The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #12

Virtual Meeting #3

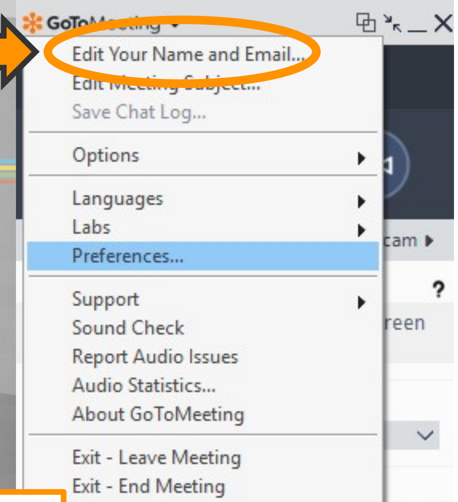
Los Angeles Department of Water & Power

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.



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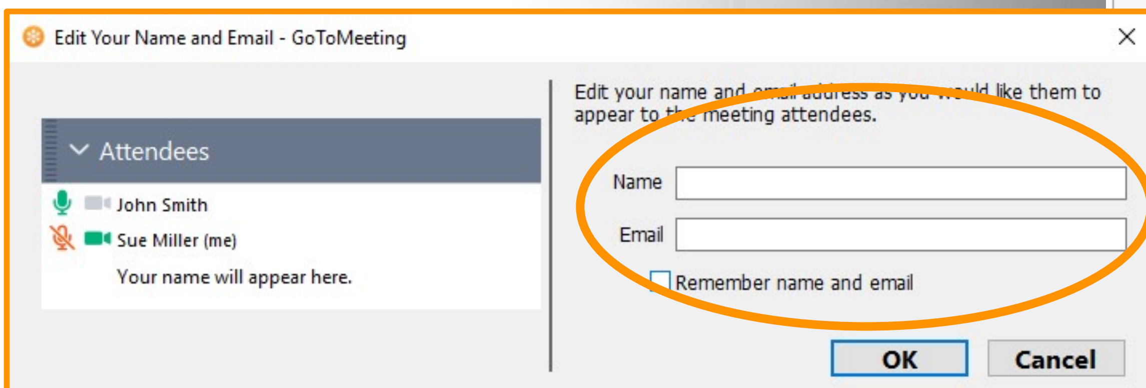
Virtual Meeting #3



Los Angeles Department of Water & Power

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Agenda

July 9
- LA100 Scenarios—Pathways to 100% RE
- Discussion/Q&A

July 16
- Continue Last Week's Discussion
- Jobs and Economic Analysis
- Discussion/Q&A

Today (July 23)
- Welcome
- Environmental Analyses:
  - EJ Updates
  - Air Pollutant Emissions Inventory
  - Mortality and Monetization Methods
- Discussion/Q&A

July 30
- Distribution Grid Analysis
- Discussion/Q&A

August 6
- Follow-up 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

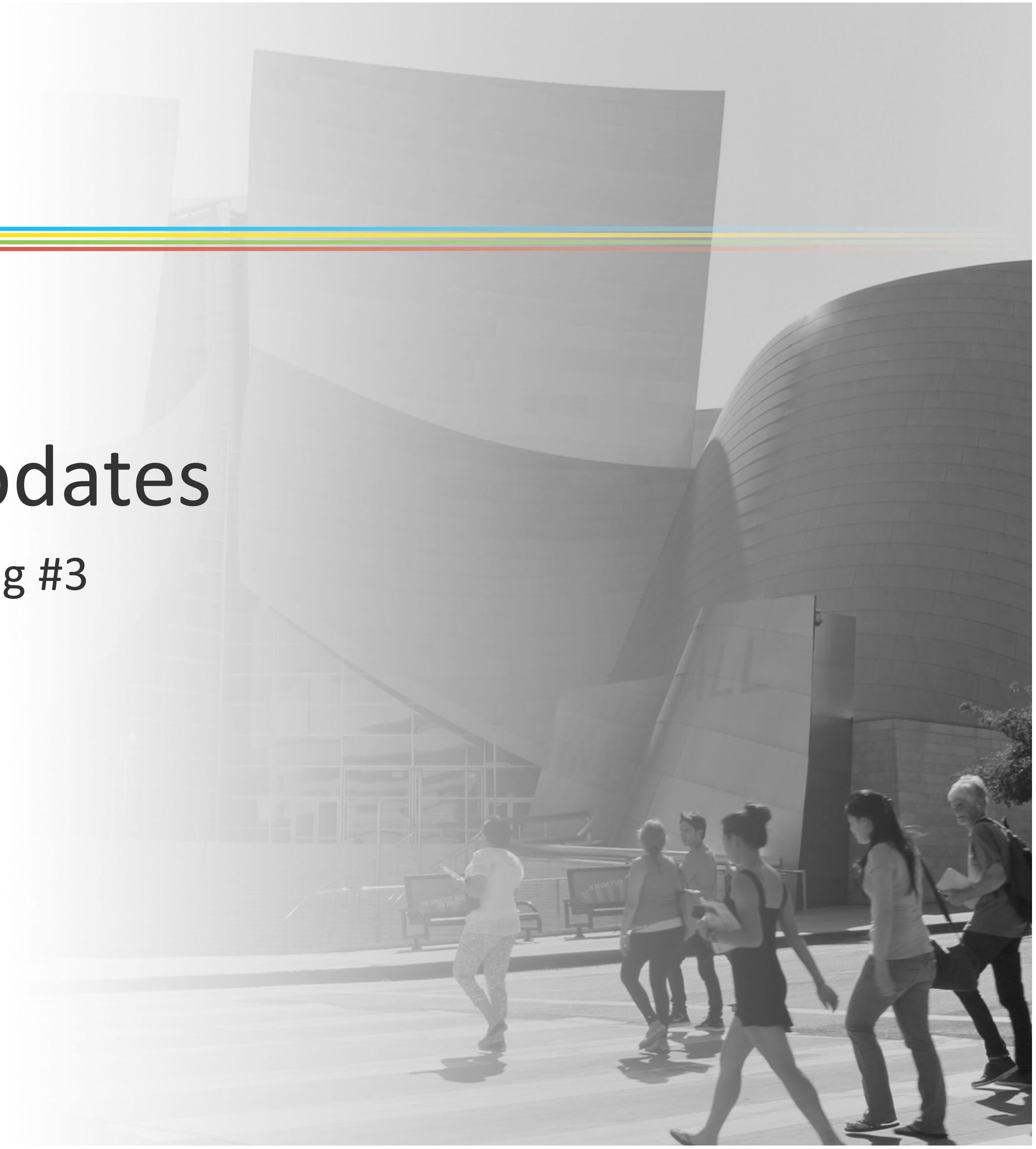
Environmental Justice Updates

Advisory Group Meeting #12, Virtual Meeting #3

Jaquelin Cochran, Ph.D.

National Renewable Energy Laboratory

July 23, 2020



Los Angeles Department of Water & Power

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Environmental Justice: Key Themes

We want to capture some of the themes that have emerged in the LA100 study on environmental justice:

- **Community outreach** (meetings, partner with community organizations, accessible information in materials and presentations, public comment)
- **Better incorporation of the range of EJ and community priorities** as framework for decisions
- **Specific outcomes** (e.g., access to high quality clean energy jobs, affordable rates, local RE infrastructure, low-income programs)

Our Plans to Address These Themes (slide 1 of 4)

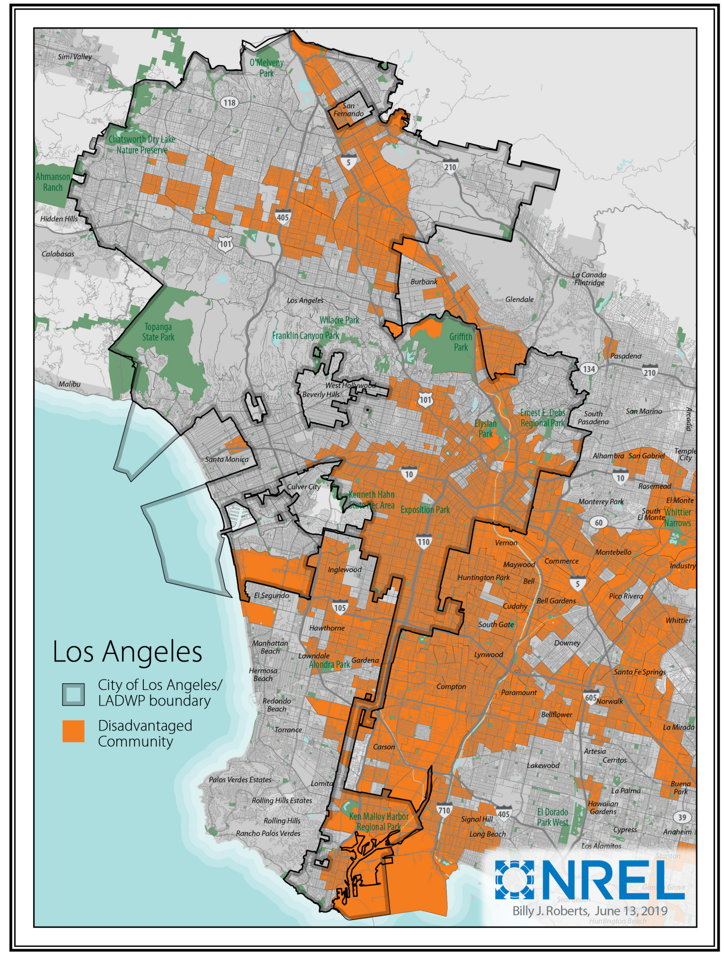
1. **Better incorporate Advisory Group priorities in how we frame our analysis**
   – For example, our effort to encourage Advisory Group input in how we should consider trade-offs among costs, decarbonization, customer-differentiated demand response

Our Plans to Address These Themes (slide 2 of 4)

2. **Hold community meetings to broaden outreach and encourage robust discussion on future of LA's power system / clean energy**
   – Develop materials that can support outreach, specifically by connecting what LA100 scenarios could mean for disadvantaged communities
   – Creating a vision(s) that is tangible, with neighborhood-specific information
      - What could a just transition look like, e.g., prioritizing health and access to jobs and clean energy infrastructure?
      - From a future better grounded in such a transition, how do technical and economic considerations inform choices?
      - How can individuals and communities be part of decision-making?
   – Use first session of AG Meeting #13 (September) to review materials and discuss process for community outreach

Our Plans to Address These Themes (slide 3 of 4)

3. Be specific about how the transition can be more inclusive of disadvantaged communities



Our Plans to Address These Themes (slide 4 of 4)

4. **Facilitate framework for decision-making on investments and programs that connect LA100 analysis with community priorities**
   - For example, are there blends of scenarios that have broad support, such as just transition/access to jobs with rapid decarbonization, with options to reduce costs if technologies or cost reductions do not materialize? Or a more rapid decarbonization for 95% of supply, with a slower pathway for remaining 5%? What does it mean to have broad support?
   - Using the first session of AG Meeting #13, discuss considerations for ensuring broad participation in LADWP and City of LA planning processes that build from LA100.
   - What information outside the scope of LA100, such as policy/program design, could be coupled with study results to support an effective decision-making process?
   - What are the collection of priorities that emerge from the Advisory Group and community outreach that can be a basis for decision-making post-LA100?

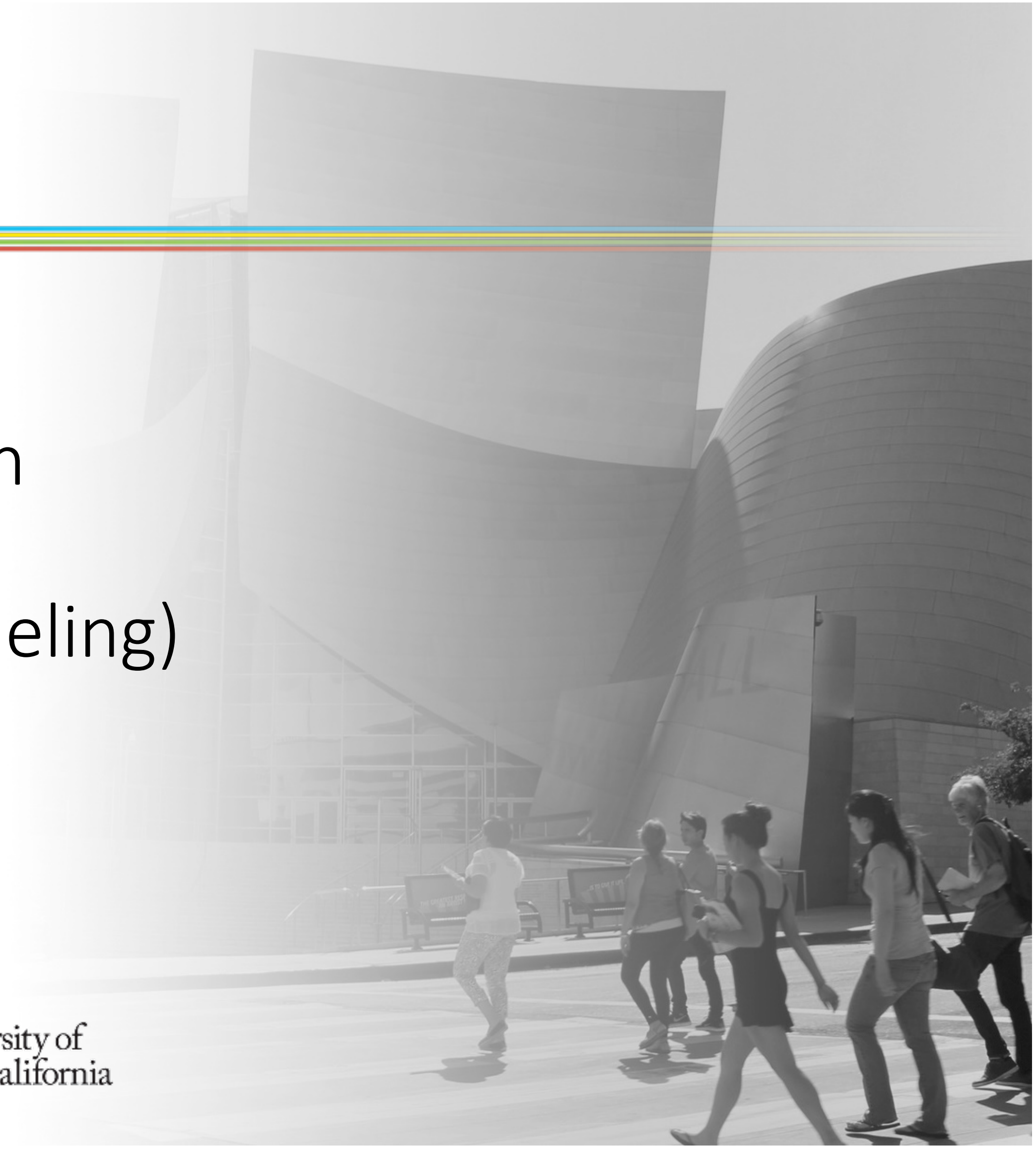
What else should we be thinking about?

Impact of LA100 Scenarios on Air Pollutant Emissions (First Step of Air Quality Modeling)

The Los Angeles 100% Renewable Energy Study

Presenter: Prof. George Ban-Weiss (USC)

Collaborators: Dr. Jiachen Zhang (USC)
Yun Li (USC)
Dr. Vikram Ravi (NREL)
Dr. Garvin Heath (NREL)



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?
   - Pollutants of focus are ozone (O_3) and particulate matter ($PM_{2.5}$)
2) How could changes in O_3 and $PM_{2.5}$ concentrations alter deleterious health consequences from air pollution exposure within LADWP service territory?

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

Overarching Method for Answering 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

While air quality modeling is challenging, time-consuming, and computing resource-intensive, **developing the emissions inventory** (steps 1 and 2) is actually the most time-consuming and critical piece

Constructing a model-ready emissions inventory from source-oriented raw emissions for "current" time

- An air pollutant emissions inventory specifies **where**, **when**, and **how much** of each pollutant is emitted
- Emissions = Activity x Emission factor

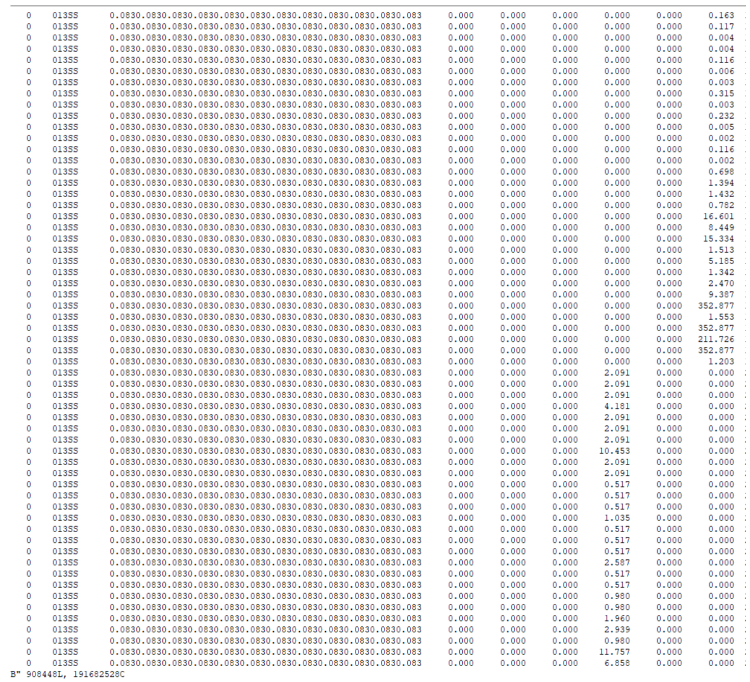
Emissions (kg) =

Activity		Emission factor
Vehicle miles traveled (miles)	×	kg/mile
Engine output of cargo handling equipment (hp-hr)	×	kg/(hp-hr)
Fuel consumption of power plants (MMBTU)	×	kg/MMBTU

Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time

Current inventory is based on the official 2012 South Coast Air Quality Management District (SCAQMD) dataset

- This was the baseline inventory for SCAQMD 2016 Air Quality Management Plan
- This is the latest year inventory that is *source oriented*, which allows us to modify specific sources that change in LA100 scenarios
- There are >5,000 different source types



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For example, the file for most area sources has >900,000 lines.
Each line of the file represents emissions from a specific source in a grid cell.

Four scenarios will be simulated to estimate the impact of future renewable energy adoption

Scenario Name	Natural gas/RECs Biofuel (power)	ELECTRIFICATION of light-duty vehicles and buses, the Port of LA, and buildings
1. CURRENT (2012)	N/A	N/A
2. LA Leads – Moderate Load Electrification	NO	Moderate
3. LA Leads – High Load Electrification	NO	High
4. SB100 – High Load Electrification	YES	High

- Effects of **electrification** can be isolated by comparing:
  ”LA Leads – Moderate Load Electrification” with “LA Leads – High Load Electrification”
- Effects of **removing natural gas power plants** can be isolated by comparing:
  “SB100 – High Load Electrification)” with “LA Leads – High Load Electrification”

Creating emissions inventories that project air pollutant emissions under various future renewable energy adoption pathways

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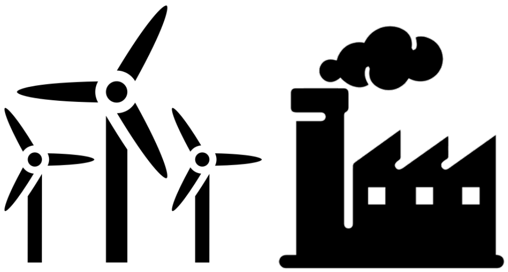
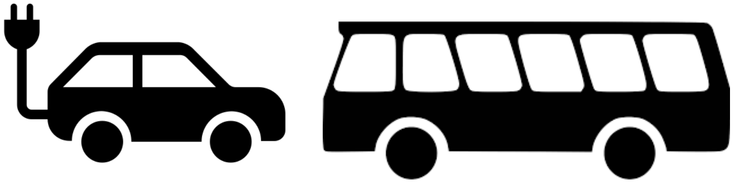
Emissions from four sectors are investigated



Power

Residential and commercial buildings



Transportation:
Light-duty vehicles and buses

THE PORT OF LOS ANGELES

Ocean-going vessels
Cargo handling equipment
Heavy-duty vehicles

Overarching assumptions and methodology for projecting 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

Developing 2045 emission inventories for residential and commercial buildings

	End use	MODERATE Electrification level	HIGH Electrification level
Commercial	Water heating	72%	100%
	Space heating	81%	96%
Residential	Water heating	50%	100%
	Space heating	49%	91%
	Clothes drying	93%	100%
	Cooking	53%	100%

Residential/commercial 2020 raw emissions

Source: SCAQMD

×

Scaling factor for natural gas consumption from 2020 to 2045

Source: NREL building energy demand models

×

Control factor for emission factor from 2020 to 2045

Source: SCAQMD

=

Emissions in 2045

Developing 2045 emission inventories for the Port of LA

	Moderate Electrification	High Electrification
Ocean-Going Vessels (OGVs, shore power at berth)	80%	90%
Cargo Handling Equipment (CHE)	100% (45%)	100% (80%)
Heavy Duty Vehicles (HDVs)	100% (10%)	100% (25%)

(Percentages in parentheses are those used in load modeling at the Port.)

2031 raw emissions

Source: SCAQMD

×

Scaling factor for activity

Source: NREL projections

×

100% minus electrification level

Source: NREL projection, The Los Angeles and Long Beach ports' 2017 Clean Air Action Plan

×

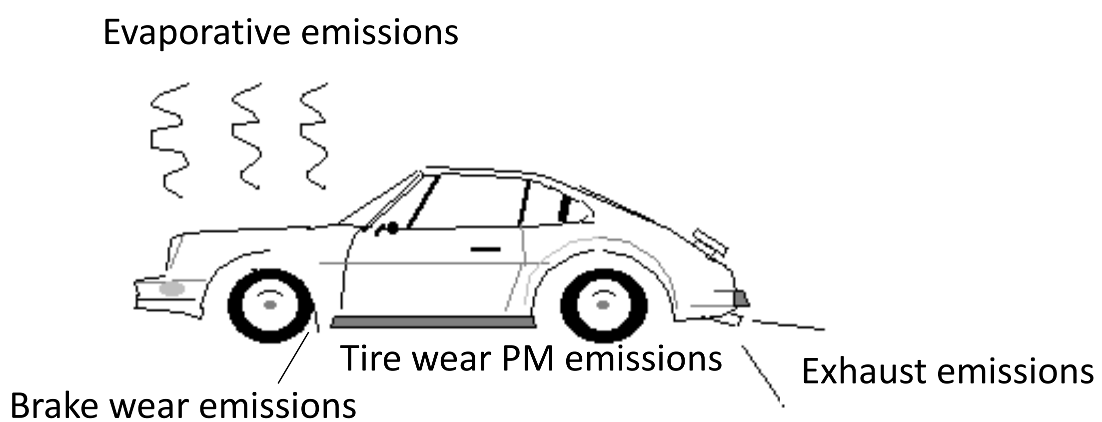
Control factor for emissions for OGVs

Source: Official emissions model from the California Air Resources Board

Developing 2045 emission inventories for the transportation sector

	Moderate Electrification	High Electrification
Light-duty vehicles	30% of stock is plug-in electric vehicles* (PEV)	80% of stock is PEV
School and urban buses	100%	100%

*PEVs consist of 50% plug-in hybrid vehicles and 50% battery electric vehicles



We evaluated the impact of electrification on various emission processes and sources from vehicles

Developing future emission inventories for the power sector

	SB100	LA Leads
Natural gas	Allowed	Not allowed for LADWP Allowed for other utilities
Hydrogen	Allowed	Allowed

*Note that power plants that are not owned by LADWP will follow SCAQMD 2031 projections.

Hourly fuel consumption in 2045
- Existing power plants
- Newly built power plants

Source: NREL's capacity expansion and operation models

×

Emission factors
- Natural gas
- Hydrogen

Source: Literature, SCAQMD regulatory limits

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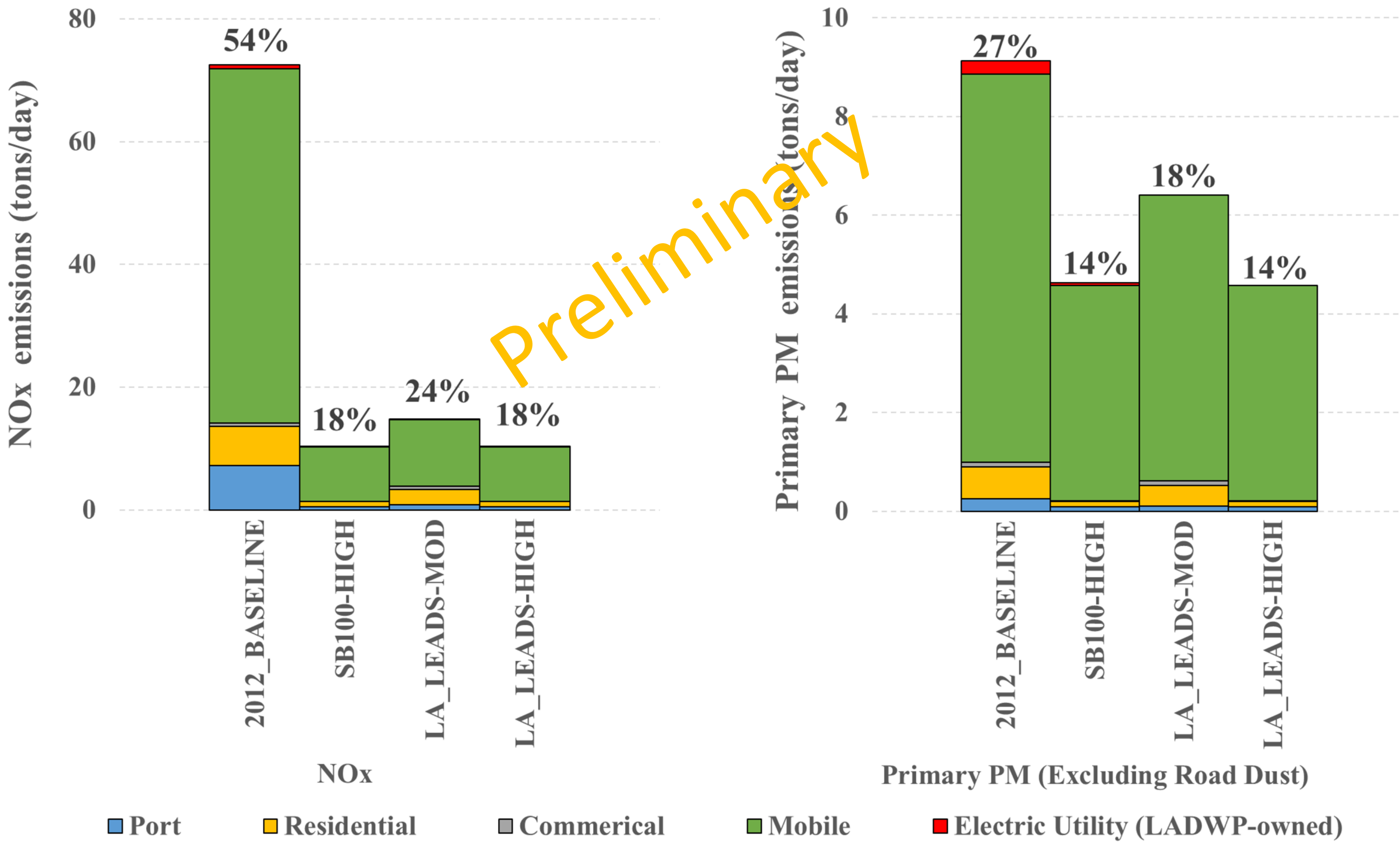
Emissions in 2045

Results: Contribution of LA100-related sectors to annual average emissions in the City of Los Angeles in 2045



- 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
- % represents the fraction of emissions that are from the five LA100-related sectors

Preliminary results: Annual total NOx emissions for LADWP-owned power plants located in the South Coast Air Basin

Fuel technology in 2045	Emission factor (kg/MMBTU)	2045 Emissions for SB100-HIGH (kg)	2045 Emissions for LA_LEADS-HIGH (kg)	2045 Emissions for LA_LEADS-MOD (kg)	2012 Emissions (kg)
NG Combined cycle	0.0033	34,782	0	0	198,657 (including all types of power plants)
NG Combustion turbine	0.0041	25,662	0	0	
H_2 Combustion turbine	0.0028*	43	8,612	6,619	0

*NOx emissions of H_2 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 PM, CO, sulfur dioxides, and organic gas emissions** from H_2 combustion turbines (which exclusively burn renewably-derived H_2).
- Note that **CO_2 and methane (GHG) emissions from H_2 combustion turbines are zero**.

Next steps

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

Questions?

LA100

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Methodology and Assumptions for Mortality Analysis and Monetization of Environmental Benefits

Presenter: Dr. Garvin Heath and David Keyser (NREL)

Collaborators: Dr. Vikram Ravi (NREL)

Prof. George Ban-Weiss, Dr. Jiachen Zhang and Yun Li (USC)

Los Angeles Department of Water & Power | NREL Transforming ENERGY

Air Quality Analysis Goals: Recap

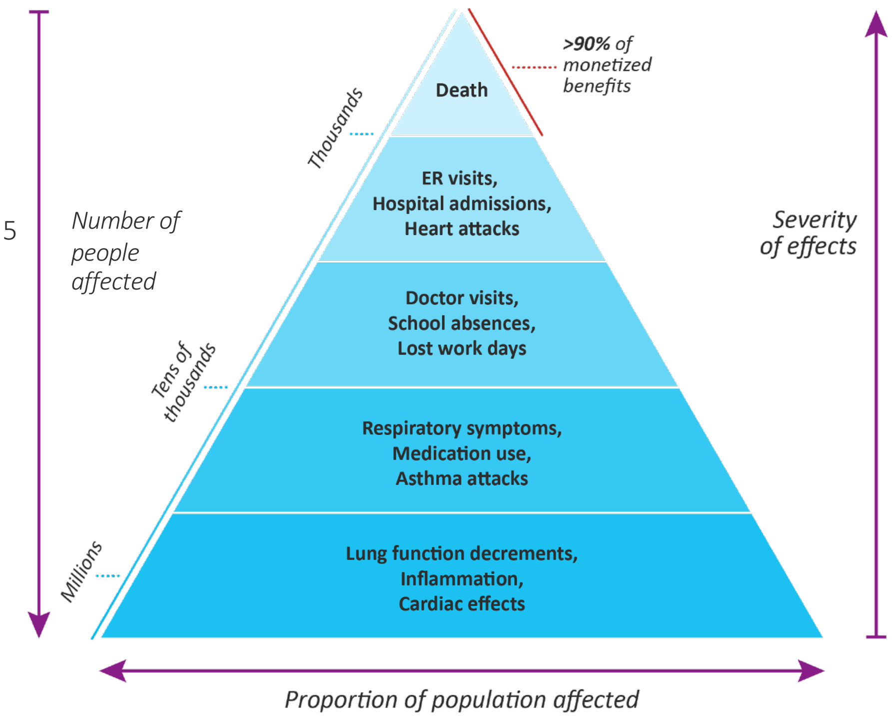
Overarching questions:

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 LADWP service territory?
    - Mortality and selected morbidity outcomes *(mortality is newly added)*
3) Monetize the health benefits from air pollution and GHG, and compare to other project costs *(newly added scope)*

Our air quality modeling will 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 (AKA "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 $PM_{2.5}$ (1^{st}) and ozone (2^{nd})
  - 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)]

Overarching Method for Answering Research Questions

1) Constructing a model-ready emissions inventory from source-oriented raw emissions for "current" time
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6) Presentation of air quality and public health results, and handoff of results for evaluation of effects on environmental justice

While air quality modeling is challenging, time-consuming, and computing resource-intensive, **developing the emissions inventory** (steps 1 and 2) is actually the most time-consuming and critical piece

Overarching Method for Answering Research Questions

(added #5 as new scope)

1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time
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While air quality modeling is challenging, time-consuming, and computing resource-intensive, **developing the emissions inventory** (steps 1 and 2) is actually the most time-consuming and critical piece

Assessing changes in health impacts from exposure to ozone and $PM_{2.5}$

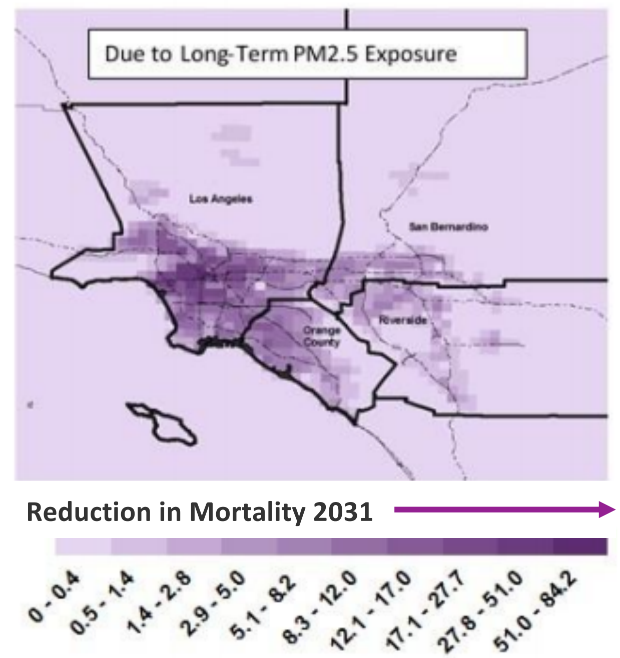
Premature Mortality (Ozone & $PM_{2.5}$)

- We will quantify premature deaths from exposure to pollutants:
  - Avoided premature deaths from change in the concentration of $PM_{2.5}$ and ozone

Morbidity (Ozone & $PM_{2.5}$)

- We will quantify morbidity health effects that are the same **health indicators used in the CalEnviro Screen**, specifically:
  - Emergency department visits for asthma (resulting from O_3 and $PM_{2.5}$) and
  - Emergency department visits for cardiovascular causes ($PM_{2.5}$)

Decreased mortality from improved air quality in 2031 in South Coast Basin

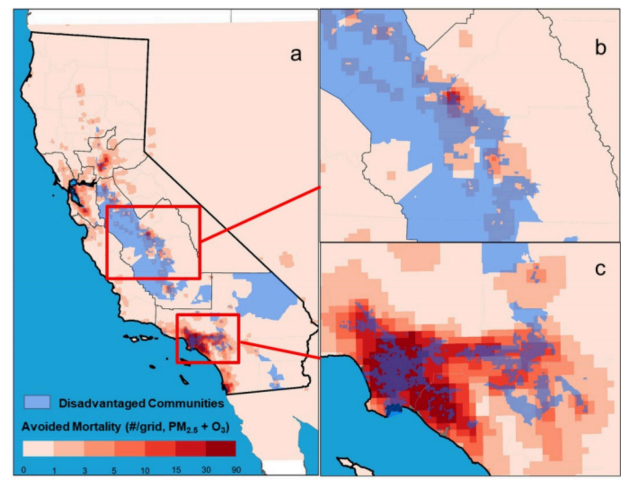


deaths reduced per grid cell; Source: SCAQMD (2017)

Health Impacts Analysis Tool: BenMAP-CE

- We will use **Benefit Mapping and Analysis Program – Community Edition (BenMAP-CE)** to estimate the health impacts and economic valuation from exposure changes to fine particulate 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; Sacks et. al., 2018)
- 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 (Regulatory Impact Analyses Website)
  - CARB: estimate health effects of air pollution (CARB Research Division)
  - SCAQMD: 2016 Air Quality Management Plan (Appendix 3-B: Quantification of Public Health Benefits, 2017)
  - 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

BenMAP
COMMUNITY EDITION



Mortality changes from an air pollution reduction scenario (Wang et al, 2020)

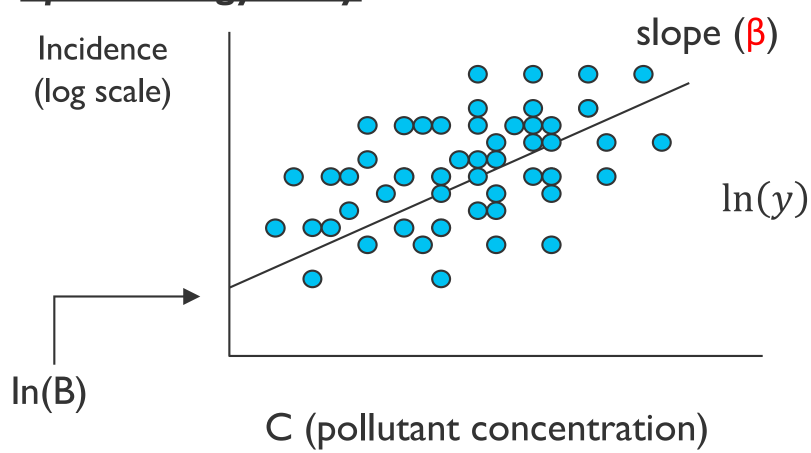
Available Health Impact Functions in BenMAP (Sacks et al., 2018)

Category	Health Endpoint	PM2.5	Ozone
Mortality	Premature mortality	✓	✓
Cardiovascular 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		✓

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

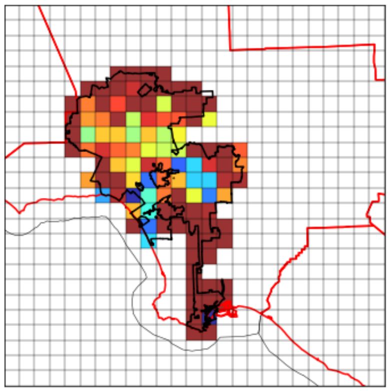
ß – effect estimate

pop – Exposed population

ΔC – pollutant concentration (air quality) change

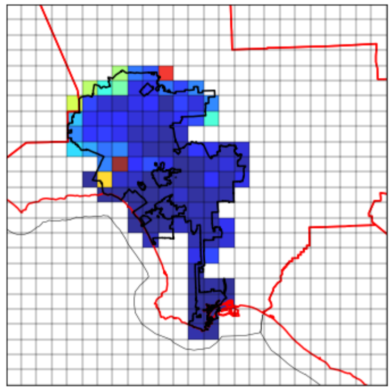
Health Impacts Calculation in BenMAP

Concentration change Δ**C**



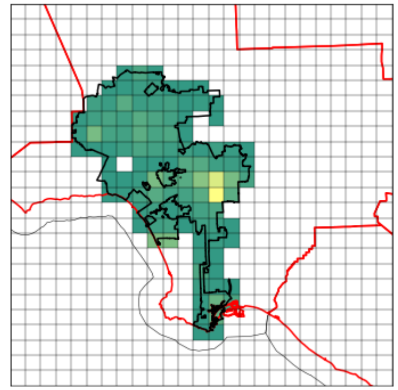
Concentration change surfaces at 2km x 2km grids from WRF-Chem

Exposed population ***pop***



Population distribution by age from BenMAP

Baseline incidences ***Yo***



Baseline incidence data from BenMAP

ß

effect estimate

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

health impact

(Example data only)

Monetization of health impacts due to pollutant concentration changes

Mortality

Value of a statistical life (VSL) reflects the $ value for reduced mortality. It is the monetary value that a group of people are willing to pay to reduce the risk of premature deaths.

1/10,000

In a population of 10,000, reducing pollution would avoid one premature death *(i.e. reduce risk by 1 chance in 10,000)*

PAY **$500** PER REDUCED RISK

Each of 10,000 are willing to pay $500 to reduce risk of death by 1 chance in 10,000

$500 x 10,000 = **$5 million**

VSL is then WTP multiplied by the inverse of the risk reduction

Morbidity

Cost of illness (e.g., hospital admission costs, prescriptions) is used for other health effects. This is used to monetize morbidity.

100

An air quality policy reduces the number of hospital admissions by 100

SAVE **$5,000** PER AVOIDED ADMISSION

The economic value of each avoided admission is $5,000 in the year 2010

100 x $5,000 = **$500,000**

The economic value is the number of cases multiplied by the value of each admission

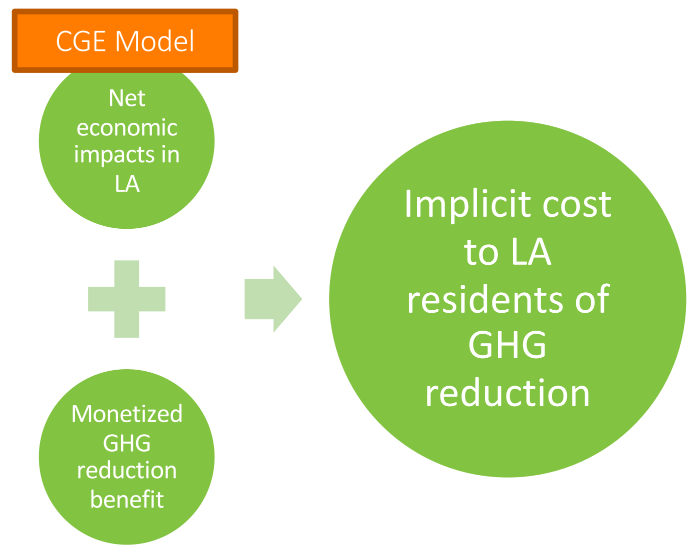
BenMAP-CE also includes valuation functions for various health end-points

Monetization of GHG reduction

- Monetization methodology follows the 2016 Interagency Working Group on the Social Cost of Carbon (IWGSCC)
  - Number of government agencies (Agriculture, Energy, EPA, Commerce, Transportation, Treasury overseen by the Council of Economic Advisors and Office of Management and Budget)
  - Looks at productivity, property, health, valuation of ecosystems
  - Combination of a review of academic literature, integrated assessment modeling, and public input

Estimating the implicit cost of GHG reduction

- Computable equilibrium (CGE) modeling provides a second methodology
- CGE assesses costs and benefits of GHG reduction
- Combined with monetization method (previous slide) → Net economic impacts within LA
- Same methodology applied to the Colorado renewable portfolio standard
  - Finding: In certain circumstances related to renewable energy variability even though the economic impact is negative, the overall impact is positive due to IWGSCC carbon cost estimates (*Journal of Energy Policy*)



Results of health impact analysis

Scenario (2045)	Avoided Premature Deaths (95% Confidence Interval)		Avoided Emergency Department Visits (95% Confidence Interval)	
	$PM_{2.5}$	Ozone	Asthma	Heart Attack
SB100 – High				
LA Leads – Moderate				
LA Leads – High				

Health benefits in the future from improved air quality for various scenarios will be calculated with respect to the base year air quality (2012)

Monetized health benefits from LA100 scenarios

Scenario (2045)	Value (million $) (95% Confidence Interval)		
	Mortality	Morbidity	Total
SB100 – High			
LA Leads – Moderate			
LA Leads – High			

Monetization of health benefits in the future from improved air quality for various scenarios will be calculated with respect to the base year air quality (2012)

Monetized benefits from GHG

Scenario	Value (million $) (95% Confidence Interval)		
SB100 – High			
LA Leads – Moderate			
LA Leads – High			

Discussion

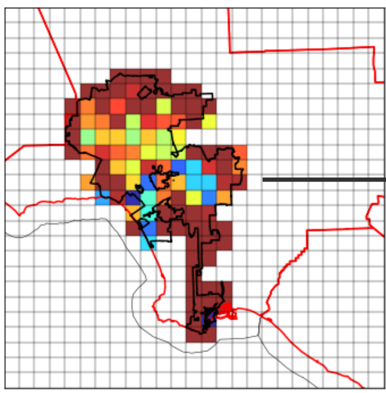
The Los Angeles 100% Renewable Energy Study

Health Impacts Calculation in BenMAP

Start with the health impact function

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

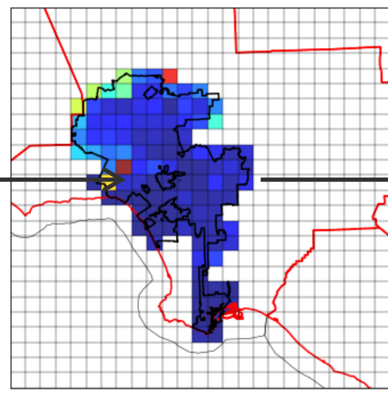
Concentration change ΔC



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

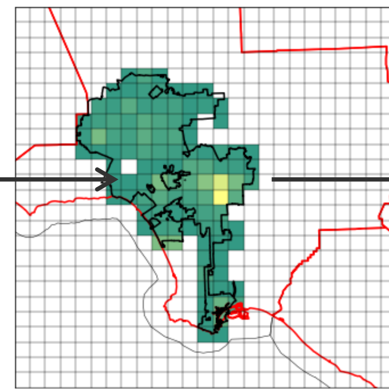
(Example data only)

Exposed population ***pop***



Population distribution by age from BenMAP

Baseline incidences ***Yo***



Baseline incidence data from BenMAP

ß

effect estimate

health impact

ΔY