The Los Angeles 100% Renewable Energy Study

Chapter 1. Introduction

FINAL REPORT: LA100—The Los Angeles 100% Renewable Energy Study

March 2021

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Los Angeles Department of Water & Power

NREL Transforming ENERGY

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Los Angeles Department of Water & Power

Transforming ENERGY

The Los Angeles 100% Renewable Energy Study

Produced under direction of the Los Angeles Department of Water and Power by the National Renewable Energy Laboratory (NREL) under ACT Agreement 18-39, LADWP Ref: 47481.

Los Angeles Department of Water & Power

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Context

The Los Angeles 100% Renewable Energy Study (LA100) is presented as a collection of 12 chapters and an executive summary, each of which is available as an individual download.

- The **Executive Summary** describes the study and scenarios, explores the high-level findings that span the study, and summarizes key findings from each chapter.
- **Chapter 1: Introduction** (this chapter) introduces the study and acknowledges those who contributed to it.
- **Chapter 2: Study Approach** describes the LA100 study approach, including the modeling framework and scenarios.
- **Chapter 3: Electricity Demand Projections** explores how electricity is consumed by customers now, how that might change through 2045, and potential opportunities to better align electricity demand and supply.
- **Chapter 4: Customer-Adopted Rooftop Solar and Storage** explores the technical and economic potential for rooftop solar in LA, and how much solar and storage might be adopted by customers.
- **Chapter 5: Utility Options for Local Solar and Storage** identifies and ranks locations for utility-scale solar (ground-mount, parking canopy, and floating) and storage, and associated costs for integrating these assets into the distribution system.
- **Chapter 6: Renewable Energy Investments and Operations** explores pathways to 100% renewable electricity, describing the types of generation resources added, their costs, and how the systems maintain sufficient resources to serve customer demand, including resource adequacy and transmission reliability.
- **Chapter 7: Distribution System Analysis** summarizes the growth in distribution-connected energy resources and provides a detailed review of impacts to the distribution grid of growth in customer electricity demand, solar, and storage, as well as required distribution grid upgrades and associated costs.
- **Chapter 8: Greenhouse Gas Emissions** summarizes greenhouse gas emissions from power, buildings, and transportation sectors, along with the potential costs of those emissions.
- **Chapter 9: Air Quality and Public Health** summarizes changes to air quality (fine particulate matter and ozone) and public health (premature mortality, emergency room visits due to asthma, and hospital admissions due to cardiovascular diseases), and the potential economic value of public health benefits.
- **Chapter 10: Environmental Justice** explores implications for environmental justice, including procedural and distributional justice, with an in-depth review of how projections for customer rooftop solar and health benefits vary by census tract.
- **Chapter 11: Economic Impacts and Jobs** reviews economic impacts, including local net economic impacts and gross workforce impacts.
- **Chapter 12: Synthesis** reviews high-level findings, costs, benefits, and lessons learned from integrating this diverse suite of models and conducting a high-fidelity 100% renewable energy study.

Acknowledgments

The Los Angeles Department of Water and Power (LADWP) has been an amazing partner, champion, technical resource, and critic throughout the LA100 study. The staff at LADWP have challenged our assumptions and results and enabled us to create a better analysis from their efforts. In particular, we want to thank Ashkan Nassiri, Steve Swift, Scott Moon, Nick Matiasz, and Greg Huynh for their daily engagement with the NREL researchers and their role in ensuring the subject-matter experts at LADWP remained engaged throughout the study. We also wish to thank Armen Saiyan for both his technical feedback on the demand side of the analysis, as well as his role in helping to ensure a strong connection between the demand group and the larger LADWP. We want to thank Jay Lim for his thoughtful feedback and reviews throughout the study. He and his colleagues deeply probed the assumptions and results to understand how LA100 findings relate to ongoing efforts within LADWP on planning the energy transition. We also thank Anton Sy, Greg Sarvas, and Paul Lee for their project management and support. The LADWP Communications and Public Affairs team of Stephanie Spicer, Dawn Cotterell, and Carol Tucker were instrumental to our work—they supported us regularly by providing feedback on our materials and organizing the LA100 Advisory Group and LA community groups. The subject-matter experts across the various departments met with us 74 times, provided written feedback on over 100 technical memos and draft products, and improved our analysis by identifying the aspects of the energy transition that were their greatest sources of uncertainty. We want to thank Martin Adams, Reiko Kerr, Jason Rondou, Louis Ting, Joseph Ramallo, James Barner, and Eric Montag for their leadership in allowing us to better connect and communicate with the Advisory Group and LA community. Finally, we want to thank the Board of Commissioners, especially President Cynthia McClain-Hill, for the improvements that they made to the study, such as establishing expectations for community outreach.

Other city leaders we want to acknowledge include the Los Angeles City Council members and Energy, Climate Change, Environmental Justice, and River Committee, who passed the motions that initiated the holistic scope of the study, especially Council Members Paul Krekorian and Mike Bonin for drafting the motions. We also want to thank the Mayor and his office for their roles in initiating and setting a bold vision for the study. From the Mayor's Office, Lauren Faber O'Connor, Liz Crosson, and Rebecca Rasmussen provided regular feedback throughout the study, which greatly benefited our modeling and communication of analyses.

The LA100 study truly represents a community-wide effort to evaluate this transition to 100% renewable electricity. As representatives of the community, the LA100 Advisory Group cannot be thanked enough for their perseverance in sharing guidance and feedback through this three-plus-year effort. It is the members of the Advisory Group who have ensured that the study is not just a power system planning study but instead reflects the passions, concerns, and deep insights of the community, which have strengthened the study and allowed us to better represent the holistic nature of electricity in our lives. The Advisory Group members diligently participated in the quarterly meetings (which turned into almost weekly, shorter meetings during the COVID-19 pandemic), poked holes in our assumptions and analysis, shared their vision for the energy transition, and provided feedback on our materials. Many members also invited us to participate at community meetings, which allowed us to hear a broader range of perspectives and questions. Participating institutions in the Advisory Group are listed at the end of the acknowledgments.

Also, notably, Executive Director Fred Pickel and Deputy Executive Director Camden Collins, Office of Public Accountability (Ratepayer Advocate), conduct third-party reviews of rate-related matters at LADWP and played critical roles in shaping the study in ways that could better support rate impact analysis. As part of their role reviewing LA100, they engaged Bruce Tsuchida of the Brattle Group to provide an independent review of our analysis. We are very thankful for the rigor and thoroughness that he applied to his review, including through his active participation in NREL's meetings with LADWP's subject-matter experts.

Joan Isaacson at Kearns & West deserves special thanks for always staying a step ahead of us in anticipating community questions and concerns and facilitating thoughtful discussions during the Advisory Group meetings. She and her team were attentive to ensuring all voices were heard. We also thank Taylor York, Jack Hughes, and Aly Spurlock for writing the meeting summaries.

Bill Barlak, who was a senior leader of planning and operations at LADWP for over 25 years, helped us navigate the technical considerations of the bulk power system. Bill helped shape our assumptions for the power flow analysis, reviewed our approach to all our bulk power models, and provided feedback regularly on all our results and analysis. His decades of expertise helped identify the particular constraints and concerns about reliability to incorporate into our modeling.

Sang-Mi Lee and Xinqiu Zhang at South Coast Air Quality Management District provided us the source-apportioned emissions inventory, and additional assistance on baseline and future emission inventory development. Pouya Vahmani at Lawrence Berkeley National Laboratory helped us with generating important land surface property inputs to air quality modeling.

Finally, we have a huge team at NREL to thank! Providing core support on project leadership and management were Scott Haase, Rachel Saxon, Paula Taylor, Molly Hames, Stephanie Hernandez, and Melissa Hudman. Members of the core LA100 data visualization team are Kenny Gruchalla, Kristi Potter, Haiku Sky, and Nick Gilroy. Additional colleagues who created the website with dynamic data viewer capabilities include Paul Edwards, Aaron Weissman, Erik Wiffin, Isabelle Galkin, and Joseph Smith. NREL staff who provided support on specific chapters of the study include Akshhay Jain, Dan Thom, Aadil Latif, Jianli Gu, Daniel Inman, Tim Larsen, Annika Eberle, Scott Nicholson, and Thomas Bowen. Billy Roberts applied his star cartography skills to our maps. In addition, the NREL authors listed for each chapter regularly engaged with and supported other modeling teams to ensure consistent treatment of data and assumptions.

NREL leadership team members Doug Arent and Dan Bilello both provided regular, thoughtful feedback throughout the study and helped us solve countless challenges. We are also especially grateful to Gian Porro, Jill Engel-Cox, Andy Walker, Adam Warren, Jeff Logan, Liz Doris, Megan Day, Keith Wipke, Barry Mather, and Zia Abdullah for reviewing the final report.

The NREL communications team, led by Devonie McCamey, included communications and outreach strategy, editing, design, and multimedia support from Mike Meshek, Elizabeth Craig, Stacy Buchanan, and Besiki Kazaishvili, and Brittany Conrad—they were especially effective in managing many requests at the last minute! The NREL high-performance computing group, including David Rager, Courtney Pailing, Kris Munch, and Chris Webber, helped us navigate the many computing challenges we faced with this study.

Other NREL colleagues we want to thank include Martin Keller, Juan Torres, Rob Leland, Yingchen Zhang, Tina Eichner, David Glickson, Aaron Bloom (formerly of NREL and the initial project lead), Ramin Faramarzi, Roderick Jackson, Matt Ringer, Mary Werner, Murali Baggu, Ben Kroposki, and the many staff who helped us navigate the financial and contractual elements of the study.

Member institutions of the LA100 Advisory Group included:

- American Clean Power Association, formerly known as American Wind Energy Association (AWEA)
- California Energy Storage Alliance (CESA)
- California Solar Energy Industry Association (CalSEIA)
- California State University, Los Angeles (Cal State LA)
- California State University, Northridge (CSUN)
- Center for Energy Efficiency and Renewable Technologies (CEERT)
- Center for Sustainable Energy
- Central City Association
- Chief Legislative Analyst (CLA)
- City Attorney
- Communities for a Better Environment (CBE)
- Council District 01 - CM Gilbert Cedillo
- Council District 02 - CM Paul Krekorian
- Council District 03 - CM Bob Blumenfield
- Council District 04 - CM Nithya Raman
- Council District 05 - CM Paul Koretz
- Council District 06 - CM Nury Martinez
- Council District 10 - CM Mark Ridley-Thomas
- Council District 11 - CM Mike Bonin
- Council District 13 - CM Mitch O'Farrell
- Council District 14 - CM Kevin de Leon
- DWP Advocacy Committee
- DWP-NC MOU Oversight Committee
- Earth Justice
- Environment California Research and Policy Center
- Environmental Defense Fund (EDF)
- Food and Water Watch
- IBEW – Local 18
- Los Angeles Business Council (LABC)
- Los Angeles Chamber of Commerce (LA Chamber)
- Los Angeles Unified School District (LAUSD)
- Los Angeles World Airport (LAWA)
- Metropolitan Transportation Agency (Metro)
- Natural Resources Defense Council (NRDC)
- Neighborhood Council Sustainability Alliance
- Office of Public Accountability (Rate Payer Advocate)
- Office of the Mayor
- Port of Los Angeles (POLA)
- RePowerLA
- Sierra Club
- South Coast Air Quality Management District (SCAQMD)
- Southern California Gas
- Southern California Public Power Authority (SCPPA)
- University of California, Los Angeles (UCLA)
- University of Southern California (USC)
- Valero Wilmington Refinery
- Valley Industry Commerce Association (VICA)

Table of Contents

List of Figures

The City of Los Angeles has set ambitious goals to transform its electricity supply, aiming to achieve a 100% renewable energy power system by 2045, along with aggressive electrification targets for buildings and vehicles. To reach these goals, and assess the implications for jobs, electricity rates, the environment, and environmental justice, the Los Angeles City Council passed a series of motions directing the Los Angeles Department of Water and Power (LADWP) to determine the technical feasibility and investment pathways of a 100% renewable energy portfolio standard.

With great ambition comes great need for actionable data and analysis—so LADWP partnered with the National Renewable Energy Laboratory (NREL) on the Los Angeles 100% Renewable Energy Study (LA100), a first-of-its-kind objective, rigorous, and science-based power systems analysis to determine what investments could be made to achieve LA's goals.

LA100 presents an analytical undertaking of unprecedented scale and complexity. While other studies have explored specific aspects of the 100% renewable challenge, LA100 is the most comprehensive, detailed analysis to date of an entirely renewable-based electric power system as complex and large as the LADWP power system.

The multiyear LA100 study ran millions of simulations to analyze the evolution of customer electricity demand,[1] including impacts of building and vehicle electrification and customer-owned solar and storage, to create detailed, bottom-up projections of electricity demand for every customer. The study then coupled these customer demand projections with simulations of generation, storage, transmission, and distribution assets to analyze which investments could achieve a 100% renewable energy power system while maintaining system reliability.[2] The study then addressed a suite of questions driven by the needs of the public and policymakers—how these investment pathways differ in terms of cost and impacts to the local economy, jobs, climate, air quality, health, and environmental justice. Finally, the study created dynamic tools to visualize the results in an effort to promote transparency, public engagement, and robust discussion of how LA can achieve its vision for the future.

1 City Council Motions

In 2016 and 2017, the Los Angeles City Council passed three motions directing LADWP to determine investments needed to achieve a 100% renewable energy portfolio. In March 2016, the Los Angeles City Council passed the first motion directing LADWP to develop and implement research partnerships with the U.S. Department of Energy (DOE), local universities, and stakeholders to determine the technical feasibility of and investment pathways to achieve a 100% renewable energy portfolio.[3]

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[1] This analysis was performed based on electricity demand projections generated prior to the COVID-19 pandemic. It does not account for changes that occurred during the pandemic, nor does it consider potentially longer-lasting impacts, such as changes in work patterns.
[2] The study addresses both resource adequacy and operating reliability, both of which are described in more detail in Chapter 6.
[3] LA City Council (March 2016) Motion 16-0243, https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB689137&RevisionSelectionMethod=LatestReleased.

Under a second motion, passed in September 2016, the Los Angeles City Council expanded the research scope beyond technical engineering by requiring analysis of potential economic development and high-quality careers associated with a transition to 100% renewables.[4]

In August 2017, the Los Angeles City Council passed a third motion requiring an analysis by the Ratepayer Advocate on the impact of a 100% renewable future on electricity rates, including for low-income customers, and the prioritization of investments that could provide immediate air quality benefits to environmental justice neighborhoods.[5]

Per the motions' guidance and with a desire to engage unbiased, third-party technical support to inform this effort, LADWP contracted with NREL to conduct targeted research toward this objective. The study was initiated in 2017.

2 Advisory Group

In coordination with the Office of Mayor Garcetti and working with city leaders, representatives from business, environmental advocacy groups, the renewable energy sector, and Los Angeles communities, LADWP convened the first meeting of the 100% Renewable Energy Advisory Group (LA100 Advisory Group) in June 2017. The Advisory Group is composed of representatives from environmental groups, neighborhood councils, academia, premier private and public accounts, city government, business and workforce groups, and renewable energy industry organizations. Its role is to guide the study in understanding and planning for issues related to feasibility, reliability, public health, and equitable local economic development, including high-quality careers and local hiring programs. The Advisory Group held 15 quarterly meetings through March 2021.

3 Study Objective

The objective of the LA100 study is to inform the City of LA, LADWP, and other stakeholders of possible pathways to 100% renewable energy, and the implications of these pathways for the people who live and work in LA. With guidance from the Advisory Group, NREL evaluated a range of future scenarios to equip LA decision makers to address the following questions:

- What are the *pathways and costs* to achieve a 100% renewable electricity supply while electrifying key end uses and maintaining LADWP's current high degree of reliability?
- What are the benefits for *greenhouse gas* reductions and *public health*?

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[4] "Energy and Environment Committee Report Relative to a Research Partnership with Appropriate Entities to Determine what Investments Should Be Made to Achieve 100 Percent Renewable Energy Portfolio for the Los Angeles Department of Water and Power (LADWP)," File No. 16-0243. https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB689138&RevisionSelectionMethod=LatestReleased.

[5] "Energy, Climate Change and Environmental Justice Committee Report Relative to Developing and Implementing Partnerships with Appropriate Entities to Determine what Investments Should Be Made to Achieve 100 Percent Renewable Energy Portfolio," File No. 16-0243. https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB689139&RevisionSelectionMethod=LatestReleased.

- How might the *economy* respond to such a change?
- How can communities shape these changes to prioritize *environmental justice*?

NREL modeled and analyzed LADWP's existing power system generation, transmission, and distribution network, and worked with local LA institutions to examine the effects on air quality and potential for high-quality careers and economic development. As a result of these integrated modeling activities, LA100's findings shed light on the options and tradeoffs among different approaches to achieving 100% renewables for LA.

4 What Makes LA100 Unique?

The real-world impact of approaching 100% renewables cannot be analyzed using just one method or model—so LA100 took a new approach. The study integrated diverse capabilities, including detailed electricity demand modeling, power system investments and operations, distribution grid modeling, economic impact analysis, air quality modeling, environmental justice analysis, and life cycle greenhouse gas analysis.

This multidisciplinary team leveraged NREL's high-performance computer to:

- Run millions of simulations of thousands of *buildings* to examine how adoption of new design elements, equipment, or appliances could change how much and when people use electricity
- Explore opportunities to electrify different *transportation* modes and assess when and where people might charge electric vehicles
- Use sophisticated aerial scans and customer adoption models for each and every roof in LA to see how much *rooftop solar* could be installed
- Apply state-of-the-art *utility planning tools* at unprecedented scale to examine costs and benefits of a wide range of technologies, including solar photovoltaics, wind, concentrating solar power, geothermal, biofuels, batteries, hydrogen storage, and demand response
- Perform detailed analysis of site-specific data for both the *distribution and transmission network* to ensure new resources will not overload lines
- Simulate how different technologies could be used, including *energy storage*, to ensure electricity demand is met every hour of the year.

5 What LA100 Does and Does Not Address

The LA100 study explores multiple scenarios to evaluate portfolios of renewable resources and system upgrades that will achieve 100% renewable energy for LADWP while maintaining the current high degree of reliability. The objective of the study is to inform stakeholders of possible pathways to 100% renewable energy, and the implications of these pathways for costs, the environment, health, economy, jobs, and environmental justice. The study also identifies areas of uncertainty to better understand ways to manage optionality.

The value of the study is in understanding high-level considerations and trade-offs, as opposed to identifying specific costs, technologies, or project sites. For example, for Angelenos interested in achieving 100% renewable energy without biofuels by 2030, the study addresses the types of characteristics of generation and storage that could maintain reliability, and what technologies are likely to be available at an earlier timeframe. For Angelenos interested in minimizing the cost of deep decarbonization, the study explores costs and greenhouse gas emissions at various combinations of renewable energy deployment and electrification of transportation and building end uses. The goal is not to predict outcomes or to provide a detailed plan that identifies specific project sites and their costs, but to allow Angelenos to make long-term policy goals informed by a better understanding of both feasibility and costs and benefits.

Importantly, the study does not present recommendations. The goals and specific implementation pathways are decisions that LADWP will make with input from community members after reviewing the study findings. Also, the study does not recommend or evaluate alternative retail rate structures, customer incentives, or efficiency programs, for example, to identify policies or programs that could be needed to realize LA100's electrification, efficiency, or demand response projections. Without identifying these programs, the study cannot analyze the cost or rate design implications of such programs. However, NREL has provided information to LADWP on the overall amount of assumed electrification, energy efficiency, and demand response to enable LADWP to assess potential costs associated with various programs.

6 Role of LA100 in LADWP's Commitment to a Clean Energy Future

LADWP has committed to achieving a 100% renewable energy power system by 2045. Through the LA100 study, LADWP is tapping NREL's unique analytical and modeling capabilities to inform LADWP's consideration of long-term investment options. The study helps inform the types of generation, transmission, and distributed assets that will be cost effective while also meeting goals for reliability, health, environmental justice, the economy, and climate. By evaluating multiple pathways to 100% renewable energy, the LA100 study offers insights from comparing options but does not recommend a specific path.

In addition to long-term planning, LADWP must also make near-term investment decisions to replace power generated by ocean-cooled units that will be retired this decade. To evaluate these near-term investment needs, LADWP launched Clean Grid LA, an in-house planning effort. These near- and long-term planning efforts—Clean Grid LA and LA100—are separate studies but they have informed each other in their execution. LADWP will formally merge these tracks in 2021 through its Strategic Long-Term Resource Plan, as illustrated in Figure 1. The goal of the stakeholder-based Strategic Long-Term Resource Plan is to consider the findings of LA100 and Clean Grid LA to identify a blueprint to implement LADWP's clean energy vision.

Figure 1. LADWP's planning process to achieve 100% renewable energy

7 About the LADWP Power System

LADWP, the nation's largest municipal water and power utility, was established more than 100 years ago to deliver reliable, safe water and electricity to LA, and currently serves more than 4 million residents. Figure 2 depicts LADWP's power system, including major generation and transmission infrastructure outside the city limits.

Figure 2. Map of LADWP's service area and major transmission and generation infrastructure

LADWP is a vertically integrated municipal utility responsible for generation, transmission, and distribution systems. Vertically integrated utilities traditionally perform integrated resource plans (IRPs) periodically to study and set the optimal mix of new resources.[6] These plans anticipate load growth, plant retirements, and other system changes.

Among LADWP's more than 4 million residents (translating to 1.5 million power customers), annual electricity demand is approximately 75% commercial and industrial (mostly commercial), 23% residential, and 2% other. LADWP has generation capacity of 7,880 megawatts (MW), and the most recent record peak load recorded was 6.5 gigawatts (GW) in August 2017. The system had a generation mix in 2019 that was 27% natural gas, 21% coal, 14% nuclear, 13% solar, 10% wind, 9% geothermal, and 7% hydro, most of which is generated outside the city limits.[7] Customer rooftop solar capacity (via net-metering connections) in 2019 totaled 300 MW. LADWP has over 3,600 miles of high-voltage transmission infrastructure to move electricity into and around the LADWP service area, and 10,400 miles of distribution lines that transport the electricity to customers. LADWP is part of the Western Interconnection and co-owns generation and transmission assets with other utilities in the West but operates independently and is currently not a member of the energy market operated by California Independent System Operator (CAISO). However, LADWP agreed to become a member of the CAISO's Energy Imbalance Market in the Spring of 2021.

Figure 3 depicts the components of the LADWP power system from bulk generation to end-use consumption. The high-voltage transmission network delivers electricity from large generation resources to receiving stations where it is stepped down to lower voltages on the distribution system.

LADWP's distribution system operates at two voltage levels. The subtransmission system (34.5kV) delivers electricity to the local distribution system as well as large industrial customers. Large in-basin solar systems are also typically integrated into this network. Distribution substations step the voltage down to the local distribution system (4.8kV), which includes the lines and equipment that connect neighborhoods and houses.

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[6] Andrew Mills and Ryan Wiser, *An Evaluation of Solar Valuation Methods Used in Utility Planning and Procurement Processes* (Berkeley CA: Ernest Orlando Lawrence Berkeley National Laboratory, 2012), LBNL-5933E, https://eta-publications.lbl.gov/sites/default/files/lbnl-5933e.pdf.
[7] LADWP, *2019 Power Content Label* (LADWP: October 2020). https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-powercontentlabel?_adf.ctrl-state=xj6bj1ypo_4&_afrLoop=614556848024722.

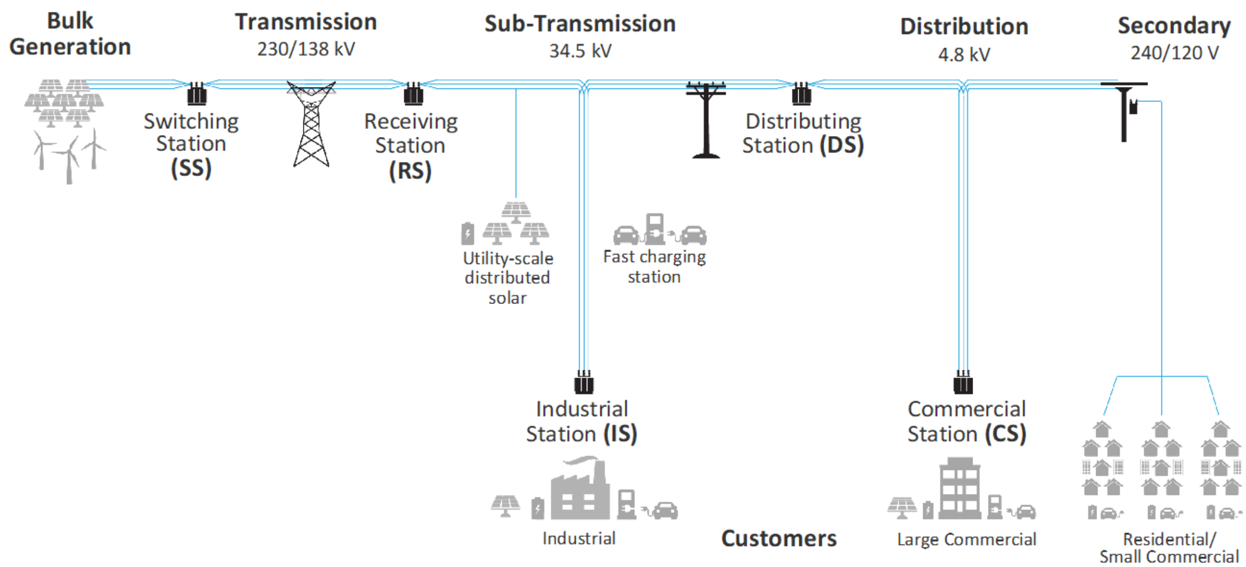

Figure 3. Components of LADWP's power system from bulk generation to end-use consumption

The bulk network of LADWP's power system has a sprawling footprint that spans much of the western United States, influencing important aspects of the system design and evolution. The bulk of the load within LADWP resides within the Los Angeles Basin—a term that is used often in this report—surrounded physically by the San Gabriel Mountains, Santa Ana Mountains, and Verdugo Mountains and the San Joaquin Hills along with the Pacific Ocean. These physical barriers create challenges to building new transmission into the load center, in addition to limiting the area immediately around Los Angeles for building large-scale generation assets. However, LADWP owns portions of two high-voltage direct-current (DC) lines used to carry power into the Los Angeles Basin from farther away, including the Pacific DC tie to Oregon and the Southern Transmission System, a line connecting resources in Utah, along with a series of alternating-current (AC) lines bringing power into the Los Angeles Basin. These key infrastructure resources enable connection of high-quality resources outside of the LADWP service territory, in particular wind resources in the Pacific Northwest and Rocky Mountain region and solar in the Desert Southwest.

Within the Los Angeles Basin, many of the 138-kV lines that transmit power generated outside the basin and at LADWP's several in-basin generating stations consist of underground cables. These buried circuits were built decades ago, leaving little room for upgrades to accommodate the growth in electricity demand that would accompany LA's development in the decades since. The potential for upgrades of overhead lines is constrained, and construction of entirely new paths is infeasible due to high residential density in all but a few areas. But, while the mountains and ocean constrain transmission into the City, they create opportunities to help manage local congestion and enhance reliability. LADWP has been making use of its terrain to provide electric power—it first began supplying electricity in 1917 with two hydroelectric plants built on the Los Angeles Aqueduct north of the city (which still run today but provide a small amount of power relative to total load). Since 1973, it has operated the Castaic Power Plant, a pumped hydro storage facility a few miles from those original hydro plants, to store energy when power is inexpensive and generate energy when the system needs it most. To the west and south, access to the Pacific Ocean gives the City options to build underwater DC transmission cables that could connect in-basin generation sites to one another or to future offshore wind farms.

8 LA100 Study Partners

NREL had many partners to help conduct the study. Kearns & West, under leadership of Joan Isaacson, provided LA100 Advisory Group facilitation and public outreach support, including process design, meeting agenda coordination, review of meeting materials, meeting facilitation, and meeting summary preparation. Kearns & West also partnered with the NREL and LADWP communications teams to assist in the public outreach strategy for the study.

The University of Southern California (USC) collaborated with NREL on several aspects of LA100, including water systems, air quality, and economic modeling. In USC's Astani Department of Civil and Environmental Engineering, Professor Kelly Sanders characterized loads related to LADWP's water infrastructure and pumping networks and Professor George Ban-Weiss, the David M. Wilson Early Career Chair, led the air quality modeling team. In the Price School of Public Policy, Professor Adam Rose and Associate Professor Dan Wei partnered with Colorado State University and NREL to adapt a regional computable general equilibrium (CGE) model to represent Los Angeles County.

Colorado State University's Department of Economics Professor Harvey Cutler and Professor Martin Shields partnered with USC and NREL to adapt the regional CGE model to represent Los Angeles County to estimate the net macroeconomic impacts of the 100% renewable transition, including effects on jobs, prices, household income, and GDP.

9 Structure of the Report

The report is structured as follows. Chapter 2 describes the LA100 study approach, including modeling framework and scenarios. Chapters 3–11 review each of the modeling components of the study and include methodology, modeling assumptions, results, and analysis (see Figure 4). Chapter 12 synthesizes conclusions and reviews lessons learned from integrating this diverse suite of models and conducting a high-fidelity 100% renewable energy study.

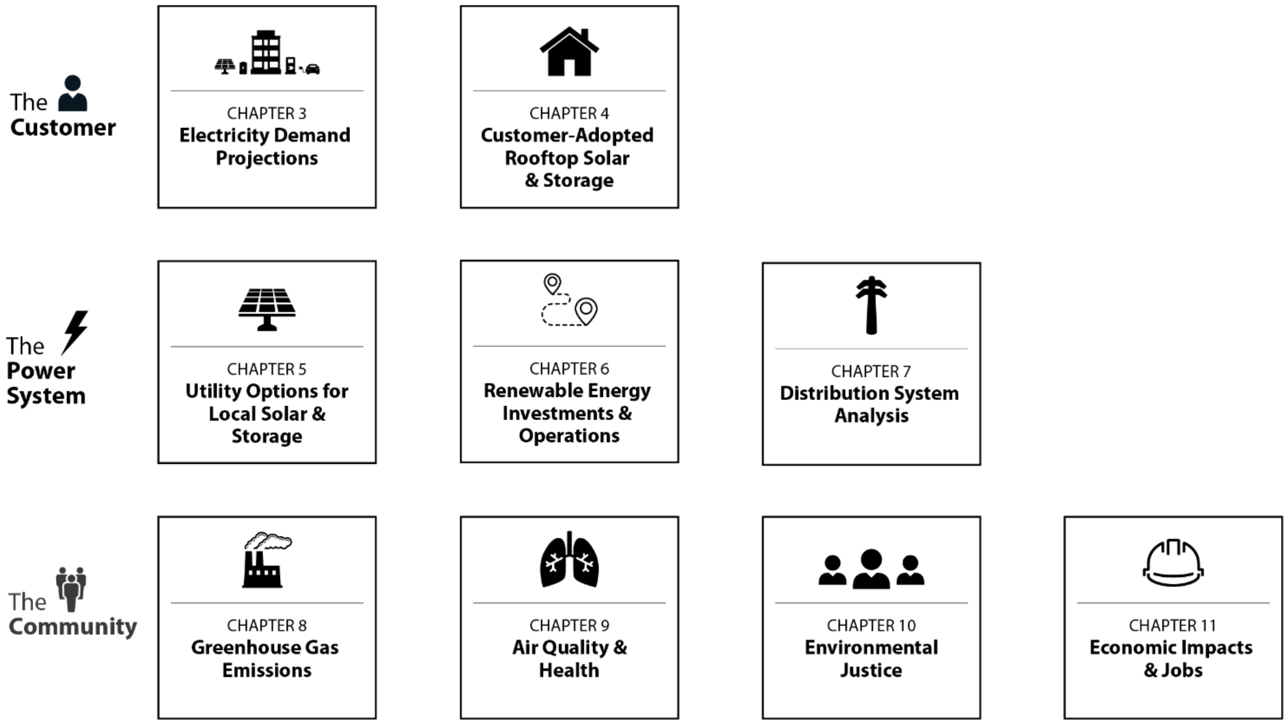

Figure 4. Overview of the modeling chapters in the LA100 study

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