Air Quality Co-benefits of San Francisco's Greenhouse Gas Reduction Measures

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San Francisco Planning + Urban Research Association (SPUR)

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Study Objectives

- Identify the air quality benefits that could result from implementation of San Francisco's greenhouse gas (GHG) reduction measures

- Proof of concept

Participants and Collaborators

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Why evaluate the air quality "co-benefits" of GHG reduction measures?

- Reducing GHG emissions may also reduce air pollution
- Reducing air pollution can improve the health of San Francisco and the Bay Area's citizens

Bay Area Air Quality

Bay Area Clean Air Plans

The Bay Area is in nonattainment for the following air quality standards:

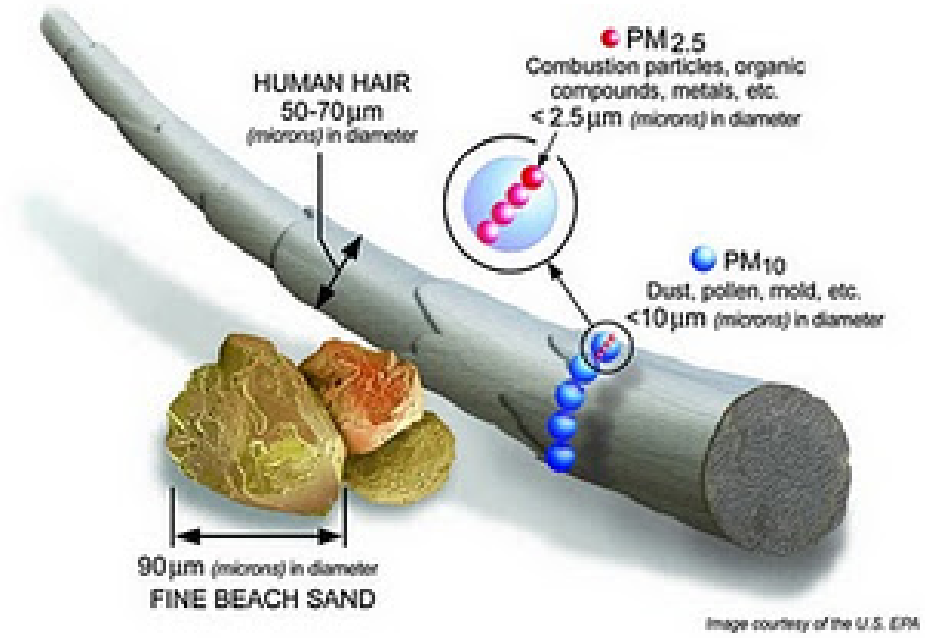
- 1- and 8-hour state ozone standards
- 24-hour PM2.5 federal standard

In September 2010, BAAQMD adopted the *Bay Area 2010 Clean Air Plan*. This *Plan* serves to:

- Update the *Bay Area 2005 Ozone Plan*
- Provide a control strategy to reduce ozone, PM, air toxics, and GHGs in a single, integrated plan
- Review progress on improving air quality in recent years
- Establish emission control measures to be adopted or implemented in the 2010–2012 timeframe

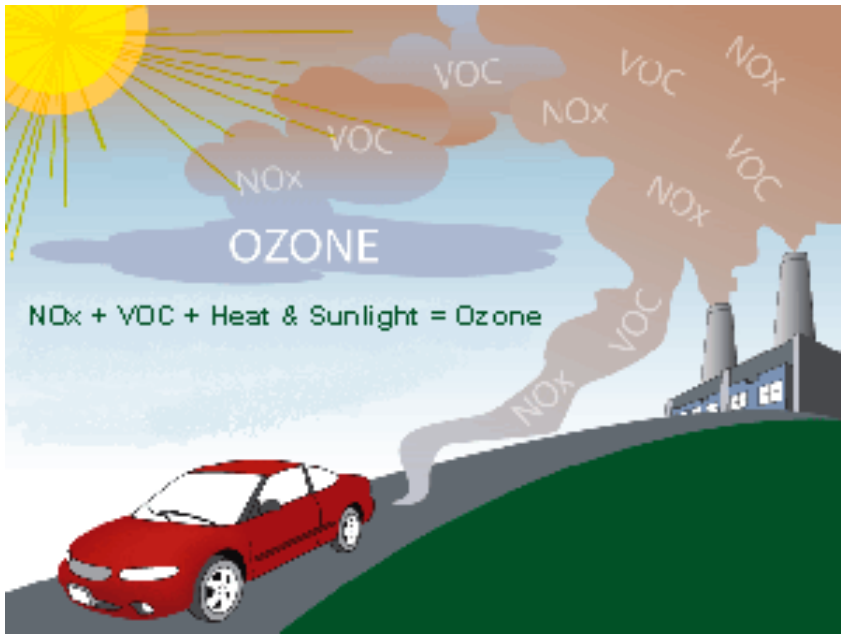
Particulate Matter

- Solid or liquid particles suspended in the atmosphere
- PM10 is a subgroup of particles with an aerodynamic diameter of 10 micrometers or less
- **PM2.5 is a subgroup of finer particles with an aerodynamic diameter of 2.5 micrometers or less (sometimes referred to as *fine PM*)**

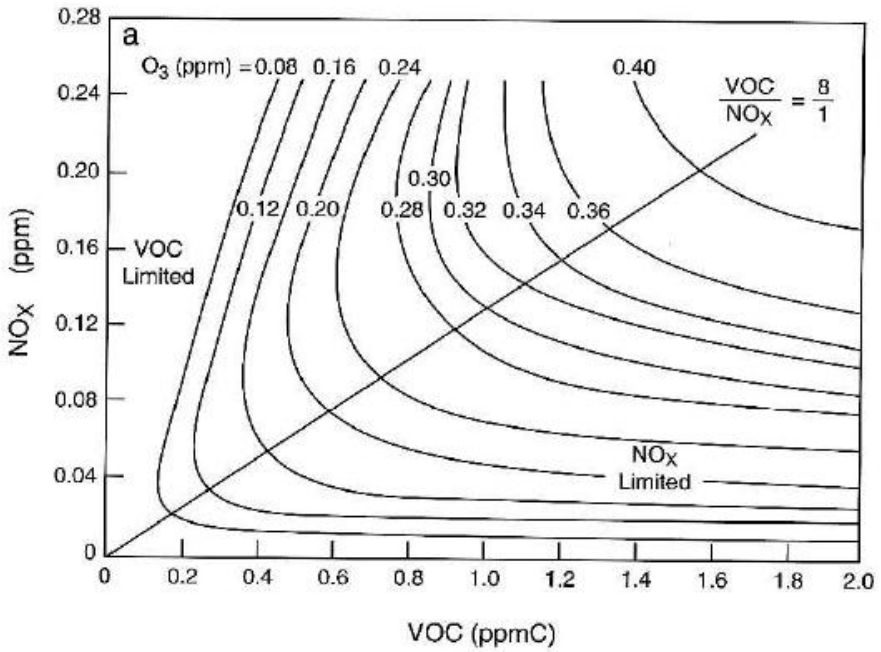


Ozone ("Good Up High, Bad *Nearby*")

"Nearby" ozone forms from the reaction between VOCs (or ROGs) and nitrogen oxides (NOx), and is dependent on the presence of heat and sunlight



http://www.epa.gov/air/ozonepollution/basic.html



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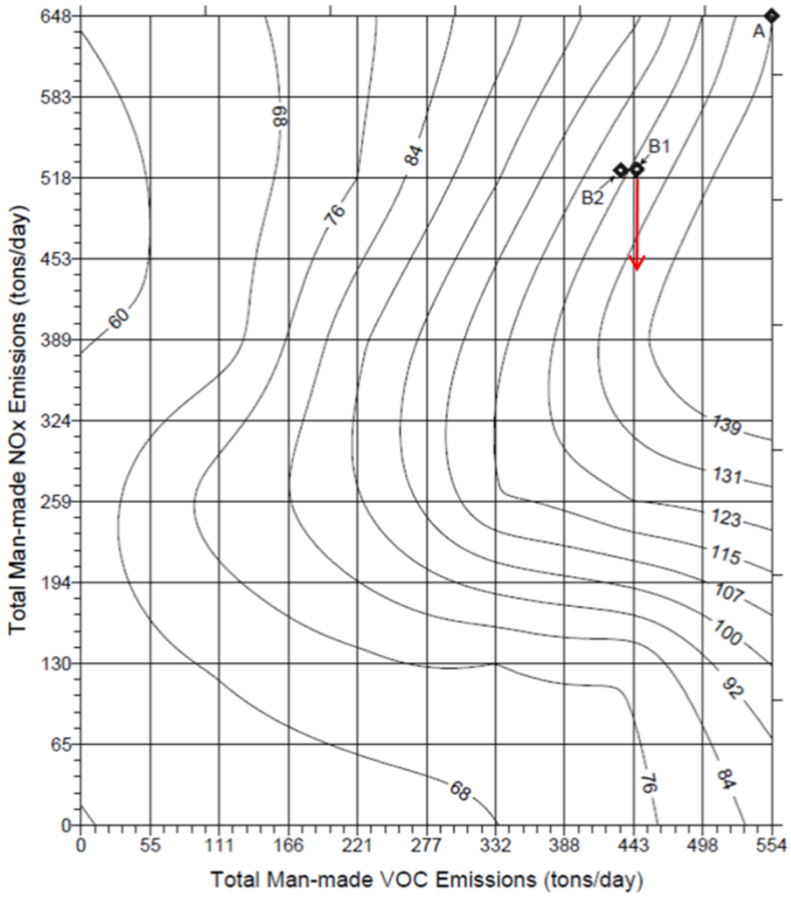
LS17 deleted period at end of sentence for consistency
Laura Smith, 11/28/2011

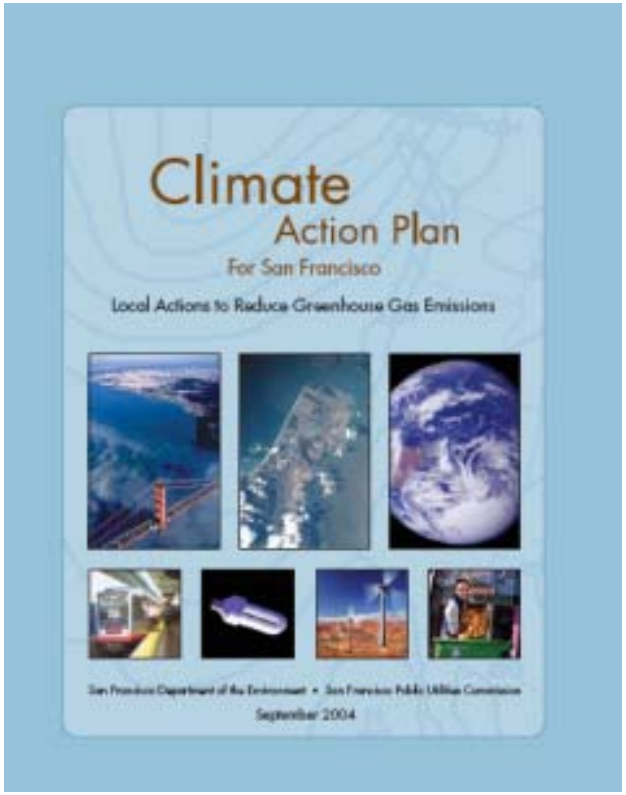
Bay Area Ozone Chemistry

- ROG-only reduction control measures lead to ozone reductions virtually everywhere
- NO_x-only reduction control measures lead to ozone *reductions* in some areas and ozone *increases* in other areas

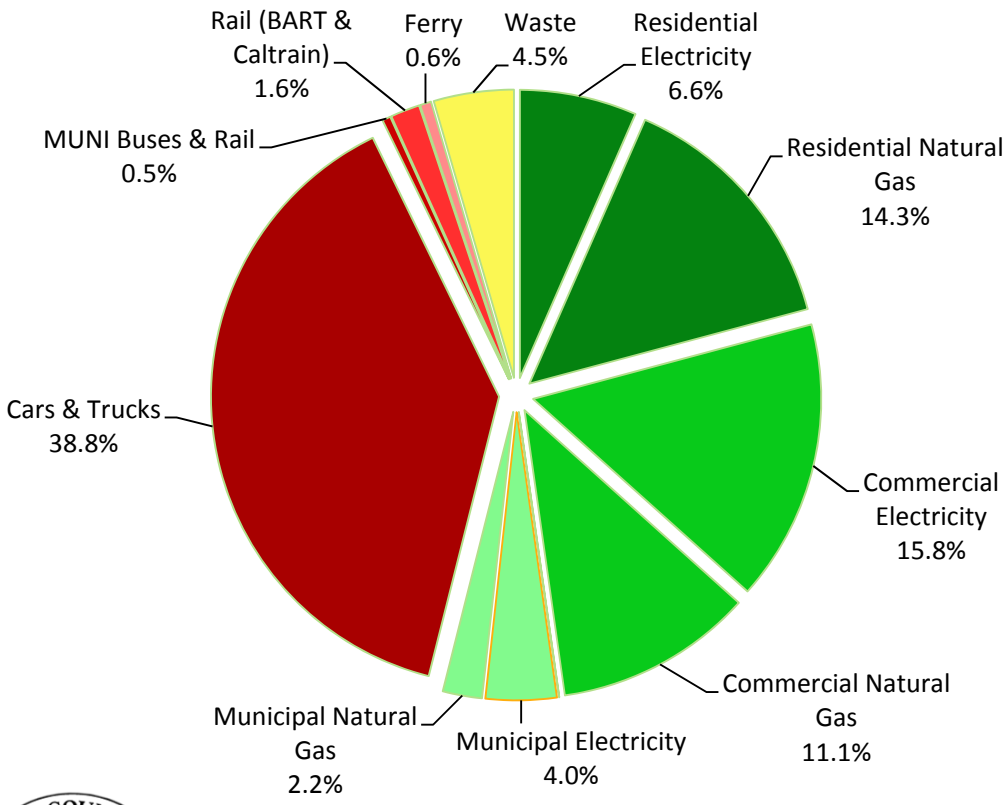


Isopleths of Livermore peak ozone concentrations (parts per billion) based on photochemical model sensitivity simulations. Point B1 represents the projected emissions for Year 2006 considering already adopted measures. Point B2 includes the effect of new control measures included in this Plan. The isopleth labeled 123 ppb represents a design value equivalent to attainment of the national 1-hour standard. The corresponding VOC emissions level is approximately 439 tons/day, given projected NOx emissions.

San Francisco Climate Planning



San Francisco's Citywide Greenhouse Gas Emissions Inventory for 2010



Source	CO_2e (MT)
Cars & Trucks	2,116,126
Commercial Electricity*	861,559
Residential Natural Gas	777,114
Commercial Natural Gas	605,381
Residential Electricity*	358,033
Waste	244,625
Municipal Electricity*	216,548
Municipal Natural Gas	119,843
Rail (BART & Caltrain)	89,530
Ferry	34,103
MUNI	25,650
Total:	**5,448,513**

**preliminary*

5.4 million metric tons
(12% below 1990)

SF Environment
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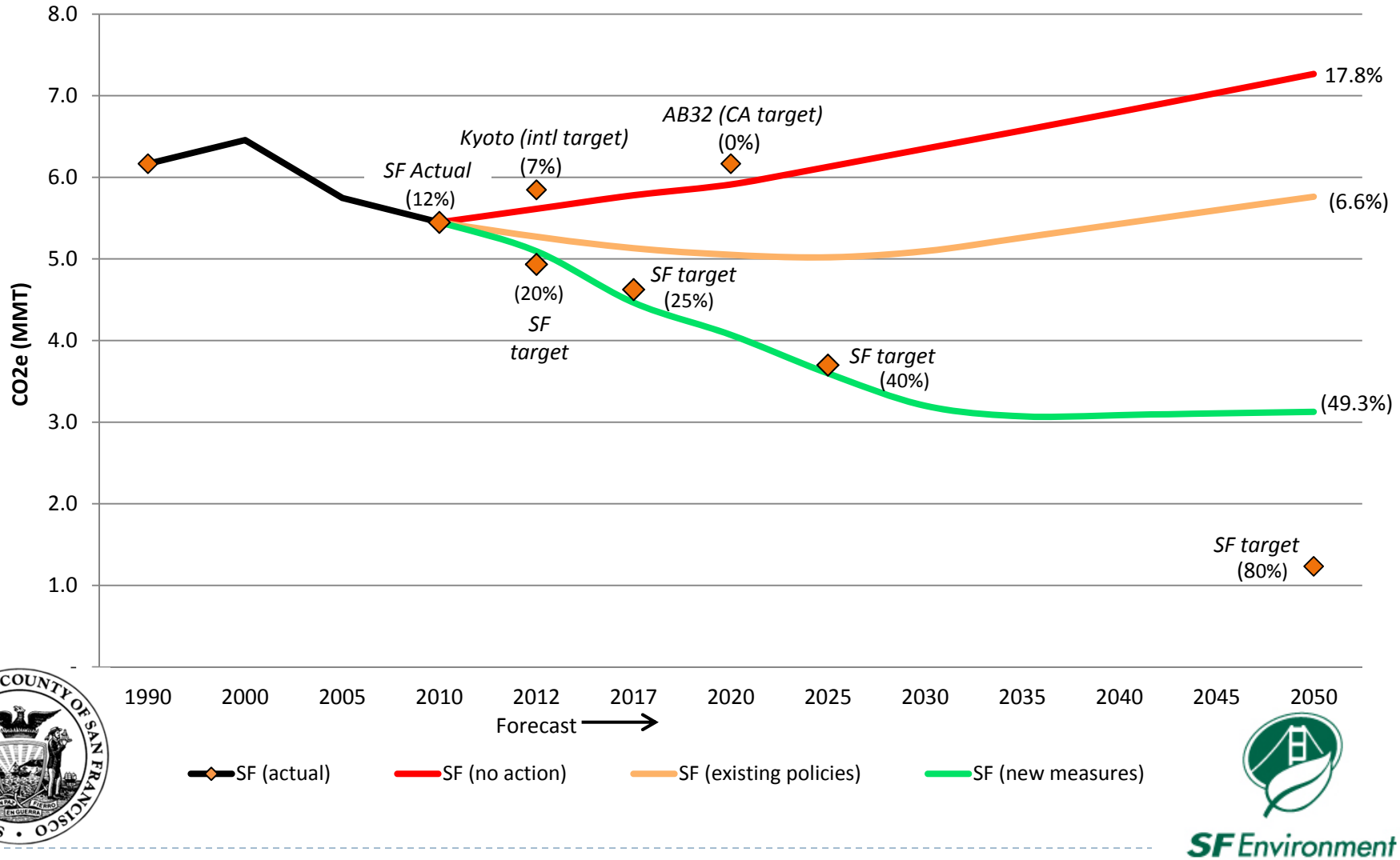
San Francisco's Climate Action Plan Progress and Targets



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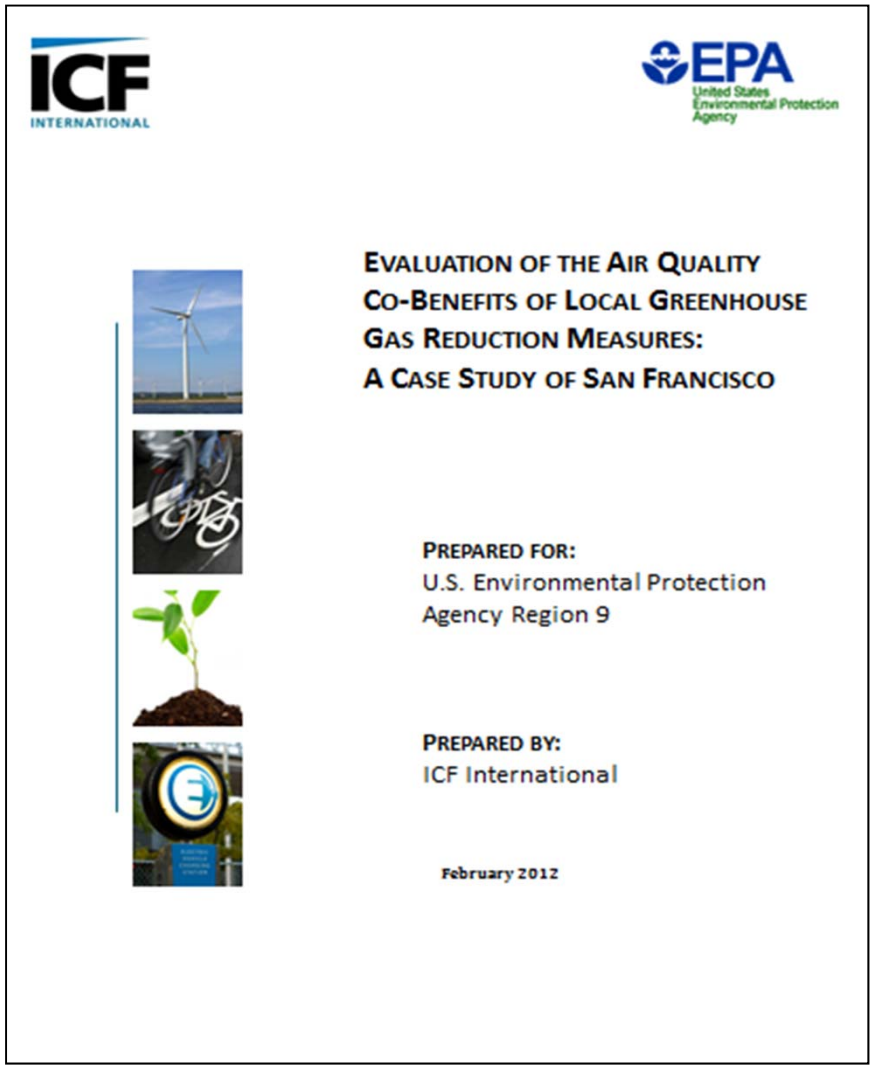
EPA Air Quality Co-Benefits Study



Study Overview

Step 1
- Identify **GHG reduction measures** to evaluate for air quality impacts

Step 2
- Quantify **criteria pollutant *direct/precursor* emission reductions** from selected GHG reduction measures

Step 3
- Determine **criteria pollutant (ozone and PM2.5) health benefits** and **GHG societal health benefits**

Step 4
- **Prioritize GHG measures** using results of previous steps and other relevant metrics

Select GHG Measures for Evaluation of Air Quality Impacts

- The City of San Francisco developed the San Francisco Climate Action Plan (SF CAP) in 2004.

- In May 2009, SPUR released a report entitled Critical Cooling: Analyzing San Francisco's Options to Reduce Greenhouse Gas Emissions that discusses the GHG reductions and cost-effectiveness of 42 options local policy options - generated from the original SF CAP and input provided at stakeholder meetings

- In 2011 at the time of this study, San Francisco was updating numerous climate change policies aimed at curbing GHG emissions.

Select GHG Measures for Evaluation of Air Quality Impacts

- Considered initial list of 42 SPUR climate mitigation measures
- Prioritized by quantitative and qualitative metrics (i.e., GHG reductions, criteria pollutant reduction potential, measure implementation feasibility, etc.)
- Solicited stakeholder input
- Finalized measure list for evaluation (updated SF CAP measures)

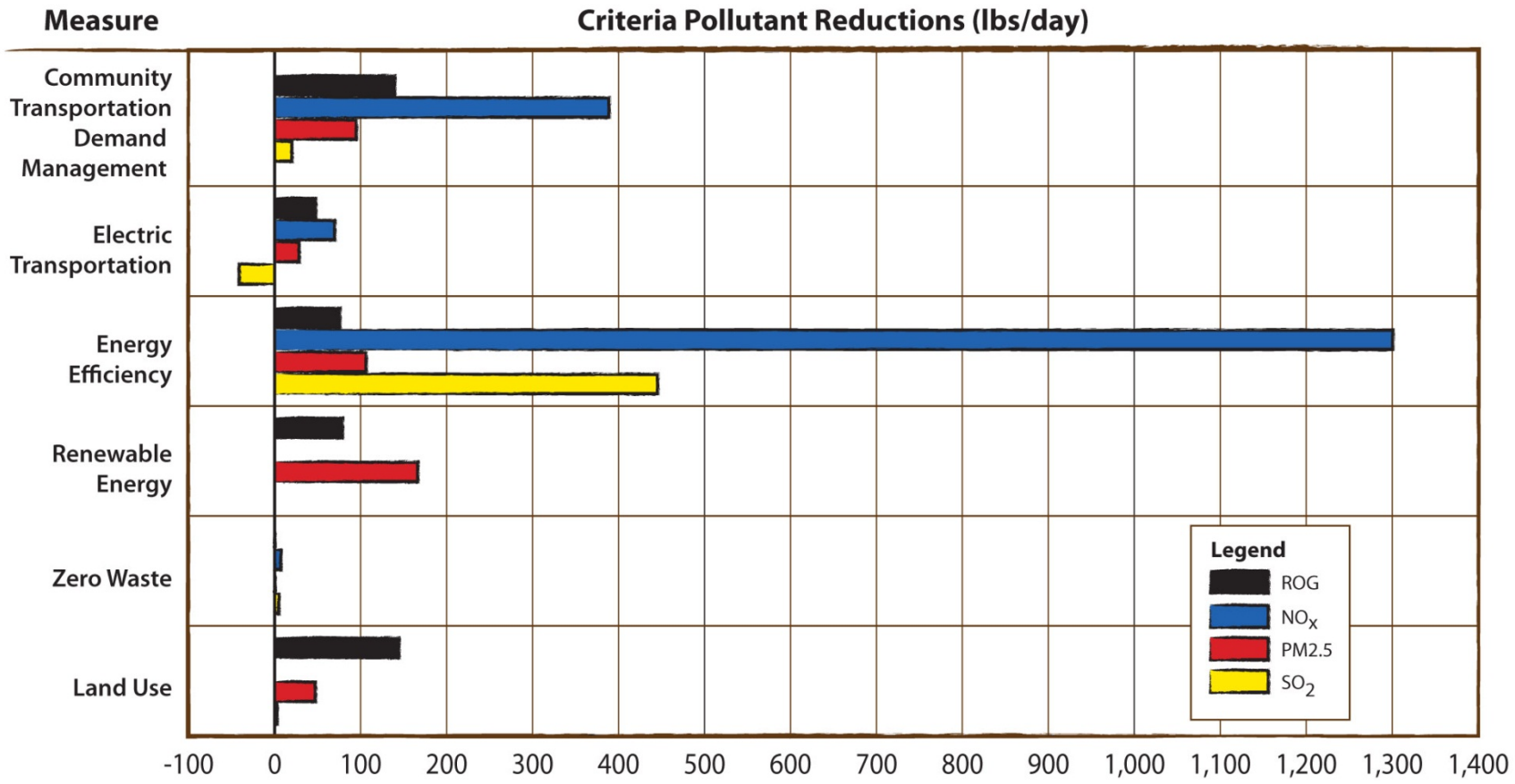
Select GHG Measures for Evaluation of Air Quality Impacts

- Transportation Demand Management:
  - Workplace Travel Demand Management
  - Community Travel Demand Management
  - Ridesharing
- Electric Vehicles:
  - Electric Vehicle Infrastructure: 10% electric vehicle market by 2015
- Renewable Energy:
  - Renewable Energy Goal: 100% renewable ele

Select GHG Measures for Evaluation of Air Quality Impacts (cont.)

- Energy Efficiency:
  - Residential Energy Conservation Ordinance (RECO) Update
  - Residential Loan Program
  - Commercial Loan Program
  - Energy Efficiency Legislation Support
  - Energy Efficiency Services (e.g., energy efficiency rebates and installation services)
- Waste:
  - Achieve Zero Waste by 2020
  - Digester Capture
- Land Use:
  - Land Use Measures: in accordance with the Bay Area's Sustainable Communities Strategy
  - Transit-oriented New Jobs
  - Tree Planting

Quantify Direct/Precursor Emission Reductions



Benefits of GHG and Criteria Pollutant Emission Reductions

For each measure, the health valuation from air quality changes and societal benefits from GHG reductions were quantified.

Health Valuation from Air Quality Changes:

- Done for PM2.5 and ozone
- Based on avoided illness, hospital visits, and mortality

Societal Benefits from GHG Reductions:

- $28/ton CO2e ("the cost to society of a ton of carbon emissions")
- Based on literature of studies that have been performed to estimate the cost or value of GHG emissions (BAAQMD's MPEM)

Modeling Tool: BAAQMD's Multi-pollutant Evaluation Method (MPEM)

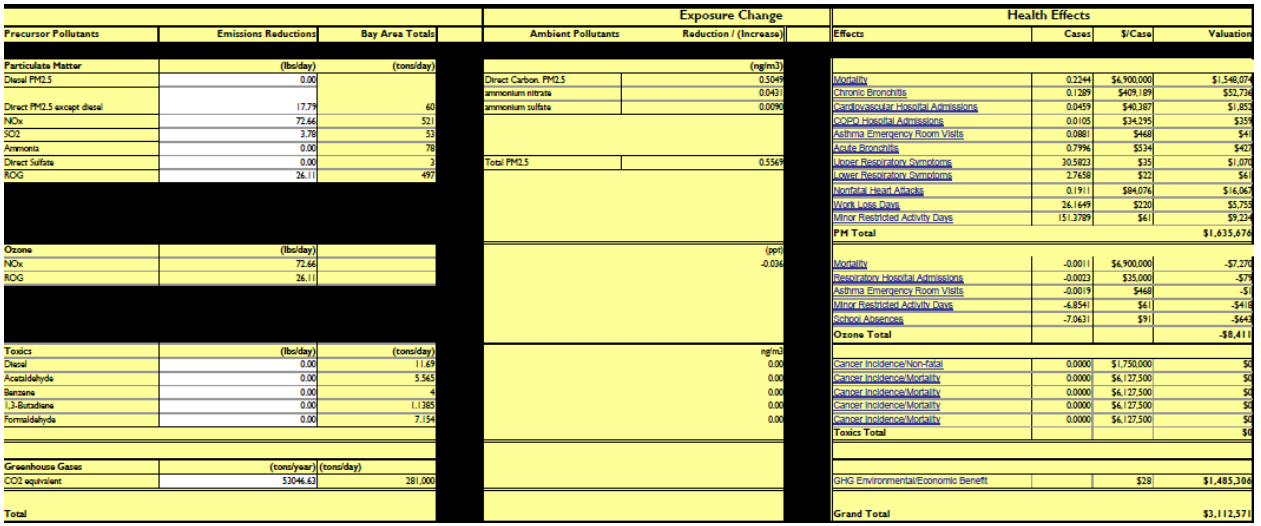
- Spreadsheet-based modeling tool to analyze emissions control measures
- Based on well-established studies and methods for quantifying health benefits from air quality measures

What does BAAQMD's MPEM do?

- **Estimates** how reductions of each *primary* pollutant affect **ambient concentrations of *secondary pollutants*, population exposures,** and **health outcomes** related to that pollutant;

- **Monetizes** the value of total health benefits for all pollutants that would be reduced by each potential control measure; and

- **Evaluates** and **compares** the estimated benefit of potential control measures based on the value of each measure in reducing **health costs** from air pollutants and **environmental/social impacts** related to climate change.

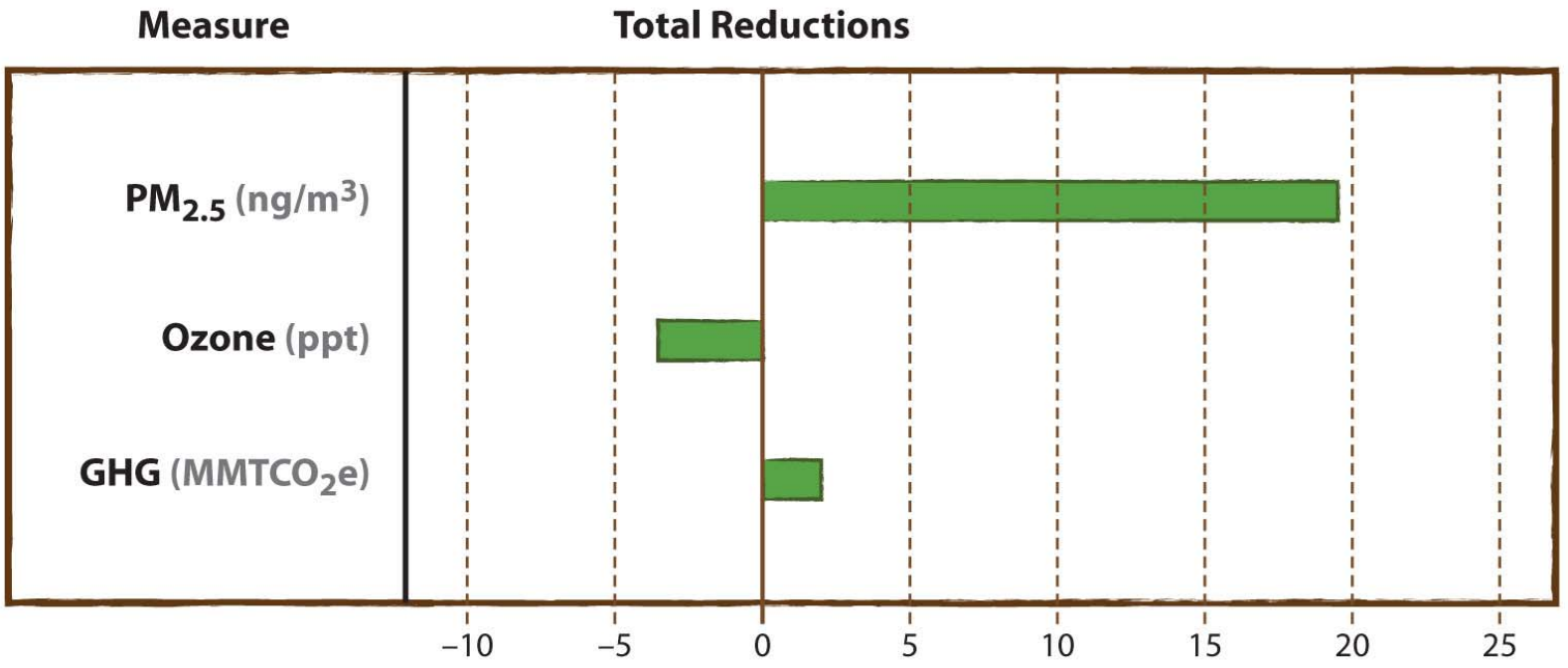


Precursor Pollutants	Emissions Reductions	Bay Area Totals
Particulate Matter	(lbs/day)	(tons/day)
Diesel PM2.5	0.00	
Direct PM2.5 except diesel	17.79	60
NOx	72.66	521
SO2	3.78	53
Ammonia	0.00	78
Direct Sulfate	0.00	2
ROG	26.11	497
Ozone	(lbs/day)	
NOx	72.66	
ROG	26.11	
Toxics	(lbs/day)	(tons/day)
Diesel	0.00	11.69
Acetaldehyde	0.00	5.565
Benzene	0.00	4
1,3-Butadiene	0.00	1.1385
Formaldehyde	0.00	7.154
Greenhouse Gases	(tons/year)	(tons/day)
CO2 equivalent	53046.63	281,000
Total		

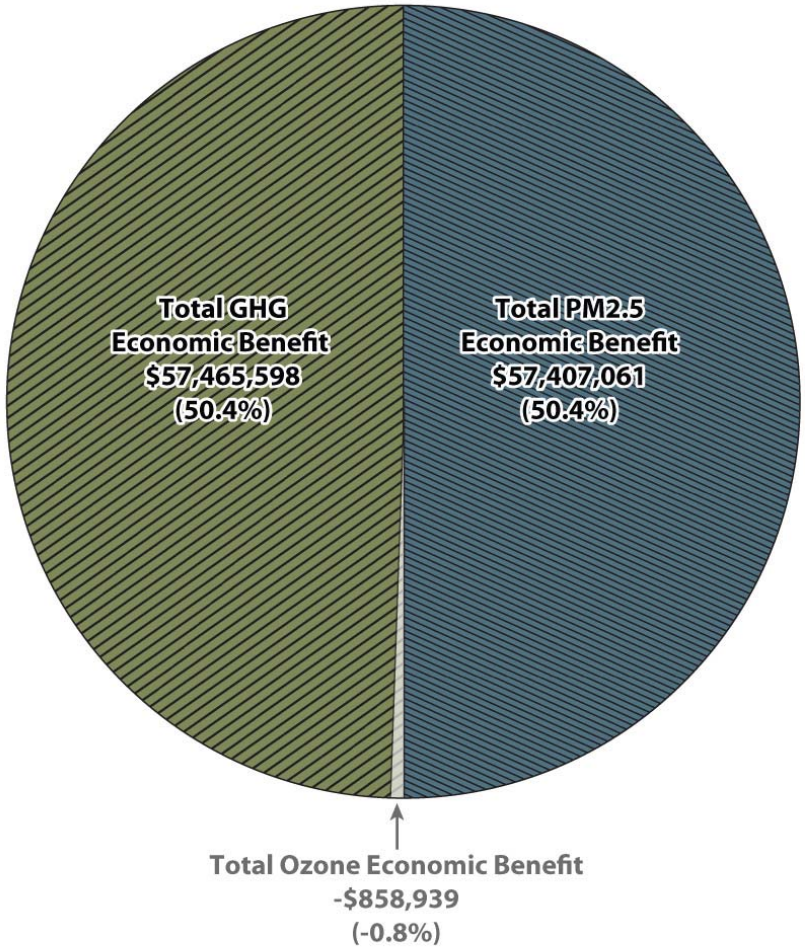
Exposure Change		
Ambient Pollutants	Reduction / (Increase)	
	(ng/m3)	
Direct Carbon. PM2.5	0.5049	
ammonium nitrate	0.0431	
ammonium sulfate	0.0090	
Total PM2.5	0.5569	
	(ppb)	
	-0.036	
	ng/m3	
	0.00	
	0.00	
	0.00	
	0.00	
	0.00	

Health Effects			
Effects	Cases	$/Case	Valuation
Mortality	0.2244	$6,900,000	$1,548,074
Chronic Bronchitis	0.1289	$409,189	$52,734
Cardiovascular Hospital Admissions	0.0459	$40,387	$1,853
COPD Hospital Admissions	0.0105	$34,295	$359
Asthma Emergency Room Visits	0.0081	$448	$4
Acute Bronchitis	0.7996	$534	$427
Lower Respiratory Symptoms	20.5822	$35	$1,070
Upper Respiratory Symptoms	2.7658	$22	$61
Nonfatal Heart Attacks	0.1911	$84,076	$16,067
Work Loss Days	26.1649	$220	$5,753
Minor Restricted Activity Days	151.3789	$61	$9,234
PM Total			$1,635,676
Mortality	-0.0011	$6,900,000	-$7,270
Respiratory Hospital Admissions	-0.0023	$35,000	-$79
Asthma Emergency Room Visits	-0.0019	$468	-$1
Minor Restricted Activity Days	-6.8541	$61	-$418
School Absences	-7.0631	$91	-$643
Ozone Total			-$8,411
Cancer Incidence/Non-fatal	0.0000	$1,750,000	$0
Cancer Incidence/Mortality	0.0000	$6,127,500	$0
Cancer Incidence/Mortality	0.0000	$6,127,500	$0
Cancer Incidence/Mortality	0.0000	$6,127,500	$0
Cancer Incidence/Mortality	0.0000	$6,127,500	$0
Toxics Total			$0
GHG Environmental/Economic Benefit		$28	$1,485,306
Grand Total			$3,112,571

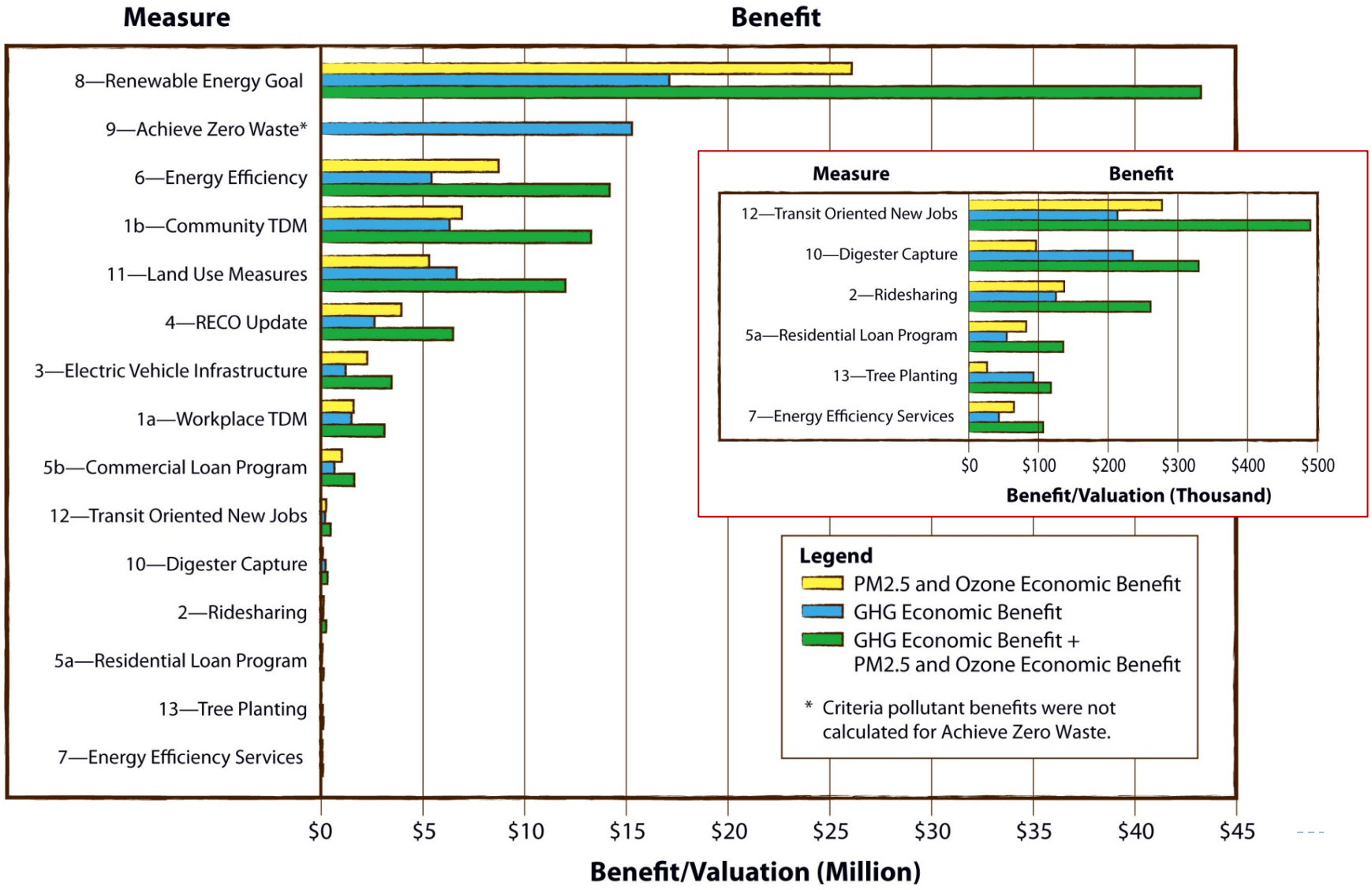
San Francisco Case Study Results



Criteria Pollutant Total Health Valuation by 2020: PM2.5, Ozone, and GHG

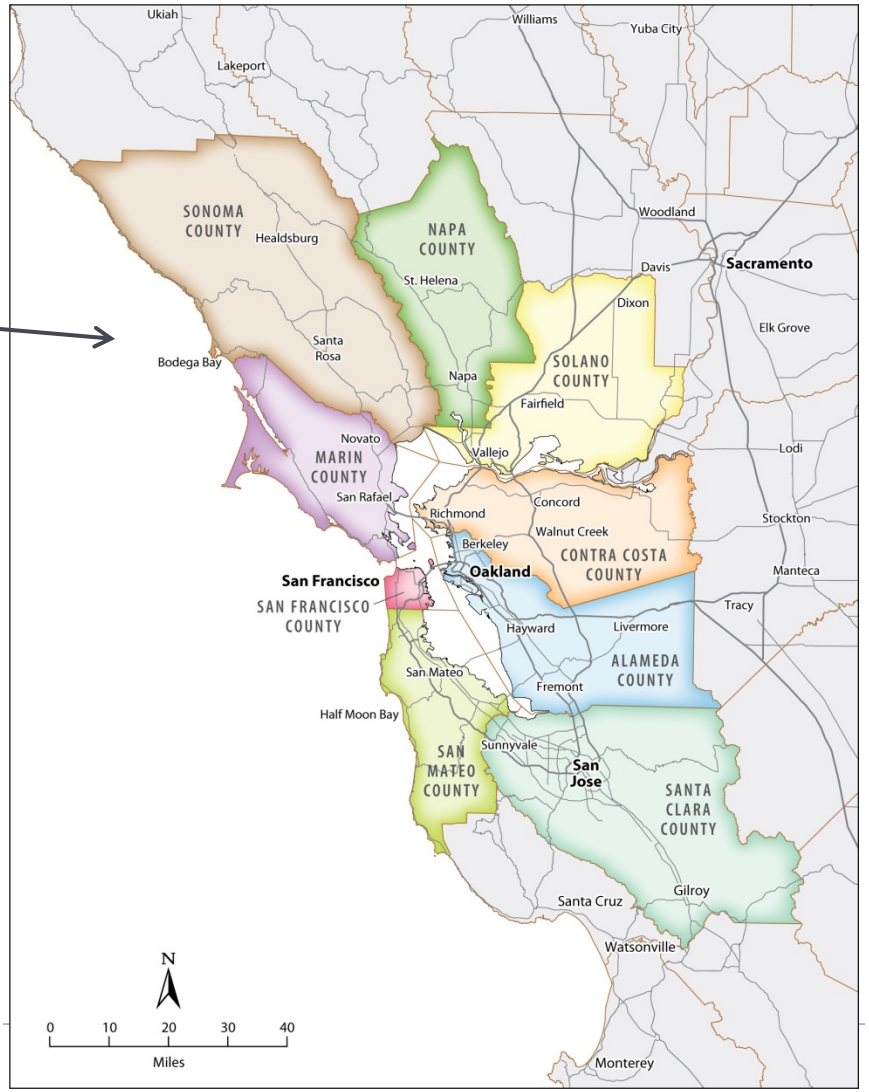


Health Valuation by SF Reduction Measure

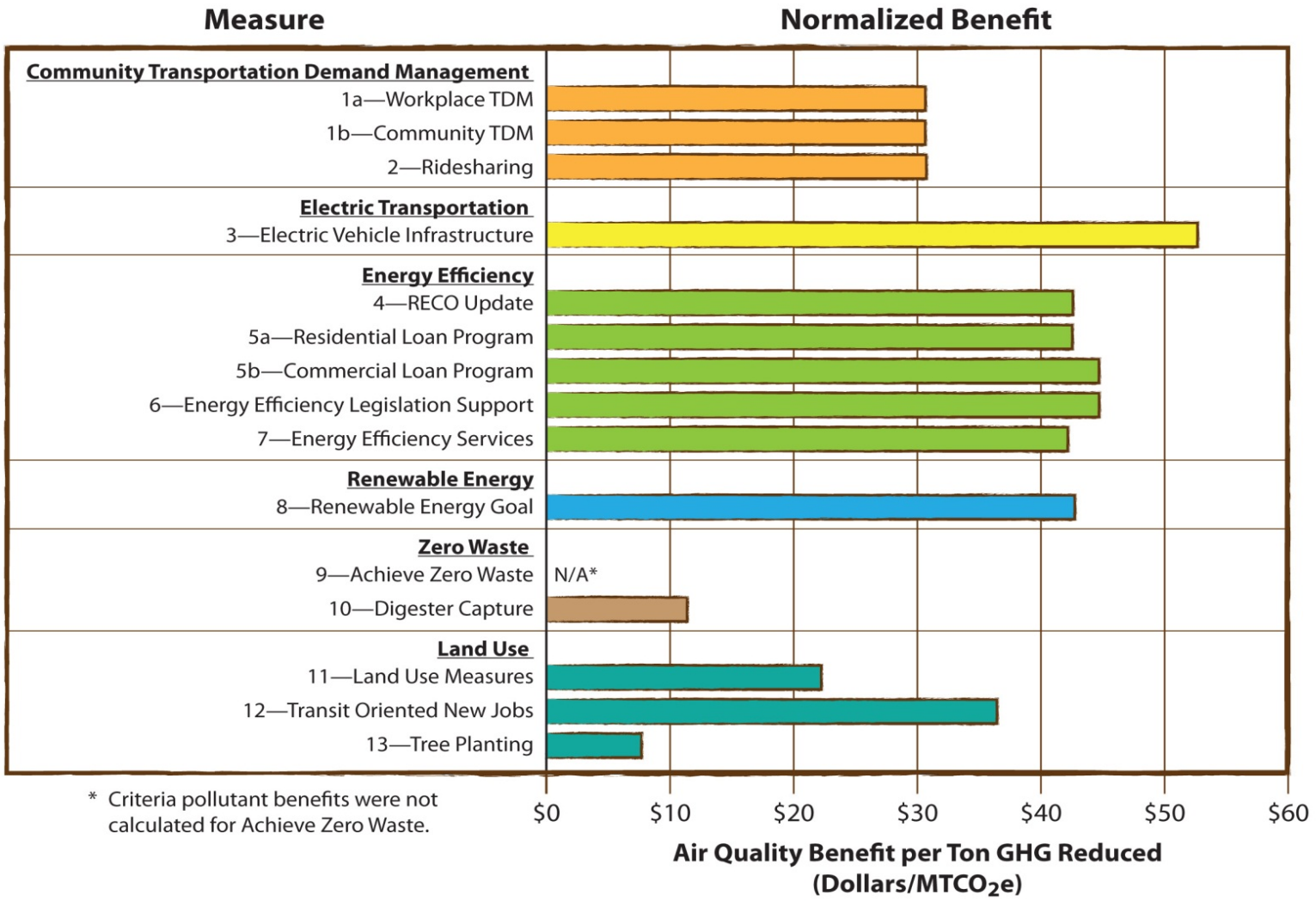


Criteria Pollutant and Societal Benefit Impact Location

Benefits based on avoided health impacts across entire Bay Area



Normalized Economic Benefit



Measure Rank by Normalized Benefit

Measure	Air Quality Benefit per Ton of GHG Reduced ($/MTCO$_2$e)
3—Electric Vehicle Infrastructure	$52.69
6—Energy Efficiency Legislation	$44.73
5b—Commercial Loan Program	$44.72
8—Renewable Energy Goal	$42.76
4—RECO Update	$42.61
5a—Residential Loan Program	$42.56
7—Energy Efficiency Services	$42.20
12—Transit Oriented New Jobs	$36.47
2—Ridesharing	$30.76
1a—Workplace TDM	$30.68
1b—Community TDM	$30.67
11—Land Use Measures	$22.26
10—Digester Capture	$11.41
13—Tree Planting	$7.71
9—Achieve Zero Waste	–

Criteria for "Other Benefits"

- Implementation feasibility
  - Ease of putting a measure into effect
- Geographic location of criteria pollutant emission reductions
  - Will emission reductions occur *inside* or *outside* the Bay Area?
- Timing of implementation or reductions
  - Shorter timeframes to achieve emission reductions
- Equity impact
  - Socioeconomic or environmental improvement for vulnerable populations
- Aesthetic impact
  - Measure results in a more beautiful environment
- Replicability
  - Measure can be implemented in other locales
- Climate adaptation
  - Supports strategies that reduce the vulnerability of natural and human systems to climate change

Considerations for Prioritizing Measures

- Rank measures by normalized air quality health benefit
- Establish qualitative criteria for "other benefits" and apply to SF GHG reduction measures
- Rank measures by the "other benefits"
- Estimate cost/savings to implement each measure
- Assess measure priority (for implementation or other purposes)

San Francisco Case Study Conclusions

- The overall SF CAP measure valuation is large (>$114m)
- The positive health valuation outcomes for PM2.5 and GHG *greatly* outweigh the smaller negative ozone effect
- MPEM provides improved decision-support for local policy-makers
- Measures that are effective at producing air quality benefits (per ton of GHG reduced) should also be evaluated for other benefits, including cost of implementation
- The steps in this study can be applied to other jurisdictions

Recommendations for Further Study

- **Include** capital and implementation costs/savings
- **Address** air toxics and other criteria pollutants
- **Consider** the sensitivity of the societal cost of carbon
- **Quantify** other, non-air quality benefits

For More Information

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Q & A / Discussion