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NATIONAL RENEWABLE ENERGY LABORATORY

LA DWP

Environmental Modeling for Los Angeles 100% Renewable Energy Study

Garvin Heath, PhD
Haley Lewis

August 16, 2018

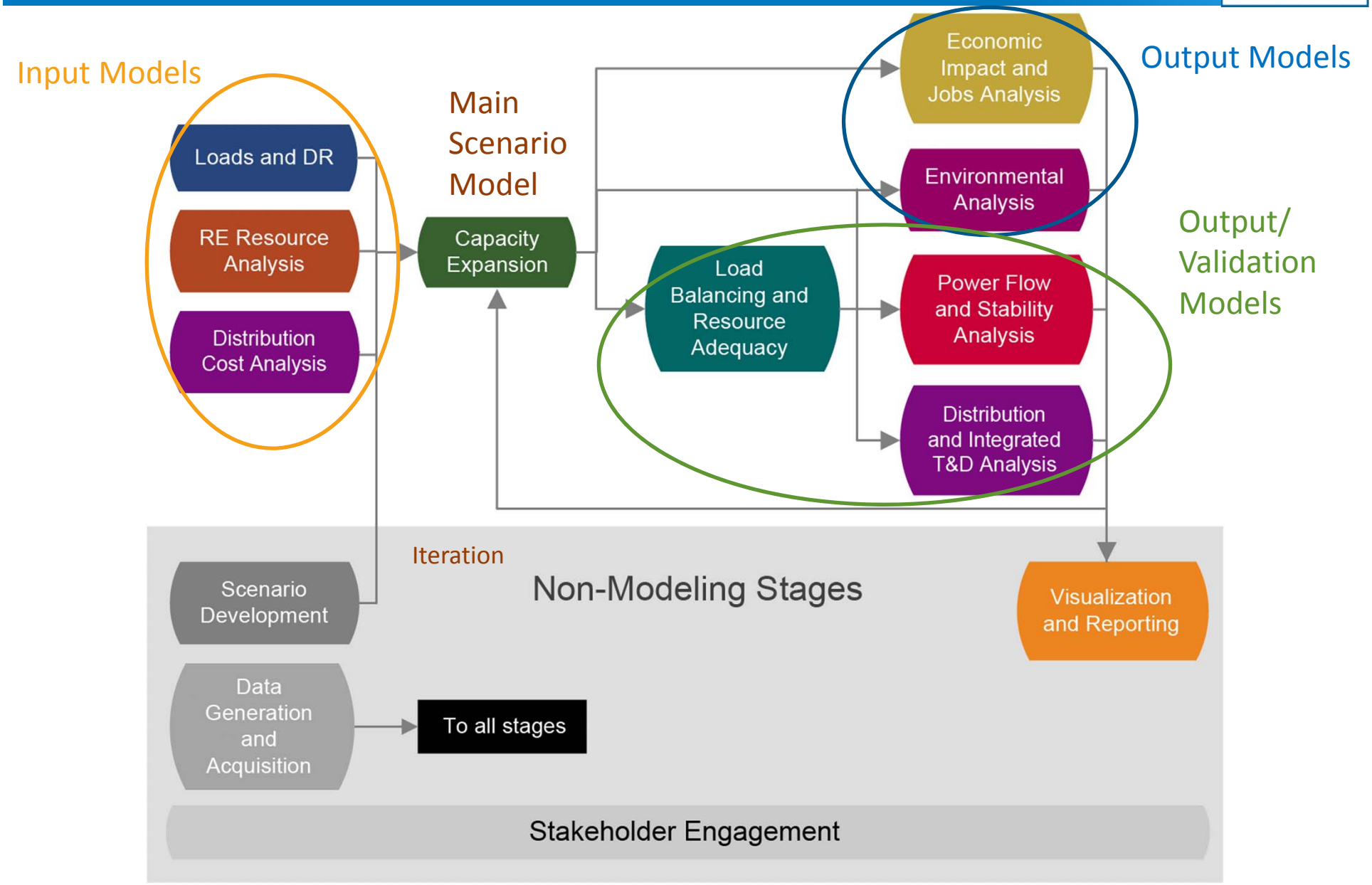
Goals for Presentation

- Establish familiarity with our methods
  - More detailed for GHG emissions analysis
  - General approach for air quality, public health, and environmental justice
- Demonstrate how environmental modeling will meet the City Council Motions
- Convey timing of environmental modeling (follows main modeling and analytical tasks of the study)
- Use your questions and comments to clarify and improve the study!

Outline

- Where environmental modeling fits in the LA 100% RE study
- Relationship to City Council Motions
- Major components of environmental modeling and (planned) team
- Greenhouse gas (GHG) analysis: experience, methods, and sample results
- Air quality and public health approach
- Environmental justice (EJ) approach

Study Modeling Stages *(previously presented)*



Environmental Modeling Requires Results of Electric-Sector and Loads Modeling

1. Data collection, scenario development
2. Estimate load growth and demand profiles
3. Determine renewable resource availability and generation profiles
4. Estimate distribution system hosting capacity and upgrade costs
5. Develop optimal expansion plan and distributed resource adoption scenario
6. Simulate grid operations and performance including load balancing, operating reserves and resource adequacy
7. Evaluate transmission system reliability
8. Validate distribution system operation and integrated T&D system performance
9. Evaluate environmental benefits and impacts
10. Evaluate local job and economic development impacts
11. Visualization and reporting


But One Step Precedes:
Determination of EJ Neighborhoods

Determination of EJ Neighborhoods Early in Study Will Help Target Approach for EE/RE

1. Data collection, scenario development
- *Define EJ neighborhoods for energy efficiency (EE)/renewable energy (RE) targeting*
2. Estimate load growth and demand profiles
3. Determine renewable resource availability and generation profiles
4. Estimate distribution system hosting capacity and upgrade costs
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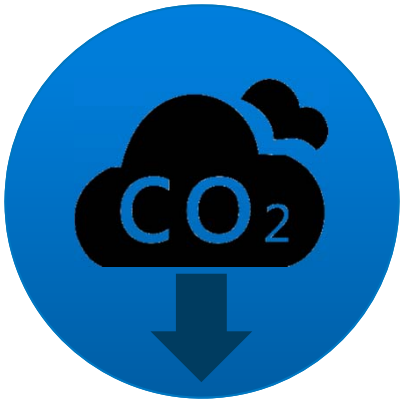
Relationship of Env. Modeling to City Council Motions

Motion Date	Motion Language	Action
March 2, 2016	"Develop and implement a research partnership … to achieve a 100% renewable energy portfolio for LADWP."	Study initiated
Sept. 16, 2016	"work with local academic institutions."	Academics are on Advisory Group; Contracting in progress
August 1, 2017	"The prioritization of environmental justice [EJ] neighborhoods as the first immediate beneficiaries of localized air quality improvements and GHG reduction."	Requires the analysis of GHG emissions and air quality-related health impacts
August 1, 2017	"Incorporation of the CalEnviro Screen …"	Basis of EJ neighborhood determination early in the project

Environmental Modeling Components

Integration of renewable energy into LADWP generation assets and managed loads has numerous benefits:



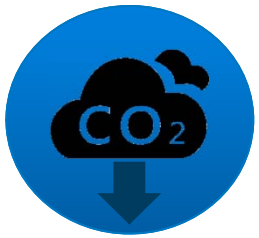
Reduction in GHG Emissions

Improved Air Quality

Improved Public Health

These analyses are followed by spatial assessment of air quality and public health improvements to compare differences across neighborhoods (EJ and non-EJ)

Team *(pending finalization)*



GHG Emissions → NREL (Heath)

Air Quality Modeling → [under discussion]

Health Effects Modeling → [under discussion]

EJ Effects → NREL (Heath, GIS team)

Bio: Garvin Heath

- 10 years at NREL leading sustainability analyses for all generation technologies as well as fuels, both renewable and conventional
- PhD from UC Berkeley
  - Energy and Resources Group
  - Dissertation advisor was an air quality engineer (which is what I am trained as)
  - Dissertation looked at the implications for inhalation exposure of shifting from large-scale power plants to small-scale (distributed generation) sources that still emit air pollutants

Methods for GHG Analysis

Scope of GHG Analysis

- NREL's Resource Planning Model directly estimates CO_2 emissions from combustion
- The study could simply use this output for LADWP-owned assets and finish there
  - This is perhaps where most analysts would stop

Goal of GHG Analysis: Include all *Attributable* GHG Emissions from Each Scenario

Besides combustion, there are other GHG emissions that are attributable to the electric sector:

1. Every electric generation technology, even RE, has to be built, operated, and decommissioned—and those activities have GHG emissions
   - Life-Cycle Assessment is a well-recognized method to quantify these emissions (see next slide)

2. Changes to one part of the electric network can impact how other parts of the network function, so changes to LADWP assets can affect assets in CAISO and beyond
   - Increasing variable RE generation can cause increased ramping, part-loading, and cycling of remaining fossil assets that degrade their performance (efficiency)
   - Not found to lead to significant degrading of the GHG emission benefits of increasing RE, but should be taken into account to address concerns

3. There are other GHGs besides CO_2—methane, nitrous oxide—that are important for certain generation technologies, even those considered renewable
   - Examples include biogas sources (landfill gas, waste water treatment plants, etc.)

Life-Cycle Assessment (LCA): Quantifying Attributable Impacts (e.g., Energy Choices)

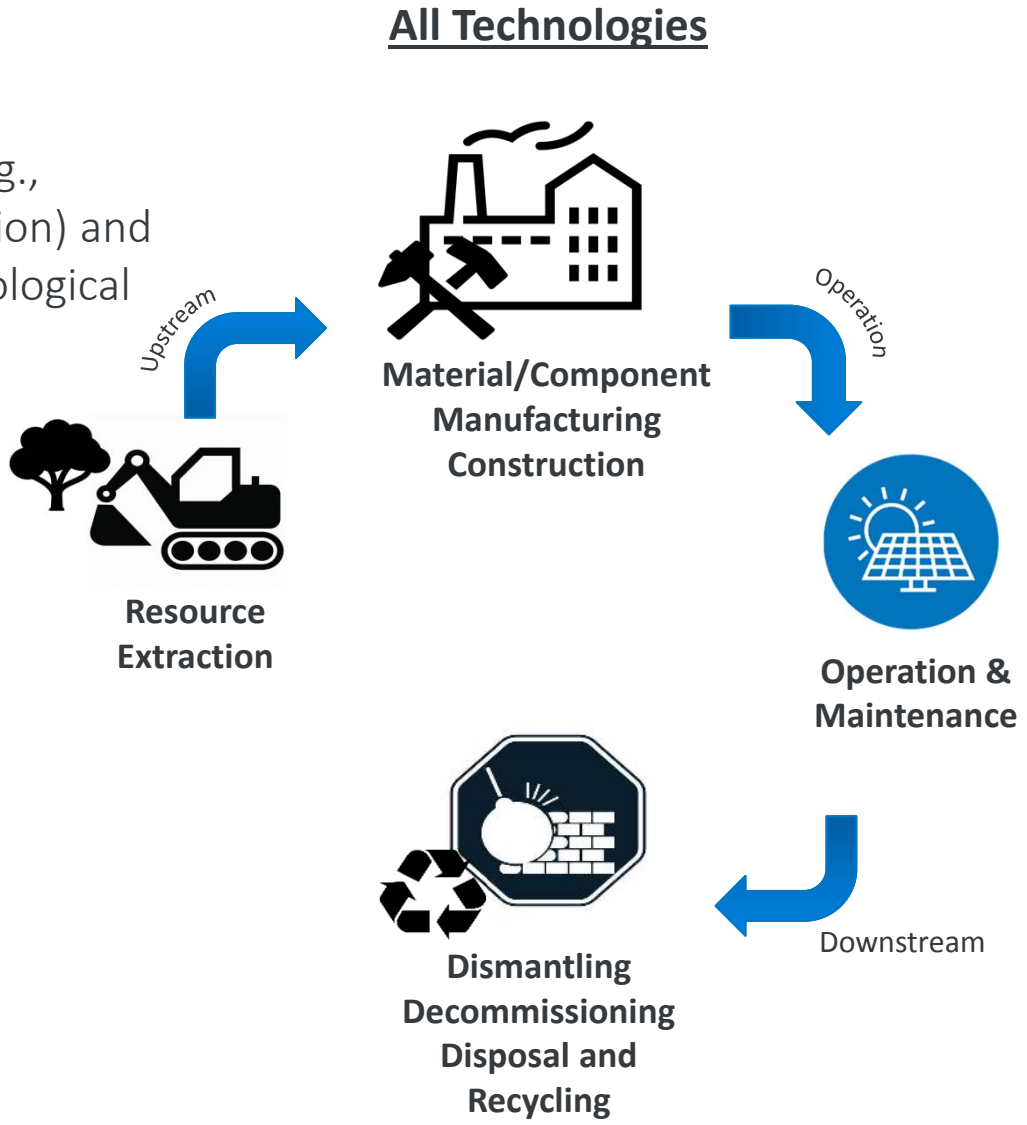
LCA quantifies resource consumption, energy use, and emissions, from cradle to grave

- Practiced for 40 years
- Methods codified in standards (e.g., International Standards Organization) and guidelines, though some methodological issues persist

Forms a basis for consistent comparison of renewable and conventional energy technologies, internationally recognized and used in, for example, Intergovernmental Panel on Climate Change (IPCC) reports

Typical metrics:

- GHG emissions
- Water consumption and discharges
- Energy use
- Raw material consumption
- Air pollutant emissions



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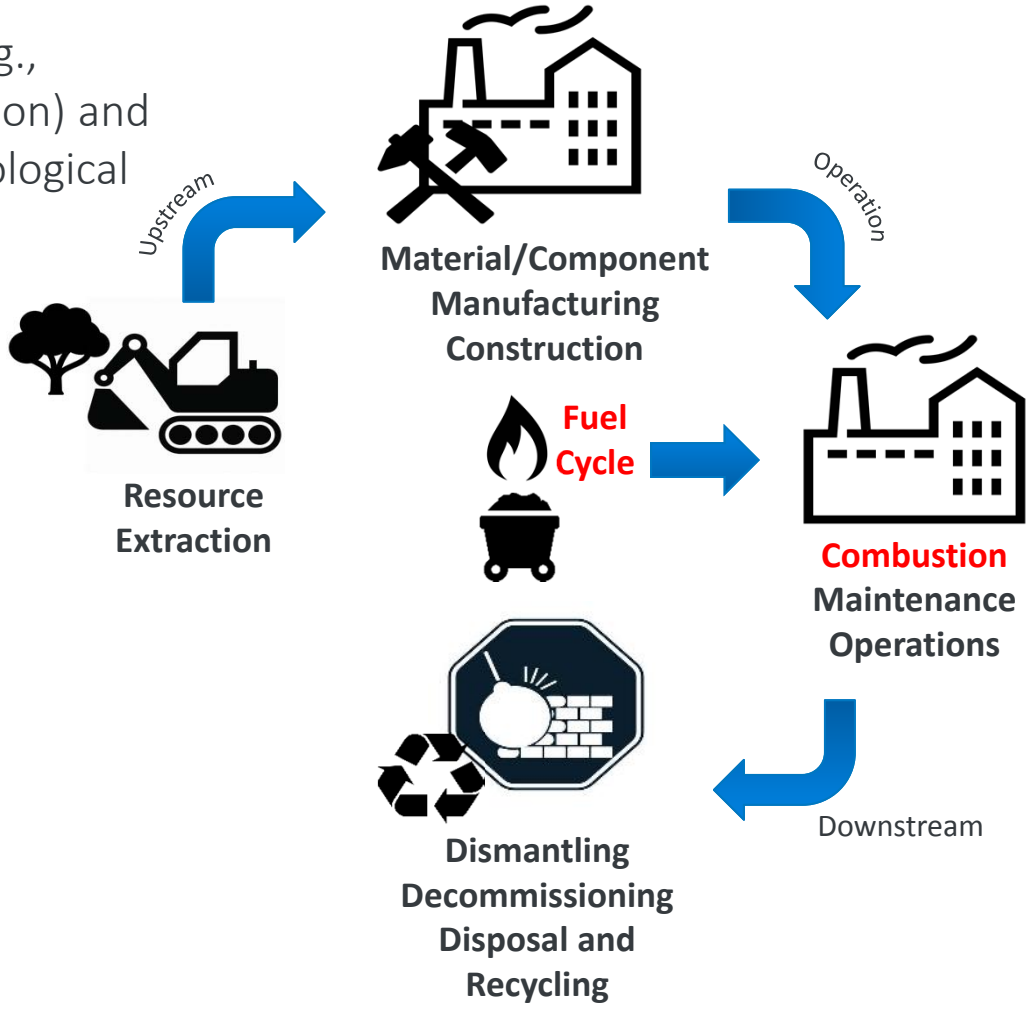
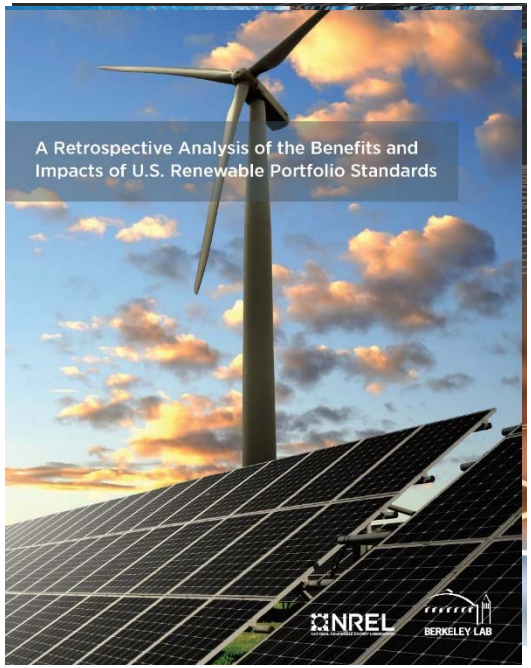
Combustion Technologies



NREL's GHG Emissions Analysis for Electric-Sector (and Fuel) Transformation Is Unparalleled

- IPCC Special Report on Renewables (SRREN)
- Renewable Electricity Futures
- On the Path to SunShot (SunShot Vision II)
- IPCC 5th Assessment Report (AR5)
- Wind Vision
- Hydropower Vision
- Renewable Portfolio Standards (RPS) Retrospective Benefits Analysis

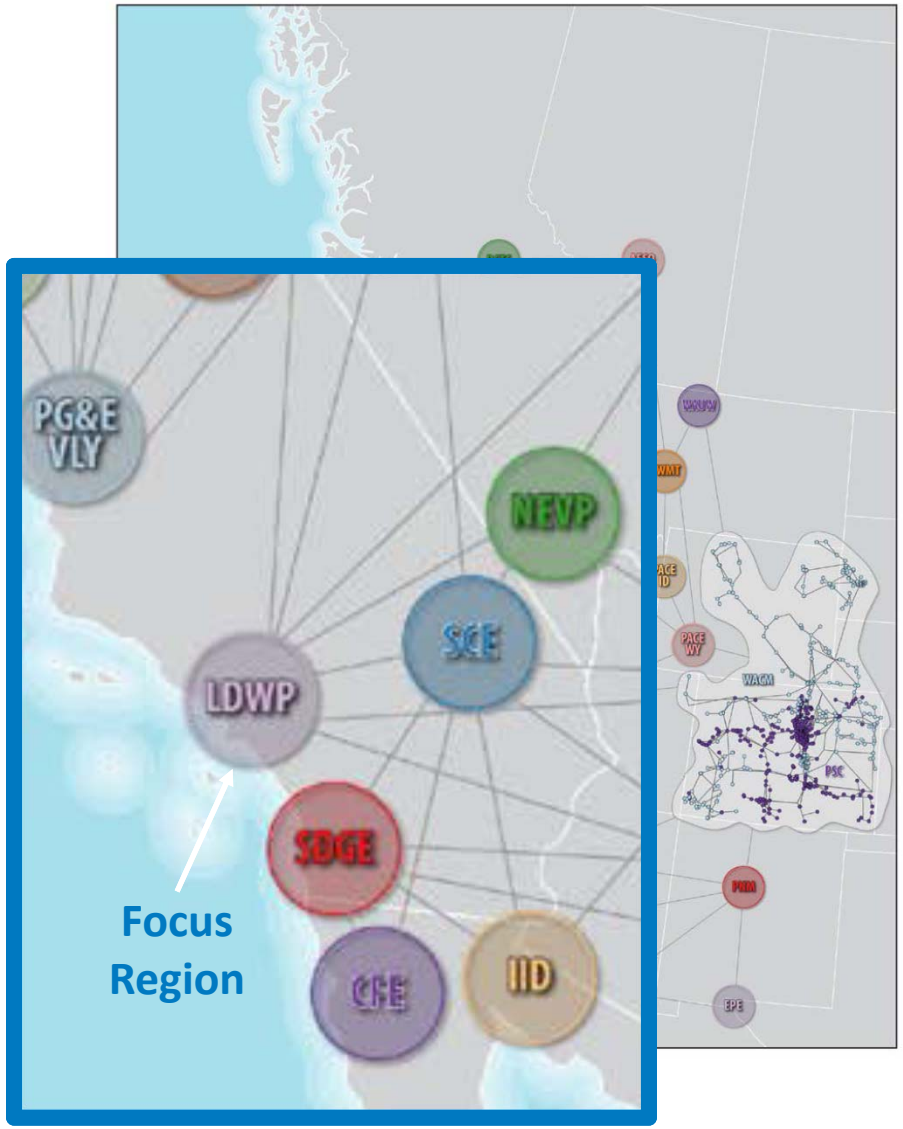


General Approach to Estimating Life-Cycle GHG Emissions

Step 1:

Resource Planning Model directly estimates combustion CO_2 emissions

- Resource Planning Model is NREL's regional electric sector capacity expansion model
- These emissions are estimated for LADWP (for each unit) and all regionally connected generators (in technology categories within each balancing area)



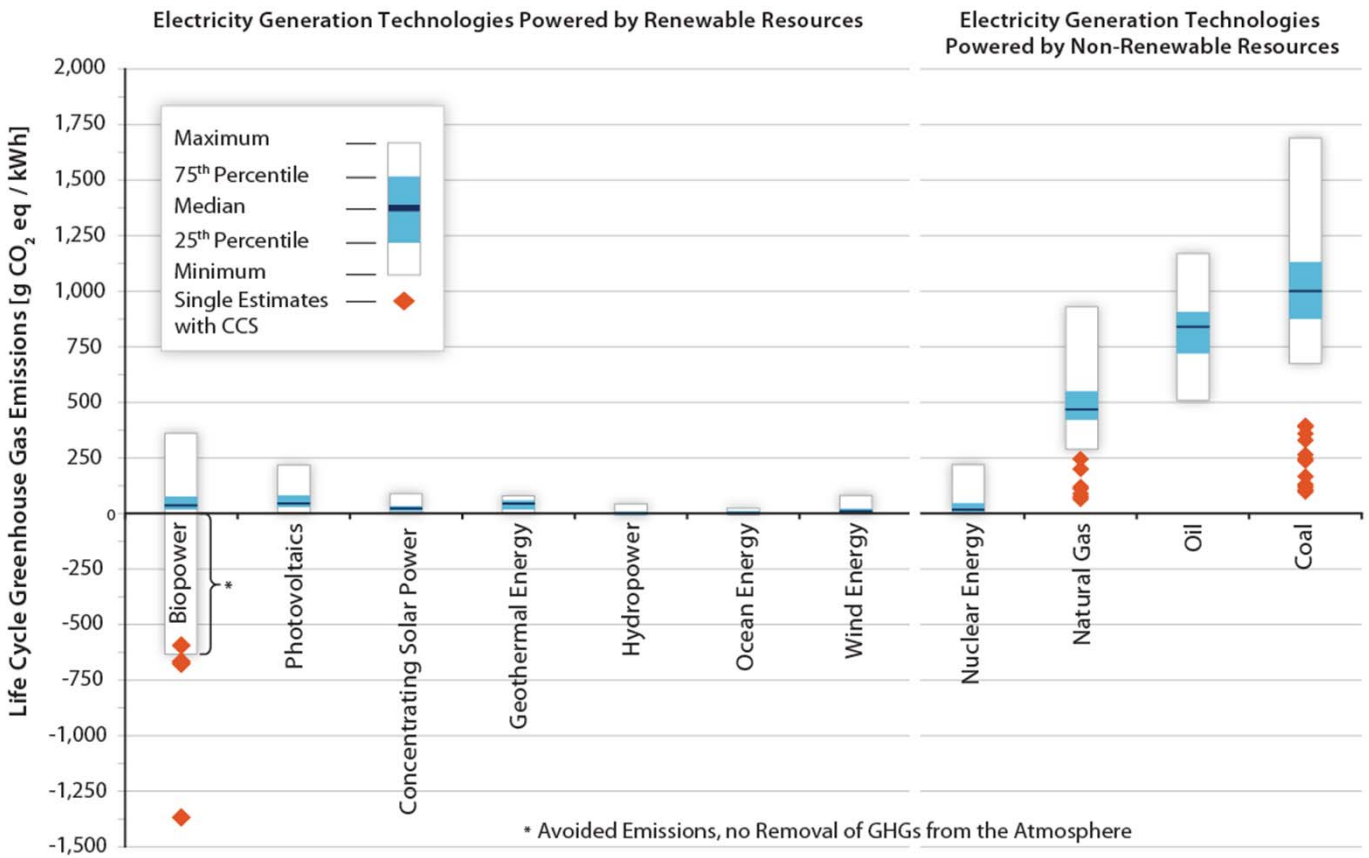
General Approach to Estimating Life-Cycle GHG Emissions

Step 2:

NREL's prior reviews of LCAs supporting the previous list of studies provide estimates for non-combustion GHG emissions, including non-CO_2 emissions:

- Three additional life-cycle phases:
  1. Upstream materials manufacturing and plant construction (per unit capacity)
  2. Downstream plant decommissioning (per unit capacity)
  3. Ongoing operations and maintenance, as well as fuel cycle emissions that are modulated by generation (per unit generation)
- One technology not previously evaluated: **battery storage**
  - Will follow same systematic literature review approach as for all prior evaluations

Systematic Review of ALL Published LCAs: IPCC Special Report on Renewables (2012)



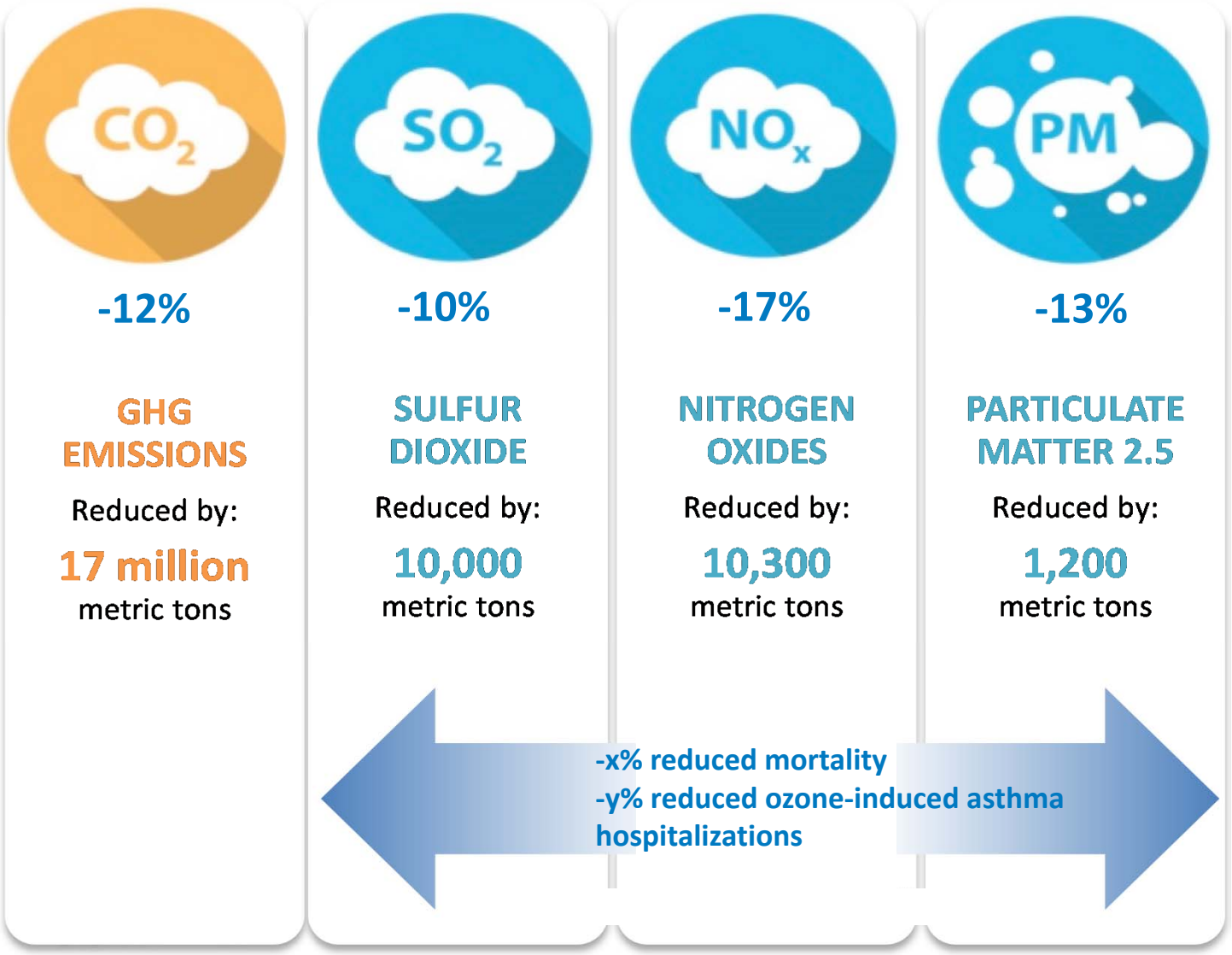
	Biopower	Photovoltaics	Concentrating Solar Power	Geothermal Energy	Hydropower	Ocean Energy	Wind Energy	Nuclear Energy	Natural Gas	Oil	Coal
Count of Estimates	222(+4)	124	42	8	28	10	126	125	83(+7)	24	169(+12)
Count of References	52(+0)	26	13	6	11	5	49	32	36(+4)	10	50(+10)

This plot shows the data that will be used in LA100, plus about 500 more studies subsequently reviewed (total close to 3,000, with consistent results to those shown here)

IPCC SRREN, Summary for Policy Makers, Fig. 8

CCS = carbon capture and sequestration

Illustrative Example of How Study Results Can Be Presented: National Benefits of End-of-2014 (existing) Solar Capacity



We will differentiate between emissions reductions within and outside of the City of LA

(percent results are illustrative of how study results can be presented)

Source: The Environmental and Public Health Benefits of Achieving High Penetrations of Solar Energy in the US

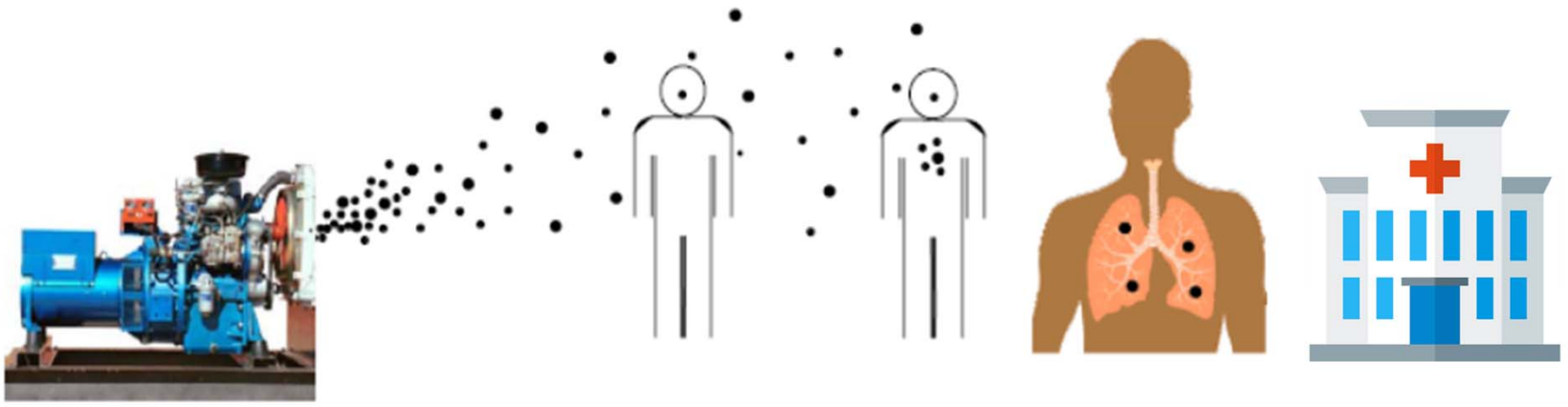
Approach for Air Quality and Public Health Modeling

City Council Requirements

August 1, 2017	"The prioritization of environmental justice neighborhoods as the first immediate beneficiaries of localized air quality improvements and GHG reduction."	Requires the analysis of air quality-related impacts

- This study fits into a long history of air quality challenges for LA and the South Coast Air Basin that continue today
- Reducing emission sources is the **key strategy** to managing air quality (once emitted, there is almost no way to control air pollution)
- "Local air quality improvements" relates to the concentration of air pollutants where people are
  - Further, they relate to the health impacts caused by these localized air pollutant concentrations

The Environmental Health Continuum



emissions → concentration → exposure → intake → dose → health effects

Air quality modeling

Environmental health / public health modeling

- Air quality modeling began in LA; many models to choose from that have been built or calibrated for LA
- Public health is based on observed relationships between (ambient) pollutant concentrations and health effects (epidemiology)
  - Reduced air emissions → reduced concentrations → reduced health impacts = benefits of 100% RE scenarios

Source: Heath, 2006

Air Pollutants and Health Effects of Concern

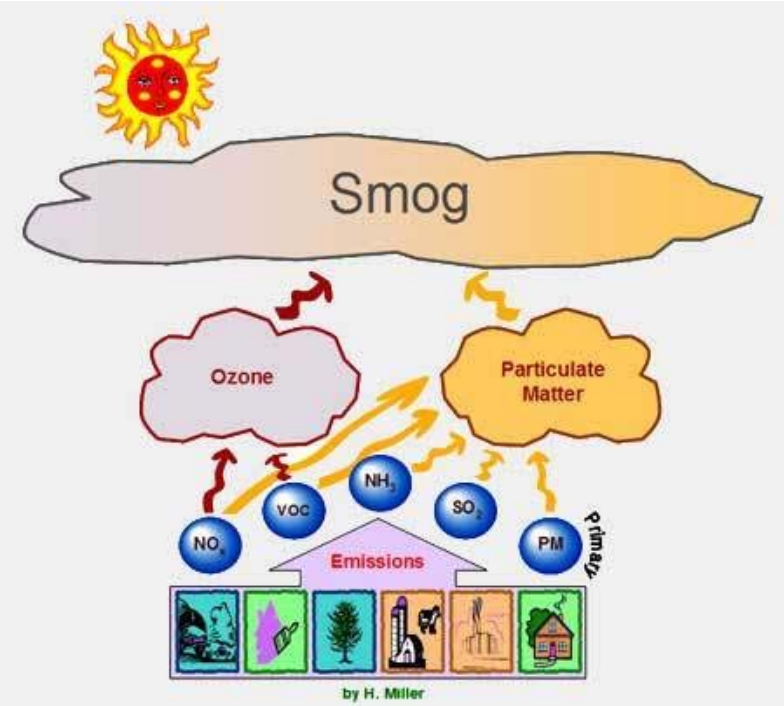
- LA is out of compliance (AKA "nonattainment") with the National Ambient Air Quality Standards (NAAQS) for two key pollutants:
  1. **Ozone (O_3)**
  2. **Particulate matter (PM)**, especially "fine PM" = $PM_{2.5}$

- Health effects with the greatest damages in monetary terms are:
  1. **Premature mortality** from long-term exposure to $PM_{2.5}$
  2. **Hospitalizations related to asthma** made worse (or instigated by) short-term exposure to ozone

- We will focus our air quality and public health modeling on these pollutants and health effects

(Simple) Science of Ozone and PM Formation

- Ozone forms in the presence nitrogen oxides (NOx), volatile organic compounds (VOCs), and sunlight
- Particulate matter has more and more complex formation pathways, and travels longer distances
- Both form urban "smog," which LA has long tried to control



- 100% RE scenarios for LADWP could help in achieving the region's air quality goals

Source: https://www.cumbriacrack.com/2011/04/21/defra-puts-uk-on-smog-alert/

Air Quality and Public Health Modeling: Final Points

- We plan to evaluate the 100% RE scenarios for air quality and public health benefits that show discernable changes to air emissions (compared to baseline and amongst themselves)
  - Criteria for scenario selection will be discussed further in a next AG meeting
- We will consider emissions transported into the basin from nearby sources, some of whose operations could be affected by the changes to the LADWP assets considered in this study
- Changes to health effects will be discerned at a spatial resolution to match with neighborhoods identified as EJ neighborhoods (see next slides)

Approach for Analysis of Impacts on EJ Neighborhoods

City Council Requirements

August 1, 2017	"The prioritization of environmental justice neighborhoods as the first immediate beneficiaries of localized air quality improvements and GHG reduction."	Requires the analysis of air quality-related impacts
August 1, 2017	"Incorporation of the CalEnviro Screen …"	Basis of EJ neighborhood determination early in the project

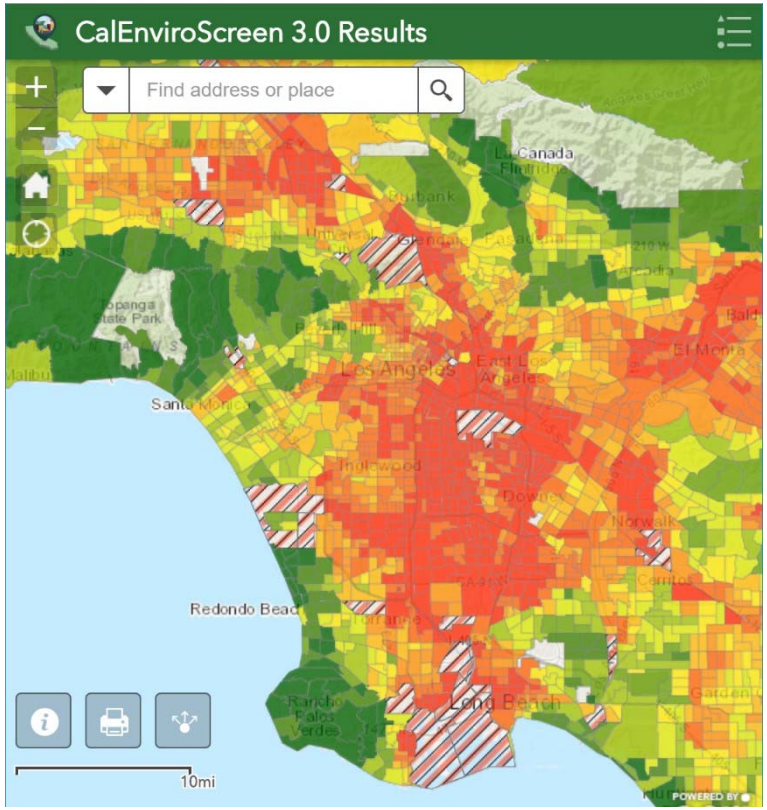
- Many neighborhoods in LA experience **socioeconomic** and **environmental** challenges; the simultaneous experience of both is what is known as **environmental justice or EJ**
- As with air quality, LA has a long history of identifying and addressing EJ challenges
- Reducing emission sources, especially local ones, is the **key strategy** to addressing EJ concerns, and all 100% RE scenarios should positively address EJ issues
- The study will discern differences in local air pollutant concentrations and health impacts between EJ neighborhoods and non-EJ neighborhoods, for the base case and evaluated 100% RE scenarios

How to Define EJ Neighborhoods

- There are many approaches to defining EJ
- Active discussion within several regional organizations as to the most appropriate definition for the LA region and (sometimes) for specific uses (grant funding, city services)
  - We are consulting with the City's Planning Department to learn about the status of various local efforts to define EJ
- City Council required that this study utilize CalEnviroScreen (latest version: 3.0)

Defining EJ Neighborhoods: CalEnviroScreen

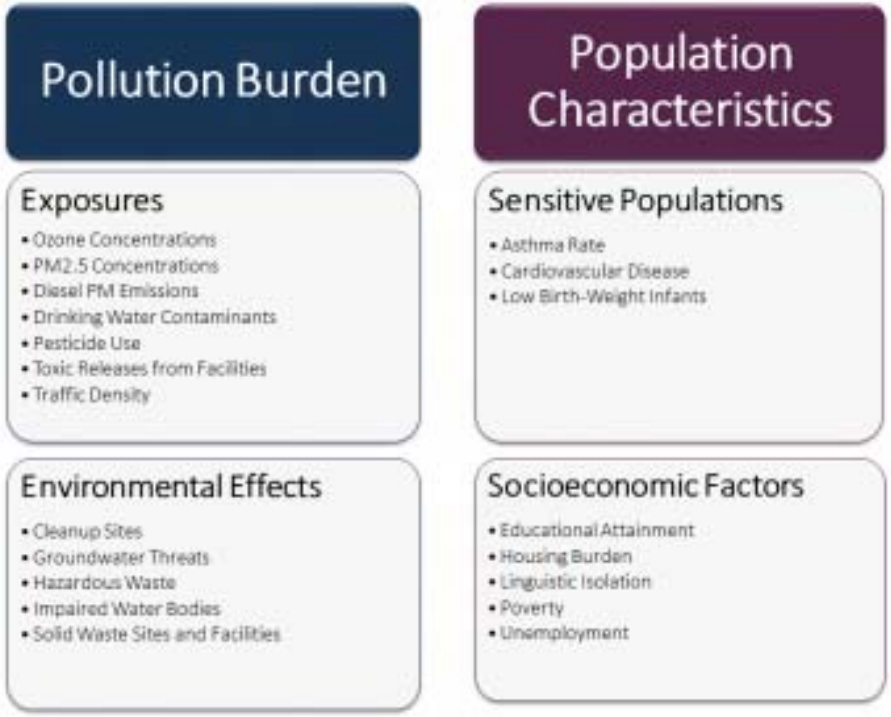
- "CalEnviroScreen is a screening tool that evaluates the burden of pollution from multiple sources in communities while accounting for potential vulnerability to the adverse effects of pollution."
- "CalEnviroScreen is being used to identify communities that face multiple burdens of pollution and socioeconomic disadvantage, [which] helps CalEPA to prioritize its work in the state's most burdened communities."
  - Also used by other state agencies and to support administration of multiple state grant programs



OEHHA, 2018

CalEnviroScreen Score

- "CalEnviroScreen ranks census tracts in California based on potential exposures to pollutants, adverse environmental conditions, socioeconomic factors and prevalence of certain health conditions [using] data from national and state sources."
- The score is reported on a 0–100 scale, which is a composite of 20 indicators each normalized to its state-level distribution
- State programs using CalEnviroScreen often set their own score cutoff criteria for program eligibility or targeting;* thus, there is no unique definition for EJ with CalEnviroScreen scores
  - Our first job is to determine which score should be used for this study in terms of targeting EE and RE deployment
  - The score threshold we choose should be consistent with prior and current uses of CalEnviroScreen relevant to the goals of this study



*See https://oehha.ca.gov/calenviroscreen/how-use for examples

Summary

- Today's goals:
  - Establish familiarity with our methods
    - More detailed for GHG emissions analysis
    - General approach for air quality, public health, and environmental justice
  - Demonstrate how environmental modeling will meet the City Council Motions
  - Convey timing of environmental modeling (follows main modeling and analytical tasks of the study)
  - **Use your questions and comments to clarify and improve the study!**

Thank you!

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