentives (Millions, 2015$)		PWV of Total Incremental Cost (Millions, 2015$)	Amortized Annual Average (2017-2031, Millions. 2015$)
SCAQMD Stationary Source Measures							
BCM-01: Commercial Cooking	**2021**	**$163.0**	+	**$0.0**	=	**$163.0**	**$17.0**
BCM-10: Greenwaste Composting	**2017-2031**	**$18.4**	+	**$0.0**	=	**$18.4**	**$1.7**
CMB-03: Non-Refinery Flares	**2017**	**$36.3**	+	**$0.0**	=	**$36.3**	**$2.2**
CMB-02: Space & Water Heating	**2018-2031**	**$1,891.4**	+	**$327.7**	=	**$2,219.1**	**$99.0**
CMB-04: Restaurant Burners and Residential Cooking	**2018-2031**	**$1,552.7**	+	**$388.2**	=	**$1,940.9**	**$118.9**
CTS-01: Coatings, Solvents, Adhesives, and Lubricants	**2020 and beyond**	**$59.0**	+	**$0.0**	=	**$59.0**	**$5.4**
ECC-03: Building Energy Efficiency	**2018-2031**	**$1,553.4**	+	**$313.5**	=	**$1,866.9**	**$103.4**
CMB-01: Transition to Zero & Near-Zero Emission Technologies	**2018-2031**	**$515.8**	+	**$337.3**	=	**$853.1**	**$34.8**
CMB-05: (RECLAIM)	**2026-2031**	**$837.8**	+	**$0.0**	=	**$837.8**	**$19.3**
FUG-01: Leak Detection and Repair	**2017-2031**	**$11.5**	+	**$0.0**	=	**$11.5**	**$1.0**
Total for SCAQMD Stationary Source Measures		**$6,639.3**	+	**$1,366.6**	=	**$8,005.9**	**$402.6**
SCAQMD Mobile Source Measures							
MOB-10: SOON for Const/Ind Equip.	**2017-2022**	**$90.8**	+	**$63.4**	=	**$154.2**	**$9.8**
MOB-11: Extended Exchange Program	**2018-2022**	**$198.6**	+	**$66.2**	=	**$264.8**	**$30.6**
MOB-14: Incentive Programs	**2017-2023**	**$572.5**	+	**$459.1**	=	**$1,031.6**	**$79.8**

	Implementation Period for Cost Analysis	Present Value of Remaining Incremental Cost (Millions, 2015$)		Present Value of Incentives (Millions, 2015$)		PWV of Total Incremental Cost (Millions, 2015$)	Amortized Annual Average (2017-2031, Millions. 2015$)
Total for SCAQMD Mobile Source Measures		**$861.9**	+	**$588.7**	=	**$1,450.6**	**$120.1**
CARB Mobile Source Measures Affecting South Coast							
On-Road Light-Duty							
Advanced Clean Cars	**2026-2031**	**($2,380.3)**	+	**$0.0**	=	**($2,380.3)**	**($90.8)**
Further Deploy. of Cleaner Tech: Light-Duty	**2017-2031**	**$10,792.3**	+	**$11,563.1**	=	**$22,355.4**	**$1,407.9**
On-Road Heavy-Duty							
Low Nox Engine Standard - California Action	**2023-2027**	**$154.3**	+	**$0.0**	=	**$154.3**	**$11.7**
Low Nox Engine Standard - Federal Action	**2024-2031**	**$281.9**	+	**$0.0**	=	**$281.9**	**$15.1**
Advanced Clean Transit	**2018-2031**	**($501.4)**	+	**$312.2**	=	**($189.2)**	**$6.6**
Last Mile Delivery	**2020-2031**	**$411.5**	+	**$0.0**	=	**$411.5**	**$29.2**
Further Deploy. of CleanTech: Heavy-Duty	**2017-2031**	**$4,448.9**	+	**$252.7**	=	**$4,701.6**	**$385.6**
Heavy-Duty (aggregated fuel change)	**2018-2031**	**($542.7)**	+	**$0.0**	=	**($542.7)**	**($55.5)**
Off-Road Federal & International							
More Stringent National Locomotive Emission Standards	**2024-2031**	**$322.6**	+	**$0.0**	=	**$322.6**	**$12.0**
Tier 4 Vessel Standard	**2025-2031**	**$129.5**	+	**$0.0**	=	**$129.5**	**$3.9**
At-Berth Regulation Amendments	**2022**	**$90.4**	+	**$0.0**	=	**$90.4**	**$5.2**
Further Deploy. of Clean Tech.	**2023-2031**	**$2,029.0**	+	**$0.0**	=	**$2,029.0**	**$118.1**
Off-Road Equipment							
Zero-Emiss.Off-Road Forklift Reg. Phase I	**2023-2030**	**($128.4)**	+	**$0.0**	=	**($128.4)**	**($8.5)**

	Implementation Period for Cost Analysis	Present Value of Remaining Incremental Cost (Millions, 2015$)		Present Value of Incentives (Millions, 2015$)		PWV of Total Incremental Cost (Millions, 2015$)	Amortized Annual Average (2017-2031, Millions. 2015$)
Zero-Emiss. Ground Support Equipment	**2023-2031**	**$3.3**	+	**$0.0**	=	**$3.3**	**$0.2**
Small Off-Road Engines	**2023-2031**	**$19.7**	+	**$0.0**	=	**$19.7**	**$2.1**
Further Deploy. of Clean Tech.	**2017-2031**	**$601.3**	+	**$0.0**	=	**$601.3**	**$49.3**
Low-Emission Diesel	**2023-2031**	**$834.3**	+	**$0.0**	=	**$834.3**	**$86.9**
Total for CARB Mobile Source Measures Affecting South Coast		**$16,566.2**	+	**$12,128.1**	=	**$28,694.3**	**$1,979.0**
Grand Total Cost for All Quantified Measures		**$24,067.5**	+	**$14,083.4**	=	**$38,150.8**	**$2,501.7**

Notes:
1) All future values are discounted at a rate of 4% to their present worth value in 2017 when the AQMP will be implemented and are expressed in 2015 dollars.
2) Numbers may not add up due to rounding.
3) Numbers in parenthese indicate cost-savings, mainly associated with fuel-savings.

About 75 percent, or $28.7 billion in present worth value, of the Draft 2016 AQMP's total incremental cost can be attributed to CARB's mobile source measures.[26] This large share reflects the large amount of NOx emission reductions that will be needed from mobile sources—which contributed about 88 percent of the region's total NOx emissions in 2012—to achieve the upcoming ozone standards. The amortized average cost is close to $2 billion a year between 2017 and 2031. CARB's mobile strategies target on-road light and heavy-duty sources like cars, trucks, and buses as well as off-road sources like trains, ocean-going vessels, planes, and construction equipment.

More than 40 percent of the $28.7 billion attributable to control strategies proposed by CARB is driven by incentive measures aimed at the further deployment of cleaner transit systems, trucks, and cars.[27] While production costs may rise initially for industries deploying cleaner technologies, incentive programs can help by offsetting a portion of the initial capital spending to shorten the

[26] The incentive amount and total incremental costs for CARB measures are derived from CARB data which differ from the cost scenarios in Chapter 4 of the Draft AQMP.

[27] In CARB's Mobile Source Strategy, Appendix A: Economic Impact Analysis (2016a), incremental costs are not presented in present worth values. Costs from CARB that apply to the SCAQMD region have been converted to present worth values in this analysis.

payback period. This would further accelerate market penetration and promote wider adoption of low-emission technologies across industries. This is critical to lowering costs in the long-run as demand ramps up and local supply chains are developed. Accelerating the deployment of cleaner technologies may also increase benefits over time. For example, four measures focusing on advanced clean cars, advanced public transit, forklifts, and cleaner heavy-duty fuel are expected to result in cost savings, mainly due to fuel savings.

The SCAQMD's local mobile source measures will further contribute to NOx emission reductions. The total incremental cost of these measures is estimated to be $1.5 billion in present worth value, with an amortized annual average of $0.1 billion between 2017 and 2031. Two measures with quantified emission reductions focus on turning over older in-use construction and industrial diesel engines (MOB-10) and increasing market penetration of electric or low-emission gas powered lawn and garden equipment (MOB-11). Another measure (MOB-14) recognizes the expected emission reductions from existing and future projects enabled by Carl Moyer funds.

The SCAQMD's stationary source measures are estimated to be $8 billion in present worth value, with an amortized annual average of $0.4 billion between 2017 and 2031. About 17 percent of these costs are associated with incentive programs that are built into a number of control strategies, including those for cleaner space and water heaters (CMB-02), restaurant burners (CMB-04), as well as enhancements in building efficiency (ECC-03) and the transition to zero and near-zero technologies at industrial facilities (CMB-01). Traditional command-and-control regulations focus on reducing NOx and/or VOC emissions from composting (BCM-10), non-refinery flares (CMB-03), fugitive leaks (FUG-01), and coatings, solvents, lubricants, and adhesives (CTS-01). The proposed NOx-reducing measures also includes further amendments to the market incentive program RECLAIM (CMB-05). BCM-01, which specifically targets PM2.5 emission controls for under-fired charbroilers, is included as a contingency measure in the event that the NOx and VOC control measures fail to produce sufficient PM2.5 co-benefits.

Distribution of Draft 2016 AQMP Costs Across Economic Sectors

The total incremental cost of the Draft 2016 AQMP is expected to affect all parts of the regional economy. Private industries, consumers, and the public sector are all expected to incur costs, although the amount borne by each party would vary. When looking at the distribution of costs across sectors in Table 2-2, government and private industries would incur the largest share of the total cost: about 37 percent each, which is equivalent to a present worth value of $14 billion. The rest of the total incremental cost, or about $10 billion in present worth value, is expected to be incurred by consumers through programs that promote zero and near-zero emission light-duty vehicles or increase energy efficiency and the use of renewable energies for residential buildings.

Table 2-2: Incremental Costs of the Plan by Sector

Sector	Present Value of Incremental Cost (Millions, 2015$)	Share (Percent)
Oil and Gas	$85	0
Utilities	$228	1
Construction	$149	0
Manufacturing	$649	2
Nurseries, Wholesale Garden	$73	0
Transportation & Warehousing	$8,515	22
Equipment Leasing and Rental	$68	0
Waste Management	$316	1
Restaurants	$1,716	4
All Industries	$2,282	6
Subtotal of Private Industries	**$14,080**	**37**
Consumers	**$9,985**	**26**
Government Spending	**$14,085**	**37**
Total	**$38,151**	**100**

Notes: 1) Numbers may not add up due to rounding.
2) An 'All Industries' category is included for measures with across-the-board cost impacts (i.e., CMB-01 & CMB-02).

Government spending captures mainly the reallocation of public funds through incentives, but it also includes the costs to public agencies.[28] Some control measures are expected to affect all industries, because widely used emission source equipment is being targeted. For example, all industries using traditional combustion for the production of facility power, heating, and steam production will be affected by a NOx control measure (CMB-01) incentivizing the transition to cleaner equipment. CMB-02 also seeks broad base NOx emission reductions from and commercial space and water heating.

Both SCAQMD and CARB's mobile source strategies will primarily affect passenger transportation and the "goods movement" sector, the core of which constitutes freight transportation and warehousing. As shown in Table 2-2, transportation and warehousing, among all private industries, is expected to incur the largest incremental cost, at an estimated $8.5 billion dollars. This is net of the incentive funds that will be used to lessen the financial impact to this industry sector.

The SCAQMD, together with CARB, are fully aware of the importance of the goods movement sector to the regional economy. Situated among the world's largest seaports and airports, the region's goods movement sector provides the critical service of delivering goods securely and

[28] For example, sanitation districts are expected to incur costs due to a greenwaste composting control strategy (BCM-10).

promptly to and from businesses across the nation. In 2015, the U.S. waterborne trade totaled $1.6 trillion in value, of which nearly a quarter moved through the Ports of Los Angeles and Long Beach; in the same year, about one tenth of the $1 billion worth of total U.S. airborne trade traveled through the airports in the Basin.[29] Over the next six years, the transportation and warehousing sector as a whole is expected to grow at an annualized rate of 1.2 percent, adding about 18,600 jobs to the region between 2016 and 2022.[30] Much of this job growth will be concentrated in the Inland Empire region. The SCAQMD and CARB will work closely with industry stakeholders during the implementation stage to further fine-tune the mobile source strategies and to explore and identify the least costly pathway to reduce mobile source emissions.

The restaurant industry is expected to incur up to $1.7 billion in estimated incremental costs. Restaurants will be mainly impacted by a NOx measure (CMB-04) which requires the installation of low-NOx burners in retail and quick service establishments utilizing commercial cooking ranges, ovens, fryers, and charbroilers. As mentioned earlier, BCM-01 is a contingency PM2.5 measure, and its associated cost of less than $0.2 billion may be potentially incurred by both small and large restaurants; currently, however, this cost is not expected to occur if ozone measures are implemented.

Restaurants are one of the major small business employers in the region. While currently providing 591,000 jobs in the region, nearly all restaurants here employ fewer than 100 people.[31] Moreover, restaurants typically offer lower paying jobs and many of their employees subsist on minimum wage[32]. Therefore, affordability for small businesses and the job impact on economically disadvantaged workers will need to be carefully taken into consideration during the implementation stage of these control strategies.

Manufacturing is the next most highly impacted industry sector based on the Draft 2016 AQMP control strategies. This sector is expected to incur an estimated incremental cost of $649 million. Some measures will impact the sector more broadly as in the case of CMB-01 which incentivizes the transition to zero and near-zero technology at industrial facilities. Other measures may potentially affect only a small number of manufacturing industries. For example, FUG-01 (leak detection and repair) and CMB-05 (RECLAIM) are expected to mainly affect the petroleum and coal products manufacturing industry, including refineries.

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[29] Staff analysis based on data compiled by the U.S. Census Bureau (U.S. Merchandise Trade, Selected Highlights: Report FT 920).

[30] Based on the California Employment Development Department's Long-Term (10 years) Industry Employment Projections for 2012-2022. All employment projections discussed below are from this source: http://www.labormarketinfo.edd.ca.gov/data/employment-projections.html.

[31] Based on establishment by size data for 4-County region from the U.S. Census 2014 County Business Patterns Database.

[32] Recent annual compensation ranged from an average about $17,000 in San Bernardino to about $20,000 in Los Angeles (source: EDD QCEW database for 2015 Q3).

The region's manufacturing sector currently provides 613,000 jobs; however, the total employment level is expected to mirror the nationwide trend and continue its long-term decline: without taking into account any potential effect from the proposed control strategies, approximately 36,000 fewer jobs are forecasted for year 2022 than for year 2016, based on projections by the California Economic Development Department.[33]

Energy producers, who are broadly considered to include the utilities sector and the oil and gas industry, are expected to incur a total incremental cost estimated at more than $310 million. The costs are associated with CMB-03 which requires the installation of newer flares implementing the best available control technology as well as the capture of flare gas at non-refinery facilities, for renewable energy.[34] The costs are also associated with CMB-05 which seeks further NOx reductions from RECLAIM Assessment. Energy producers are generally capital intensive and employ fewer workers per dollar of capitalization.

Other industries that will be directly impacted by the proposed control measures include waste management and construction industries. Waste management is expected to incur an estimated incremental cost of up to $316 million. The industry will be mainly impacted by a VOC/PM2.5 measure (BCM-10) which will require the use of emerging organic waste processing technology while restricting the direct land application of chipped and ground uncomposted greenwaste. Landscapers, who also work in this industry and primarily for small operations, may incur incremental costs associated with voluntarily upgrading to cleaner gardening equipment (MOB-11). The construction industry is expected to incur an estimated incremental cost of up to $150 million for converting to cleaner equipment through SCAQMD's SOON program (MOB-10) and a VOC measure (CTS-01) to reduce emissions from chemical products like architectural adhesives and sealants used in construction. In the meantime, however, construction could potentially benefit from additional revenues that stem from installing control equipment and other activities that are expected to occur in other industries due to the proposed control strategies.

Incremental Costs over Time

Figure 2-1 illustrates the incremental costs of control measure equipment and programs attributable to each implementation year. Unlike the costs reported in, these costs are not discounted to their present worth values, nor are they amortized over the equipment life.

The total incremental cost increases over time, due to each successive year of the Draft 2016 AQMP which will require a greater amount of more costly equipment and activities in order to achieve NAAQS. The cost per year remains approximately constant from 2018 through 2022, as

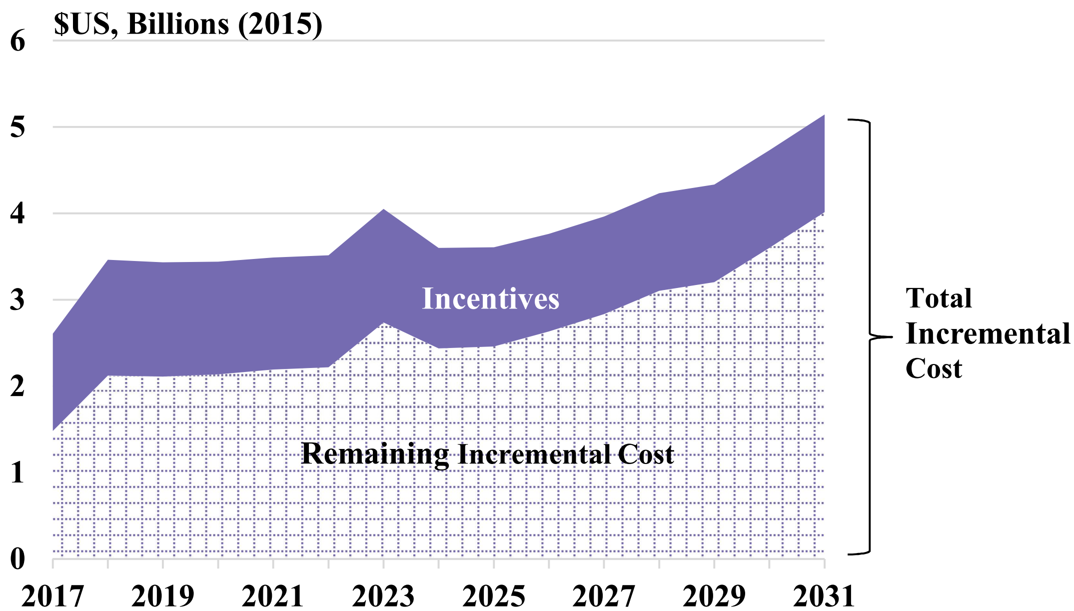
[33] Based on the California EDD's Long-Term (10 years) Industry Employment Projections for 2012-2022. All employment projections discussed below are from this source: http://www.labormarketinfo.edd.ca.gov/data/employment-projections.html.

[34] The potential economic benefits of energy conversion are not taken into account.

similar equipment and programs are assumed to phase in over that time period to attain the 1997 8-hour ozone standard in 2023. The largest amount of incremental cost occurs towards the end of the analysis horizon, with the greatest cost year being the last year of attainment demonstration in the Draft 2016 AQMP (2031), or the year when the 2008 8-hour ozone standard needs to be attained.

The total incremental cost increases from about $2.6 billion in 2017 to about $5.1 billion in 2031. The total incremental cost in 2017 consists of about $1.1 billion in incentives and $1.5 billion of the remaining cost to be paid for by consumers or affected industries, while in 2031, it consists of about $1.1 billion in incentives and $4.0 billion remaining incremental cost.[35]

Figure 2-1: Incremental Cost over Time



[Placeholder for small business impact]

[Placeholder for cost-effectiveness discussion: Cost-effectiveness evaluation using the Discounted Cash Flow and the Levelized Cash Flow methods will be discussed. The draft cost-effectiveness estimated for the stationary and mobile sources control measures proposed by the SCAQMD are reported in Appendix 4-A of the Draft 2016 AQMP and reproduced below.]

[35] The small peak in incremental cost in 2023 is a result of both a number of measures first being implemented or having increased incremental cost that year (Further Deployment: Off-Road Federal and International, CMB-02, and CMB-04) and the incremental cost of measures decreasing in 2024 (CMB-02, CMB-04, ECC-03, and MOB-14).

Measure	Pollutant	Control Cost	Incentive Cost
SCAQMD Stationary Source			
ECC-03 (Building Energy Efficiency)	NOx	$42,346/ton	$230 to $700 million in total to reduce emissions by 2.1 tpd[1] by 2031
CMB-01 (Transition to Zero & Near-Zero Emission Technologies)	NOx	n.a.	$40,000/ton
	VOC	n.a.	n.a.
CMB-02 (Space and Water Heating)	NOx	$15,000 to $30,000/ton	$440 million in total to reduce emissions by 1.1 tpd[1] by 2023 and by 1.5 tpd[1] by 2031
CMB-03 (Non-Refinery Flares)	NOx	< $20,000/ton	n.a.
	VOC	n.a.	n.a.
CMB-04 (Restaurant Burners and Residential Cooking)	NOx	$15,000 to $30,000/ton	$30,400/ton; $250 million in total to reduce emissions by 1.5 tpd[2] by 2031
CMB-05 (RECLAIM)	NOx	$13,500 to $21,000/ton	n.a.
FUG-01 (Leak Detection and Repair)	VOC	$11,000/ton	n.a.
CTS-01 (Coating, Solvents, Adhesives, and Lubricants)	VOC	$8,000 to $12,000/ton[3]	n.a.
BCM-01 (Commercial Cooking)			
BCM-10 (Greenwaste Composting)	VOC	$1,350/ton	n.a.
	NH3	$25,000/ton	n.a.
SCAQMD Mobile Source			
MOB-10 (SOON for Construction/Industrial Equipment)	NOx	TBD	TBD
MOB-11 (Extended Exchange Program)	NOx	$800 to $10,000/ton	n.a.
	CO	n.a.	n.a.
	VOC	n.a.	n.a.
MOB-14 (Incentive Programs)	NOx	$18,262/ton	n.a.
	PM2.5	n.a.	n.a.

[1] Summer planning period average.
[2] Annual average.
[3] SCAQMD rules regulating coating, solvents, adhesives, and lubricants traditionally use the levelized cash flow (LCF) method to calculate cost-effectiveness, i.e., annual incremental cost ÷ annual VOC emission reductions.

Chapter 3: Public Health and Other Benefits

Preface

The public health benefits quantified herein are preliminary and subject to future revision. The revisions may be due to revisions to the proposed control measures and updates to regional air quality modeling in the Draft 2016 AQMP. Additional revisions are also expected as staff is currently refining the data inputs, such as the baseline incidence data, used in the estimation.

The Draft 2016 AQMP contains a suite of control strategies that are designed to attain the 80 ppb 8-hour ozone standard in 2023 and the 75 ppb 8-hour ozone standard in 2031. They are devised to also attain the 12.0 $\mu g/m^3$ annual PM2.5 standard and the 35 $\mu g/m^3$ 24-hour PM2.5 standard. Reaching ozone and PM2.5 attainment standards will produce various benefits including better public health, improved visibility, and avoided damage to animals, crops, vegetation, and buildings.

One of the major recommendations put forward in the 2014 independent review of past socioeconomic analyses was to update the literature and methodology for benefits analysis (Abt Associates 2014). This report prioritizes the implementation of this recommendation in the area of public health benefits for two reasons. First, public health benefits usually account for the majority of quantified benefits associated with improved air quality.[36] Second, the primary ambient air quality standards were set to provide public health protection, whereas the secondary standards, in some cases less stringent than the corresponding primary standard,[37] were set to provide public welfare protection in other areas mentioned above. Moreover, Abt recommended that these analyses be updated with more current methodologies, which cannot be done in time for this report.

SCAQMD staff has worked closely with Industrial Economics, Inc. and its scientific advisors to update the health benefits literature and fine-tune the methodology used to quantify public health benefits and address the associated uncertainties in estimates. Despite these efforts, a full assessment of public health benefits in dollar terms is not possible until advances occur in human health sciences, physical science, and economic disciplines that will allow monetary estimates to be made for currently unquantifiable areas. Public welfare benefits of the Draft 2016 AQMP will not be quantified as explained above; however, these benefits are scientifically documented and are qualitatively discussed toward the end of this chapter. Additionally, this chapter also includes a preliminary discussion regarding the health effects of unemployment and their potential linkage to a benefits analysis.

[36] For example, quantified public health benefits of the 2007 AQMP amounted to $16 billion for year 2023, compared to other quantified public welfare benefits of about $6 billion (in 2000 dollars). Similarly, quantified public health benefits of the 2012 AQMP amounted to $1.7 billion for year 2023, compared to other quantified public welfare benefits of $0.66 billion (in 2005 dollars).

[37] For annual PM2.5 standards, the secondary standard is 15.0 $\mu g/m^3$ whereas the primary standard is 12.0 $\mu g/m^3$.

Projected Emission Reductions and Changes in Pollutant Concentrations

Regional air quality modeling indicates that significant NOx reductions with additional strategic, limited VOC reductions will lead to the attainment of ozone standards. As shown in Table 3-1, the proposed control strategies are projected to significantly reduce NOx emissions by 131 and 126 tpd and strategically reduce VOC emissions by 74 and 73 tpd, in 2023 and 2031 respectively. These control strategies will also generate sufficient PM2.5 co-benefits that will lead to attainment of the annual PM2.5 standard by 2025.

Table 3-1: Projected Emission Reductions by Pollutant

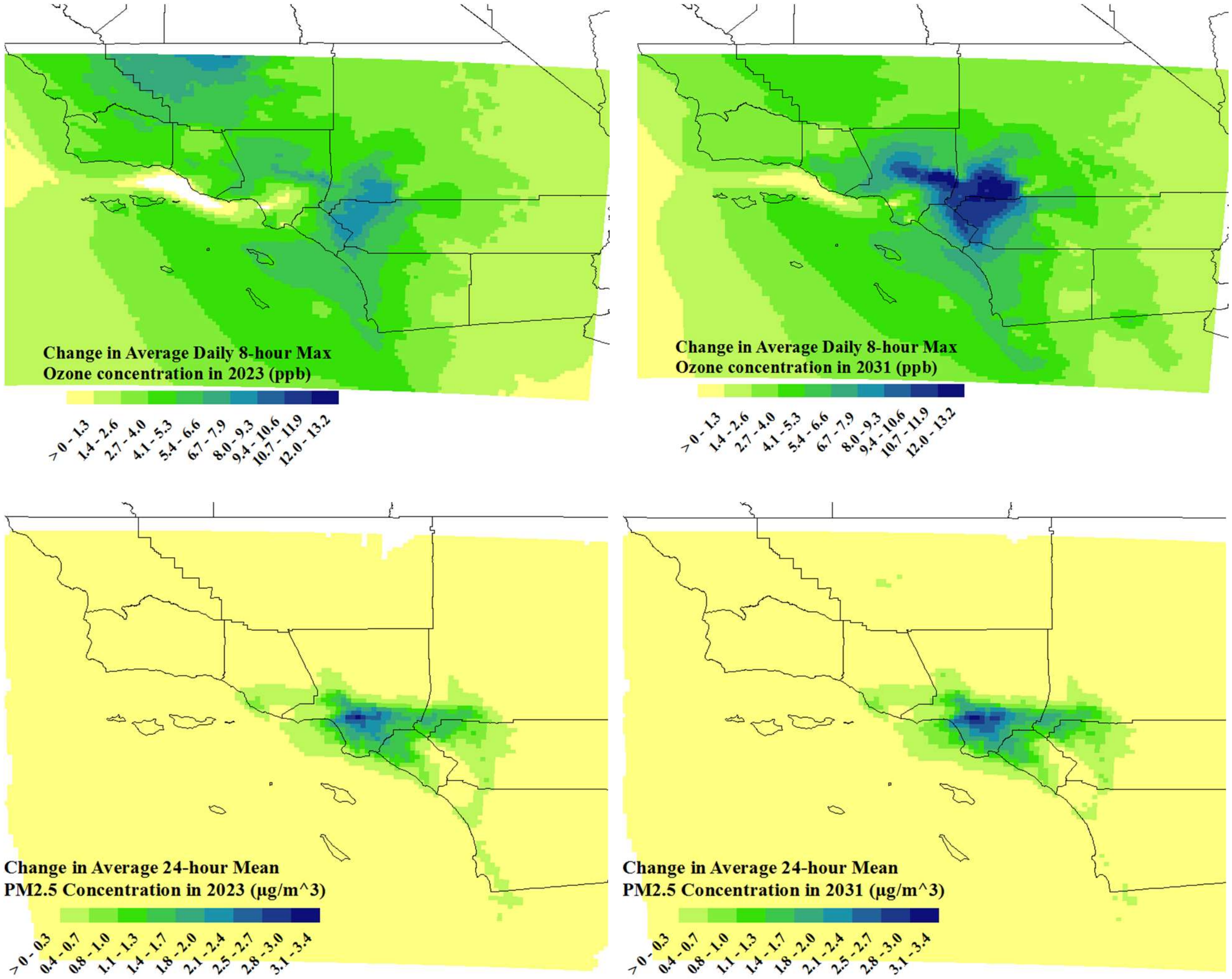
NOx Emissions (tpd)	2023	2031
Baseline Inventory	265	224
Reductions from Draft Control Strategies	131	126
Remaining Emissions	134	98
VOC Emissions (tpd)	**2023**	**2031**
Baseline Inventory	379	363
Reductions from Draft Control Strategies	74	73
Remaining Emissions	305	290

Note: Projected emission reductions are the average of the summer planning period (May 1 to September 30). The NOx emission reductions reported in this table reflect the latest regional air quality modeling results; however, the ozone and PM2.5 concentration changes reported below and used as an input for public health benefits quantification have not incorporated this update and will be revised in the next draft release.

Although each attainment demonstration is performed with respect to the worst air quality site, the benefit assessment herein is analyzed with respect to the changes in the projected air pollutant concentrations between the baseline scenario (without Draft 2016 AQMP) and the control scenario (with Draft 2016 AQMP) in each air quality modeling grid of 4 kilometer by 4 kilometer. Thus, the quantified public health benefits discussed in this report are based on where projected air quality changes are expected to occur. Figure 3-1 reflects models of future ozone and PM2.5 concentrations based on measures proposed in the Draft 2016 AQMP, which will move beyond the already adopted regulations and already implemented programs to the level needed to meet the federal ozone and PM2.5 standards. Air quality modeling methods account for background concentrations of pollutants and thus concentrations projected in the control scenarios are above backgound concentration levels.[38]

[38] Background concentrations of chemical species are calculated with a global chemistry transport model (Model for Ozone and Related chemical Tracers, MOZART). Species concentrations from this model are fed into the modeling domain along the model boundaries. Temporally- and spatially-dependent MOZART data are used to capture the variability in background concentrations throughout the entire modelling year. Biogenic and Anthropogenic emissions from within the modeling domain are simulated with the MOZART-derived boundary conditions to estimate pollutant concentrations within the Basin. Therefore, the PM concentrations modeled for future years in this analysis are above the background levels.

Figure 3-1: Modeled Changes in Ozone and PM2.5 Concentrations, 2023 and 2031



Note: Ozone concentrations are the summer planning period average of daily 8-hour maxima whereas PM2.5 concentrations are the annual average of 24-hour means.

Quantified Public Health Benefits

Numerous epidemiological as well as controlled laboratory studies have demonstrated a positive association between ambient air pollution exposure and increases in illness and other health effects (morbidity endpoints) and increases in death rates from various causes (mortality endpoints) (U.S. EPA 2009; U.S. EPA 2013). Groups that are most sensitive to the effects of air pollution are children, elderly persons, and people with certain respiratory and heart conditions.

Table 3-2 summarizes the causal determinations documented in the U.S. EPA ISAs, based on the current weight of evidence regarding ozone and PM2.5 exposure (U.S. EPA 2009; U.S. EPA 2013).[39] Exposure to other pollutants, such as NO_2 and SO_2, is also found to cause adverse respiratory effects.[40] However, based on the recommendation by Industrial Economics, Inc., staff analysis does not quantify these effects to avoid potentially double counting benefits with reduced PM2.5 exposure (Industrial Economics and Thurston 2016b). Similarly, due to concerns of potentially double counting over the same health endpoint, not all causal or likely causal relationships listed in Table 3-2 are quantified in this report.

Table 3-2: Summary of Causal Determinations for Ozone and PM2.5 Exposure

Health Category	Causal Determination	Quantified?
Short-Term Exposure to Ozone		
Mortality	**Likely to be a causal relationship**	**Y**
Cardiovascular Effects	**Likely to be a causal relationship**	N
Respiratory Effects	**Causal relationship**	**Y**
Central Nervous System Effects	*Suggestive of a causal relationship*	N
Effects on Liver and Xenobiotic Metabolism	*Inadequate to infer a causal relationship*	N
Effects on Cutaneous and Ocular Tissues	*Inadequate to infer a causal relationship*	N
Long-Term Exposure to Ozone		
Mortality	*Suggestive of a causal relationship*	N
Cardiovascular Effects	*Suggestive of a causal relationship*	N
Respiratory Effects	**Likely to be a causal relationship**	N
Reproductive and Developmental Effects	*Suggestive of a causal relationship*	N
Central Nervous System Effects	*Suggestive of a causal relationship*	N
Cancer	*Inadequate to infer a causal relationship*	N

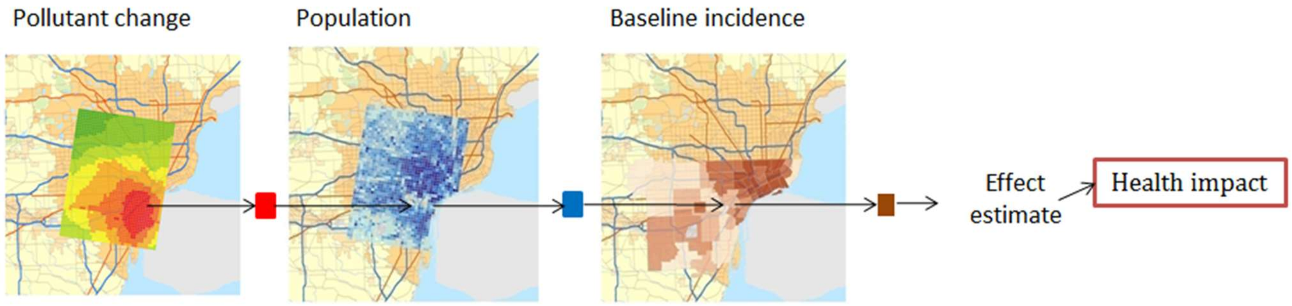
[39] Descriptions for Weight of Evidence for Causal Determinations are provided in Appendix 3-A.
[40] See the 2016 Draft AQMP Appendix 1 for a discussion of health effects of ambient air pollution.

Health Category	Causal Determination	Quantified?
Short-Term Exposure to PM2.5		
Mortality	**Causal relationship**	**Y**[1]
Cardiovascular Effects	**Causal relationship**	**Y**
Respiratory Effects	**Likely to be a causal relationship**	**Y**[2]
Central Nervous System Effects	*Inadequate information to assess*	
Long-Term Exposure to PM2.5		
Mortality	**Causal relationship**	**Y**
Cardiovascular Effects	**Causal relationship**	N
Respiratory Effects	**Likely to be a causal relationship**	**Y**
Reproductive and Developmental Effects	*Suggestive of a causal relationship*	N
Cancer, Mutagenicity, Genotoxicity	*Suggestive of a causal relationship*	N

[1] Health effects of short-term PM2.5 exposure on all-cause mortality is quantified and discussed separately due to concerns for potential double-counting with mortality effects due to long-term exposure.
[2] Effects of PM2.5 exposure on new onset of wheeze among adult populations are quantified but not monetized, due to lack of valuation method.
Source: U.S. EPA ISAs (2009; 2013).

The first step of a public health benefits analysis is the health effects quantification. First, appropriate concentration-response (C-R) functions need to be selected, which numerically characterize the causal and likely causal relationships between exposure to a pollutant and various health endpoints. Specifically, the C-R function used in this analysis relates changes in ambient air pollution concentration with changes in mortality or morbidity incidence, the magnitude of which also depends on the baseline incidence rate and the population exposed to a specific health risk being analyzed (see Figure 3-2 for a graphic illustration).

Figure 3-2: Health Effects Quantification



Source: U.S. EPA BenMAP-CE User's Manual.

C-R functions were recommended based on a systematic review of the epidemiological literature, where studies were evaluated for quality and applicability according to numerous criteria (Industrial Economics and Thurston 2016a; Industrial Economics and Thurston 2016b). These criteria include: peer-review, date of the study, geography and population characteristics, and study design. Thus, the C-R functions applied in this analysis are found from recent, peer-reviewed articles, derived from local studies of the SCAQMD region or studies that report separate estimates using sub-samples pertaining to the SCAQMD region, where feasible. The 2016 RTP/SCS population forecast was provided by SCAG for each air quality modeling grid. When feasible, local health data based on public administrative records were utilized to obtain baseline incidence rates. Appendix 3-B describes in detail the input data and methodology used, as well as analytical assumptions such as cessation lags for mortality effects associated with long-term PM2.5 exposure that will have implications for monetizing health benefits.

Table 3-3 reports the health effect estimates for each health endpoint by pollutant. In total, it is estimated that more than 2,000 premature deaths will be avoided in 2023, and more than 2,500 in 2031, due to improved air quality as a result of implementing the Draft 2016 AQMP control measures. Figure 3-3 shows that mortality risks will be reduced in each of the four SCAQMD counties, with the largest number of avoided premature deaths concentrated in the densely populated Los Angeles County area.

Table 3-3: Health Effect Estimates, 2023 & 2031*

	2023	2031
Premature Deaths Avoided, All Cause (25 or Older)		
Short-Term Ozone Exposure[1]	51	87
Long-Term PM2.5 Exposure	2,111	2,425
Short-Term PM2.5 Exposure[2]	NYQ	NYQ
Reduced Morbidity Incidence		
Short-Term Ozone Exposure[1]		
Hospital Admissions (HA), All Respiratory (65 or Older)	89	167
Hospital Admissions (HA), Asthma (19 or Younger)[3]	NYQ	NYQ
Emergency Room Visits, Asthma	1,401	2,296
Minor Restricted Activity Days[5]	427,964	690,235
School Loss Days, All Cause[5]	129,616	209,276
Long-Term PM2.5 Exposure		
Acute Bronchitis	1,766	1,941
Short-Term PM2.5 Exposure		
HA, All Respiratory (less Asthma)[4]	234	297
HA and Emergency Department Visits, Asthma (18 or Younger)	244	268
Asthma Exacerbation (Wheeze, Cough, Shortness of Breath)	39,953	43,932
Asthma, New Onset (Wheeze)	5,027	5,699
Lower Respiratory Symptoms	20,897	22,959
Upper Respiratory Symptoms	41,730	45,953
HA, Ischemic Stroke	136	175
HA, All Cardiovascular (less Myocardial Infarctions)	283	346
Acute Myocardial Infarction, Nonfatal	57	73
Minor Restricted Activity Days[5]	908,234	984,397
Work Loss Days[5]	157,623	170,896

* Each health effect represents the point estimate of a statistical distribution of potential outcomes. Please see Appendix 3-B where the 95-percent confidence intervals are reported. Health effects for other years during the period of 2017 to 2031 will be quantified in a revision to this report and based on interpolated, as opposed to modeled, air quality changes.

[1] Health effects of ozone exposure are quantified for the summer planning period only (i.e., May 1 to September 30). There are potentially more premature mortalities and morbidity conditions avoided outside the ozone peak season. Mortality effects for populations younger than age 25 years may be added in the upcoming revision to this report.

[2] Health effects related to this endpoint will be quantified in the upcoming revision to this report. Premature deaths avoided due to short-term exposure to PM2.5 are likely to partially overlap with those due to long-term PM2.5 exposure. Therefore, the total premature deaths associated with PM2.5 will be lower than simply summing across mortality effects from both short-term and long-term exposure (Industrial Economics and Thurston 2016a; Kunzli et al. 2001).

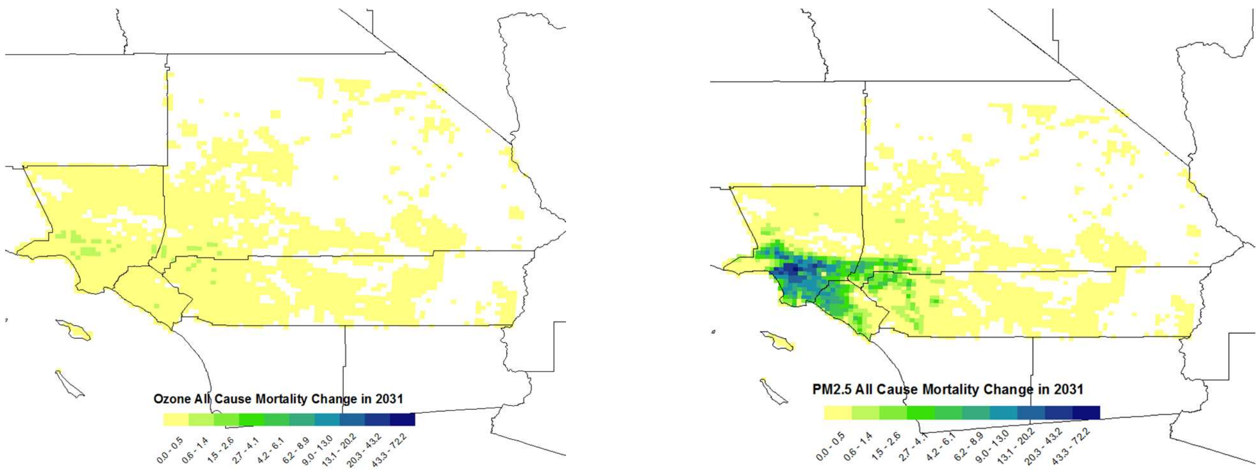
[3] Health effects related to this endpoint will be quantified in the upcoming revision to this report.

[4] This is the pooled estimate of two health endpoints: HA, Chronic Lung Disease (less Asthma) (18-64 years old) and HA, All Respiratory (65 or older).

[5] Expressed in person-days. Minor Restricted Activity Days (MRAD) refer to days when some normal activities are avoided due to illness.

Figure 3-3: Spatial Distribution of Estimated Premature Deaths Avoided (Year 2031)

Due to Short-Term Ozone Exposure **Due to Long-Term PM2.5 Exposure**



South Coast residents are also expected to benefit from the avoidance of large numbers of hospital admissions, emergency room visits, school and work loss days, as well as various respiratory and cardiovascular symptoms. The all-cause mortality effects related to short-term ozone exposure are based on pooling two LA city-specific C-R functions from Bell et al. (2005a), and the all-cause mortality effects associated with long-term PM2.5 exposure are based on pooling C-R functions estimated in Jerrett et al. (2005), Jerrett et al. (2013), and the kriging and land-use regression results from Krewski et al. (2009). Details of these selected functions and the C-R functions used for morbidity effect estimates can be found in Appendix 3-B.

It should be noted that there is no threshold employed in the health effect estimates. In the analysis, health benefits will continue to accrue due to reduced exposure to ambient air pollution at all levels of pollutant concentration, even at levels below the current national ambient air quality standards.[41] This practice is recommended by Industrial Economics, Inc. and based on the latest scientific evidence, including those summarized in the ISAs (U.S. EPA 2009; U.S. EPA 2013). It is also

[41] Note that the control scenario being analyzed here is based on the Draft 2016 AQMP control strategies which are designed to bring the Basin into attainment of the federal ozone and PM2.5 standards. Due to the nature of emissions and air quality dynamics, there are spatial variations of pollutant concentrations across the Basin (see Chapter 5 of the Draft 2016 AQMP for detailed discussions). In the baseline scenario (without Draft 2016 AQMP), there are certain areas in the Basin where the modeled pollutant concentrations are already below the federal standards; however, there are also many other areas with modeled pollutant concentrations still exceeding the standards by attainment deadlines. In the control scenario, pollutant concentrations in all areas are expected to fall below the standards, with some falling slightly below and others significantly below. By not employing a threshold in the analysis, public health benefits are being quantified for all reductions in pollutant concentrations between the baseline and the control scenarios that are attributable to the Draft 2016 AQMP.

consistent with the current analytical approach adopted by the U.S. EPA in its regulatory impact analyses (U.S. EPA 2012; U.S. EPA 2015).[42] It should also be noted that health effects related to ozone exposure are quantified only for the summer planning period of May 1 to September 30. There are potentially more premature mortalities and morbidity conditions avoided outside the peak ozone season.

After health effects are quantified, they are then translated into dollar values using two types of valuation methodology.[43] Monetized benefits associated with avoided premature deaths are monetized based on a population's willingness-to-pay (WTP) for a small reduction of mortality risk in a year and generally expressed as the "value of statistical life (VSL)". As illustrated in Figure 3-4, the concept of VSL does not place a monetary value on saving a life with certainty; instead, it is an aggregate WTP of a population so that the associated risk reductions are statistically equivalent to one case of premature death avoided.[44] The total monetized benefits of avoided premature deaths are derived by multiplying the number of premature mortalities reduced by the VSL. For morbidity effects, the valuation is primarily based on estimated cost of illness (COI) avoided, and whenever applicable, supplemented by WTP for morbidity risk reductions. Avoided COI is generally regarded as a conservative estimate of monetized health benefits, as it accounts for avoided resource costs including direct medical costs and indirect productivity losses, but generally cannot fully account for the benefits of pain and suffering being prevented.

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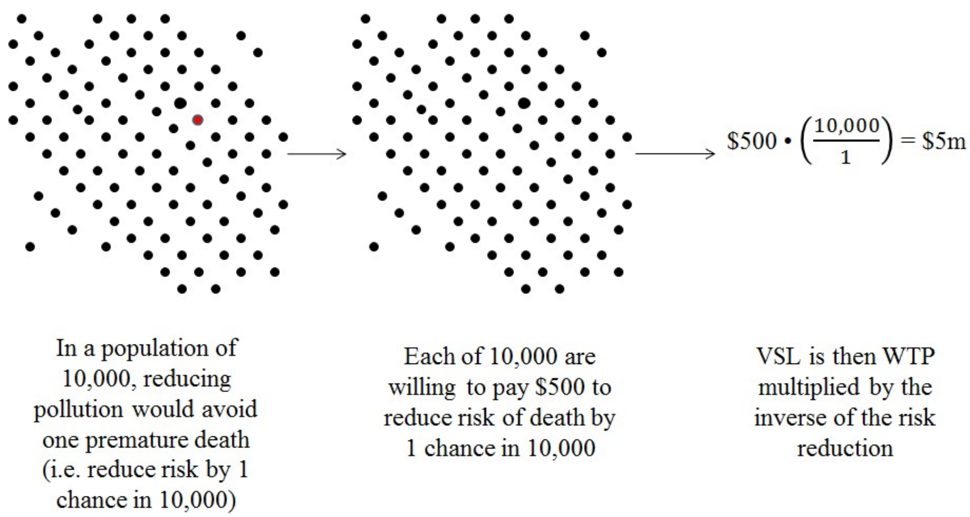
[42] There was no threshold used in quantifying public health benefits of reduced ozone exposure in the 2015 Regulatory Impact Analysis (RIA) of the Final Revisions to the NAAQS for Ground-Level Ozone. In the same document and in the 2012 RIA for the Final Revisions to the NAAQS for Particulate Matter, the estimated total premature deaths avoided due to long-term exposure to PM2.5 was reported as the sum of two numbers: one represents the number of premature deaths avoided estimated at or above the lowest measured level (LML) of PM2.5 concentration, and the other represents the number of premature deaths avoided estimated below the same LML. This was done as one of the concentration benchmark analyses to address uncertainty. Meanwhile, the mortality-related benefits associated with reduced PM2.5 exposure was monetized for the total premature deaths avoided. More discussion can be found in Appendix 3-B.

[43] Health effects quantification and valuation in this analysis rely on existing high quality studies whose results are applicable and suitable for a benefits analysis of the Draft 2016 AQMP. This "benefit transfer" from existing studies to the analysis herein is necessary as it is not feasible for staff to conduct original research for all necessary inputs.

[44] For more details, please see Industrial Economics and Robinson (2016) and Robinson and Hammitt (2016).

Figure 3-4: Illustrative Example of Value of Statistical Life



(Source: U.S. EPA, modified by Industrial Economics, Inc. and SCAQMD staff.)

As shown in Table 3-4, the overall quantifiable and monetized annual public health benefits are estimated to be $26.9 billion for the year of 2023 and $36.9 billion for the year of 2031 (all expressed in 2015 dollars). More than 99 percent of these benefits are attributable to mortality-related benefits, especially due to anticipated reductions in mortality risk related to long-term exposure to PM2.5. The estimates are based on the VSL of $9.0 million (2013 dollars[45] and income levels) and the assumption that the WTP for mortality risk reductions will increase as income grows; specifically, a one percent increase in income is assumed to raise VSL by 1.1 percent (i.e., an income elasticity of 1.1) (Industrial Economics and Robinson 2016).

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[45] The analysis adjusts VSL to 2015 dollars using published U.S. GDP deflators.

Table 3-4: Monetized Annual Public Health Benefits (Billions of 2015 dollars)

	2023	2031
Mortality-related benefits	**$26.8**	**$36.7**
Short-Term Ozone Exposure	$0.6	$1.3
Long-Term PM2.5 Exposure	$26.1	$35.4
Morbidity-related benefits	**$0.1**	**$0.2**
Grand Total	**$26.9**	**$36.9**

Notes: 1) Numbers may not add up due to rounding.
2) Premature deaths avoided due to short-term exposure to PM2.5 are monetized separately due to potentially double counting concerns with benefits associated with long-term exposure.
3) Health effects of the endpoint "Asthma, New Onset (Wheeze)" are not monetized, due to lack of a valuation method.
4) The monetized public health benefits reported in this table were estimated for the SCAQMD four-county region, which includes areas that are located outside the South Coast Air Basin. However, staff estimated that mortality-related benefits accrued to the areas within the Basin would account for 99 percent of the total. In other words, the difference is minimal between quantifying public health benefits for the Basin and for the four-county region.
5) See Appendix 3-B for a detailed discussion regarding morbidity-related public health benefits.

It should be emphasized that, as with any scientific studies and evaluations, there are various sources of uncertainty surrounding the estimated public health benefits, including the uncertainty embedded in data inputs, uncertainty of the C-R functions chosen, and uncertainty of valuation. Given the significant contribution of mortality-related benefits, staff conducted a sensitivity analysis regarding the valuation parameters used and will conduct a sensitivity analysis on health effects using alternative C-R functions for premature deaths avoided.

The first set of sensitivity analyses considers alternative VSL and income elasticities. The base VSL of $9.0 million represents the mid-point of the recommended VSL range of $4.2 million to $13.7 million, with all values expressed in 2013 dollars and income levels (Industrial Economics and Robinson 2016). This VSL range is based on a review of recent, peer-reviewed studies on the value of mortality risk reductions and considered as reasonable for regulatory analysis (Robinson and Hammitt 2016a). In addition, a lower income elasticity of 0 (i.e., VSL does not change with income level) and a higher income elasticity of 1.4 (i.e., a one percent income growth increases VSL by 1.4 percent) were also recommended to be used in the sensitivity analyses, based on a study by Viscusi (2015). Table 3-5 shows a range of monetized public health benefits, where the lower bound assumes a VSL of $4.2 million and an income elasticity of 0 while the upper bound assumes a VSL of $13.7 million and an income elasticity of 1.4. In 2023, the range of benefits is from $9.1 to $49.4 billion, and for 2031, the range is from $10.6 to $70.9 billion. For both 2023 and 2031, the lower bound is approximately 30 percent of the mid-point benefits and the upper bound nearly doubles the mid-point estimate.

Table 3-5: Sensitivity Analysis of Mortality Effects Valuation

Monetized Public Health Benefits (Billions of 2015 dollars)						
	2023			2031		
	Lower Bound	Mid-point	Upper Bound	Lower Bound	Mid-point	Upper Bound
Base VSL (millions of 2013 dollars and 2013 income levels)	4.2	9	13.7	4.2	9	13.7
Income Elasticity	0	1.1	1.4	0	1.1	1.4
Mortality-related benefits	**$9.1**	**$26.8**	**$49.4**	**$10.6**	**$36.7**	**$70.9**

[Place holder: sensitivity tests using non-local C-R functions]

[Place holder: distribution of PM2.5 mortality health effects by LML]

[Place holder: monetized public health benefits due to short-term exposure to PM2.5]

The quantifiable public health benefits associated with improved air quality were assessed relative to reduced morbidity conditions and premature mortalities from exposure to ozone and PM2.5, respectively. To avoid potentially double counting health effects, this analysis uses C-R functions that do not have overlapping health endpoints for the same age group, whether the overlap may be large or small. It also does not add to the overall quantified public health benefits the monetized value of avoided premature deaths due to short-term exposure to PM2.5, again due to concerns over potentially double counting benefits with those associated with long-term exposure to PM2.5. Moreover, the present state of knowledge allows a quantitative assessment of the relationship between ozone and PM2.5 and the health effects as noted in Table 3-2. However, not enough information is currently available in the scientific literature to allow for all adverse health effects identified to be measured and valued in dollars, mainly because sufficient data are not available to establish a quantitative relationship between these pollutant levels and some of these health effects. Hence, the quantified public health benefits may be underestimated.

It should be also emphasized that improved public health can generate direct economic benefits other than increased productivity and fewer lost work days in the short-term. A recent study (Isen et al. forthcoming) showed that improvement in early-childhood health has long-term economic benefits as well. Reductions of in-utero and early-infancy exposure to air pollution were found to increase labor participation among the affected individuals 30 years later; that is, working-age adults are more likely to hold a job when they were less exposed to air pollution as an infant.

Public Welfare Benefits

NAAQSs for criteria pollutants, set pursuant to the CAA, include both primary standards designed to protect public health and secondary standards to protect public welfare, including preventing damage to agriculture, ecology, visibility, buildings, and materials. In the previous section, the public health benefits associated with the Draft 2016 AQMP, which is designed to attain the federal ozone and PM2.5 standards, were quantified. The Draft 2016 AQMP is additionally expected to provide benefits protective of the public welfare. Although these additional benefits are not specifically quantified for this AQMP, we provide a qualitative description of these public welfare benefits. We additionally include a discussion of the benefits estimated in these categories from the Socioeconomic Reports of previous AQMPs and the scientific literature that provided the methodological basis for quantification. The 2014 report by Abt Associates recommended that the literature and methodologies be updated to reflect the latest advancement in scientific knowledge and that the sufficiency of data and information should also be evaluated. Implementation of these recommendations will be conducted for future AQMPs.

Agricultural Benefit

Agriculture is an integral part of the economy in the South Coast region. Riverside and San Bernardino counties are ranked in the top 25 of counties in California in value of agricultural commodity production. The total value of agricultural production in the four-county region was $2.3 billion, comprised of $1.36 billion from Riverside, $527 million from San Bernardino, $230 million from Los Angeles, and $132 million from Orange (CDFA 2015). Some of the leading commodities produced in these counties include: milk, nursery, grapes (table), hay (alfalfa), eggs, and cattle (milk cows).

Ozone damages vegetation and many crops more than all other pollutants combined. Since the early 1970s, numerous studies have shown that ozone inhibits crop productivity in California, resulting in reductions in crop yield (Larsen and Heck 1976; Oshima et al. 1976; CARB 1987). Improvements in air quality, in particular reductions in ozone concentrations, can improve the productivity of crops. The benefits to agriculture from improved air quality have been quantified in the Socioeconomic Report of previous AQMPs. Using results from more recent studies on the effects of ozone on crop yield (Olszyk and Thompson 1989; Randall and Soret 1998), combined with land-use and economic data, the cash value of increased crop yields that would result from implementation of the 2007 AQMP was estimated. It was projected that the 2007 AQMP would result in a cash value of $23.2 million (in 2000 dollars) for the year 2023. Since the 2012 AQMP was a PM2.5 plan, ozone concentrations were not modeled to derive agricultural benefits. In addition to the benefits to crops from reducing ozone, air contaminants can also damage livestock as they do humans. This livestock benefit was not quantified in previous AQMPs and is also not quantified here.

Implementation of the Draft 2016 AQMP will result in agricultural benefits such as increased productivity of agricultural crops in the four counties. However, updating the economic methods used for quantifying these benefits was suggested by Abt Associates (2014). These updates cannot be implemented in time but are planned for socioeconomic assessments in future AQMPs.

Material Benefit

Material benefit is the benefit accrued by reduction of damage to materials from air pollution. Studies have identified the types of damage that can occur from air pollution and estimated their monetary value. For total suspended particulate matter (TSP) in particular, it causes accelerated wear and breakdown of painted wood and stucco surfaces of residential and commercial properties (Murray et al. 1985). In addition, TSP leads to additional household cleaning costs due to soiling damages (Cummings et al. 1985). Using the results from these studies, the benefits of air pollution controls under previous AQMPs were estimated. The monetary benefit, as a result of implementing the 2007 AQMP, from decreases in cost for repainting stucco and wood surfaces, and cleaning and replacing damaged materials was projected to be $308 million (in 2000 dollars) for the year 2023. Material benefits due to the 2012 AQMP was projected to be about $13 million (in 2005 dollars) for the year 2023. The large difference between the benefits estimated from these two previous AQMPs is due to the 2007 AQMP being an ozone attainment plan with more PM2.5 co-benefits, whereas the 2012 AQMP was a PM2.5 attainment plan with fewer PM2.5 reductions.

In addition to the these damages, a link exists between several pollutants (ozone, sulfur dioxide, PM2.5, and nitrogen oxides) and ferrous metal corrosion; erosion of cement, marble, brick, tile, and glass; and the fading of fabric and coated surfaces (Cummings et al. 1985; Murray et al. 1985). The damage and conversely the potential benefits from reducing the exposure to these items currently cannot be quantified and valued in dollars.

There will also be benefits of reduced damage to materials as a result of the Draft 2016 AQMP, which will reduce PM2.5 and correspondingly TSP. However, the studies used previously to quantify these benefits are outdated, and the Abt report (2014) recommended not quantifying these benefits until a systematic literature review of current research on this topic could be conducted and the sufficiency of data and information could be reevaluated. This literature review is planned for socioeconomic assessments in future AQMPs.

Visibility Benefit

Visibility benefits are the benefits individuals place on the ability to see distant vistas, in places where they live, work, and travel. In qualitative terms, an example of this for the Basin is the value people place on being able to see the San Gabriel Mountains, which were designated a National Monument, from much greater distances, more often. Studies have found that individuals place a monetary value on being able to see distant vistas (V. K. Smith and Osborne 1996). A local study by Beron et al. (2001), which estimated parameters that could quantify the value of these visibility benefits,[46] was applied to valuation of the visibility improvements of previous AQMPs. The

[46] This study used a method called hedonic price analysis, which uses property values along with a diverse set of attributes to estimate the implicit prices of attributes that are associated with a good exchanged in the market.

visibility benefit of the 2007 AQMP was projected to be $5.2 billion (in 2000 dollars) for the year of 2020, and $649 million (in 2005 dollars) as a result of the 2012 AQMP for the year of 2023. The larger benefit from the 2007 AQMP is due to a greater reduction of PM2.5 concentrations than those achieved in the 2012 AQMP.

There will also be benefits to visibility as a result of the air quality improvements achieved from implementing the Draft 2016 AQMP. However, quantification of these benefits was not performed in this analysis based on a recommendation from Abt Associates (2014). The Abt report argued that the local study used to monetize the visibility benefits in previous AQMPs had shortcomings and was dated;[47] therefore, an updated methodology is needed to accurately estimate these benefits. This methodology update is planned for socioeconomic assessments in future AQMPs.

Preliminary Discussion of Health Effects of Unemployment

Recent economics literature has shown that job displacement, particularly due to plant closings and layoffs, could lead to adverse health effects on the individuals who experience job losses (see Tekin (2015) for a thorough review). In a groundbreaking study by Sullivan and von Wachter (2009), displaced workers were found to experience increased mortality risk immediately following their job loss. The heightened risk, although subsiding over time, was still present to some extent 20 years after the initial episode of job displacement. On these grounds, some of the SCAQMD's stakeholders have requested further investigation and analysis on whether air regulations and programs, while aimed to protect public health, may have actually resulted in job losses and thus produced undesirable health outcomes. These concerns were expressed during the stakeholder interviews conducted by Abt Associates as part of their review of SCAQMD socioeconomic assessment, and Abt recommended that staff keep abreast of the findings from U.S. EPA's ongoing efforts to review methodology for employment effects of regulation (Abt Associates 2014).

There are two major analytical difficulties in conducting a formal analysis on this topic. First, a macroeconomic impact assessment—including the policy simulations conducted using the Regional Economic Models, Inc. (REMI)'s Policy Insight Plus model—generates job impacts in terms of the projected number of jobs foregone. This number consists of two conceptually distinctive components: job losses and forecasted jobs not created, but they cannot be numerically separated. At the same time, while job losses are associated with higher health risks, the linkage between a job that never existed and public health is not well understood, let alone quantified. Furthermore, while a number of empirical studies, based on observed or surveyed data, have identified negative job impacts of past environmental regulations in the heavy polluting industries (e.g., Greenstone (2002)), the overall impact on economy-wide employment has been found to be largely muted, due to various factors including employment shifts from heavy polluting to less

[47] The methodological improvements since Beron et al. (2001) was published would address issues such as endogeneity in spatial sorting of communities, choice of functional form for the econometric model, and the difficulty of measuring amenities from available data that are likely present in that research.

polluting industries (see Morgenstern (2002)for a literature review). There is also empirical evidence suggesting that the negative job impact observed among the more polluting industries was, in large part, a result of slower or decreased hiring and had minimal impacts on the incumbent workers (Curtis 2014).[48]

Another major analytical difficulty is how to account for public health effects of unemployment, regardless of whether they are related to environmental regulations. Rhum (2000) and a series of follow-up studies have reported the counterintuitive finding that, as headline unemployment rates went up, public health metrics improved (usually measured by reduced mortality rate). Interestingly, it was also found that the improvement was most pronounced among the elderly, who were unlikely to be directly impacted by labor market fluctuations.[49] The SCAQMD commissioned Dr. Erdal Tekin to conduct a literature review and examine the health effects of unemployment in the four-county region. His final report provided similar results; that is, adverse health effects were generally observed among individuals who recently became unemployed, but the overall mortality risk as a public health indicator decreased when unemployment rose (Tekin 2015).[50]

To be integrated into the quantitative analysis of public health benefits discussed in the earlier section, health effects of unemployment on both displaced workers and on other segments of the population will need to be taken into account. Furthermore, a methodology needs to be developed to project job losses, which are usually an unknown fraction of projected jobs foregone. In the October 2015 meeting of the U.S. EPA's Science Advisory Board – Economy-Wide Modeling Panel, several economists on the panel did not support the inclusion of health effects of unemployment and other second-order effects when conducting macroeconomic impact modeling or cost-benefit analysis of environmental policies and regulations. The reasons cited included the current lack of sufficient empirical evidence, the difficulty to establish causality, and the anticipated small magnitude of such effects (U.S. EPA 2015a).

Although it is not currently possible to systematically quantify the health effects of potential unemployment related to air regulations and programs, it does not mean that the consequences of facilities closing and job losses are not considered when developing the Draft 2016 AQMP or during rulemaking process. The SCAQMD is committed to protecting the health of residents, while remaining sensitive to businesses. These commitments are manifested through the SCAQMD's efforts at many fronts, including public processes to solicit input and comments from all interested parties and continuous outreach to the general public and affected businesses, as well as

[48] It is worth emphasizing, however, that these empirical studies were usually based on large samples of firm-level data and the findings were derived for the general pattern of firm behavior observed in the data. These findings cannot be taken to rule out outlying behavior of an individual firm, and they also cannot be relied upon to predict the outcome of an environmental regulation that is of a very different scale or targets very different industry sectors.

[49] Stevens et al. (2015) posited that one of the many plausible mechanisms could be the effect of labor market competition on the quality of senior healthcare. During periods of low unemployment, shortage of skilled healthcare workers could adversely impact nursing home operations and raise mortality risks for their elderly residents.

[50] Full report available here: http://www.aqmd.gov/docs/default-source/clean-air-plans/socioeconomic-analysis/unemploymentandhealth_dec2015_012616.pdf

performing a socioeconomic assessment which the Governing Board must consider for rules or rule amendments significantly affecting air quality or emission limitations.

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Appendix 2-A: Compilation of Incremental Costs of Control Measures

The Draft 2016 AQMP includes control strategies for emission reductions from both stationary sources and local mobile sources, as well as broader mobile source control measures proposed by CARB that will contribute to further emission reductions and help the region attain upcoming federal air quality standards.

This appendix consists of two parts. Part I presents the incremental costs of the SCAQMD control measures with quantified emission reductions to be committed into the SIP. It also includes a discussion of currently known or available cost information for the SCAQMD's stationary source control measures with TBD emission reductions. Part II presents the incremental costs of the state's SIP control strategies. These costs are based on CARB data and assumptions,[51] and they are estimated for those control strategies with quantified emission reductions in the Basin.

Part I – Incremental Costs of the SCAQMD Control Measures

(a) Incremental Costs of Control Measures with Quantified Emission Reductions

Direct costs associated with the Draft 2016 AQMP control measures generally include capital expenditures on control or replacement equipment or on research and development to reformulate chemical products. They also include annual operating and maintenance costs such as fuel, utilities, filter replacement and so on.

The present worth value (PWV) of incremental costs by measure was calculated based on a four-percent discount rate which discounts all future stream of costs to year 2017.[52] Conversely, the amortized annual average cost was obtained by amortizing the PWV of the incremental costs over the average equipment life using the same discount rate. Notice that the analysis horizon which is used in the macroeconomic impact evaluation in Chapter 4 of this report is from 2017 to 2031, or from the year after the anticipated Plan adoption to the year when the 2008 8-hour ozone standard of 75 ppb will need to be achieved. However, many categories of equipment included in the cost analysis will continue to be in operation after year 2031, either because of their long equipment life or because they are expected to come online at a later date. The PWV reported in Table 2-1 of Chapter 2 includes all recurring costs over the entire equipment life; thus, it may include costs occurring after 2031. In that same table, the amortized annual average cost over the period 2017-

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[51] See CARB's Mobile Source Strategy, Appendix A: Economic Impact Analysis (2016a).

[52] In 1987, SCAQMD staff began to calculate cost-effectiveness of control measures and rules using the Discounted Cash Flow method with a discount rate of 4 percent. Although not formally documented, the discount rate is based on the 1987 real interest rate on 10-year Treasury Notes and Bonds, which was 3.8 percent. The maturity of 10 years was chosen because a typical control equipment life is 10 years; however, a longer equipment life would not have corresponded to a much higher rate—the 1987 real interest rate on 30-year Treasury Notes and Bonds was 4.4 percent. Since 1987, the 4 percent discount rate has been used by SCAQMD staff for all cost-effectiveness calculations, including BACT analysis, for the purpose of consistency. The incremental cost reported in this assessment was thus annualized using a real interest rate of four percent as the discount rate. As a sensitivity test, a real interest rate of one percent will also be used, which is closer to the prevailing real interest rate (see https://www.whitehouse.gov/omb/circulars_a094/a94_appx-c/).

2031 is also reported. This cost, in contrast, includes recurring costs up to 2031, and the amortized capital and other upfront costs beyond 2031 are not included. The amortized costs are comparable to the costs reported in the Economic Analysis for the Proposed 2016 State Strategy for the State Implementation Plan (2016b).

Cost assumptions and cost breakdown by measure are presented below (see Chapter 4 and Appendixes 4-A and 4-B of the Draft 2016 AQMP for the detailed description of each measure). All costs presented herein are expressed in 2015 dollars, with conversion based on the Marshall and Swift Index of equipment costs. It should be noted that the implementation period for the cost analysis may differ somewhat from the "Implementation Period" listed in the Draft 2016 AQMP Table 4-2 on page 4-10. The implementation period for the cost analysis herein generally refers to the year(s) when the control or replacement equipment will be purchased, installed, and begin operation. It is assumed that the purchase and installation of all equipment is evenly distributed over the implementation period unless otherwise noted.

Finally, the control measures that recognize co-benefit ozone emission reductions from other programs will not have incremental costs. They include *ECC-02 (Co-benefits from existing residential and commercial building energy efficiency measures)* which have quantified NOx emission reductions. They also include *ECC-01 (Co-benefit emission reductions from GHG programs, policies, and incentives)* and *ECC-04 (Reduced ozone formation and emission reductions from cool roof technology)*, both with TBD NOx emission reductions. These measures are part of federal, state, and local programs and are being implemented across multiple energy sectors and are generally mandated by law, regardless of whether the Draft 2016 AQMP is adopted. Their costs therefore are not a result of the proposed control measures.

Stationary Source Measures (NOx and/or VOC Emission Reductions)

❖ *CMB-01 (Transition to zero, near-zero emission technologies for stationary sources)*

This proposed control measure would seek emission reductions of NOx from traditional combustion sources by replacement with zero and near-zero emission technologies including low NOx emitting equipment, electrification, alternative process changes, efficiency measures, or fuel cells for combined heating and power (CHP).

Implementation period for cost analysis: 2018-2031
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost	Per Unit/Facility Incentive Amount	Number of Units	Years of Equipment Life
ICE upgrade	All Industries	$135,000	$58,582	5,500	25
Boilers	All Industries	$800,000	$81,203	133	25
Ovens/furnaces	All Industries	$35,000	$33,030	1,000	25
Facility Modernization	Landfills (562)	$6,700,000	$1,862,069	29	25
Facility Modernization	Waste Water Treatment (221)	$1,500,000	$771,429	35	25

No additional operating and maintenance costs were assumed.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
CMB-01	$515.8	+	$337.3	=	$853.1	$34.8

❖ *CMB-02 (Emission reductions from commercial and residential space and water heating)*

This control measure seeks annual average NOx emission reductions from unregulated commercial space heating furnaces and from incentive programs to replace existing older boilers, water heaters, and space heating furnaces.

Implementation period for cost analysis: 2018-2031[53]
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Per Unit Incentive Amount	Number of Units	Years of Equipment Life
Various Categories of Water Heater/Boiler	All Industries	$750-$28,000	$5,000-$10,000	2,000-50,000	15-25

No additional operating and maintenance costs were assumed.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
CMB-02	$1,891.4	+	$327.7	=	$2,219.1	$99.0

❖ *CMB-03 (Emission reductions from non-refinery flares)*

This control measure proposes that, consistent with the all feasible control measures, all non-refinery flares meet current BACT for NOx emissions and thermal oxidation of VOCs. The preferred method of control would involve capturing the gas that would typically be flared and converting it into an energy source (e.g., transportation fuel, fuel cells).

Implementation period for cost analysis: 2017
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Incentive Amount	Number of Units	Years of Equipment Life
Bekaert Flares	Oil and Gas (211), Utilities (221), Waste Water Treatment (221), Chemical Manufacturing (325), Transportation Equipment Manufacturing (336), Pipeline Transportation (486), Support Activities for Transportation (488), Landfills (562)	$420,000	$0	40	25

Additional operating and maintenance costs were estimated at $30,000 per unit.

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[53] Depending on the category of water heater/boilers, some are assumed to be evenly phased in between 2018 and 2023, some between 2018 and 2031, and others between 2023 and 2031.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
CMB-03	$36.3	+	$0	=	$36.3	$2.2

❖ *CMB-04 (Emission reductions from restaurant burners and residential cooking)*

This control measure applies to retail restaurants and quick service establishments utilizing commercial cooking ovens, ranges and charbroilers by funding development of, promoting and incentivizing the use and installation of low-NOx burner technologies. In addition, the SCAQMD would consider developing a manufacturer based rule to establish emission limits for cooking appliances used by restaurants and residential applications.

Implementation period for cost analysis: 2018-2031
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit Cost[54]	Per Unit Incentive Amount	Number of Units	Years of Equipment Life
Restaurant Burners	Restaurants (722)	$3,000-$7,000	$1,000	500,000	15

No additional operating and maintenance costs were assumed.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
CMB-04	$1,552.7	+	$388.2	=	$1,940.9	$118.9

54 Sources: Southern California Gas Company and industry representatives.

❖ *CMB-05 (Further NOx reductions from RECLAIM assessment)*

This control measure identifies a series of approaches, assessments, and analyses that can be explored to make the RECLAIM program more effective in ensuring equivalency with command and control regulations implementing BARCT, and to potentially generate further NOx emission reductions at RECLAIM facilities.

Implementation period for cost analysis: 2026-2031
Cost assumptions:[55]

Equipment Name	Affected Industries (NAICS)	Capital and Installation Costs (Millions)	Total O& M Costs (Millions)	Years of Equipment Life
Fluid Catalytic Cracking Units (FCCUs)	Petroleum and Coal Products(324)	$227.01	$10.86	25
Gas Turbine	Petroleum and Coal Products(324)	$15.64	$3.67	25
Coke Calciner	Petroleum and Coal Products(324)	$50.84	$2.58	25
Boilers/Heaters	Petroleum and Coal Products(324)	$201.0	$2.42	25
Sulfur Recovery Units	Petroleum and Coal Products(324)	$114.62	$0.64	25
Glass Melting Furnaces	Nonmetallic Mineral Product Manufacturing(327)	$5.68	$0.47	25
Sodium Silicate Furnace	Chemical Manufacturing (325)	$2.0	$0.13	25
Metal Heat Treating Furnace	Primary Metal Manufacturing (331)	$2.8	$0.32	25
Non-Refinery Gas Turbines	Oil and Gas(211), Paper Manufacturing (322), and Support Activities for Transportation (488)	$17.06	$2.36	25
Non-Refinery ICEs	Utilities (221)	$36.2	$2.72	25

55 Source: 2015 Amendments to the NOx RECLAIM (SCAQMD 2015).

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
CMB-05	$837.8	+	$0	=	$837.8	$19.3

❖ *ECC-03 (Additional enhancements in reducing existing residential building energy use)*

This control measure would seek to provide incentives for existing residences that include weatherization, upgrading older appliances with highly efficient technologies and renewable energy sources to reduce energy use for water heating, lighting, cooking and other large residential energy sources.

Implementation period for cost analysis: 2018-2031
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Per Unit Incentive Amount	Number of Units	Years of Equipment Life
Water Heater (Electric Heat Pump)	Consumers	$1,660	$200	660,559	13
Pool Heater (Cover)	Consumers	$500	$200	583,893	6
Dryer (Electric)	Consumers	$900	$100	803,762	14
High efficiency Furnace	Consumers	$2,627	$200	216,352	30

Annual operating and maintenance net cost/(savings) assumptions:[56]

Equipment Name	Per Unit Cost	Number of Units
Water Heater (Electric Heat Pump/w Solar Energy)	$(132)	62,612
Water Heater (Electric Heat Pump)	$15	62,612
Pool Heater (Cover)	$(170)	55,345
Dryer (Electric)	$30	76,186
Weatherization to reduce furnace & AC usage	$(79)	201,102

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
ECC-03	$1,553.4	+	$313.5	=	$1,866.9	$103.4

Stationary Source Measures (VOC and/or PM2.5 Emission Reductions)

❖ *BCM-10 (Emission reductions from greenwaste composting)*

This control measure proposes potential emission minimization through emerging organic waste processing technology and potential emission reductions through restrictions on the direct land application of chipped and ground uncomposted greenwaste and through increased diversion to anaerobic digestion systems.

[56] $0.09 per kWh for electricity is the Federal average price in the U.S; $0.93 per therm for gas is the Federal average price in the U.S.; $1.107 cents/therm for Los Angeles area (Source: US Bureau of Labor Statistics http://www.bls.gov/regions/west/news-release/averageenergyprices_losangeles.htm.)

Implementation period for cost analysis: 2017-2031
Capital cost assumptions[57]:

Affected Facilities (Types of Operations)	Affected Industries (NAICS)	Annual Cost	Per Unit/Facility Incentive Amount	Number of Units
Facility A (Landscaping& Nursery)	Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers (424930)	$186,448	$0.0	1
Facility B (Recycle Wood Products)	Other Miscellaneous Durable Goods Merchant Wholesalers (423990)	$196,480	$0.0	1
Facility C (Chipping and Grinding)	Landscaping Services (561730)	$106,976	$0.0	1
Facility D (Green Waste Operation)	Farm Supplies Merchant Wholesalers (424910)	$74,688	$0.0	1
Facility E (Landscape Operations)	Landscaping Services (561730)	$3,834	$0.0	1
Facility F (Disposal Services)	Other Waste Collection (562119)	$218,508	$0.0	1
Facility G (Landscape Operations)	Other heavy and civil engineering construction (237990)	$68,282	$0.0	1
Facility H (Other Wood Product Manufacturing)	Cut Stock, Resawing Lumber, and Planing (321912)	$162,1999	$0.0	1
Facility I (Solid Waste Management)	Solid waste landfill (562212)	$232,175	$0.0	1

[57] http://www.sunshinegrowersnursery.com for compost covering and material pickups; https://www.eia.gov/ for water and gasoline retail Prices; SCAQMD, Socioeconomic Assessment for PAR 1133.1 & PR 1133.3, July 2011; SCAQMD, Final Staff Report for PAR 1133.1 & PR 1133.3, July 2011; CalRecycle, Emissions Testing of VOC from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley, October 2007.

Affected Facilities (Types of Operations)	Affected Industries (NAICS)	Annual Cost	Per Unit/Facility Incentive Amount	Number of Units
Facility J (Nursery and Garden Supplies)	Nursery, Garden Center, and Farm Supply Stores (444220)	$75,325	$0.0	1
Facility K (Landscape Operations)	Other Waste Collections (561730)	$4,070	$0.0	1
Facility L (Landscape Operations)	Landscaping Services (561730)	$40,325	$0.0	1
Facility M (Solid Waste Management)	Other Waste Collections (561730)	$283,626	$0.0	1

No additional operating and maintenance costs were assumed.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
BCM-10	$18.4	+	$0	=	$18.4	$1.7

❖ *FUG-01 (Improved leak detection and repair)*

This control measure seeks to reduce emissions from a variety of VOC emission sources including, but not limited to, oil and gas production facilities, petroleum refining and chemical products processing, storage and transfer facilities, marine terminals, and other sources, where VOC emissions occur from fugitive leaks in piping components, wastewater system components, and process and storage equipment leaks.

Implementation period for cost analysis: 2017-2031
Capital cost assumptions:[58]

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Incentive Amount	Number of Units	Years of Equipment Life
Advanced LDAR	Oil and Gas Production (211), Petroleum and Coal Products Manufacturing (342)	$250,000	$0	33	10

An additional annual cost of $75 for electricity and an additional annual maintenance cost of $25,000 were assumed for the affected facilities.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
FUG-01	$11.5	+	$0.0	=	$11.5	$1.0

❖ *CTS-01 (Further emission reductions from coatings, solvents, adhesives, and sealants)*

This control measure seeks limited VOC emission reductions by focusing on select coating, adhesive, solvent and sealant categories by further limiting the allowable VOC content in formulations or incentivizing the use of super-compliant technologies.

[58] http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2014/may-specsess-10.pdf

Implementation period for cost analysis: 2020 and beyond[59]
Reformulation cost assumptions:[60]

Equipment Name	Affected Industries (NAICS)	Average Cost per Gallon	Incentive Amount	Volume per Year (Gallon)	Years for Cost Recovery
Certain Coating, Adhesive, Solvent and Sealant Categories	Specialty Trade Contractors (238110)	$1.76	$0	3,300,000	14

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
CTS-01	$59.0	+	$0.0	=	$59.0	$5.4

<u>Stationary Source Measures (PM2.5 Emission Reductions)</u>

❖ *BCM-01(Further emission reductions from commercial cooking)*

This control measure seeks to establish a tiered program targeting higher efficiency controls for under-fired charbroilers at large volume restaurants, with more affordable lower efficiency controls at smaller restaurants.

59 It is assumed that reformulation cost spending would begin in 2018 to meet compliance requirements.
60 Incremental cost for VOC measures and rules is typically approximated as the price difference between the existing products that have already met the proposed product standard and those that will need to undergo reformulation to comply with the new proposed standard. The overall incremental cost is then derived from multiplying the incremental cost per unit by the number of potentially affected units. The latter is approximated by the most recent annual sales volume of the existing products that have not met the proposed new standard, multiplied by the years estimated for reformulation cost recovery.

Implementation period for cost analysis: 2021
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Incentive Amount	Number of Units	Years of Equipment Life
Electrostatic Precipitator (ESP)	Restaurant Operations (722513)	$40,500	$0	1,000	10
Vent hood cartridge + filter	Restaurant Operations (722513)	$3,000	$0	7,000	10

For large restaurants an additional annual maintenance cost of $8,000 per electrostatic precipitator is assumed. For smaller restaurants an annual cost $1,132 resulting for vent hood cartridge maintenance, based on an assumption of 52 hours of labor at $10/hour, and 72 filter replacements at $8.50/unit.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
BCM-01	$163.0	+	$0.0	=	$163.0	$17.0

<u>SCAQMD Mobile Source Measures (NOx and/or VOC, PM2.5 Emission Reductions)</u>

❖ *MOB-10 (Extension of the SOON provision for construction/industrial equipment)*

This proposed measure seeks to continue the SOON provision of the Statewide In-Use Off-Road Fleet Vehicle Regulation beyond 2023 through the 2031 timeframe to promote turnover (i.e., retire, replace, retrofit, or repower) of older in-use construction and industrial diesel engines.

Implementation period for cost analysis: 2017-2022
Capital cost assumptions:[61]

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Per Unit Incentive Amount	Number of Units	Years of Equipment Life
Off-Road Construction Equipment (Repower)	Construction (283110)	$180,226	$155,000	135	20
Off-Road Construction Equipment (Replacement)	Construction (283110)	$444,521	$155,000	315	20

An additional annual cost of $1,248 for urea usage was assumed for each repower or replacement engine.[62]

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
MOB-10	$90.8	+	$63.4	=	$154.2	$9.8

- *MOB-11 (Extended exchange program)*

This measure seeks to continue the successful lawnmower and leaf blower exchange programs in order to increase the penetration of electric equipment or new low emission gasoline-powered equipment used in the region. The proposed extended exchange program will focus on incentives to accelerate the replacement of older equipment with new Tier 4 or cleaner equipment or zero-emission equipment where applicable. In addition, other small off-road equipment (SORE) may also be considered for exchange programs for accelerating the turnover of existing engines.

[61] Source: SOON program, 2014-2016.
[62] Urea (DEF) cost of $1,248/truck/year = 3% x 200 gal fuel/week x 52 weeks/year.

Implementation period for cost analysis: 2018-2022
Capital cost assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit Cost	Per Unit Incentive Amount	Number of Units	Years of Equipment Life[63]
Replace Commercial Diesel Equipment 15-25 HP with T4 or Cleaner	Landscaping Services (561730)	$12,000	$3,000	14,550	10
Replace Commercial Diesel Tractors 5-15 HP with T4 or Cleaner	Landscaping Services (561730)	$8,000	$2,000	11,600	8
Replace Commercial Gasoline Equipment 5-25 HP with Cleanest or Zero Emission Equipment	Landscaping Services (561730)	$14,000	$1,000	7,500	8

No additional operation and maintenance costs were assumed for this measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
MOB-11	$198.6	+	$66.2	=	$264.8	$30.6

❖ *MOB-14 (Emission reductions from incentive programs)*

This measure seeks to develop a rule similar to the San Joaquin Valley Air Pollution Control District Rule 9610 to recognize emission reduction benefits associated with incentive programs. The proposed rule would recognize the emission benefits resulting from incentive funding programs such as the Carl Moyer Memorial Air Quality Standards Attainment Program and Proposition 1B such that the emission reductions can be accounted for in the SIP.

Implementation period for cost analysis: 2017-2023
Capital cost assumptions:

[63] Based on CARB Offroad2007 model AgeDist table (used all years in age distribution).

Equipment Name (Implementation Period)	**Affected Industries (NAICS)**	**Per Unit Cost**	**Per Unit Incentive Amount**	**Number of Units**	**Years of Equipment Life**
CNG School Buses (2017-2023)	Transit Buses (485)	$200,000	$175,000	600	15
Tier 4 Freight Locomotives (2017)	Rail Yards (482)	$3,000,000	$2,550,000	10	30
Electric Cargo Handling Equipment (2017-2019)	Ports (488)	$300,000	$100,000	68	12
0.02 g/bhp-hr On-Road Heavy-Duty Trucks (2017-2023)	Truck Transportation (484)	$125,000	$50,000	7,500	15

An annual fuel cost-savings of $8,000 were assumed for each of the 600 school buses.[64] An annual fuel cost-savings of $8,320 were assumed for each of the 68 electric cargo handling equipment.[65] An additional annual cost of $1,248 for urea usage was assumed for each of the 7,500 heavy-duty trucks.[66]

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	**Present Value of Remaining Incremental Cost**		**Present Value of Incentives**		**Present Worth Value of Total Incremental Cost**	**Amortized Annual Average (2017-2031)**
MOB-14	$572.5	+	$459.1	=	$1,031.6	$79.8

(b) Stationary Source Control Measures with TBD Emission Reductions

The control measures listed below are not part of the attainment demonstration. SCAQMD staff will conduct further assessments to the quantify cost and emission reductions for these measures as data becomes available. Currently available, but limited, cost information is provided below for each measure:

- *BCM-02 (Emission reductions from cooling towers)*

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64 Fuel cost-savings: 20% of diesel fuel cost = 10,000 gal/year x $4/gal x 20%.
65 Fuel cost-savings: 80% of diesel fuel cost = 2,600 gal/year x $4/gal x 80%.
66 Urea (DEF) cost of $1,248/truck/year = 3% x 200 gal fuel/week x 52 weeks/year.

SCAQMD Rule 219(d) exempts cooling towers that do not contain chromium compounds from permitting requirements. As such, the universe of equipment that may cost-effectively benefit from the use of high efficiency drift eliminators is currently unavailable and would be addressed during rule development if rulemaking is determined to be necessary.

❖ *BCM-03 (Further emission reductions from paved road dust sources)*

A street sweeping and wheel washing system can be leased for about $3,000 per month with one-time installation/removal, including transportation cost of about $14,000. However, the number of facilities and local jurisdictions that may participate and benefit from the use of these additional programs are unknown at present and would be the subject of the rule development effort, if rulemaking is determined to be necessary.

❖ *BCM-04 (Emission reductions from manure management strategies)*

This control measure includes a wide range of manure control strategies which can be applied on a year-round basis. To reduce costs, some techniques could be seasonally or episodically applied during times when high ambient PM2.5 levels are of concern. Given the current serious nonattainment status for PM 2.5, unique rule requirements for local dairies in the Basin may be the best approach and feasibility and effectiveness may require a case-by-case assessment. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

❖ *BCM-05 (Ammonia emission reductions from NOx controls)*

The purpose of this control measure is to seek reductions of ammonia from NOx controls such as Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR). The use of these control systems can result in potential emissions of ammonia that slip past the equipment and into the atmosphere. Ammonia precursor for PM. Recent advances in catalyst technology have resulted in the development of ammonia slip catalysts that selectively convert ammonia into nitrogen. These catalysts could be installed post-SCR and would result in less ammonia slip. Based on a recent estimate from Ammonia Slip Catalyst (ASC) vendor, an ASC equipment adder (which includes ASC catalyst and a means of loading it into the SCR reactor) is estimated to cost about 6 percent to 12 percent over the cost of SCR emission system equipment. Further cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

❖ *BCM-06 (Emission reductions from abrasive blasting operations)*

The California Health and Safety Code Section 41904 prohibits local districts from requiring emission and performance standards more or less stringent that the state regulation. SCAQMD Rule 1140 – Abrasive Blasting has been developed to conform to the 17 CCR §§92000 et seq (Abrasive Blasting). Due to this pre-emption, this control measure proposes only a voluntary application of limited possible air pollution control methods by providing incentives. The inherent uncertainty in operator preferences limits the ability to forecast resultant emission reductions and costs at this time. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

❖ *BCM-07 (Emission reductions from stone grinding, cutting and polishing operations)*

SCAQMD Rule 219(g) exempts from permitting requirements machining equipment exclusively used for polishing, cutting, surface grinding, etc. The universe of affected facilities under this control measure is not fully developed and needs assessment outside of the permitting arena. Due to the absence of operational data at existing facilities, the emission, potential reductions and associated costs are not available and would be addressed during rule development, if rulemaking is determined to be necessary.

❖ *BCM-08 (Further emission reductions from agricultural, prescribed and training burning)*

Changes to prescribed burning programs are anticipated to have minimal direct costs as burning would likely be shifted to other times of the year, although training and fire suppression issues would take precedence. Incentivizing or requiring burning alternatives (e.g., chipping/grinding with land application) could increase costs to the agricultural community although 90 percent of agricultural burning occurs in the Coachella Valley portion of the Salton Sea Air Basin which, unlike the Basin, is currently classified as a PM2.5 unclassifiable/attainment area and would not be targeted as part of an attainment demonstration.

❖ *BCM 09 (Further emission reductions from wood-burning fireplaces and wood stoves)*

Increasing the number of no burn days would result in relatively few direct cost increases to the impacted community as regional residential wood burning is primarily for aesthetic purposes. Based on results of the current and former SCAQMD incentive programs, a basic gas log set can be purchased at a local retailer and installed by a contractor into a home with an existing wood burning fireplace plumbed for natural gas for approximately $400 to $500. The average cost associated with removal and replacement of conventional (uncertified) wood heaters with a U.S. EPA Phase II-certified device has been estimated at $4,000 per unit. The devices are unpermitted and the total number is market and consumer driven. Wood heater upgrades are allowed under the current targeted incentive program but participation has been low due to the small eligible geographic area, whereas, over 10,000 gas log sets have been voluntarily installed into traditional wood-burning fireplaces under various incentive programs implemented since 2008. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

- *FLX-01 (Improved education and public outreach)*

This proposed control measure seeks to provide education, outreach, and incentives for consumers to contribute to clean air efforts. Examples include consumer choices such as the use of energy efficient products, new lighting technology, "super-compliant" coatings, tree planting, transportation choices, and the use of lighter colored roofing and paving materials which reduce energy usage by lowering the ambient temperature. Potential cost of this control measure cannot be quantified at this time due to the fact that the number of individuals, facilities, and public entities that may participate and benefit from the use of these additional programs are unknown at the present. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

- *FLX-02 (Stationary source VOC incentives)*

This control measure would seek to incentivize VOC emission reductions from various stationary and area sources through incentive programs for the use of clean, low emission materials or processes. Facilities would be able to qualify for incentive funding if they utilize equipment or material, or accept permit conditions which result in cost-effective emission reductions that are beyond existing requirements. The decision regarding when to replace existing equipment can vary; some facilities may replace equipment or reformulate material when it is no longer operable or outdated, while other facilities may replace equipment or material well before it reaches that point. Predicting VOC emission reductions from these voluntary activities is challenging as the availability and amount of incentives would directly affect the level of VOC emission reductions achieved. Emission benefits from incentives can be quantified based on program participation, technology/material penetration, and other assessment and inventory methods.

The cost and cost-effectiveness of this measure cannot be determined at this time, given the potential variety of programs and projects that will be developed. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

❖ *MCS-01 (Improved breakdown procedures and process re-design)*

SCAQMD existing Rule 430 – Breakdown Provisions, applies to breakdowns that result in a violation of any rule or permit conditions, with some exceptions, and stipulates reporting requirements. This control measure would introduce improved breakdown procedures and/or process re-designs that would apply to breakdowns from all emission sources, providing pollutant concentration, work practice, and/or incidence limits to comply with U.S. EPA's Startup, Shutdown, and Maintenance (SSM) policy. This would apply for combustion equipment that can be tested readily with a portable analyzer such as boilers, engines, and some ovens and furnaces, along with associated control equipment such as SCR. Due to the nature of this control measure, cost-effectiveness cannot be calculated. The inherent uncertainty in operator preferences limits the ability to forecast resultant emission reductions and costs at this time. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

❖ *MCS-02 (Application of all feasible measures)*

This control measure serves as a placeholder for any future control measures that may become feasible, prior to subsequent SIP revisions, through technology advances and/or cost decreases. The SCAQMD staff continually monitors evolving control technologies, price changes, and the actions of other air quality agencies to determine the feasibility of implementing additional controls to achieve emission reductions.

For example, almost all processes in the pulp and recycled paper mills (e.g., pulping machines, press and dryers to convert waste-paper –newspaper, cardboard, etc. – back into cardboard paper) are sources of fugitive VOC emissions, yet currently very high air flow of vent gases makes it impractical and not cost-effective to vent the exhaust gas to a control device. Similarly, breweries, wineries, distillers and other similar operations that store and process grains, ferment, age, store and package the spirits (beer, wine, whiskey, etc.,) and treat the wastewater on site generate VOC and PM emissions.

Cost and cost-effectives for this control measure cannot be determined because there is currently no known feasible control potentially available for fugitive VOC emissions generated by these type of sources. As a result, cost analysis will be addressed during rule development, if rulemaking is determined to be necessary.

❖ *Local mobile source TBD control measures*

Several mobile source control measures proposed by the SCAQMD have emission reductions TBD. Many of these control measures are proposed to facilitate local implementation of the State SIP control strategy's further deployment of advanced technology measures proposed by CARB.

Therefore, they are not expected to generate additional emission reductions beyond the state's emission reduction commitments.

Part II – Incremental Costs of the of the State's SIP Control Strategies

To arrive at the cost of the Mobile Source Strategy, CARB 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 operation and maintenance costs associated with each mobile source type. These cost differentials are used to calculate the costs over a vehicle or equipment population generated by the Vision model.

CARB proposed four categories of mobile source measures: On-road light-duty, On-road heavy-duty, Off-Road Federal, and International, and Off-Road Equipment.

Vision Model

CARB staff used the Vision model, version 2.1, to estimate the emission reductions as outlined in the State Mobile Source Strategy. Vision 2.1 is estimation tool that can analyze multiple potential technology and fuel pathways for individual emission sources while collectively considering multiple sectors, fuels, and technologies in comprehensive scenarios to study different pathways to meeting California's air quality and climate goals (CARB 2015). Vision 2.1 incorporates updated CARB inventory work including EMFAC2014, and reflects currently adopted policies.[67] In addition, Vision 2.1 scenarios illustrate the type of technology transformation that would be required to meet the kinds of deadlines/goals that California faces. In this model, a typical user can define penetration rates and technology availability and receive outputs such as greenhouse gas emissions, criteria pollutant emissions, and energy mix.

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 (for more details see CARB (2016b)).

For control measures where CARB staff has provided the change in the quantity of energy expected by measure, SCAQMD staff uses the energy price projections for the Pacific region from U.S. Department of Energy, Energy Information Administration's Annual Energy Outlook 2015 (2015) to calculate cost/savings.

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

(a) On-Road Light-Duty

❖ *Advanced Clean Cars* 2

This proposed measure is designed to ensure that zero and near-zero emission technology options continue to be commercially available, with range improvements to address consumer preferences for greater ease of use, and maximize electric vehicle miles travelled (eVMT). The regulation 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 look at ways to improve real world emissions through implementation programs. Additionally, new standards would be considered to further increase the sales of zero-emission vehicles (ZEVs) and plug-in hybrid electric vehicles (PHEVs) beyond the levels required in 2025. The Advanced Clean Cars 2 program is expected to result in price increases (mainly borne by consumers) for new vehicles, while also leading to reduced operating and fuel costs (electricity and hydrogen versus gasoline).

Implementation period for cost analysis: 2026-2031

Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units	Years of Equipment Life
BEV(Battery) Electric Vehicles	Consumers	$11,237	$0	176,200	14
PHEV(Plug-in-Hybrid Electric Vehicles)	Consumers	$10,676	$0	392,100	14
FCEV(Fuel Cell/Battery Electric Vehicles)	Consumers	$8,788	$0	116,600	14

Additional annual operating and savings of $126 was assumed for each of affected vehicles. The additional savings from fuel/energy demand is presented in table below, all in millions of 2015 dollars:

Years	Gasoline (Billions of Gallons)	Price of Gasoline ($/ Gallon)	Diesel (Billions of Gallons)	Price of Diesel ($/Gallon)	Quantity of Electricity (MWhs)	Electricity Price ($/ MWh)	Quantity of Hydrogen kg	Price of Hydrogen ($/ kg)
2026	-0.022	$3.29	-0.0002	$3.54	77,000	$137.9	1250,000	$6.00
2027	-0.041	$3.34	-0.0003	$3.59	139,000	$138.0	2410,000	$6.00
2028	-0.057	$3.41	-0.0004	$3.67	189,000	$137.4	3190,000	$6.00
2029	-0.069	$3.47	-0.0005	$3.73	235,000	$136.8	3950,000	$6.00
2030	-0.079	$3.52	-0.0006	$3.78	267,000	$136.8	450,0000	$6.00
2031	-0.077	$3.58	-0.0005	$3.85	228,000	$136.7	3,900,000	$6.00

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Advanced Clean Cars 2	($2,380.3)	+	$0	=	($2,380.3)	($90.8)

❖ *Further Deployment of Cleaner Technology On-Road Light-Duty Vehicles*

This proposed measure is designed to achieve further emission reductions for the Basin's attainment needs through a suite of additional actions, including greater penetration of zero and near-zero technologies through incentive programs, and emission benefits associated with increased transportation efficiencies, as well as the potential for autonomous vehicles and advanced transportation systems. This measure aims to achieve 2,000,000 ZEVs/PHEVs in SCAQMD by 2031. The number of vehicles is assumed to spread out evenly from 2017 to 2031. Funding would be available through Enhanced Fleet Modernization Program ($14,500 per vehicle) which will sunset on 1/1/2024. This measure is expected to result in price increases (mainly borne by consumers) for new vehicles, while also leading to reduced operating and fuel costs (electricity and hydrogen versus gasoline). While fuel savings are expected to result from this measure they are not quantified by CARB.

Implementation period for cost analysis: 2017-2031
Cost Assumptions[68]:

[68] Per-unit incentive amount only applies up to 2024, implementation costs persist up to 2031.

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit Incentive Amount ($) up to 2024	Number of Units 2017-2031	Years of Equipment Life
ZEVs/PHEVz	Consumers	$14,500	$14,500	2,000,000	14

No annual operating/savings or fuel savings were quantified for this control measure.

The incremental cost is presented below, all in millions of 2015 dollars[69]:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Further Deployment of Cleaner Technology for On-Road Light-Duty Vehicles	$10,792.3	+	$11,563.1	=	$22,355.4	$1,407.9

(b) On-Road Heavy-Duty

❖ *Low-NOx Engine Standard-California Action*

This proposed measure is designed to require near-zero emission engine technologies that will substantially lower NOx emissions from on-road heavy-duty vehicles. CARB will begin development of a new heavy-duty low-NOx emission standard in California in 2017, with Governing Board action expected in 2019. A California-only low-NOx standard would apply to all vehicles with new heavy-duty engines sold in California starting in 2023. CARB 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. SCAQMD has already petitioned the U.S. EPA to establish a national new low-NOx standard.

Implementation period for cost analysis: 2023-2027
Cost Assumptions:

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[69] The PV of incentives for this measure is found by dividing the total incentive amount ($15B) by the population (2 million) and discounting according to the implementation schedule.

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($) up to 20124	Number of Units 2026-2027	Years of Equipment Life
ZEVs/PHEVz	Truck Transportations (484)	$1,500	$0	140,600	10

No additional annual operating/savings or fuel savings were assumed for this control measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Low NOx Engine Standard-California Action	$154.3	+	$0	=	$154.3	$11.7

❖ *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, CARB will coordinate its California feet rulemaking efforts with the federal regulation.

Implementation period for cost analysis: 2024-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($) up to 20124	Number of Units 2024-2031	Years of Equipment Life
ZEVs/PHEVz	Truck Transportations (484)	$1,500	$0	282,600	10

No additional annual operating/savings or fuel savings were assumed for this control measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Low NOx Engine Standard-Federal Action	$281.9	+	$0	=	$281.9	$15.1

❖ *Advanced Clean Transit*

This measure is designed to continue the transition of transit fleets to cleaner technologies to support NOx and GHG emission reduction goals. The measure will consider a variety of approaches to enhance the deployment of advanced clean technology and increase the penetration of the first wave of zero-emission heavy-duty technology into transit applications that are well suited to its use. CARB staff will develop and propose an Advanced Clean Transit 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. For this measure, the operating and maintenance cost and fuel savings will more than offset the incremental cost of (electric or CNG or fuel cell,) and infrastructure buses. 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.

Implementation period for cost analysis: 2018-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units by 2031	Years of Equipment Life
BEV(Battery) Electric Vehicles	Transit and Ground Transportation (485)	$89,445-$211,122	$89,445-$211,122	1,600	12
Low-NOx	Transit and Ground Transportation (485)	$50,000	$50,000	1,210	12
FCEV(Fuel Cell/Battery Electric Vehicles)	Transit and Ground Transportation (485)	$255,000-$605,000	$255,000-$605,000	270	12

Additional annual operating and costs/savings and additional costs infrastructure are presented in table below, all in millions of 2015 dollars:

Incremental O&M	2018-2020	2021-2031
BEB (slow charge)	($18,000)	($18,000)
FCEB	$16,000	($7,000)

Infrastructure	n/a	2018	2025
Slow charging (cost per bus)	20,000		
H2 Station ($5M Each)	3	15,000,000	$15,000,000

Additional change in energy and fuel demand are presented in the table below, all in millions of 2015 dollars:

Years	Gasoline (Billions of Gallons)	Diesel (Billions of Gallons)	Electricity (MWh)	Natural Gas (Bcf)	Hydrogen (kg)
2018	-0.00045	-0.00037	0.0083	-0.0225	0.00001
2019	-0.00056	-0.00016	0.0086	-0.0496	0.00002
2020	-0.00056	-0.00016	0.0087	-0.0498	0.00002
2021	-0.00056	-0.00015	0.0089	-0.0493	0.00003
2022	-0.00056	-0.00015	0.0092	-0.0493	0.00003
2023	-0.00053	-0.00014	0.0092	-0.0476	0.00003
2024	-0.00051	-0.00013	0.0091	-0.0454	0.00003
2025	-0.00076	-0.00019	0.0141	-0.0692	0.00004
2026	-0.00102	-0.00025	0.0188	-0.0945	0.00005
2027	-0.00129	-0.00031	0.0234	-0.1206	0.00007
2028	-0.00128	-0.0003	0.0229	-0.1195	0.00007
2029	-0.00125	-0.00029	0.0220	-0.1169	0.00006
2030	-0.0026	-0.0006	0.0452	-0.2453	0.00012
2031	-0.00267	-0.00049	0.0454	-0.3410	0.00002

Corresponding price forecast from the above energy categories are listed below from U.S. DOE EIA (2015):

Years	Gasoline Price ($/ Gallon)	Diesel Price ($/Gallon)	Electricity Price ($/MWh)	Natural Gas Price ($/MMBtu)	Hydrogen Price ($/kg)
2018	$2.97	$3.39	$123.04	$9.86	$6.00
2019	$2.98	$3.44	$122.13	$10.28	$6.00
2020	$3.03	$3.50	$122.24	$10.71	$6.00
2021	$3.07	$3.56	$122.55	$11.01	$6.00
2022	$3.10	$3.63	$122.62	$11.18	$6.00
2023	$3.15	$3.70	$121.84	$11.35	$6.00
2024	$3.20	$3.76	$121.28	$11.44	$6.00
2025	$3.24	$3.82	$121.66	$11.69	$6.00
2026	$3.29	$3.89	$122.28	$11.91	$6.00
2027	$3.34	$3.95	$122.31	$11.92	$6.00
2028	$3.41	$4.03	$121.42	$11.81	$6.00
2029	$3.47	$4.10	$120.38	$11.79	$6.00
2030	$3.52	$4.15	$120.09	$11.82	$6.00
2031	$3.58	$4.23	$119.70	$11.92	$6.00

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Advanced Clean Transit	($501.4)	+	$312.2	=	($189.2)	($6.6)

❖ *Last Mile Delivery*

This measure is designed to increase the penetration of the first wave of zero-emission heavy-duty technology into applications that are well suited to its use. This proposed measure will require the use of low-NOx engines and the purchase of zero-emission trucks for certain Class 3-7 last mile delivery trucks in California starting in 2020, with a low fraction initially and gradually ramping up to a higher percentage of the fleet at time of normal replacement through 2030. This control measure would affect truck transportation and couriers and messengers.

Implementation period for cost analysis: 2020-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units 2020- 2031	Years of Equipment Life
BEV(Battery) Electric Vehicles	Truck Transportation (484) Couriers and Messengers (492)	$31,000	$0	9,800	10
Fuel Cell (FCET)		$90,000	$0	1,100	10

Cost assumption for the infrastructure is presented below.

Truck Type/Infrastructure	Population	Incremental Capital Cost
FCEV Infrastructure	73	$20,000,000
BEV Infrastructure	980	$20,000

No additional annual operating/savings or fuel savings were assumed for this control measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Last Mile Delivery	$411.5	+	$0	=	$411.5	$29.2

❖ *Further Deployment of Cleaner Technology On-Road Heavy-Duty Vehicles*

This proposed measure is designed to achieve further emission reductions for the Basin's attainment needs through a suite of additional actions, including greater penetration of zero and near-zero technologies through incentive programs. The emission reductions will be achieved through a combination of actions to be undertaken by both CARB and the SCAQMD, benefitting

California's air quality, toxics, and climate change goals.

The costs associated with this measure concept will mainly be borne by the trucking industry as newly manufactured trucks must meet lower emission standards in order to be sold in California and consequently would cost more than the conventional counterparts. Carl Moyer and CARB's Low Carbon Transportation Program and Air Quality Improvement Program (AQIP) funds, both a component of Greenhouse Gas Reduction Funds (GGRF) are available to cover a portion of the incremental cost.

Source of Funds	Amount	Years
Carl Moyer (annually)	$28,000,000	2016-2020
ARB Low Carbon Transportation (GGRF) - annually	$7,000,000	2016-2019

Implementation period for cost analysis: 2017-2031
Cost Assumptions[70]:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units 2017-2031	Years of Equipment Life
ZEVs/PHEVs	Truck Transportations (484)	$50,825	$3,500-$4,375	120,000	10

No annual operating/savings or fuel savings were quantified for this control measure.

[70] Per-unit incentive amount only applies up to 2023, implementation costs persist up to 2031.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Further Deployment of Cleaner Technology for On-Road Heavy-Duty Vehicles	$4,448.9	+	$252.7	=	$4,701.6	$385.6

❖ *Heavy Duty Fuel (Aggregate Fuel Changes)*

CARB has provided an overall aggregate fuel/energy demand changes from all the on-road heavy duty control measures. As listed below.

Implementation period for cost analysis: 2018-2031
Cost Assumptions:

Calendar Year	Gasoline Billion Gallons	DSL Billion Gallons	CNG (Bcf)	Electricity (MWh)	Hydrogen (Kg)
2018		-0.0007			
2019		-0.0016		200	700
2020	-0.0001	-0.0035	-0.0014	5,400	17,900
2021	-0.0006	-0.0099	-0.033	11,600	38,600
2022	-0.0013	-0.0190	-0.068	27,600	91,800
2023	-0.0023	-0.0302	-0.054	48,700	162,100
2024	-0.003	-0.050	0.96	72,000	240,000
2025	-0.005	-0.075	2.33	98,100	326,800
2026	-0.006	-0.101	3.85	124,600	415,100
2027	-0.008	-0.127	5.28	150,500	501,300
2028	-0.009	-0.154	6.79	175,800	585,700
2029	-0.010	-0.183	8.34	200,600	668,400
2030	-0.012	-0.213	10.11	225,200	750,300
2031	-0.013	-0.245	12.08	248,800	828,900

Source: Vision 2.1 Model

The overall aggregate fuel cost increase/savings, including the total increase in cost of electricity and Fuel cell Hydrogen as well as other fuel savings are presented below.

Calendar Year	Gasoline (million $)	Diesel (million $)	CNG (million $)	Electricity (million $)	Hydrogen (million $)
2018	$0.00	($2.37)	$0.00	$0.00	$0.00
2019	$0.00	($3.10)	$0.00	$0.02	$0.00
2020	($0.30)	($6.65)	($0.02)	$0.64	$0.10
2021	($1.54)	($22.76)	($0.36)	$0.76	$0.12
2022	($2.17)	($33.08)	($0.40)	$1.96	$0.32
2023	($3.15)	($41.40)	$0.16	$2.57	$0.42
2024	($2.24)	($74.45)	$11.93	$2.83	$0.47
2025	($6.49)	($95.60)	$16.47	$3.18	$0.52
2026	($3.29)	($101.03)	$18.60	$3.24	$0.53
2027	($6.69)	($102.58)	$17.54	$3.17	$0.52
2028	($3.41)	($108.94)	$18.27	$3.07	$0.51
2029	($3.47)	($118.81)	$18.82	$2.99	$0.50
2030	($7.05)	($124.60)	$21.56	$2.95	$0.49
2031	($3.58)	($135.34)	$24.12	$2.82	$0.47

Source: Vision 2.1

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Heavy-Duty (aggregated fuel change)	($542.7)	+	$0.0	=	($542.7)	($55.5)

(c) Off-Road Federal & International

❖ *More Stringent National Locomotive Emission Standards*

This proposed measure is designed to reduce emissions from new and remanufactured locomotives. CARB would petition U.S. EPA for both new Tier 5 national locomotive emission standards for new locomotives, and for more stringent national requirements for remanufactured locomotives. CARB staff estimates that the U.S. EPA could require manufacturers to implement the new locomotive emission regulations as early as 2023 for remanufactured locomotives, and 2025 for newly manufactured locomotives. A new federal standard could also facilitate development and deployment of zero-emission track mile locomotives and zero-emission locomotives by building incentives for those technologies into the regulatory structure. This analysis looks at incremental costs and benefits above Tier 4 standards. Under this concept, CARB 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.

It is assumed that the rail sector would bear the total capital cost for the purchases of locomotives with the compact SCR and Diesel Oxidation Catalyst (DOC) after treatment 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.

Implementation period for cost analysis: 2024-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units 2017-2031	Years of Equipment Life
Tier 5	Rail Transportations (482)	$1,000,000	$0.0	4,690	15
Remanufacture		$250,000	$0.0	3,840	15

Annual operating costs/savings are presented below, all in millions of 2015 dollars:

Incremental Annual O&M Savings	
Tier 5	$60,000
Remanufacture	$21,600
Fuel Savings (Tier 5 only)	($135,000)

In addition, urea infrastructure for a one-time cost of $1,500,000 is assumed for this control measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	**Present Value of Remaining Incremental Cost**		**Present Value of Incentives**		**Present Worth Value of Total Incremental Cost**	**Amortized Annual Average (2017-2031)**
More Stringent National Locomotive Emission Standards	$322.6	+	$0	=	$322.6	$12.0

❖ *Tier 4 Vessel Standards*:

The goal of this measure is to reduce emissions from ocean going vessels. CARB 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 water transportation sector is expected to bear the costs of the transition to the Tier 4 technology. These costs include the incremental cost above the Tier 3 Exhaust Gas Recycling (EGR) to the Tier 4 SCR technology.

Implementation period for cost analysis: 2025-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units 2015-2031	Years of Equipment Life
Tier 4 OGV	Water Transportations (483)	$467,000	$0.0	504	20

The additional annual cost of urea usage of is estimated to be $147,000 per each Tier 4 OGV.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Tier 4 Vessel Standards	$129.5	+	$0	=	$129.5	$3.9

❖ *At-Berth Regulation Amendments*

This measure is designed to further reduce emissions from ships auxiliary engines at-berth. CARB would investigate expanding the current At-Berth Regulation to include smaller fleets and/or additional vessel types (including roll-on/roll-off vehicle carriers, bulk cargo carriers, and tankers) in the requirements for shore power. This measure will examine the potential to include other vessel types such as bulk, general cargo, roll-on roll-off (car carrier), and tanker vessels. The proposed measure would increase costs for fleet operators and potentially for terminal operators. In addition, to the extent 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 business owners that purchase these goods.

Implementation period for cost analysis: 2022
Cost Assumptions:

Cost Incurred by Ports	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units 2018-2031	Years of Equipment Life
Aggregate Vessel Equipment (bulk, general cargo, tanker vessels)	Water Transportations (483)	$10,000,000	$0.0	11	20

No additional annual operating and maintenance costs were assumed for this measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
At-Berth Regulation	$90.4	+	$0	=	$90.4	$5.2

❖ *Further Deployment of Cleaner Technology: Off-Road Federal and International Sources*

This measure is designed to achieve further emission reductions from three categories off-road federal and international sources: ocean-going vessels, aircraft, and locomotives. These actions include: expanding and enhancing incentive programs to increase the deployment of cleaner technologies; incentivizing cleaner ships and aircraft to come to California; partnering with engine manufacturers. As envisioned by CARB, the first strategy would be to increase the number of Tier 5 locomotives and Tier 4 vessels servicing California.

Costs of this measure were estimated using estimates from the More Stringent National Locomotive Emission Standards and Tier 4 Vessel Standards measures. Capital cost were distributed evenly to obtain a 30 tpd reduction from the following state wide estimate (CARB 2016b).

Control Measure	Estimated Annual Capital Cost	TPD Reductions
More Stringent National Locomotive Emission Standards	$800M	44
Tier 4 Vessel Standards	$100M	25

A total of 30 tpd were allocated for the SCAB portion. To estimate the cost, CARB used the ratio of emission reductions (44*0.34 = 15tpd) and (25*0.66= 15tpdy) for the locomotive and tier 4 vessel standard, respectively. Applying these shares to the overall cost of this measure in the SIP would result in:

Average annual capital cost to Rail Transportation multiplied by 0.34 (44*0.34) to reach 15tpd = $800M x 0.34 = $272M

Average annual capital cost to Water Transportation multiplied by 0.639 to reach 15tpd = $100M x 0.6 = $60M as presented in the table below, all in millions of 2015 dollars:

Control Measure	Estimated (Annual) Capital Cost	Estimated Annual Production Cost converting to a combined 30tpd reduction
More Stringent National Locomotive Emission Standards	$800M	$272M
Tier 4 Vessel Standards	$100M	$60M

Implementation period for cost analysis: 2023-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Total capital Costs ($) 2023-2031	Per Unit/Facility Incentive Amount ($)	Number of Units 2023-2031	Years of Equipment Life
Rail Yards	Rail Transportations (482)	2,241,000,000	$0.0	N/A	10
Ports	Water Transportations (483)	747,000,000	$0.0	N/A	10

No additional annual operating and maintenance costs were assumed for this measure.

The incremental cost is presented below in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Further Deployment of Cleaner Technology: Off-Road Federal and International	$2,029	+	$0	=	$2,029	$118.1

(d) Off-Road Equipment

❖ *Low-Emission Diesel Fuel Requirement*

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

Additional cost of Low-Emission Diesel was distributed evenly among sectors of Rail Yards (NAICS 483) and Water Transportations (NAICS 488).

Implementation period for cost analysis: 2023-2031
Cost Assumptions:

Years	Costs in Millions
2023	$76.8
2024	$107.1
2025	$131.8
2026	$150.9
2027	$164.0
2028	$170.7
2029	$171.1
2030	$165.4
2031	$165.4

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Low-Emission Diesel Requirement (All Off-Road)	$834.3	+	$0	=	$834.3	$86.9

❖ *Zero-Emission Off-Road Forklift Regulation Phase I*

This measure is designed to increase penetration of ZEVs in off-road applications, advance ZEV commercialization, and to send a market signal to technology manufacturers and investors. CARB staff would develop and propose a regulation with specific focus on forklifts with lift capacities equal to or less than 8,000 pounds for which zero-emission technologies have already gained appreciable customer acceptance and market penetration.

Implementation period for cost analysis: 2023-2030
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit capital Costs ($) 2023-2031	Per Unit/Facility Incentive Amount ($)	Number of Units 2018-2031	Years of Equipment Life
ZEVs Forklift	Truck Transportations (484), Water Transportations (488), Production Cost - Fruit and Vegetable Preserving and Specialty Food Manufacturing (311), Wholesale (423)	$12,700	$0.0	3,670	10

Additional electricity cost/fuel and maintenance savings are listed below.

Incremental Annual O&M Costs, per unit	
Electricity	$1,253
Fuel (savings)	$(7,495)
Maintenance (Savings)	(1,560)

Additional savings are expected to offset the incremental capital cost, resulting in an overall savings for this control measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Zero-Emission Off-Road Forklift Regulation	($128.4)	+	$0	=	($128.4)	($8.5)

❖ *Zero-Emission Airport Ground Support Equipment*

This measure is designed to increase the penetration of the first wave of zero-emission heavy-duty technology in applications that are well suited to its use, and to facilitate further technology development and infrastructure expansion. CARB would develop and propose a regulation to accelerate the transition of diesel and large spark ignition airport ground support equipment to zero-emission technology. Additional costs are assumed to be incurred evenly by the Air transportation and scenic and sightseeing transportation and support activities industries, respectively.

Implementation period for cost analysis: 2023-2031
Cost Assumptions:

Equipment Name	**Affected Industries (NAICS)**	**Per Unit capital Costs ($) 2023-2031**	**Per Unit/Facility Incentive Amount ($)**	**Number of Units 2018-2031**	**Years of Equipment Life**
Zero-emission GSE Equipment	Scenic and sightseeing transportation and support activities (488), Air Transportation (481)	$7,733	$0.0	320	10
Electrical Infrastructure		$800	$0.0	320	10
Battery Replacement (every 5 years)		$7,773	$0.0	320	10
Engine Replacement, savings (every 5 years)		($6,950)	$0.0	320	10

Additional electricity cost/fuel and maintenance savings are listed below.

Incremental Annual O&M Costs, per unit	
Electricity	$1,238
Fuel (savings)	$(7,409)
Annual Parts savings	$(1,538)
Maintenance (Savings)	$(1,330)

Additional savings are expected to offset the incremental capital cost, resulting in an overall savings for this control measure.[71]

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Zero-Emission Ground Support Equipment	$3.3	+	$0	=	$3.3	$0.2

❖ *Small Off-Road Engines*

This measure is designed to reduce emissions from Small Off-Road Engines (SORE), and to increase the penetration of zero-emission technology. SORE that are subject to CARB regulations are used in residential and commercial lawn and garden equipment, and other utility applications. CARB will develop and propose tighter exhaust and evaporative emission standards, encourage increased use of zero-emission equipment, and enhance enforcement of current emission standards for SORE.

Implementation period for cost analysis: 2023-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Per Unit/Facility Cost ($)	Per Unit/Facility Incentive Amount ($)	Number of Units	Years of Equipment Life
Lawn movers (incremental)	Consumers	$74	$0	24,276	10
String Trimmers (incremental)	Consumers	$41	$0	24,276	10
Exhaust emission controls 80-225 cc (incremental)	Consumers	$28	$0	24,276	10
Exhaust emission controls 225 cc+ (incremental)	Consumers	$97	$0	24,276	10

71 Fuel and O&M savings for this measure have not yet been incorporated in the calculation of PWV. They will be included in the Draft report.

Additional electricity costs and fuel savings per unit are presented below.

Incremental Annual O&M Costs, per unit	
Electricity	$2
Fuel (savings)	($24)

Source: Cost estimates from CARB staff

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	**Present Value of Remaining Incremental Cost**		**Present Value of Incentives**		**Present Worth Value of Total Incremental Cost**	**Amortized Annual Average (2017-2031)**
Small Off-Road Engines	$19.7	+	$0	=	$19.7	$2.1

❖ *Further Deployment of Cleaner Technologies: Off-Road Equipment*

This measure is designed to achieve further emission reductions for the Basin's attainment needs through a suite of additional actions, including greater penetration of zero and near-zero technologies through incentive programs, 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 CARB and the SCAQMD. The costs associated with this measure will mainly be incurred by the construction and mining industries as well as airports.

Costs of this control measure are estimated using capital cost estimates from Zero-Emission Off-Road Forklift Regulation Phase I, Zero-Emission Ground Support Equipment and Small Off-Road Engines. CARB staff used the following assumptions to arrive the SCAQMD annual control measure cost.

Control Measure	Estimated Annual Capital Cost	Tpd Reductions
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

Source: Mobile Source Strategy. Appendix A: Economic analysis (CARB 2016a)

The total annual cost of this control measure is estimated by CARB to be $52 million and was arrived at using the weighted average cost-effectiveness of the other Off-road Equipment control measures based on 17 tpd of emission reductions (for more information see (CARB 2016a)).

Implementation period for cost analysis: 2017-2031
Cost Assumptions:

Equipment Name	Affected Industries (NAICS)	Total capital Costs ($) 2017-2031	Per Unit/Facility Incentive Amount ($)	Number of Units 2023-2031	Years of Equipment Life
Zero, Near-Zero Technologies	Air Transportations (481), Water Transportations (483), Commercial and Industrial Machinery Equipment Rental and Leasing (532), Food Transportation (311), Ports (488), Truck Transportation (484)	$780,000,000	$0.0	N/A	10

No additional annual operating and maintenance costs were assumed for this measure.

The incremental cost is presented below, all in millions of 2015 dollars:

Control Measure	Present Value of Remaining Incremental Cost		Present Value of Incentives		Present Worth Value of Total Incremental Cost	Amortized Annual Average (2017-2031)
Further Deployment of Cleaner Technology: Off-Road Equipment	$601.3	+	$0	=	$601.3	$49.31

Appendix 3-A: Weight of Evidence Descriptions for Causal Determination

DETERMINATION	WEIGHT OF EVIDENCE
Causal relationship	Evidence is sufficient to conclude that there is a causal relationship with relevant pollutant exposures. That is, the pollutant has been shown to result in health effects in studies in which chance, bias, and confounding could be ruled out with reasonable confidence. For example: (a) controlled human exposure studies that demonstrate consistent effects; or (b) observational studies that cannot be explained by plausible alternatives or are supported by other lines of evidence (e.g., animal studies or mode of action information). Evidence includes replicated and consistent high-quality studies by multiple investigators.
Likely to be a causal relationship	Evidence is sufficient to conclude that a causal relationship is likely to exist with relevant pollutant exposures, but important uncertainties remain. That is, the pollutant has been shown to result in health effects in studies in which chance and bias can be ruled out with reasonable confidence but potential issues remain. For example: (a) observational studies show an association, but co-pollutant exposures are difficult to address and/or other lines of evidence (controlled human exposure, animal, or mode of action information) are limited or inconsistent; or (b) animal toxicological evidence from multiple studies from different laboratories that demonstrate effects, but limited or no human data are available. Evidence generally includes replicated and high-quality studies by multiple investigators.
Suggestive of a causal relationship	Evidence is suggestive of a causal relationship with relevant pollutant exposures, but is limited because chance, bias, and confounding cannot be ruled out. For example, at least one high-quality epidemiologic study shows an association with a given health outcome but the results of other studies are inconsistent.
Inadequate to infer a causal relationship	Evidence is inadequate to determine that a causal relationship exists with relevant pollutant exposures. The available studies are of insufficient quantity, quality, consistency or statistical power to permit a conclusion regarding the presence or absence of an effect.
Not likely to be a causal relationship	Evidence is suggestive of no causal relationship with relevant pollutant exposures. Several adequate studies, covering the full range of levels of exposure that human beings are known to encounter and considering susceptible populations, are mutually consistent in not showing an effect at any level of exposure.

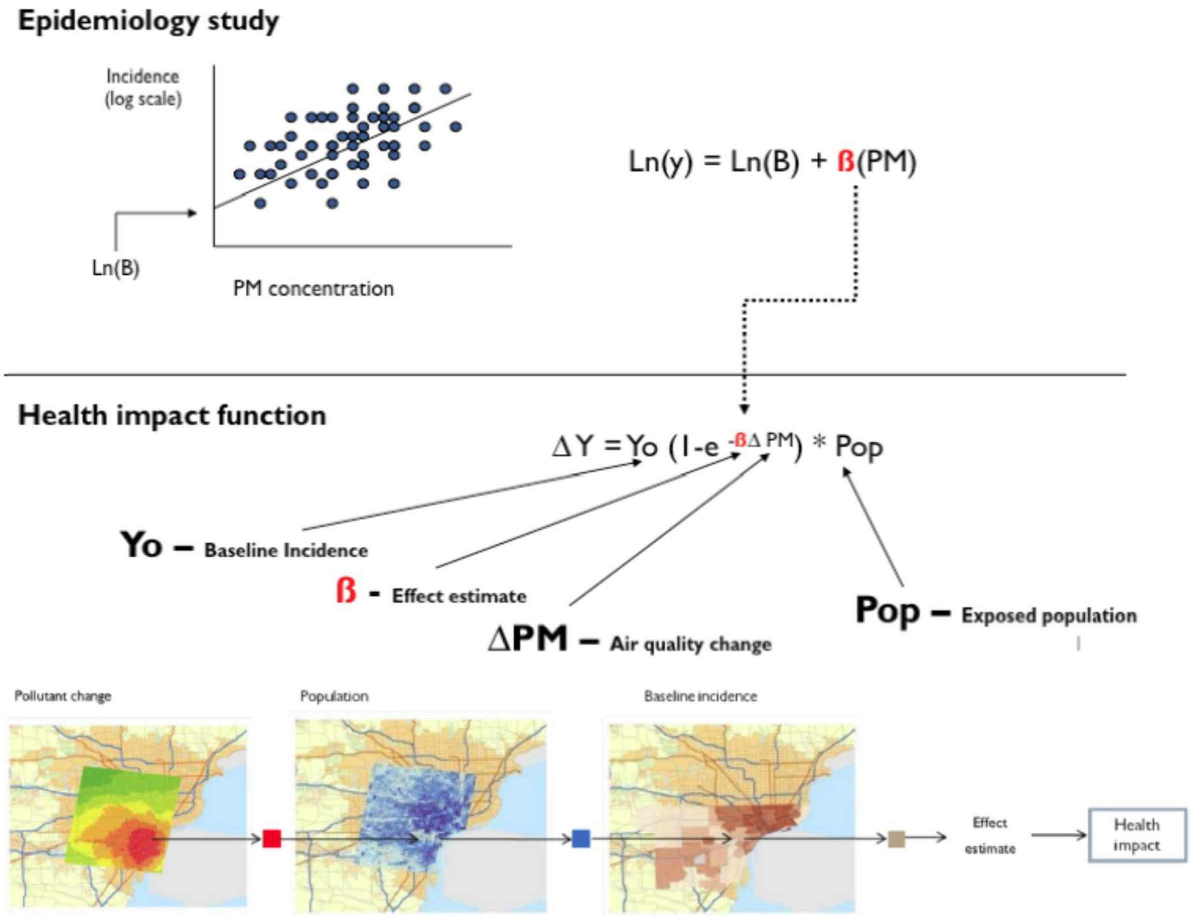
Appendix 3-B: Quantification of Public Health Benefits

Implementation of the Draft 2016 Air Quality Management Plan will result in improved air quality, including lower ozone and PM2.5 concentrations in the SCAQMD four-county region. Research in epidemiology and health economics has shown that reduced exposure to air pollutants reduces incidence of mortality and morbidity endpoints. The effect of these air quality improvements on the number of various health endpoints are quantified in these analyses, and valuation methods are used to monetize these quantified public health effects to arrive at the overall value of public health benefits. This appendix describes the methodology and data inputs used. More detailed results, including breakdowns by county and by each health endpoint evaluated, are provided as well.

Methodology

The methodology employed to quantify public health benefits consists of several components. The first component is the health impact analysis (see Figure 3B-1). This analysis is based on the use of a health impact function to estimate the change in incidence of a particular endpoint. The variables in the analysis include: the change in air quality concentrations, baseline incidence, population exposed to the particular health risk, and an effect estimate. The effect estimate is derived from epidemiology studies, which use health and air quality data to estimate Concentration-Response (C-R) functions which relate the concentration of a particular pollutant to a mortality or morbidity endpoint. With all of these data taken together, the health impact function can be evaluated to estimate the health effect for a given geographic unit. In the case where there are multiple different C-R functions in epidemiology literature that need to be taken into account, a pooling method can be used. Pooling allows for a calculation of change in incidence of particular endpoint using multiple effect estimates from different epidemiology studies combined together. Once the health impacts have been estimated (pooled or un-pooled), a valuation function is applied, which places a monetary value on the change in incidence of a given endpoint which is either a scalar value or a distribution of values for a given type of incidence. The valuation function can also be pooled together to account for differences among valuation studies.

Figure 3B-1: Health Impact Methodology



Source: BenMAP-CE User's Manual 2015, U.S. EPA.

This methodology is implemented in the application named Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE), which is used for this analysis. BenMAP-CE is a free and open-source application maintained by the U.S. EPA. Earlier editions of BenMAP were used to quantify the public health benefits of the 2007 and 2012 AQMPs, as well as for numerous other studies.[72]

Data

The first input into the health impact calculation is the projected changes in air quality for a particular pollutant, which are derived from the difference between the "baseline" and the "control" air quality scenarios, or the scenarios without and with the Draft 2016 AQMP respectively. The projected baseline and control air quality scenarios are the result of emission inventories (see Appendix 3 of the Draft 2016 AQMP) and air quality simulations based on these emission inventories and other variables (see Appendix 5 of the Draft 2016 AQMP). These air

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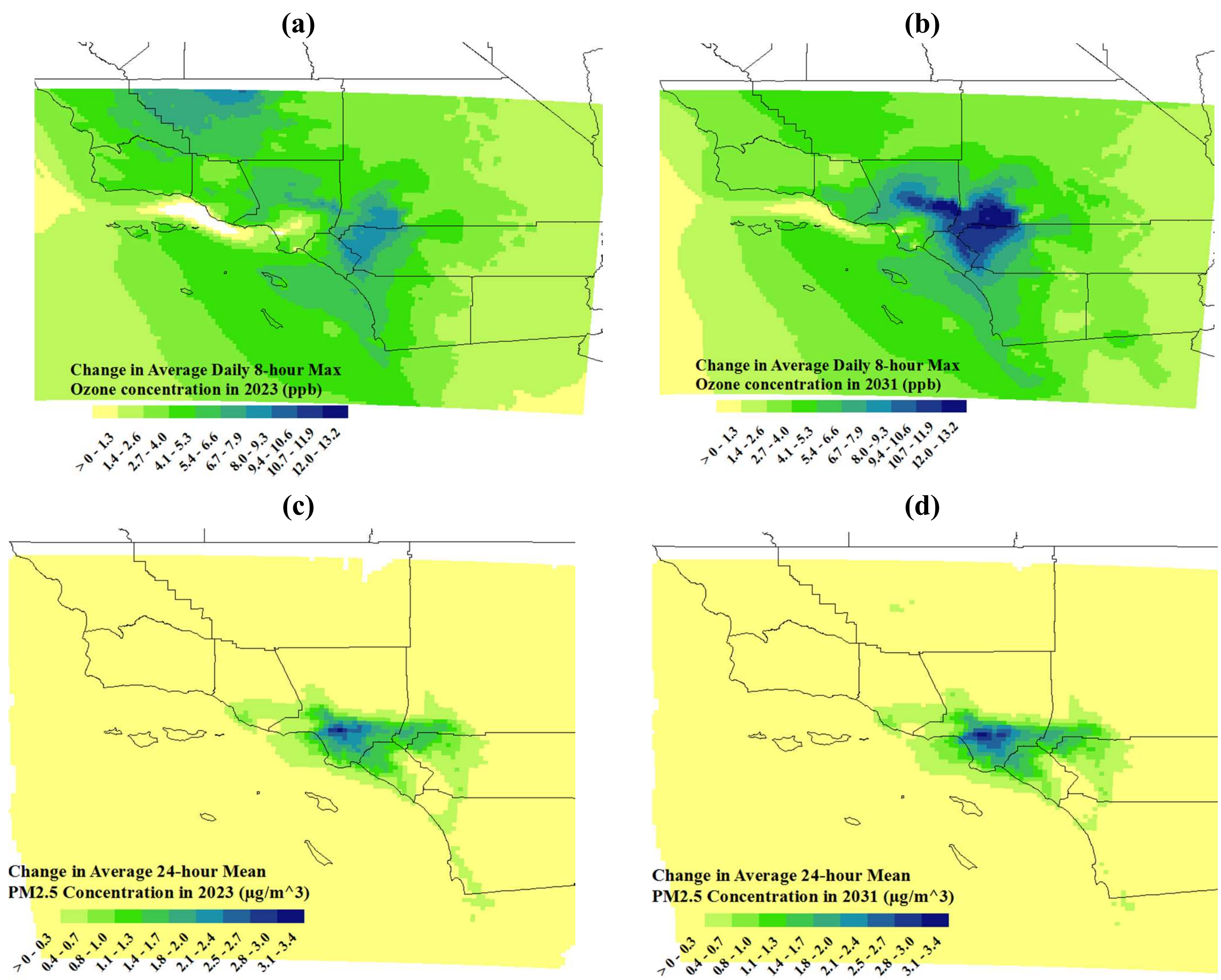
[72] U.S. EPA lists examples of these studies at: https://www.epa.gov/benmap/benmap-ce-applications-articles-and-presentations

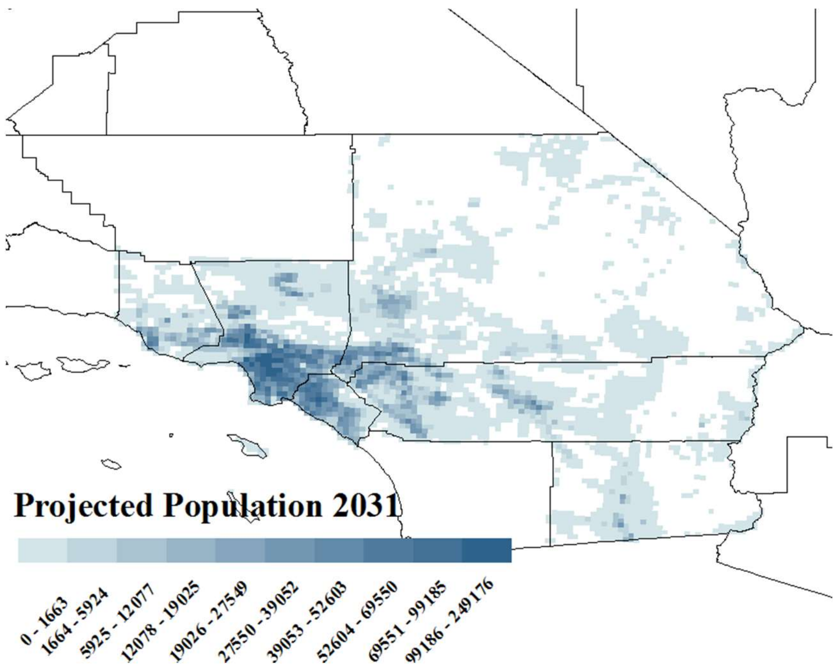
quality projections are produced at the level of a 4km x 4km grid for the Basin. The projections are hourly for each modeled year and consist of 365 days for PM2.5 and 153 days during the Summer Planning Season for ozone. These hourly data are converted into daily metrics of air quality changes for each pollutant (daily 8-hour max for ozone and daily 24-hour mean for PM2.5), then loaded into BenMAP for analysis. The average of the daily changes for each pollutant in milestone years 2023 and 2031 is illustrated in Figure 3B-2. As shown in panels (a) and (b), the control measures result in decreases in average ozone concentration levels throughout the region for both years, with the largest decreases located around the western portions of San Bernardino and Riverside Counties. Panels (c) and (d) illustrate the changes in average PM2.5 concentration levels, which decrease throughout the region for both years, with the largest decreases concentrated in central Los Angeles County.

Figure 3B-2: Air Quality Change from Draft 2016 AQMP Measures, 2023 & 2031



The population projections in 2031 (Figure 3B-3) are from the 2016 RTP/SCS Growth Forecast (SCAG 2016), as described in the Baseline Update Appendix of the Socioeconomic Analysis of the Draft 2016 AQMP, and are provided at the 4km x 4km grid-cell level. For the purposes of this analysis, SCAG staff converted the population forecast, originally modeled at the level of Transportation Analysis Zones (TAZs), to the 4km x 4km grid-cell used for air quality modeling.

Figure 3B-3: Projected Population in 2031



The baseline incidence rates for mortality and morbidity used are provided by Industrial Economics, Inc. (IEc), based on recommendations from their report (2016) at the county level, by five-year age group. Baseline mortality incidence rates for the base year 2012 are collected for historical years 2011-2013 from the California Department of Public Health and averaged to account for year to year variation. Projected baseline mortality rates for future years are based on the projected trend of U.S. crude death rates, which is available from the U.S. Census Bureau. This U.S. trend was applied to the base year local mortality rates, by age group, to obtain the projected mortality rates for all future years for each county.[73] Baseline incidence for hospital admissions and emergency department visits are based on the publicly accessible database from the Health Care Utilization Project (HCUP). County-level estimates of baseline incidence for nonfatal myocardial infarctions and ischemic stroke are obtained from U.S. Center for Disease Control's Interactive Atlas of Heart Disease and Stroke. Baseline incidence rates for new onset of asthma in children are provided by IEc for the Los Angeles area for 2002-2005 from the Children's Health Study cohort (McConnell et al. 2010). Baseline incidence for all other endpoints not discussed here are based on the data included with BenMAP-CE (RTI International 2015).

The effect estimates for each health impact function are from C-R functions as described in Table 3B-1. Local estimates in the SCAQMD four-county region were selected whenever available and

[73] Staff is looking into procuring more local mortality rate projections and will update the analysis based on these new data once they are obtained.

meeting other selection criteria recommended by IEc (Industrial Economics, 2016a and 2016b). The health effect is often estimated as a relative risk (RR), which is the ratio of the probability of an incidence of a particular endpoint in an exposed group to the probability of it occurring in an unexposed group. The RRs from the recommended studies for all-cause mortality from short-term ozone exposure are 1.0035 (NMMAPS[74]) and 1.005 (meta-analysis) from Bell et al. (2005b). The RRs from the recommended studies for all-cause mortality from long-term PM2.5 exposure are: 1.14 (Jerrett et al. 2005), 1.104 (Jerrett et al. 2013), 1.17 and 1.14 from Krewski et al. (2009)'s kriging and land-use regression estimates, respectively.

Table 3B-1: C-R functions and Valuation Functions by Endpoint Group

Endpoint	C-R Function	Valuation Function
Short-term Exposure to Ozone		
Mortality, All Cause	Pooling of: LA-specific NMMAPS and meta-analysis (Bell, Dominici, and Samet 2005b)	VSL (Robinson and Hammitt 2016b). $9 million ($4.2-$13.7 million)
School Loss Days All Cause	Gilliland, et al. (2001)	$217/day (BLS, 2012)
Hospital Admissions (HA), All Respiratory	(Katsouyanni et al. 2009)	$21,509 (HCUP, Chestnut et al. 2006)
Minor Restricted Activity Days	(B. D. Ostro and Rothschild 1989)	$17-$294/day (Brandt, Vásquez Lavín, and Hanemann 2012; Dickie and Hubbell 2004)
Emergency Room Visits, Asthma	(Mar and Koenig 2009)	HA: $9,131 (Chestnut et al. 2006) ED: $519 (D. H. Smith et al. 1997; Stanford, McLaughlin, and Okamoto 1999; Meng et al. 2010)
Long-term Exposure to PM2.5		
Mortality, All Cause	Pooling of: LA-specific estimates (Jerrett et al. 2005; Jerrett et al. 2013), Kriging and LUR (Krewski et al. 2009)	VSL (Robinson and Hammitt 2016b). $9 million ($4.2-$13.7 million)
Acute Bronchitis	(Dockery et al. 1996)	$17-$294/day (Brandt, Vásquez Lavín, and Hanemann 2012; Dickie and Hubbell 2004)

[74] National Morbidity and Mortality Air Pollution Study (NMMAPS).

Endpoint	C-R Function	Valuation Function
Short-term Exposure to PM2.5		
Minor Restricted Activity Days	(B. D. Ostro and Rothschild 1989)	$17-$294/day (Brandt, Vásquez Lavín, and Hanemann 2012; Dickie and Hubbell 2004)
Lower Respiratory Symptoms	(Schwartz and Neas 2000)	
Upper Respiratory Symptoms	(Pope et al. 2015)	
Asthma Exacerbation (Wheeze, Cough, Shortness of Breath)	Pooling of: Ostro et al. (2001) (cough, wheeze, shortness of breath) and Mar et al. (2004) (cough, shortness of breath)	
HA All Cardiovascular (less Myocardial Infarctions)	(Moolgavkar 2000)	$23,469 (Chestnut et al. 2006)
HA, All Respiratory	(Zanobetti et al. 2009; Moolgavkar 2000)	$21,509 (HCUP, (Chestnut et al. 2006)
HA, Ischemic Stroke	(Shin et al. 2014)	$61,384 (Lee et al. 2007)
HA and ED Visits, Asthma	(Delfino et al. 2014)	HA: $9,131 (Chestnut et al. 2006) ED: $519 (D. H. Smith et al. 1997; Stanford, McLaughlin, and Okamoto 1999; Meng et al. 2010)
Asthma, New Onset (Wheeze)	(Young et al. 2014)	No valuation function applied.
Work Loss Days	(B. D. Ostro 1987)	$217/day (BLS, 2012)
Acute Myocardial Infarction Nonfatal	(Pope et al. 2015; Zanobetti and Schwartz 2006; Zanobetti et al. 2009; J. Sullivan et al. 2005)	$106,293 to $223,214 depending on age (Cropper and Krupnick 1990; Russell et al. 1998; Wittels, Hay, and Gotto 1990)

The valuation functions associated with each endpoint are also described in Table 3B-1. The highest valued endpoint is premature mortality. Mortality is valued using the concept of the Value of Statistical Life (VSL). VSL is a measure of the willingness-to-pay (WTP) of a society to reduce the risk of a mortality, aggregated up to the amount of risk reduction required to avoid one statistical death over the population. A range of VSL is recommended by IEc (2016) from $4.2 to $13.7 million, with a midpoint of $9 million, all of which are expressed in 2013 dollars and based on 2013 income levels. This range is found in Robinson and Hammitt (2016b), and falls within the range of Viscusi (2015). Avoided morbidity conditions are valued primarily based on the concept of cost of illness (COI) avoided, which includes the cost of healthcare and the cost of lost productivity, though a few endpoints do include a WTP component. The COI and WTP valuations functions for morbidity endpoints are based on recommendations from the IEc report (2016). It is also recommended that WTP valuations be adjusted for income growth, based on the concept that the income elasticity of VSL is positive. The recommended income elasticity for VSL is $\varepsilon_I = 1.1$ based on Viscusi (2015), with $\varepsilon_I = 0$ and $\varepsilon_I = 1.4$ for sensitivity analyses, while $\varepsilon_I = 0.5$ is recommended for WTP portions of morbidity endpoints.[75]

Income growth data for historical years 2013-2015 and projections for 2016-2019 are from the California Department of Finance (DOF). The DOF publishes forecasts of both total personal (nominal) income growth and a forecast of the consumer-product index (CPI-U)[76]. Using the inflation forecast to adjust the nominal income forecast, a forecast of real income growth to 2019 was derived. Lacking a local forecast of income growth post-2019, the annual real income growth rate was assumed to remain constant at the 2019 forecast (1.9%) up to 2031.

Results

The health impacts are calculated according to the methodology and data described above. The health impacts are categorized into three different types of exposure: short-term ozone exposure, short-term PM2.5 exposure, and long-term PM2.5 exposure. Annual health impacts from short-term ozone exposure are calculated as the sum of the daily impacts for the Summer Planning season. Health impacts from off-season short-term ozone exposure are not calculated here due to data limitations. Thus, the health impacts shown can be interpreted as conservative estimates of the annual health impact, only representing daily impacts of less than half of a year. Annual health impacts from short-term PM2.5 exposure are calculated as the sum of daily impacts for 365 days of a year.77 Annual health impacts for long-term PM2.5 exposure are calculated based on the annual average of the mean daily concentrations.

Annual health impacts for all endpoints are estimated with no threshold effects for all types of pollutant exposure. This practice is recommended by Industrial Economics, Inc. and based on the latest scientific evidence, including those summarized in the Integrated Science Assessments (U.S. EPA 2009; U.S. EPA 2013).

Pooling methods are used to calculate the annual health impact from pollutant exposure for endpoints where multiple C-R functions are recommended as described in Table 3B-1. The pooling method used here for overlapping C-R functions is either Fixed Effects or Random Effects as implemented in BenMAP-CE. The choice between using Fixed Effects or Random Effects for pooling is made automatically by BenMAP-CE based on a test statistic evaluated at an alpha of 5% (RTI International, 2015).[78] The independent sum pooling method is used for C-R functions with non-overlapping age-groups.

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[75] The income elasticity adjustment is done according to the formula $VSL_{t+n} = VSL_t \left(\frac{incom_{\ t+n}}{incom_{\ t}}\right)^{\epsilon_I}$, where n is the number of years of income growth.

[76] The forecast of CPI-U All Items is used.

[77] In leap-years, February 29th is excluded from health impact calculation due to limitations of BenMAP-CE.

[78] The test statistic used by BenMAP-CE is $Q_w = \sum_i \left[\left(\frac{1}{v_i}\right)\left(\beta_{fe} - \beta_i\right)^2\right]$, where v_i is the variance of study i, β_{fe} is the weighted parameter from fixed-effects estimation, β_i is the beta coefficient of study i. Q_w is chi-squared distributed with n-1 degrees of freedom.

The health impacts of mortality based on the recommended C-R functions are shown in Table 3B-2. The effect of reduced short-term ozone exposure will result in a reduction of 51 all-cause premature deaths per year in the year 2023 and 87 per year in the year 2031 (both these numbers represent point estimates of a statistical distribution of possible outcomes). The effect of ozone improvements on mortality reduction is significant at the 95% confidence level as shown by the confidence intervals (CI).[79] The effect of reduced long-term PM2.5 exposure on all-cause mortality incidence is much larger than from ozone; reduced long-term PM2.5 levels result in a reduction of 2,111 premature deaths per year in year 2023 and 2,425 per year in year 2031, both point estimates as well. The rate of change of reduced premature mortalities from year 2023 to 2031 is about 71% and 15% from ozone and PM2.5 exposure, respectively. The larger rate of increase from ozone than PM2.5 is primarily related to a larger reduction in pollutant concentration post-2023 for ozone, compared to a relatively larger amount of PM2.5 reductions occurring before 2023.

Table 3B-2: Annual Mortality and Morbidity Health Effect Estimates

	2023	2031
Premature Deaths Avoided, All Cause		
Short-Term Ozone Exposure[1]	**51**	**87**
	(6; 97)	(9; 163)
Long-Term PM2.5 Exposure	**2,111**	**2,425**
	(336; 3,912)	(387; 4,490)
Short-Term PM2.5 Exposure[2]	**NYQ**	**NYQ**
Reduced Morbidity Incidence		
Short-Term Ozone Exposure[1]		
Hospital Admissions (HA), All Respiratory (65 or Older)	**89**	**167**
	(-22; 200)	(-42; 376)
Hospital Admissions (HA), Asthma (19 or Younger)[3]	**NYQ**	**NYQ**
Emergency Room Visits, Asthma	**1,401**	**2,296**
	(757; 2,045)	(1,259; 3,334)
Minor Restricted Activity Days	**427,964**	**690,235**
	(177,490; 674,661)	(286,817; 1,086,037)
School Loss Days, All Cause	**129,616**	**209,276**
	(-15,534; 265,174)	(-25,369; 423,590)
Long-Term PM2.5 Exposure		
Acute Bronchitis	**1,766**	**1,941**
	(-425; 3,834)	(-468; 4,206)

[79] A 95% Confidence Interval (CI) is found from the 2.5 percentile and 97.5 percentile of an empirical distribution resulting from Monte Carlo simulation.

	2023	2031
HA, All Respiratory (less Asthma)[4]	**234**	**297**
	(143; 300)	(181; 381)
HA and Emergency Department Visits, Asthma (18 or Younger)	**244**	**268**
	(-41; 644)	(-45; 707)
Asthma Exacerbation (Wheeze, Cough, Shortness of Breath)	**39,953**	**43,932**
	(-2,468; 87,038)	(-2,714; 95,686)
Asthma, New Onset (Wheeze)	**5,027**	**5,699**
	(-2,371; 11,433)	(-2,704; 12,897)
Lower Respiratory Symptoms	**20,897**	**22,959**
	(8,062; 33,275)	(8,869; 36,512)
Upper Respiratory Symptoms	**41,730**	**45,953**
	(7,582; 75,646)	(8,351; 83,292)
HA, Ischemic Stroke	**136**	**175**
	(42; 246)	(54; 316)
HA, All Cardiovascular (less Myocardial Infarctions)	**283**	**346**
	(192; 351)	(234; 430)
Acute Myocardial Infarction, Nonfatal	**57**	**73**
	(21; 152)	(27; 195)
Minor Restricted Activity Days	**908,234**	**984,397**
	(741,118; 1,074,021)	(803,393; 1,163,905)
Work Loss Days	**157,623**	**170,896**
	(133,523; 181,576)	(144,779; 196,850)

[1] Health effects of ozone exposure are quantified for summer planning period only (i.e., May 1 to September 30). There are potentially more premature mortalities and morbidity conditions avoided outside the ozone peak season. Mortality effects for population younger than age 25 years may be added in the upcoming revision to this report.
[2] Health effects related to this endpoint will be quantified in the upcoming revision to this report. Premature deaths avoided due to short-term exposure to PM2.5 are likely to partially overlap with those due to long-term PM2.5 exposure. Therefore, the total premature deaths associated with PM2.5 will be lower than simply summing across mortality effects from both short-term and long-term exposure (Industrial Economics and Thurston 2016a; Kunzli et al. 2001).
[3] Health effects related to this endpoint will be quantified in the upcoming revision to this report.
[4] This is the pooled estimate of two health endpoints: HA, Chronic Lung Disease (less Asthma) (18-64 years old) and HA, All Respiratory (65 or older).
[5] Expressed in person-days. Minor Restricted Activity Days (MRAD) refer to days when some normal activities are avoided due to illness.
(Note: Parenthesis are a 95% CI.)

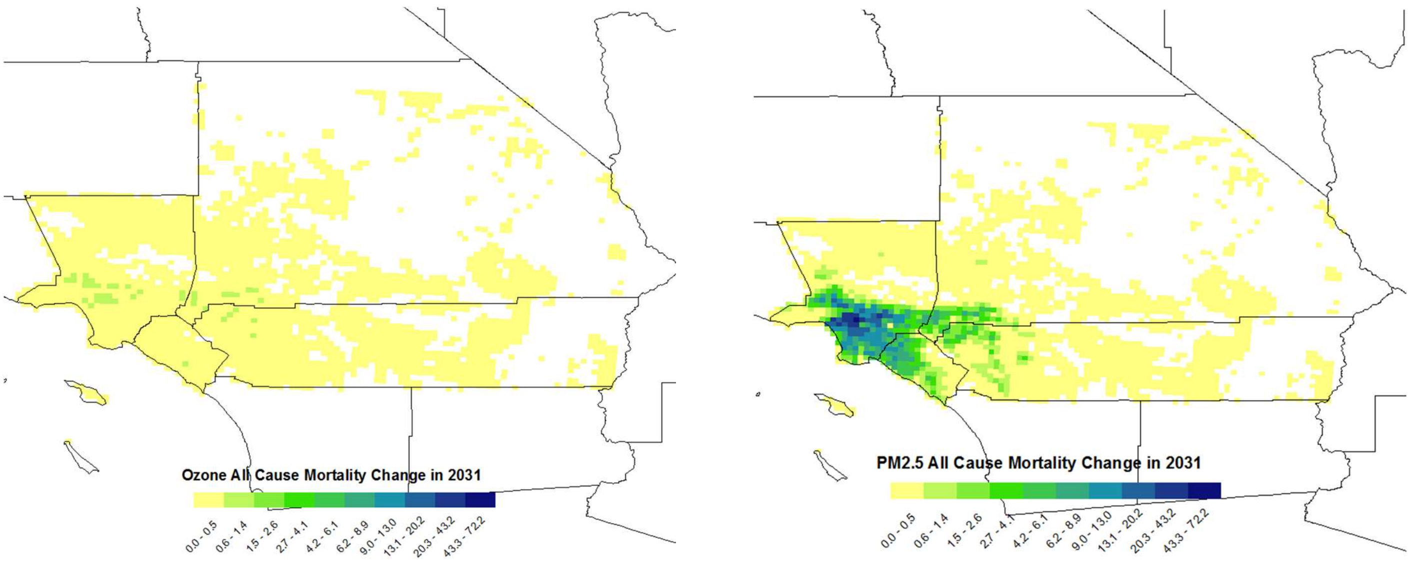
Figure 3B-4 maps the location of the avoided premature deaths by pollutant type in 2031. Ozone exposure reductions result in relatively small reductions in mortality throughout the basin, with concentrations in western Riverside and San Bernardino counties, and central Los Angeles County. The reduced PM2.5 exposure results in much more significant reductions in premature mortality, which are concentrated in central Los Angeles County.

While the U.S. EPA concluded that, for both ozone and PM2.5, the current scientific evidence does not support the existence of a threshold concentration level below which no health impacts occur (U.S. EPA 2009; U.S. EPA 2013), various different health impact analysis have included a threshold, particularly for PM2.5, for the purpose of addressing the issue of statistical uncertainty at very low concentration levels (U.S. EPA 2012; U.S. EPA 2015b; CARB 2010). In these analyses, a threshold was determined by the lowest measured level (LML) of PM2.5 concentration in the study where the selected C-R function was estimated. For example, CARB selected the C-R function for cardiopulmonary deaths estimated in Krewski et al. (2009) and used the study's LML of 5.8 $\mu g/m^3$ as the threshold (CARB 2010). CARB did not consider health effects associated with reduced concentrations below this level to be conservative. However, in the U.S. EPA's recent regulatory impact analyses (U.S. EPA 2012; U.S. EPA 2015b), the LML related to each selected C-R function was used to describe the distribution of health impacts with respect to the LML.

To address the uncertainty associated with this topic, SCAQMD staff conducted a sensitivity analysis on the preliminary public health benefits of the Draft 2016 AQMP, using a threshold of 5.8 $\mu g/m^3$ based on the LML found in Krewski et al. (2009). It is found that the 94 percent of the premature deaths avoided reported in Table 3B-2 for year 2031 are associated with PM2.5 concentrations that were reduced to 5.8 $\mu g/m^3$ or above, and thus, only six percent of the same estimated effect are associated with reductions below this level. This corresponds to a total of 2,287 avoided mortalities at or above the LML and 138 below.

Figure 3B-4: Change in All-Cause Mortality from short-term ozone exposure and long-term PM2.5 exposure in 2031

(a) **(b)**



The change in incidence of specific morbidity endpoints as a result of air quality improvements are also shown in Table 3B-2. There are different sets of morbidity endpoints for different pollutant exposures, but both reductions in ozone and PM2.5 exposures result in fewer school loss days, fewer hospital admissions related to all respiratory causes, and fewer asthma-related emergency room visits.

The valuation of reduced mortality and morbidity incidence, is based on the valuation functions described in Table 3B-3, along with an income elasticity and cessation lag where applicable. The valuation of avoided premature deaths is based on the recommended VSL and income elasticity as described above, along with a 20-year cessation lag for long-term PM2.5 exposure. Cessation lag describes how the avoided premature deaths from annual exposure are lagged over time. The 20-year cessation lag as recommended by IEc (2016a) assigns 30% of the reduction to the first year, 13% for years 2-5, and 1% for all following years.[80] The valuation estimates for reduced premature mortality incidence are shown in Table 3B-3, along with lower and upper bounds resulting from sensitivity analysis. The results of this analysis show that the annual public health benefits from avoided premature deaths have a midpoint estimate of $26.8 billion in 2023 and $36.7 billion in 2031 (expressed in 2015 dollars), based on a base VSL of $9 million and an income elasticity ε_I of 1.1. The lower- (upper-) bound shows the value of public health benefits if the base VSL is at $4.2 million ($13.7 million) and $\varepsilon_I = 0$ ($\varepsilon_I = 1.4$), this represents an extreme bound of the valuation of the mean health impact and shows the sensitivity of the results to the assumptions of the analysis. The annual public health benefits range from $9.1-$49.4 billion in

[80] Consistent with the rest of the Socioeconomic Report, a four-percent discount rate is applied to the valuation of avoided premature mortalities lagged over the 20-year period.

2023 and $10.6-$70.9 billion in 2031. As expected from the health impact results, the largest public health benefits are derived from the reduction in PM2.5 concentration in the basin.

Table 3B-3: Monetized Public Health Benefits

	Monetized Public Health Benefits (Billions 2015$ per year)					
	2023			2031		
	Lower Bound ($4.2M, ε_I=0)	Midpoint ($9M, ε_I=1.1)	Upper Bound ($13.7M, ε_I=1.4)	Lower Bound ($4.2M, ε_I=0)	Midpoint ($9M, ε_I=1.1)	Upper Bound ($13.7M, ε_I=1.4)
Mortality, All Cause	$9.1	**$26.8**	$49.4	$10.6	**$36.7**	$70.9
Mortality - Short-term Ozone Exposure	$0.2	**$0.6**	$1.2	$0.4	**$1.3**	$2.4
Los Angeles	$0.1	**$0.3**	$0.5	$0.2	**$0.6**	$1.1
Orange	$0.0	**$0.1**	$0.2	$0.1	**$0.2**	$0.4
Riverside	$0.0	**$0.1**	$0.2	$0.1	**$0.2**	$0.5
San Bernardino	$0.0	**$0.1**	$0.2	$0.1	**$0.2**	$0.4
Mortality - Long-term PM2.5 Exposure	$8.9	**$26.1**	$48.3	$10.2	**$35.4**	$68.4
Los Angeles	$6.2	**$18.3**	$33.9	$7.2	**$24.9**	$48.2
Orange	$1.3	**$4.0**	$7.3	$1.5	**$5.2**	$10.0
Riverside	$0.6	**$1.7**	$3.2	$0.7	**$2.4**	$4.7
San Bernardino	$0.7	**$2.1**	$3.9	$0.8	**$2.9**	$5.5

The monetary benefits of avoided morbidity incidence are shown in Table 3B-4. The greatest benefit from short-term ozone exposure reductions is the avoided productivity loss from school loss days valued at $45.3 million in 2031 and minor restricted activity days valued at $15.9 million in 2031. The greatest benefits from short-term PM2.5 exposure is from avoided work loss days valued at $37.5 million in 2031 and reduced minor restricted activity days valued at $22.8 million in 2031.

Table 3B-4: Monetized Annual Morbidity Benefits (Millions of 2015 Dollars)

Morbidity Endpoint by Exposure	2023	2031
Short-term Ozone Exposure (Total)	**$38.8**	**$63.9**
Hospital Admissions (HA), All Respiratory (65 and older)	$1.1	$2.1
Hospital Admissions (HA), Asthma (19 or younger)	NYQ	NYQ
Emergency Room Visits, Asthma	$0.4	$0.6
Minor Restricted Activity Days	$9.2	$15.9
School Loss Days	$28.1	$45.3
Long-Term PM2.5 Exposure (Total)	**$6.1**	**$7.2**
Acute Bronchitis	$6.1	$7.2
Short-term PM2.5 Exposure (Total)	**$78.1**	**$90.7**
HA, All Respiratory	$5.3	$6.8
HA and Emergency Department Visits, Asthma	$0.4	$0.5
Asthma Exacerbation (Wheeze, Cough, Shortness of Breath)	$1	$1.2
Asthma, New Onset (Wheeze)	NQ	NQ
Lower Respiratory Symptoms	$0.4	$0.5
Upper Respiratory Symptoms	$0.9	$1.1
HA, Ischemic Stroke	$7.9	$10.1
HA, All Cardiovascular (less Myocardial Infarctions)	$6.9	$8.6
Acute Myocardial Infarction, Nonfatal	$1.2	$1.6
Minor Restricted Activity Days	$19.5	$22.8
Work Loss Days	$34.6	$37.5
Total Morbidity Benefits	**$123.0**	**$161.8**

The total of the monetized public health benefits from reduced incidence of mortalities and morbidity conditions are the sum values from Tables 3B-3 and 3B-4. The total annual public health benefits of the emission reductions resulting from implementation of the Draft 2016 AQMP are $26.9 billion in 2023 and $36.9 billion in 2031. The majority of the public health benefits are derived from premature deaths avoided, with the remaining amount coming from reduced incidence of morbidity conditions.