The Los Angeles 100% Renewable Energy Study

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #7

Thursday, November 15, 2018, 8:45 a.m. to 1:45 p.m.

Meeting Summary[1]

(Meeting Notes Compiled by Kearns & West Staff)

Location

City of Los Angeles Department of Water and Power (LADWP)
John Ferraro Building
111 N. Hope St., Cafeteria Conference Room (A-Level)
Los Angeles, CA 90012

Attendees

Advisory Group Members

Adam Lane, Los Angeles Business Council
Alexandra Nagy, Food and Water Watch
Andrea Leon-Grossman, Food and Water Watch
Andy Schrader, Council District 5
Armando Flores, Valley Industry and Commerce Association
Camden Collins, Office of Public Accountability (Ratepayer Advocate)
Carlos Baldenegro, Port of Los Angeles
Christos Chrysillou, Los Angeles Unified School District
Dan Wei, University of Southern California
Dominique Hargreaves, Office of the Mayor
Evan Gillespie, Sierra Club
Frank Lopez, Southern California Gas Company
Fred Pickel, Ratepayer Advocate
Jack Humphreville, Greater Wilshire Neighborhood Council
Jasmin Vargas, RepowerLA
Jim Caldwell, Center for Energy Efficiency and Renewable Technology
Jin Noh, California Energy Storage Alliance
Katie Goldman, Office of the Mayor
Kendal Asuncion, Los Angeles Chamber of Commerce
Lauren Faber O'Connor, Office of the Mayor
Loraine Lundquist, California State University, Northridge
Luis Amezcua, Sierra Club

[1] These meeting notes are provided as a summary of the meeting and are not meant as an official record or transcript of everything presented or discussed. They are compiled to the best of the ability of the note takers.

Los Angeles Department of Water & Power
NREL Transforming ENERGY

Matt Gregori, Southern California Gas Company
Matt Hale, City of Los Angeles Council District 2
Michele Hasson, Natural Resource Defense Council
Michael Webster, Southern California Public Power Authority
Molly Deringer Croll, California Energy Storage Alliance
Nurit Katz, University of California, Los Angeles
Priscila Kasha, City Attorney
Rebecca Rasmussen, Office of the Mayor
Shane Phillips, Central City Association
Ted Beatty, Southern California Public Power Authority
Tim O'Connor, Environmental Defense Fund (EDF)
Tony Wilkinson, Neighborhood Council
Virginia Cormier, International Brotherhood of Electrical Workers (IBEW) Local 18
Zelinda Welch, University of Southern California

LADWP Staff

Atique Rahman
Anton Sy
Ashkan Nassiri
Dan Scorza
Dawn Cotterell
Eric Montag
Greg Sarvas
James Barner
Jay Lim
Joe Avila
Julie Van Wagner
Leilani Johnson Kowal
Louis Ting
Luis Martinez
Steve Swift

Project Team

Aaron Bloom, National Renewable Energy Laboratory (NREL)
Daniel Steinberg, NREL
David Keyser, NREL
Doug Arent, NREL
Ramin Faramarzi, NREL
Scott Haase, NREL
Jack Hughes, Kearns & West
Joan Isaacson, Kearns & West
Taylor York, Kearns & West

Guests

Ben Hwang, WorleyParsons
Bruce Tsuchida, The Brattle Group
Elaine Ulrich, US Department of Energy - Solar

Welcome and Introductions

Joan Isaacson, lead facilitator from Kearns & West, welcomed members to the seventh meeting of the Advisory Group (AG) for the Los Angeles 100% Renewable Energy Study (hereafter LA100). She provided an overview of the agenda (see Appendix A) and explained the primary goals of the meeting: discuss current events regarding California Senate Bill 100 (SB 100) and proposed changes to LA100 scenarios, explain how costs are accounted for in LA100, and introduced the approach for analyzing the jobs and economic impact of a transition to 100% renewable energy. Isaacson noted that that the seventh AG meeting presents an opportunity to expand the knowledge base of AG members to facilitate a greater level of understanding once results of the technical study are presented.

Eric Montag, Senior Manager of Strategic Initiatives and Resource Development for LADWP, welcomed the AG members and thanked them for their dedication, time, and passion. He reported that Anton Sy, LA100 project manager, will no longer lead the Study process after the seventh meeting, as he has been selected for a new position within LADWP. Ashkan Nassiri will assume the project manager role. Sy welcomed the AG members and thanked them for their efforts and commitment. Scott Haase also welcomed the AG members, and noted that this meeting will be the first since the passing of SB 100. Haase introduced Doug Arent, Deputy Associate Lab Director for NREL, who then conveyed NREL's excitement about the study and said he plans to attend AG meetings more regularly moving forward.

Slides from all presentations are contained in Appendix B and are available on the LA100 website.

Update Exchange

Project team members and AG meeting attendees were invited to provide updates during this portion of the meeting.

Revised Meeting Plan

Isaacson announced that meeting plan dates have been set for 2019 on the following Thursdays:

- March 28, 2019
- June 27, 2019
- September 19, 2019
- December 5, 2019

AG members requested that calendar entries be sent out for the entire upcoming year.

Advisory Group Member Updates

No updates were provided by AG members.

Senate Bill 100 Overview

Leilani Johnson Kowal, LADWP Legislative Affairs, provided an overview of SB 100, which is entitled The 100 Percent Clean Energy Act of 2018. The bill sets a requirement of 100% clean energy in California by 2045 and was signed into law on September 10, 2018. It will take effect January 1, 2019.

- Accelerated renewable portfolio standards (RPS), addressing the first 60% renewable energy, including a regulatory component that amends the Public Utilities Code and includes enforcement. RPS obligations increase from 40% to 60% in three increments between 2024 and 2030.

- Zero-carbon policy addressing the remaining 40%, which amends the Public Utilities Code but does not include enforcement. By design, the bill does not contain a definition of zero-carbon, avoiding the creation of any official compliance definitions until a more detailed discussion of implementation approaches and impacts takes place.

Kowal also called attention to the letter of intent submitted to the Senate Daily Journal by Senator De León, which outlined his intent for defining zero-carbon policy, including: inclusion of all zero-carbon resources, technology neutrality, and honoring existing obligations. More details on this can be found on slide 12 of the presentation slides contained in Appendix B.

The California Public Utilities Commission (CPUC), California Energy Commission (CEC), and California Air Resources Board (CARB) are tasked with ensuring that implementation actions related to this goal maintain a safe and reliable electric system, prevent unreasonable economic impacts, ensure equality among sectors, and do not negatively impact the California RPS program. The CPUC, CEC, and CARB will be required to submit a progress report to the California Legislature in January 2021. More details on the SB 100 overview can be found in the presentation slides 8 to 13 contained in Appendix B.

Scenario Updates

Aaron Bloom, Project Manager from NREL, provided an overview of changes made to LA100 scenarios to incorporate adjustments in allowance of Renewable Energy Credits for certain scenarios. These changes include adjustments to reference cases, including the addition of SB 100.

The scenarios are now grouped as reference cases and LA100 cases. The two reference cases are the 2017 LADWP Power Strategic Long-Term Resource Plan (SLTRP) Recommended Case and SB 100. The LA100 scenarios begin with an assumption that by 2030 LA achieves net 100% renewable energy, i.e., the net emissions of operations can be offset through the purchase of Renewable Energy Credits (RECs) or by exporting excess renewable energy (generated by LADWP) to neighboring balancing areas, thereby offsetting any remaining in-basin fossil-fuel-fired generation. The LA100 scenarios then accelerate renewable energy goals beyond existing policy to achieve by 2045 or earlier operations with 100% renewable energy *at all hours*, with no compliance via RECs in all but one scenario. All scenarios meet or exceed requirements of SB 100. More detailed information and visuals that illustrate the changes to the framework can be found on slides 34 to 40 of the presentation in Appendix B.

Major Themes from Advisory Group Member Discussion

The following represent questions and major themes from discussion following the Scenario Updates presentation.

- The Ratepayer Advocate should comment on reliability and cost aspects of the project.
- If we expect energy efficiency to play a big role in the future power system, what is the need to conduct analysis of low energy efficiency scenarios?
- Do assumptions in the High Load Stress scenario consider large users such as the ports and airports?
- AG members should have the opportunity to review the individual resources assumptions of each scenario.
- The Mayor, through City Council actions, has committed to ensuring all new buildings will achieve zero net carbon by 2030. All buildings, including existing buildings, will be expected to meet this goal by 2050.

Jobs and Economic Development Analysis

David Keyser, Economist for NREL, provided an overview of LA100's jobs and economic development analysis for the City of Los Angeles. He noted that NREL has established a partnership with the University of Southern California (USC) and Cutler Consulting to conduct the analysis. Cutler will develop the model with input from USC, and USC will be responsible for conducting the analysis. NREL began with three options for models: Input-Output, REMI, and Computable General Equilibrium (CGE). NREL has chosen to use CGE. More information on these different model types can be found on slides 42 to 58 of the presentation in Appendix B.

The CGE economic impact model is custom-built and flexible, capturing a highly detailed representation of an economy. Price inputs are flexible and substitutions are allowed. The model was originally developed by Professor Harvey Cutler, of Cutler Consulting, at Colorado State University, and Cutler Consulting is working with NREL to customize the model for LA100, including an increased focus on the electricity sector. The model considers factors that might both positively or negatively impact an economy, however it does not capture economic effects that might occur outside the region as a result of the transition to 100% renewable energy (e.g., economic impacts to solar panel production in China). It also does not capture certain economic activity that might increase as a result of the transition (e.g., companies moving to Los Angeles to take advantage of the renewable energy image).

The core dataset used in the CGE model is the Social Accounting Matrix, which represents interactions among industries, workers, households, the government, and outside regions as inputs and outputs. Every input, such as goods used for production, is an output provided by another sector. The model has been expanded with more specificity for industries such as construction and utilities, in order to more directly address changes in the power system. Two publications are now available that address the model. Information on these publications can be found on slide 52 of the presentation in Appendix B, along with further details about CGE inputs, technologies captured in LA100, and sample results from model applications on the Colorado RPS.

Major Themes from Advisory Group Member Discussion

The following represent questions and major themes from discussion following the Jobs and Economic Development Analysis presentation.

- Are economic impacts from changes in health being addressed as part of the economic analysis? It was noted that the summary from the August 2018 AG meeting indicates that monetized impacts from health impacts will not be part of the scope of the environmental modeling, but comments made during this meeting indicate that they might – clarification is needed.
- Will the analysis include parts of the county outside of Los Angeles city boundaries that are an integral part of the city economy, such as the Westside and Southgate cities?
- Will the analysis take into account investments made outside city boundaries that might have impacts on rates within the city boundaries?
- Increased cost of electricity could have a negative impact on adoption of electric vehicles. It was noted that achieving 80% renewable may be reasonable, but the high cost of achieving the extra 20% might make mass adoption of electric vehicles cost prohibitive. This could impact scenarios that rely on this type of electrification.
- Interest in reading the two publications on CGE referenced by Keyser was expressed, including a request that they be posted soon.

Accounting for Costs in Power Systems Planning

Daniel Steinberg, Senior Policy and Economic Analyst for NREL, provided an overview of how costs are accounted for in power systems planning. He reviewed components of cost in power systems, why cost matters, methodology and approach to modeling costs, and described the rate impact analysis that will be conducted by LADWP and the ratepayer advocate.

Defining Power Systems Costs and Their Importance

Power providers must consider two main types of power system costs: capital costs and operating costs. Capital costs are the one-time investments made into the system (e.g., building of infrastructure). Operating costs include all fixed and variable costs of running the power system. These can be further broken down into costs for generation and transmission, distribution, and end-use.

Transforming power systems to 100% renewable or zero emissions may require new investments in transmission capacity and generation facilities, and upgrades to distribution. For an entity like LADWP, these investment costs will ultimately be paid for by its customers. It is important to recognize that the cost of carbon abatement increases significantly as total emissions approach zero, meaning that achieving the last few percentage points of renewable energy are substantially more expensive.

With heavy reliance on variable electricity generation, there may either be too much or not enough energy at any point in time. This can be addressed through various methods, such as overbuilding generation or battery storage, but these approaches increase costs.

Methodology and Approach to Modeling Costs

NREL has compiled an integrated suite of models linked through a set of inputs and outputs. The process begins with a generalized investment model called a capacity expansion model, which helps identify the optimal investment pathway to achieve 100% renewable energy. The operations of the model are informed by both current and future conditions, and include both physical and environmental constraints. From this model it is possible to learn how the energy generation mix changes over time. Because it is not possible to model the entire system down to the second over decades, the model represents a reduced form of generator dispatch in order to inform investment decisions. Specifically, rather than optimize dispatch for all 8760 hours of the year, the model simulates hourly dispatch for 4 days in each year selected as days that are representative of low, mid, high, and peak load conditions. As the model informs what investments to make, it evaluates whether those investments will meet load requirements in all hours.

NREL uses a production cost model to detail the unit commitment and dispatch of all generation units down to a 5-minute level for up to 7 years, revealing both details on operational costs and the problems that might arise during system operation. The model helps to identify time periods during which particular stresses in the system might be mitigated with new investments. That information can then be used to further constrain the capacity expansion model in order to refine the output. Power flow modeling is then used to analyze the system at the millisecond resolution—ensuring that the system remains stable during times of stress and has the ability to maintain frequency and voltage under steady state and following a disturbance.

Further details on accounting for costs can be found in slides 61 to 80 of the presentation in Appendix B.

Rate Impact Preview

LA100 will include analysis of the potential impacts of 100% renewable energy on LADWP rates, but calculating rate impacts out to 2045 is very difficult. The rate structures will likely evolve considerably over the next 25 years.

Major Themes from Advisory Group Member Discussion

The following represent questions and major themes from discussion following the Accounting for Costs in Power Systems Planning presentation.

- If the production cost modeling identifies, for example, a transmission constraint where you have the option to upgrade storage or transmission lines, how does it decide what to feed back into the capacity expansion model?
- If the production cost modeling detects a sub-hour issue that might not be factored into the capacity expansion model, would NREL apply a load-following constraint?
- Is NREL modeling different scenarios for backup of remote and local resources? There are different solutions for different failure scenarios.
- How much of the power flow analysis is going to be a diagnostic tool to understand the impact of one location on the grid?
- Where can I find the most recent report for the power reliability program, as well as information on the investment cycle?
- LADWP should consider how it can support ratepayer with adoption of distributed generation, e.g., will LADWP help with the cost of solar panels on ratepayer roofs if it benefits the system as a whole?
- How do you model assumptions for costs of curtailment?
- Business ratepayers may be burdened and choose to leave Los Angeles if they cannot afford electricity prices. Those who stay behind will then be subject to even higher rates.
- Is the capacity expansion model capable of handling hybrid resources such as solar combined with storage?
- The 2016 Integrated Resource Plan addresses interactions between high electrification scenarios and lower rates. It would be helpful to think about how those two things interact in the cost of the overall system.
- It would be helpful for AG members to understand what variables are in what scenario, as well as what variables are in multiple scenarios.
- Is it possible for LA100 to present costs for scenarios lower than 100% renewable adoption?
- When considering distributed energy scenarios, is NREL taking into account the need to transition land use patterns with higher densities?
- Will LA100 consider distributed storage?
- Is NREL looking at incentives to encourage things like efficiency and demand response?

Conclusions and Next Steps

Sy provided a recap of AG accomplishments over the past year. Isaacson provided a review of the 2019 meeting dates.

The next two quarterly AG meetings are scheduled for March 28, 2019 and June 27, 2019.

The Los Angeles 100% Renewable Energy Study

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #7

Thursday, November 15, 2018, 8:45 a.m. to 1:45 p.m.

Appendix A

Agenda

Los Angeles Department of Water & Power

NREL Transforming ENERGY

City of Los Angeles 100% Renewable Energy Study
Thursday, November 15, 2018
8:45 am – 1:45 pm
Los Angeles Department of Water and Power, Cafeteria Conference Room (A-Level)

Meeting Purpose: This meeting has three goals, all which include soliciting Advisory Group input and feedback: 1) discuss current events regarding the Senate Bill 100 and proposed changes to the LA100 study scenarios; 2) explain how costs are accounted for in the study; and 3) provide an introduction to the approach for analyzing the jobs and economic impact of a transition to 100% renewable energy.

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 – 9:20 am	**Welcome and Introductions** **LADWP:** Eric Montag and Anton Sy **NREL:** Aaron Bloom
9:20 – 9:45 am	**Update Exchange** • **Updated Advisory Group Meeting Road Map and Dates** **K&W:** Joan Isaacson • **Update on Data Gathering/Analysis** **LADWP:** Anton Sy All
9:45 – 10:00 am	**Senate Bill 100 Overview** • **Briefing on Senate Bill 100** **LADWP:** Leilani Johnson Kowal, Legislative Affairs
10:00 – 10:30 am	**Scenario Updates** • **Suggested Changes to Scenarios Based on Senate Bill 100** **NREL:** Aaron Bloom
10:30 – 10:45 am	**Break**
10:45 – 11:45 am	**Jobs and Economic Development Analysis** • **Overview of Methods** • **Introduction to Subcontractor** • **Timeline** **NREL:** David Keyser **USC:** Adam Rose
11:45 am – 12:15 pm	**Lunch Served**

12:15 – 1:30 pm	**Accounting for Costs in Power Systems Planning**

- **Defining Power System Costs**
- **Calculating Costs: Approach**
  - **Investment and Reduced-Form Operating Costs**
  - **Detailed Operating Costs**
  - **Validation**
- **Rate Impact Preview**
  - **Preliminary Discussion of Ratepayer Advocate Analysis**

NREL: Daniel Steinberg

1:30 – 1:45 pm	**Wrap-up and Next Steps**

- **Accomplishments/Year in Review**
  LADWP: Anton Sy
- **Next Meeting Date: March 28, 2019**

The Los Angeles 100% Renewable Energy Study

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Appendix B

Presentation Slides

Los Angeles Department of Water & Power

NREL Transforming ENERGY

LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group #7

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Today’s Focus

- SB 100 and the LA 100 Scenarios
- Jobs and Economic Development Analysis
- Accounting for Costs in Power Systems Planning

Agenda

- Call to Order
- Welcome and Introductions
- Update Exchange
- Senate Bill 100 Overview
- Scenario Updates
- Jobs and Economic Development Analysis **
- Lunch
- Accounting for Costs in Power Systems Planning **
- Wrap-up and Next Steps

***Q&A and Discussion*

Welcome and Introductions

Update Exchange

Advisory Group Meeting Plan

COMPLETED MEETINGS/TASKS (grey) · PLANNED MEETINGS/TASKS (blue)

QUARTER	Phase 1 | 2017 LAUNCH AND ORGANIZATION	Phase 2 | 2018 SCENARIOS	Phase 3 | 2019 ANALYSIS AND MODELING	Phase 4 | 2020 FINAL REPORT
Q1		• 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	• Preliminary Scenario Tests • Environmental Analysis II • LADWP Financial Office MARCH 28	• Final 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	• Load Analysis • Jobs & Economic Analysis II • Advanced Engineering Concepts JUNE 27	• Final Report • Final Presentation JUNE 25
Q3	• Advisory Group Charge and Operating Protocols • Introduction to NREL and 100% Renewable Energy Study AUGUST 3	• 100% Data • 100% Methods • Environmental Analysis I • Once-Through Cooling Study Update AUGUST 16	• Preliminary Electric System Results • Preliminary Visualizations SEPTEMBER 19	
Q4	• Defining Clean Energy and Renewable Energy • Considerations for Study • Once-Through Cooling Study Overview • Public Outreach Overview NOVEMBER 16	• Methods for Calculating Investment & Operating Cost • Jobs & Economic Analysis I NOVEMBER 15	• Preliminary Economy & Jobs Results • Preliminary GHG & Air Pollution Results DECEMBER 5	

LA DWP Los Angeles Department of Water & Power

NREL NATIONAL RENEWABLE ENERGY LABORATORY

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

Senate Bill 100

100 Percent Clean Energy Act of 2018

Governor Brown signed into law September 10, 2018

LeiLani Johnson Kowal

Legislative & Intergovernmental Affairs

November 15, 2018

California Legislative History: Statewide RPS

- Senate Bill 1078 (Sher) (2002)
  - 20% by 2017
- Senate Bill 107 (Simitian) (2006)
  - 20% renewables by 2010
- Senate Bill 2 x1 (Simitian) (2011)
  - 20% renewables by 12/31/2013
  - 25% renewables by 12/31/2016
  - 33% renewables by 12/31/2020
- SB 350 (De León) (2015)
  - 40% renewables by 12/31/2024
  - 45% renewables by 12/31/2027
  - 50% renewables by 12/31/2030

Senate Bill 100 (De León)
100 Percent Clean Energy Act of 2018

Two Parts

- Accelerated RPS Targets under California RPS Program (to 60%)
- Zero Carbon Policy (for the remaining 40%)

Part 1: RPS Targets (regulatory)

- Accelerates the RPS obligations for retail sellers - IOUs, CCAs, ESPs, and POUs as follows:
  - 40% increased to 44% by 2024
  - 45% increased to 52% by 2027
  - 50% increased to 60% by 2030

Part 2: Zero Carbon Policy (non-regulatory/planning goal)

- 100% retail sales of electricity by December 31, 2045 = renewables + zero carbon resources.
  - No increase in carbon emissions in the western grid
  - No resource shuffling

Senate Bill 100 (De León)
100 Percent Clean Energy Act of 2018

Zero Carbon Policy

- CPUC/CEC/CARB shall ensure actions related to 100% goal:
  - Maintain and protect the safety, reliable operation, and balancing of the electric system
  - Prevent unreasonable impacts to electric, gas, water customer rates and bills, taking into consideration economic and environmental costs and benefits of renewables and zero carbon resources
  - Lead to adoption of policies and actions in other sectors to obtain GHG reductions that ensure equity between other sectors and electricity sector
  - Not affect rules, requirements for oversight of and enforcement of the California RPS Program

Senator De León:
Letter to the Senate Daily Journal on SB 100

- Resource Shuffling Prohibition
  - Should be implemented in a manner that does not run afoul of the Dormant Commerce Clause
- SB 100 has two separate provisions:
  - 1) Accelerated RPS, and 2) Zero-Carbon Policy
- Zero-Carbon Policy:
  - Includes all zero-carbon resources
    - RPS-eligible resources and existing zero-carbon resources serving California customers
  - Technology neutral
    - If a resource does not produce GHG emissions it is eligible to meet the 100% target
  - Existing obligations
    - Does not seek to require retail sellers to default on existing contractual obligations to deliver electricity to California customers from existing zero-carbon generation facilities

Senate Bill 100: Zero Carbon Policy Next Steps?

- CPUC/CEC/CARB
  - Utilize programs authorized under existing statutes to achieve policy
  - In consultation with all California Balancing Authorities, in a public process, issue joint report to Legislature by 1/01/2021, and every 4 years thereafter:
    1. Review policy focused on technologies, forecasts, transmission, safety, environmental and public safety protection, affordability, system and local reliability
    2. Evaluate potential benefits and impacts on system and local reliability
    3. Evaluate anticipated financial costs and benefits to electric, gas, and water utilities, including customer rate impacts and benefits
    4. Barriers to, and benefits of, achieving the policy
    5. Alternative scenarios in which the policy can be achieved and estimated costs and benefits of each scenario

The Los Angeles 100% Renewable Energy Study

The Los Angeles 100% Renewable Energy Study

Aaron Bloom, NREL

Los Angeles Department of Water & Power

NREL Transforming ENERGY

California aims to be entirely green powered by 2045, as Gov. Jerry Brown signs SB 100

Climate change is "a real and present danger to California and to the people of the world," Brown said.

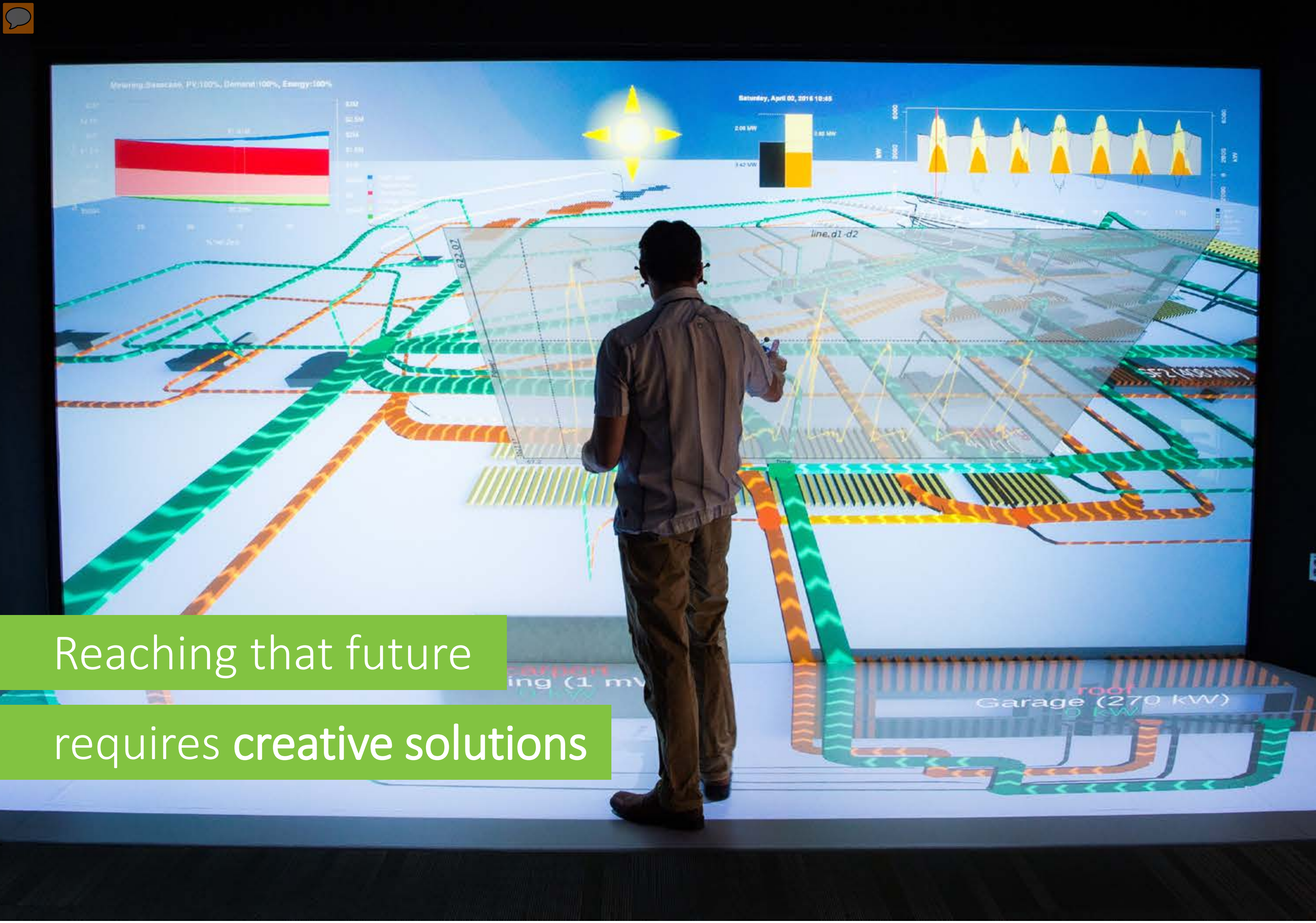
by James Rainey / Sep.10.2018 / 1:39 PM ET / Updated Sep.10.2018 / 5:51 PM ET

California is **moving fast**

toward a clean energy future.

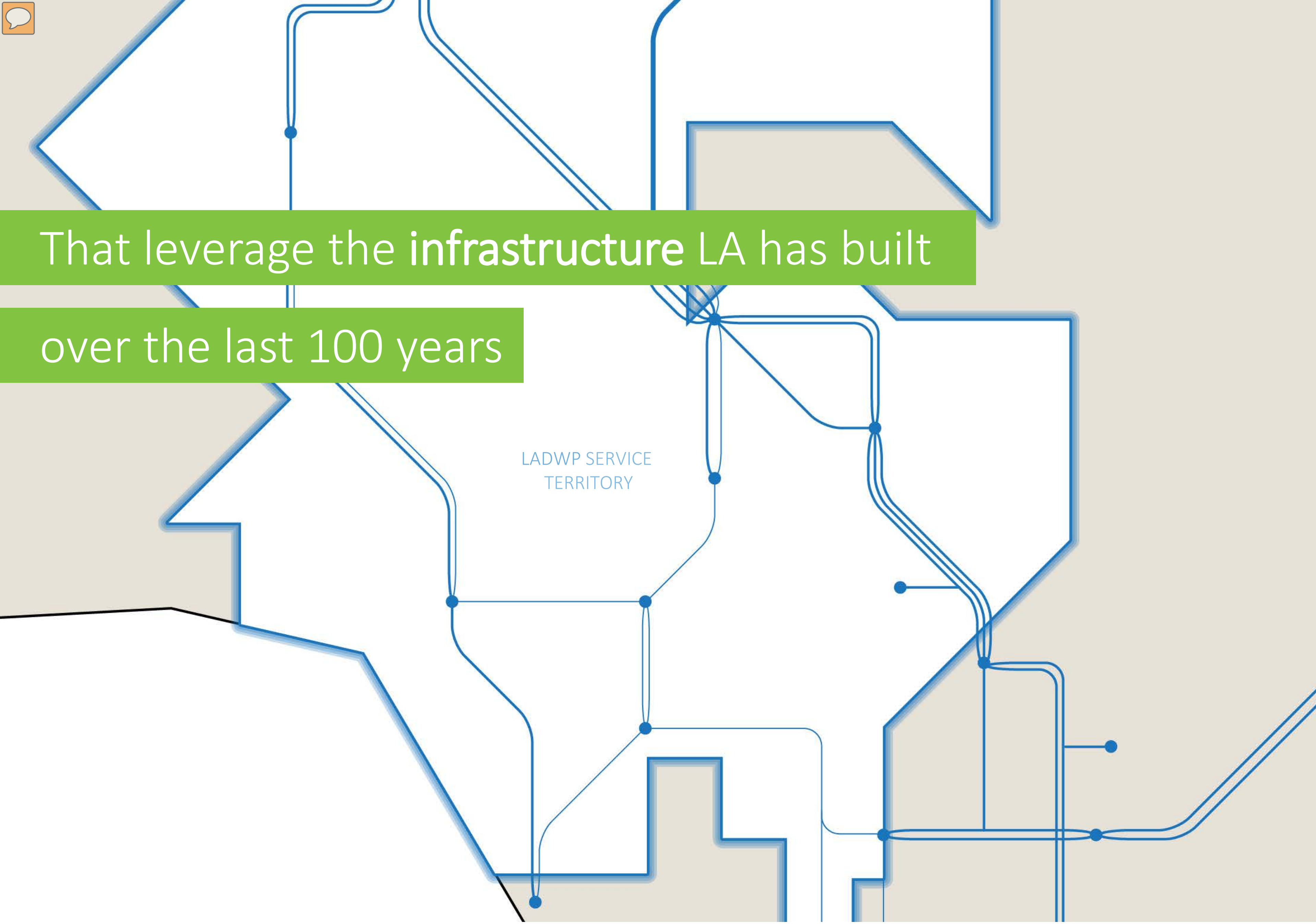

And LA is leading the charge


Toward 100% renewable energy to benefit 100% of LA.



Reaching that future requires **creative solutions**

That leverage the **infrastructure** LA has built over the last 100 years



To harness the **resources** it will need


to power the **next 100**.

The Los Angeles 100% Renewable Energy Study

will give LA the information it needs to get there.

Here’s our approach.

The energy system used to be all about the **grid**.

Today, it’s about the **people**, too.

We are **impacting** and **contributing to** the grid in ways we never have before.

How will people **interact** with the grid as it evolves?

How do we make sure the system is **reliable**?

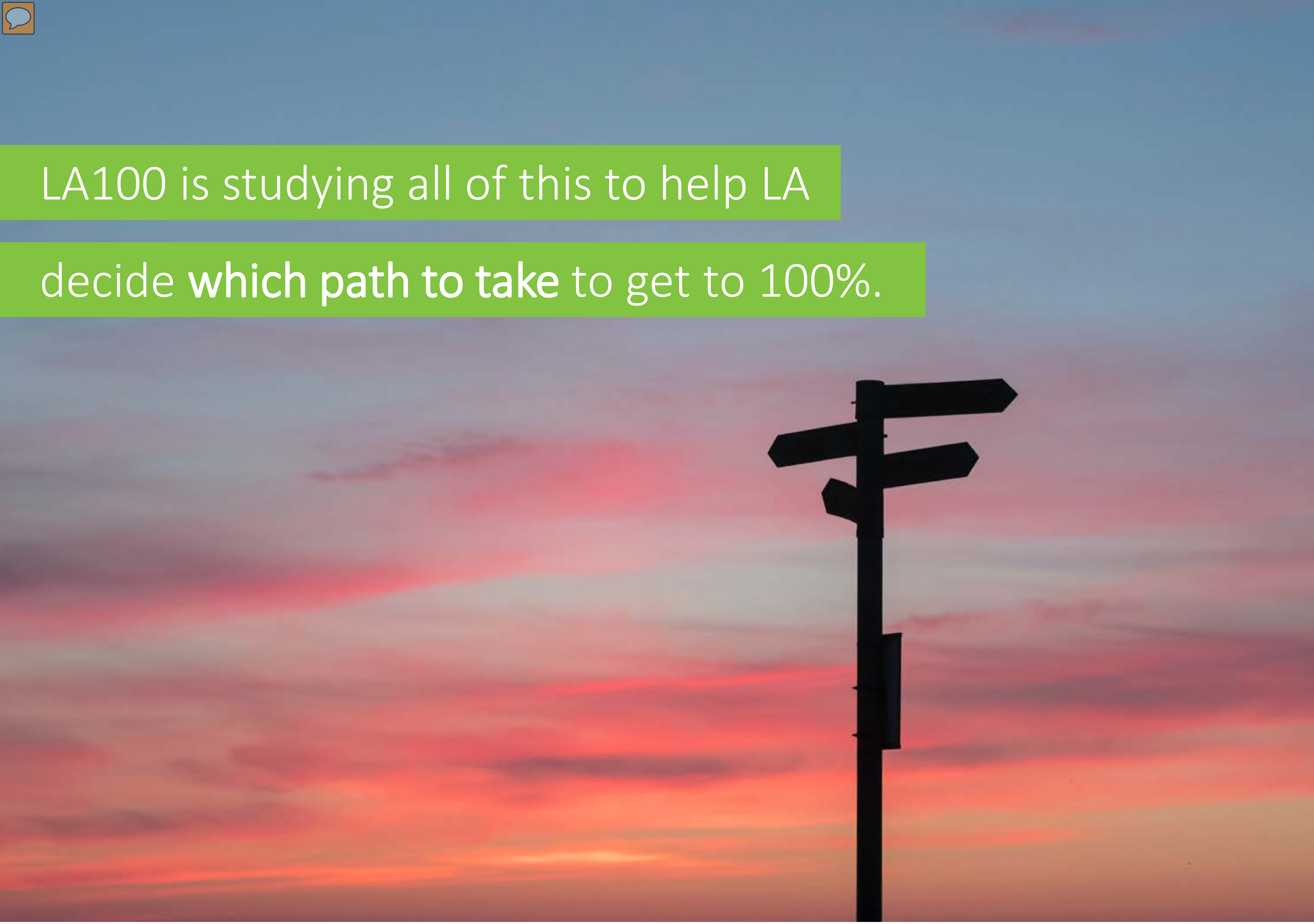
And **affordable** for all of LA?

What are the potential **economic** and **environmental** impacts?

LA's future power system needs to work **with** its people, **for** its people

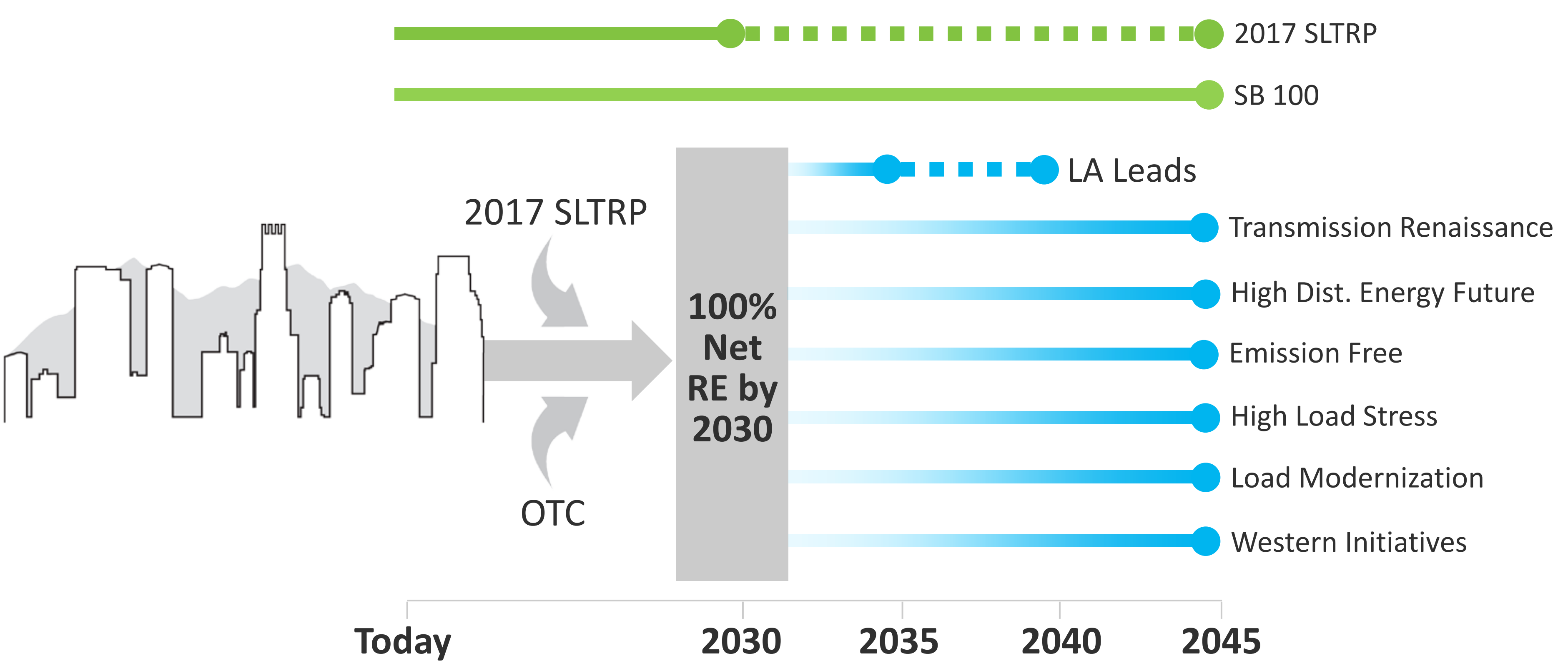
for **decades** to come.

LA100 is studying all of this to help LA decide **which path to take** to get to 100%.



Here are the scenarios.

Scenario Framework



Scenario Descriptions

	Scenario Name	Scenario Abbreviation	Net 100 RE* Target Year	Final Target Year	Scenario Description
Reference	LADWP 2017 SLTRP *Recommended Case*	DWP-SLTRP17	-	-	The DWP-SLTRP scenario matches the planned generation, tranmission, and distribution system investments, as well as the planned end-use initiatives--energy efficiency, demand response, and electrification--from LADWP's 2017 SLTRP *Recommended Case* . In addition, this scenario will incorporate relevant results from the OTC Study. Under this scenario, renewable generation comprises 65% of load by 2036.
Reference	Senate Bill 100	SB100	-	2045	The SB100 scenario ensures that the LADWP system is compliant with Senate Bill--100; 60% net renewable energy by 2030 & 100% carbon-free energy by 2050.
LA100	LA-Leads	LA-Leads	2030	2035/2040**	Through more aggressive pursuit of both energy efficiency, demand response, and electrification initiatives, as well as rapid deployment of both distributed and utility-scale resources, a 100% clean energy system is achieved by 2035. Importantly, the Palo Verde Nuclear Plant continues to provide generation through the early 2040s, but is retired by and offset with new renewable sources by 2045. RECs are not allowed as part of compliance.
LA100	Transmission Renaissance	Trans+	2030	2045	New transmission corridors (along with upgrades to existing corridors) allow rapid increases in the availability of transmission capacity; adoption of distributed generation is decreased relative to the 100-RE case, due to the decreased barriers to importing utility scale renewable generation from out-of-basin. RECs are not allowed as part of compliance.
LA100	High Distributed Energy Future	Hi-DEF	2030	2045	Adoption of distributed generation is aggresively pursued to make up for decreased ability to import out-of-basin renewable generation; similarly, energy efficiency, demand response, and electrification are rapidly implemented. RECs are not allowed as part of compliance.
LA100	Emissions Free	No-Emis	2030	2045**	Compliance must be achieved without any combustion-based generation (including biomass and biofuels), but nuclear generation is allowed to contribute towards compliance. RECs are not allowed as part of compliance.
LA100	High Load Stress	HiStress	2030	2045**ǂ	Identical to the SB-100 case--i.e. net carbon-free--but load evolves in a way that is highly challenging for renewable integration: electrification is large and rapid, while flexibility in load (demand response) and efficiency are minimal.
LA100	Load Modernization	Load-Mod	2030	2045	Energy efficiency measures, demand response measures, and electrification are rapidly implemented through robust incentives, programs, and technology breakthroughs; RECs are not allowed as part of compliance.
LA100	Western Initiatives	WECC	2030	2045	Variable renewable generation achieves high penetration in the rest of WECC; RECs are not allowed as part of compliance.

*'All LA100 scenarios (blue) will reach 100% net renewable energy by 2030. This approach mirrors the one taken by many corporations and municipals to reach 100% renewable energy. It allows LADWP to meet a portion of the 100% goal using Renewable Energy Credits (RECs) that net out the emissions caused by LADWP generation.

**'Nuclear generation is allowed to contribute towards the 100% target

ǂ RECs can be used as a component of compliance

Old Scenario Matrix

		LADWP 2017 IRP *Recommended Case*	100% RE Reference	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	Net 100%	Load Modern-ization	Western Initiatives
	Compliance Year:	--	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technol-ogies Eligible in the Compliance Year	Biomass	Matches 2017 IRP Technology Mix	Y	Y	Y	Y	N	Y	Y	Y
	Biogas		Y	Y	Y	Y	N	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		N	N	N	N	N	Y	N	N
	Nuclear - Existing		N	Y	N	N	Y	Y	N	N
	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
DG	Distributed Adoption	Reference	Balanced	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	-	N	N	N	N	N	Yes	N	N
Load	Energy Efficiency	Reference	Moderate	High	Moderate	High	Moderate	Moderate	High	Moderate
	Demand Response	Reference	Moderate	High	Moderate	High	Moderate	Moderate	High	Moderate
	Electrification	Reference	Moderate	High	Moderate	High	Moderate	Moderate	High	Moderate
Trans-mission	New or Upgraded Transmission Allowed?	Matches 2017 IRP	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	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

Updated Scenario Matrix-changes

		Reference		LA100						
		LADWP 2017 SLTRP *Recommended Case*	SB 100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
				All LA100 cases reach 100% Net Renewable Energy by 2030						
	Compliance Year:	2045	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Matches 2017 SLTRP Technology Mix	Y	Y	Y	Y	N	Y	Y	Y
	Biogas		Y	Y	Y	Y	N	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		Y	N	N	N	N	Y	N	N
	Nuclear - Existing		Y	Y	N	N	Y	Y	N	N
	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
DG	Distributed Adoption	Reference	Balanced	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	Y	Y	N	N	N	N	Y	N	N
Load	Energy Efficiency	Reference	Moderate	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	Moderate	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	Moderate	High	Moderate	High	Moderate	High	High	Moderate
Transmission	New or Upgraded Transmission Allowed?	Matches 2017 SLTRP	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	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

Updated Scenario Matrix

		Reference		LA100						
		LADWP 2017 SLTRP *Recommended Case*	SB 100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
				All LA100 cases reach 100% Net Renewable Energy by 2030						
	Compliance Year:	2045	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass	Matches 2017 SLTRP Technology Mix	Y	Y	Y	Y	N	Y	Y	Y
	Biogas		Y	Y	Y	Y	N	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		Y	N	N	N	N	Y	N	N
	Nuclear - Existing		Y	Y	N	N	Y	Y	N	N
	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
DG	Distributed Adoption	Reference	Balanced	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	Y	Y	N	N	N	N	Y	N	N
Load	Energy Efficiency	Reference	Moderate	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	Moderate	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	Moderate	High	Moderate	High	Moderate	High	High	Moderate
Transmission	New or Upgraded Transmission Allowed?	Matches 2017 SLTRP	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	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

Summary of Changes in Light of SB 100

- Reference scenario was replaced by new SB 100 scenario
- New LA100 scenario was added to replace Net 100% scenario
  - High Load Stress
  - Designed to reflect what could happen if load grows and there is no improvement in energy efficiency
- All scenarios meet or exceed requirements of SB 100
- Goal of these changes is not to perfectly model SB 100
  - CPUC, CEC, and Courts will likely spend considerable time interpreting SB 100
  - NREL objective is to maintain schedule and include a reasonable representation of SB 100

Jobs and Economic Development Analysis

Overview

- City Council Motion
  - "Work with local academic institutions to examine…the potential for high quality careers and equitable local economic development, including local hiring programs.."
- Partnerships
  - University of Southern California
    - Prof. Adam Rose, Prof. Dan Wei
  - Cutler Consulting
    - Prof. Harvey Cutler, Prof. Martin Shields
- Cutler consulting will develop the model, USC is responsible for the analysis.
- Both will work with each other throughout the project

Model Selection

- Several modeling options, all commonly used
- All assume projects are feasible
- Input-Output (I-O)
  - ”Gross” economic impacts that are based on demand
  - Cannot take into account changes such as changes in prices and taxes
  - Cannot estimate substitution between inputs (i.e., if pork becomes expensive perhaps households would eat more chicken)
- REMI
  - Proprietary impact model that is based on I-O, CGE, and econometric models
  - Some ability to change prices
- Computable general equilibrium (CGE)
  - Economic impact model that is custom built and highly flexible
  - Captures a highly detailed representation of an economy
  - All prices flexible and substitution is allowed

CGE Decision

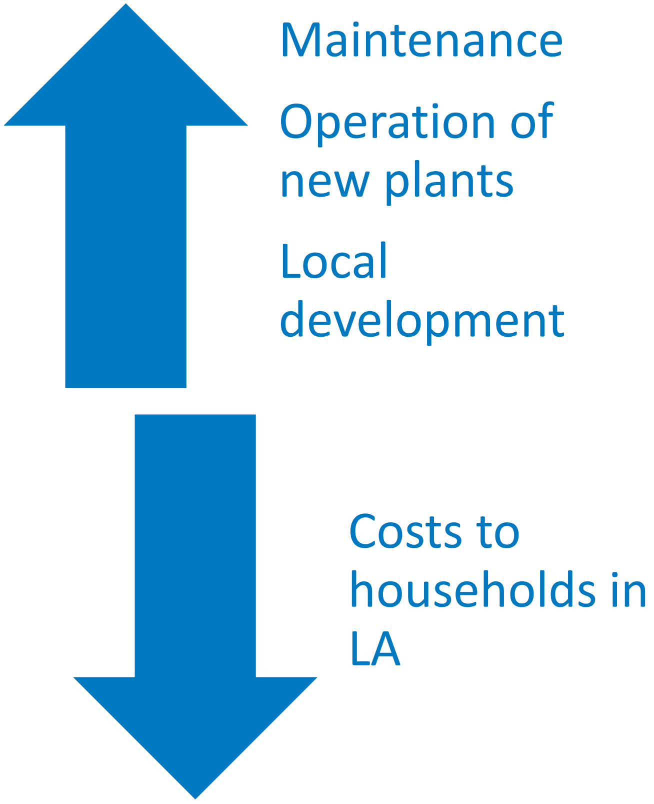
- Decision to use a CGE model
- CGE models capture detailed interactions between households, industries, government, and the region outside of the City of LA
- CGE models are flexible, so the electricity sector – the focus of the study – can be modified to better capture details and differences between different renewable and fossil technologies

Unique Characteristics of CGE Model Used

- Model used was initially developed by Professor Cutler at Colorado State University
- Original intent was to be a regional model to capture impacts within focused areas
- NREL worked with Professor Cutler through the NREL Joint Institute for Strategic Analysis to refine the electric sector to capture specific types of energy deployment and operation

CGE Model

- Model captures changes in prices, taxes as well as demand for goods and services
- “Net” impact because these interactions are captured
- Positive economic growth from new capacity
- Potential downward pressure on growth from displaced fossil industries, higher costs for electricity

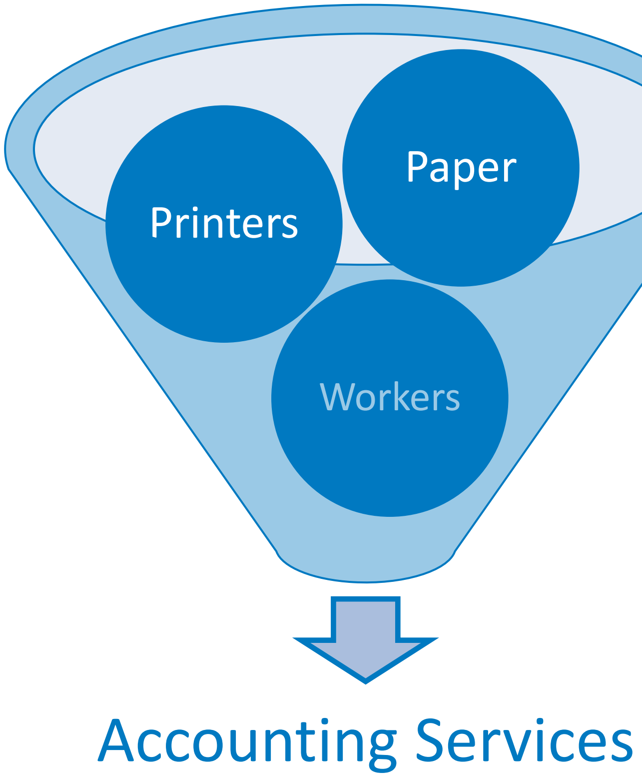


What the Model Doesn't Capture

- Impacts from activity outside of LA
  - Goods manufactured outside of the city such as solar panels or appliances
  - Services performed by companies outside of LA such as computer software providers or outside engineering firms
- Economic activity that might arise as a result of the LA100 project that aren't directly related to the project
  - Companies may choose to locate in LA because they value renewable energy or for branding
  - Economic activity may arise due to co-location benefits. For example, an electrical company that doesn't do much PV work may locate in LA to increase the pool of available electricians

Producing Detail – Base Data

- Social accounting matrix (SAM) is the core dataset that goes into the CGE model
- The SAM represents interactions between industries, workers, households, the government, and outside regions as inputs and outputs
- Every input such as goods industries use for production is an output provided by another sector
- I.e., an accounting firm provides accounting services and purchases paper from a paper manufacturer. Paper is an input for the accounting firm and an output from the paper manufacturer.



CGE Base Data: Social Accounting Matrix

Social accounting matrix (SAM) shows initial structure of the economy via inputs and outputs

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">Consumption (Inputs)</td><td colspan="4">Final Demand (GDP)</td><td rowspan="8">Total Output</td></tr>
<tr><td>Industry A</td><td>Industry B</td><td>Industry C</td><td>Households</td><td>Investment</td><td>Government</td><td>Rest of World (Net Exports)</td></tr>
<tr><td rowspan="3">Production (Outputs)</td><td>Industry A</td><td colspan="3" rowspan="3">Intermediate Inputs and Outputs</td><td colspan="4" rowspan="3">Final Demand</td></tr>
<tr><td>Industry B</td></tr>
<tr><td>Industry C</td></tr>
<tr><td rowspan="3">Value Added (GDP)</td><td>Labor</td><td colspan="3" rowspan="3">Value Added</td><td colspan="4" rowspan="3"></td></tr>
<tr><td>Property-type income</td></tr>
<tr><td>Taxes</td></tr>
<tr><td></td><td colspan="8">Total Output</td><td></td></tr>
</table>

New Industries

- Additional detail added by creating new industries in the construction and utility sectors
- Utility does not differentiate between technologies
- Construction not even specific to electricity
- Industries disaggregated and allocated to different electricity technologies
- Input data pulled from a number of sources such as journal articles, reports, and the NREL Jobs and Economic Development Impacts (JEDI) suite of economic impact models
- JEDI has been validated (Billman and Keyser 2013) and results are similar to other studies (Wei et al. 2009)

New Industries

SAM example of how different energy technologies are treated

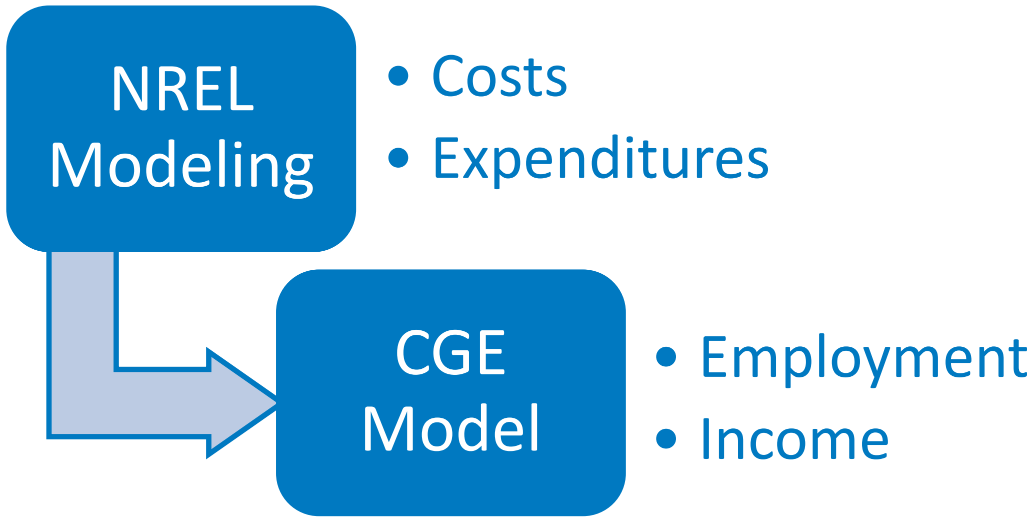
	Industry A	**Industry B**	**Industry C**	**Energy**
Industry A	A_1	B_1	C_1	E_1
Industry B	A_2	B_2	C_2	E_2
Industry C	A_3	B_3	C_3	E_3
Energy	A_4	B_4	C_4	E_4
Property-type Income	A_5	B_5	C_5	E_5
Taxes	A_6	B_6	C_6	E_6
Labor	A_7	B_7	C_7	E_7
Total Output	A-out	B-out	C-out	E-out

Two Major Publications to Date With the Modified Model

- Hannum, Christopher; Cutler, Harvey; Iverson, Terrance; Keyser, David. "Estimating the Implied Cost of Carbon in Future Scenarios using a CGE Model: The Case of Colorado." Energy Policy. Vol. 102 (2017): pp. 500-511.
- Hurlbut, David; Haase, Scott; Barrows, Clayton; Bird, Lori; Brinkman, Greg; Cook, Jeff; Day, Megan; Diakov, Victor; Hale, Elaine; Keyser, David; Lopez, Anthony; Mai, Trieu; McLaren, Joyce; Reiter, Emerson; Stoll, Brady; Tian, Tian; Cutler, Harvey; Bain, Dominique; Acker, Tom. "Navajo Generation Station and Federal Resource Planning; Volume 1: Sectoral, Technical, and Economic Trends." (2016). NREL/TP-6A20-66506. https://www.nrel.gov/docs/fy17osti/66506.pdf
- Many more publications of the model before additional detail added to energy sector

CGE Parameterization

- Primarily informed by RPM model
- Costs for new infrastructure
- Expenditures to operate new infrastructure



Technologies Explicitly Captured in the LA 100 Study

Selections made based on technologies represented in the RPM model

- Land-based wind
- Offshore wind
- CSP
- Solar PV
- Geothermal
- Natural gas
- Bioenergy
- Storage
- Coal

Model Results: Labor and Households

- Results by labor earning and household income category
- Labor is specific to a worker
- Can be more than one income source for a household

Nine Earnings and Income Categories

- ≤ $10,000
- $10,001 ≤ $15,000
- $15,001 ≤ $25,000
- $25,001 ≤ $35,000
- $35,001 ≤ $50,000
- $50,001 ≤ $75,000
- $75,001 ≤ $100,000
- $100,001 ≤ $150,000
- ≥ $150,001

Sample Results: Colorado RPS

	Absolute Change	Percent Change
Employment	7,115	0.19%
State tax revenue ($millions)	$21.4	0.07%
Local tax revenue ($ millions)	$0.4	0.00%
SO_2 (tons)	-81,651	-72.39%
NOX (tons)	-60,973	-40.68%
CO_2 (tons)	-43,619,599	-42.41%

- 30% renewables for investor owned utilities, 20% larger co-ops, 10% small co-ops and municipal utilities
- Sample scenario in which renewables replace coal-fired generation
- Low variability scenario uses Xcel Energy's figures
- Results can also be negative based on the scenario, especially with increased taxes or rates

Household Income Impacts (example from CO analysis)

Household Income Group	Absolute Change ($mil)	Percent Changes
≤ $10,000	$151	0.08%
$10,001 ≤ $20,000	$87	0.08%
$20,001 ≤ $40,000	$170	0.09%
$40,001 ≤ $50,000	$164	0.08%
$50,001 ≤ $70,000	$212	0.05%
$70,001 ≤ $100,000	$398	0.06%
≥ $100,001	$832	0.07%

Geography and Sub-City Detail

- Model covers the City of LA as defined by zip codes
- Results, therefore, are citywide
- Working with the California demography office to identify where households are clustered by income group at the sub-city level
- Level doesn’t have to be zip codes – defined by Census demographic data
- The model may say, for example, that income increases 4% for households that earn $25,001 to $35,000. We can identify where households in this income cohort tend to live.

Thank you. Questions?

Lunchtime

LA100

The Los Angeles 100% Renewable Energy Study

Accounting for Costs in Power Systems Planning

Daniel Steinberg

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Outline

- Why do costs matter?
- Defining power system costs
- Estimating future power system costs
- Rate impact preview

Why do costs matter?

Why Costs Matter

Los Angeles Department of Water & Power
www.ladwp.com

BILL DATE
Nov 12, 2013
ACCOUNT NUMBER
000 000 1000

DATE DUE
Dec 2, 2013
AMOUNT DUE
$ 244.29

Los Angeles Department of Water & Power
www.ladwp.com 1-800-342-5397
Hours of operation - 7 am to 10 pm

DEFINITIONS

CRPSEA – (Capped Renewable Portfolio Standard Energy Adjustment) a charge reflecting the costs associated with RPS Operations and Maintenance, RPS debt service, and Energy Efficiency Programs.

ECA – (Energy Cost Adjustment) an adjustment that reflects the variations of fuel, energy and other associated costs.

ESA – (Electric Subsidy Adjustment) a charge reflecting the costs of subsidies including senior, disabled, low income, traffic control lighting, and enterprise zone.

IRCA – (Incremental Reliability Cost Adjustment) a charge reflecting Operations and Maintenance and debt service related to Power Reliability Program cost and legacy RCA under-collection.

kWh – (kilo-watt-hour) the units in which electric usage is measured. One kWh equals 1000 watts of electricity used for one hour.

RCA – (Reliability Cost Adjustment) a charge reflecting the costs to support additional capital investments needed to improve reliability in areas of power distribution, transmission and generation infrastructure.

VEA – (Variable Energy Adjustment) a charge reflecting the costs of fuel, non-RPS power purchase agreements, non-RPS economy purchases, legacy ECAF under-collection, and base rate decoupling from energy efficiency impact.

VRPSEA – (Variable Renewable Portfolio Standard Energy Adjustment) a charge reflecting the costs of RPS market purchases and RPS costs above and beyond any Operations and Maintenance and debt service payments.

Electric Charges

Questions about these charges? 1-800-342-5397

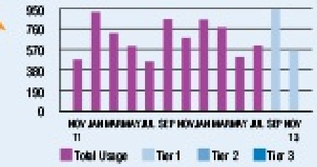
BILLING PERIOD 9/12/13 - 11/11/13
DAYS 60
ZONE 2

RATE SCHEDULE
R-1 and R-1 [i] Residential Electric - Rate A Standard Service

NEXT SCHEDULED READ DATE
1/13/14

10

USAGE HISTORY *(Total kWh)*



	Prev Yr	Nov 13
Total kWh used	684	558
Average daily kWh	12	9
Days in billing period	59	60
Your average daily cost of electricity		$1.43

METER NUMBER	CURRENT READ	–	PREVIOUS READ	=	TOTAL USED
00006-00334905	7068		6510		558 kWh

Tier 1 Energy	558 kWh x $0.13935/kWh	77.76
Subtotal Energy Charges		**$77.76**
City of Los Angeles Utility Tax	$77.76 x 10%	7.78
State Energy Surcharge	558 kWh x $0.00029/kWh	0.16
Total Electric Charges		**$ 85.70**

This service was previously billed on Account Number 1042614809.

11

Your Electric Usage by Tier

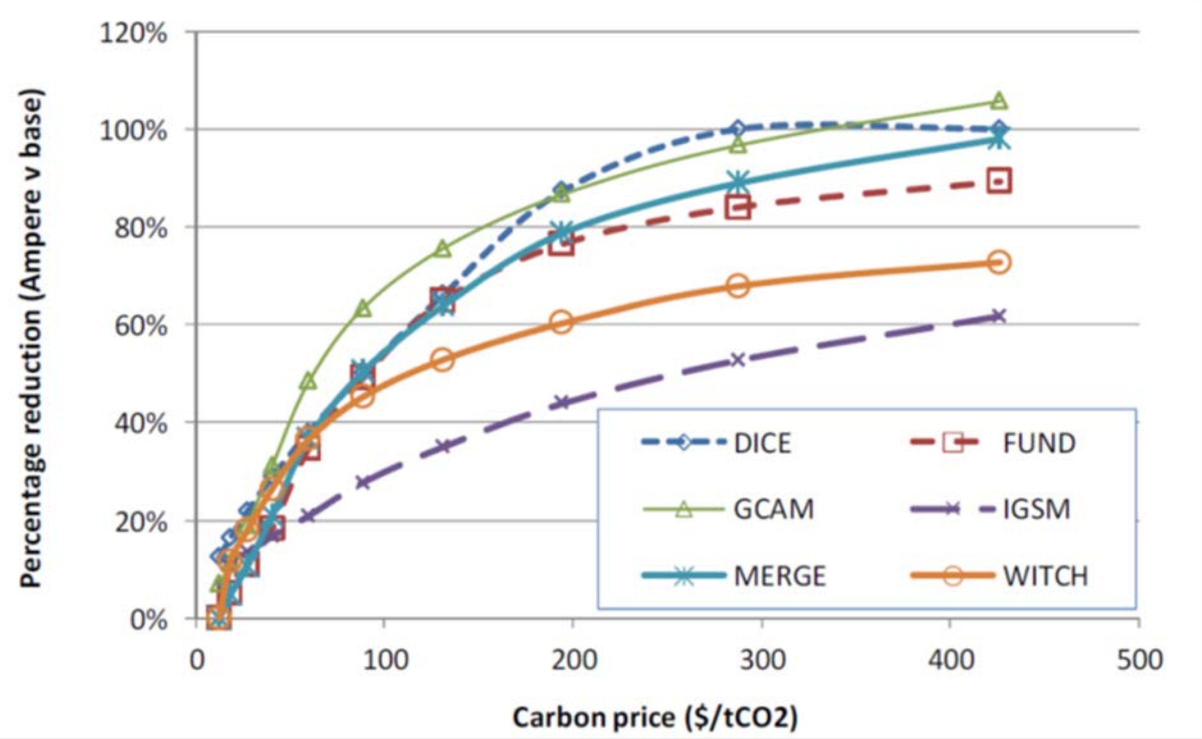
Tier 1 $0.13935/kWh	Tier 2	Tier 3
First 1,000 kWh	Next 2,000 kWh	More than 3,000 kWh

Usage is billed at different rates, depending on how much you use. This graph shows how your energy usage relates to these tiers, and the rate you paid in each tier. For more, visit www.ladwp.com/res_electric

Green Power for a Green LA *– LADWP's Green Power program replaces electricity from polluting power plants with energy generated from renewable resources. To learn more and sign up, visit www.ladwp.com/greenpower*

Source: LADWP Website: How to Read the LADWP Bill

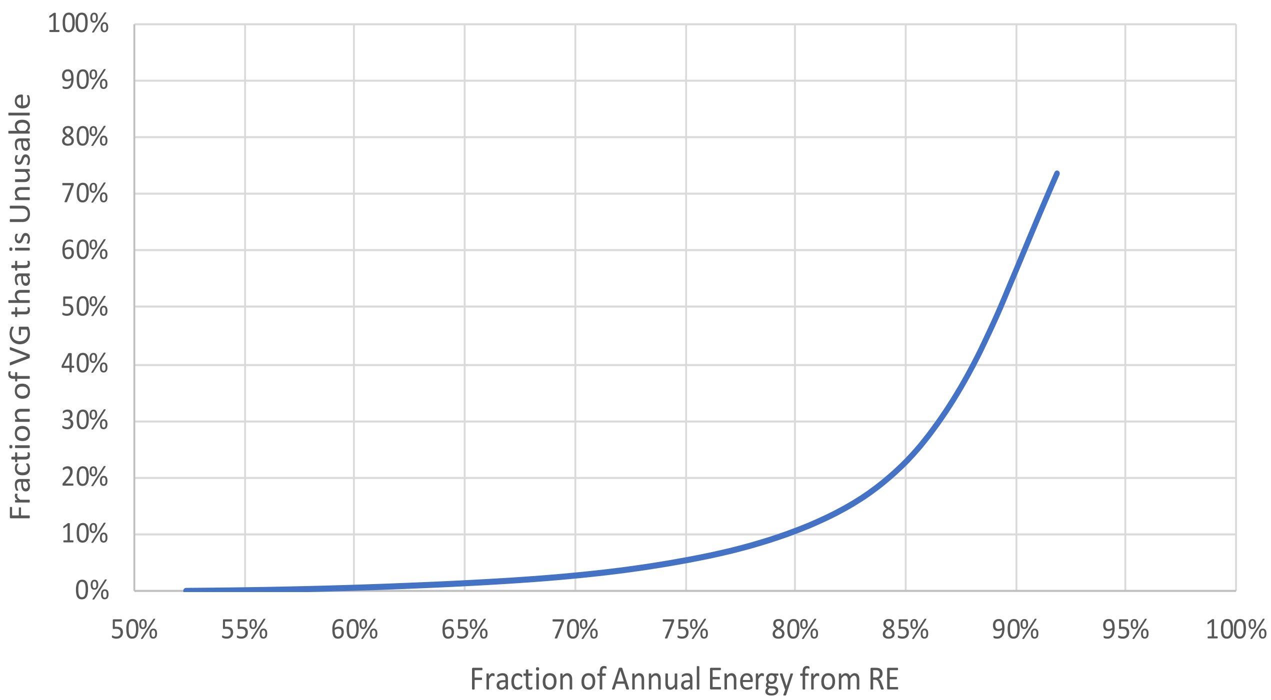
The Lower You Go, the Higher the Cost



Source: K. Gillingham, Nordhaus, W., Anthoff, D., Blanford, G., Bosetti, V., Christensen, P., McJeon, H., Reilly, J., Sztorc, P. 2015. Modeling uncertainty in climate change: a multi-model comparison. National Bureau of Economic Research.

- Scientific consensus is that the cost of carbon abatement increases significantly as total emissions approach zero.

Cost Challenges Arise Due to Variable Generation Sources



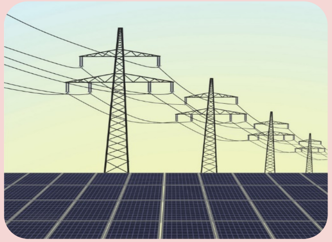
Defining Power System Costs

Power System Costs

Capital Costs: all one-time fixed costs associated with investment in bulk system infrastructure, distribution infrastructure, and/or end-use efficiency or demand response measures

Operating Costs: all fixed and variable operation and maintenance costs associated with least-cost unit commitment and dispatch of all generation, transmission, distribution, and consumption assets

Power System Costs



Generation and Transmission

- Capital: generation and transmission capacity, storage capacity
- Operating: fuel, labor, environmental compliance, purchased energy (e.g., PPAs)

Distribution

- Capital: transformers, distributed generation capacity, advanced inverters, new lines (overhead or underground), reconductoring, capacitors
- Operating: labor, fuel, trucks, cranes, parts

End-use

- Capital: device replacement, building envelope improvement, smart-meters
- Operating: labor, fuel, parts

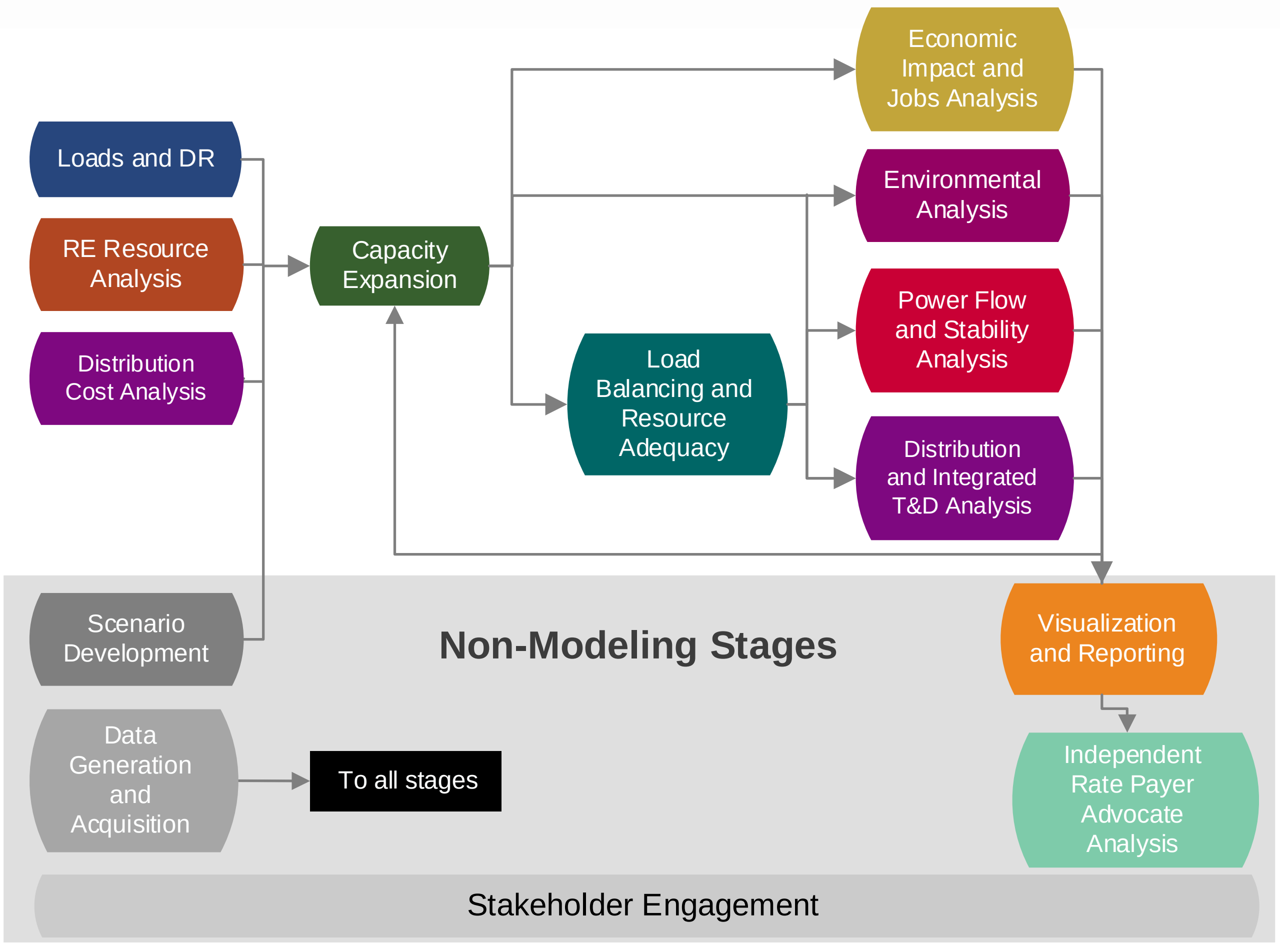
How Do We Calculate Costs?

The Ideal

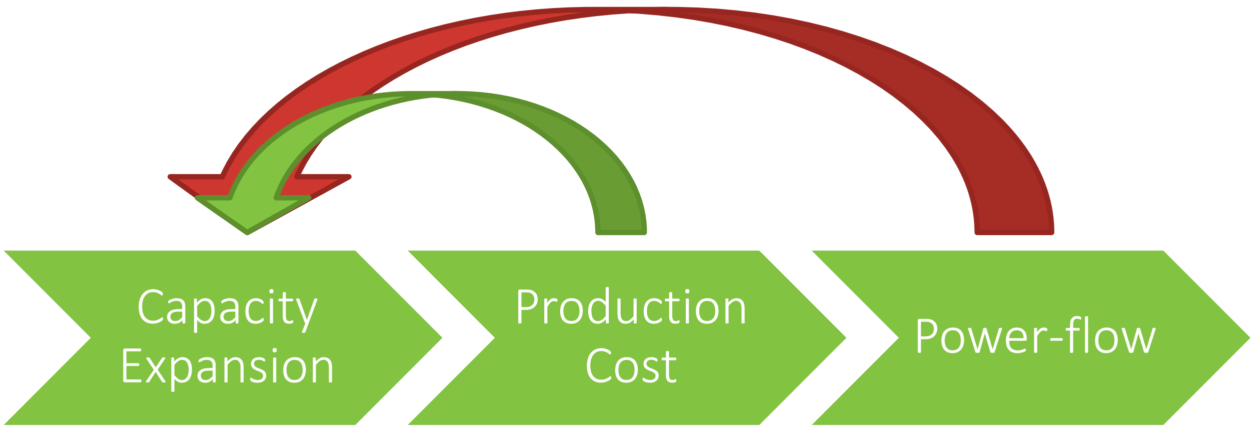
$$\min \sum_{t,y} \frac{I_{t,y} + O_{t,y}}{(1+r)^y}$$

Where *I* is a vector of investment costs;
O is a vector of operating costs in timestep, *t*, in year, *y*;
r is the discount rate

Too Big a Problem for One Model



General Approach: Estimate, Then Refine



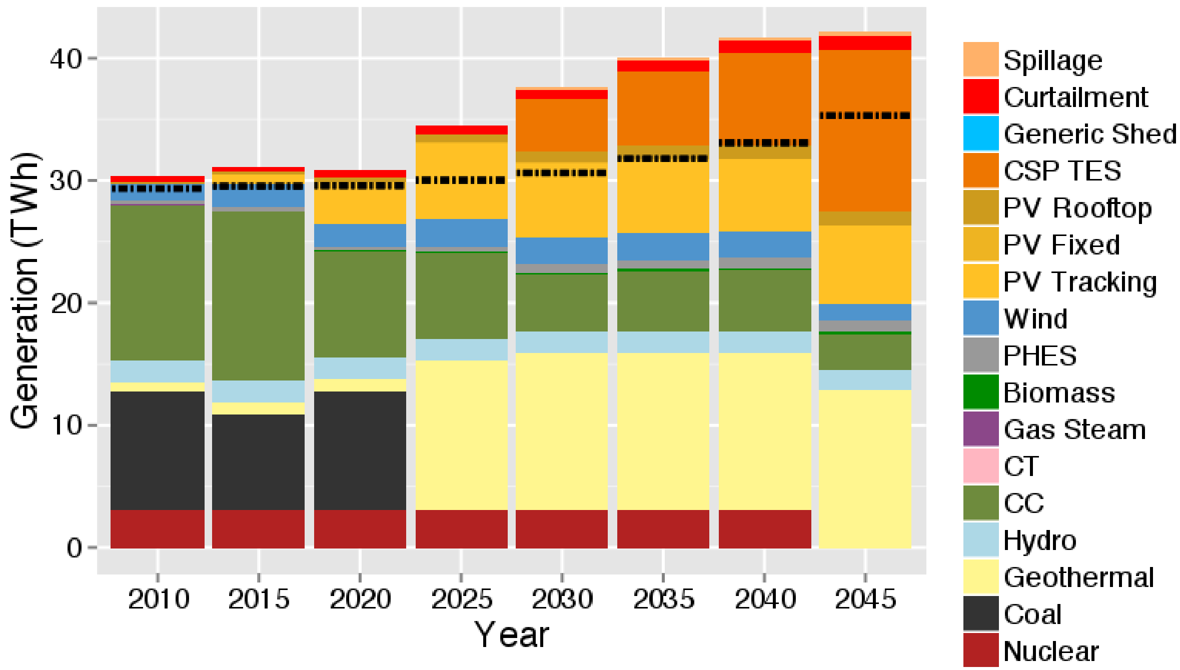
Estimate investment & reduced-form operational costs

Calculate detailed operational costs; identify additional investments needed to address congestion

Identify any other necessary bulk and distributed infrastructure to mitigate power-flow issues

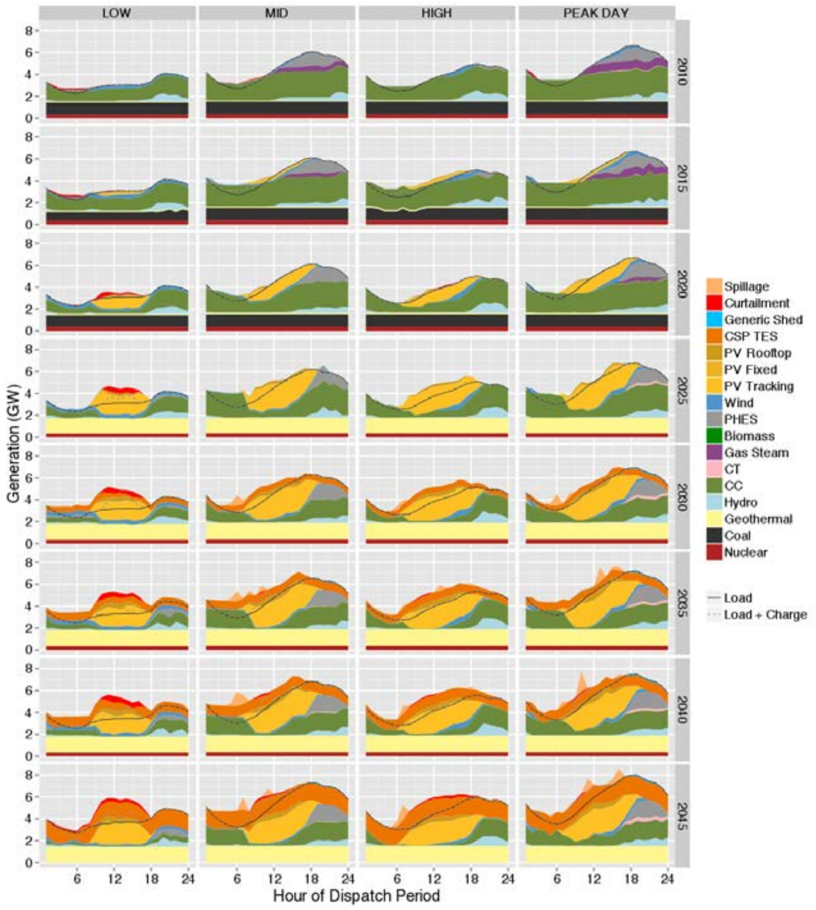
Capacity Expansion Models (CEMs)

- Main goal is to identify optimal investment pathway to future
- This study utilizes multiple investment and adoption models:
  - RPM (bulk system generation and transmission), dGen (distributed generation), DISCO (distribution-scale transmission)



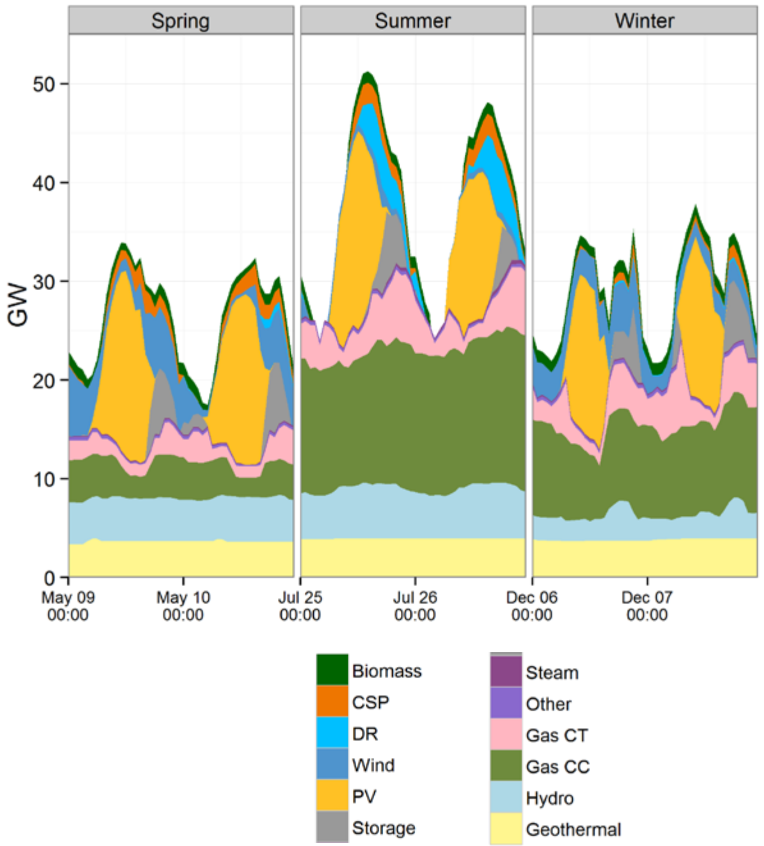
CEMs Estimate and Rely on Reduced-Form Dispatch

- RPM informs investment decision-making based on hourly dispatch for 4 representative days within the year
- Operational costs are relatively rough estimates



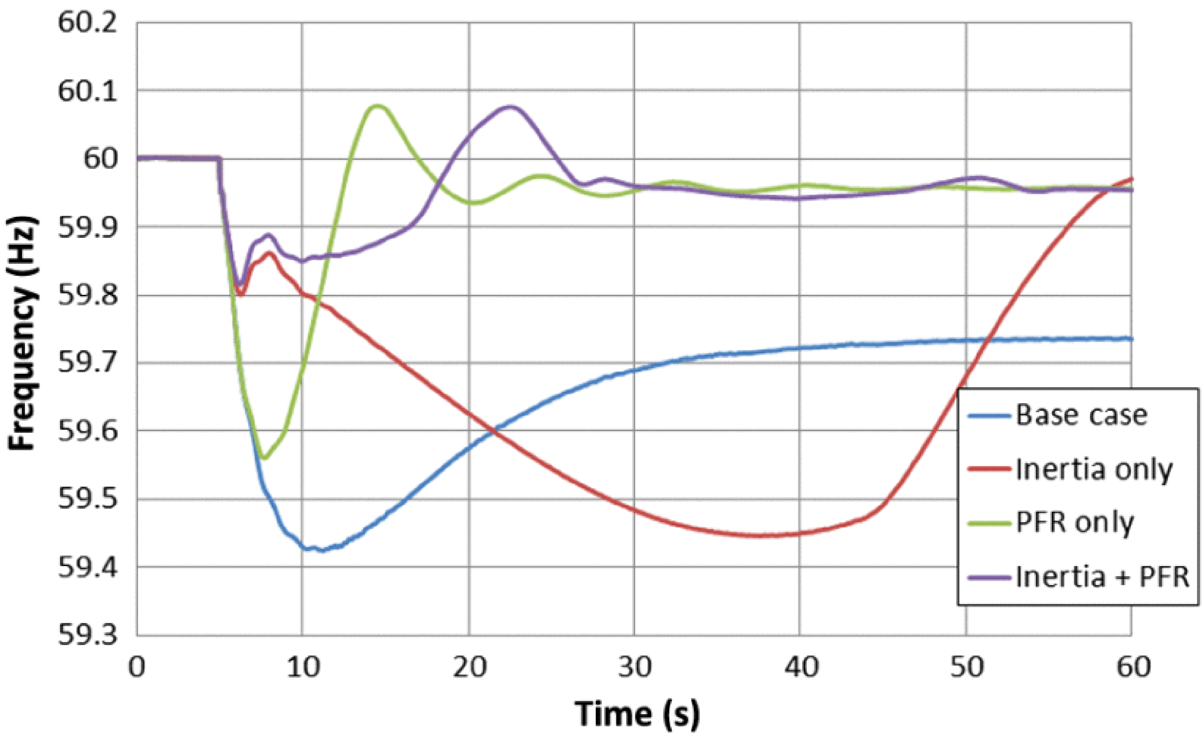
Detailed Operational Modeling: Production Cost Models (PCMs)

- PCMs use the system specified by CEMs and calculate detailed 5-minute dispatch for a full year
- Allows for detailed accounting of operational costs—fuel, startup, shutdown, ramping, etc.
- Identify any substantial congestion issues that could be resolved with additional bulk or distributed assets (e.g. additional transmission or generation capacity)



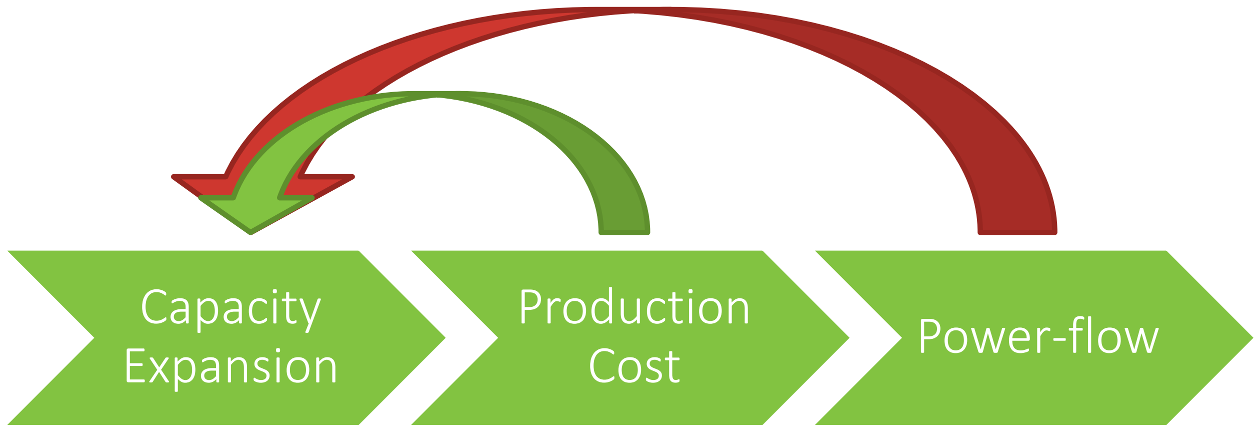
Power-Flow Modeling Identifies Steady-State Issues That Need to Be Resolved with Additional Capital Investments

Steady-state analysis can identify and demonstrate the value of alternative options for mitigating power-flow constraints and very short-term disruptions in the grid



Source: Gevorgian, V., Y. Zhang, and E. Ela. 2015. Investigating the impacts of wind generation participation in interconnection frequency response. IEEE Trans. on Sustainable Energy. 6 (3): 1004-1012

Approach: Review

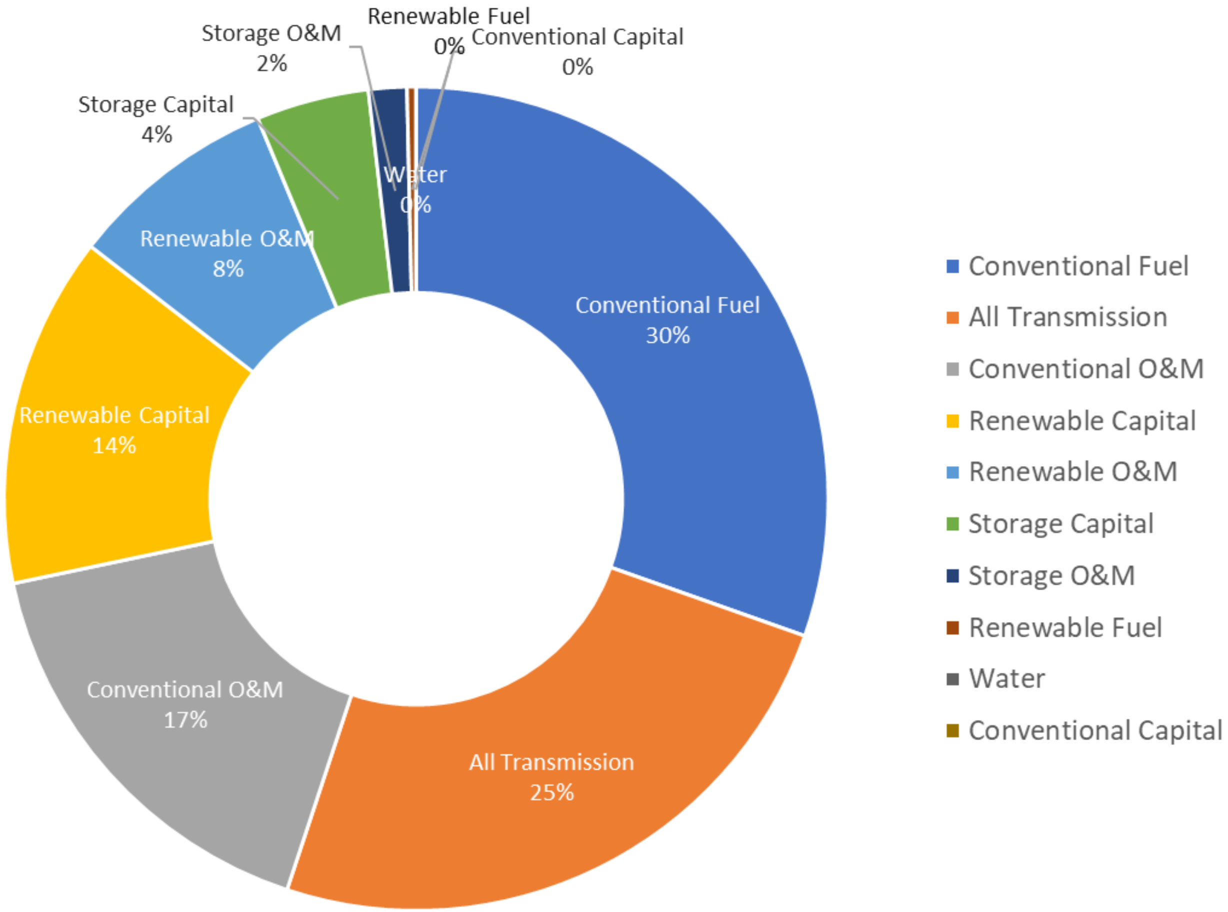


Estimate investment & reduced-form operational costs

Calculate detailed operational costs; identify additional investments needed to address congestion

Identify any other necessary bulk and distributed infrastructure to mitigate power-flow issues

A Detailed View of System Costs



Example composition of the total present value of system costs

Rate Analysis

- This study will include an analysis of the *potential* impacts of 100% renewable energy on LADWP rates
- NREL will calculate all costs necessary to calculate potential rate impacts
- LADWP will use NREL cost data to conduct rate impact analysis
- Rate Payer Advocate will review costs and rate analysis
- Results will be presented to Advisory Group
- *Caveat:* Estimating rate impacts accurately out to 2045 is very difficult. It is likely that rate structures will evolve considerably over the next 25 years.

Thank you

The Los Angeles 100% Renewable Energy Study

100% Renewable Energy Study Summary/Milestones

Anton Sy
Project Manager

November 15, 2018

LA100 Advisory Group

- City Council motion
- Representatives from environmental groups, neighborhood councils, academia, premier customers, City government, business associations, utilities
- Protocols and operating principles
- Meeting plan

LA100 is Unique

- Over 4 million residents
- 1.5 million ratepayers
- Largest municipal utility
- Fully vertically integrated
- Balancing Authority

LADWP Electrical System

- Study examines:

  - Reliability
  - Health
  - Equity
  - Affordability

Advisory Group and Project Team Tour

Pine Tree Wind

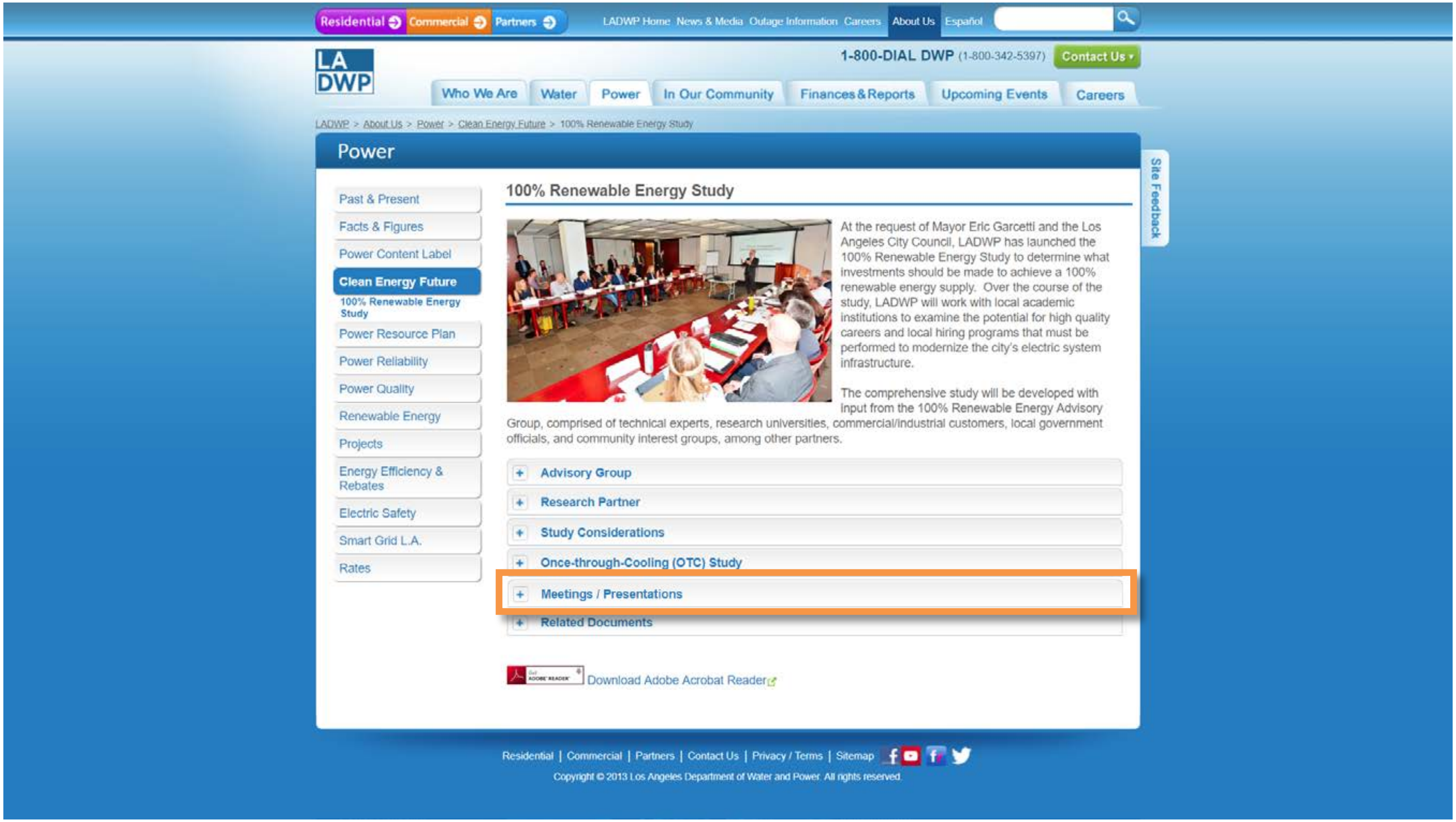
Barren Ridge SS

Beacon Solar and Energy Storage

2019 – 2020 Quarterly meetings

- Preliminary results
- Environmental analysis
- Visualizations
- Final results
- Final report
- Future quarterly meetings
  - March 28, 2019
  - June 27, 2019
  - September 19, 2019
  - December 5, 2019
  - March 5, 2020
  - June 25, 2020

Project Website



www.ladwp.com/CleanEnergyFuture

Thank You!