LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #15

Virtual Meeting #1

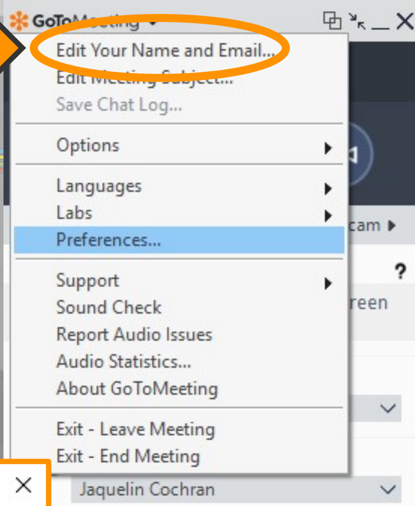
Los Angeles Department of Water & Power

NREL Transforming ENERGY

LA100

The Los Angeles 100% Renewable Energy Study

Welcome to the LA100 Advisory Group meeting!
Please consider adding your affiliation to your name identification.



Advisory Group Meeting #15

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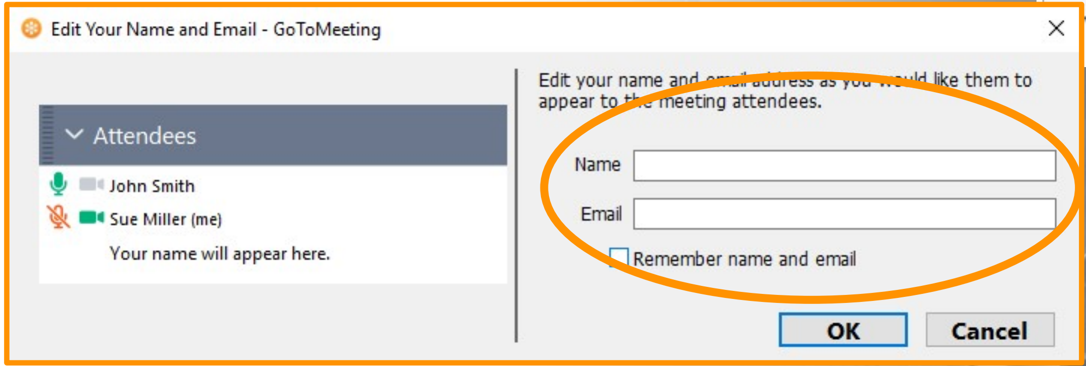


Los Angeles Department of Water & Power

NREL Transforming ENERGY

Advisory Group #15 Agenda

Today (March 3)

- Welcome
- Final Air Quality Results
- Final Public Health Results
- Discussion/Q&A

March 4

- Environmental Justice
- Discussion/Q&A

March 11

- Economic Impact Analysis
- Workforce Analysis
- Discussion/Q&A

March 18

- LA100 Results: Costs and Benefits
- Summary of Key Findings
- Discussion/Q&A

Tips for Productive Discussions

Let one person speak at a time

Keep phone/computer on mute until ready to speak

Help ensure everyone gets equal time to give input

Type "Hand" in Chat Function to raise hand

Keep input concise so others have time to participate

Also make use of Chat function

Actively listen to others, seek to understand perspectives

Offer ideas to address questions and concerns raised by others

Hold questions until after presentations

LA100

The Los Angeles 100% Renewable Energy Study

Impact of Selected LA100 Scenarios on Air Quality in Los Angeles

Presenter: Prof. George Ban-Weiss (USC)

Collaborators: Yun Li (USC)

Dr. Jiachen Zhang (USC)

Dr. Vikram Ravi (NREL)

Dr. Garvin Heath (NREL)

Los Angeles Department of Water & Power | NREL Transforming ENERGY | USC University of Southern California

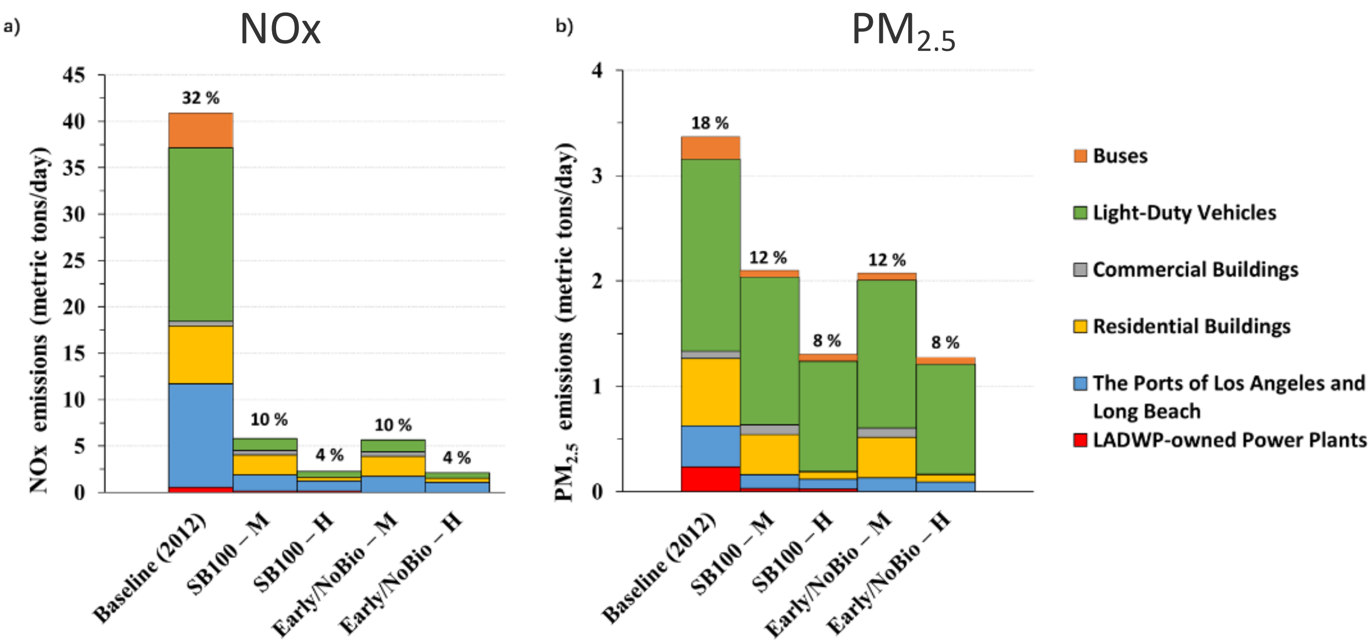
Air Quality Analysis Goals

Overarching questions:

1) How could future scenarios of renewable energy adoption by LADWP change LA's air pollutant emissions and concentrations?
   – Focus on ozone and fine particulate matter ($PM_{2.5}$), two regional air pollutants with National Ambient Air Quality Standards (NAAQS), for which LA is out of compliance
2) How could changes in ozone and $PM_{2.5}$ concentrations alter deleterious health consequences from air pollution exposure within City of Los Angeles?

Through evaluating impacts of selected LA100 scenarios, we aim to identify the affected *LA100-influenced* sectors and source types that could contribute most to overall air pollutant reductions in LA.

Contribution of LA100-Influenced Sectors to Annual-Average Emissions in the City of LA



M: Moderate Electrification
H: High Electrification

Light-duty vehicles are the primary cause of emission reductions (especially for NOx) due to

- Electrification in LA100
- Decreases from policies outside of LA100

Changes to LADWP-owned power plants are one of the smallest contributors to these emission changes

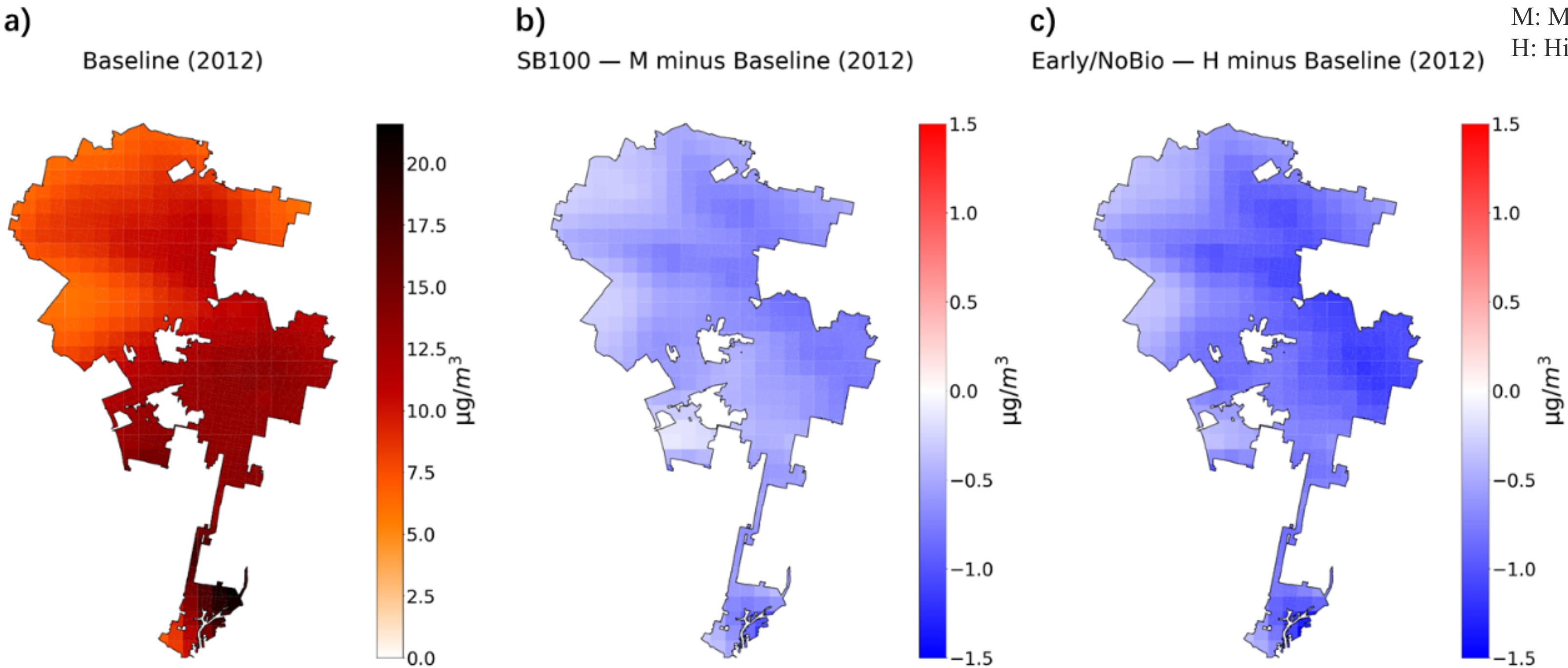
- % represents the fraction of emissions that are from the LA100-influenced sectors in the total city of LA inventory
- Non-LA100 related sources are not included in this figure
- The power sector represents LADWP-owned power plants located in the South Coast Air Basin

All scenarios have significant reduction in annual NOx emissions from LADWP-owned power plants located in the South Coast Air Basin vs. 2012

Fuel technology	2012 Emissions for Baseline (metric ton)	2045 Emissions for SB100 – Moderate (metric ton)	2045 Emissions for SB100 – High (metric ton)	2045 Emissions for Early & No Biofuels – Moderate (metric ton)	2045 Emissions for Early & No Biofuels – High (metric ton)
Natural Gas Combined Cycle	199 (including all LADWP plants)	30	31	0	0
Natural Gas Combustion Turbine		26	24	0	0
Hydrogen Combustion Turbine	0	0	0.004	6.6	8.6
Total (% change from 2012)	199	56 (-72%)	55 (-72%)	6.6 (-97%)	8.6 (-96%)

- Citywide annual total NOx emission from all sources is 46,000 metric tons (2012).
- NOx emissions of hydrogen combustion turbines in 2045 are assumed to comply with current SCAQMD regulations on natural gas combustion turbine (2.5 ppmv)
- We assume zero emissions of primary particulate matter, carbon monoxide, sulfur dioxides, and organic gas emissions from hydrogen combustion turbines (which exclusively burn renewably-derived H_2)
- Note that CO_2 and methane (GHG) emissions from hydrogen combustion turbines are zero

Annual-average daily $PM_{2.5}$ concentrations decrease across Los Angeles between 2012 and 2045 in all LA100 scenarios



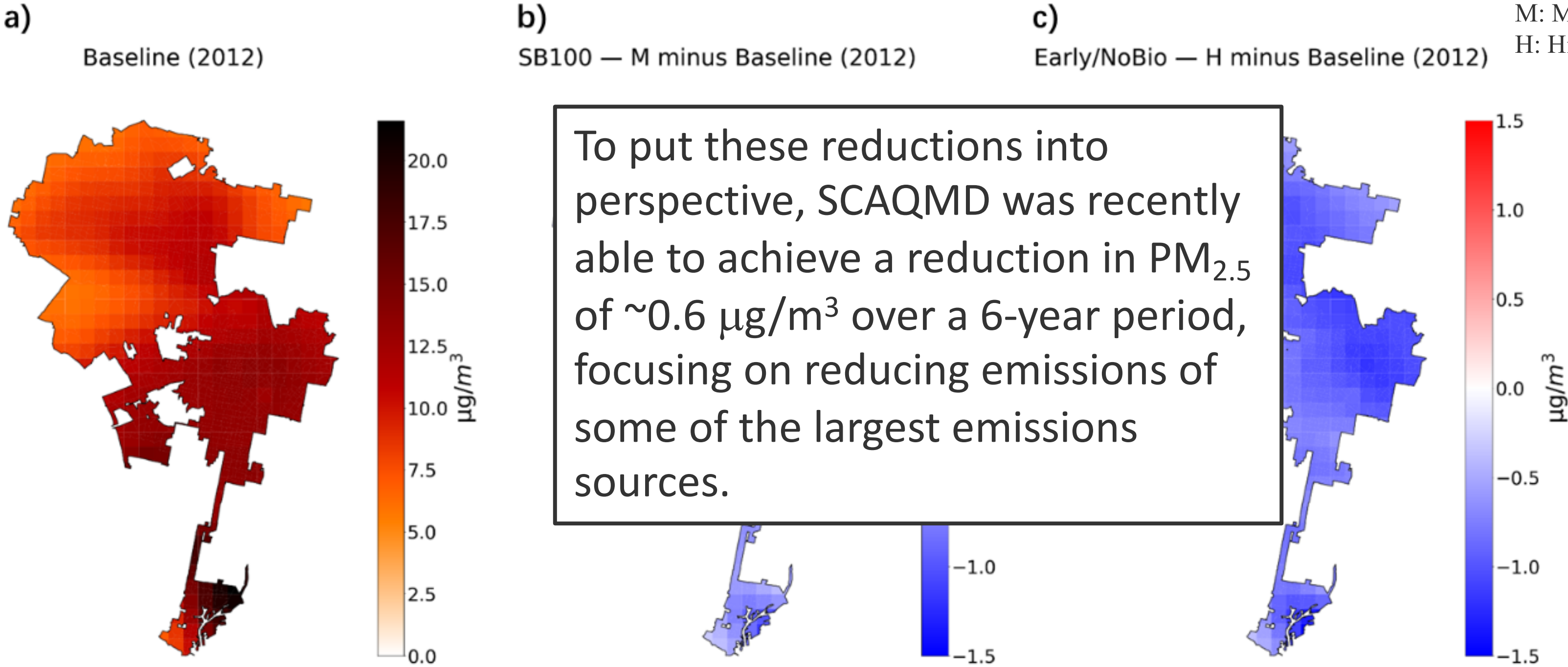
M: Moderate Electrification
H: High Electrification

Comparison to 2012 includes changes outside the scope of LA100

City Average	Baseline (2012)	SB100 – Moderate		Early & No Biofuels – High	
	10.6 µg/m³	10.0 µg/m³	-6%	9.8 µg/m³	-8%

Annual-average daily $PM_{2.5}$ concentrations decrease across Los Angeles between 2012 and 2045 in all LA100 scenarios

M: Moderate Electrification
H: High Electrification



To put these reductions into perspective, SCAQMD was recently able to achieve a reduction in $PM_{2.5}$ of ~0.6 µg/m³ over a 6-year period, focusing on reducing emissions of some of the largest emissions sources.

Comparison to 2012 includes changes outside the scope of LA100

City Average	Baseline (2012)	SB100 – Moderate		Early & No Biofuels – High	
	10.6 µg/m³	10.0 µg/m³	-6%	9.8 µg/m³	-8%

Comparing LA100 Scenarios within 2045

- The largest changes are between the baseline (2012) and the future (2045), though this comparison includes emissions changes outside the scope of LA100
- Smaller differences occur between scenarios within 2045

Comparisons among scenarios in 2045

Isolate effects of power sector assumptions (LADWP-owned power plants)

SB100 – Moderate vs. **Early & No Biofuels – Moderate**
SB100 – High vs. **Early & No Biofuels – High**

Isolate effects of moderate versus high electrification for LA100-influenced sources (Vehicles, Buildings, Port)

SB100 – Moderate vs. **SB100 – High**
Early & No Biofuels – Moderate vs. **Early & No Biofuels – High**

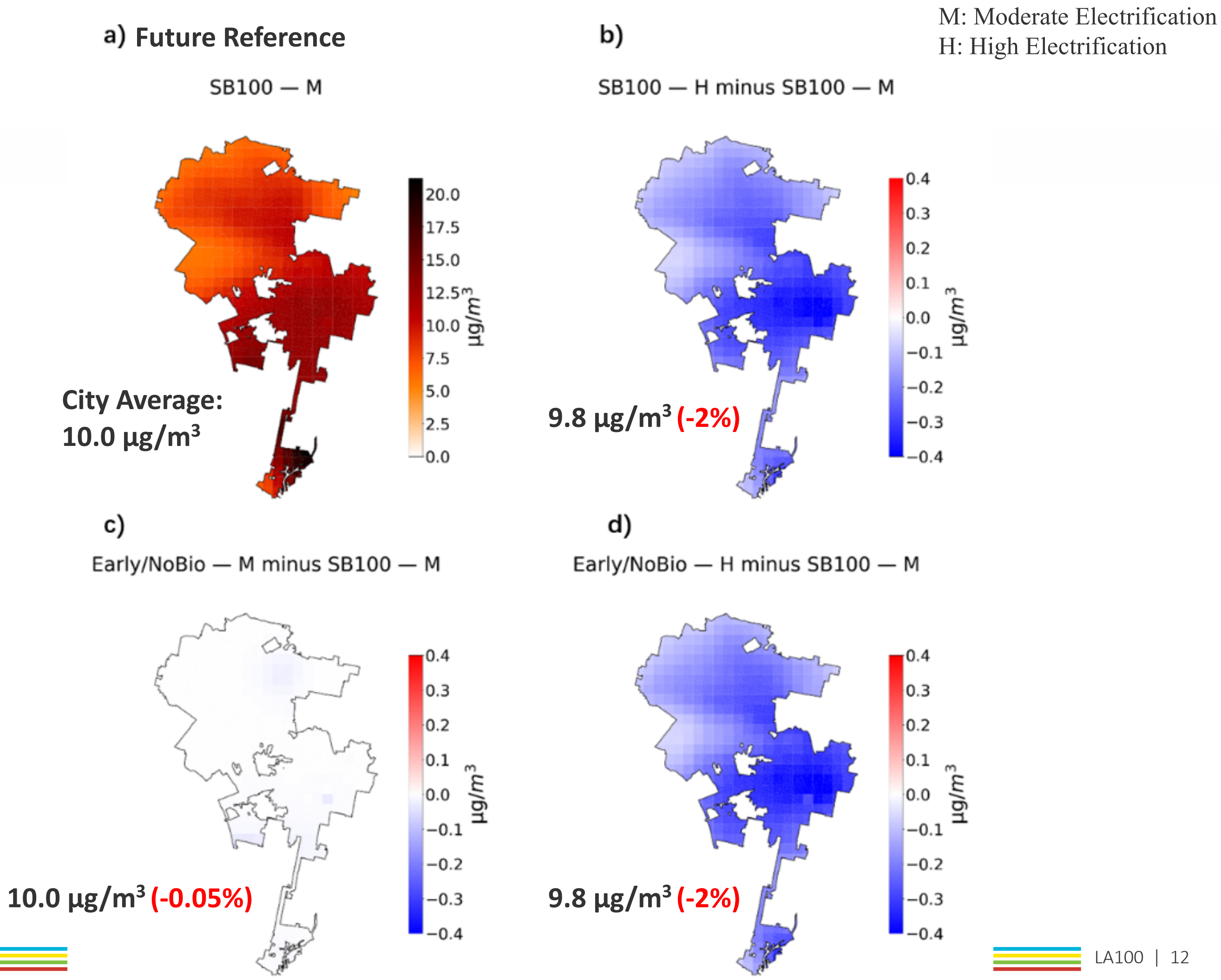
Combined changes of power sector assumptions and increased electrification

SB100 – Moderate vs. **Early & No Biofuels – High**

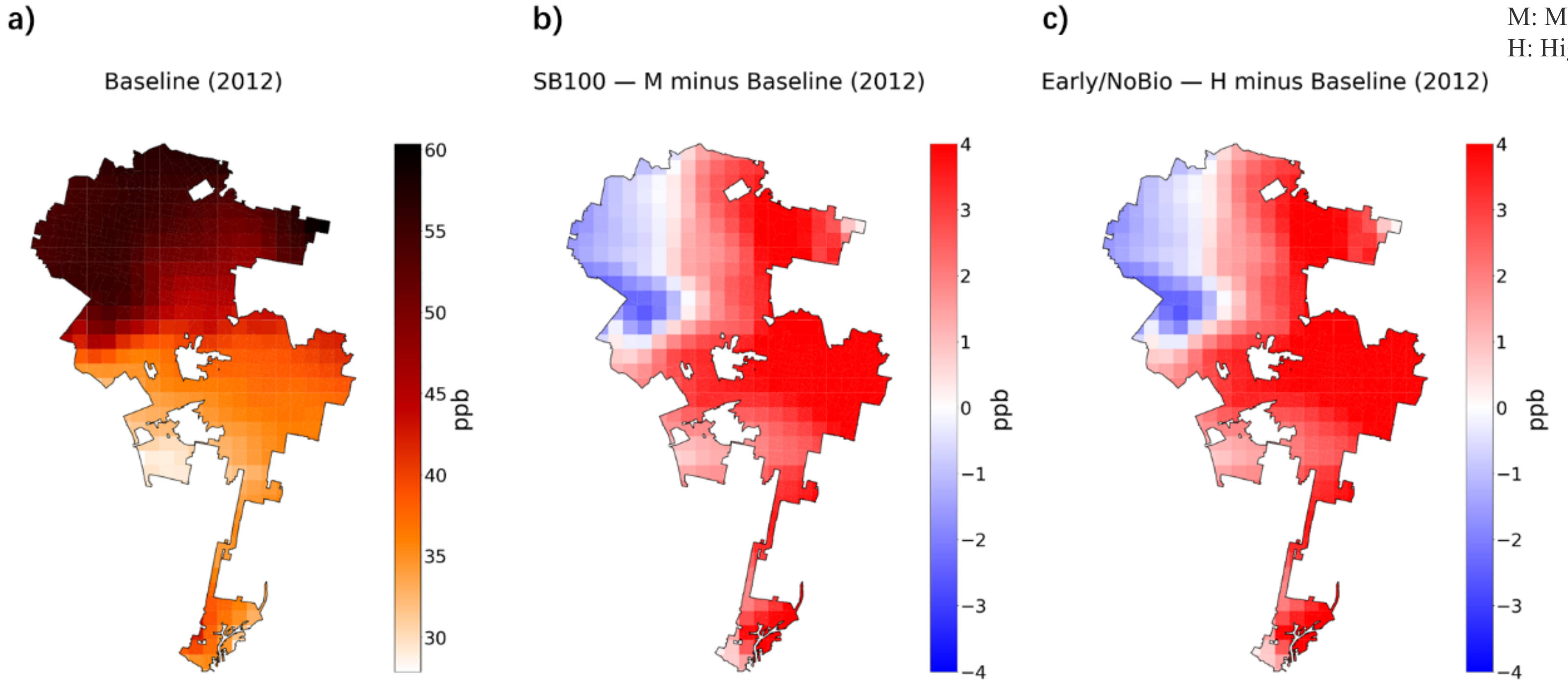
Reductions in citywide $PM_{2.5}$ concentrations in 2045 are dominated by increases in electrification levels (panel b and d).

Differences between scenarios in 2045 regarding LADWP power plants (fuel use and type) has a small impact at regional scale in 2045 (panel c).

Recall that all scenarios have little combustion from LADWP powerplants in 2045.



All selected LA100 scenarios in 2045 show increases in summertime ozone concentrations for most parts of Los Angeles compared to 2012

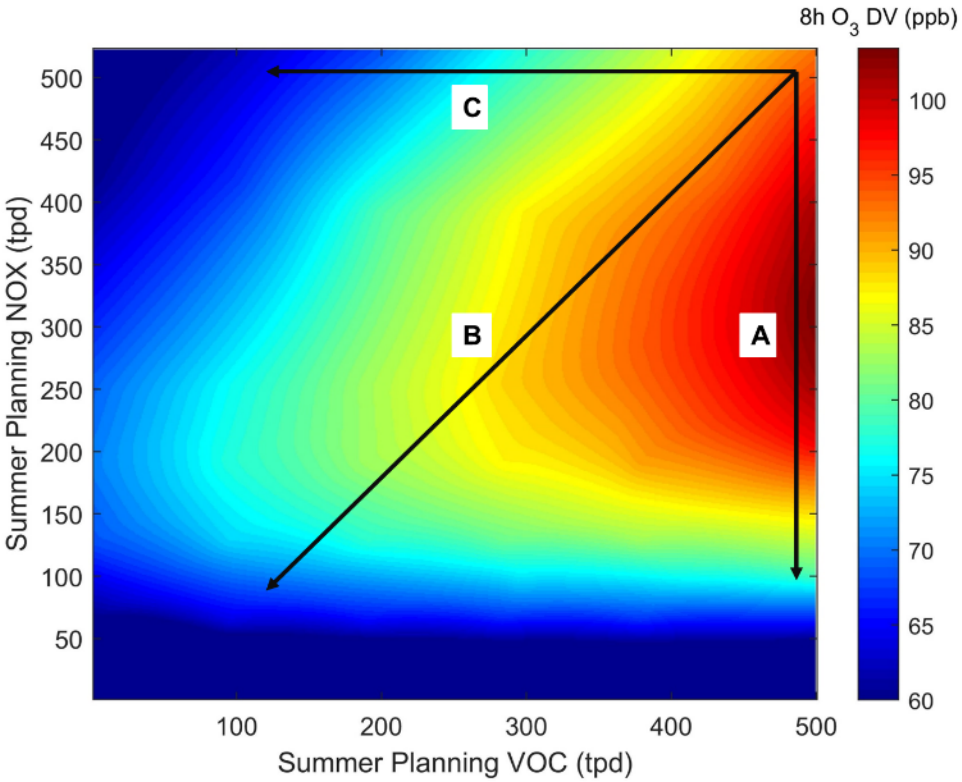


M: Moderate Electrification
H: High Electrification

Comparison to 2012 includes changes outside the scope of LA100

City Average	Baseline (2012)	SB100 – Moderate		Early & No Biofuels – High	
	43.8 ppb	46.0 ppb	+5%	46.1 ppb	+5%

Ozone "isopleth" to illustrate how ozone concentrations change in response to decreases in NOx and volatile organic compound (VOC) emissions*



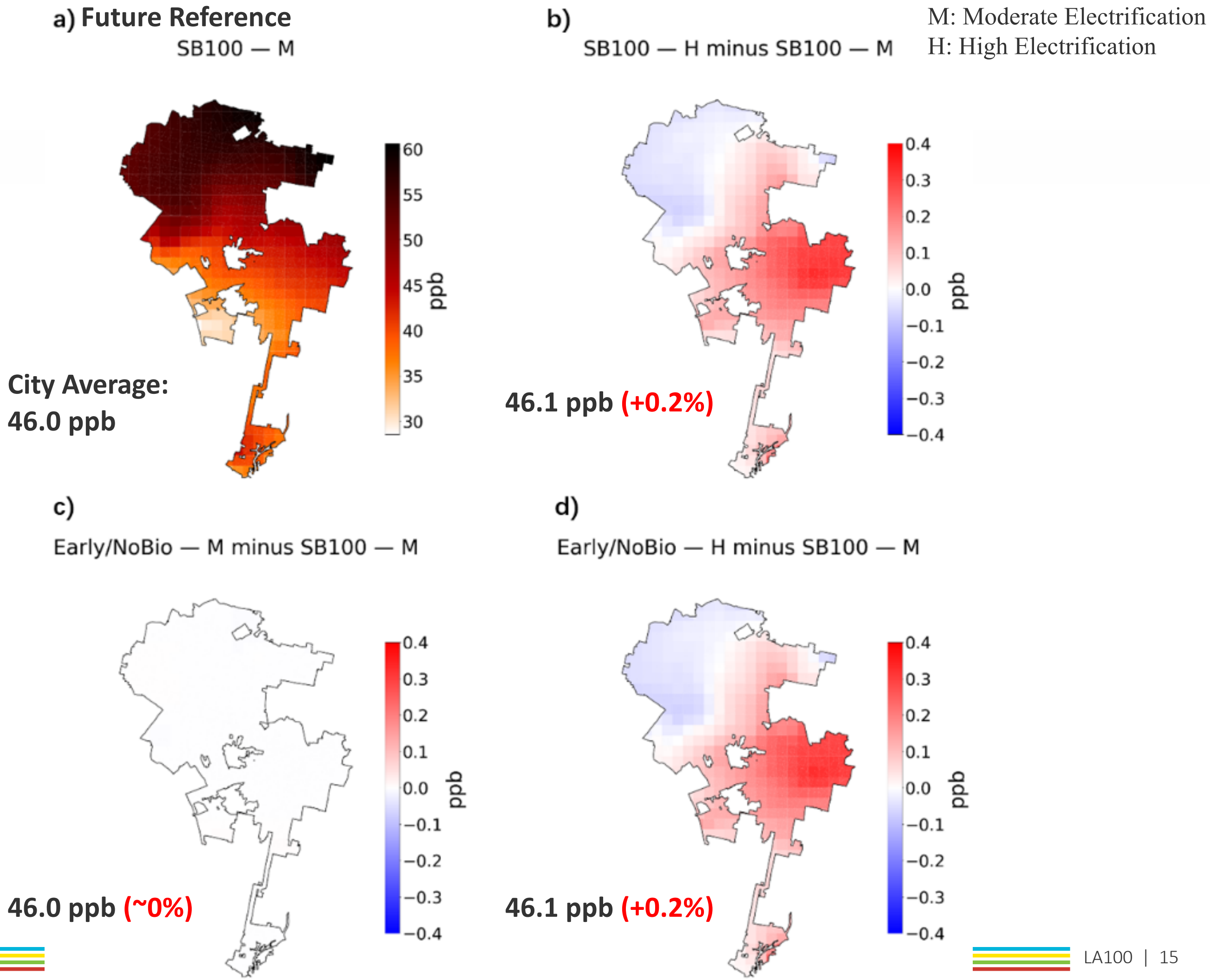
- In LA100, ozone concentration increases despite NOx emission reductions
- This can be thought of as temporary "growing pains". Once NOx emissions get sufficiently low, further emissions decreases will lead to ozone reductions (Pathway A)
- Could avoid these ozone increases by having commensurate reductions in emissions of VOCs (Pathway B)
- The response of ozone to emissions decreases is highly dependent on the scenarios investigated and the baseline used.

*This figure is modified from a presentation at SCAQMD Scientific Technology Modeling & Peer Review (STMPR) meeting on Jan. 27, 2021.

Changes in citywide ozone concentrations are dominated by increases in electrification levels in 2045 (frames b and d).

Differences between scenarios in 2045 regarding LADWP power plants (fuel use and type) does not have a noticeable impact (frame c).

Recall that all scenarios have little combustion from LADWP powerplants in 2045.



Conclusions (1)

- Relative to the 2012 baseline, the evaluated LA100 scenarios **reduce** annual NOx and $PM_{2.5}$ emissions from LA100-influenced sectors in 2045.
- Reductions in air pollutant emissions lead to simulated **reductions in $PM_{2.5}$** concentrations across LA in 2045.
  - Citywide average concentration decreases by 6% and 8% from Baseline (2012) to SB100 – Moderate and Early & No Biofuels – High, respectively.
- These same emission decreases lead to simulated **increases in ozone** concentrations for most parts of LA.
  - Citywide average concentration increases by 5% from Baseline (2012) to SB100 – Moderate and Early & No Biofuels – High.

Conclusions (2)

- Changes in air pollutant emissions and concentrations resulting from the LA100 scenarios are dominated by **increases in electrification for light-duty vehicles. Electrification of the Port and building appliances also contribute**.
  - Within 2045, differences in emissions between LADWP-owned power plants using little natural gas versus only (little) hydrogen had a negligible impact on city-scale air pollution.
  - This conclusion is driven in part by the fact that fuel consumption in 2045 for both SB100 (natural gas) and Early & No Biofuels (hydrogen) is very small (as predicted by power sector modeling)

- Reductions in $PM_{2.5}$ concentrations induced by LA100 are **beneficial** for the city, for instance to help in meeting National Ambient Air Quality Standards.

- Increases in ozone concentrations despite decreases in NOx emissions can be thought of as temporary **"growing pains"** that are necessary to ultimately reduce ozone based on further reductions in NOx (and VOC) emissions in Los Angeles.

Caveats on Air Quality Results

- Air quality results shown here are highly dependent on the ways that the scenarios were defined.
  - Simulated ozone responses to emissions reductions are highly dependent on atmospheric context, and thus the scenarios investigated.

- Including additional emissions reductions policies beyond what was covered in LA100 will lead to higher emissions reductions. Examples;
  - Medium and heavy-duty trucks
  - Off-road sources (e.g., construction equipment, locomotives, airplanes, ships)
  - There are already some relevant policies and LA100 can inform further policy design to further air pollution co-improvements with GHG emission reduction.

- This analysis focuses on changes to city-scale air quality for two regional pollutants that are federally regulated. It is NOT an exhaustive environmental hazards analysis.
  - For instance, we do not analyze near-source exposure to emissions sources (e.g., power plants, freeways, the Port), fuel leaks, etc.

Acknowledgement

South Coast Air Quality Management District (SCAQMD) for providing the source-oriented emissions inventory and providing additional assistance

Questions?

The Los Angeles 100% Renewable Energy Study

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Impact of LA100 Scenarios on Public Health

Presenter: Dr. Garvin Heath (NREL)

Collaborators: Dr. Vikram Ravi (NREL)

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LA DWP Los Angeles Department of Water & Power | NREL Transforming ENERGY | USC University of Southern California

Air Quality Analysis Goals: Recap

Overarching questions:

1) How could future scenarios of renewable energy adoption by LADWP change LA's air pollutant emissions and concentrations?
   - Pollutants of focus are O_3 and $PM_{2.5}$
2) How could changes in O_3 and $PM_{2.5}$ concentrations alter deleterious health consequences from air pollution exposure within City of Los Angeles?
   - Mortality and selected morbidity outcomes
   - Monetize the health benefits from air pollution

In our air quality modeling, we identify **the sectors and source types** affected by LA100 scenarios that could contribute most to overall air pollutant reductions and subsequent health effects and their monetization.

Background: Air Pollutants and Health Effects of Concern

- The South Coast Air Basin (SoCAB) is out of compliance (i.e., “nonattainment”) with the National Ambient Air Quality Standards (NAAQS) for two key pollutants:
  - **Ozone (O_3)**
  - **Particulate matter (PM)**, especially “fine PM” = $PM_{2.5}$
- Health effects with the greatest damages in monetary terms are premature mortality from long-term exposure to $PM_{2.5}$ (1st) and ozone (2nd)
  - There are also numerous “morbidity” effects, which are health effects not including death, e.g., asthma, heart attacks, respiratory diseases
- Note that ozone, and many $PM_{2.5}$ species, are “secondary” pollutants (i.e., formed via chemical reactions in the atmosphere)

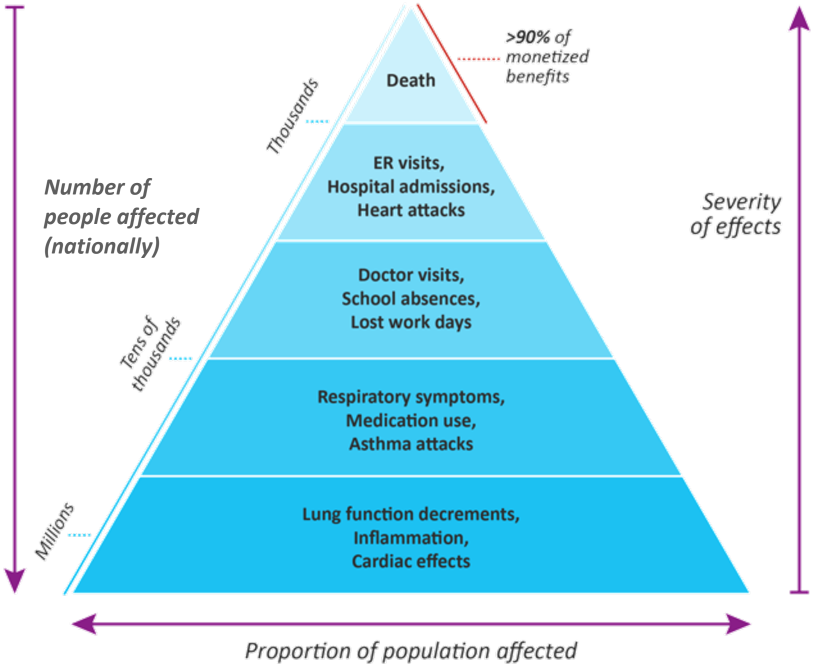


Image courtesy of Neal Fann (US EPA)

Health Impacts Analysis Tool: BenMAP-CE

- We used **Benefit Mapping and Analysis Program – Community Edition (BenMAP-CE)** to estimate the health impacts and economic valuation from exposure changes to $PM_{2.5}$ and ozone pollution
- BenMAP-CE is a peer-reviewed, frequently updated, free, and open-source software available from the US EPA (https://www.epa.gov/benmap)
- The tool has been used for local, regional, and national analysis
- Example regulatory and research applications:
  - US EPA: Regulatory Impacts Analysis for the 2012 PM NAAQS and for Nonroad Diesel and Clean Air Interstate Rules
  - CARB: estimate health effects of air pollution
  - SCAQMD: 2016 Air Quality Management Plan
  - Academic studies about CA: quantify mortality burdens due to local and nonlocal sources (Wang et al., 2019) and GHG reduction related health co-benefits (Wang et al., 2020)
- BenMAP is based on expert review of health effects literature

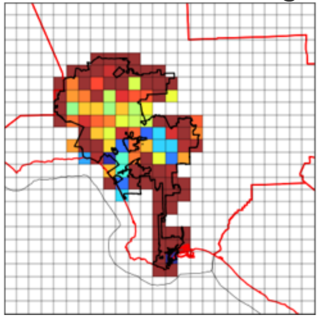
Category	Health Endpoint	$PM_{2.5}$	Ozone
Mortality	Premature mortality	✓	✓
Cardio-vascular effects	Nonfatal heart attacks	✓	
	Hospital admissions, cardiovascular	✓	
Respiratory effects	Hospital admissions, respiratory	✓	✓
	Asthma emergency department visits	✓	✓
	Acute respiratory symptoms	✓	✓
	Asthma attacks	✓	✓
	Work loss days	✓	
	School absence days		✓

Red: evaluated in LA100 (Source: Sacks et al., 2018)

Health Impacts Calculation in BenMAP

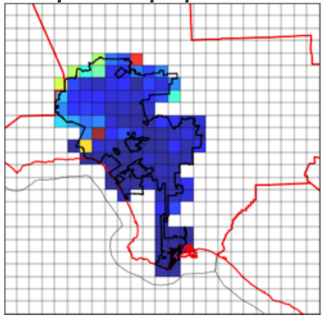
(Find your district – map will be repeated in next slides)

ΔC
Concentration change



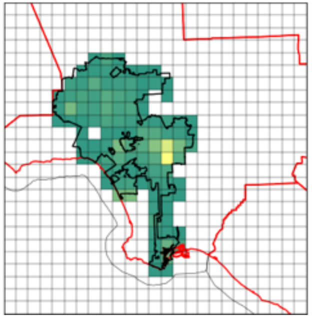
Concentration change surfaces at 2km x 2km grids from WRF-Chem

pop
Exposed population



Population distribution by age from BenMAP

Yo
Baseline incidences

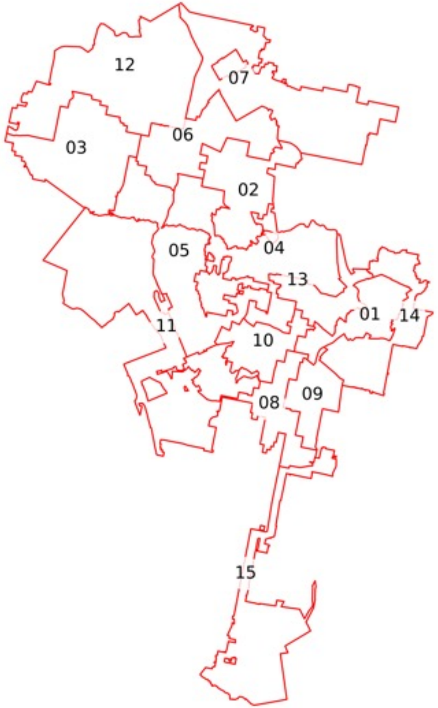


Baseline incidence data from BenMAP

ß
effect estimate

$$\Delta \boldsymbol{Y} = Y_o\left(1 - e^{-\beta*\Delta C}\right) * pop$$

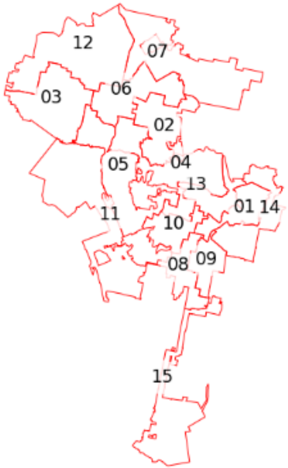
health impact



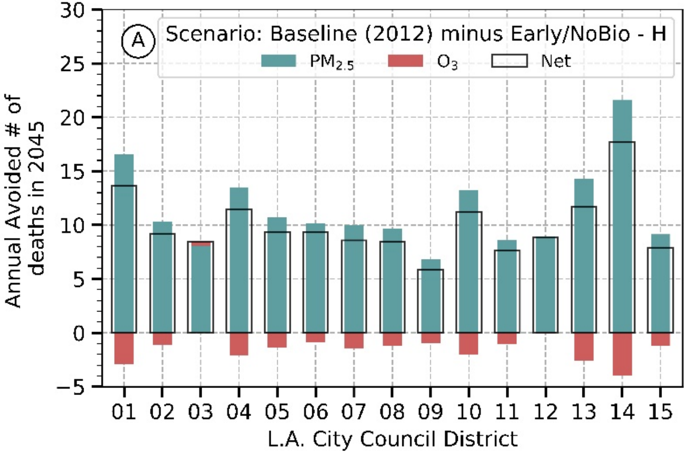
Results aggregated to 15 L.A. City Council Districts

(Example data)

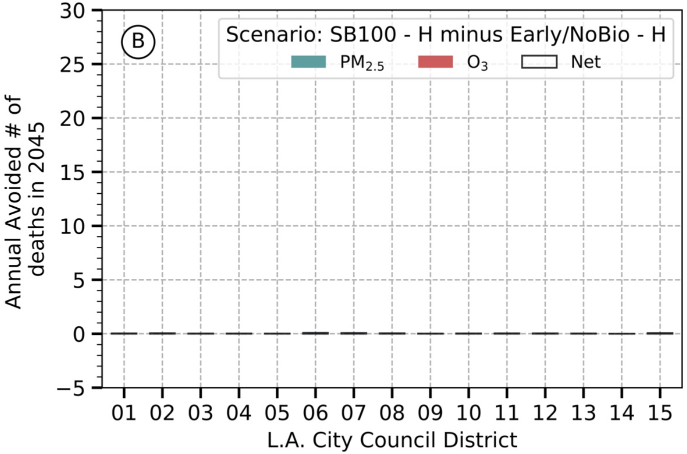
Avoided number of annual deaths per City Council District in 2045



Future High End-use Electrification in 2045 relative to 2012



Isolating the Impact of Power Sector Changes in 2045



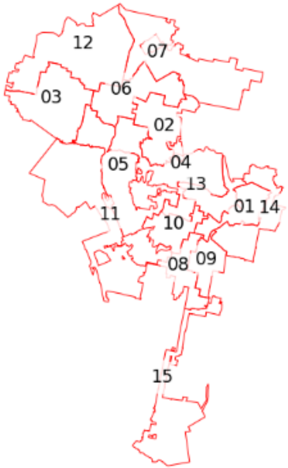
- Net premature deaths from exposure to the two pollutants are always positive, i.e., a health benefit in all scenarios compared.
- Largest net benefits are associated with increased electrification in end-use sectors (transportation, residential and commercial buildings, and ports).

Avoided number of annual deaths in LA in 2045

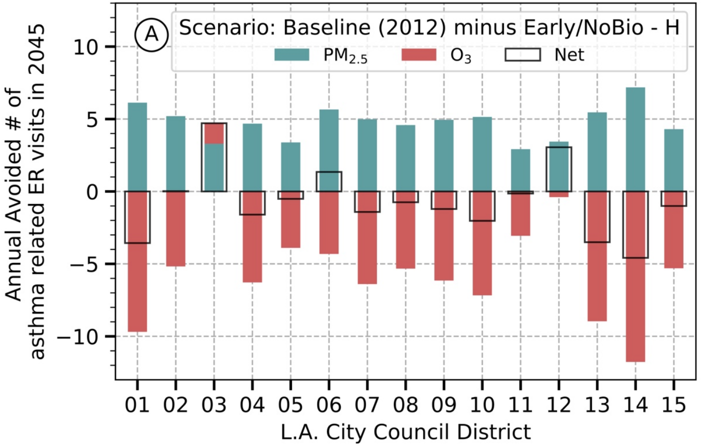
Scenario	**Mean annual avoided deaths in the city in 2045** (95% confidence interval)
Comparison of selected future scenarios (2045) versus Baseline (2012)	
SB100 – Moderate versus Baseline (2012)	**96** (67 - 130)
Early & No Biofuels – High versus Baseline (2012)	**150** (100 - 200)
Comparison of future scenarios isolating power sector changes in 2045	
Early & No Biofuels – Moderate versus SB100 – Moderate	**1** (0 - 1)
Early & No Biofuels – High versus SB100 – High	**1** (0 - 1)
Comparison of future scenarios isolating impacts of high electrification in end-use sectors in 2045	
Early & No Biofuels – High versus Early & No Biofuels – Moderate	**52** (35 - 70)
SB100 – High versus SB100 – Moderate	**53** (35 - 70)

As a reference, an average of 200 traffic accident fatalities occurred in L.A. City per year (based on 2012 – 2017 data from L.A. DOT)

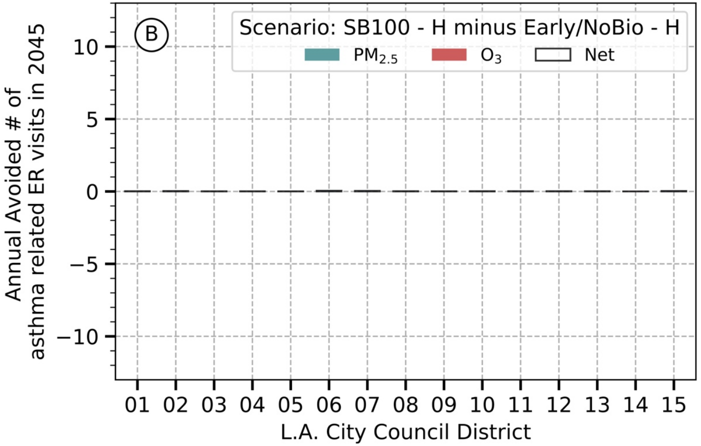
Projected annual morbidity benefits: Asthma-related ER visits in 2045



Future High End-use Electrification in 2045 relative to 2012

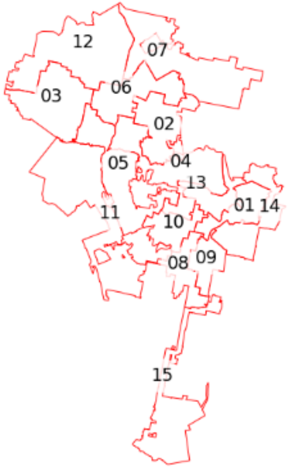


Isolating Impacts of Power Sector Changes in 2045

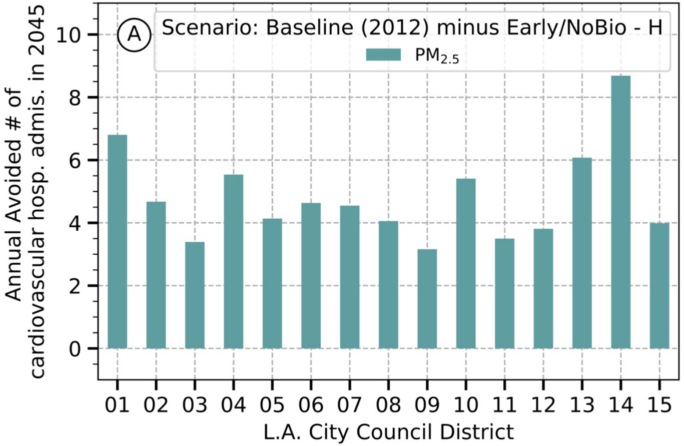


- Asthma-related ER visits result from exposure to both ozone and $PM_{2.5}$
    - Ozone exerts a larger effect on asthma.
- Since ozone concentration increases owing to LA100 scenarios (despite a decrease in NOx emissions), asthma incidences increase compared to the 2012 Baseline scenario.

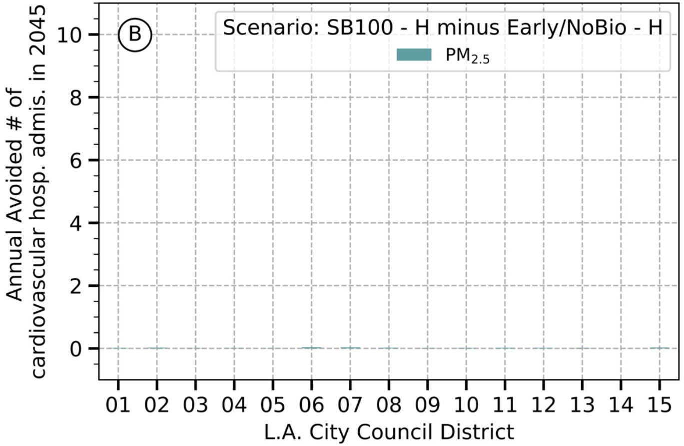
Projected annual morbidity benefits: Cardiovascular-related hospital admissions (non-heart attack) in 2045



Future High End-use Electrification in 2045 relative to 2012



Isolating the Impact of Power Sector Changes in 2045



- Cardiovascular diseases are associated with $PM_{2.5}$ exposure, not ozone.
- Annual cardiovascular-related hospital admissions in the city in 2045 decrease in all scenarios compared.
- Largest benefits are associated with high electrification in the end-use sectors as compared to those associated with changes to the power sector.

Estimates of annual avoided morbidity (non-death) outcomes in 2045

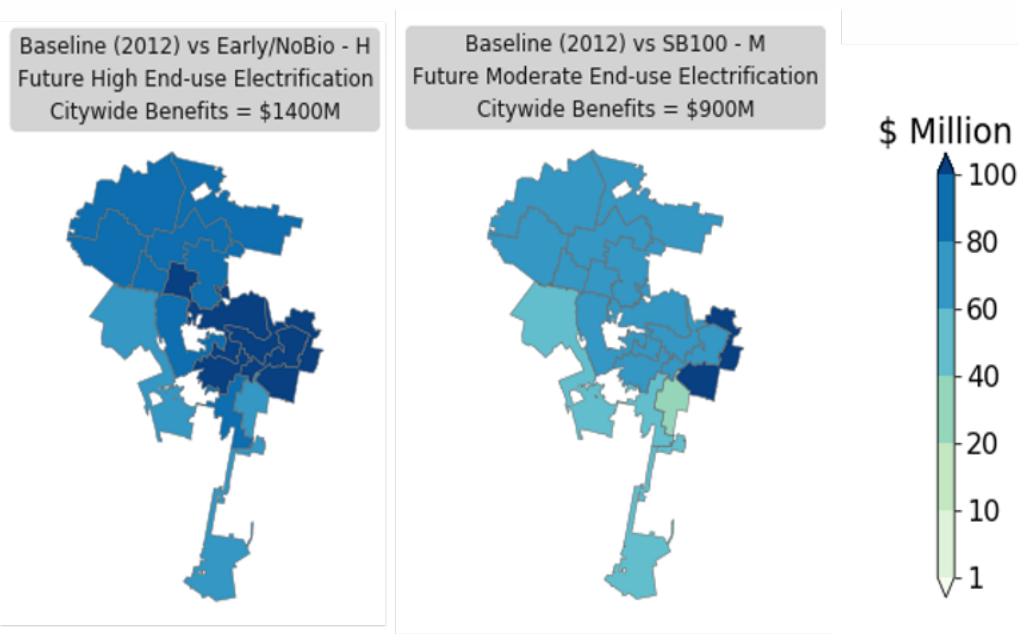
Scenario	Mean avoided incidences in City of L.A. in 2045 (95% confidence interval)		
	Asthma-related ER Visits	**Cardiovascular Hospital Admissions**	**Heart attacks**
Comparison of future scenarios (2045) versus Baseline (2012)			
Baseline (2012) versus SB100 – Moderate	**-30** (-40 – -20)	**50** (28 – 71)	**13** (6 – 20)
Baseline (2012) versus Early & No Biofuels – High	**-11** (-51 – 27)	**72** (41 – 100)	**19** (9 – 29)
Comparison of future scenarios isolating power sector changes in 2045			
SB100 – Moderate versus Early & No Biofuels – Moderate	**0** (0 – 1)	**0** (0 – 1)	**0** (0 – 0)
SB100 – High versus Early & No Biofuels – High	**0** (0 – 1)	**0** (0 – 0)	**0** (0 – 0)
Comparison of future scenarios isolating impacts of high electrification in end-use sectors in 2045			
Early & No Biofuels – Moderate versus Early & No Biofuels – High	**18** (-10 – 47)	**22** (13 – 32)	**6** (3 – 9)
SB100 – Moderate versus SB100 – High	**19** (-10 – 47)	**22** (13 – 32)	**6** (3 – 9)

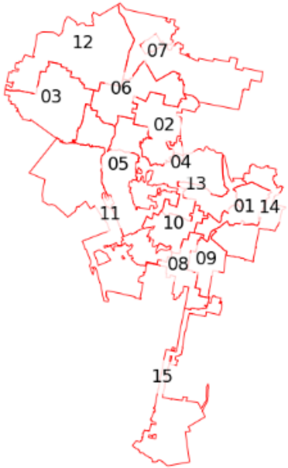
High electrification levels are associated with better outcomes as compared to those at Moderate electrification levels

Changes to LADWP power plants (fuel use and type) in 2045 do not change results significantly.

Annual, Monetized Benefits Relative to Baseline (2012)

Air pollution-related health benefits for each of the 15 LA city council districts



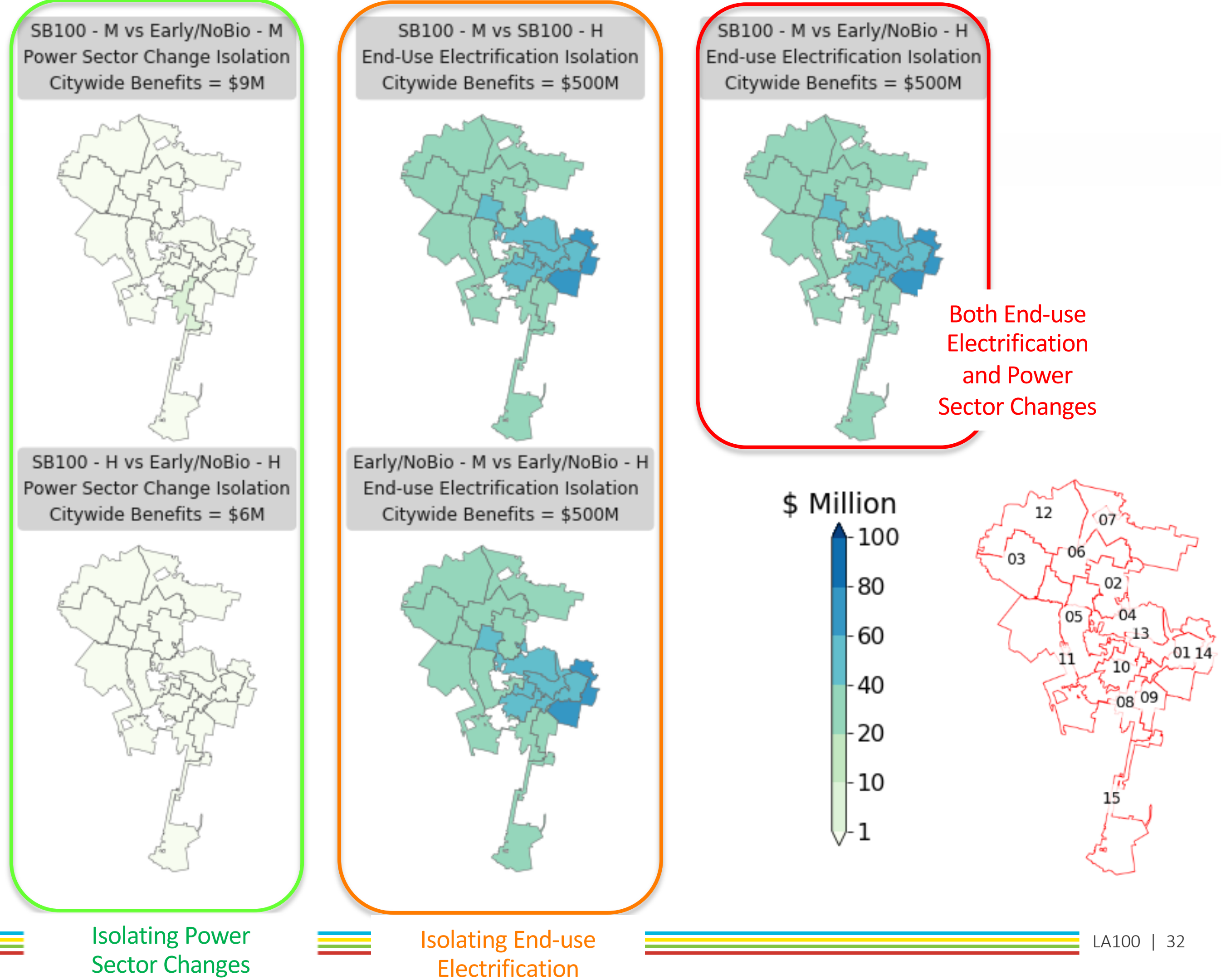


Note that these benefits are in 2045 alone, and do not include cumulative benefits across the LA100 study period for any of the scenarios compared.

Relative, Annual, Monetized Benefits Among LA100 Scenarios (2045)

Air pollution-related health benefits for each of the 15 LA city council districts

Note: these benefits are in 2045 alone, and do not include cumulative benefits across the LA100 study period for any of the scenarios compared.



Transitioning the city of Los Angeles to 100% renewable energy in the power sector, and associated electrification of end use sectors, could yield nearly a billion dollars, and up to $1.4 billion, of avoided health impacts in 2045 alone as compared to current air pollution

Scenarios	Mean Value of Annual Avoided Health Impacts (Savings) (Million 2019 $) (95% Confidence Interval)		
	Morbidity	Mortality	Total
Comparison of future scenarios (2045) versus Baseline (2012)			
Baseline (2012) versus SB100 – Moderate	**5** (3 - 8)	**890** (-490 – 3,000)	**900** (-480 – 3,000)
Baseline (2012) versus Early & No Biofuels – High	**8** (4 - 10)	**1,400** (-470 – 4,400)	**1,400** (-470 – 4,400)
Comparison of future scenarios isolating power sector changes in 2045			
SB100 –Moderate versus Early & No Biofuels – Moderate	**0** (0 - 0)	**9** (1 - 20)	**9** (1 - 20)
SB100 – High versus Early & No Biofuels – High	**0** (0 - 0)	**6** (-1 - 20)	**6** (-1 - 20)
Comparison of future scenarios isolating impacts of high electrification in end-use sectors in 2045			
Early & No Biofuels – Moderate versus Early & No Biofuels – High	**2** (1 - 4)	**500** (20 – 1,400)	**500** (20 – 1,400)
SB100 – Moderate versus SB100 – High	**2** (1 - 4)	**500** (20 – 1,400)	**500** (20 – 1,400)

Differences amongst scenarios in 2045 are much smaller than the long-term benefits of all scenarios (2012 to 2045)

Differences between different electrification levels could reach nearly a half a billion dollars on an annual basis in 2045.

Note that these benefits are in 2045 alone, and do not include cumulative benefits across the LA100 study period for any of the scenarios compared.

Recall that power system capital costs are cumulative; health benefits are annual.

Conclusions

- All future scenarios provide health benefits to LA residents
  - Level of benefits vary.
- The difference between SB100 and Early & No Biofuels in 2045 in terms of power plant eligibility is not estimated to provide significant health benefits, for instance
  - ~1 avoided premature mortality when summed over the city.
- The largest health benefits are driven by high electrification in end uses.
  - Early & No Biofuels High saves 150 lives in 2045 compared to the Baseline (2012)
  - 53 saved lives compared to SB100 Moderate *(for 2045 alone).*

Conclusions

- The greatest differences in annual monetized value of the health benefits could reach *(for 2045 alone)*
  - Nearly **$500 million when comparing future scenarios in 2045** (between High and Moderate electrification levels for either tested scenario), and
  - **Up to $1.4 billion compared to the 2012 baseline** (Early & No Biofuels – High).

Important Caveats and Next Steps

- LA100 air quality modeling focuses on regional air pollutants and CalEnviroScreen's health impacts (plus premature death). This implies several limitations and in general, likely underestimation of benefits:
  - Near-source (e.g., power plants, major roads, Ports) impacts are not modeled (e.g., toxics, NO_2)
  - There are other health effects not considered (like chronic bronchitis)
- Because these public health changes are only modeled for a single year, cumulative benefits from various LA100 scenarios are likely to be much higher.
  - Follow-on studies could quantify benefits from various electrification pathways.
  - It is unlikely that cumulative benefits differ owing to power sector eligibility criteria, rather will be driven by electrification projections (Moderate vs. High)
- Potential additional benefits are likely to occur from additional emission reductions in other sectors that are not considered here (e.g., heavy-duty diesel trucks to electric/ZEV).

Important Caveats and Next Steps

- Recall that power system capital costs are cumulative; health benefits are annual. Thus, they cannot be directly compared.
- Potential changes to climate are not considered. This was to ensure we reduced the number of changing parameters such that we could isolate changes due to LA100 scenarios.
  - Climate change could lead to a multitude of different effects from today's climatic assumptions, such as increased evaporative emissions, changing atmospheric reaction rates, etc.
  - Without further research, it is impossible to say on net what effect a changing climate would have on the results from LA100

Questions?

The Los Angeles 100% Renewable Energy Study

Appendix

Background material and additional results

Appendix 1: Methods Recap

Overarching Method for Answering Air Quality and Health Research Questions

1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time
2) Creating emissions inventories that project air pollutant emissions under selected LA100 scenarios for 2045
3) Predicting future ozone and $PM_{2.5}$ concentrations with the emissions created in step 2 using a state-of-the-science, open-source air quality model
4) Assessing changes in health impacts from exposure to ozone and $PM_{2.5}$
5) Presentation of air quality and public health results, and handoff of results for evaluation of effects on environmental justice

Overarching assumptions and methodology for projecting air emissions from different sectors in 2045

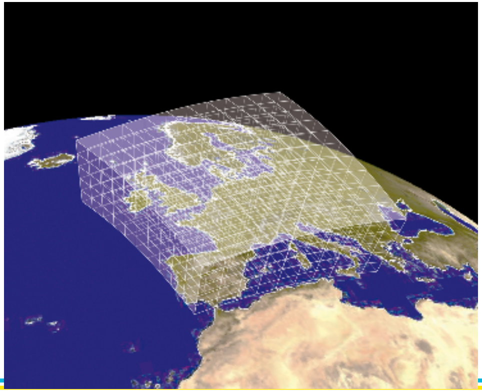
- Emissions **in the City of LA** from **sectors investigated for LA100 scenarios** (or power plants owned by LADWP) are projected to 2045 using NREL model output or input assumptions

- Two approaches for projection:
  - Power sector:
    - Emissions in 2045 = Activity in 2045 x Emission factor in 2045
  - Other sectors:
    - Emissions in 2045 = Emissions in 2020 or 2031 x Scaling factor for activity x Control factor for emission factor

- Emissions out of the scope of LA100 follow SCAQMD's projection for 2031, assuming their emissions in 2045 are the same as 2031

Brief Introduction of Air Quality Modeling

- Simulates physics and chemistry of the atmosphere to quantify how emitted air pollutants disperse and react in the atmosphere.
- Weather Research and Forecasting Model coupled with Chemistry (WRF-Chem, v3.7), an open-source model from National Center for Atmospheric Research
    - Widely used for air quality studies of Southern California
- Simulated January, April, July and October using 2012 meteorology as representative months for calculating $PM_{2.5}$ concentrations; July is also used as representative for O_3 concentrations in the summer O_3 "season" (May – Sep.)



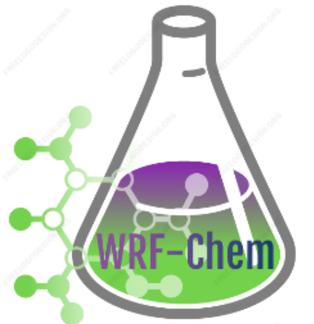


Figure credit to: https://www.empa.ch/web/s503/modelling-remote-sensing, and https://ruc.noaa.gov/wrf/wrf-chem/

Assumptions for Moderate Load Electrification in 2045

Transportation:
Light-duty vehicles and buses

Light-duty vehicles: 30% of stock is plug-in electric vehicles (PEV)

School and urban buses: 100% electrification

Residential buildings
Commercial buildings

Residential Electrification: Water heating 50%, space heating 49%, clothes drying 93% and cooking 53%

Commercial Electrification: Water heating 72% and space heating 81%

THE PORT OF LOS ANGELES

Ocean-going vessels
Cargo handling equipment
Heavy-duty vehicles

Ocean-going vessels (shore power at berth): 80%

Cargo handling equipment: 100% electrification

Heavy duty vehicles: 100% electrification

Assumptions for High Load Electrification in 2045

Transportation:
Light-duty vehicles and buses

Light-duty vehicles: 80% of stock is plug-in electric vehicles (PEV)

School and urban buses: 100% electrification

Residential buildings
Commercial buildings

Residential Electrification: Water heating 100%, space heating 91%, clothes drying 100% and cooking 100%

Commercial Electrification: Water heating 100% and space heating 96%

THE PORT OF LOS ANGELES

Ocean-going vessels
Cargo handling equipment
Heavy-duty vehicles

Ocean-going vessels (shore power at berth): 90%

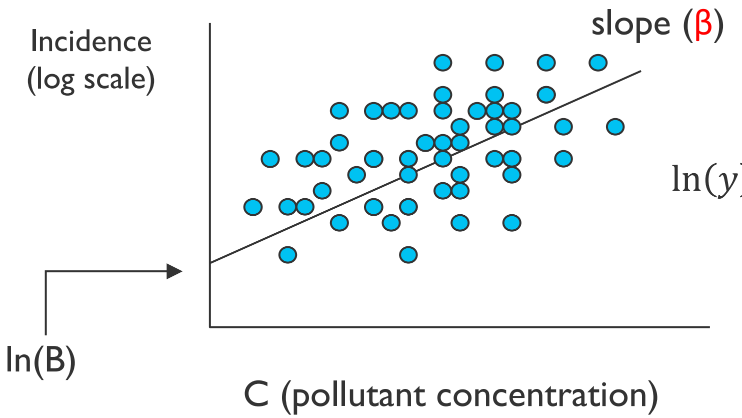
Cargo handling equipment: 100% electrification

Heavy duty vehicles: 100% electrification

Health Impact Functions from Epidemiology Literature

- Epidemiologic studies often report the effects of pollutant concentration changes on incidences
- Their results are used to develop health impact functions relating concentration changes to health effects

Epidemiology study



$$\ln(y) = \ln(B) + \beta(C)$$

Health impact function

$$\Delta Y = Y_o\left(1 - e^{-\beta * \Delta C}\right) * pop$$

Yo – baseline incidence

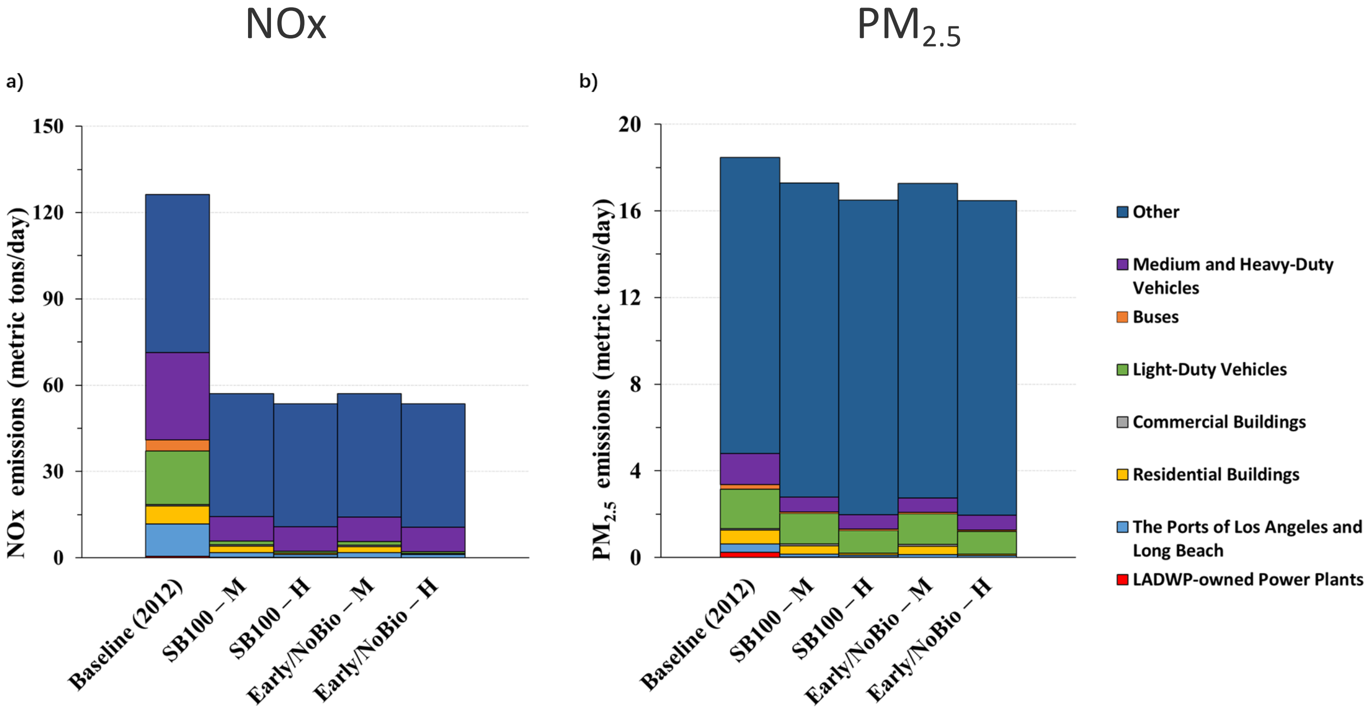
ß – effect estimate

pop – Exposed population

ΔC – pollutant concentration (air quality) change

Appendix 2: Additional Results

Contribution of LA100-influenced sources in the context of all sources in the City of Los Angeles in 2045 (annual average emissions)

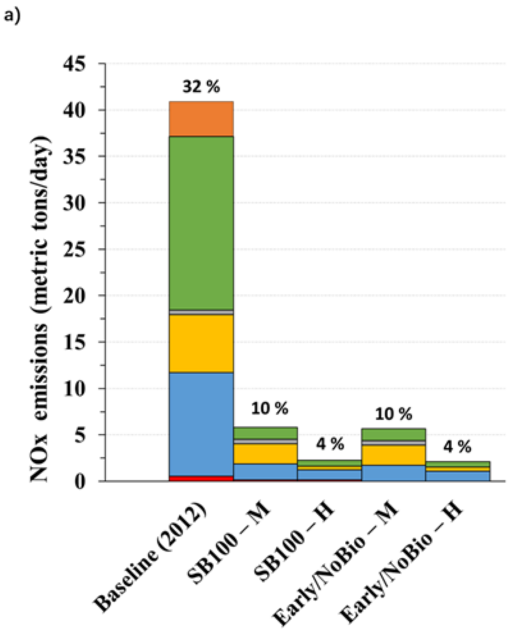


Examples of non-LA100 related sources shown as "Other":

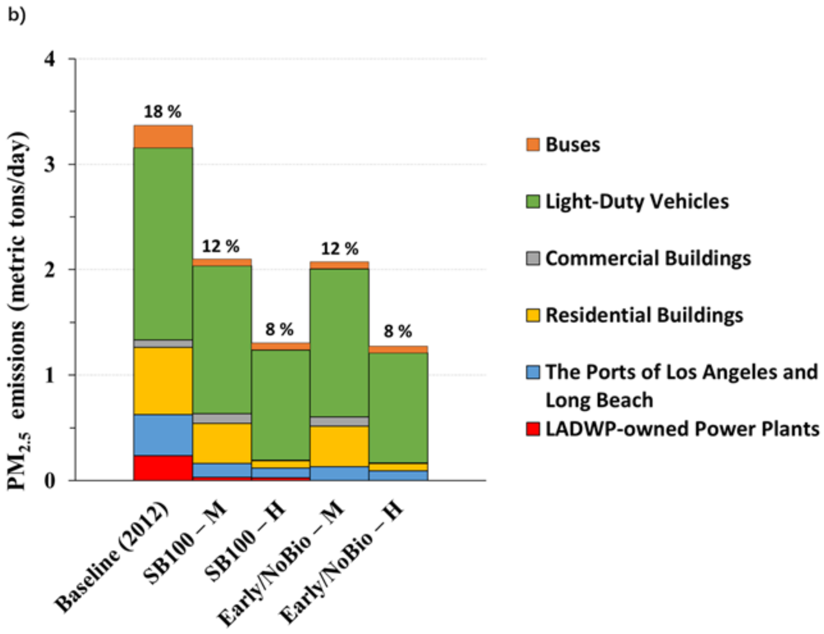
- For NOx:
  - Off-road equipment
  - Trains
  - RECLAIM (large point sources)
  - Aircraft
- For Primary $PM_{2.5}$:
  - Cooking
  - Road Dust
  - Off-road equipment
  - Mineral Processes

City-wide LA100-influenced nitrogen oxides (NOx) and fine particulate matter ($PM_{2.5}$) emissions are reduced from 2012 to 2045.

NOx



$PM_{2.5}$



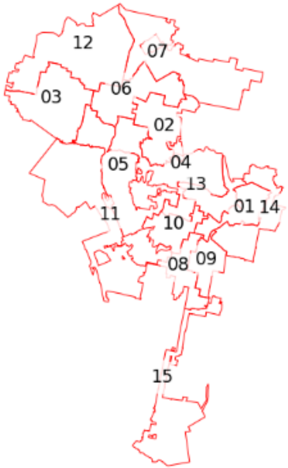
M: Moderate Electrification
H: High Electrification

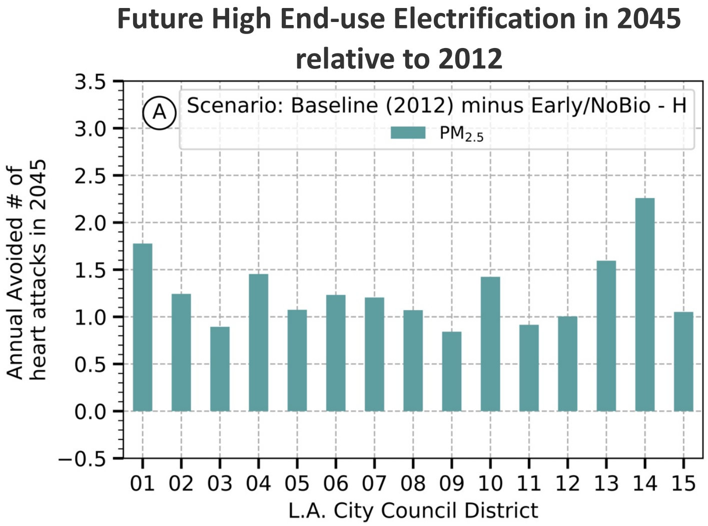
Light-duty vehicles are the primary cause of emission reductions (especially for NOx) due to

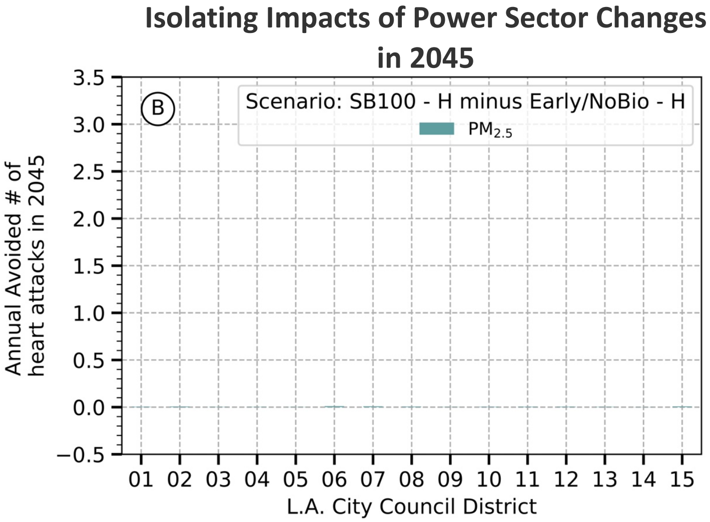
- Electrification in LA100
- Decreases from policies outside of LA100

Changes to LADWP-owned power plants are one of the smallest contributors to these emission changes

Additional Results:
Projected annual morbidity benefits in 2045: Heart attacks







- Heart attacks are associated with fine particulate matter ($PM_{2.5}$) exposure only.
- Annual number of heart attacks (acute myocardial infarctions) from exposure to $PM_{2.5}$ in the city is expected to decrease in all scenarios compared in 2045.
- Largest benefits are associated with high electrification in the end-use sectors (transportation, residential and commercial buildings, and ports) as compared to those associated with changes to the power sector.