

Preliminary Costs of Draft 2022 AQMP Control Measures



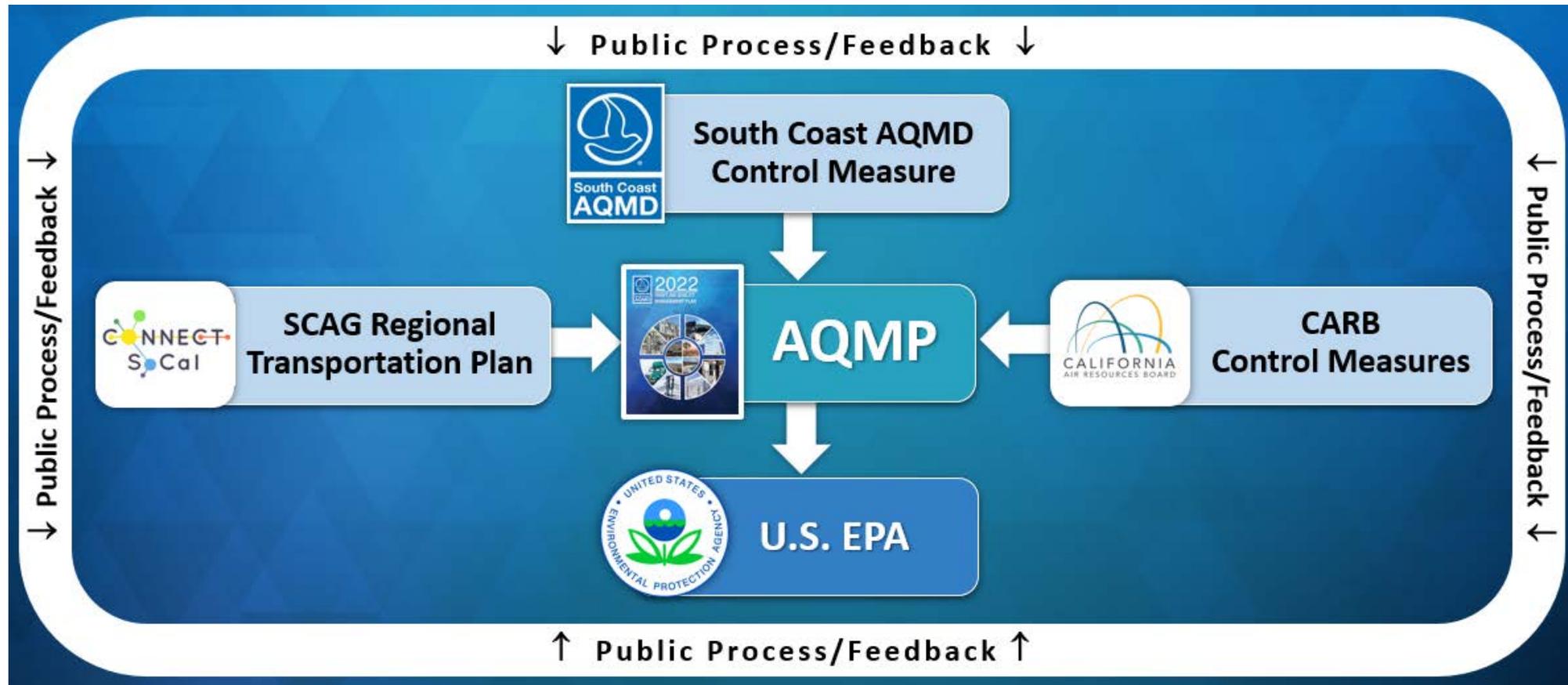
South Coast Air Quality Management District
2022 Air Quality Management Plan
Socioeconomic Impact Assessment

Science, Technical, and Modeling Peer Review Advisory Group Meeting

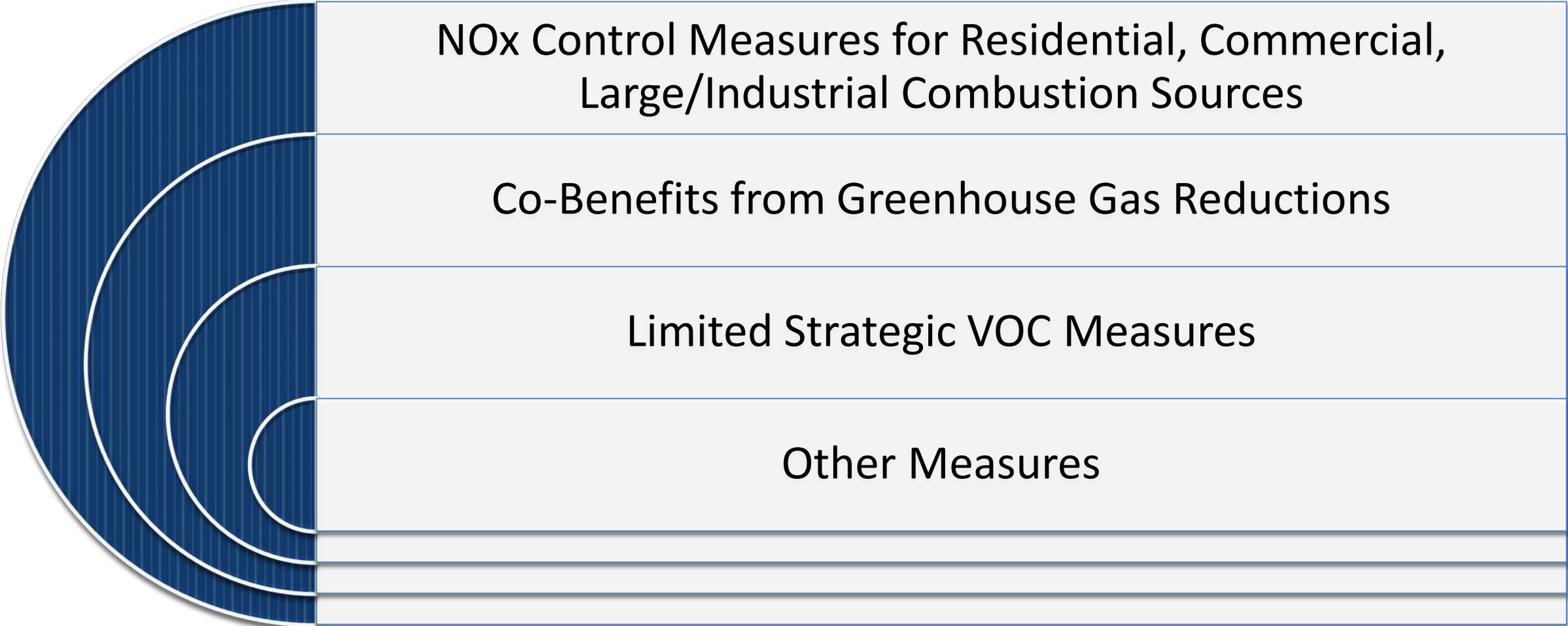
May 31, 2022

Draft 2022 AQMP Control Measures

- The Draft 2022 Air Quality Management Plan (AQMP) is designed to attain the 70 ppb 8-hour ozone standard in 2037.



Overview of Draft South Coast AQMD Stationary and Area Source Control Strategy



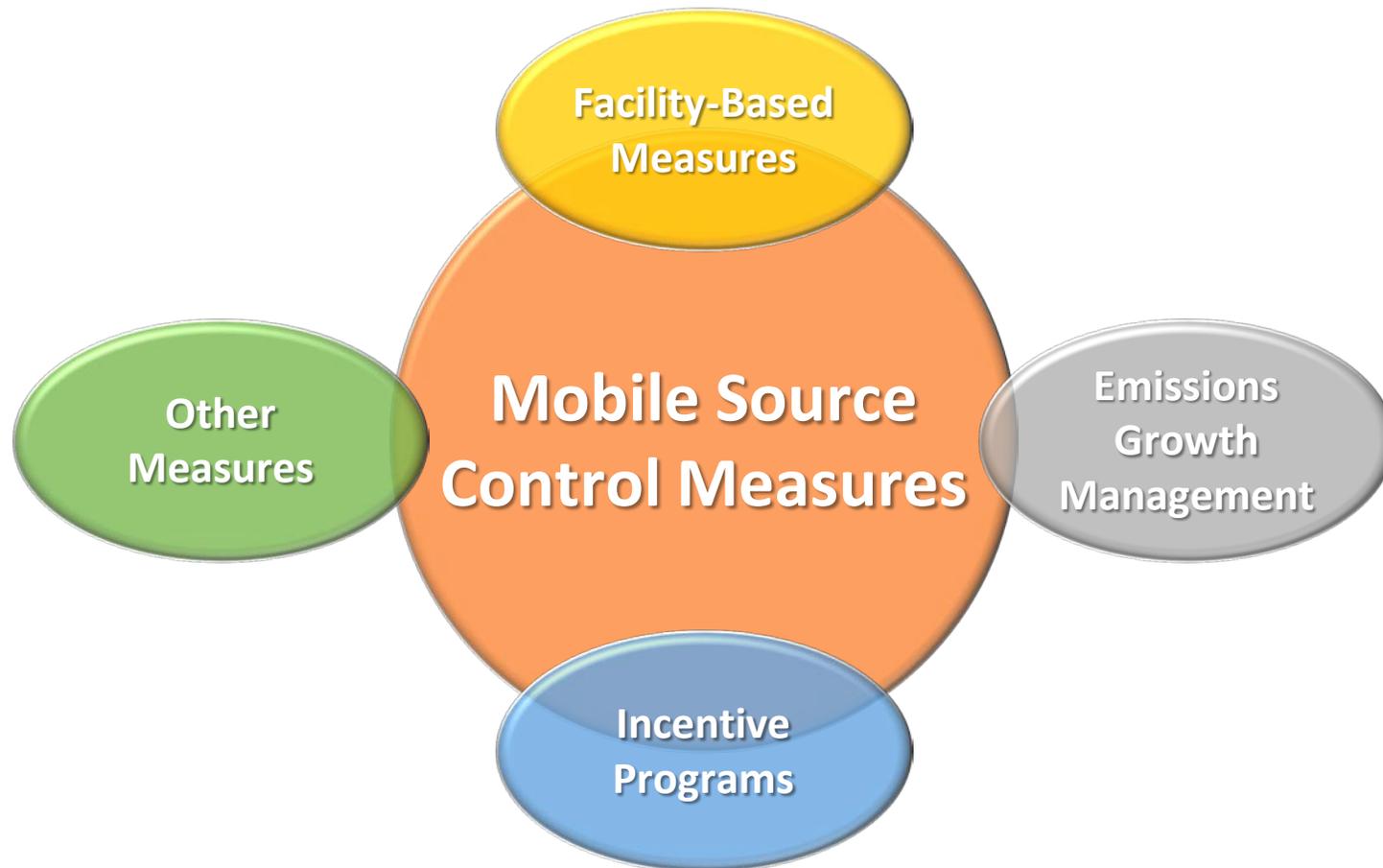
NOx Control Measures for Residential, Commercial,
Large/Industrial Combustion Sources

Co-Benefits from Greenhouse Gas Reductions

Limited Strategic VOC Measures

Other Measures

Overview of Draft South Coast AQMD Mobile Source Control Strategy



- Most mobile source measures have to-be-determined (TBD) emission reductions
- Except for those measures associated with long-established incentive programs

What Costs Are Quantified for South Coast AQMD Control Measures?

- Measures with quantified emission reductions ready to be committed into State Implementation Plan (SIP)
 - Measures recognizing co-benefit reductions from other programs will not have incremental costs
 - Costs for measures relying on not-yet-defined technologies (i.e., “Black Box” measures) may not be quantifiable
 - Infrastructure costs resulting from transition to near-zero and zero-emission will be quantified to the extent possible

- Measures with to-be-determined (TBD) or not-yet-quantified (NYQ) emission reductions
 - preliminary costs may be discussed separately

Summary of Preliminary Costs* of Draft 2022 AQMP South Coast AQMD Measures

Measures	Present Value of Incremental Compliance Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
Stationary and Area Sources¹	\$17,390.3	\$1,492.2
Mobile Source Incentive Measures^{1,2}	\$1,565.6	\$276.1
Total (South Coast AQMD)	\$18,956.0	\$1,768.3

Note: Numbers may not add up due to rounding. A discount rate of 4% is used to calculate present values and amortized costs.

1 – For more detail on each South Coast AQMD control measure, see Appendix IV-A of the Draft 2022 AQMP

(<http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/appiv-a.pdf>)

2 – South Coast AQMD mobile source measure costs are incentive costs borne by society, representing cost savings to the vehicle/equipment purchaser. Many South Coast AQMD mobile source measures have TBD emission reductions and costs.

**Values shown on this slide and subsequent slides reflect most recent draft analysis of costs, and may differ from preliminary analysis shown in Draft AQMP*

Preliminary Costs of Draft 2022 AQMP Stationary Source NOx Measures: Residential Sector

Measures	Title	Present Value of Incremental Compliance Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
R-CMB-01	Residential Water Heating	\$1,851.0	\$105.0
R-CMB-02	Residential Space Heating	\$925.5	\$31.3
R-CMB-03	Residential Cooking	\$315.5	\$17.8
R-CMB-04	Residential Other Combustion	\$57.1	\$2.6
TOTAL		\$3,149.1	\$156.8

Note: Numbers may not add up due to rounding. A discount rate of 4% is used to calculate present values and amortized costs.

- Control technologies included in cost estimation:
 - Electric: Heat pumps, laundry dryers, pool heaters, induction cooktops, and cooking appliances . Includes associated electric panel or 240V outlet upgrades.
 - Low-NOx: Water and space heaters, laundry dryers, pool heaters, barbecue grills, cooktops, and cooking appliances.

Preliminary Costs of Draft 2022 AQMP Stationary Source NOx Measures: Commercial Sector

Measures	Title	Present Value of Incremental Compliance Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
C-CMB-01	Commercial Water Heating	\$128.7	\$10.2
C-CMB-02	Commercial Space Heating	\$319.5	\$20.6
C-CMB-03	Commercial Cooking	\$1,378.4	\$128.8
C-CMB-04	Small Internal Combustion Engines (Non-permitted)	\$3,720.3	\$244.9
C-CMB-05	Miscellaneous Small Commercial Combustion Equipment (Non-permitted)	\$1,907.2	\$304.0
	TOTAL	\$6,440.8	\$708.5

- Control technologies included in cost estimation:
 - Electric: Heat pumps, fryers, ovens, stoves, griddles, broilers, welders, air compressors, pumps, generators, pressure washers, ovens, dryers, furnaces, and kilns. Includes associated electric panel or 240V outlet upgrades.
 - Low-NOx: Water and space heaters, fryers, ovens, stoves, griddles, broilers, welders, air compressors, pumps, generators, pressure washers, ovens, dryers, furnaces, and kilns.

Preliminary Costs of Draft 2022 AQMP Stationary Source NOx Measures: Industrial Sector (1/2)

Measures	Title	Present Value of Incremental Compliance Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
L-CMB-01	NOx RECLAIM	\$25.9	\$0.7
L-CMB-02	Large Boilers and Process Heaters	\$155.0	\$3.3
L-CMB-03	Large Internal Combustion Prime Engines	\$515.9	\$7.3
L-CMB-04	Large Internal Combustion Emergency Standby Engines	\$1,035.3	\$20.8
L-CMB-05	Large Turbines	\$107.7	\$0.7

Note: Numbers may not add up due to rounding. A discount rate of 4% is used to calculate present values and amortized costs.

- Control technologies included in cost estimation:
 - Zero-emission: Electric boilers and fuel cells.
 - Low-NOx/NOx controls: Burners, selective catalytic reduction (SCR) units, microturbines, and Tier 4 engines.

Preliminary Costs of Draft 2022 AQMP Stationary Source NOx Measures: Industrial Sector (2/2)

Measures	Title	Present Value of Incremental Compliance Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
L-CMB-06	Electric Generating Facilities	\$4,079.1	\$200.6
L-CMB-07	Petroleum Refining	\$238.1	\$7.1
L-CMB-08	Landfills and POTWs	\$46.9	\$0.4
L-CMB-09	Incineration	\$5.1	\$0.2
L-CMB-10	Miscellaneous Combustion	\$380.0	\$5.9
	TOTAL	\$6,588.9	\$246.9

Note: Numbers may not add up due to rounding. A discount rate of 4% is used to calculate present values and amortized costs.

- Control technologies included in cost estimation:
 - Zero-emission: Electric boilers and fuel cells.
 - Low-NOx/NOx controls: Burners, selective catalytic reduction (SCR) units, microturbines & turbine replacement, and Tier 4 engines.

Preliminary Costs of Draft 2022 AQMP Stationary Source VOC Measures

Measures	Title	Present Value of Incremental Compliance Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
FUG-01	Improved Leak Detection and Repair	\$147.2	\$4.6
CTS-01	Further Emission Reduction from Coatings, Solvents, Adhesives, and Sealants	\$51.0	\$4.4
	TOTAL	\$198.2	\$9.0

Note: Numbers may not add up due to rounding. A discount rate of 4% is used to calculate present values and amortized costs.

- Control technologies included in cost estimation:
 - Optimal gas imaging (OGI) camera systems.
 - Lower VOC content coatings, solvents, adhesives, and sealants.

Preliminary Costs of Draft 2022 AQMP Mobile Source Measures

Measures	Title	Present Value of Incremental Incentive Cost (2022) Year 2021 Dollars (\$millions)	Average Annual Amortized Cost (2022-2037) Year 2021 Dollars (\$millions)
MOB-05	Accelerated retirement of older light-duty and medium-duty vehicles	\$182.1	\$47.1
MOB-11	Emission reductions from incentive programs	\$1,383.5	\$124.7
	TOTAL	\$1,565.6	\$171.8

Note: Numbers may not add up due to rounding. A discount rate of 4% is used to calculate present values and amortized costs.

- Control technologies included in cost estimation:
 - Electric light- and medium-duty vehicles.
 - Replacement or repower of on-road heavy-duty and off-road vehicles & equipment through incentive programs including, but not limited to, Carl Moyer Memorial Air Quality Standards Attainment Program, Proposition 1B, Lower Emission School Bus, Community Air Protection Program, and Volkswagen Environmental Mitigation Trust.

Preliminary Cost Effectiveness of Draft 2022 AQMP South Coast AQMD Control Measures

Measures	Sector/Sources	Units	Discounted Cash Flow (DCF)	Levelized Cash Flow (LCF)
R-CMB-01 – R-CMB-04	Residential	\$2021/ton NOx	\$5,000 – \$700,000	\$6,000 – \$830,000
C-CMB-01 – C-CMB-05	Commercial	\$2021/ton NOx	\$61,000 – \$664,000	\$94,000 – \$816,000
L-CMB-01 – L-CMB-10	Industrial	\$2021/ton NOx	\$1,000 – \$784,000	\$1,000 – \$1,206,000
FUG-01, CTS-01	VOC Measures	\$2021/ton VOC	\$27,000 - \$34,000	\$27,000 - \$48,000
MOB-05, MOB-11	Mobile Source	\$2021/Carl Moyer ton*	\$24,000 - \$263,000	\$29,000 - \$273,000

Note: A discount rate of 4% is used to calculate present values and amortized costs.

The discounted cash flow (DCF) method divides the present value of all compliance costs in \$2021 by their associated emission reductions.

The levelized cash flow (LCF) method divides the annual amortized value of all compliance costs in \$2021 by their associated annual emission reductions.

*A Carl Moyer ton is calculated as: NOx reductions + reductions of reactive organic gas (ROG) + (20 x PM reductions).

Cost-Effectiveness Calculation Methods

- **DCF:**
$$\frac{\text{Upfront Costs} + \text{Present Value of Annual O\&M Costs Incurred over Equipment Life}}{\text{Annual Emission Reductions} \times \text{Years of Equipment Life}}$$
- **LCF:**
$$\frac{\text{Amortized Upfront Costs} + \text{Annual O\&M Costs}}{\text{Annual Emission Reductions}}$$



What's in the numerator? A home-buying analogy:

DCF: Today's home price + money set aside today in a fixed interest rate account to pay for annual costs for utilities, maintenance, etc.

LCF: Annual fixed-rate mortgage payment with zero down payment + annual costs for utilities, maintenance, etc. at any given future year

Proposed Cost-Effectiveness Approach for South Coast AQMD Control Measure Implementation

Source Type	Cost-Effectiveness Threshold ^{a,b}
Stationary Sources	\$59,000/ton NOx \$36,000/ton VOC
Mobile Sources	\$200,000/weighted ton [NOx+ROG+(20 x PM)]

a Thresholds are in 2021 dollars and will be inflated to the dollar year used in a socioeconomic analysis for each specific control measure as it is implemented.

b The threshold for stationary sources is based on the Discounted Cash Flow method, as traditionally used in South Coast AQMD rulemaking. In comparison, the threshold for mobile sources is based on the Levelized Cash Flow method to be consistent with CARB practice for statewide mobile source regulations.

- Stationary source threshold
 - Guide for setting BARCT* emission limits, not a hard threshold
 - If proposed BARCT exceeds threshold, conduct a public meeting to discuss alternatives
 - Present multiple options to South Coast AQMD Board at public hearing
- Mobile source threshold
 - Higher threshold based on past experience with existing incentive programs

2022 AQMP Socioeconomic Report Schedule

Title	Anticipated Release Date
Draft 2022 AQMP	May 2022*
Draft 2022 AQMP Socioeconomic Report	June
Revised Draft 2022 AQMP	July
Draft Final 2022 AQMP	September
Draft Final 2022 AQMP Socioeconomic Report	
Final 2022 AQMP	October

* Released and available at: <http://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan>.

Staff Contacts

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<p>For more information, visit: www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/socioeconomic-analysis</p>		

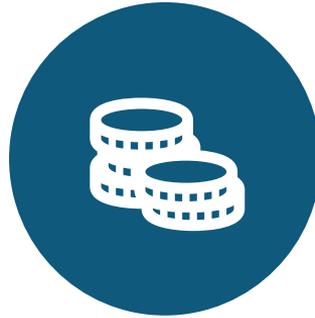


2022 State Strategy for the State Implementation Plan: Economic Analysis Approach

State SIP Strategy Economic Analysis



PROPOSED
MEASURES



COST
ESTIMATES



ECONOMIC
IMPACT ANALYSIS



Proposed 2022 State SIP Strategy Measures

On-Road

- Advanced Clean Fleets Regulation
- Zero-Emission Trucks
- On-Road Motorcycle New Emissions Standards
- Clean Miles Standard
- Enhanced Regional Emission Analysis in State Implementation Plans

Off-Road

- Tier 5 Off-Road Engine Standard
- Amendments to In-Use Diesel-Fueled Fleets Regulation
- Zero-Emission TRU Part II
- Commercial Harbor Craft
- Cargo Handling Equipment
- Off-Road Zero-Emission Targeted Manufacturer Rule
- Clean Off-Road Fleet Recognition Program
- Spark-Ignition Marine Engine Standards

Primarily Federally-Regulated

- In-Use Locomotive Regulation
- Future Measures for Aviation Emissions Reductions
- Future Measures for OGV Emissions Reductions

Other

- Consumer Products
- Zero-Emission Standard for Space and Water Heaters



Federal Actions Needed



On-Road Heavy-Duty Vehicles

- Low-NOx Engine Standards
- Zero-Emission Engine Standards



Off-Road Equipment

- Tier V Standards
- Zero-Emission Standards Where Feasible



Locomotives

- More Stringent National Emission Standards
- Zero-Emissions Standards for Switcher
- Address Remanufacturing Loophole



Ocean-Going Vessels

- More Stringent NOx and PM Standards Requirements
- Cleaner Fuel and Visit Requirements



Aviation

- More Stringent Engine Standards
- Cleaner Fuel and Visit Requirements
- Zero-Emission Airport On Ground Support Requirements



Determining Measure Costs

- Assumptions are informed by foundational technical work and ongoing technology assessments
- These assumptions are refined throughout measure implementation
- Depending on the current state of a measure, the source of cost data varies



Stages in Cost Development

Emissions Only

- Apply average cost per ton factors for similar measures that have preliminary, draft or final rulemaking data available

Preliminary Cost Analysis

- Initial analysis of incremental cost of technology

Draft Rulemaking Analysis

- Information shared in public workshops
- Forthcoming or published Standardized Regulatory Impact Assessment (SRIA) on Dept of Finance website

Final Rulemaking Analysis

- Published SRIA and numerous opportunities for public comment
- Analysis in review by Dept of Finance and Office of Administrative Law.



Stages of Costs by Measure

Emissions Only

- Zero-Emission Trucks
- Zero-Emission TRU Part II
- Federal Low-NOx Engine Standards*

Preliminary Cost Analysis

- Tier 5 Off-Road Engine Standard
- Spark-Ignition Marine Engine Standards
- Consumer Products
- Zero-Emission Standard for Space and Water Heaters
- Cargo Handling Equipment
- Clean Fuel and Visit Requirements for OGV*

Draft Rulemaking Analysis

- Advanced Clean Fleets
- On-Road Motorcycle New Emission Standards
- Amendments to In-Use Diesel-Fueled Fleets Regulation
- In-Use Locomotive Regulation

Final Rulemaking Analysis

- Clean Miles Standard
- Commercial Harbor Craft

*measures that require federal action



Preliminary Costs by Measure for South Coast: On-Road & Other

Measure	Total Amortized Cost Through 2037 (Millions)	Avg. Annual Amortized Cost (Millions)	Proportion Method
Clean Miles Standard	(\$282)	(\$19)	Emissions
Advanced Clean Fleets Regulation	\$3,466	\$248	Emissions
On-Road Motorcycle New Emission Standards	\$105	\$8	Emissions
Building Electrification/Decarb.	\$3,762	\$314	Equipment Population
Consumer Products	NYQ	NYQ	Population
Zero-Emissions Truck Measure	\$1,572	\$196	Emissions



Preliminary Costs by Measure for South Coast: Off-Road

Measure	Total Amortized Cost Through 2037 (Millions)	Avg. Annual Amortized Cost (Millions)	Proportion Method
Amendments to the In-Use Diesel-Fueled Fleets Regulation	\$668	\$45	Emissions
Commercial Harbor Craft	\$585	\$39	Emissions
In-Use Locomotive Regulation	\$1,839	\$123	Emissions
Zero-Emission TRU Part II	\$1,142	\$82	Emissions
Off-Road Zero-Emission Targeted Manufacturing Rule	NYQ	NYQ	NYQ
Cargo Handling Equipment	NYQ	NYQ	NYQ
Tier 5 Off-Road Engine Standards	\$208	\$21	Emissions
Spark-Ignition Marine Engine Standards	\$7	\$1	Emissions



Preliminary Costs by Measure for South Coast: Federal Actions Needed

Measure	Total Amortized Cost Through 2037 (Millions)	Average Annual Amortized Cost (Millions)	Proportion Method
Clean Fuel and Visit Requirements for Ocean-Going Vessels	NYQ	NYQ	NYQ
On-Road Heavy-Duty Vehicle Low-NOx Engine Standards	\$48	\$4	Emissions
Off-Road Equipment Tier V Standards for Preempted Engines	\$137	\$14	Emissions
More Stringent NOx and PM Standards for Ocean-Going Vessel Requirements	NYQ	NYQ	NYQ



Economic Impact Analysis Approach

- Utilize Regional Economic Models, Inc (REMI) economic forecasting and policy analysis model
 - REMI Policy Insight Version 2.5.0, single region, 160 sector model
- REMI includes detailed inter-industry relationships and supply/demand responses, to answer “what if...?” questions about the economy
- Utilized by CARB for analysis of all major regulations and approved by CA Department of Finance for evaluating economic impacts



REMI Modeling Steps

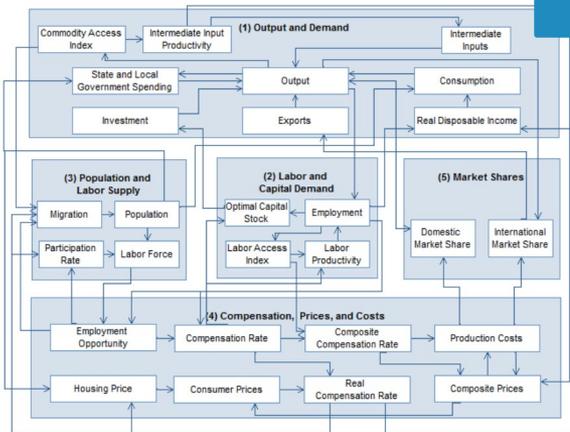
1

Convert direct costs to REMI policy variables, including:

- Production costs for CA businesses
- Final demand for industries supplying goods and services
- Prices and spending on consumer goods

2

Run the REMI model:



3

Model outputs:

- Employment
 - Industry revenues
 - Personal income
 - Gross state product
- Impacts on major sectors evaluated for 2024 to 2037



CARB Next Steps

- Mid-July (tentative) - publish Proposed 2022 State SIP Strategy, including cost assumptions and results of economic impact analysis
- July/August – 4th public workshop
- September (tentative) - Board hearing

IEc

Public Health Benefits of SCAQMD Draft 2022 AQMP: Preliminary Estimates

Presented by:
Industrial Economics, Inc.
Henry Roman
William Raich

May 31, 2022

Presentation Overview

- Background and Objectives
- Health Impacts
 - Approach
 - Updates since 2016
 - Mortality Results
 - Morbidity Results
- Valuation
 - Approach
 - Updates since 2016
 - Results

Background and Objectives

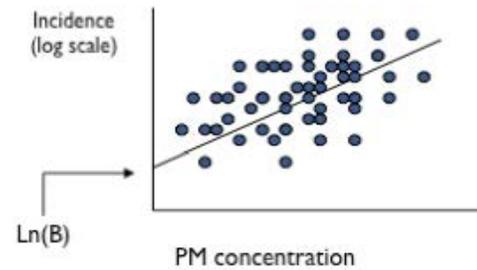
- Implementation of the Draft 2022 Air Quality Management Plan (AQMP) will result in lower ozone and PM2.5 concentrations in the South Coast Air Basin.
- Epidemiological research shows that improved air quality reduces mortality and morbidity.
- As part of the Socioeconomic Analysis of the Draft 2022 AQMP, we quantify these effects and use welfare valuation methods to express public health benefits in dollar terms.

Methodology - Overview

- Follow standard health impact approach
- Review and update approach from 2016 AQMP:
 - Health endpoints and epidemiological studies / health impact functions
 - Valuation studies and functions
 - Baseline incidence rates
 - Population
- Use EPA's BenMAP-CE to quantify and monetize health impacts of draft 2022 AQMP effects on PM_{2.5} and O₃.

Methodology - Standard Health Impact Approach

Epidemiology study



$$\ln(y) = \ln(B) + \beta(\text{PM})$$

Health impact function

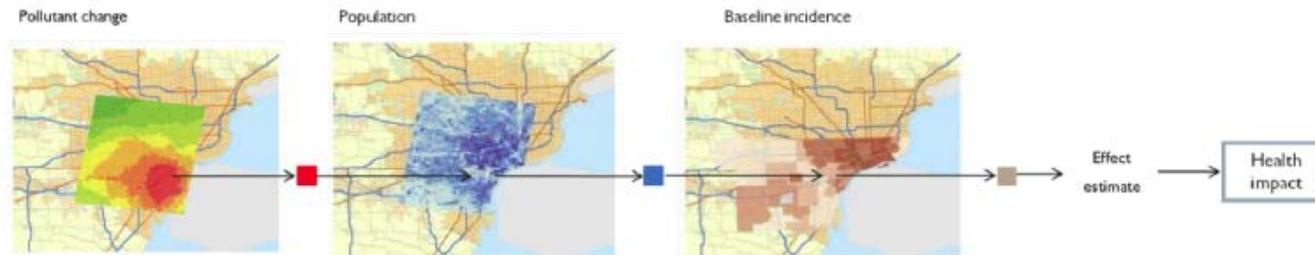
$$\Delta Y = Y_0 (1 - e^{-\beta \Delta \text{PM}}) * \text{Pop}$$

Y_0 – Baseline Incidence

β – Effect estimate

ΔPM – Air quality change

Pop – Exposed population



Source: BenMAP-CE User Manual, 2021

Methodology - Local Data Inputs

- Projected baseline and AQMP concentrations of PM2.5 and O3 in 2037, 4km x 4km scale.
- Population forecast by age group at the 4km x 4km grid-level (from SCAG's 2020 RTP/SCS Growth Forecast)
- Baseline mortality and morbidity incidence rates by age group, by county.
- California or LA-specific C-R functions are used where feasible.
- Local baseline incidence and prevalence data used where available

Methodology - BenMAP Tool

- The Environmental Benefits Mapping and Analysis Program (BenMAP) is developed by U.S. EPA that uses a systematic method of quantifying and valuing health impacts.
- Used for the last three AQMPs.
- 2016 AQMP uses BenMAP-Community Edition, version 1.5.8.17
- A list of articles and presentations where BenMAP has been applied can be found here: <https://www.epa.gov/benmap/benmap-ce-applications-articles-and-presentations>

Health Impact Review - Criteria

- Review of:
 - U.S. EPA ISAs
 - More recent literature

- Review criteria emphasize:
 - Study quality
 - Geographical relevance
 - Representative populations
 - Timeframe
 - Transparency

CRITERIA
GENERAL:
<ol style="list-style-type: none"> 1. Study is peer-reviewed. 2. Study is written in English. 3. Study measures exposure to at least one of the following pollutants: O₃, PM_{2.5}. 4. Preference given to studies or groups of studies that significantly advance our understanding of the relationship between air pollution exposures and mortality and morbidity endpoints, including those endpoints previously quantified by the SCAQMD in its Air Quality Management Plans as well as new endpoints. 5. Study was published after IEC's previous socioeconomic review (2016 - present)
GEOGRAPHY AND STUDY POPULATION:
<ol style="list-style-type: none"> 6. Study measures exposures at or near ambient levels found in the South Coast Air Basin. Order of preference of study location: <ol style="list-style-type: none"> a. South Coast Air Basin (Los Angeles, Orange, Riverside, and San Bernardino Counties) b. Within State of California c. Within Western United States d. Within United States or Canada 7. Study uses study population with similar characteristics as found in Los Angeles, Orange, Riverside, and San Bernardino counties.
STUDY DESIGN:
<ol style="list-style-type: none"> 8. Study is population-based, preferably using cohort and case-control epidemiological study designs. Controlled human exposure studies may be evaluated for supporting evidence. Animal and in-vitro studies excluded. 9. Study controls for factors that may obscure the true concentration-response relationship, including selection bias, misclassification, recall bias, confounding (including by other pollutants), effect modification, mortality displacement, loss to follow-up, etc. 10. Study appropriately assesses any potential lag between exposure and outcomes. 11. Study appropriately assesses any potential exposure thresholds for health outcomes. 12. Study clearly presents information about uncertainty in results to facilitate evaluation and comparison with other studies. 13. Prefer studies that assess changes in the risk of incidence of disease, rather than exacerbation of existing cases or changes in symptoms. 14. Prefer studies that characterize pollutant exposure using advanced air quality models that fuse data from multiple sources (e.g., monitors, satellite sensors).

Health Impact Review - Mortality

- PM_{2.5} - No changes from 2016

ENDPOINT	POLLUTANT	STUDY	STUDY POPULATION
Premature mortality—all-cause, long-term exposure ^a	PM2.5 annual avg	Pooled estimate of: 1. Jerrett et al. (2013) LA 2. Jerrett et al. (2005) LA 3. Krewski et al. (2009) LA	Adults >30 years

- O₃ - Add Long-term respiratory mortality

ENDPOINT	POLLUTANT	STUDY	STUDY POPULATION
Premature mortality—respiratory, long-term exposure ^a	O3, D8HourMax, April - September	1. Turner et al., 2016	Adults >30 years

- No threshold assumed for either pollutant
 - IEc recommendation based on latest scientific evidence
 - U.S. EPA's practice (e.g., draft 2021 PM_{2.5} Policy Assessment)

Morbidity, PM

ENDPOINT	STUDY	STUDY POPULATION
Chronic Illness		
Asthma	Garcia et al., 2019* Tetreault et al., 2016	0-17
Non-fatal MI	Wei et al., 2019	18-99
Out of Hospital Cardiac Arrest	Ensor et al. 2013	18-99
Lung Cancer	Gharibvand et al., 2016	30-99
Stroke (Ischemic)	Shin et al. 2014	65-99
Hospital Admissions & ED visits		
All Respiratory HA	Ostro et al., 2009; Zanobetti et al., 2009	0-17; 65-99
All Cardiac HA	Talbott et al., 2014	0-99
Asthma HA	Delfino et al., 2014*	0-17
Asthma ED	Ostro et al., 2016*	0-99
Alzheimers (HA)	Kioumourtzoglou et al., 2016	65-99
Parkinsons (HA)	Kioumourtzoglou et al., 2016	65-99

Morbidity, PM (continued)

ENDPOINT	STUDY	STUDY POPULATION
Other Health Effects		
Asthma symptoms, albuterol use	Rabinovitch et al., 2006	6-17
Hay Fever/Rhinitis	Parker et al., 2009	3-17
Minor Restricted Activity Days	Ostro and Rothschild, 1989	18-64
Lung Cancer	Gharibvand et al., 2016	30-99
Work Loss Days	Ostro, 1987	18-64

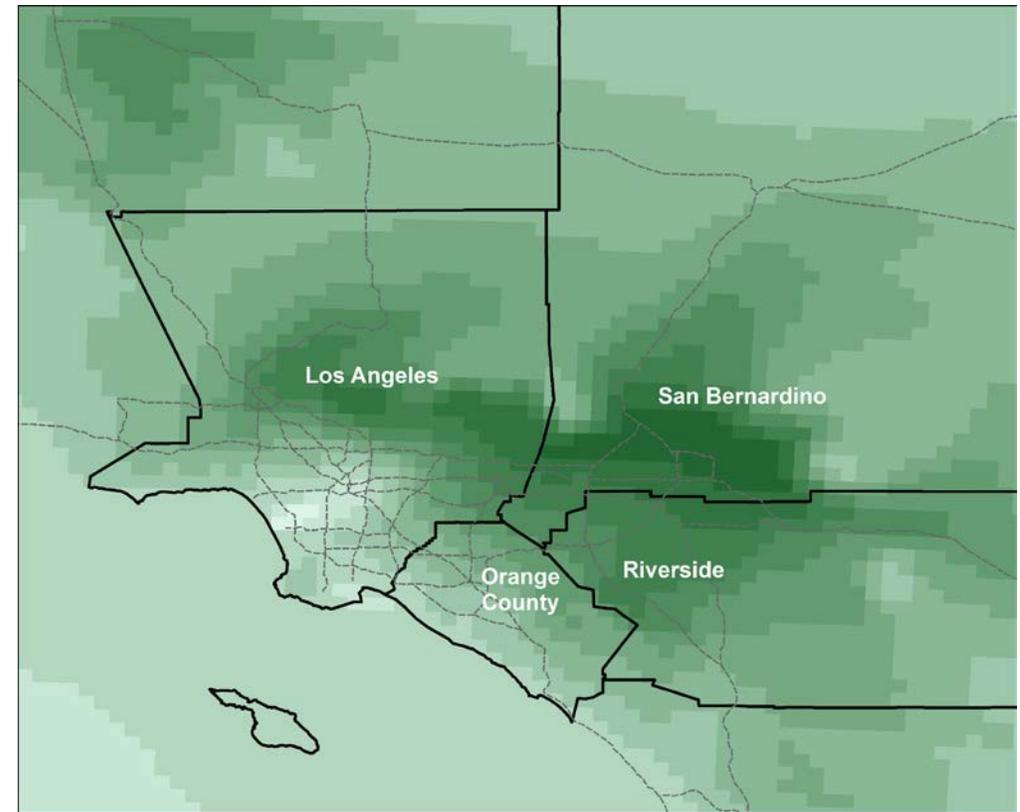
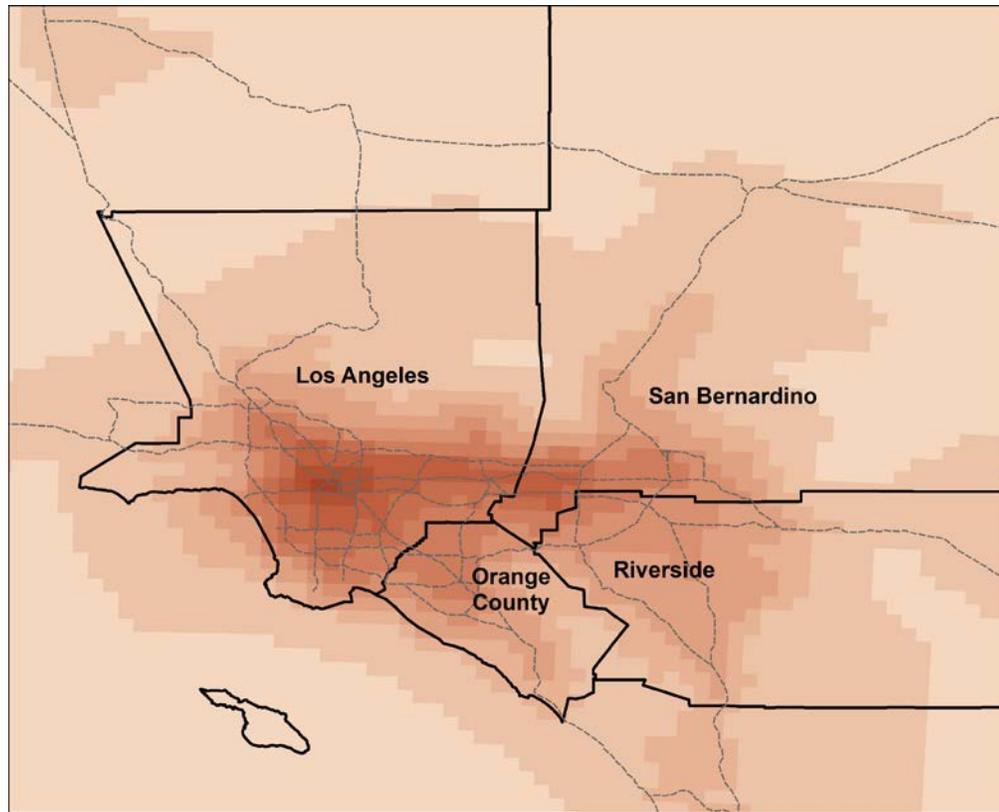
*California Study

Morbidity, Ozone

ENDPOINT	STUDY	STUDY POPULATION
Chronic Illness		
Asthma	Garcia et al., 2019* Tetreault et al., 2016	0-17
Hospital Admissions & ED visits		
All Respiratory ED visits	Malig et al., 2016*	0-99
Asthma HA	Moore et al., 2008	0-17
Asthma ED	Malig et al., 2016*; Gharibi et al., 2019*	0-99
Other Health Effects		
Asthma Symptoms (Cough, Wheeze, Chest Tightness, Shortness of Breath)	Lewis et al., 2013	5-17
Minor Restricted Activity Days	Ostro and Rothschild, 1989	18-64
School Loss Days	Gilliland et al., 2001	5-17

*California Study

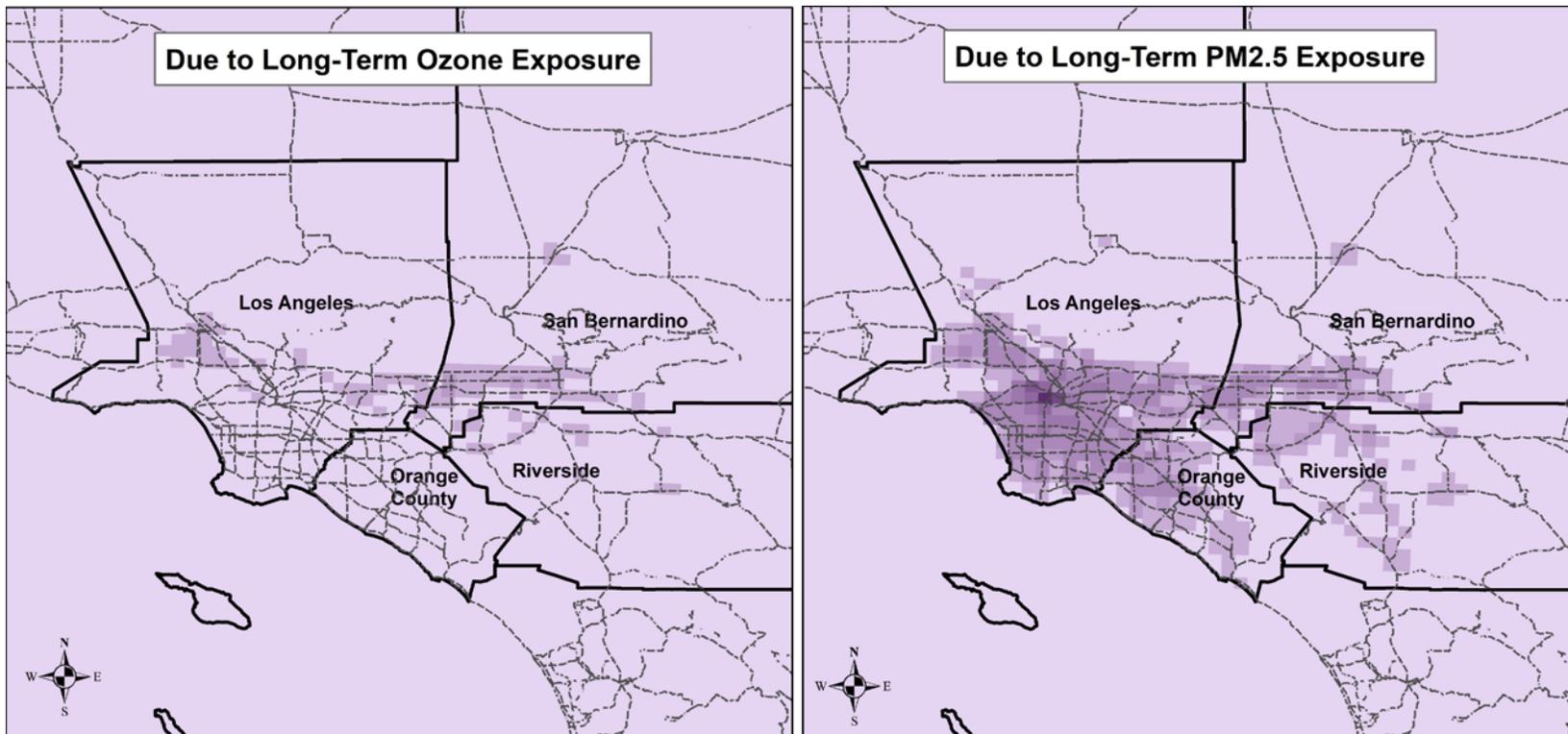
Projected Air Quality Changes in 2037



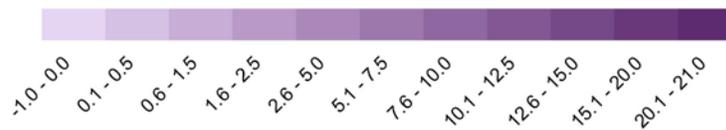
Preliminary Draft Health Impacts - Mortality

Avoided Premature Mortality	
	2037
Mortality, Respiratory / Mortality, All Cause	1,090
Ozone	187
Los Angeles	69
Orange	17
Riverside	43
San Bernardino	57
PM	903
Los Angeles	580
Orange	107
Riverside	95
San Bernardino	121

Preliminary Draft Health Impacts - Mortality (cont'd)



----- Major Highways
Avoided Mortality in 2037



Preliminary Draft Health Impacts - Morbidity

Reduced Morbidity Incidence	2037
Short-Term Ozone Exposure	
Asthma Symptoms (Chest Tightness, Cough, Shortness of Breath, Wheeze)	2,465,621
Asthma, New Onset	11,374
ED Visits, Asthma	904
ED Visits, All Respiratory	794
HA, Asthma	26,012
Minor Restricted Activity Days	1,005,811
School Loss Days, All Cause	295,091

Reduced Morbidity Incidence	2037
Short-Term PM2.5 Exposure	
Acute Myocardial Infarction, Nonfatal	36
Asthma Symptoms, Albuterol use	896,949
Asthma, New Onset	5,212
ED Visits, Asthma	184
ED Visits, All Cardiac Outcomes	895
ED Visits, All Respiratory	226
EHA, Asthma	11
HA, All Cardiac Outcomes	81
HA, All Respiratory	227
HA, Alzheimer's Disease	56
HA, Parkinson's Disease	27
Incidence, Hay Fever/Rhinitis	25,288
Incidence, Ischemic Stroke	78
Incidence, Lung Cancer (non-fatal)	243
Incidence, Out-of-Hospital Cardiac Arrest	23
Minor Restricted Activity Days	1,220,901
Work Loss Days	208,835

Approach to VSL Review

- Literature review and “benefit transfer” approach
- Based largely on Robinson and Hammitt, 2015
 - Current, comprehensive VSL review
 - Stringent criteria derived from EPA SAB recommendations
 - Includes illness-based VSLs
- Supplemented with review 2014-present
 - Searched Scopus PubMed, EBSCO EconLit, Business, and Environment databases, Google Scholar
 - Included term for CA-specific estimates
- Adjustments for inflation and growth in real income

Results of VSL Review

- Robinson and Hammitt, 2015
 - Most qualifying estimates based on wage-risk
 - \$5.3 million to \$13.7 million range; mid-point of \$9.5 million
 - Three qualifying SP studies (two illness based):
 - \$4.2 million to \$11.2 million range; mid-point of \$7.7 million
 - Results from illness studies similar to others
 - Combined range \$4.2 million to \$13.7 million; mid-point of \$9.0 million (2013\$)
- No evidence of CA-specific estimates
- Supplemental review found no newer studies that met criteria

VSL Adjustments for 2022 AQMP

Data sources

- Default (national) income growth projections in BenMAP-CE:
 - 2013 → 2037 adjustment
- Income elasticity:
 - 1.1 (10% increase in real income results in an 11% increase in VSL)
 - Sensitivity analyses with 0.4 - 1.4
- Consumer price index (inflation):
 - 2013\$ to 2020\$

VSL estimates

Description	VSL (millions \$)		
	Low	Central	High
2013\$ 2013 income levels	\$4.20	\$9.00	\$13.70
2020\$ 2037 income levels	\$4.67	\$13.96	\$23.28

Criteria - Morbidity Valuation

CRITERIA FOR MORBIDITY VALUATION STUDIES

CRITERIA
GENERAL:
<ol style="list-style-type: none">1. Study is publicly available.2. Study is written in English.3. Study is conducted in the U.S.
FOR STATED-PREFERENCE STUDIES:
<ol style="list-style-type: none">4. Study elicits values for private risk reductions that accrue to the respondent.5. Study estimates WTP, not WTA compensation.
FOR COI STUDIES:
<ol style="list-style-type: none">6. Study includes clear description of the elements that make up the COI estimate.7. Study includes clear description of health endpoint and estimates incidence-based or prevalence-based cost as appropriate for the health endpoint evaluated.8. Prefer studies that estimate costs specific to affected groups (especially, affected age groups).

Morbidity Valuation Results

- Lack of high-quality, relevant WTP studies remains an issue
 - Primarily COI-based estimates
- Updated COI-based estimates where appropriate
- COI estimates likely underestimate true value of health effects.
- Adjustments for 2022 analysis
 - Inflate costs to appropriate dollar year
 - Adjust WTP estimates for income growth through 2037 (elasticity = 0.5)
 - Apply discount rates* (1%, 4%) for multi-year impacts

Valuation Review - Morbidity (PM_{2.5})

Endpoint	Valuation Method	Valuation Source
<i>New Endpoints</i>		
ER Visits, All Cardiac Outcomes	COI: med costs	HCUP NEDS
HA, All Cardiac Outcomes	COI: med costs + wage loss	HCUP NIS
HA, Alzheimer's Disease	COI: 5 yrs med, 3% DR	Alzheimer's Association. (2020) and Jutkowitz et al. (2017)
HA, Parkinson's Disease	COI: 14.6 yrs med, 3% DR	Yang et al. (2020)
EHA, Asthma*	COI: med costs	HCUPnet SID (CA)
Incidence, Hay Fever/Rhinitis	COI: 1 yr med costs	Soni, A. (2008)
Incidence, Ischemic Stroke	COI: 1 yr med costs (excluding hospitalization costs)	Mu et al. (2017)
Incidence, Lung Cancer (non-fatal)	COI: 5 yrs med, 3% DR	Kaye et al. (2018)
Incidence, Out-of-Hospital Cardiac Arrest	COI: 3 yr med costs, 3% DR	Sullivan et al. (2011)
Asthma Symptoms, Albuterol Use	COI: Use of inhaler	Average prescription costs derived from Epocrates.com and Goodrx.com
<i>Updated Endpoints</i>		
Acute Myocardial Infarction	COI: 3 yr med costs, 5 yr wages, 3% DR	Sullivan et al. (2011)
ER Visits, Asthma	COI: med costs	Average of two studies: *Smith et al. (1997) *Standford et al. (1999)
HA, All Respiratory	COI: med costs + wage loss	HCUP NIS

Valuation Review - Morbidity (Ozone)

Endpoint	Valuation Method	Valuation Source
<i>New Endpoints</i>		
ER Visits, All Respiratory*	COI: med costs	HCUPnet NEDS
Incidence, Asthma (new onset)	COI: lifetime med, lifetime productivity, 3% DR	Belova et al. (2020)
<i>Updated Endpoints</i>		
Asthma Symptoms (previously Asthma Exacerbation)	WTP: 1 symptom-day	Dickie and Mesmen (2005)
ER Visits, Asthma	COI: med costs	Smith et al. (1997) and Standford et al. (1999)
HA, Asthma*	COI: med costs	HCUPnet SID (CA)

Preliminary Draft Health Benefits - Mortality

- Monetized premature mortalities avoided with VSL (before income adjustments):
 - Range of \$4.3-\$13.9 million (2020\$)
 - Midpoint of \$9.2 million
- Applied income elasticity (ϵ):
 - Range from 0-1.4
 - 1.1 for main estimate
- Included a 20-year cessation lag of $PM_{2.5}$ mortality effects with 1 and 4% discount rates

Monetized Public Health Benefits (Billions 2020\$ per year)			
	2037		
	Lower Bound (\$4.3M, $\epsilon_i=0$)	Midpoint (\$9.2M, $\epsilon_i=1.1$)	Upper Bound (\$13.9M, $\epsilon_i=1.4$)
Mortality, Respiratory / Mortality, All Cause	\$4.48	\$13.40	\$22.34
Ozone	\$0.77	\$2.29	\$3.82
Los Angeles	\$0.28	\$0.85	\$1.41
Orange	\$0.07	\$0.21	\$0.34
Riverside	\$0.18	\$0.53	\$0.89
San Bernardino	\$0.24	\$0.71	\$1.18
PM	\$3.71	\$11.10	\$18.51
Los Angeles	\$2.38	\$7.13	\$11.89
Orange	\$0.44	\$1.31	\$2.19
Riverside	\$0.39	\$1.17	\$1.95
San Bernardino	\$0.50	\$1.49	\$2.48

Preliminary Draft Health Benefits - Morbidity

Total Morbidity Benefits (Millions 2020\$): \$2,063.3

Reduced Morbidity Incidence	2037 (Millions \$2020)
Short-Term Ozone Exposure (Total)	\$1,574.9
Asthma Symptoms (Chest Tightness, Cough, Shortness of Breath, Wheeze)	\$669.1
Asthma, New Onset	\$581.7
ED Visits, Asthma	\$0.5
ED Visits, All Respiratory	\$0.8
HA, Asthma	\$198.3
Minor Restricted Activity Days	\$89.0
School Loss Days, All Cause	\$35.5

Reduced Morbidity Incidence	2037 (Millions \$2020)
Short-Term PM2.5 Exposure (Total)	\$488.5
Acute Myocardial Infarction, Nonfatal	\$4.2
Asthma Symptoms, Albuterol use	\$0.4
Asthma, New Onset	\$266.6
ED Visits, Asthma	\$0.1
ED Visits, All Cardiac Outcomes	\$0.9
ED Visits, All Respiratory	\$0.3
EHA, Asthma	\$0.1
HA, All Cardiac Outcomes	\$7.0
HA, All Respiratory	\$5.8
HA, Alzheimer's Disease	\$11.1
HA, Parkinson's Disease	\$18.0
Incidence, Hay Fever/Rhinitis	\$17.6
Incidence, Ischemic Stroke	\$3.1
Incidence, Lung Cancer (non-fatal)	\$5.2
Incidence, Out-of-Hospital Cardiac Arrest	\$1.0
Minor Restricted Activity Days	\$108.0
Work Loss Days	\$39.1

Preliminary Draft Health Benefits - Total

- The preliminary total value of quantified public health benefits:
 - \$15.46 Billion in 2037

	2037 (Billions \$2020)
Mortality-related benefits	\$13.40
Long-Term Ozone Exposure	\$2.29
Long-Term PM2.5 Exposure	\$11.10
Morbidity-related benefits	\$2.06
Grand Total	\$15.46

- Exploring estimation of benefits in 2032 and (potentially) additional years

Future Updates

- Update to incorporate more local inputs.
 - California HA and ED visit data (from HCAI)
 - Incidence rates
 - Healthcare costs
 - California real income growth projections (from CA DOF)
- Update to reflect any future revisions to air quality surfaces.
- Potential inclusion of additional years (e.g., 2032) and discounting of future benefits.

IEC

Questions?



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