The Los Angeles 100% Renewable Energy Study

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #9

Thursday, September 19, 2019, 8:45 a.m. to 3:45 p.m.

Meeting Summary[1]

Meeting Notes Compiled by Kearns & West

Location

City of Los Angeles Department of Water and Power (LADWP)
John Ferraro Building
111 N. Hope St., Room 1514
Los Angeles, CA 90012

Attendees

Advisory Group Members

Adam Lane, Los Angeles Business Council
Alfred Tong, Los Angeles World Airport (LAWA)
Andres Pojas, Sierra Club
Andy Shrader, Council District 5
Armando Flores, Valley Industry Commerce Association
Bonny Bentzin, University of California, Los Angeles
Camden Collins, Office of Public Accountability (Rate Payer Advocate)
Christos Chrysiliou, Los Angeles Unified School District
Clara Karger, Central City Association
Dan Kegel, Neighborhood Council Sustainability Alliance
Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Gina Palencar, RePowerLA
Hilary Firestone, Natural Resource Defense Council
Jack Humphreville, Greater Wilshire Neighborhood Council
Jasmin Vargas, Food and Water Watch
Jean-Claude Bertet, City Attorney
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies
Jin Noh, California Energy Storage Alliance
Kathryn Goldman, Office of the Mayor
Kendal Asuncion, Los Angeles Chamber of Commerce
Lauren Faber O'Connor, Office of the Mayor

[1] This summary is provided as an overview of the meeting and is not meant as an official record or transcript of everything presented or discussed. The summary was prepared to the best of the ability of the note takers.

Luis Amezcua, Sierra Club
Martin Marrufo, International Brotherhood of Electrical Workers (IBEW) Local 18
Matt Gregori, Southern California Gas Company
Matt Hale, Council District 2
Matthew Thomas, Los Angeles Unified School District
Michele Knab Hasson, Natural Resource Defense Council
Randy Krager, Southern California Public Power Authority
Rebecca Rasmussen, Office of the Mayor
Tony Wilkinson, Neighborhood Council
Virginia Cormier, IBEW Local 18
Walker Foley, Food and Water Watch

LADWP Staff

Ashkan Nassiri
Carol Tucker
Ellen Cheng
Greg Huynh
Imudiase Aimiuwu
Jad Awad
James Barner
Jason Rondou
Jay Lim
Jeremiah Valera
Joseph Avila
Joseph Ramallo
Julie Van Wagner
Leilani Johnson
Leonor Garcia
Louis Ting
Luis Martinez
Luke Sun
Martin (Marty) Adams
Michelle Figueroa
Nicholas Matiasz
Paola Adler
Paul Schultz
Scott Moon
Silvia Lozano
Simon Zewdu
Stephanie Spicer
Steve Swift
Tony Chan

Project Team

Ben Sigrin, National Renewable Energy Laboratory (NREL)
David Keyser, NREL
Garvin Heath, NREL
Jaquelin Cochran, NREL
Paul Denholm, NREL
Scott Haase, NREL
George Ban-Weiss, University of Southern California
Jack Hughes, Kearns & West
Jenna Tourje, Kearns & West
Joan Isaacson, Kearns & West
Taylor York, Kearns & West

Observers

Bruce Tsuchida, The Brattle Group
Dan Wei, University of Southern California
Duane Muller, University of California, Los Angeles
Jiachen Zhang, University of Southern California

Welcome Remarks

Marty Adams, General Manager and Chief Engineer for LADWP, provided opening remarks. Adams highlighted LADWP's role in providing reliable power supply to the City of Los Angeles. He addressed NREL's hard work in conducting the Los Angeles 100% Renewable Energy Study (hereafter LA100), which will lead to a good roadmap for the future. Adams thanked the Advisory Group members for their roles in representing the breadth of stakeholder interests and concerns and sharing their perspectives, expertise, and input on the renewable energy future. He thanked them for their dedication, time, consideration, and thoughtfulness.

Louis Ting, Director of Power Planning Development & Engineering at LADWP, remarked that LA100 has been quite a journey already. He highlighted the Eland Project as an example of the accelerated progress toward clean energy. Ting announced a new division of LADWP, the Clean Grid LA Strategy Division, and introduced key division staff involved in LA100: James Barner, Manager of Integrated Resource Planning; Jason Rondou, Director of Clean Grid LA Strategy; and Greg Huynh, Manager of 100 Percent Clean Energy Innovation. Rondou then addressed the Advisory Group and remarked that he was fortunate to be involved in a process like LA100. He said it was a great opportunity to have a division dedicated to the future of the grid.

Lauren Faber O'Connor, Chief Sustainability Officer in the Mayor's Office, expressed that the Mayor's Office highly values the Advisory Group's time, and she thanked members for continuing to provide essential input and feedback. She noted that the Mayor has released an up-to-date sustainability plan and the City of Los Angeles remains committed to inspiring ambition across the country and the world. O'Connor said that the City is focusing on many goals, including decarbonizing building stock and transportation. She said that the Mayor's Office continues to work at advancing the alignment of parallel processes and efforts like LA100.

Call to Order and Agenda Overview

Joan Isaacson, Advisory Group meeting facilitator from Kearns & West, welcomed members to the ninth meeting. She provided an overview of the agenda (see Appendix A). She noted that some topics on the agenda were introduced at earlier meetings, and NREL would provide updates at this meeting and solicit additional input.

Updates and Discussion Topics

See Appendix B for LA 100 Updates and Discussion Topics presentation slides.

Jaquelin Cochran, NREL LA100 project manager, started the technical presentations by sharing important news and updates, including the incorporation of climate change into the study, reorganization of the scenarios, and status of the modeling runs and assumptions.

Concerning climate change, Cochran first acknowledged that NREL heard the Advisory Group's input from June 2019 about incorporating the issue into the study, particularly the impact of rising temperatures on electricity demand and load. As a result of this input, NREL is now incorporating temperature considerations in the modeling. Temperature will be reflected in higher electricity demand in buildings due to cooling needs. Other impacts are either difficult to capture or have a small impact relative to other sources of uncertainty (see slides 6 through 16).

Cochran then reviewed the reorganization of the scenarios. The scenarios, as defined, would not yield results that could be easily compared to one another. Isolating the effects of variables would have been difficult. The reorganized scenarios have two common levels of load electrification (moderate and high) and efficiency (moderate and high) across all scenarios. With the changes, the scenarios can be compared by level of ambition, location of new renewable energy, the extent of electricity and efficiency, and impact of efficiency. Components of the initial scenarios that are not included in the reorganized scenarios are the lowest projections for electrification and distributed generation, variation in the Western Electricity Coordinating Council (WECC) renewable penetration, and separate scenarios for LA Leads/Emissions Free. The core intent of each scenario will remain, and the reorganized scenarios will make it easier for NREL to isolate the impact of individual variables and compare scenarios (see slides 18 through 39).

Cochran next spoke about the LA100 assumptions and gave an update on modeling. An assumptions summary and detailed booklet were circulated to the Advisory Group in August 2019, and a follow-up webinar was held on September 12, 2019, to address Advisory Group questions. The document is a working draft, and before future Advisory Group meetings, NREL will share updated assumptions summaries that highlight updates and changes.

Regarding the status of the modeling, Cochran explained that there are two parallel tracks underway: the initial and final run. The initial run has utilized load model outputs that do not incorporate the more aggressive electrification assumptions or climate change assumptions. Nonetheless, the initial run can be used to fine-tune and calibrate the models for the final run.

Major Themes from Advisory Group Member Questions and Discussion

- What are the temperature changes in Fahrenheit?
- Assessing changes in storm frequency and intensity would help to understand potential future risks to power systems.
- How does this modeling correlate with global climate modeling?
- Are climate change impacts captured in the high assumptions for load?
- How are the impacts of electrification balanced in LA100?
- Do the scenarios consider 100% electric vehicle adoption?
- Does LA100 consider the electrification of LAX?
- When will reliability be discussed?
- Some coastal power plants are repowered and will run to 2045.
- LA100 should consider sulfur hexafluoride emissions.
- Will LA100 consider the costs of land acquisition for solar farms?

- Cycle gas plants will be uneconomic by 2035.
- There are no scenarios that help to learn about the cost and reliability of using gas to power the coastal plants versus replacing them with short-term battery storage.
- Are demand response and load flexibility being considered in LA100?
- Are zero-energy building codes being incorporated in LA100?

Distributed Photovoltaic Solar and Storage

See Appendix B for Distributed Solar & Storage: Methods & Framework presentation slides.

Ben Sigrin, Energy Systems Modeling Engineer, NREL, presented on methods and the framework for projecting distributed solar and storage deployment. Sigrin noted that, in the context of this project, distributed solar primarily refers to solar panels on consumer rooftops in behind-the-meter applications. However, it can also refer to solar panels on carports and electric vehicle charger-specific applications, as well as ground-mounted solar panels installed within the LADWP service territory. Distributed solar is generated by the consumer rather than procured by LADWP, creating a level of uncertainty in the quantity, location, and producer of the energy, and shifting the value perspective from agency to consumer. Sigrin noted that siting is an especially important consideration. Analysis of distributed solar is guided by the number and location of sites.

Distributed generation, said Sigrin, is analyzed using the dGen model, which is an agent-based model that simulates consumer decision-making, forecasts consumer solar and storage adoption at the building level, and incorporates detailed spatial data to inform distribution planning. The dGen model informs the distributed generation element of the capacity expansion model. “Agents” include any component or actor in the system, such as buildings and other structures, parking lots, and energy consumers. The framework for projecting adoption includes three components:

- Technical potential: The maximum feasible capacity that can be deployed
- Economic potential: The capacity that would be economical for the consumer to adopt
- Deployment estimate: Is based on the decision for the agent to adopt in a given year and, if so, the amount of system capacity

To determine technical potential, the model uses Lidar data to determine the suitability of rooftops for solar, explained Sigrin. He noted that rooftop age is not a factor in this analysis, as the suitability of a rooftop may change with time. The NREL team now has data on all buildings within the LADWP service territory. Geographic Information Systems (GIS) will be used for each parcel to screen and rank sites for solar potential. Sites will be ranked by the cost of generation, including land value, cost for interconnection, and ownership. Sites can optionally also be ranked by proximity to an environmental justice address or the potential to serve environmental justice communities.

To determine economic potential, the model considers economic impacts on agents – the system capacity that is optimal for all agents, according to Sigrin. Factors in this analysis include system cost and maintenance, retail bill savings, and any incentives, rebates, or avoided tax. An example result of this analysis is a supply curve showing the amount of solar capacity ranked by its economic attractiveness. Sigrin noted that distributed generation produces value by avoiding retail electricity costs. The NREL team is modeling two types of compensation for distributed generation, that result in high and moderate deployment projections. In the high deployment case, all solar generation is valued at retail price, LADWP’s current compensation type. In the moderate deployment, self-consumed generation is valued at retail level; however, any non-consumed generation is valued at the wholesale level.

To determine technology deployment, a predictive model based on historic observations of adoption is used to estimate the probability of adoption. Sigrin noted that solar adoption is in part a social phenomenon and that probability of adoption increases with proximity to other adopters. He also noted that ownership status and income affect adoption.

The NREL team will also study the adoption of distributed storage by end-users, considering customer versus LADWP control of storage dispatch, and how it will affect the grid. Analysis of distributed storage will be similar to distributed generation.

Major Themes from Advisory Group Member Questions and Discussion

- Land acquisition cost is a key part of determining where to site solar. However, care should be taken to prevent high concentrations of solar in low-income areas and on land that could serve other community needs, such as pocket parks. There needs to be careful consideration and discussion of the distribution of solar in low-income areas and areas with lower property values, and also discussion of unintended consequences of concentrating solar in these areas.
- How is compensation modeled in scenarios where buildings are feeding 100% of generated energy back to the grid?
- The age of roofs should be considered in the modeling. Low-income communities may see higher adoption rates if roof age is addressed. The analysis is not as realistic if it doesn't consider roof age.
- What percentage of overall production is represented by rooftops?
- How is the cost of distributed generation considered in the modeling?
- Does siting analysis include the potential for solar at public school sites and within LADWP and LA Metro easements?
- How does the technical potential analysis take into account increasing density of construction?
- Has the project team considered LAX and other aviation sites' potential for solar?
- There is a need to ensure that distributed generation is being developed where it is needed most. Policymakers should understand local environmental and economic benefits of distributed generation, as well as who is benefiting.
- Is the study considering new technologies such as window-integrated solar? Are these included in the models?
- Battery storage presents its own set of social and environmental challenges.
- Consider ways that energy conservation can reduce the need for deployment of new generation.

Progress Update on Methodology for Modeling Air Quality and Public Health

See Appendix B for Air Quality and Public Health presentation slides.

Garvin Heath, Senior Scientist at NREL, provided an update on the LA100 air quality and public health modeling. He began with a recap of the air quality presentation at the previous Advisory Group meeting, provided background on local air quality concerns and important air quality components. The analysis, said Heath, seeks to highlight how the LA100 scenarios could affect air pollution in Los Angeles. The South Coast Air Basin is out of compliance with the National Ambient Air Quality Standards for two key pollutants: ozone and particulate matter 2.5 ($PM_{2.5}$). The study will examine how reductions in these two air quality components could impact health effects from exposure.

This modeling effort uses a five-step approach:

1. Create an inventory of existing emissions from all sources using the best and latest data from the South Coast Air Quality Management District (SCAQMD). Heath noted that this data is from 2012 and is the emissions data included in the 2016 SCAQMD Air Quality Management Plan.
2. Project air pollution emissions for a select group of LA100 scenarios. The scenarios include current emissions, LA Leads/Emissions Free moderate and high load electrification scenarios, and SB 100 High Load Electrification. This allows the analysis of impacts from two sectors: electrification (including transportation and buildings) and the removal of natural gas power plants.
3. Assess future ozone and $PM_{2.5}$ concentrations in the South Coast Air Basin. It also accounts for some pollutants that may enter from outside the basin.
4. Assess changes in health impacts from exposure to ozone and $PM_{2.5}$, focusing on morbidity (disease and illness) rather than mortality (number of deaths), as morbidity aligns with CalEnviroScreen.
5. Visualize and present results at the March 2020 Advisory Group meeting.

Major Themes from Advisory Group Member Questions and Discussion

- Is NREL modeling the economic benefits of reduced health impacts?
- Mortality may have more value than morbidity. It is a dominant factor when considering economic effects. Consider analyzing mortality and economic impacts of health impacts.
- If there is an opportunity to analyze additional scenarios, consider including high distributed energy resources scenarios.
- Along with the economic value of emissions, cost-effectiveness in emission reduction is an important metric ($/ton abated). This provides good guidance for policy development.
- How well are Vehicle Miles Traveled reductions incorporated into the air quality analysis? How does this analysis address the rollback of Corporate Average Fuel Economy standards?
- Emissions sources will change over time, affecting the accuracy of predicting future emissions from these sources.
- There is value in modeling health effects on their own merits.
- Is it more appropriate for the public health department to study the economic effects of health?
- Does the study consider the lifecycle analysis of emissions?

Progress Update on Methodology for Modeling Environmental Justice

See Appendix B for Environmental Justice presentation slides.

Heath also reported on updates regarding the modeling work for the environmental justice analysis required by the City Council. LA100 is addressing differences in selected local air pollutant concentrations and health impacts between environmental justice neighborhoods and non-environmental justice neighborhoods, for the scenarios. Reducing emission sources, especially local ones, is a key strategy in addressing air quality in environmental justice communities.

Since the previous report to the Advisory Group in Fall 2018, NREL has determined that the California Office of Environmental Health and Hazard Assessment (OEHHA) guidance for defining disadvantaged communities – a CalEnviroScreen score of 75% or higher – will be used to define environmental justice communities for LA100. LA100 will estimate changes to ozone concentrations and $PM_{2.5}$ concentrations as air quality variables, and asthma and cardiovascular disease emergency department visits as public health variables aligned with the CalEnviroScreen framework. NREL will statistically compare absolute concentration and improvements (from the selected LA100 scenarios compared to current) among environmental justice and non-environmental justice census tracts.

NREL will also look at technology deployment in environmental justice communities. Under each scenario evaluated, NREL will aim to quantify implementation by tract-level environmental justice status for rooftop solar, energy efficiency in residential and commercial buildings, and electric vehicle and charging infrastructure. NREL models primarily estimate physical implementation, such as photovoltaic modules, number of electric vehicles, or change in building energy use intensity. Results will point to where prioritization of environmental justice communities can be achieved while minimizing costs, and where programs or policies could be considered to achieve a satisfactory level of prioritization.

Major Themes from Advisory Group Member Questions and Discussion

- Light- and medium-duty vehicles make a significant impact on air quality and public health but are not reflected in LA100.
- Could all pertinent City Council motions be posted on the LA100 project website?
- Amazon is purchasing 100,000 electric delivery trucks.
- LA Metro and Southern California Association of Governments have reported that electric vehicles save money.
- Daimler announced the suspension of developing gas engines.
- There should be more outreach to environmental justice communities and the council members that represent them.

Jobs and Economic Analysis

David Keyser, Senior Economist at NREL, presented on the methodology and assumptions for the LA100 jobs and economic analysis. The objectives are to estimate, for the scenarios, the workforce needs within and outside the LADWP service territory, assess the potential net employment and income impacts in the City, and estimate both the positive and negative impacts on the economy as well as who is affected. NREL uses two models to accomplish these objectives, the Jobs and Economic Development Impact (JEDI) and Computable General Equilibrium (CGE) models.

The JEDI model estimates the jobs that would be generated by the construction and operation of renewable and nonrenewable technologies, according to Keyser. The JEDI model does not incorporate assumptions about changes in the economy or technological advances, and electricity prices stay fixed.

The CGE model estimates the other two objectives of the analysis. It takes a comprehensive view of the economy and how different sectors interact with one another. The model incorporates different energy technologies into its underlying data and captures both the positive and negative economic impacts for the LA100 scenarios due to theoretical electricity price and rate changes over time. The impacts are assessed across all industries and only include whatever is monetized. The results are aggregated and do not show absolute changes in the city's entire economy. Keyser concluded his presentation by showing example estimates of theoretical price changes and employment effects.

Major Themes from Advisory Group Member Questions and Discussion

- For construction jobs, is a trained workforce assumed?
- Does the analysis consider the retirement of LADWP employees?
- Has NREL considered different rate structures?
- Rates impact what people spend money on and therefore affect the economy.
- Did NREL consider the construction, operation, and maintenance workforce needed by LADWP specifically?
- When will Local 18 sit down with management to discuss jobs in relation to the transition to renewable energy?

- The sample numbers are sizable; do they show a decrease in LADWP jobs and an increase economy-wide?
- It is unfortunate that the base case has been dropped since it would be good as a reference. Policies come and go. Repowering of the coastal Once-Through Cooling units should be considered, and lower threshold of renewable energy like 80 or 90% should be studied.

Wrap-Up and Next Steps

When wrapping up, the project team asked the Advisory Group if they were interested in another webinar call two weeks from the meeting date, to ask follow-up questions. Several members expressed interest, and a call was tentatively scheduled.

The Advisory Group will next meet on December 5, 2019.

The Los Angeles 100% Renewable Energy Study

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Advisory Group Meeting #9

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Appendix A

Agenda

City of Los Angeles 100% Renewable Energy Study (LA100)

Thursday, September 19, 2019
8:45 am – 3:45 pm
Los Angeles Department of Water and Power, Room 1514

Meeting Purpose: The purpose of the Advisory Group is to guide the Los Angeles 100% Renewable Energy Study (LA100) and provide input and review throughout the study. At this point of the study, the National Renewable Energy Laboratory's (NREL) has built and tested its models and is conducting preliminary evaluations of each LA100 scenario. The Advisory Group's feedback and questions received during this meeting will help to fine-tune NREL's assumptions and investigations as they continue to refine the models.

8:45 – 9:00 am **Arrive at LADWP / Networking / Continental Breakfast**

9:00 – 9:05 am **Call to Order and Agenda Overview**
Kearns & West (K&W): Joan Isaacson, Facilitator

9:05 – 9:30 am **Advisory Group Roundtable Introductions**
Mayor's Office: Lauren Faber O'Connor, Chief Sustainability Officer
LADWP: Louis Ting, Director, Power Planning Development & Engineering
NREL: Jaquelin Cochran, Manager, Grid Systems Group

9:30 – 10:30 am **LA100—Updates and Discussion Topics**
- Incorporation of Climate Change
- Reorganized Scenarios
- Assumptions—Recap of Webex Discussion on Modeling Assumptions
- Modeling Status
- Discussion/Q&A

NREL: Jaquelin Cochran

10:30 – 10:45 am **Break**

10:45 – 11:45 am **LA100—Distributed PV and Storage**
- Technical and Economic Potential—Assumptions and Preliminary Findings
  - Rooftop PV
  - Local Solar
  - Virtual Net Metering for Multifamily Buildings
  - Distributed Storage
- Discussion/Q&A

NREL: Ben Sigrin, Senior Engineer

11:45 – 12:15 pm **Lunch Served**

12:15 – 1:15 pm **LA100—Jobs and Economic Analysis**

- Methodology and Assumptions
- Example Estimates
- Discussion/Q&A

NREL: David Keyser, Senior Economist

1:15 – 1:25 pm **Break**

1:25 – 2:25 pm **LA100—Progress Update on Methodology for Modeling Air Quality and Public Health**

- Presentation
    - Recap of prior AG presentation and background
    - Goals and Methods
    - Timeline
- Discussion/Q&A

NREL: Garvin Heath, Senior Scientist
USC: Professor George Ban-Weiss

2:25 – 3:25 pm **LA100— Progress Update on Methodology for Modeling Environmental Justice**

- Presentation
    - Recap of prior AG presentation and background
    - Cal EnviroScreen metrics and methods
    - Approach to assess environmental justice effects of LA100 scenarios
- Discussion/Q&A

NREL: Garvin Heath, Senior Scientist

3:25 – 3:45 pm **Wrap-up and Next Steps**

- All feedback welcome; please send to: Ashkan.Nassiri@ladwp.com
- Next meeting date: December 5, 2019

K&W: Joan Isaacson

The Los Angeles 100% Renewable Energy Study

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Appendix B

Presentation Slides

LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #9

September 19, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Agenda

- Call to Order
- Introductions
- LA100 Updates and Discussion Topics **
- Distributed PV and Storage **
- Lunch
- Jobs and Economic Analysis **
- Air Quality and Public Health **
- Environmental Justice **
- Wrap-up and Next Steps

*****Q&A and Discussion***

Tips for Productive Discussions

Let one person speak at a time

Help to make sure everyone gets equal time to give input

Keep input concise so others have time to participate

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

LA100 Updates & Discussion Topics

Jaquelin Cochran, Ph.D.

September 19, 2019

LA DWP Los Angeles Department of Water & Power | NREL Transforming ENERGY

Agenda for This Session

- Climate Change
- Reorganized Scenarios
- LA100 Assumptions
- Modeling Progress

Climate Change

Incorporation of Climate Change

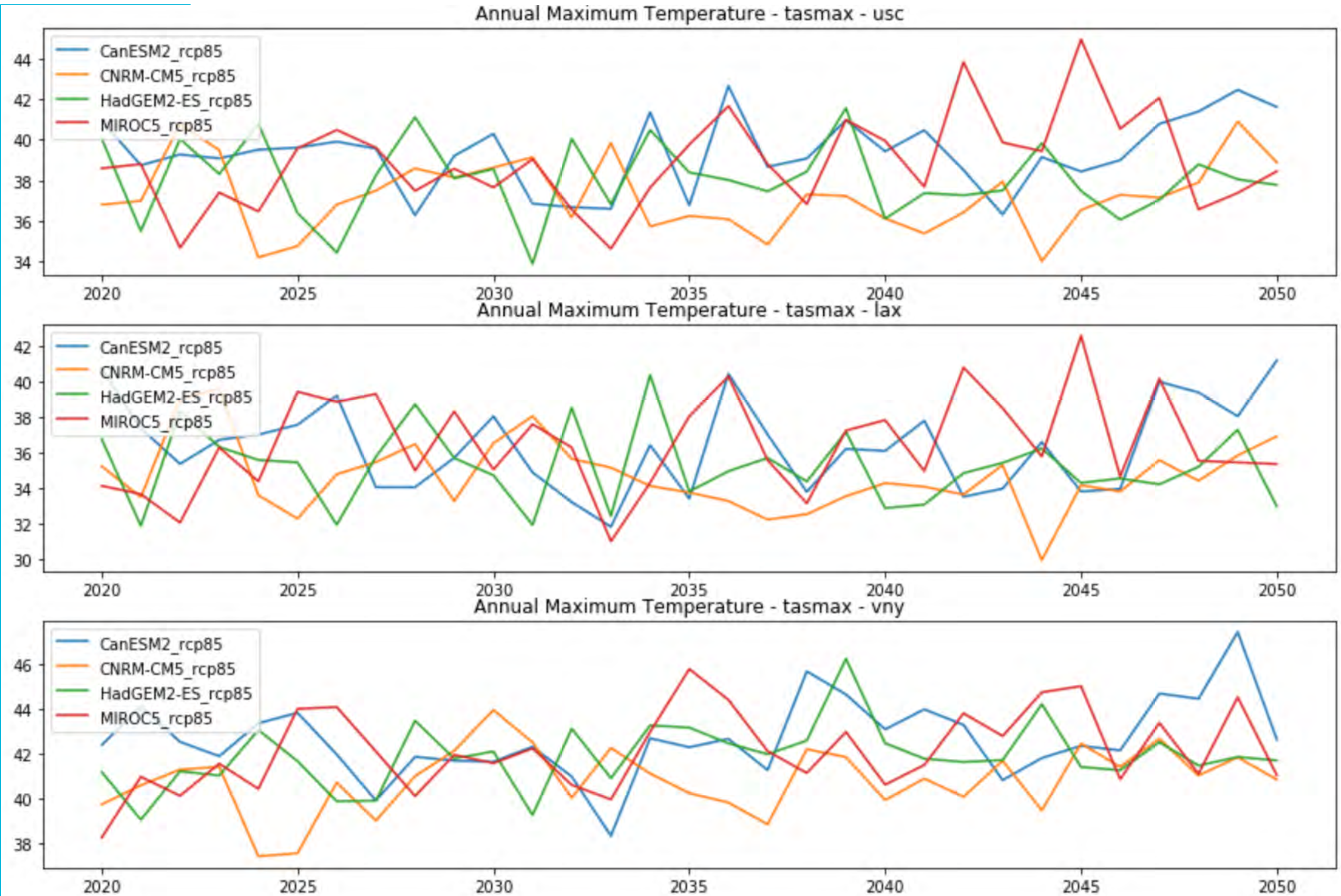
In June, AG members requested that LA100 consider impacts of climate change on the power system; in particular, the impact of projected higher temperatures on space cooling loads

Response

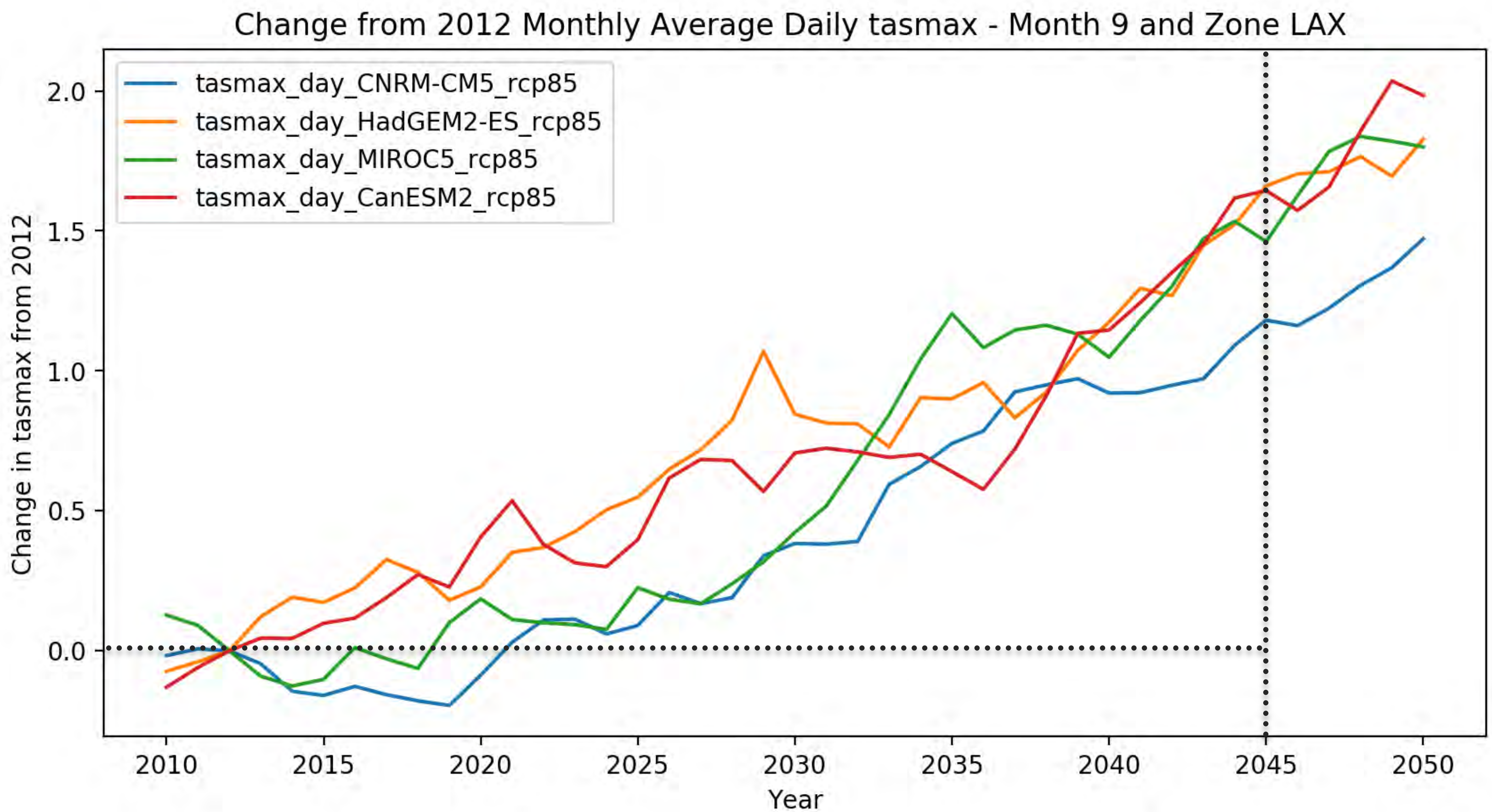
The LA100 load projections will reflect the impact of projected temperature changes on space cooling loads

Global Climate Models:

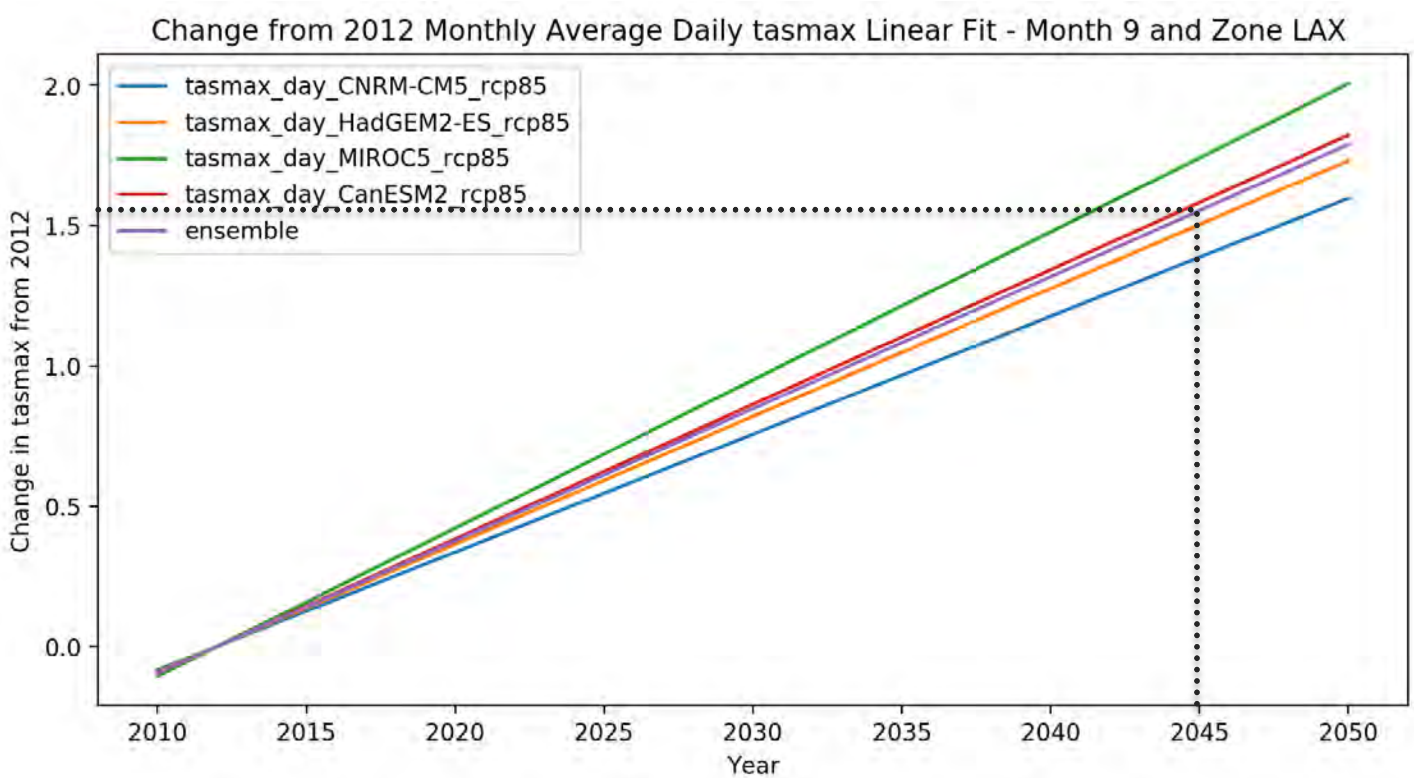
Maximum Temperature (Celsius) for the Three LA100 Climate Zones



Change in the 20-year rolling average of daily maximum September temperatures (°C) (from 2012-2050)



Linear trend of change in a rolling 20-yr monthly (September) average maximum daily temperature (°C)



1.5 °C = 2.7 °F

Methodology—Data Source

- **Data Source:**
  - UCSD (Scripps Institute of Oceanography) spatially downscaled climate projections from global climate models
  - Four models prioritized by the CA Climate Action Team Research Working Group:
    - HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5
  - Data can be downloaded from https://cal-adapt.org/

- **Data Type:**
  - Daily max and min temperature and humidity projections through 2045 (6km resolution)
  - Averaged to the 3 climate zones used in LA100
  - **RCP 8.5** scenario*: Emissions continue to rise strongly through 2050 and plateau around 2100)

*RCP = Representative Concentration Pathway

Methodology – Data Processing

- For each global climate model:
  - Calculate monthly means of daily maximum temperatures for all months and years
  - Calculate a 20-year rolling mean of monthly means; for example, the 2035 August value is the average of the August daily max temps from 2026-2045
  - Fit a linear trend to the rolling mean of monthly means
  - Using the linear trend, calculate the deltas between each future year-month, and the 20 year monthly mean from 2012.
  - Calculate the ensemble mean (the average year-month 20-yr delta across the models)
- Apply the month-year ensemble mean delta to the 2012 weather data

Climate Impacts in LA100

What's Changing in the Study

Hotter temperatures reflected in electricity demand (buildings)

Climate Impacts in LA100

What's Not Changing in the Study

RE generation profiles
RE plant efficiencies
Line losses
Air quality modeling
Precipitation (hydro availability)
Cloud coverage
Temperatures of cooling waters
Frequency of storms
Same projected increase in air conditioner adoption

What's Not Considered

Fire risks

Climate Impacts in LA100

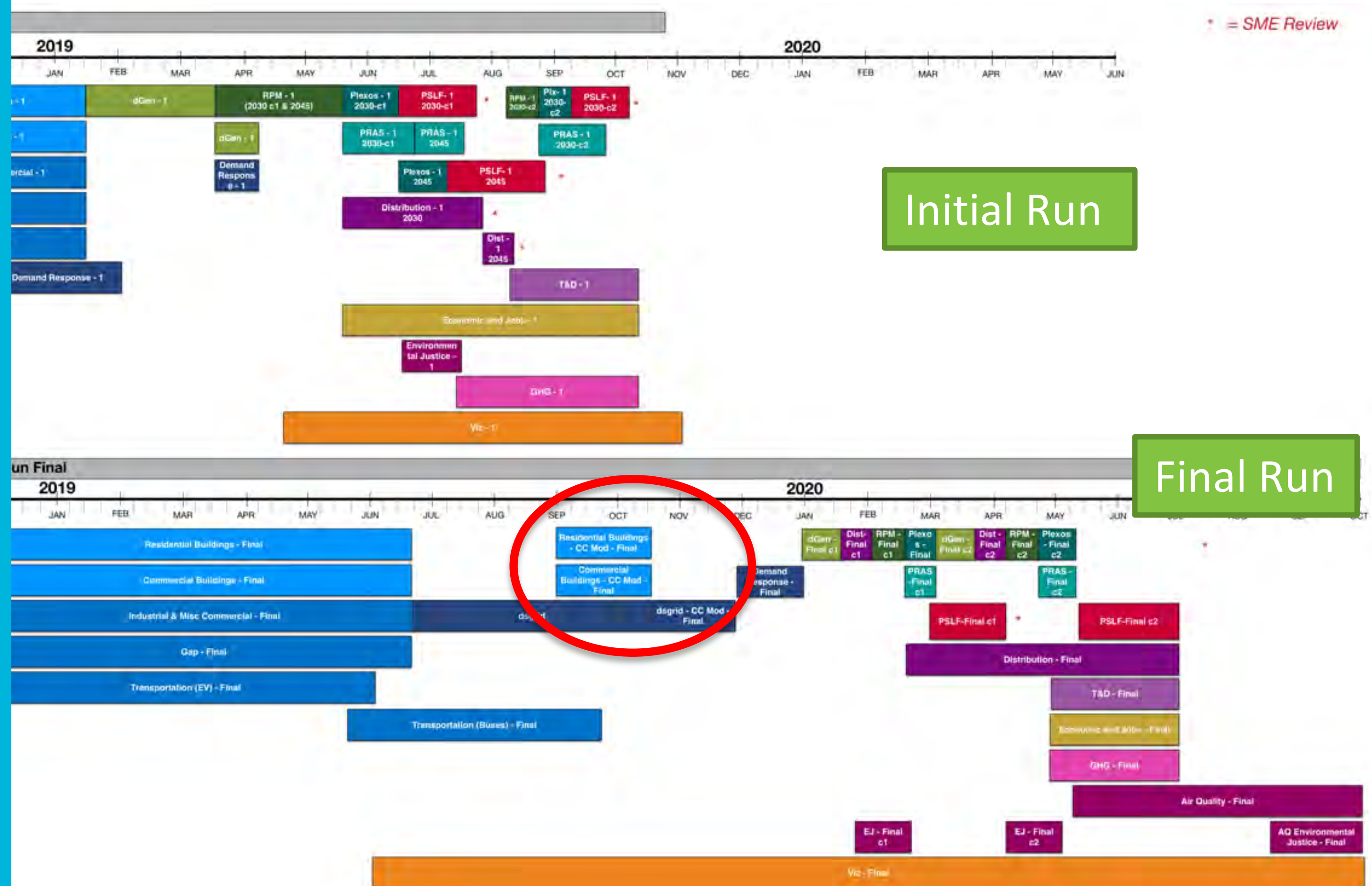
What's Changing in the Study

Hotter temperatures reflected in electricity demand (buildings)

- Temperature is the dominant impact to the study
- Other impacts are either difficult to capture or have a small impact relative to other sources of uncertainty

Impact to Timeline

Minimum 6 weeks delay, more depending on start of buildings modeling



Questions on Climate Impacts?

Scenario Reorganization

Scenario Matrix as of June 2019

		LA100 Scenarios							
		SB100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
	2030 RE Target	60%	100% Net Renewable Energy						
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	N	Yes	N	N
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No
	Nuclear - New	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Reference	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	N	Yes	N	N
Load	Energy Efficiency	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	High	Moderate	High	Moderate	High	High	Moderate
Transmission	New or Upgraded Transmission Allowed?	Matches 2017 SLTRP	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

Scientific Challenge to our Analysis

Load projections have changed significantly since scenarios were originally designed

Challenge: Scenarios are not easily comparable with different load levels

RE supply (types, locations) and **electricity demand** (extent of electrification) change simultaneously across scenarios

Example

Transmission Renaissance

Moderate load electrification

vs.

High Distributed Energy Future

High load electrification
→ higher **RE capacity** → higher **costs**

Likely takeaway from casual observer?
Cheaper to build remotely than locally

Isolating effects due to **location** of RE (remote vs. local) vs. **quantity** of RE (moderate vs. high electrification) will be challenging

NREL's Proposed Solution

- Reorganize the scenarios to have **two common levels of load electrification & efficiency across all scenarios**
  - Example: Transmission and High Distributed Energy would be evaluated with <u>both</u> moderate and high electrification projections
- Map existing scenarios to reorganized set, each with two levels of load electrification

Reorganized Scenarios

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
	2030 RE Target	60%	100% Net RE	100% Net RE	100% Net RE	60%	100% Net RE	100% Net RE	100% Net RE	60%
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Previous Scenario Matrix (as of June 2019)

		LA100 Scenarios							
		SB100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
	2030 RE Target	60%	100% Net Renewable Energy						
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	N	Yes	N	N
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No
	Nuclear - New	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Reference	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	N	Yes	N	N
Load	Energy Efficiency	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	High	Moderate	High	Moderate	High	High	Moderate
Transmission	New or Upgraded Transmission Allowed?	Matches 2017 SLTRP	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

Where did these scenarios go?

Previous Scenario Matrix (as of June 2019)

		1	2	3	4	5	6	7	8
		SB100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
	2030 RE Target	60%	100% Net Renewable Energy						
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	N	Yes	N	N
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No
	Nuclear - New	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Reference	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	N	Yes	N	N
Load	Energy Efficiency	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	High	Moderate	High	Moderate	High	High	Moderate
Transmission	New or Upgraded Transmission Allowed?	Matches 2017 SLTRP	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

Where did these scenarios go?

Reorganized Scenarios

1

SB100:

With moderate and high electrification & efficiency rather than reference to improve ability to compare to other scenarios

		LA100 Scenarios								
						High Load Electrification (Load Modernization)				High Load
		SB100			istributed gy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
	2030 RE Target	60%			% Net RE	60%	100% Net RE	100% Net RE	100% Net RE	60%
	Compliance Year for 100%	2045			2045	2045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y			Y	Y	No	Y	Y	Y
	Biogas	Y			Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y			Y	Y	Y	Y	Y	Y
	Fuel Cells	Y			Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y			Y	Y	Y	Y	Y	Y
	Hydro - New	N			N	N	N	N	N	N
	Hydro - Upgrades	Y			Y	Y	Y	Y	Y	Y
	Natural Gas	Yes			N	Yes	N	N	N	Yes
	Nuclear - Existing	Y			No	Y	Y	No	No	Y
	Nuclear - New	N			N	N	N	N	N	N
	Wind, Solar, Geo	Y			Y	Y	Y	Y	Y	Y
	Storage	Y			Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N			N	N	N	N	N	N
DG	Distributed Adoption	Moderate			High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes			N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate			oderate	High	High	High	High	Reference
	Demand Response	Moderate			oderate	High	High	High	High	Reference
	Electrification	Moderate			oderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Corridors	Allowed	o New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Reorganized Scenarios

1

2

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification				igh Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)			Load Stress (SB100)
	2030 RE Target	60%	100% Net RE	100% Net RE	100% Net RE	60%	100% Net RE			60%
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2035/2040			2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No			Y
	Biogas	Y	No	Y	Y	Y	No			Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y			Y
	Fuel Cells	Y	Y	Y	Y	Y	Y			Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y			Y
	Hydro - New	N	N	N	N	N	N			N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y			Y
	Natural Gas	Yes	N	N	N	Yes	N			Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y			Y
	Nuclear - New	N	N	N	N	N	N			N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y			Y
	Storage	Y	Y	Y	Y	Y	Y			Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N			N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

LA-Leads:

Merged with Emissions Free

Also with moderate electrification

Reorganized Scenarios

		1		3			2			
		LA100 Scenarios								
		Moderate Load Electrification					ctrification (Load Modernization)			High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance			ds, ree (No ss)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
	2030 RE Target	60%	100% Net RE	100% Net RE			et RE	100% Net RE	100% Net RE	60%
	Compliance Year for 100%	2045	2035/2040	2045			040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y				Y	Y	Y
	Biogas	Y	No	Y				Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y				Y	Y	Y
	Fuel Cells	Y	Y	Y				Y	Y	Y
	Hydro - Existing	Y	Y	Y				Y	Y	Y
	Hydro - New	N	N	N				N	N	N
	Hydro - Upgrades	Y	Y	Y				Y	Y	Y
	Natural Gas	Yes	N	N				N	N	Yes
	Nuclear - Existing	Y	Y	No				No	No	Y
	Nuclear - New	N	N	N				N	N	N
	Wind, Solar, Geo	Y	Y	Y				Y	Y	Y
	Storage	Y	Y	Y				Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Transmission Renaissance:

Also with high electrification (Load Modernization)

Reorganized Scenarios

		1		3			2		4	
		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	S			High Distributed Energy Future	High Load Stress (SB100)
2030 RE Target		60%	100% Net RE	100% Net RE	100% Net RE				100% Net RE	60%
Compliance Year for 100%		2045	2035/2040	2045	2045				2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y				Y	Y
	Biogas	Y	No	Y	Y				Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y				Y	Y
	Fuel Cells	Y	Y	Y	Y				Y	Y
	Hydro - Existing	Y	Y	Y	Y				Y	Y
	Hydro - New	N	N	N	N				N	N
	Hydro - Upgrades	Y	Y	Y	Y				Y	Y
	Natural Gas	Yes	N	N	N				N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

High Distributed:

Also with moderate electrification

Reorganized Scenarios

		1	5	3			2		4	
		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)			100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
	2030 RE Target	60%	100% Net RE			0%	100% Net RE	100% Net RE	100% Net RE	60%
	Compliance Year for 100%	2045	2035/2040			045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No			Y	No	Y	Y	Y
	Biogas	Y	No			Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y			Y	Y	Y	Y	Y
	Fuel Cells	Y	Y			Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y			Y	Y	Y	Y	Y
	Hydro - New	N	N			N	N	N	N	N
	Hydro - Upgrades	Y	Y			Y	Y	Y	Y	Y
	Natural Gas	Yes	N			es	N	N	N	Yes
	Nuclear - Existing	Y	Y			Y	Y	No	No	Y
	Nuclear - New	N	N			N	N	N	N	N
	Wind, Solar, Geo	Y	Y			Y	Y	Y	Y	Y
	Storage	Y	Y			Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Emissions Free:

Merged with LA Leads

Also with Load Modernization

Reorganized Scenarios

		1	5	3			2		4	6
		LA100 Scenarios								
		Moderate Load Electrification				**High Load Electrification (Load Modernization)**				**High Load**
		SB100	**LA-Leads, Emissions Free (No Biomass)**	**Transmission Renaissance**	**High Distributed Energy Future**					**High Load Stress (SB100)**
	2030 RE Target	60%	100% Net RE	100% Net RE	100% Net RE					60%
	Compliance Year for 100%	2045	2035/2040	2045	2045					2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y					Y
	Biogas	Y	No	Y	Y					Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y					Y
	Fuel Cells	Y	Y	Y	Y					Y
	Hydro - Existing	Y	Y	Y	Y					Y
	Hydro - New	N	N	N	N					N
	Hydro - Upgrades	Y	Y	Y	Y					Y
	Natural Gas	Yes	N	N	N					Yes
	Nuclear - Existing	Y	Y	No	No					Y
	Nuclear - New	N	N	N	N					N
	Wind, Solar, Geo	Y	Y	Y	Y					Y
	Storage	Y	Y	Y	Y					Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N					N
DG	Distributed Adoption	Moderate	High	Moderate	High					Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N					Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

High Load Stress:

With 60% 2030 target to mirror SB100

This allows comparison with SB100 (High) to show impact of efficiency and demand response

Reorganized Scenarios

		1	5	3			2	7	4	6
		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
2030 RE Target		60%	100% Net RE	100% Net RE	100% Net RE	60%	100% Net RE	100% Net RE	100% Net RE	60%
Compliance Year for 100%		2045	2035/2040	2045	2045	2045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y				Y
	Fuel Cells	Y	Y	Y	Y	Y				Y
	Hydro - Existing	Y	Y	Y	Y	Y				Y
	Hydro - New	N	N	N	N	N				N
	Hydro - Upgrades	Y	Y	Y	Y	Y				Y
	Natural Gas	Yes	N	N	N	Yes				Yes
	Nuclear - Existing	Y	Y	No	No	Y				Y
	Nuclear - New	N	N	N	N	N				N
	Wind, Solar, Geo	Y	Y	Y	Y	Y				Y
	Storage	Y	Y	Y	Y	Y				Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N				N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Load Modernization:

Now applied to four scenarios

Reorganized Scenarios

		1	5	3			2	7	4	6
		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
	2030 RE Target	60%	100% Net RE	100% Net RE	100% Net RE	60%	100% Net RE	100% Net RE	100% Net RE	60%
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor									
DG	Distributed Adoption									
RECS	Financial Mechanisms (RECS/Allowances)									
Load	Energy Efficiency									
	Demand Response									
	Electrification									
Transmission	New or Upgraded Transmission Allowed?	Corridors	Corridors	Allowed		Corridors	Corridors	Allowed		Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

8

Western Initiatives:

We are increasing WECC RE penetration across all scenarios to NREL's mid-level projections (~50% Variable Renewable Energy in 2045)

What We Gain:

Scenarios Can Be Compared by Level of **Ambition**

Level of Ambition

SB100 — Natural gas, RECs allowed

vs.

Transmission/Distribution — No natural gas; 2045 compliance; biomass OK

vs.

LA Leads/Emissions Free — Earlier compliance, no local emissions

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
	2030 RE Target	60%	100% Net RE	100% Net RE	100% Net RE	60%	100% Net RE	100% Net RE	100% Net RE	60%
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

What We Gain:

Scenarios Can Be Compared by **Location of New RE**

Transmission Renaissance
Transmission-oriented growth

vs.

High Distributed Energy Future
Distribution-oriented growth

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
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	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2035/2040	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
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WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

What We Gain:

Scenarios Can Be Compared by **Extent of Electrification & Efficiency**

Moderate Electrification

Moderate growth, efficiency, and demand response potential

vs.

High Electrification

Strong growth, efficiency, and demand response potential

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
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Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
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DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
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WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

What We Gain:

Scenarios Can Be Compared by **Impact of Efficiency**

SB100, High Electrification

vs.

High Load Stress

Identical to SB100 (High Load) but with **reference efficiency and demand response**

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
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	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
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	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
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RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
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WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

What We Lose

- Lowest projections for electrification and distributed generation (rooftop PV)
- Variations in WECC renewable energy penetration
- Separate scenarios for LA Leads and Emissions Free

But core scenario distinctions remain.

Reorganized scenarios will be easier to interpret, communicate, and compare

And the transparency of study increases because impacts are easier to isolate

Reorganized Scenarios—Questions?

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
		SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biomass)	Transmission Renaissance	High Distributed Energy Future	High Load Stress (SB100)
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Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
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WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

LA100 Assumptions

LA100 Assumptions

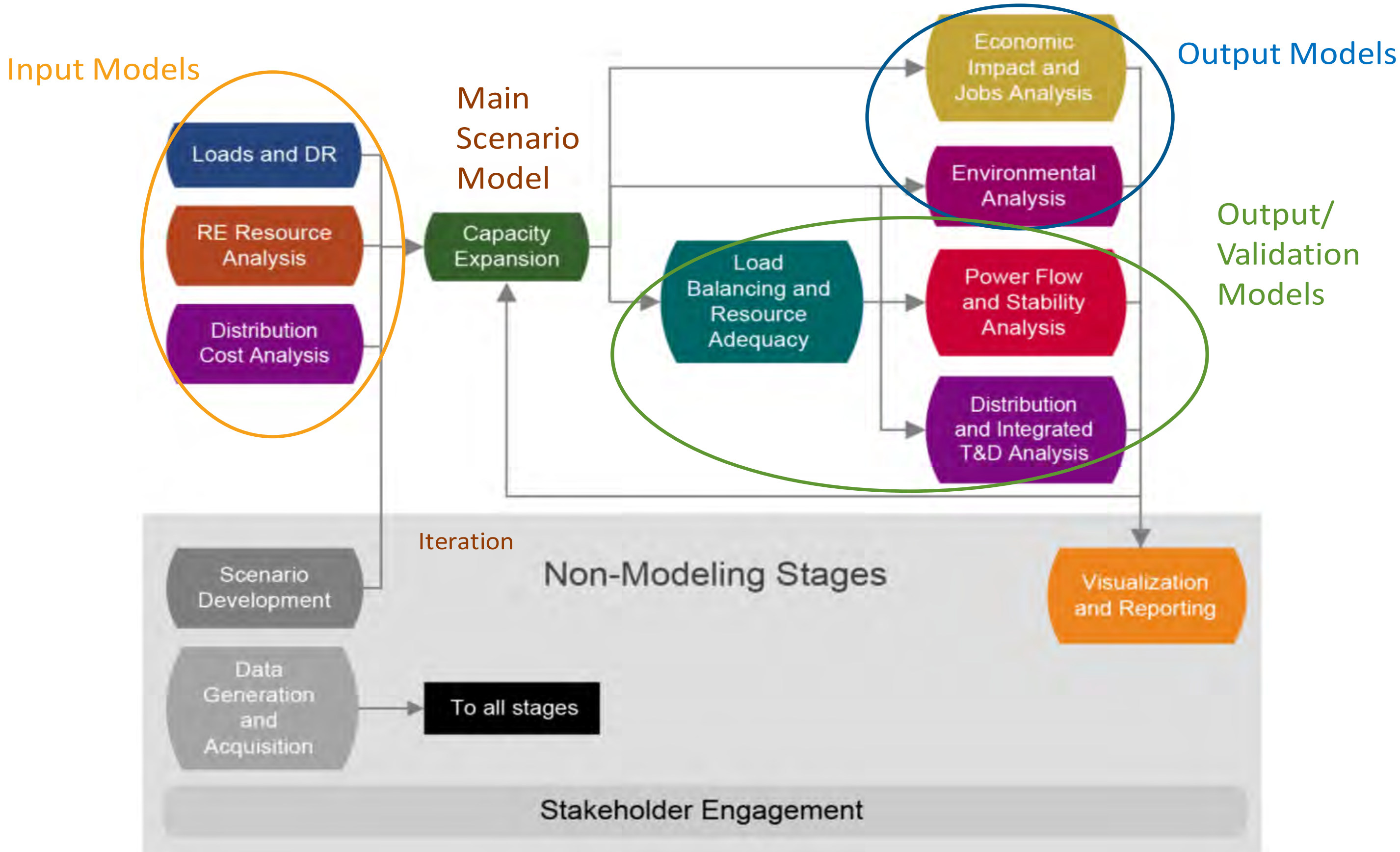
- Assumptions summary and detailed booklet circulated to AG last month
- Follow-up call held September 12
- Summary of call shared at this AG

- This document remains a **working draft**. We will share updated drafts before each AG, highlighting what has changed.

Questions on Assumptions?

Modeling Progress

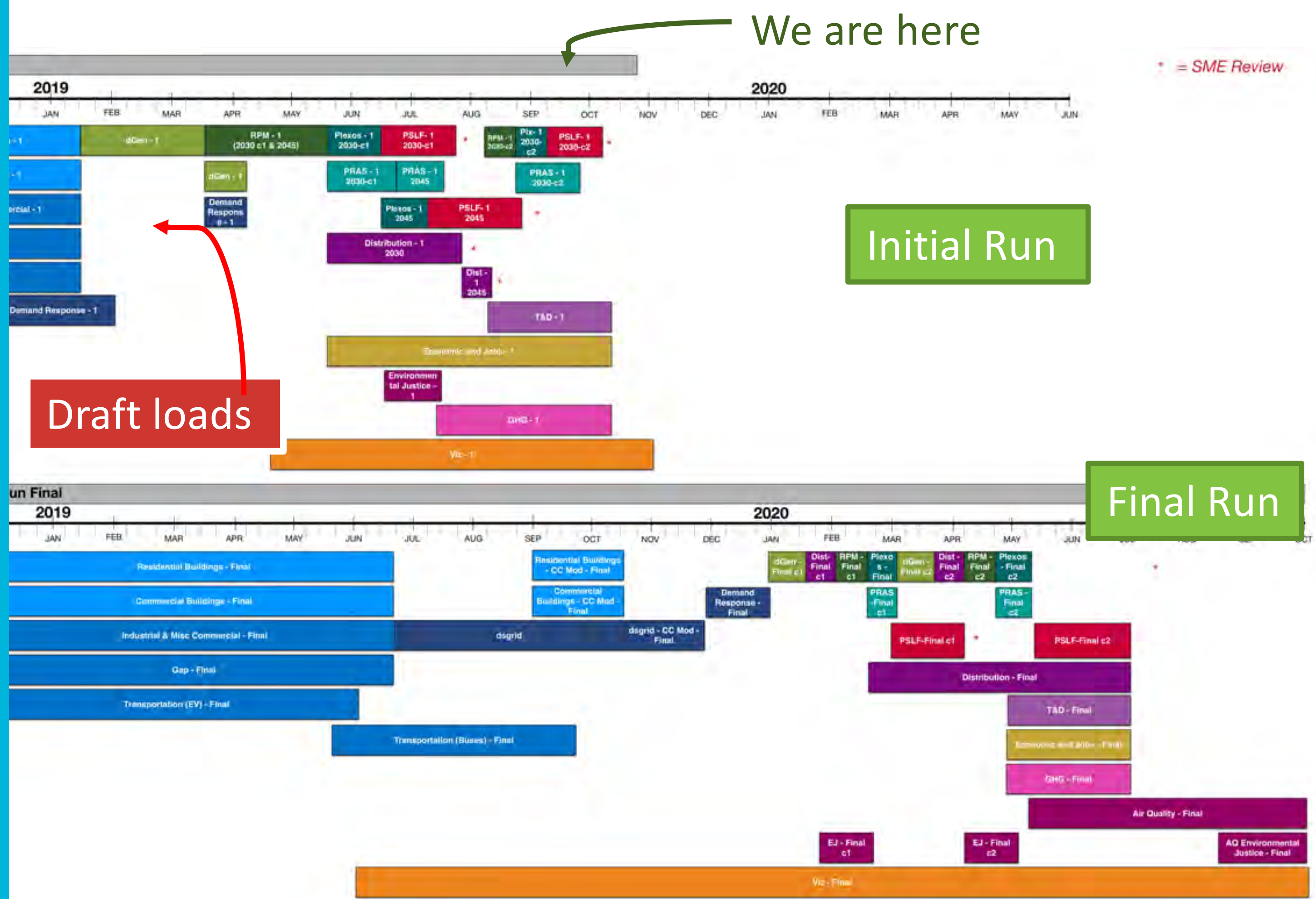
Modeling Framework



Two Parallel Tracks of Modeling Activity Underway

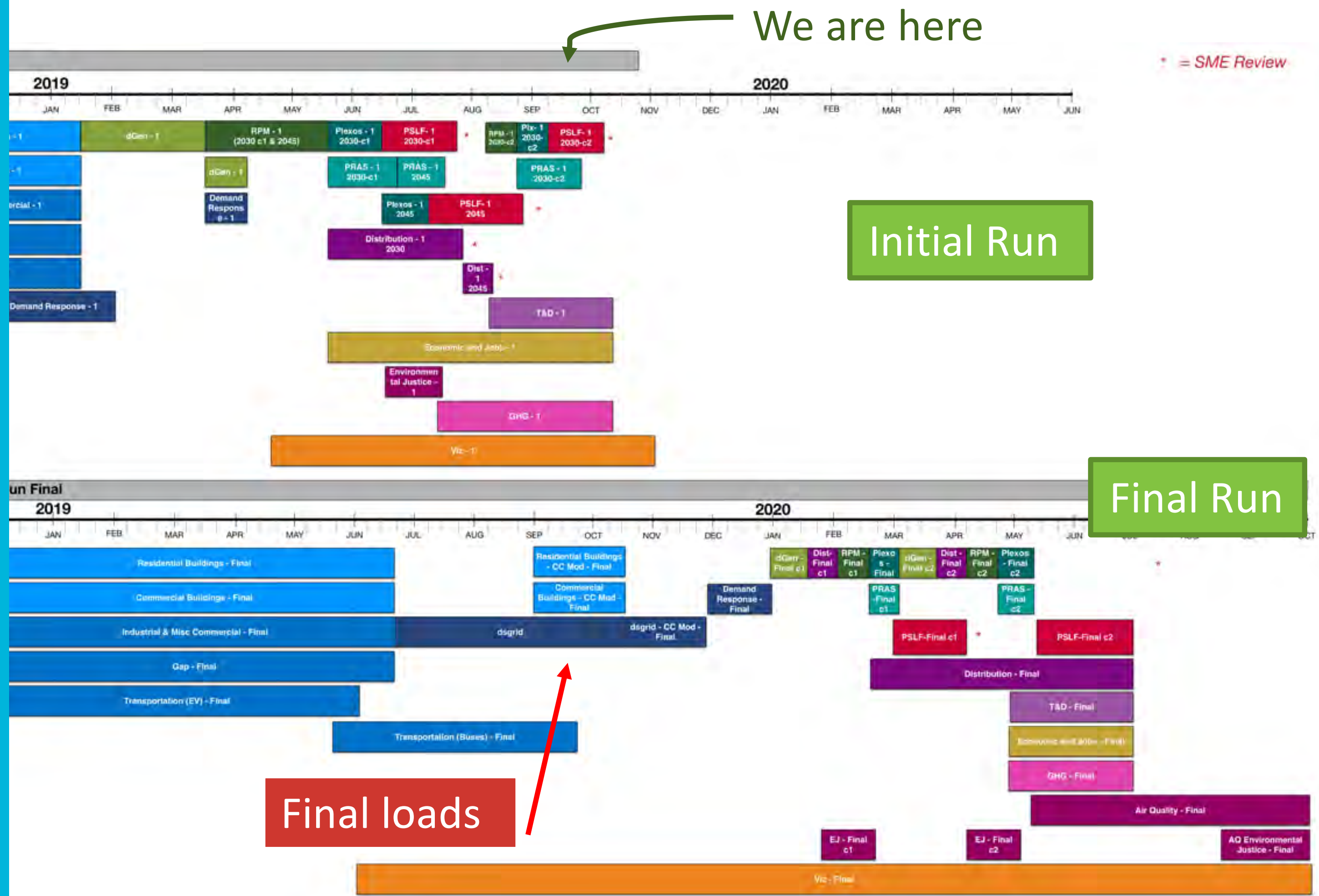
Initial Run Uses Draft Load Results

- 2045 projections are being validated through bulk power models
- Distribution grid models are being finalized
- We have started bridging bulk and distribution systems in September

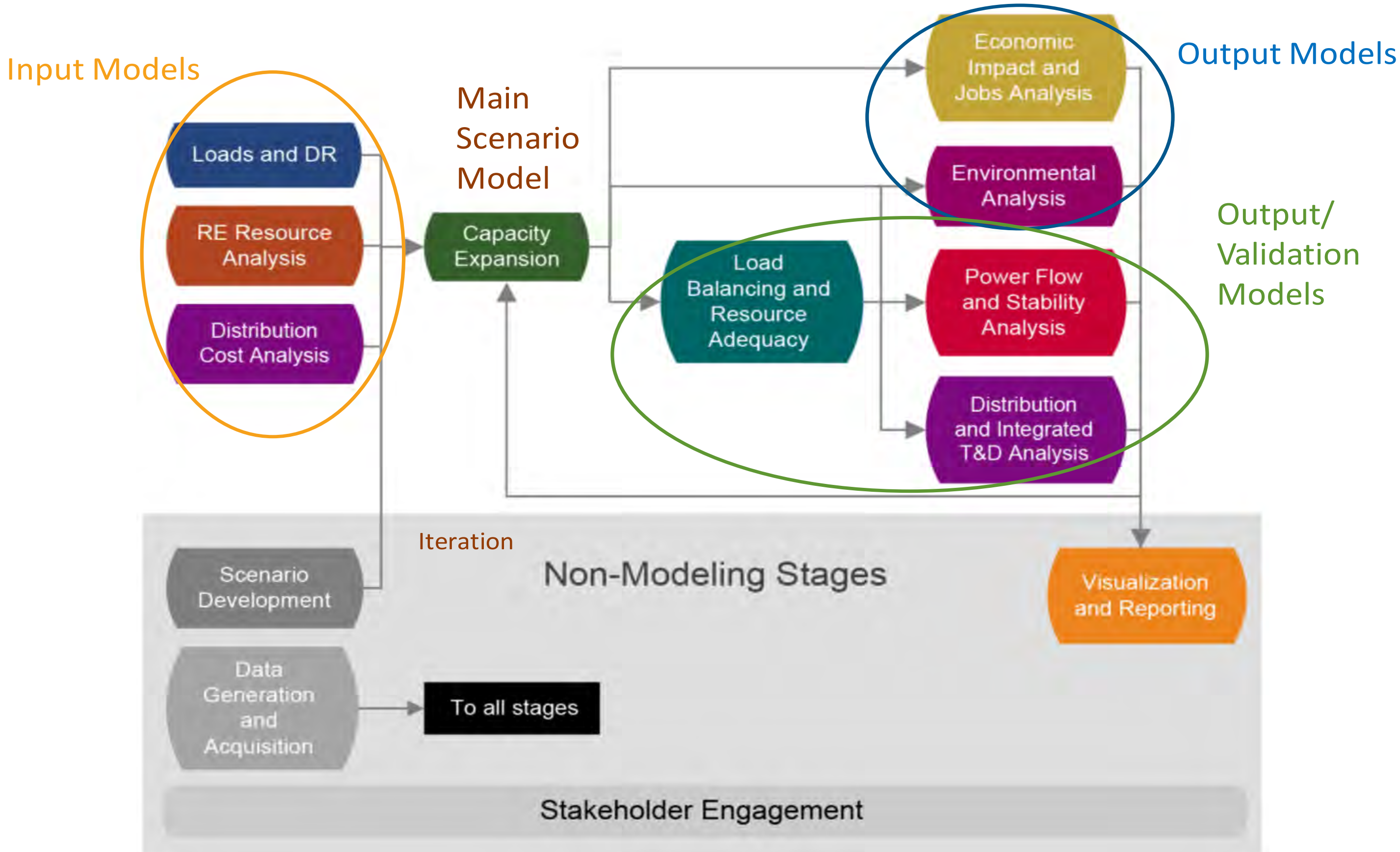


Final Run Uses Final Load Results

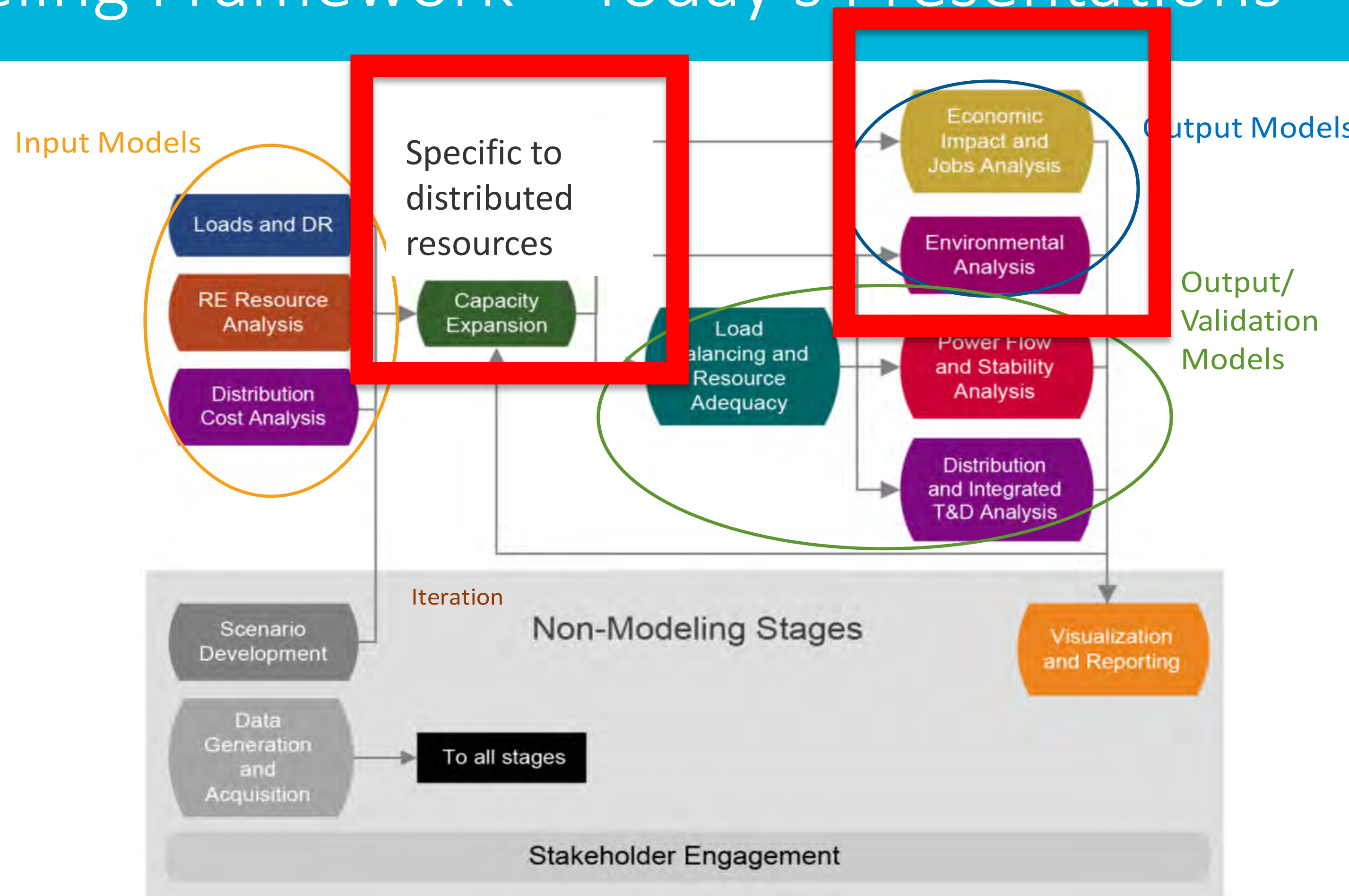
- Buildings load models ready to be rerun with higher temperatures
- Bus electrification is almost complete
- Large effort to integrate bottom-up loads data to transfer to downstream models



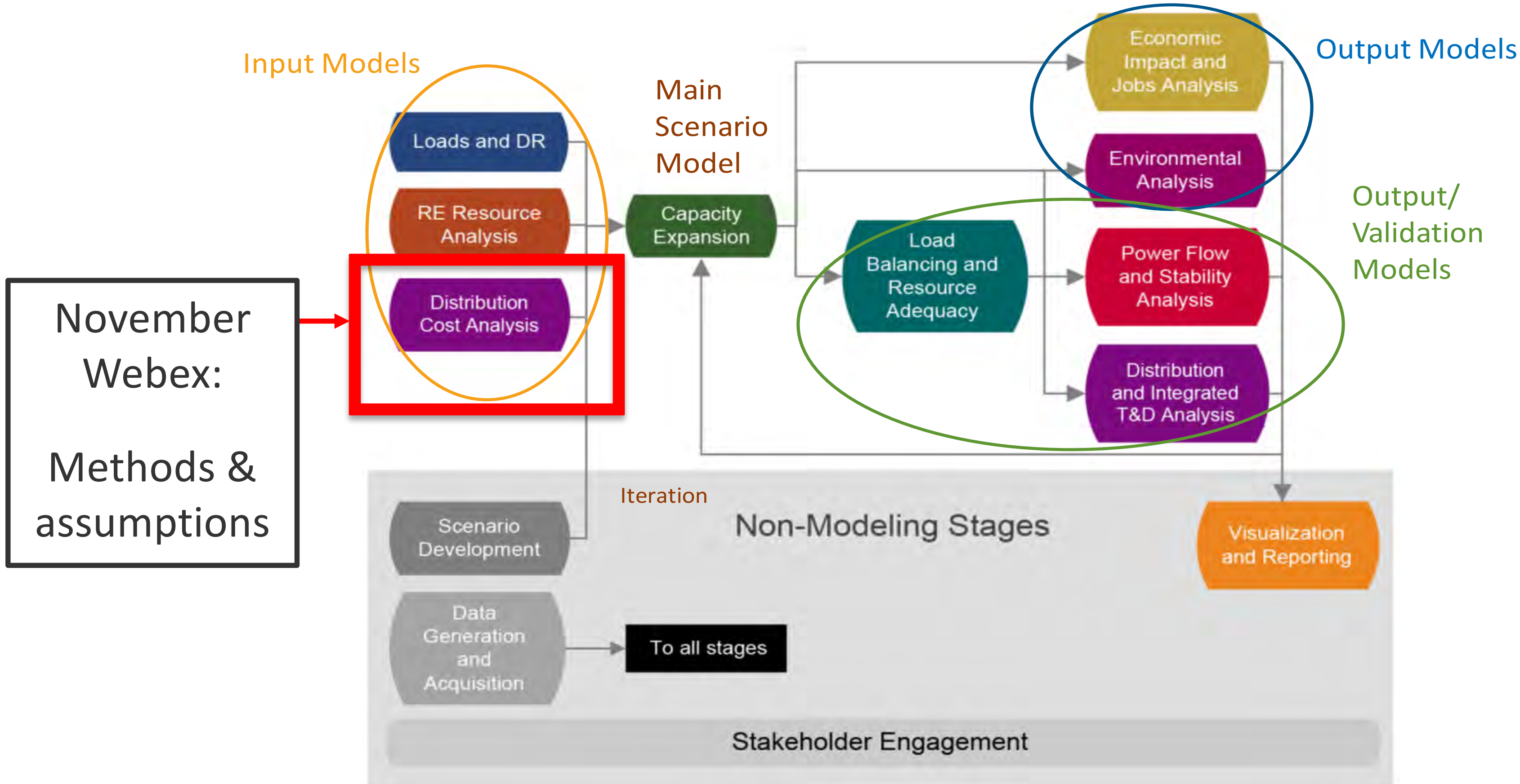
Modeling Framework



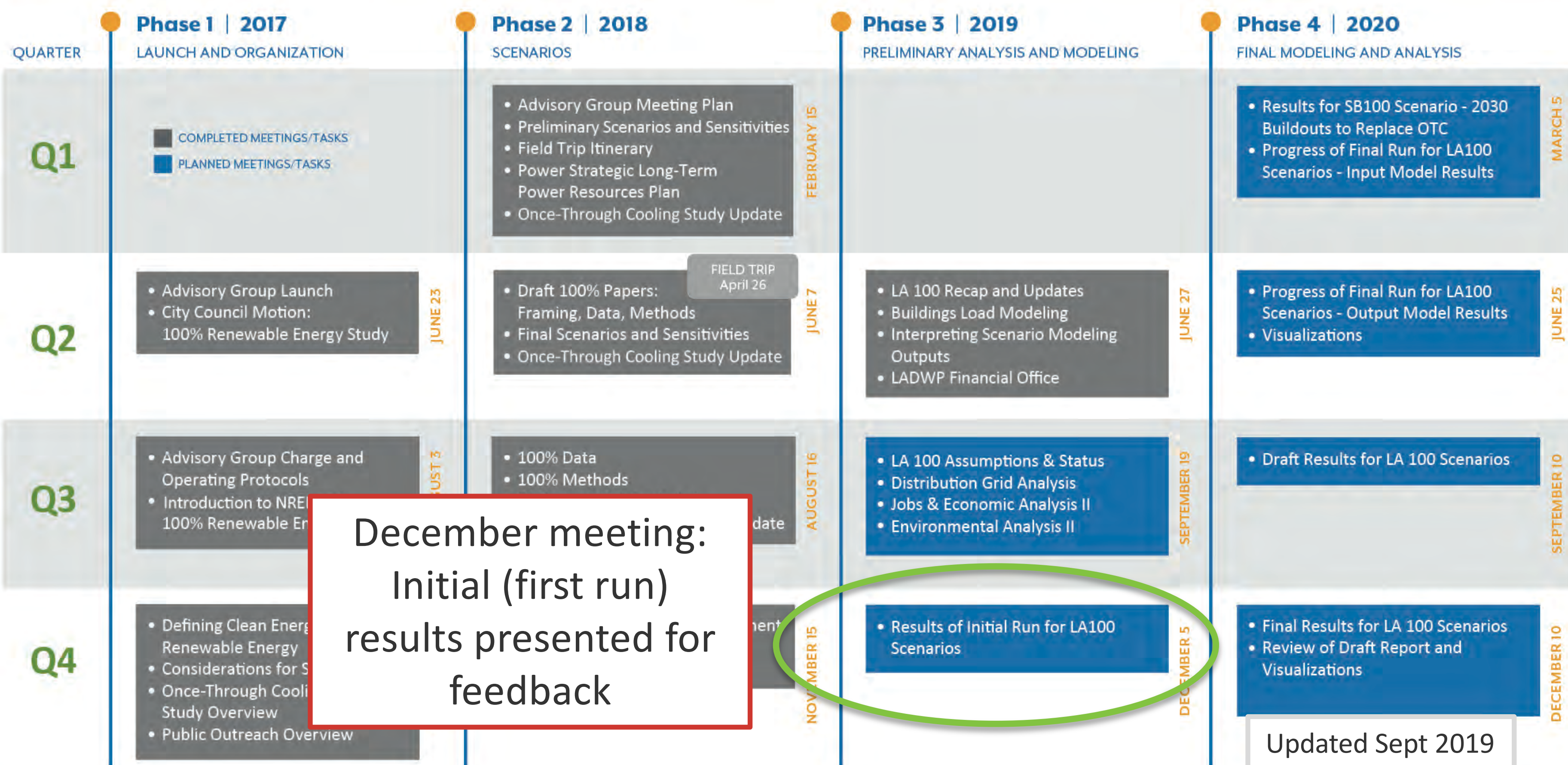
Modeling Framework—Today's Presentations



Modeling Framework—Interim AG WebEx (November)



AG Timeline



QUARTER
Phase 1 | 2017
LAUNCH AND ORGANIZATION
Phase 2 | 2018
SCENARIOS
Phase 3 | 2019
PRELIMINARY ANALYSIS AND MODELING
Phase 4 | 2020
FINAL MODELING AND ANALYSIS
Q1
COMPLETED MEETINGS/TASKS
PLANNED MEETINGS/TASKS
• Advisory Group Meeting Plan
• Preliminary Scenarios and Sensitivities
• Field Trip Itinerary
• Power Strategic Long-Term Power Resources Plan
• Once-Through Cooling Study Update
FEBRUARY 15
• Results for SB100 Scenario - 2030 Buildouts to Replace OTC
• Progress of Final Run for LA100 Scenarios - Input Model Results
MARCH 5
Q2
• Advisory Group Launch
• City Council Motion: 100% Renewable Energy Study
JUNE 23
FIELD TRIP April 26
• Draft 100% Papers: Framing, Data, Methods
• Final Scenarios and Sensitivities
• Once-Through Cooling Study Update
JUNE 7
• LA 100 Recap and Updates
• Buildings Load Modeling
• Interpreting Scenario Modeling Outputs
• LADWP Financial Office
JUNE 27
• Progress of Final Run for LA100 Scenarios - Output Model Results
• Visualizations
JUNE 25
Q3
• Advisory Group Charge and Operating Protocols
• Introduction to NREI
100% Renewable Er
• 100% Data
• 100% Methods
date
AUGUST 16
• LA 100 Assumptions & Status
• Distribution Grid Analysis
• Jobs & Economic Analysis II
• Environmental Analysis II
SEPTEMBER 19
• Draft Results for LA 100 Scenarios
SEPTEMBER 10
Q4
• Defining Clean Energ
Renewable Energy
• Considerations for S
• Once-Through Cooli
Study Overview
• Public Outreach Overview
NOVEMBER 15
• Results of Initial Run for LA100 Scenarios
DECEMBER 5
• Final Results for LA 100 Scenarios
• Review of Draft Report and Visualizations
DECEMBER 10
December meeting: Initial (first run) results presented for feedback
Updated Sept 2019

Questions?

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Impact of LA100 Scenarios on Air Pollution and Consequent Health Impacts: an Overview of Methods

Presenter: Prof. George Ban-Weiss (USC)

Collaborators: Dr. Garvin Heath (NREL)

Dr. Jiachen Zhang (USC)

Emma Tome (UC Berkeley & NREL)

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

Agenda

- Recap and Background
  - Recap of prior AG presentation of air quality and public health
- Goals and Methods

AG Meeting #6: August 16, 2018

The context and methods were presented at a high level for **air quality and public health**

Goals for Presentation

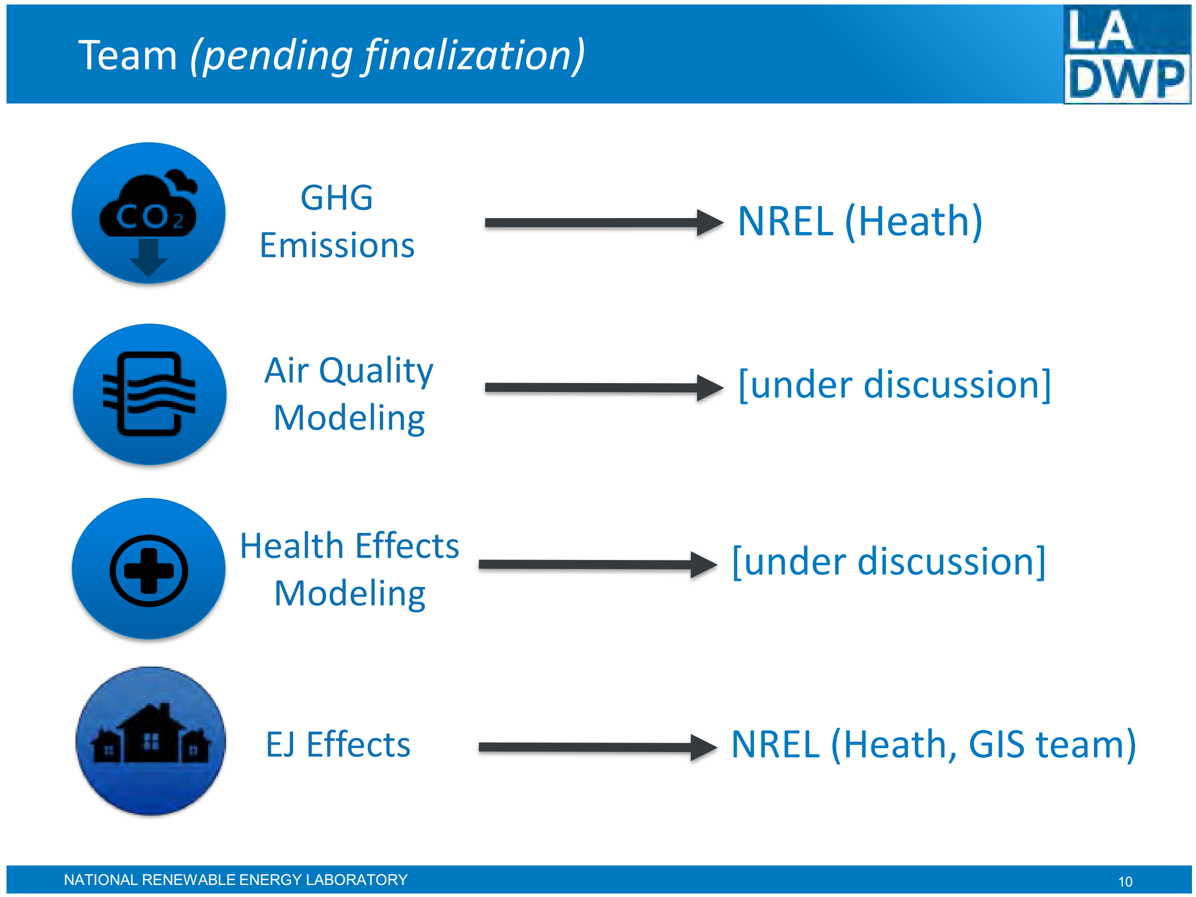
LA DWP

- 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!**

NATIONAL RENEWABLE ENERGY LABORATORY 2

Leads for Each Environmental Modeling Component

Contracted with University of Southern California (USC) for air quality and public health modeling



Final Points Made at AG #6

Will be elaborated in the next slides

Air Quality and Public Health Modeling: Final Points

LA DWP

- 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)

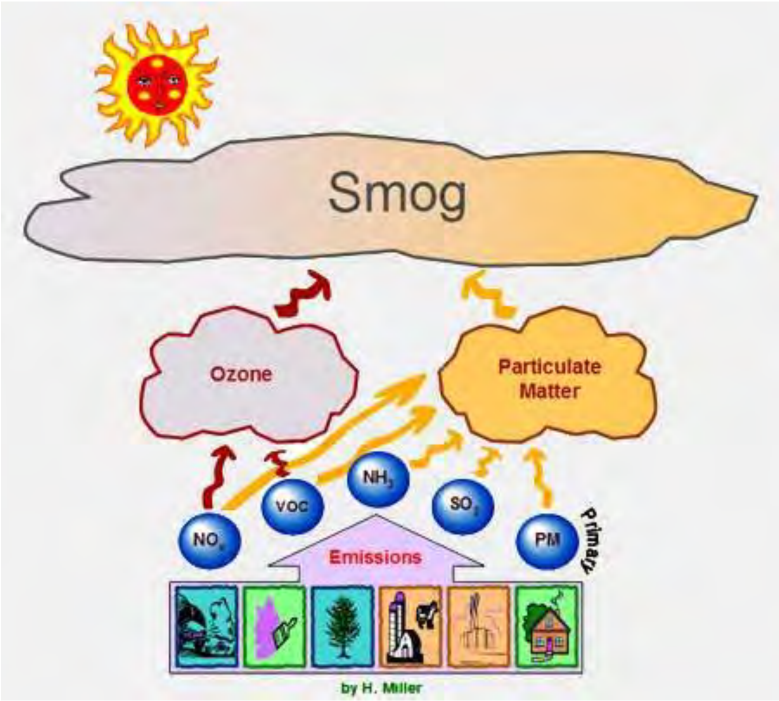
Air Pollutants and Health Effects of Concern

- 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 $PM_{2.5}$ (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)

Source: https://www.theguardian.com/sustainable-business/2016/jul/05/how-air-pollution-affects-your-health-infographic

How Are Ozone and $PM_{2.5}$ Formed?

- Ozone forms in the presence of nitrogen oxides (NOx), volatile organic compounds (VOCs), and sunlight
- Particulate matter is both directly emitted ("primary PM") and also formed in the atmosphere ("secondary PM") via *numerous* complex pathways
- Both form urban "smog," which LA has long tried to control



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

Project 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 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?

Through evaluating impacts of selected LA100 scenarios, we aim to identify the sectors and source types affected by LA100 scenarios 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
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 a computing resource-intensive step, **developing the emissions inventory** (steps #1 and 2) is actually the most time-consuming and critical step

1) Constructing a model-ready emissions inventory from source-oriented raw emissions for "current" time (part 1)

- An air pollutant emissions inventory specifies where, when, and how much of each pollutant is emitted
- Current inventory will be based on the official 2012 South Coast Air Quality Management District (SCAQMD) dataset, which is the latest available
  - This was the baseline inventory for the 2016 Air Quality Management Plan
  - 2012 is the same base year of meteorology for the LA100 study as a whole
  - SCAQMD has provided raw inventory files needing processing
  - This answers a question asked in AG #6 about what baseline inventory we would use

1) Constructing a model-ready emissions inventory from source-oriented raw emissions for "current" time (part 2)

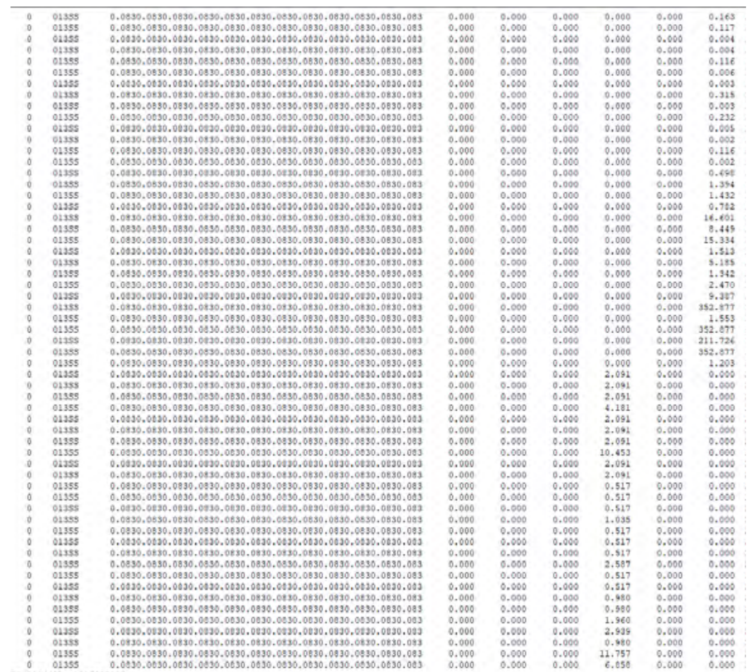
- Inventories include emissions from all sources
  - All source types: mobile sources (on-road and off-road), point sources (e.g., power plants, large industrial sources), and area sources (individually small but collectively significant)
  - There are ~2,500 source categories and >3 million individual sources
- Hourly emissions for the entire year of 2012 at 4km x 4km resolution
- Includes all pollutants relevant to formation of ozone and $PM_{2.5}$ (e.g., NOx, volatile organic compounds, ammonia, sulfur dioxide, and primary particulate matter)

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

We obtained the latest state-of-the-art source-oriented emissions from SCAQMD

Challenges:

- Raw emissions are large (37 GB), compiled in hundreds of txt files each with different formatting
- Reading and spatially allocating emissions from on-road mobile sources took ~40 hours for our server (and more time for chemical speciation)
- There's no documentation for the raw emissions, so we have to rely on personal communication with SCAQMD experts



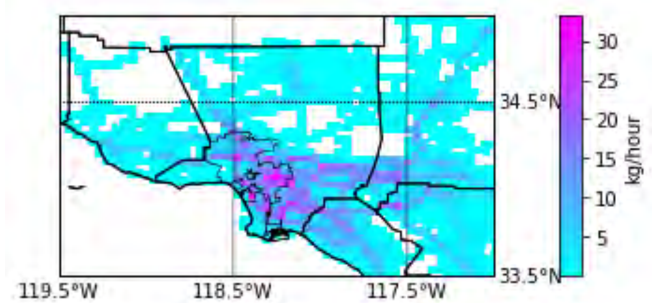
For example, the file for most area sources has >900,000 lines. Each line of the file represents emissions from a specific source in a grid cell.

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

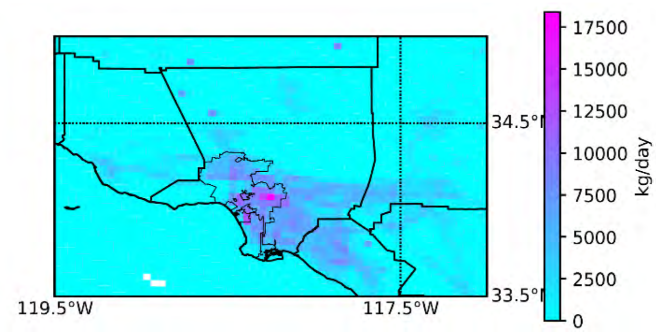
Procedure:

- Raw emissions import
- Spatial allocation
- Temporal allocation
- Chemical speciation
    - 6 species =>73 species (e.g., NO_x => NO, NO_2, HONO)
- Unit conversion
- Aggregate emissions from different sources

Example map for on-road mobile-source NOx emissions at 08:00 LST on Jan 01, 2012



Example map for annual average CO emissions from all source types



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

The climate/air pollution model is very computationally expensive, so we can carry out simulations for only ~four scenarios including a "current" one

Below are scenarios currently recommended to analyze - **We welcome your feedback!**

- If the scenario definitions change, we will be able to adapt to choose the best ones until January 2020

Scenario Name	NATURAL GAS / RECS (power)	ELECTRIFICATION of light-duty vehicles and buses, and buildings
1. CURRENT (2012)	N/A	N/A
2. LA-Leads/Emissions Free (Moderate Load Electrification)	NO	Moderate
3. LA-Leads/Emissions Free (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)"

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  "SB100 (High Load Electrification)" with "LA-Leads (High Load Electrification)"

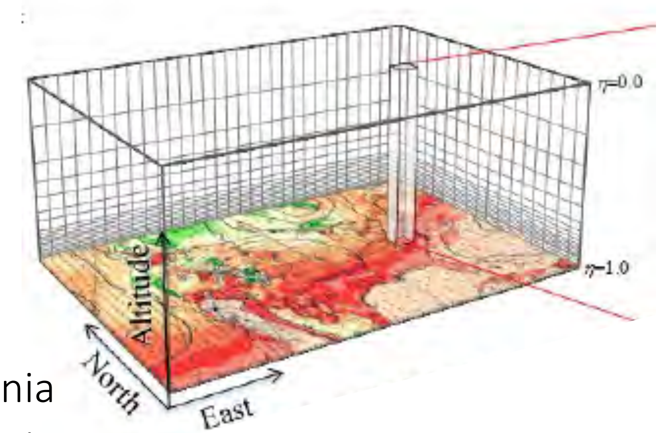
2) Creating emissions inventories that project air pollutant emissions under various future renewable energy adoption pathways

Future emissions for the LA100 scenarios of focus will be created using "current" as a base, and then altering emissions per sector using outputs from various models run by NREL, as follows:

1. **Power sector:** We will use hourly power generation profiles from NREL electric sector models to generate emissions. We will attempt to use specific emission factors for four use phases: start up, ramp, partial load, full load.
2. **Transportation sector:** NREL transportation team will project light-duty (LD) EV adoption and bus electrification. We will scale LD emissions based on projected EV adoption (normalized to total vehicles in DWP territory).
    a) LA100-caused changes in this sector are expected to lead to the largest changes to air quality of all sectors considered in this study.
3. **Building sector:** ResStock and ComStock models will project future hourly on-site natural gas consumption. We will scale building-level emissions (focusing on high emitters) using these outputs.
4. **Industrial sector:** Port of LA and LAX emissions will be scaled based on renewable energy adoption (as informed by NREL).

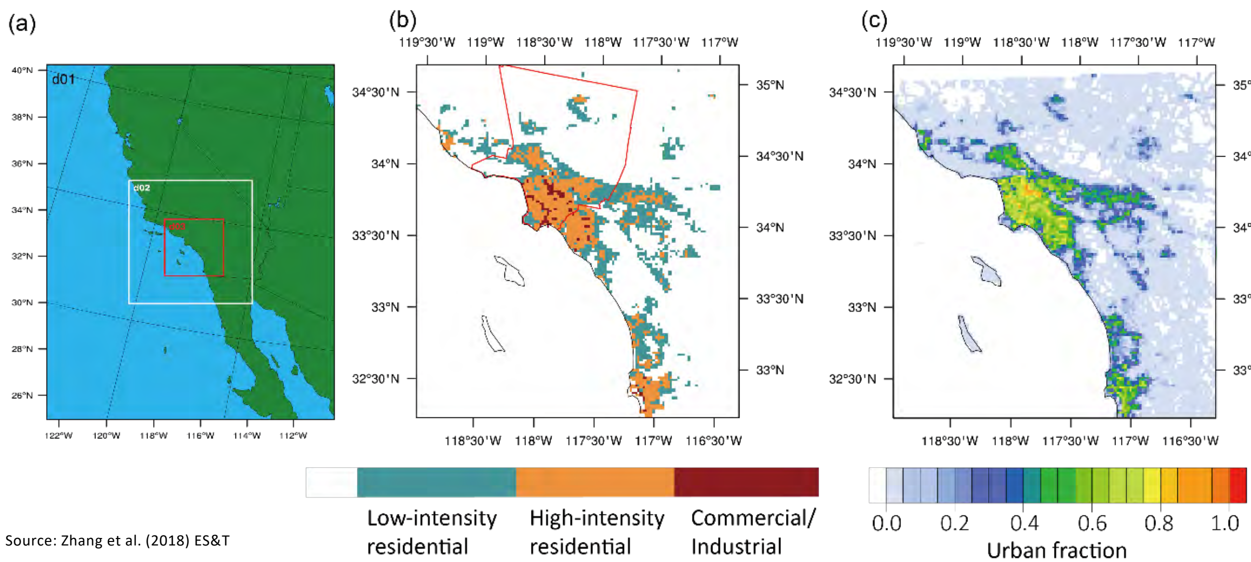
3) Predicting future ozone and $PM_{2.5}$ concentrations using a state-of-the-science air quality model

- We use a fully coupled climate – chemistry model to simulate how changes in emissions will alter atmospheric concentrations of ozone and $PM_{2.5}$
- Weather Research and Forecasting coupled to Chemistry model (WRF-Chem v3.7) is a 3D, gridded, photochemical air quality model developed by the National Center for Atmospheric Research (run by the National Science Foundation)
- The WRF model is an open-source, community model commonly used by scientists and regulators; e.g., https://ruc.noaa.gov/wrf/wrf-chem/Real_time_forecasts.htm
- The Ban-Weiss group at USC has implemented several modifications to the model to enable accurate simulations of climate and air pollutant concentrations for Southern California
  - Described and used in ~7 recent peer-reviewed journal articles



Source: ADD!

3) Assessing future ozone and $PM_{2.5}$ concentrations using a state-of-the-science air quality model



Source: Zhang et al. (2018) ES&T

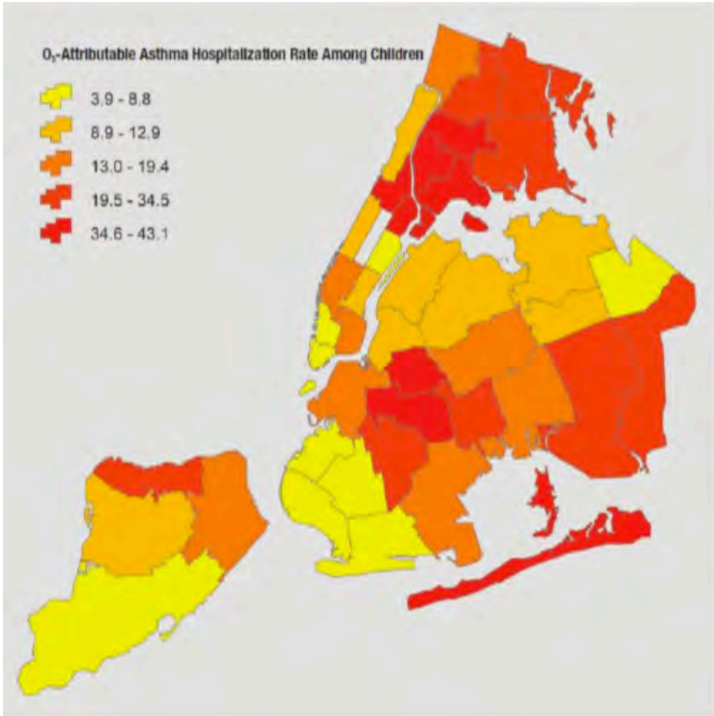
- Model spatial resolution uses 2km x 2km grid cells for inner domain of LA
- We will identify and run simulations for four to six ~2-week episodes with "typical" (2012) meteorology and pollutant concentrations for each season
  - This approach has been common in regulatory air quality modeling
  - 2012 is the same year of meteorology used for power sector and loads modeling in LA100
- Results will be translated to annual mean changes for health effects analysis

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

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 ($PM_{2.5}$)
- Use established methods from Environmental Protection Agency that are commonly used by regulatory agencies to quantify public health impacts of proposed changes to air pollution regulations
  - Likely model we will use: US EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), which is also used by SCAQMD

ED Visits, Asthma, New York City



Source: Ito et al. 2007
https://www.epa.gov/sites/production/files/2014-10/documents/hia_for_benmap_webinar_8.7.13.pdf

5) Presentation of results

- Spatial maps displaying air pollutant ***emissions*** from primary sectors, per scenario analyzed
  - These are the results that will be ready to present by the March 2020 AG meeting ("Preliminary GHG and Air Pollution Results")
- Ozone and $PM_{2.5}$ annual average concentrations, and rates of premature morbidity and (hopefully) mortality under analyzed scenarios, are to be presented at June 2020 AG meeting
- Each of these outcomes will be presented as both absolute results for the reference case scenario and the differences between the selected LA100 scenarios and reference case
- We will also present spatially averaged results for the LADWP service territory

Questions?

LA100

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Environmental Justice

Garvin Heath, Ph.D.

Emma Tome

September 19, 2019

Los Angeles Department of Water & Power | NREL Transforming ENERGY

Overview

- Recap and background
  - Recap of prior AG presentation on Environmental Justice
- Cal EnviroScreen metrics and methods
  - Designation of EJ neighborhoods
- Approach to assess environmental justice effects of LA100 scenarios

AG Meeting #6: August 16, 2018: Where does EJ analysis fit in study sequence

Environmental Modeling Requires Results of Electric-Sector and Loads Modeling

LA DWP

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

NATIONAL RENEWABLE ENERGY LABORATORY

AG Meeting #6: August 16, 2018

- Additional EJ metrics have been added to LA100 evaluation since last AG (beyond Cal EnviroScreen)

City Council Requirements

LA DWP

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

Defining EJ neighborhoods

- Since AG6, we found an OEHHA memo defining official cut-off for DAC (EJ) designation which we will use

How to Define EJ Neighborhoods

LA DWP

- 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)

CES 3.0 Variables

CES ranks census tracts on these variables (0-100 score) using retrospective data from national and state sources

Pollution Burden	Population Characteristics
Exposures • Ozone concentrations • $PM_{2.5}$ concentrations • Diesel PM emissions • Drinking water contaminants • Pesticide Use • Toxic releases from facilities • Traffic density	**Sensitive populations** • Asthma emergency department visits • Cardiovascular disease (emergency room visits for heart attacks) • Low birth-weight infants
Environmental effects • Cleanup sites • Groundwater threats • Hazardous waste • Impaired water bodies • Solid waste sites and facilities	**Socioeconomic factors** • Educational attainment • Housing burdened low income households • Linguistic isolation • Poverty • Unemployment

LA100 environmental justice analysis approach: Seeking your feedback

1. **Identify Environmental Justice (EJ) neighborhoods**
   A. Follow Cal OEHHA definition.
2. **Quantify environmental health benefits:**
   A. Changes to applicable pollution exposure and sensitive populations criteria used in the Cal EnviroScreen.
3. **Quantify technology deployment benefits:**
   A. Distributed PV,
   B. Energy efficiency in buildings, and
   C. Electric vehicle adoption.
4. **Evaluate degree of prioritization of benefits to EJ neighborhoods**

Defining EJ neighborhoods

1. Identify Environmental Justice (EJ) neighborhoods
   - A. Use ‘Disadvantaged Communities’ definition of the top 25% of Cal EnviroScreen (CES) scores, in alignment with recommendation by Cal OEHHA
     - i. Plus several other census tracts which don’t have complete CES scores but are high on the part of the score that exists

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SECRETARY FOR
ENVIRONMENTAL PROTECTION

EDMUND G. BROWN JR.
GOVERNOR

**DESIGNATION OF DISADVANTAGED COMMUNITIES
PURSUANT TO SENATE BILL 535 (DE LEÓN)**

APRIL 2017

I. INTRODUCTION

California is embracing a decarbonized economy. How to meet the global threat of climate change, while improving conditions throughout the state in communities over-burdened by pollution, socioeconomic, and health impacts, is one of our greatest challenges. One of our best opportunities to meet this challenge is to direct climate investments to disadvantaged communities.

The California Environmental Protection Agency (CalEPA) is responsible for identifying disadvantaged communities for purposes of the Cap-and-Trade funding program. In October 2014, after a series of public workshops, the Agency designated as disadvantaged communities the 25% highest scoring census tracts using results of the California Communities Environmental Health Screening Tool Version 2 (CalEnviroScreen 2.0).

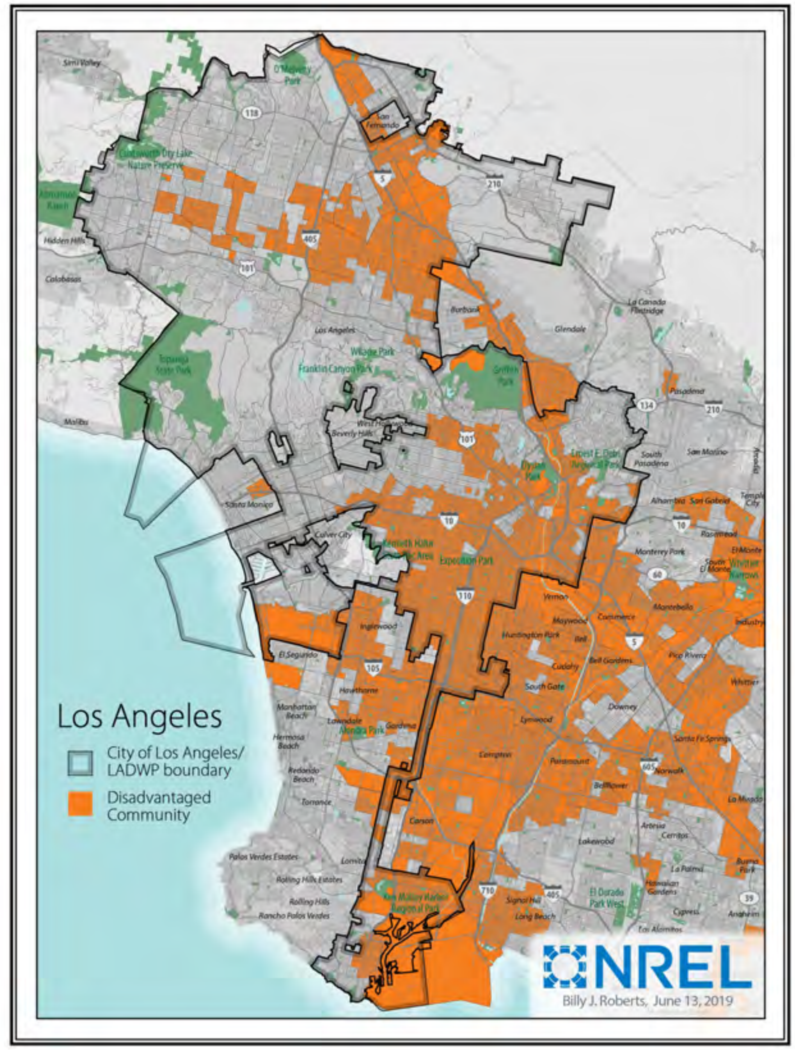
Early this year, the Office of Environmental Health Hazard Assessment (OEHHA) released CalEnviroScreen 3.0. This version of CalEnviroScreen incorporates more recent data for nearly all of its indicators, adds two indicators and improves the way some indicators are calculated to better reflect environmental conditions and a population’s vulnerability to environmental pollutants. While the overall pattern of high-scoring census tracts across the state is similar between the 2.0 and 3.0 versions of CalEnviroScreen, the presence of the new data and results led CalEPA to reassess the identification of disadvantaged communities.

After reviewing the updated results from CalEnviroScreen 3.0 and taking into consideration previous comments and input received over the past two years, including workshops held in February 2017, CalEPA is designating the highest scoring 25% of census tracts from CalEnviroScreen 3.0 as disadvantaged communities. Additionally, 22 census tracts that score in the highest 5% of CalEnviroScreen’s Pollution Burden, but do not have an overall CalEnviroScreen score because of unreliable socioeconomic or health data, are also designated as disadvantaged communities.

This document describes how CalEPA arrived at its decision to identify disadvantaged communities pursuant to SB 535 (De León, Chapter 830, Statutes of 2012). Starting in the 2017-2018 fiscal year, administering agencies approving projects using appropriation from the Greenhouse Gas Reduction Fund must use this designation of disadvantaged communities in determining how to satisfy the project funding requirements of this and related legislation.

Defining EJ neighborhoods

1. Identify Environmental Justice (EJ) neighborhoods
   A. Use 'Disadvantaged Communities' definition of the top 25% of Cal EnviroScreen (CES) scores, in alignment with recommendation by Cal OEHHA
      i. Plus several other census tracts which don't have complete CES scores but are high on the part of the score that exists
   B. **About 50 percent of census tracts in LADWP service territory are classified as EJ/Disadvantaged Communities.**



CES 3.0 Variables

Pollution Burden	Population Characteristics
Exposures • Ozone concentrations • $PM_{2.5}$ concentrations • Diesel PM emissions • Drinking water contaminants • Pesticide Use • Toxic releases from facilities • Traffic density	**Sensitive populations** • Asthma emergency department visits • Cardiovascular disease (emergency room visits for heart attacks) • Low birth-weight infants
Environmental effects • Cleanup sites • Groundwater threats • Hazardous waste • Impaired water bodies • Solid waste sites and facilities	**Socioeconomic factors** • Educational attainment • Housing burdened low income households • Linguistic isolation • Poverty • Unemployment

Applicable CES 3.0 Variables

Red font for variables whose changes can be measured in LA100

Pollution Burden	Population Characteristics
Exposures • **Ozone concentrations** • **PM2.5 concentrations** • Diesel PM emissions • Drinking water contaminants • Pesticide Use • Toxic releases from facilities • Traffic density	**Sensitive populations** • **Asthma emergency department visits** • **Cardiovascular disease (emergency room visits for heart attacks)** • Low birth-weight infants
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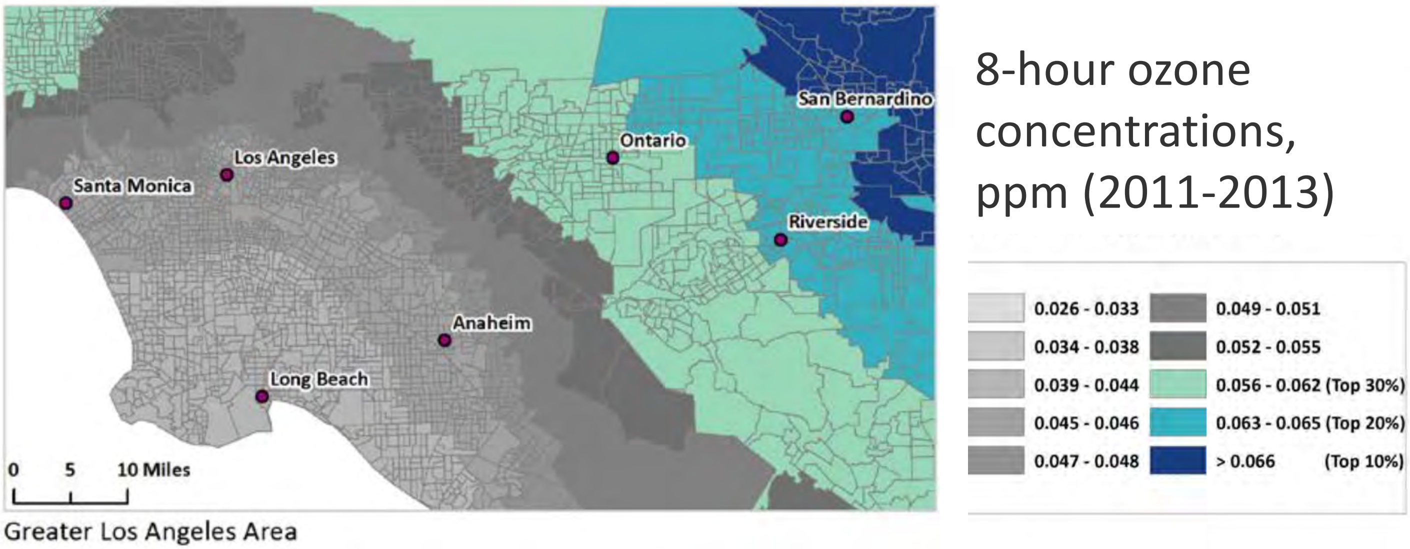
Air quality measures

CES Method: Ozone



8-hour ozone concentrations, ppm (2011-2013)

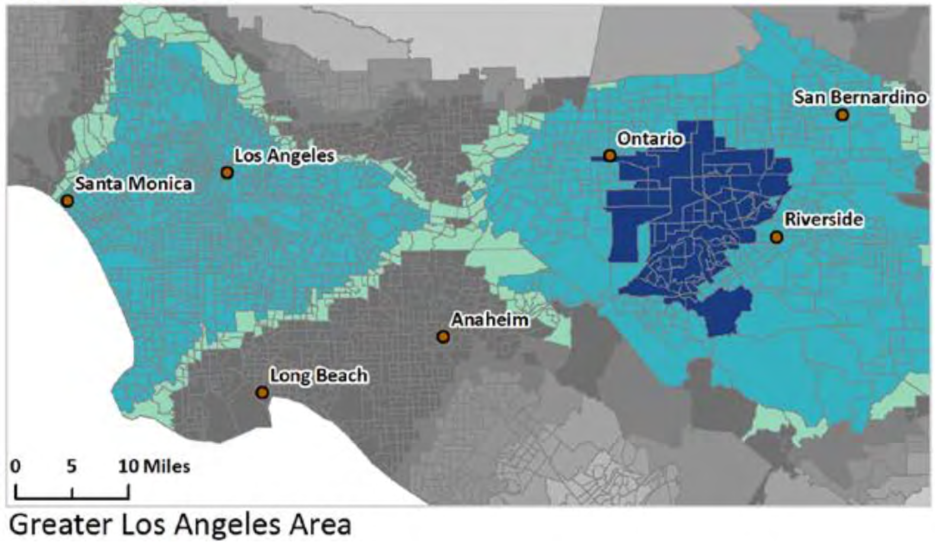
- California Air Resources Board (CARB) monitoring network measurements.
- Inverse distance weighting (IDW) from monitors assigns values to census tracts.

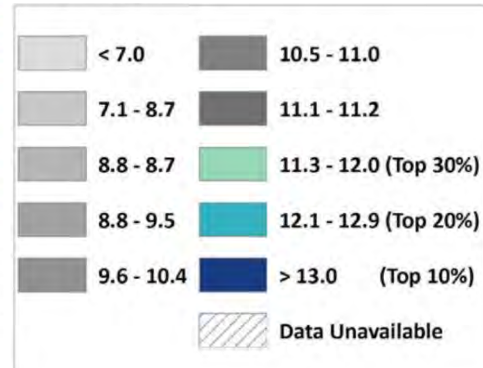
[Source: OEHHA CES 3 Report, p.22-25]

OEHHA CES 3.0 Report p. 22-25

CES Method: $PM_{2.5}$

Annual mean concentration of $PM_{2.5}$ ($\mu g/m^3$) (2012-2014)





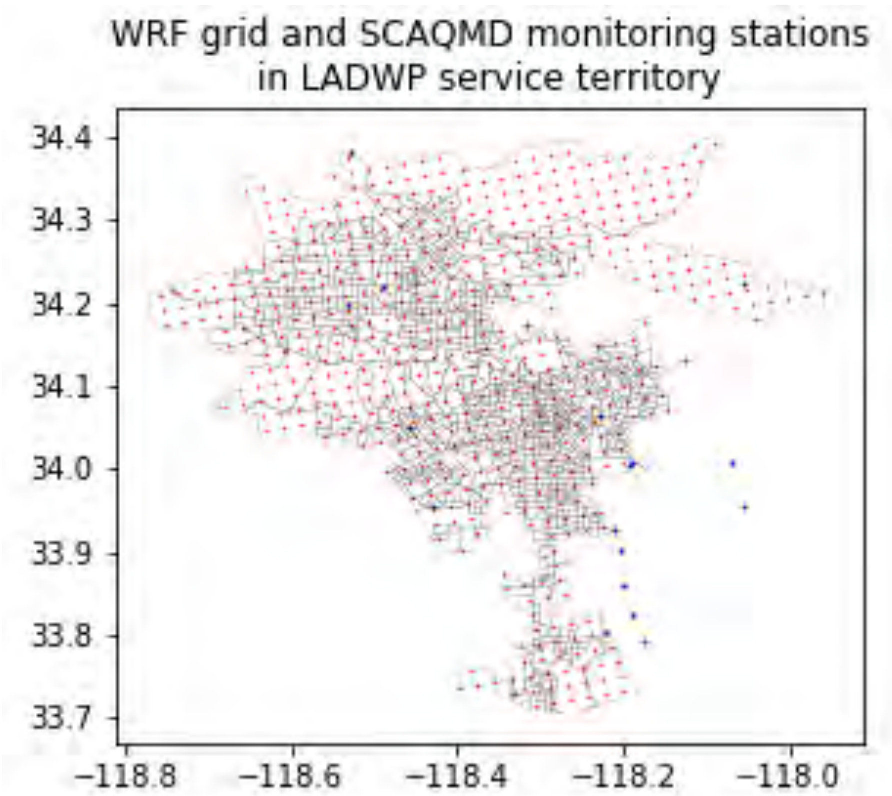
- California Air Resources Board (CARB) monitoring network measurements.
- Mean concentrations estimated at census tract center using ordinary kriging.

[Source: OEHHA CES 3 Report, p.26-29]

OEHHA CES 3.0 Report p. 26-31

Resolving air quality measurements and simulations

- WRF-Chem simulations yield ozone and PM2.5 concentration estimates at a 2x2 kilometer resolution.
  - Finer than CalEnviroScreen.
- However, we must be cautious to not assign too much accuracy to individual grid-cell concentration estimates when attempting to estimate tract-level changes.



WRF = Weather Research and Forecasting-Chemistry air quality model

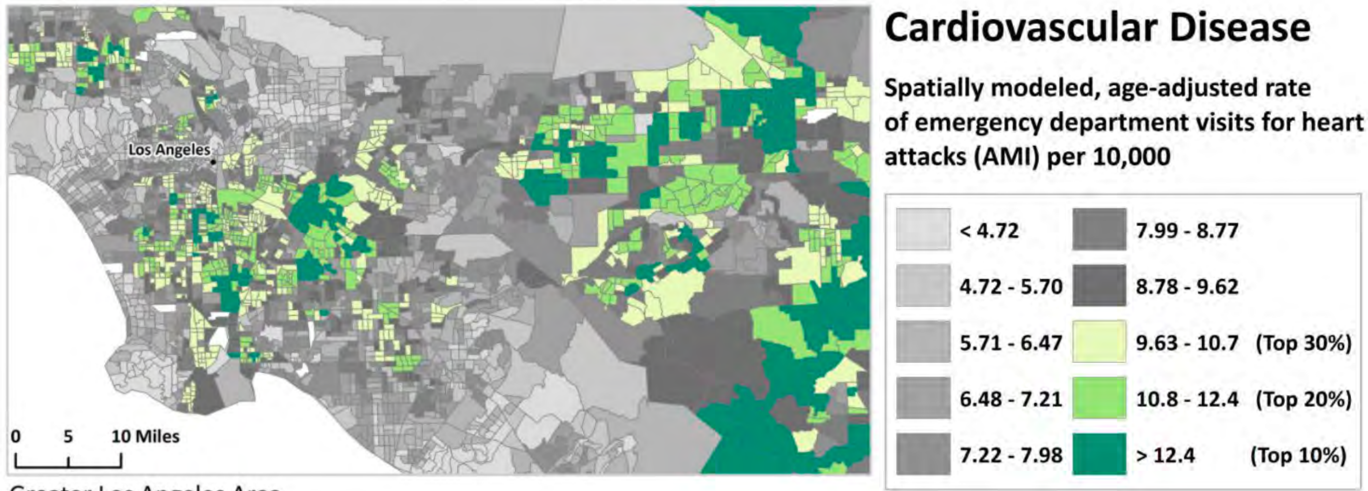
LA100: Quantifying air quality changes

- Statistically compare absolute concentration and improvements (compared to current) among CES-classified EJ and non-EJ census tracts.
- Also adjust CES scores for the individual criteria, comparing EJ to non-EJ tracts
  - We will also calculate composite CES score changes, but since only 2 of 12 pollution burden indicators will have modeled changes, total CES score is unlikely to change much.
- For both, leveraging more spatially granular underlying data than CES

Public health measures

CES Method:

Cardiovascular Disease



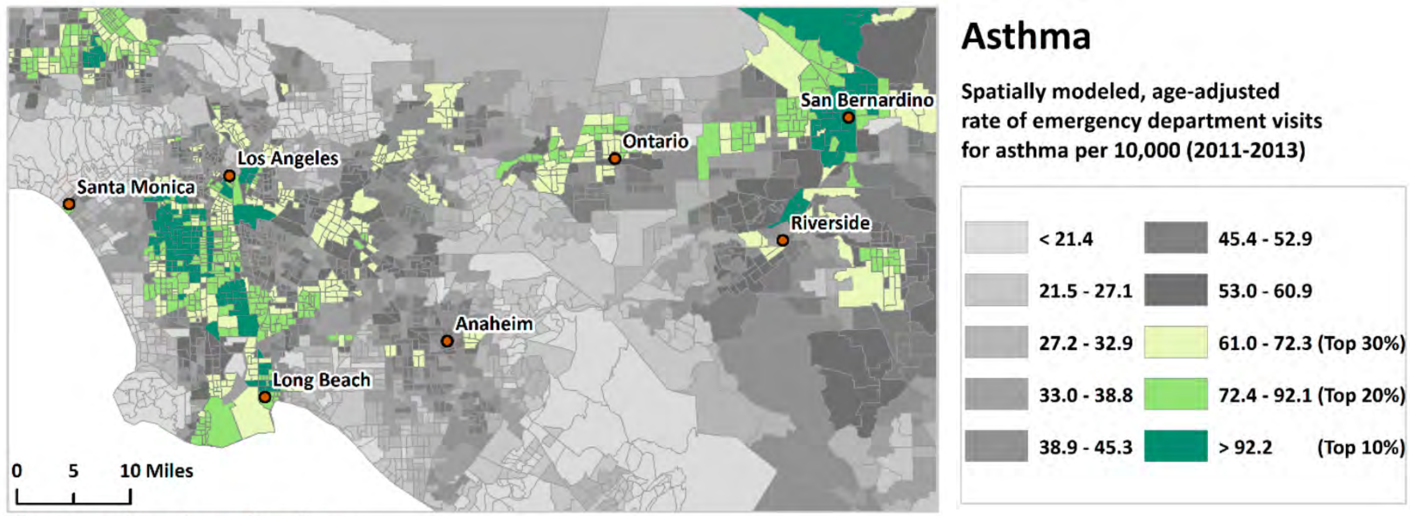
Greater Los Angeles Area

- California Office of Statewide Health Planning and Development, California Environmental Health Tracking Program data
- ZIP code-scale emergency department visits for heart attacks assigned to tracts based on population

Source: OEHHA CES 3 Report, p.111-114

OEHHA CES 3.0 Report p. 111-115

CES Method: Asthma



Greater Los Angeles Area

- California Office of Statewide Health Planning and Development, California Environmental Health Tracking Program data
- ZIP code-scale emergency department visits for asthma assigned to tracts based on population

Source: OEHHA CES 3 Report, p.106-109

OEHHA CES 3.0 Report p. 106-110

LA100: Quantifying EJ-relevant health effects

- Develop a method to estimate tract-level changes to asthma and cardiovascular disease:
  - Statistically compare health effects in EJ and non-EJ census tracts based on USC health effects modeling grid (2x2 km)
  - Consider if we can adjust CES indicator scores for asthma and cardiovascular disease metrics based on USC health effect modeling results
- As with air quality, we will be leveraging more spatially granular results than CES's

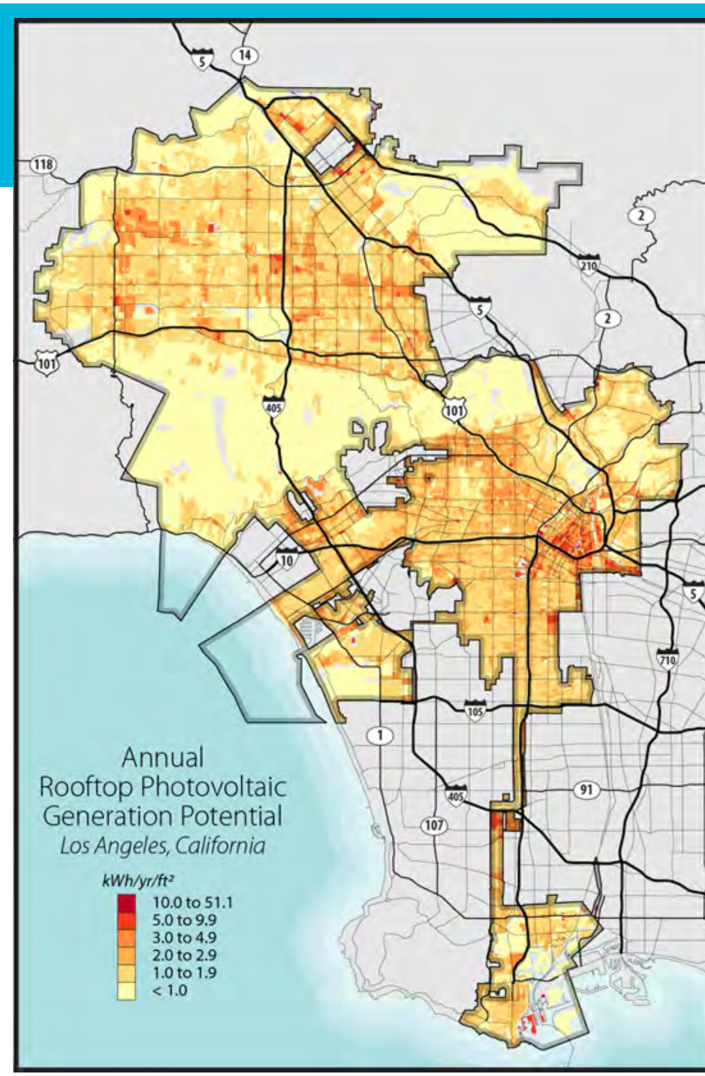
Technology deployment benefits

LA100 modeling: Technology deployment

- Under each scenario evaluated, we aim to quantify implementation by tract-level EJ status for:
  - Rooftop solar (dGen)
  - Energy efficiency in residential and commercial buildings (ResStock, ComStock)
  - Electric vehicles and charging infrastructure (EVI-Pro)
- NREL models primarily estimate physical implementation, e.g., PV modules (MW), number of electric vehicles, or change in building energy use intensity

Residential and community solar, and storage

- We will compare simulated PV adoption levels (installed capacity) in EJ and non-EJ tracts in LADWP service territory.
  - We will evaluate the cases that dGen analyzes
- We could also compare simulated storage (installed capacity) in EJ and non-EJ tracts



Energy efficiency in buildings

ComStock

ResStock

- Buildings energy-demand modeling will identify opportunities for greatest energy savings, which will naturally prioritize energy efficiency measures to the housing stock not as recently built or renovated.
- We will compare tract-level change in energy use intensity (EUI) for each modeled scenario, inside and outside of EJ tracts, for both building types.

Electric vehicles and charging infrastructure

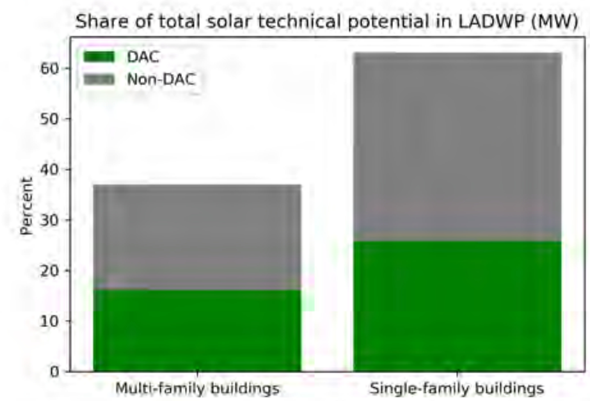
- EVI-Pro models:
  - Light-duty electric vehicle adoption aggregated to tracts.
    - Note that adoption is based on historical sales only. Historic sales occurred mostly in wealthier neighborhoods.
  - Deployment of direct current fast charging (DCFC) plugs/stations by tract.
- We will compare both metrics inside and outside of EJ tracts, in terms of number of vehicles and DCFC chargers deployed.
- Also, for transit buses, we will attempt to compare the number of stops serviced by electrified buses inside and outside of EJ tracts.

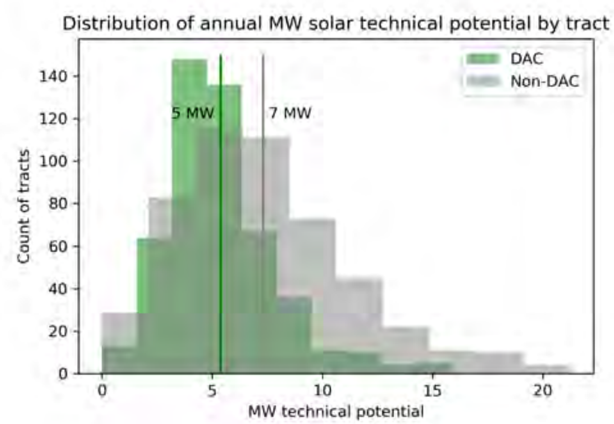
EVI-Pro

Evaluating technology deployment equity: Overview

1. Report deployment model outputs at the tract level, by EJ status.
2. Calculate fraction of total deployment between EJ and non-EJ tracts
   a) Consider statistical tests for difference in mean technology deployment
   b) Report results to inform question of whether deployment was prioritized according to stakeholder and decision-maker values

SAMPLE MOCK RESULTS





Summary

- Evaluate two aspects of EJ using best-in-class models with realistic deployment
  - Air quality and environmental health
    - Within framework of Cal EnviroScreen
  - Energy efficiency and renewable energy deployment
    - Distributed solar and storage
    - Building retrofits
    - Electric vehicle and charging infrastructure
- We will compare benefits in EJ and non-EJ census tracts
- Results will point to where prioritization of EJ communities is achieved while minimizing costs, and where programs or policies could be considered to achieve a satisfactory level of prioritization.

Thank you

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Distributed Solar & Storage: Methods & Framework

Ben Sigrin

Paritosh Das, Meghan Mooney, Jane Lockshin

September 19th, 2019

LA DWP Los Angeles Department of Water & Power | NREL Transforming ENERGY

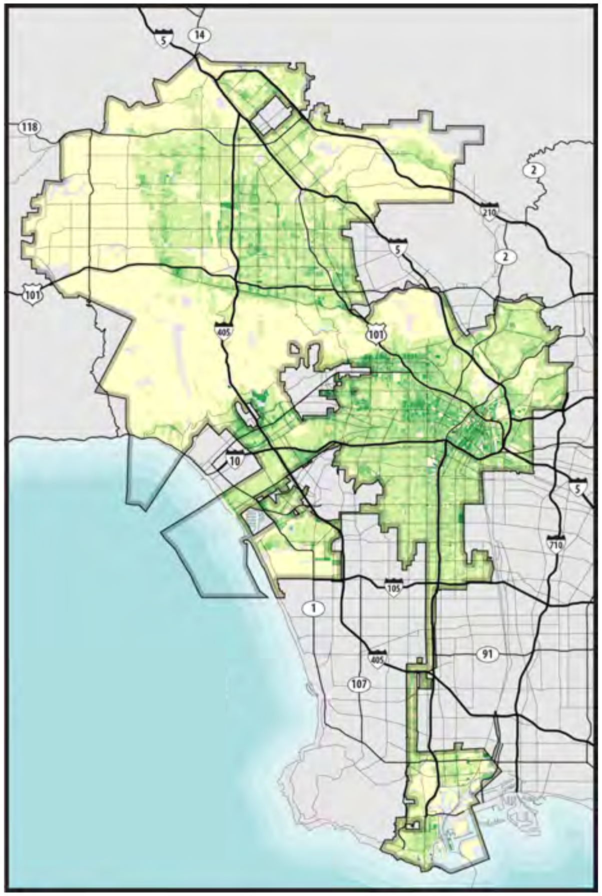
Outline

1. Lightning overview
2. Distributed generation analysis in the project context
3. Modeling assumptions and methodology
4. Discussion

Lightning overview: Analysis questions

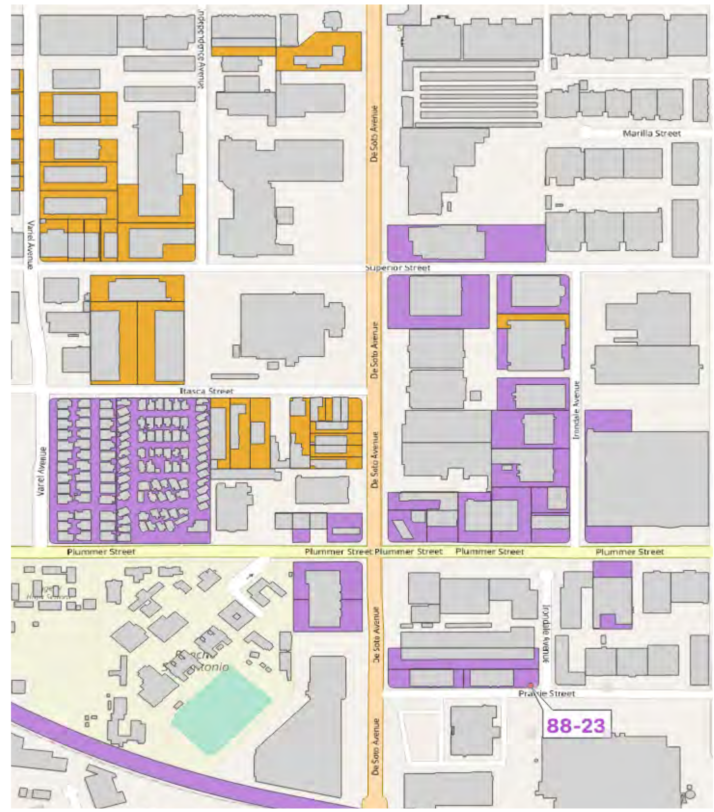
How much distributed solar and storage could be adopted?

Where are **optimal sites** for local solar?



Lightning overview: Model development

- Assess the **technical potential** for rooftop and carport solar
- Identify the **optimal sites** for local solar
- Create a **database of “agents”** for modeling distributed solar

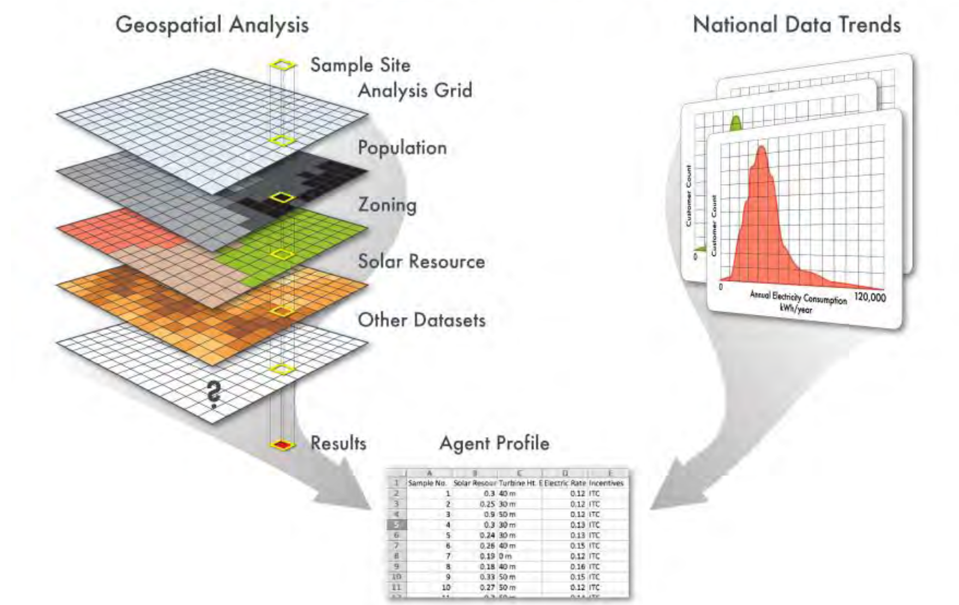


Screenshot of GIS-based agent database

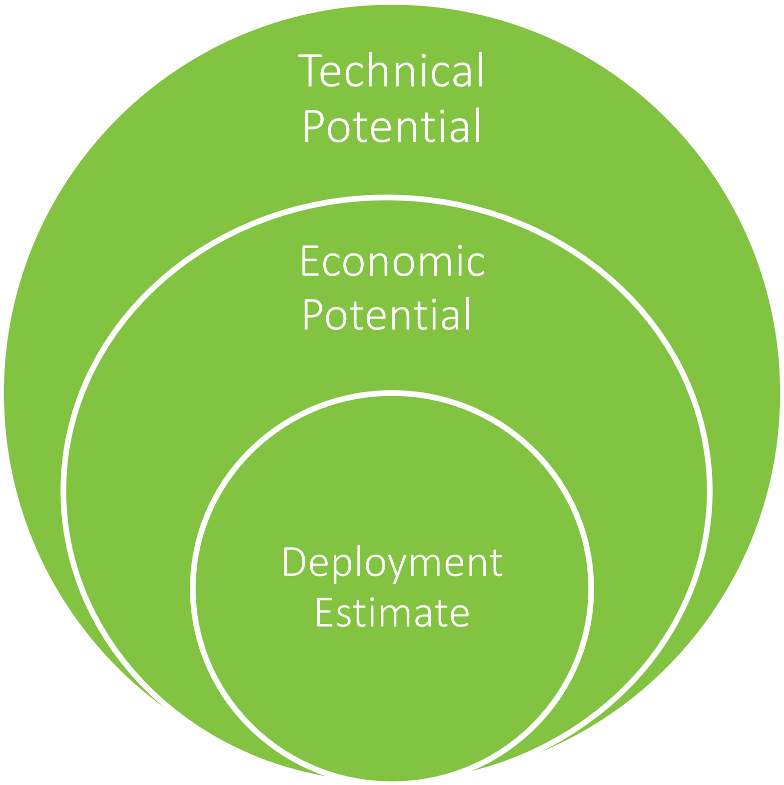
Lightning overview: dGen model

Agent-based model that:

- Simulates **consumer decision-making**
- Forecasts **customer adoption of distributed solar and storage** at the building level
- Incorporates **detailed spatial data** to inform distribution planning questions



Lightning overview: Framework for projecting adoption



- **Technical potential** is the maximum feasible amount of capacity that could be deployed
- **Economic potential** is the amount of capacity that meets or exceeds a rate of return threshold, i.e., would be economic for the consumer to adopt
- **Deployment** is the decision for the agent to adopt in a given year and, if so, the amount of system capacity. The agent can only adopt if the system is technically and economically feasible

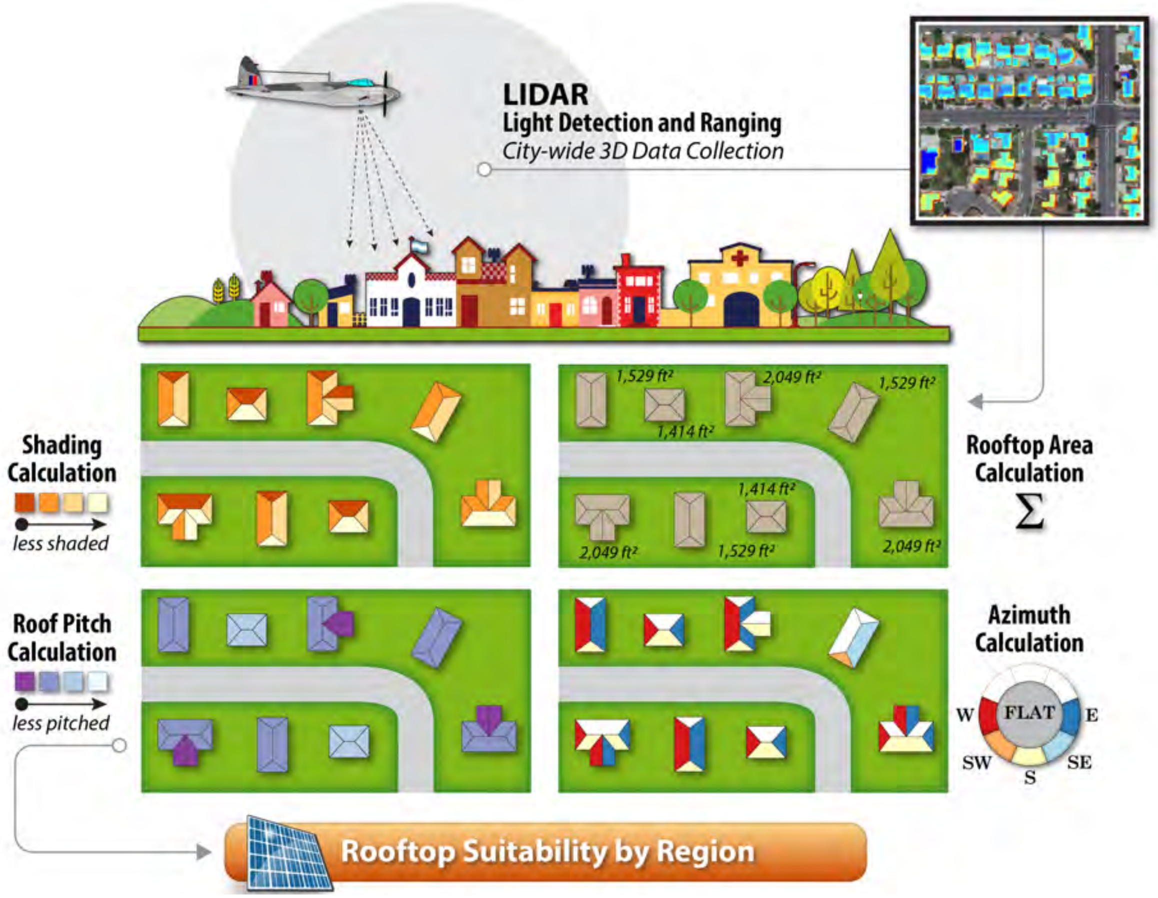
Project Context

dGen in the project context

- dGen **informs the distributed generation element of the capacity expansion modeling**
  - We use the consumer load profiles developed by the NREL Buildings team
  - For "moderate" projections, we use outputs of the capacity expansion model (RPM), e.g., modeled wholesale electricity prices, to analyze how the value of rooftop generation to the power system would influence customer adoption
- dGen outputs are **used in the distribution analysis**, e.g., the projected adoption for each feeder
- dGen outputs are also **used for environmental justice (EJ) analysis**

Methodology

Assess rooftop suitability for solar



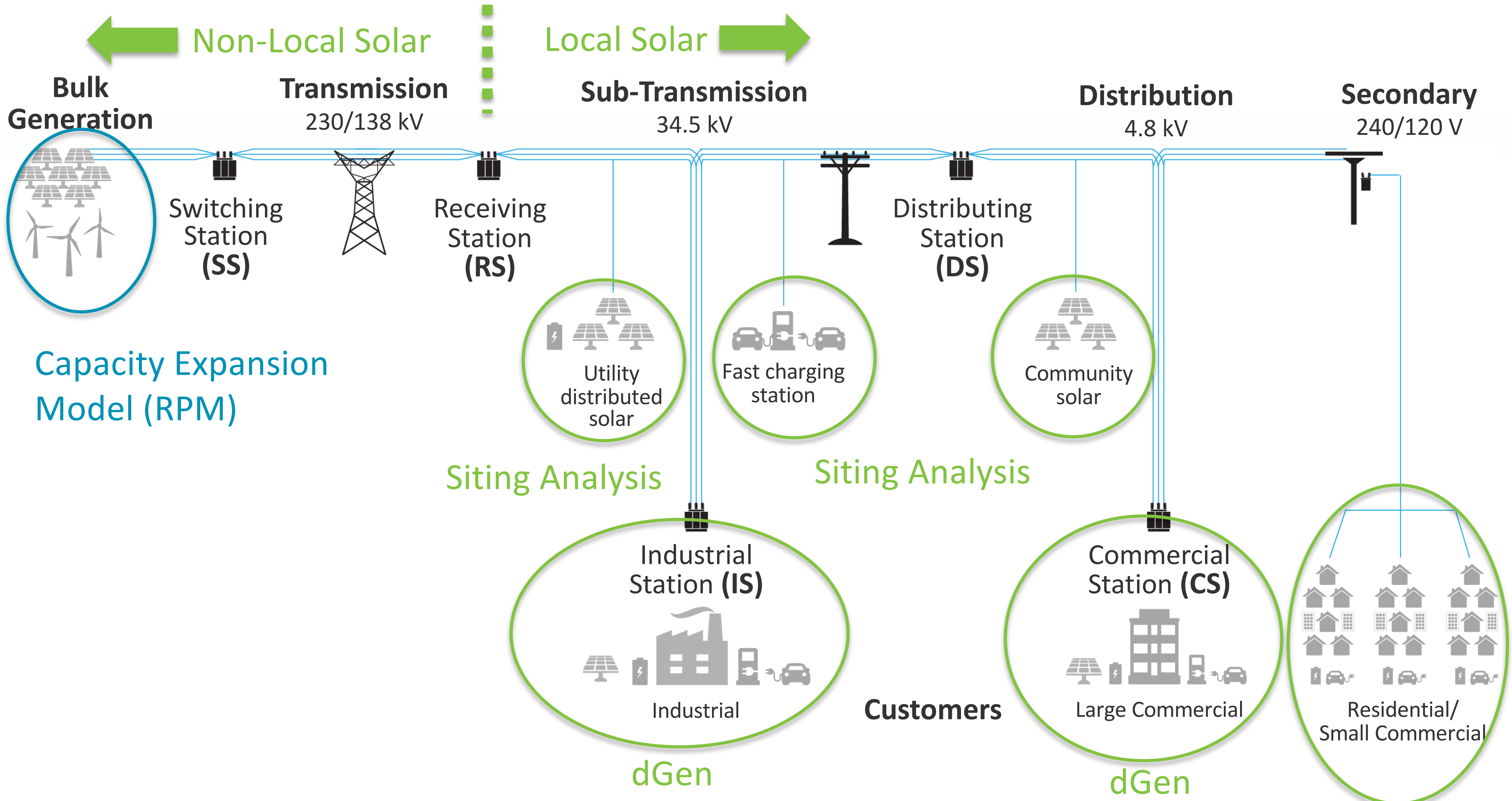
Rooftop and carport technical potential results

- Approximately **10.5 GW_{DC} of technical potential for rooftops** and **3.3 GW_{DC} for parking lot canopies** in LADWP
  - Roof age not considered as a suitability criteria
- Most is in the **residential sector**, followed by manufacturing and commercial
- Nearly half is in census tracts designated as **disadvantaged communities**

Land Use	Dev. Bldgs (n)	Dev. Area (m^2)	Annual Gen. Potential (TWh)	Capacity Potential (GW)
Airport	477	353,297	0.10	0.06
Commercial	46,844	8,268,321	2.35	1.51
Industrial	1,673	556,524	0.16	0.10
Manufacturing	24,981	9,804,638	2.80	1.79
Open Space	2,743	352,591	0.10	0.06
Other	12,121	2,523,079	0.72	0.46
Residential	738,438	35,439,864	10.18	6.49

Summary of technical potential study results

Note: Actual adoption will be substantially less than the technical potential



Non-Local Solar
Local Solar
Bulk Generation
Transmission
230/138 kV
Sub-Transmission
34.5 kV
Distribution
4.8 kV
Secondary
240/120 V
Switching Station (SS)
Receiving Station (RS)
Distributing Station (DS)
Capacity Expansion Model (RPM)
Utility distributed solar
Fast charging station
Community solar
Siting Analysis
Siting Analysis
Industrial Station (IS)
Industrial
Customers
Commercial Station (CS)
Large Commercial
Residential/ Small Commercial
dGen
dGen

Siting analysis methods

We conduct a GIS analysis for each LA parcel to screen and rank sites for local solar

Criteria Used to Exclude Sites

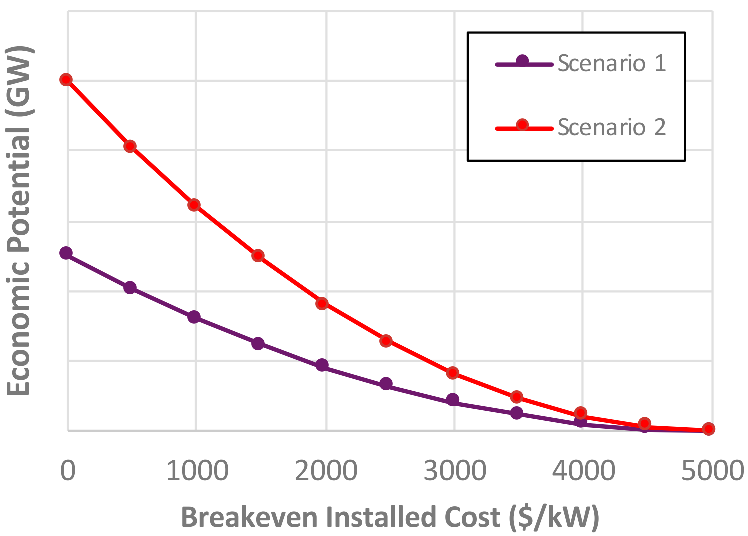
- Already developed
- Landcover (water, wetlands, etc.)
- Parks
- Steep terrain
- Landmarks
- Bike paths
- Technology specific land exclusions

Variables Used to Rank Sites

- **By cost of generation**:
  - Land value and zoning
  - Cost for interconnection to 34.5 kV and 4.8 kV distribution lines
  - Existing ownership, e.g., city-owned, closed coastal generation plants
- **Optional—By location to address EJ:**
  - Environmental Justice tracts
  - Serving low income, renters, and multi-family

Results: A framework for evaluating pathways to local solar deployment

Methodology for economic potential



Example of how dGen outputs can be used to produce supply curves of economic potential and how it varies by scenario, system cost, or degree of compensation for distributed solar

Agents complete a discounted cash flow analysis that includes:

- System **cost and expected maintenance**
- **Retail bill savings** from avoided electricity consumption
- Whether the system is **eligible for incentives, rebates, or avoided tax**

These result in:

- The **system capacity** that maximizes the agents' economic return
- **Net present value** and **payback period** of potential investment

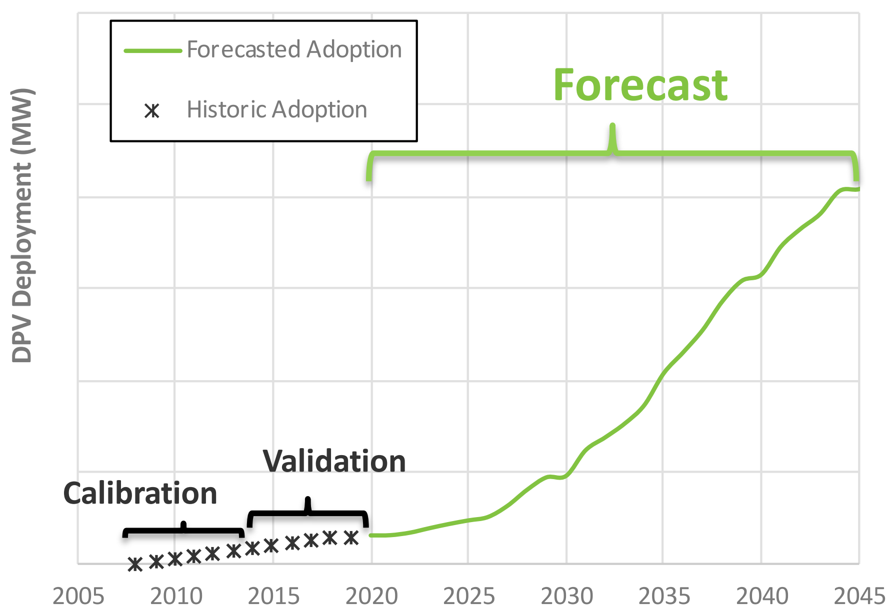
Methodology for economic potential

Distributed generation produces value by **avoiding retail electricity costs**.
We are modeling two projections of future distributed generation compensation:

High Deployment - Net metering: All solar generation is valued at the retail level with no changes to the tariff's structure. However retail prices escalate with future changes to the cost of the power system. ***This is LADWP's current compensation type.***

Moderate Deployment - Net billing: All self-consumed solar generation is valued at the retail level, however any non-consumed generation, i.e. exported to the grid is valued at the real-time wholesale price. ***This represents a hypothetical change in the compensation type.***

Methodology for technology deployment



Example of model calibration, validation, and application for forecasting. Actual model forecasts are resolved at the building level but can be aggregated at different geographic levels

We will train a **predictive model of historic observations of adoption** in LADWP to estimate the agents' probability of adoption in each year.

- Only technically eligible agents can adopt
- Probability of adoption increases with NPV and proximity to other adopters
- Ownership status (e.g., multifamily) and income will affect adoption

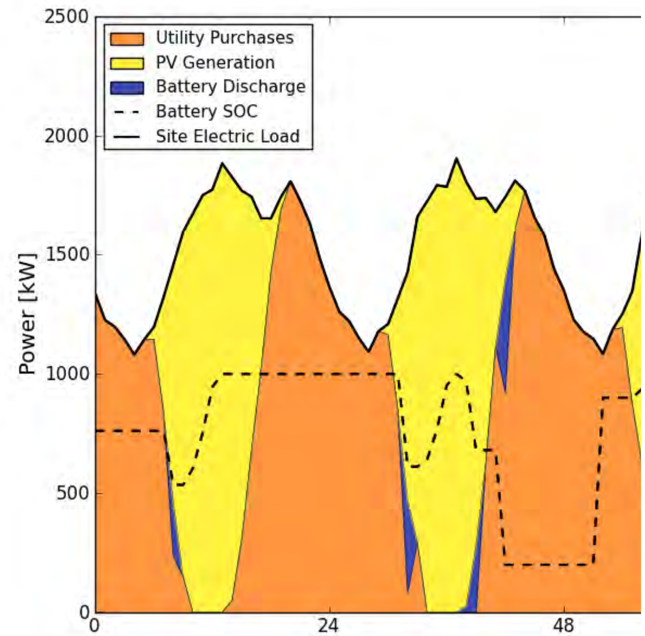
Result: Credible, spatially granular adoption patterns informed by historic trends

Methodology for distributed storage

We will study:

- **Adoption** of distributed storage by end users
- Two projections with **customer control versus LADWP control** of storage dispatch and how these could affect grid operations

Storage adoption will be from the agents' perspective and their respective economic value



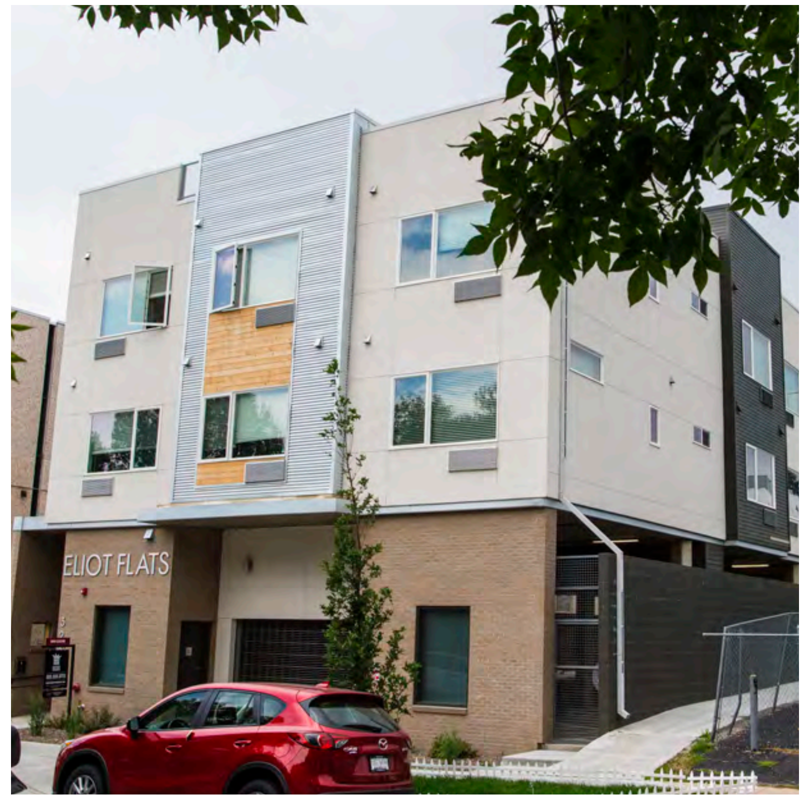
Representative diurnal storage, PV, and grid power flows

Methodology for multi-family and low-income solar

We will develop High and Moderate adoption projections for multi-family and low-income buildings.

This includes **the amount of technical and economic potential** for these sectors.

We will also study the extent to which load could be offset by on-site PV.



Questions?

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The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Jobs and Economic Impact Modeling

David Keyser

September 19th, 2019

AG Meeting #9

LA DWP Los Angeles Department of Water & Power

NREL Transforming ENERGY

Modeling objectives

Estimate **workforce needs** within and outside of the LADWP basin — JEDI Model

Assess **potential net employment and income impacts** within the City of LA for different LA100 scenarios — CGE Model

Estimate **both positive and negative impacts** to the economy, along with **who** is most affected — CGE Model

Address LADWP and AG **feedback**

Workforce needs

JEDI Model

- LADWP funded construction and operation of energy facilities requires **workers and supports economic activity** within and outside of LA
- Identify the **energy workforce** needed for each LA100 scenario
- NREL suite of Jobs and Economic Development Impacts (JEDI) models can be used to estimate **jobs supported** by the construction and operation of renewable and non-renewable technologies
- Impacts estimated using **expenditures** for construction, installation, and operation of each scenario

JEDI result metrics

JEDI Model

Onsite, supply chain, and induced impacts

Impacts for **construction** (equivalent of one year) and **O&M** (annual, ongoing)

Jobs: Full-time equivalent – equal to one person working full time for one year

Earnings: Total compensation to workers, including benefits

GDP: The contribution of an industry to an economy – earnings, property-type income such as profits, and taxes

Gross output: An overall level of economic activity – at the business level can be thought of as revenue

Types of impacts included in results

JEDI Model

Onsite	Supply Chain	Induced

• Occur solely within immediately impacted industries
  • For example, a change in electricity expenditures directly impacts the electricity provider
	• "Ripple effect" through industries that provide goods and services to onsite companies
	  • In the electricity expenditure example, this could include construction companies within LA that maintain facilities
		• Accrue as a result of expenditures made by workers in the onsite and supply chain impacts
		  • For example, if a ratepayer pays more for electricity she or he may reduce leisure activities

Impact of LA100 scenarios

JEDI Model

- Scenarios that are more expensive and/or have more expenditures made within LA will tend to support **higher job numbers**
- Installation of rooftop solar is **more labor intensive** than the construction of a wind plant outside of the LADWP basin, so it would support more jobs in LA
- JEDI does not consider **who makes these expenditures**, which could slow economic growth as those who pay for each scenario spend less money elsewhere in the economy

JEDI limitations

JEDI Model

- No assumptions about **changes in the economy** such as future recessions
- No assumptions about **technological advances** or other changes in the productivity of workers or equipment
- Prices – including electricity rates – **stay fixed**
- JEDI shows **jobs that are supported** by each scenario, not overall economy-wide impacts that account for how consumers and businesses react to price changes
- Industries and consumers **don’t make substitutions** because the economy remains fixed
  - All inputs (e.g., different materials, labor) used by industries remain fixed at the same proportions
  - Households make purchases (e.g., housing, transportation) in the same proportions as well

Net impacts within the City of LA

CGE Model

- JEDI provides information about the workforce but what about **net** economy-wide impacts that account for changes in prices?
- Businesses and consumers change how they spend when prices change
- Increased spending in one area will result in less spending in other areas
  - i.e., if electricity prices increase a household would react both by trying to **reduce electricity consumption** and **spending less elsewhere** such as at restaurants

Modeling team

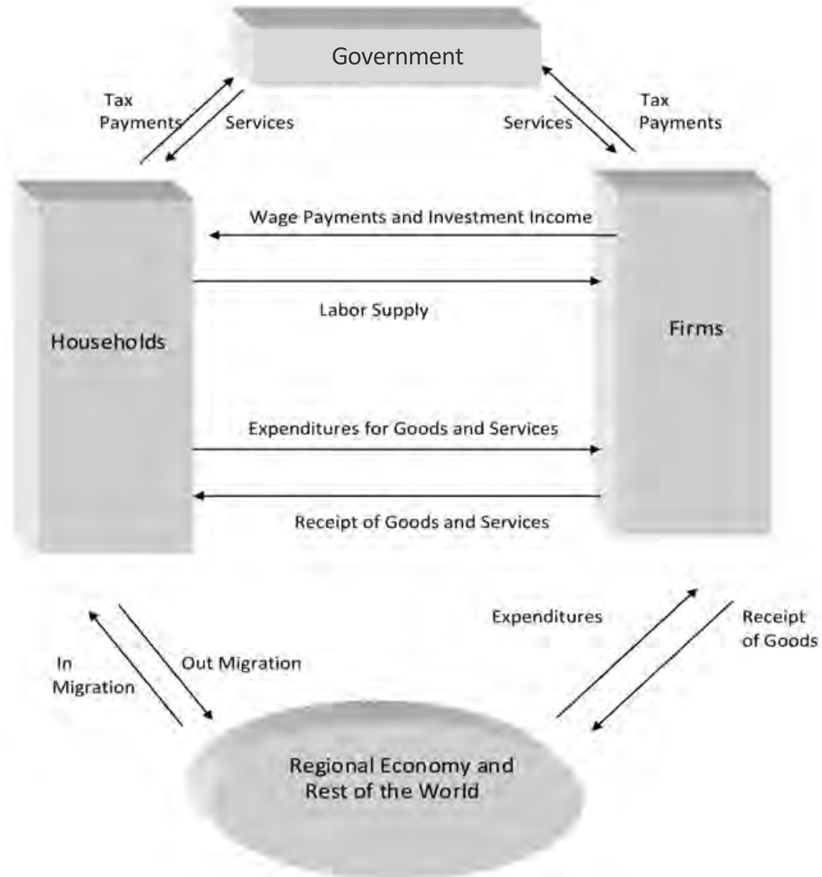
CGE Model

- Tasked with **model selection, development, and analysis**
- Collaboration among the University of Southern California, Colorado State University, and NREL
  - Professor Adam Rose, Professor Dan Wei from the University of Southern California
  - Professor Harvey Cutler, Professor Martin Shields from Colorado State University

Model selection: City of LA

CGE Model

- Selected a **computable general equilibrium (CGE) model**
- CGE models take a **comprehensive view** of an economy and how different sectors interact with one another
  - Industries/businesses, households, investors, the government, and the rest of the world outside of LA (imports, exports)



Incorporating energy data

CGE Model

- The CGE model developed by Colorado State University **explicitly incorporates different energy technologies** such as wind and solar into its underlying data
- **Regional model** can be used for the City of LA
- Energy data is pulled from the **JEDI** suite of models

Capturing net impacts of different scenarios

CGE Model

- Model captures **both positive and negative** economic impacts of LA100 scenarios
- Example: Installing solar PV
  - **Increase** in activity from local purchases such as mounting hardware or profits to wholesalers
  - **Decrease** due to households spending money on solar instead of other goods and services
  - Positive or negative impact **depends heavily on electricity price (rate) changes**

↑ Maintenance

Operation of new plants

Local development

↓ Increased electricity cost to households in LA

Decreased expenditures

Initial price changes for example estimates

CGE Model

- Model temporarily changes **theoretical electricity price changes over time** to illustrate potential impacts
- Actual price changes **could vary** for a number of reasons, including:
  - Capacity expansion and operations and maintenance (O&M)
  - Structure of rates
- Scenario has some hypothetical construction that is not tied to LA100 scenarios

Future modeling to reflect LA100 study outputs and AG feedback

CGE Model

- Temporary price change example estimates are **not explicitly associated with expansion scenarios** because these changes are not yet estimated by NREL
- **LA100 outputs** will provide data on the mix of generation technologies. CGE model will reflect expenditures to develop this mix
- Future estimates will reflect a number of **potential price change scenarios** for each each LA100 scenario
- We will **incorporate AG and LADWP feedback**, particularly on electricity price changes due to factors other than the scenario-specific investments

How price changes affect consumers

CGE Model

Households spend different amounts on electricity and **will be affected differently** by electricity price

Household (HH) Income	Annual Electricity Spending per HH	Monthly Electricity Spending per HH	Number of HHs	Total Expenditures
< $10k	$561	$47	103,516	$61,786,278
10k-25k	$566	$47	91,149	$54,883,561
25k-30k	$663	$55	148,040	$104,347,873
30k-40k	$767	$64	121,888	$99,391,057
40k-60k	$850	$71	156,590	$141,505,703
60k-80k	$854	$71	207,562	$188,490,583
80k-125k	$1,025	$85	139,713	$152,248,029
125k-150k	$1,025	$85	166,766	$181,728,220
> $150k	$1,025	$85	179,054	$195,118,697

What is (and is not) included in temporary estimates

CGE Model

Estimated impacts are:

- Solely tied to theoretical electricity price changes
- For the City of LA as a whole
- Applied as a single percent change to all income groups
  - This can be changed in the future

Estimated impacts are not:

- Tied to LA100 outputs
- Split out by neighborhood
- Directly tied to expenditures captured in the model – does not include quality of life or health impacts
  - Re: December 2018 AG question about economic impact of emissions reductions

Interpreting positive and negative impacts

CGE Model

- Positive and negative impacts are **across all industries** and do not indicate growth or decline in the energy workforce
- Results are **aggregate**, so different types of impacts could have different signs—some could be positive while others are negative
- Impacts **only include what is monetized** and do not show impacts that are not explicitly monetized in the CGE model, such as health

Impacts show "pressure" on changes in the economy

CGE Model

- **Results do not show absolute changes for the entire economy in LA**
- Example: A 3,000-job impact does not indicate that employment will grow by 3,000 in LA
  - It would just show that employment would grow by 3,000 jobs **faster** than it would otherwise
- Example: A negative employment number does not necessarily mean that the economy would lose jobs
  - It just means that employment growth might not be **as high** as it otherwise would have been
    - i.e., a business may not hire a worker

Example estimates of theoretical price changes: annual employment

CGE Model

- Results show **relatively low net changes** in employment

Electricity Price Change	**10% Decrease**	**10% Increase**
Example annual change in employment	3,369	-2,919
Example annual percent change	0.18%	-0.16%

- Estimates are **theoretical** and **do not include the expansion and associated expenditures in LA100 scenarios**
- **Different expenditures** on **different technologies** will drive different results.
  - Expenditures for different components, industries
  - Expenditures within LA will drive more local economic activity

Questions?

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The Los Angeles 100% Renewable Energy Study