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AGENDA: 4

Building Appliance Rules: Benefits to Outdoor Air Quality and Health

**Advisory Council Meeting
February 14, 2022**

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Overview



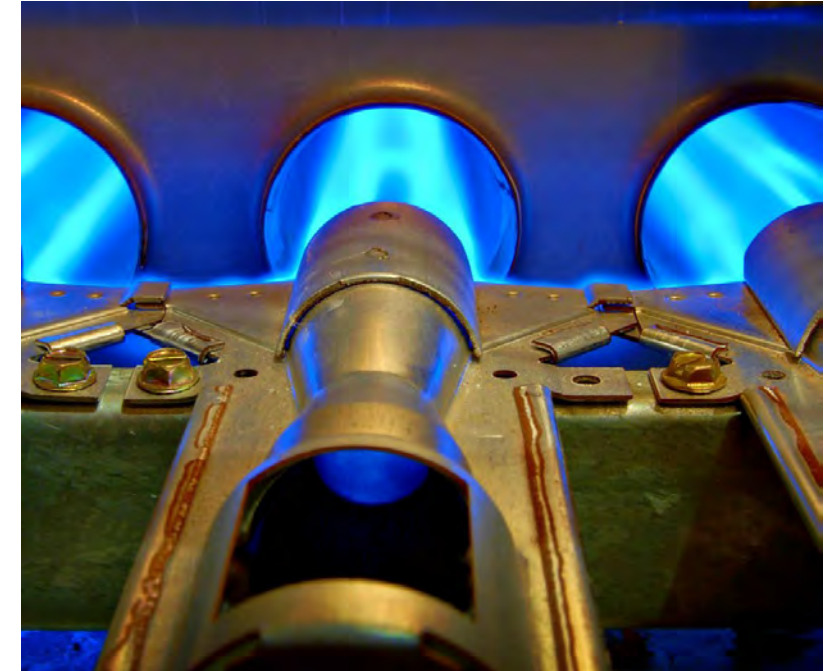
- Study Purpose
- Background
 - Scope and Prior Studies
- Methods
 - Inputs and Modeling Approach
- Findings
 - Ambient Concentrations, Health Impacts, and Valuations
- Next Steps

- Advisory Council guidance will help improve this study.
- Guidance is also broadly valuable because this study is a prototype for future assessments.

Study Purpose



- **Provide supplemental information** for proposed amendments to Air District rules to limit emissions of oxides of nitrogen (NO_x) from building appliances:
 - **Rule 9-4 for residential and commercial natural gas-fired furnaces***
 - **Rule 9-6 for residential and commercial water heaters and boilers****



Rule 9-4 would limit NO_x from natural gas-fired furnaces. Image: energy.gov

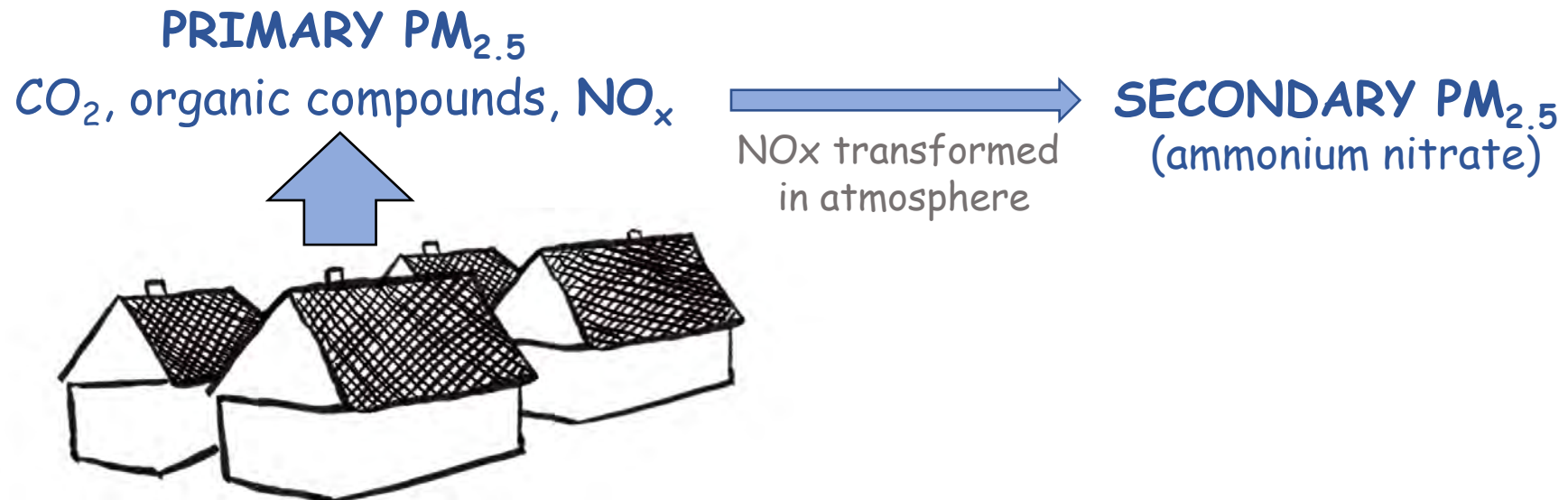
* Rule 9-4: Equipment with max. heat input rating under 175,000 BTU/hr

** Rule 9-6: Equipment with max. heat input rating under 2 million BTU/hr

Scope: What's Included



- Outdoor air quality and health impacts from
 - Sources covered by proposed amendments to building appliance rules
 - Residential exposures to outdoor fine particulate matter (PM_{2.5})
 - **Secondary PM_{2.5}** (particles formed via reaction of gaseous NO_x in the atmosphere)
 - **Total PM_{2.5}** = primary PM_{2.5} + secondary PM_{2.5}



This Study: Bay Area



Geography	<ul style="list-style-type: none">• Bay Area
Scope	<ul style="list-style-type: none">• Natural gas-fired space and water heating*• Residential exposure to outdoor PM_{2.5} (primary + secondary)• Equity assessment (In preparation)
Method – Emissions – Concentrations – Health benefits	<ul style="list-style-type: none">• Bay Area Air Quality Management District (BAAQMD; 2018)• Full chemistry model• US EPA’s Benefits Mapping and Analysis Program (BenMAP)
Key finding	<ul style="list-style-type: none">• Eliminating combustion emissions from space and water heating building appliances would avoid 39–89 deaths annually
References	<ul style="list-style-type: none">• Tanrikulu, <i>et al.</i>, 2021, BAAQMD (In draft)• Holstius, <i>et al.</i>, 2021, BAAQMD (In preparation)

*Excluding large sources requiring an Air District permit.

Prior Study: U.S.



Geography	<ul style="list-style-type: none">• U.S.
Scope	<ul style="list-style-type: none">• All building appliances: gas, oil, and other fuels^{*,**}• Residential exposure to outdoor PM_{2.5} (primary + secondary)• Equity assessment
Method – Emissions – Concentrations – Health benefits	<ul style="list-style-type: none">• National Emissions Inventory (NEI; 2017)• Reduced chemistry models• Consistent with BenMAP[†]
Key finding	<ul style="list-style-type: none">• Eliminating combustion emissions from building appliances would avoid 5,400 deaths annually
References	<ul style="list-style-type: none">• Dennison, <i>et al.</i>, 2021, RMI https://rmi.org/insight/outdoor-air-quality-brief/• Buonocore, <i>et al.</i>, 2021, <i>Environ. Res. Lett.</i> https://iopscience.iop.org/article/10.1088/1748-9326/abe74c• Tessum, <i>et al.</i>, 2021, <i>Sci. Adv.</i> https://www.science.org/doi/10.1126/sciadv.abf4491

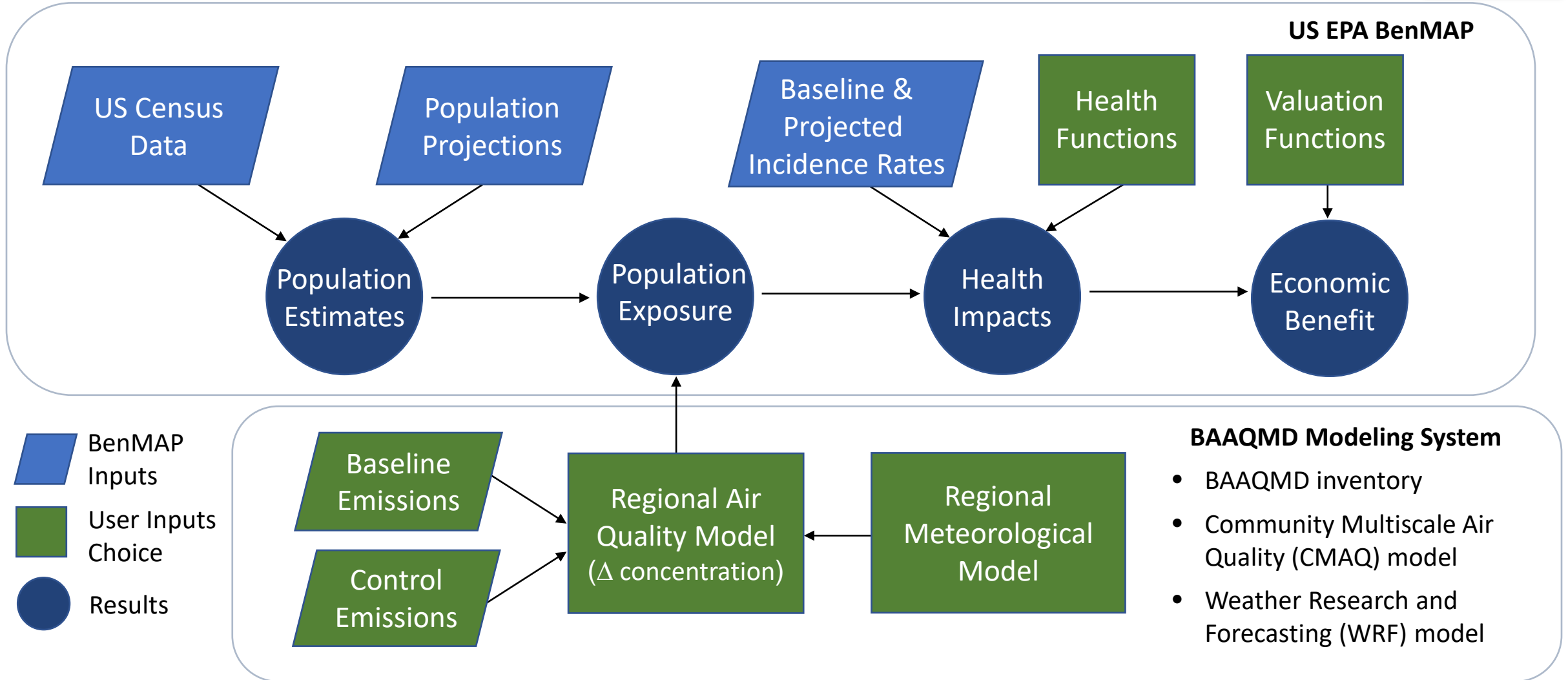
*Excluding coal & wood/biomass. **Space heaters with capacity less than 10 million Btu/hr.

†InMAP model applied in California using BenMAP health impact functions.

Prior Study: California

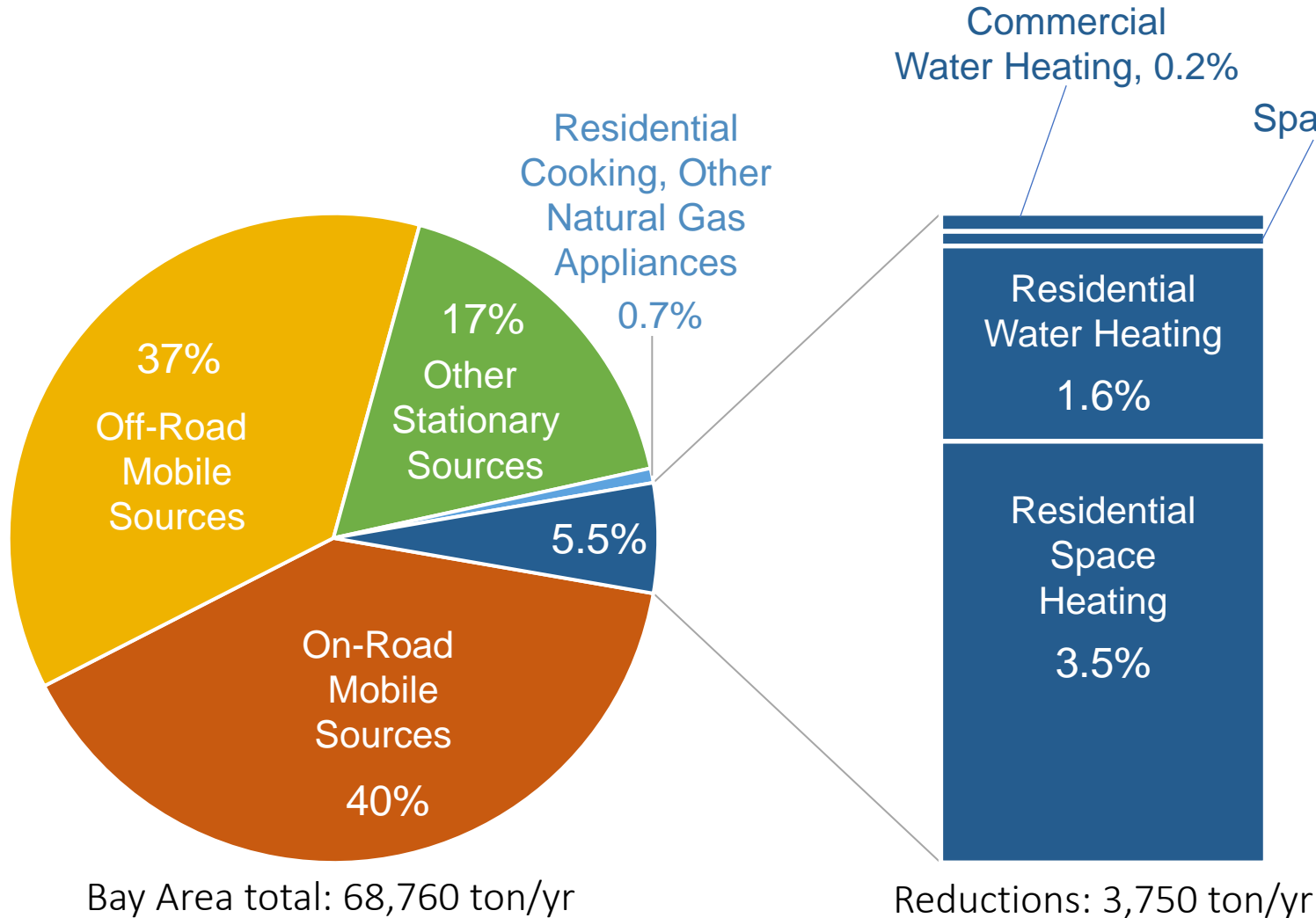
Geography	<ul style="list-style-type: none">• California
Scope	<ul style="list-style-type: none">• All natural gas building appliances• Residential exposure to outdoor PM_{2.5} (primary + secondary)• Discussion of indoor air quality impacts from cooking
Method – Emissions – Concentrations – Health benefits	<ul style="list-style-type: none">• California Air Resources Board (CARB; 2018); county totals• Emissions ratio• BenMAP
Key finding	<ul style="list-style-type: none">• Eliminating combustion emissions from building appliances would avoid 354 deaths annually
References	<ul style="list-style-type: none">• Zhu, <i>et al.</i>, 2020, UCLA https://ucla.app.box.com/s/xyzt8jc1ixnetiv0269qe704wu0ihif7

Methods Overview



Model Inputs

NOx Emissions



Baseline (Pie Chart)

- Emissions, 2018
- Of nitrogen oxides (NO_x)
- From all inventoried sources in Bay Area

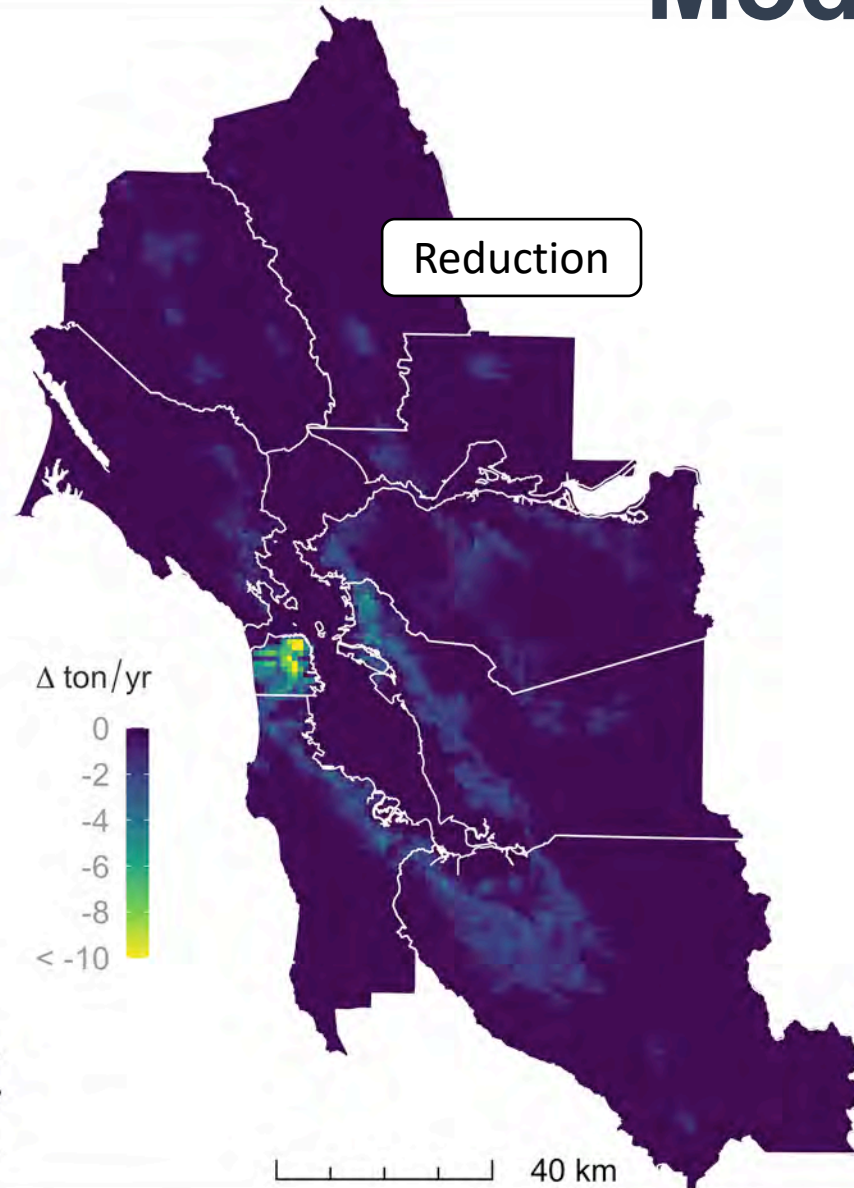
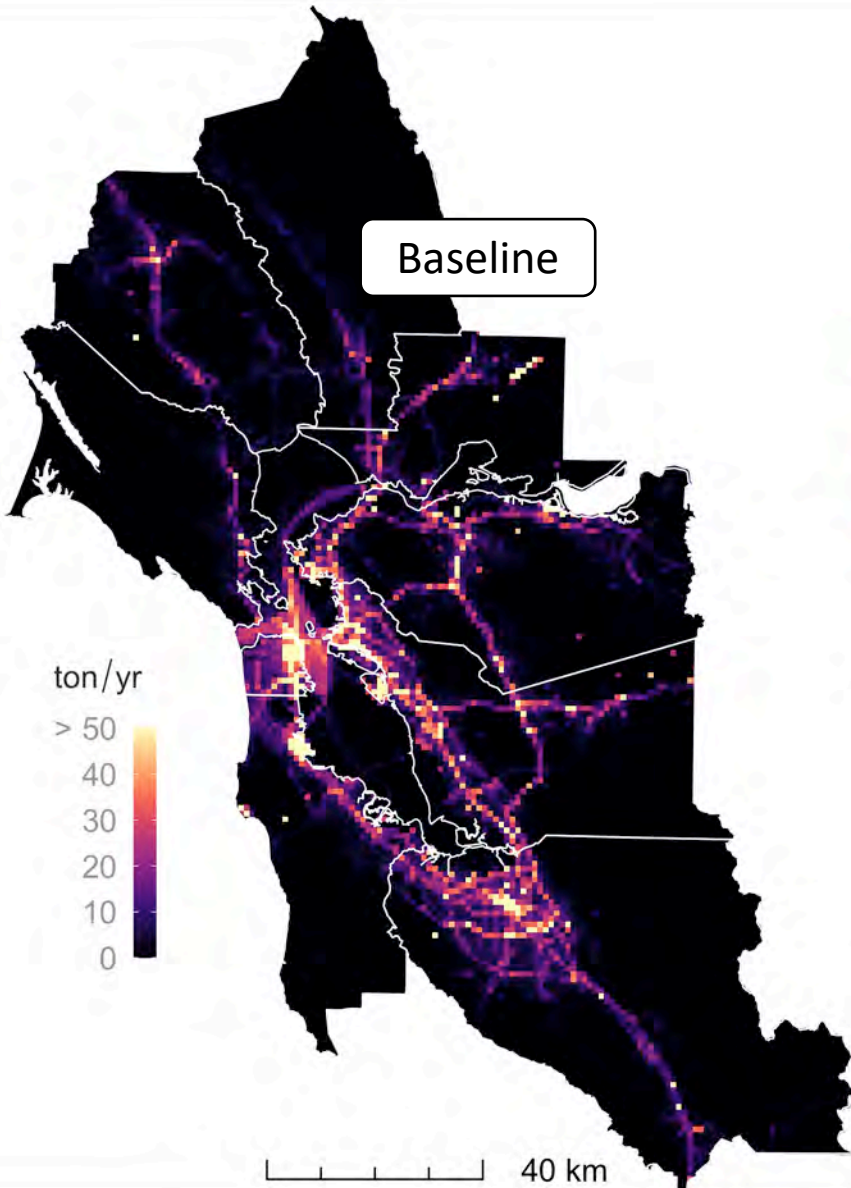
Reductions (Bar Chart)

- From elimination of NO_x emissions from Bay Area NG-fueled commercial & residential space/water heating*
- ~6% of total NO_x eliminated

* Excluding permitted sources.

Model Inputs

NO_x Emissions



Baseline (Left Map)

- Gridded 1-km *emissions*, 2018
- Of nitrogen oxides (NO_x)
- From all inventoried sources in Bay Area*

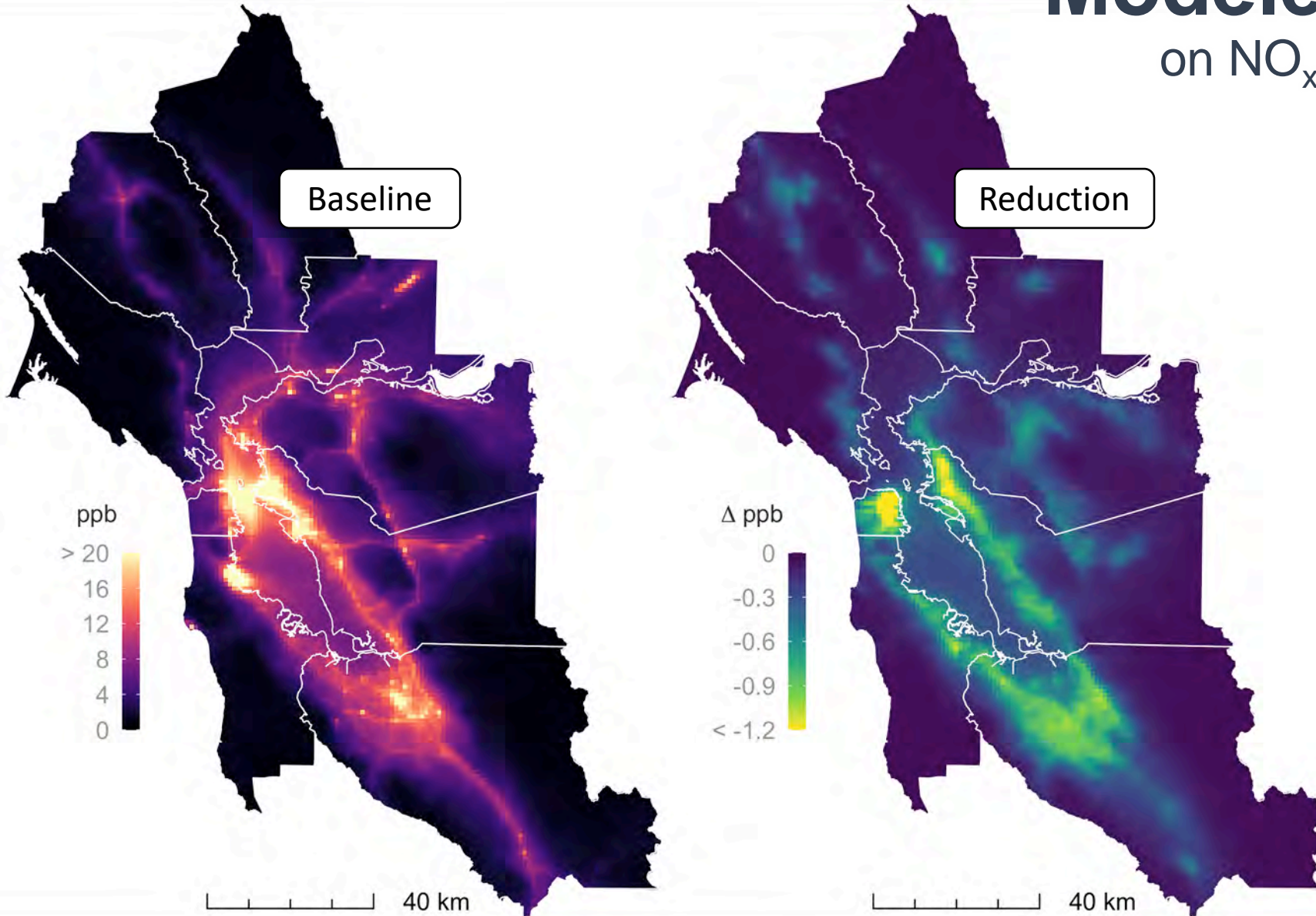
Reductions (Right Map)

- From elimination of NO_x emissions from Bay Area NG-fueled commercial & residential space/water heating**

* Not just NG appliances. Includes mobile, stationary, and area sources.

** Excluding permitted sources.

Modeled Impact on NO_x Concentrations



Baseline (Left Map)

- Annual average outdoor concentrations, 2018
- Of nitrogen oxides (NO_x)
- Attributed to all sources in modeling domain*

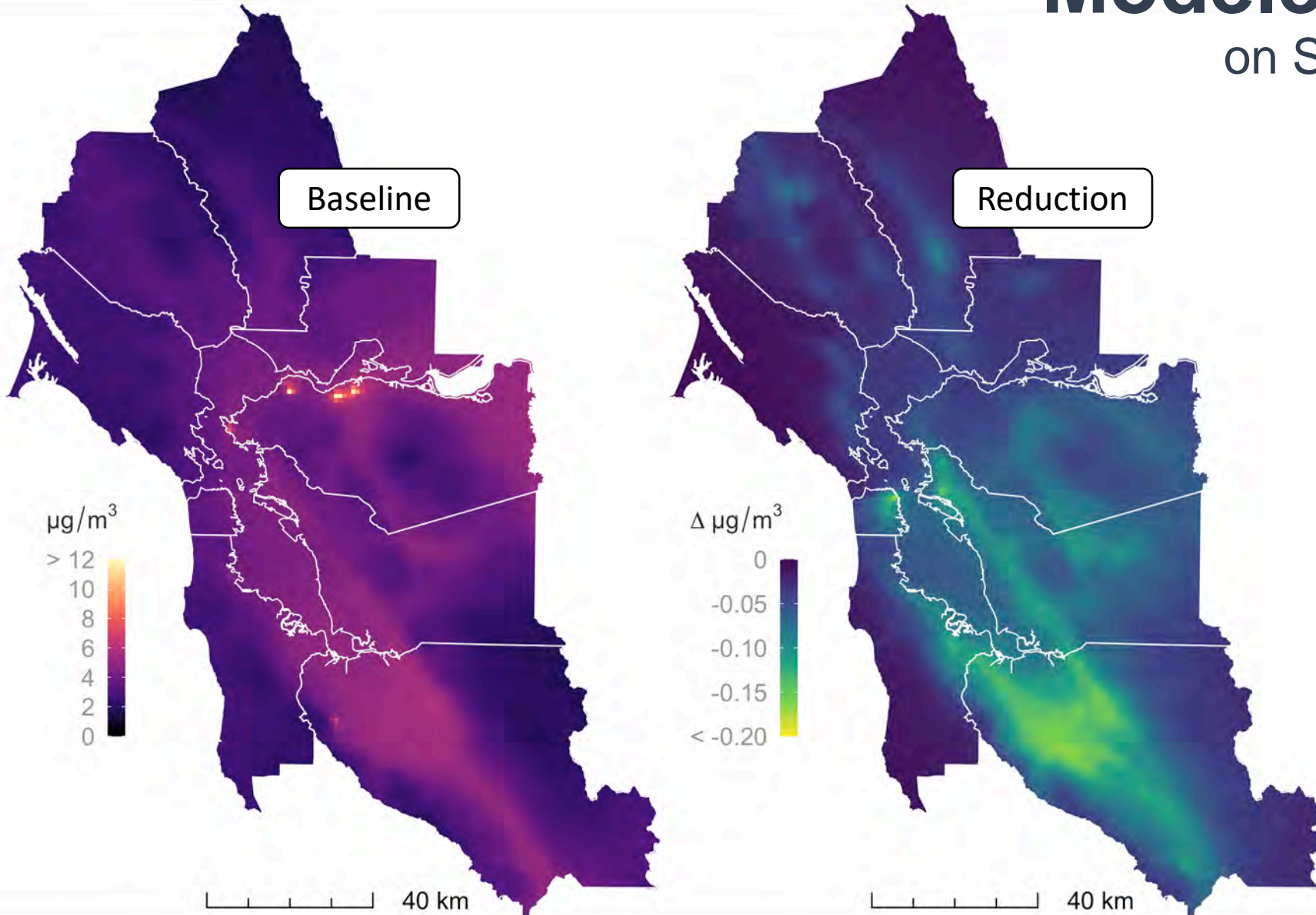
Reductions (Right Map)

- From elimination of NO_x emissions from Bay Area NG-fueled commercial & residential space/water heating**

* Not just NG appliances. Includes some sources outside SF air basin.

** Excluding permitted sources.

Modeled Impact on Secondary PM_{2.5}



Baseline (Left Map)

- Annual average outdoor concentrations, 2018
- Of secondary PM_{2.5}
- Attributed to all sources in modeling domain*

Reductions (Right Map)

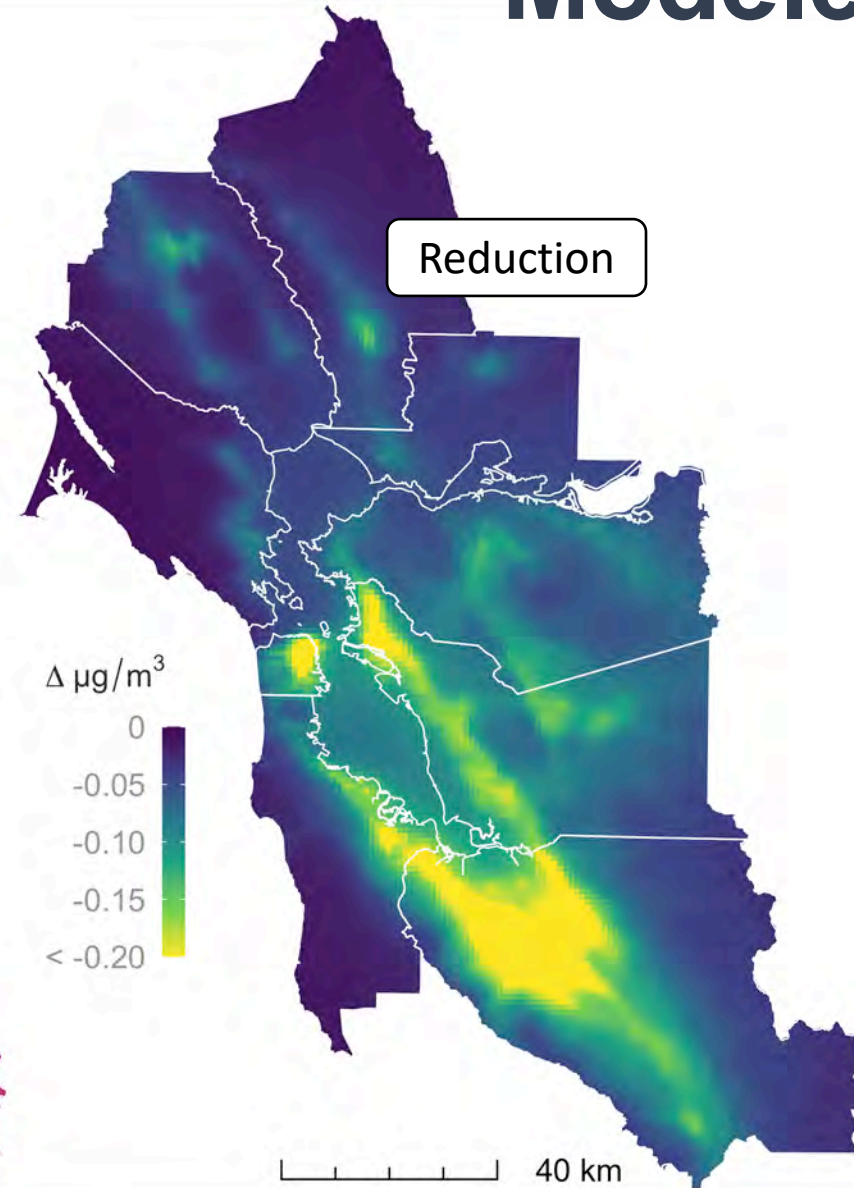
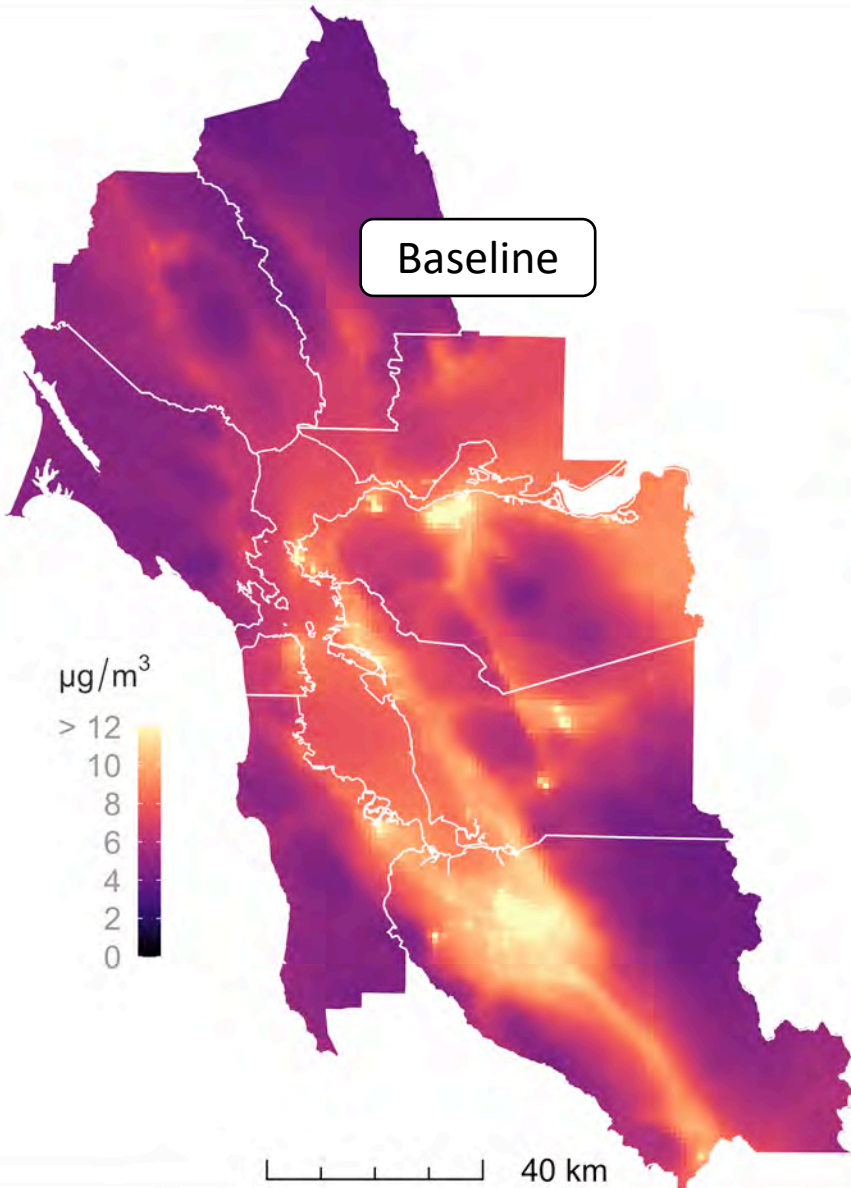
- From elimination of NO_x emissions from Bay Area NG-fueled commercial & residential space/water heating**

* Not just NG appliances. Includes some sources outside SF air basin.

** Excluding permitted sources.

Modeled Impact

on Total PM_{2.5}



Baseline (Left Map)

- Annual average outdoor concentrations, 2018
- Of total (secondary and primary) PM_{2.5}
- Attributed to all sources in modeling domain*

Reductions (Right Map)

- From elimination of NO_x and primary PM_{2.5} emissions from Bay Area NG-fueled commercial & residential space/water heating**

* Not just NG appliances. Includes some sources outside SF air basin.

** Excluding permitted sources.

Estimated Health Impacts and Valuations



Health Endpoints	Annual Health Impacts (Incidence Avoided)		Annual Valuations (Million US\$, 2020)	
	Secondary PM _{2.5}	Total PM _{2.5}	Secondary PM _{2.5}	Total PM _{2.5}
Premature mortality	25–56	39–89	260–570	400–910
Non-fatal heart attack	2.8–26	4.4–41	0.25–2.3	0.39–3.6
Hospital admission, neurological	8.3	13	0.12	0.19
Out of hospital cardiac arrest	0.48	0.76	0.020	0.032
Stroke	1.6	2.5	0.063	0.1
Lung cancer	2.1	3.2	0.060	0.096
Hospital admission, respiratory	2.6	4.1	0.030	0.047
Hospital admission, cardiovascular	3.2	5.2	0.059	0.095
ER visit, respiratory	13	21	0.014	0.022
ER visits, cardiovascular	6.7	11	0.009	0.014
Restricted activity days	26,000	41,000	1.9	3.3
Work loss days	4,400	7,000	1.2	1.9
Hay fever/allergic rhinitis	480	750	0.33	0.52
Asthma symptoms/albuterol use	9,900	15,000	0.004	0.0062
Asthma onset	77	120	3.9	6.1
			270–580	410–930

Summary



- Potential premature deaths avoided: 39–89 deaths/yr
- Potential total benefit valuation: \$410–930 million/yr
- About 60% of benefits accrue from secondary PM_{2.5} reductions
- Annual deaths normalized by population (deaths/M people) are consistent with prior studies (within a factor of 2-3)
 - High range of estimates is most consistent with prior work
- Study strengths:
 - Detailed, gridded Bay Area emissions estimates
 - Full chemistry model for concentration estimates

Next Steps



- Include an equity assessment
 - Disaggregate modeled exposures by race/ethnicity
- Incorporate Advisory Council feedback on
 - Methods and findings presented
 - Equity assessment methods
 - What equity assessments have you found useful?
 - What would improve them?
 - Consider a joint meeting with Community Advisory Council to discuss equity assessment methods?
- Complete draft documentation



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Regulatory Toolbox and PM Health Impacts Methodology

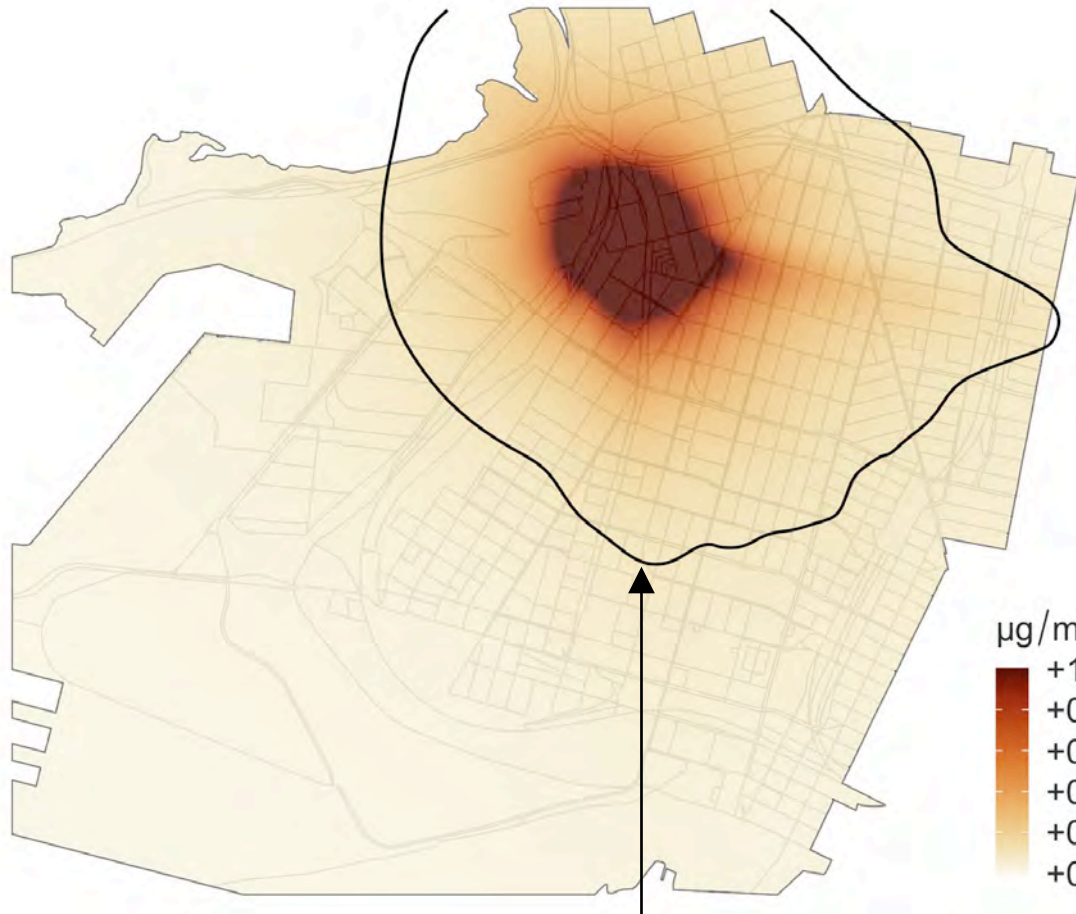
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**Greg Nudd
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PM_{2.5} and Health Risk



Developing method to assess local health impacts: But how will it be used?



I	Exposure increment	0.1 µg/m ³ PM _{2.5}
	Effect size	ln(1.07)
	<i>Excess risk (multiplicative)</i>	0.07%
		↓
II	Relative risk	1.0007
	Baseline	9×10 ⁻³ death/yr
	<i>Excess risk (additive)</i>	6×10 ⁻⁶ death/yr

Tools for Regulating Stationary Sources



- Air District has a complimentary suite of tools to regulate stationary sources:
 - New Source Review Permitting
 - Regulations for Existing Sources
 - Point-of-Sale Rules

New Source Review Permitting



- Applies to new and modified sources
 - Significant modifications trigger a new source review
 - Smaller sources may be exempt
- Sets a regional cap on PM_{2.5} and precursors to PM_{2.5} and ozone formation
- Any new source must be offset with in the region at a 1:1 ratio or greater
- Requires Best Available Control Technology for pollutants
- Sets maximum health risk impacts for new/modified facility
 - Uses OEHHA methodology for estimating increases in acute and chronic risk for listed toxic air contaminants
 - ***No analogous method for undifferentiated PM***

Regulations for Existing Sources



- Require feasible emission reductions at existing sources, usually requires retrofits
- Can set emission limits or health impact limits

Point-of-Sale Rules



- Set emissions performance limits for products sold and used in the Air District's jurisdiction
- Examples include volatile organic compound limits on architectural coatings, nitrogen oxides limits on residential space and water heaters

Criteria for using Regulatory “Tools”



- Must be a “stationary” source; mobile sources are under the jurisdiction of the California Air Resources Board and/or U.S. Environmental Protection Agency (EPA)
- There must be technically feasible mechanisms for reducing emissions
- The source or source category must be “necessary” to control

Regulatory Criteria: Examples



Source Category	Stationary ?	Feasible Controls?	Significant ?
Residential Wood Combustion	YES	YES	YES
Refineries	YES	YES	YES
Road dust	NO	Unclear	YES
Brake and tire wear	NO	Unclear	YES
Restaurants	YES	Unclear	YES
Off-road equipment	NO	Varies	Varies

Considerations for New or Strengthened Rules



- What are the baseline emissions?
- What are the expected reductions in emissions?
- How much will it cost to implement the rule?
- What's the cost effectiveness of the rule?
- What are the economic implications for the regulated facilities?
- What are the non-air quality environmental impacts of the rule?
- Is the rule necessary to protect public health and the environment?
- Optional: What are the health and equity impacts of the rule?

PM_{2.5} Local Risk Methodology



A PM_{2.5} local risk methodology is needed to fill key gaps in the regulatory toolbox

- New Source Review Permitting:
 - **Exemptions:** Permitting regulations currently exempt sources that emit less than 10 lb/day or 150 lb/yr. Blanket exemptions for sources such as restaurants
 - **Maximum Risk Limit:** Permitting regulations limit maximum health risks for new and modified facilities and is set lower for facilities in overburdened communities. *No analogous limits for health risk from undifferentiated PM_{2.5} emissions.*

PM_{2.5} Local Risk Methodology (cont.)



A PM_{2.5} local risk methodology is needed to fill key gaps in the regulatory toolbox

- Regulations for Existing Sources:
 - **Prioritizing rulemaking by PM_{2.5} health risk**
 - **Estimating the health benefits of prospective rules**

Initial Key Questions about the PM_{2.5} Local Risk Methodology



- Focus on mortality or include other health endpoints, like asthma and heart disease?
- How do we handle baseline incidence rates?
 - Should the evaluation focus on increases in relative risk or risk difference?
 - At what scale are the baseline mortality rates suitably reliable?



Questions/Discussion



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AGENDA: 6

2022 Advisory Council Work Plan Review

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Work Plan Components



- Particulate Matter (PM) Health Impacts Methodology
- Region-wide Combustion Strategy (including wood smoke)
- Joint work with the Community Advisory Council
 - Air pollution and health disparities
 - Metrics to track progress in improving air quality in overburdened communities
 - Other topics?

2022 Advisory Council Work Plan



- April
 - Appliance Rules Equity Assessment
 - Regulatory Toolbox and Combustion Strategy
 - Considerations of key Questions for PM Health Impacts Methodology
 - Possible coordination with the Community Advisory Council
- June
 - Fugitive Emissions from Refineries
 - Combustion Sources and PM Exposures
 - PM Health Impacts Methodology
- August-December
 - Development of a regional Combustion Strategy Report/Recommendations
 - PM Health Impacts Methodology



Discussion