The Los Angeles 100% Renewable Energy Study

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #13

October 1, 8, 22, and 29, 2020

Meeting Summary[1]

Meeting Notes Compiled by Kearns & West

Location

Virtual Meeting

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Virtual Session #1

Thursday, October 1, 2020, 10:00 a.m. to 12:00 p.m.

Virtual Session #1 Attendees

Advisory Group Members

Adam Lane, Los Angeles Business Council
Agustin Cabrera, RePowerLA
Allison Smith, Southern California Gas
Andrea Rojas, Sierra Club
Andy Shrader, Council District 5
Armando Flores, Valley Industry Commerce Association
Bonny Bentzin, University of California, Los Angeles
Bruce Tsuchida, The Brattle Group
Camden Collins, Office of Public Accountability (Ratepayer Advocate)
Carlos Baldenegro, Port of Los Angeles
Carter Atkins, Los Angeles World Airports
Christos Chrysiliou, Los Angeles Unified School District
Clara Karger, Central City Association of Los Angeles
Dan Kegel, Neighborhood Council Sustainability Alliance
Duane Muller, University of California, Los Angeles

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

Los Angeles Department of Water & Power | NREL Transforming ENERGY

Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Frank Lopez, Southern California Gas
Fred Pickel, Office of Accountability (Ratepayer Advocate)
Jack Humphreville, DWP Advocacy Committee
Jasmin Vargas, Food & Water Action
Jean-Claude Bertet, City of Los Angeles Attorney
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies
Jin Noh, California Energy Storage Alliance
Kendal Asuncion, Los Angeles Chamber of Commerce
Laura Nelson, Green Hydrogen Coalition
Luis Amezcua, Sierra Club
Matt Hale, Council District 2
Priscila Kasha, City of Los Angeles Attorney
Rebecca Rasmussen, Office of Mayor Eric Garcetti
Tony Wilkinson, Neighborhood Council

LADWP Staff

Ann Santilli
Ashkan Nassiri
Carol Tucker
Dawn Cotterell
Doug Tripp
Faranak Sarbaz
Greg Huynh
James Barner
James Lin
Jason Rondou
Jay Lim
Julie Van Wagner
LeiLani Johnson
Lisa Yin
Louis Ting
Luis Martinez
Nicholas J. Matiasz
Paul Habib
Scott Moon
Stephanie Spicer
Steve Ruiz
Steve Swift

Project Team

Daniel Steinberg, NREL
Doug Arent, NREL
Garvin Heath, NREL
Haiku Sky, NREL
Jaquelin Cochran, NREL
Meghan Mooney, NREL
Nicholas Gilroy, NREL
Paul Denholm, NREL

Ramin Faramarzi, NREL
Robert Leland, NREL
Scott Haase, NREL
Vikram Ravi, NREL
Alyson Scurlock, Kearns & West
Joan Isaacson, Kearns & West
Taylor York, Kearns & West
Yun Li, University of Southern California
Zelinda Welch, University of Southern California

Observers

Anna Yenyk, Southern California Gas
Diane Moss, Renewables 100 Policy Institute
Hongjun Moushegian, Southern California Gas
Jovy Kroh, Southern California Gas

Call to Order and Agenda Overview

Joan Isaacson, LA100 Advisory Group meeting facilitator from Kearns & West, welcomed the virtual meeting attendees. She explained that this was the first of four virtual sessions comprised in Meeting #13 of the Advisory Group for the City of Los Angeles 100% Renewable Energy Study (LA100 study). The Advisory Group, noted Isaacson, was convened to solicit input, feedback, and guidance from the many stakeholders that have varying interests around the transition to renewable energy. This session's focus was community outreach and engagement and a demonstration of the draft LA100 study website for reporting results.

Welcome Remarks

Doug Arent, NREL Deputy Associate Lab Director, welcomed Advisory Group members and noted that their participation is invaluable for the LA100 study. He expressed sincere appreciation for Advisory Group member participation and emphasized that the study process is entering its final stages and has provided many insights into challenges and opportunities for achieving 100% renewable energy. He highlighted the LA100 study website and noted that Advisory Group member feedback is essential, as the website is intended to be a critical public-facing method for disseminating information. He expressed appreciation for City of Los Angeles leadership in transitioning to renewable energy.

Greg Huynh, LADWP Manager of the 100% Clean Energy Innovation Group, welcomed Advisory Group members, thanked them for their efforts, and also noted the nearing of the year end and completion of the LA100 study. He provided updates on recent related LADWP activities, including approval of the new Red Cloud Wind Project in New Mexico and the Bring Your Own Thermostat Program which was rolled out in June 2020.

Jaquelin Cochran, NREL LA100 Study Principal Investigator, provided an overview of topics for each session of the Advisory Group Meeting #13 series, noting that the current (October 1) session would cover community outreach and engagement, including environmental justice communities, and an interactive demonstration of the LA100 study website. Subsequent sessions will address final results for the 100% renewable energy pathways in two parts (October 8 and 15, later changed to October 29), and final results for greenhouse gas emissions for power and non-power sectors (October 22). In response to previous Advisory Group member requests, Cochran provided an overview of topics covered at previous Advisory Group meetings.

Community Outreach and Engagement

Stephanie Spicer, LADWP Community Affairs Manager, presented LADWP's plan for community outreach and engagement for LADWP's Clean Energy Future program, which includes the LA100 study. Spicer explained that a clean energy future is reliable, affordable, and sustainable, adding that LADWP's renewable energy targets include achieving 55% renewable energy by 2025, 80% by 2036, and 100% by 2045. To achieve these targets, LADWP will need to increase renewable energy supply by eliminating coal, increasing local solar and energy storage, and investing in proven technologies. In addition, LADWP will need to meet and manage demand by investing in energy efficiency, increasing demand response, and expanding electric vehicle and building electrification.

Spicer explained the relationship between the LA100 study and Clean Grid LA. While the LA100 study provides insights for a 25-year path to more broadly achieve 100% renewable energy, Clean Grid LA is a shorter-term, 10-year path to replace 1,660 MW of generation with clean sources by 2030. The LA100 study and Clean Grid LA inform each other and efforts related to the Strategic Long-Term Resource Plan (SLTRP), through which LADWP will chose its investment paths.

Spicer identified two fundamental goals for the outreach: awareness and feedback. She explained that generating project awareness is a fundamental goal of community outreach, as well as communicating LA's 100% clean energy goals and the options for achieving them. LADWP will conduct citywide outreach that is broad but that has a focus on engaging environmental justice communities that are most significantly impacted. Community outreach and engagement will also provide community members with insight on impacts to air quality, public health, jobs and workplace development, affordability, electrification, and resiliency. Spicer noted that LADWP wants to raise awareness of the driving factors behind the transition to 100% renewable energy, including legislative requirements, local renewable energy targets, and climate change. She stated that LADWP wants today's plans to become tomorrow's projects and programs – LADWP wants to ensure that investments are connected directly to applications.

Spicer then turned to the second goal of feedback. She highlighted the importance of understanding LADWP customer perspectives that inform the path to renewable energy, including desired level of involvement. She noted that the various paths to achieve 100 percent renewable energy require customer participation and offer different opportunities for involvement. LADWP wants to hear about community priorities and concerns, which will help them create opportunities and eliminate barriers throughout the transition.

Outreach and engagement opportunities will include community meetings and events organized through partnerships with neighborhood councils and Advisory Group partners. LADWP will use social media channels (Facebook, Twitter, Instagram, and Nextdoor), traditional media, emails/newsletters, the project website, videos created by NREL, and fact sheets to spread the word about outreach and engagement opportunities. She also highlighted the importance of ensuring access and inclusion for all communities to participate. It will be especially important to navigate COVID-19 restrictions, utilizing a mix of virtual and in-person outreach opportunities.

Spicer reviewed the outreach and engagement timeline for the LA100 study, which includes two rounds. Round 1 outreach is targeted for early December 2020 to mid-January 2021 and will focus on assessing the preliminary results and describing the study. Round 2 outreach is targeted for March 2021 and will focus on reporting the final results and explaining the scenarios in more detail. The next steps towards implementation will occur through the SLTRP, which is updated every 2 years through a participatory process. Spicer noted that developments from the LA100 study are critical for developing the 2021 SLTRP, outreach for which is expected to begin in early 2021.

Following Spicer, Cochran shared how NREL can serve as a resource for community outreach and to the Advisory Members' groups. She noted that NREL staff are available to participate in meetings to help communicate the study objectives, scenarios, and results to date. In addition, NREL staff can communicate aspects of a 100% renewable energy system that could inform decision-making such as impacts on costs, jobs, health, and reliability. Cochran then reviewed an example agenda outlining the topics that could be presented during a meeting:

- Introductions, Review City Council Motions, Clean Grid LA
- What could a transition to a 100% renewable energy system look like?
- What is the LA100 study?
- What do the results mean for decisions that might result from the study?
- How can ratepayers get involved and provide input to LADWP?
- What LADWP programs can help residents lower their bills?

Major Themes from Advisory Group Member Questions and Discussion

- The City of Los Angeles Climate Emergency Mobilization Office should be contacted when planning community meetings. They are currently conducting outreach and can provide input on effective techniques and venues.
- LADWP needs to solicit ratepayers' input and ratepayers' priorities should be weighed when making decisions.
- LADWP should prioritize involvement along with education. Rather than just informing community members, there should be interactive engagement and not only lectures. This includes how the community engagement is both framed and implemented.
- Engagement needs to accommodate community members with transportation and childcare challenges.
- LADWP needs to provide dedicated meeting access for language interpretations, including Spanish and sign language. Meetings should be conducted in Spanish with English interpretation. Interpretation also needs to be two-way, interpreting the presentation to participants and interpreting feedback to the presenter. The cost of interpretation needs consideration when developing the outreach budget.
- Meetings that do not allow chat and suppress discussion essentially turn off public participation while allowing the City to claim that they conducted outreach meetings.
- While the Advisory Group process can serve as a conduit for providing information to the community as the study is developed, the community engagement process will involve the public on how LADWP should use the results of the study.

LA100 Study Interactive Website

Cochran introduced the Advisory Group to the LA100 study website. She noted that the initial presentation would focus less on specific results and more on how the website can effectively communicate with different audiences. She noted that NREL would share the URL with interested Advisory Group members who wanted to review the website further, and she asked that Advisory Group members request login information. Additionally, she noted that NREL would offer a follow-up website tutorial for Advisory Group members on Monday, October 5. Cochran stated the following goals of sharing the website with the Advisory Group before the study is final: increase transparency by providing data and analysis, provide more time to review results and ask questions, and solicit feedback on how to improve the content on the website.

Cochran then gave an interactive demonstration of the LA100 study website. She walked the Advisory Group members through the main sections on the home page, including key findings, exploratory questions, data viewer, about, and glossary. She noted that the key findings section compiles the less detailed scenario-specific results and more detailed topic-specific results. The exploratory questions section includes several video clips

intended to address common questions people may have. In the data viewer section, viewers can filter results by time period, location, or result type. Lastly, she highlighted a FAQ page to be supplemented over time and a glossary section that defines words and acronyms used across the site.

Major Themes from Advisory Group Member Questions and Discussion

- There was concern that the website will not provide the cost data.
- While the study focuses on the power system in 2045, LADWP needs to consider the impacts of reducing 2,000 MW of fossil fuel base load generation in the short term. Impacts on the system created in 2030 will affect the ability to attain 100% renewable energy by 2045.
- What does it mean to attain too high of a reliability?
- Does NREL consider extreme weather scenarios or extreme scenarios over multiple weeks in the LA100 study evaluation? For example, periodic drought, availability of hydropower, or two weeks of clouds with hot nights?
- Does the model have the ability to consider how extreme scenarios for LADWP are integrated into the Western markets?
- Will the study show a current baseline for comparison with the model outputs? Model assumptions should always be transparent. Will the model show, in a particular year, the current system capacity (base load, renewable, storage, and dispatchable combinations with hours available for that emergency capacity)?
- A number of Advisory Group members stated that they thought the website was impressive.
- The website shows the complexity of the LA100 study, for the Advisory Group and even more so for the public. We need to think about how to simplify the issues that people may be concerned about when we talk to our communities.
- Bringing back the website to a simplified context is important. We can focus on how quickly we can get to 100% renewable energy, the associated costs, and if it will be reliable with regard to outages.
- In the shorter term, the cost of electricity will remain affordable, but a vast amount of literature indicates the cost of storage will significantly increase as greater levels of renewable energy generation are accomplished. Equity metrics include the cost of power, and power is essential on a daily basis. There is concern about how the highest levels of renewable energy generation will be paid for.
- LADWP should maintain hydrogen as an option and not rely too heavily on renewables and battery storage, as hydrogen can provide flexibility at a lower cost.

Wrap-up and Next Steps

Isaacson noted that the next two sessions will cover the near-final results and will take place on Thursday, October 8 and Thursday, October 15 (later changed to October 29). She reminded Advisory Group members of the follow-up website tutorial on Monday, October 5 at 4:00 p.m.

Virtual Session #2

Thursday, October 8, 2020, 10:00 a.m. to 12:00 p.m.

Virtual Session #2 Attendees

Advisory Group Members

Allison Smith, Southern California Gas
Andrea Rojas, Sierra Club
Andy Shrader, Council District 5
Armando Flores, Valley Industry Commerce Association
Austin Eriksson, California State University, Northridge
Bruce Tsuchida, The Brattle Group
Camden Collins, Office of Public Accountability (Ratepayer Advocate)
Carlos Baldenegro, Port of Los Angeles
Christos Chrysiliou, Los Angeles Unified School District
Dan Kegel, Neighborhood Council Sustainability Alliance
Duane Muller, University of California, Los Angeles
Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Fred Pickel, Office of Public Accountability (Ratepayer Advocate)
Jack Humphreville, DWP Advocacy Committee
Jasmin Vargas, Food & Water Action
Jean-Claude Bertet, City of Los Angeles Attorney
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies
Kendal Asuncion, Los Angeles Chamber of Commerce
Liz Anthony Gill, Center for Energy Efficiency and Renewable Technologies
Loraine Lundquist, California State University, Northridge
Luis Amezcua, Sierra Club
Matt Hale, Council District 2
Rebecca Rasmussen, Office of Mayor Eric Garcetti
Sergio Dueñas, California Energy Storage Alliance
Tony Wilkinson, Neighborhood Council

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Jay Lim
LeiLani Johnson
Lisa Yin
Louis Ting

Luke Sun
Luis Martinez
Nicholas J. Matiasz
Paul Habib
Paul Schultz
Robert Hodel
Scott Moon
Stephanie Spicer
Steve Ruiz
Steve Swift

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Garvin Heath, NREL
Jaquelin Cochran, NREL
Paul Denholm, NREL
Ramin Faramarzi, NREL
Robert Leland, NREL
Scott Haase, NREL
Vikram Ravi, NREL
Alyson Scurlock, Kearns & West
Joan Isaacson, Kearns & West
Taylor York, Kearns & West

Observers

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Bill Engels, Water and Power Associates
Blaine Waymire, Southern California Gas
Brissa Sotelo, Valero Energy Corporation
Dale Fontanez, Southern California Gas
Hongjun Moushegian, Southern California Gas
Janice Lin, Strategen
Jovy Kroh, Southern California Gas
Lauren Harper, Los Angeles Cleantech Incubator
Mayte Sanchez, Los Angeles Cleantech Incubator
Megan Ross, LA Mayor's Office of Sustainability
Randolph Krager, Southern California Public Power Authority
Rosalinda Magana, Sempra Energy

Call to Order and Agenda Overview

Joan Isaacson, LA100 Advisory Group meeting facilitator from Kearns & West, welcomed the virtual meeting attendees. She explained that this was the second of four virtual sessions for Meeting #13 of the Advisory Group for the City of Los Angeles 100% Renewable Energy Study (LA100). This session's focus was the near-final results from the 100% renewable energy investment pathways. Isaacson noted that the LA100 Study has moved beyond the model output phase, as NREL is now able to provide context on how study results fit into the bigger picture of renewable energy.

Welcome Remarks

Greg Huynh, LADWP Manager of the 100% Clean Energy Innovation Group, thanked the Advisory Group members for participating in another virtual session. He complimented the level of Advisory Group member engagement and the valuable input provided. He noted that the LA100 team remains very interested in hearing Advisory Group member perspectives and encouraged members to continue providing input inside and outside of the meetings, especially as the completion of the study nears.

Robert Leland, NREL Associate Lab Director, thanked the Advisory Group members for their participation and effort. He emphasized the importance of the LA100 study for NREL, noting that the study process has been a tremendous learning opportunity, one which NREL aspires to replicate and build on in support of the nation's transformation to a clean energy system. He noted that NREL is very excited about the results to be presented and the impact they will have.

Jaquelin Cochran, NREL LA100 Principal Investigator, noted that the October 15 Advisory Group session was rescheduled for October 29. She provided an overview of topics for the remaining sessions of the Advisory Group Meeting #13 series, noting that the October 8 session would address part one of the final results for the 100% renewable energy pathways, with a focus on technology and cost sensitivity analysis. She also invited Advisory Group members to provide input on the LA100 study website. Future sessions will address final results for greenhouse gas emissions for power and non-power sectors (October 22) and part two of the final results for the 100% renewable energy pathways, with a focus on reliability (October 29).

100% Renewable Energy Investment Pathways, Part 1

Daniel Steinberg, NREL Economics and Forecasting Group Manager, presented the near-final results for the 100% renewable energy pathways, focusing on technology and cost sensitivity analysis. He provided background information on the four core scenarios in LA100 study: SB100, LA Leads, Transmission Renaissance, and High Distributed Energy Future. NREL explored all four scenarios across moderate and high load electrifications. SB100 was also explored for a high load stress case. Steinberg reminded Advisory Group members of preliminary LA100 insights from previous Advisory Group meetings, including:

- Wind and solar resources meet the majority of energy needs, accounting for 69% to 88% of total energy needs in 2045 depending on the scenario.
- Resources with four to 12 hours of storage capability are key to enabling increased utilization of wind and solar.
- New in-basin firm renewable capacity—power plants that can come online within minutes and run for hours to days—comprise the least-cost options to maintain reliability given the assumed retirement of the in-basin coastal once-through-cooling generators and reliance on out-of-basin resources for the majority of energy needs.

Steinberg discussed costs related to the total bulk system and explained that the total costs are dominated by investments in new solar, wind, storage, and geothermal assets. Additionally, the LA Leads scenario shows increased costs across moderate and high load electrification due to the need to rely on hydrogen technologies for in-basin firm capacity, which have higher costs than renewable combustible turbines.

Steinberg reviewed five key drivers of the 100% renewable energy investment pathways and their associated costs: target definition and eligibility of alternative compliance mechanisms; speed of transition; evolution of load; trade-offs in large-scale infrastructure deployment; and technology cost assumptions, availability, and eligibility. He noted that reliability would be discussed at the October 29 session, including operational changes, the robustness of the systems to different weather years, and how power will be delivered during emergencies.

Steinberg emphasized that the results presented at this meeting are not final and will undergo revisions. He also highlighted aspects of the two different technologies used in the LA100 study: renewable combustion turbine and hydrogen combustion turbine. Renewable combustion turbine technologies are assumed to use market-purchased fuels whereas hydrogen combustion turbine technologies and fuel cells are assumed to use self-produced fuel. In addition, the LA100 study assumes that RE-CT technologies are converted from biofuel to hydrogen by 2041.

Implications of Target Definitions (Basis) and/or Allowing a Portion of Compliance to be Met with Renewable Energy Certificates

Steinberg discussed the following sensitivities to the SB100 scenario and one sensitivity to the LA Leads-High electrification scenario:

- **SB100 – Generation Based Target:** The 100% target is based on total generation instead of sales, creating a more stringent target.
- **SB100 – Generation Based Target and No RECs by 2045:** The target is based on generation, but in addition, renewable energy certificates (RECs) are not allowed in the 2045 compliance year. Fossil fuels cannot provide energy or capacity resources.
- **LA Leads with RECs:** Use of unbundled RECs is allowed to satisfy up to 10% of the target.

Steinberg compared the capacity mix in 2035 and 2045 along with cumulative bulk system costs through 2045 for the SB100 and LA Leads-High scenarios. For SB100, changes in target definition have minor impacts on the 100% renewable energy pathway and costs if RECs are allowed. He noted that eliminating the eligibility of RECs has a significant impact on costs. For LA Leads-High, allowing RECs through 2040 (thereby allowing the use of RE-CT through 2040 and shifting the 100% no-REC target to 2045) reduces costs by 16% by 2045.

Implications of Speed of Transition

Steinberg discussed two sensitivities related to the speed of transition to renewable energy in the LA Leads scenario:

- **LA Leads scenario 100% renewable energy target compliance by 2045 instead of 2035:** Use of unbundled RECs is allowed to satisfy up to 10% of the target in all but the final year.
- **LA Leads scenario with Renewable Combustion Turbines:** Renewable combustion turbines (i.e., biofuels through 2040) are allowed.

Steinberg noted that the cost of the LA Leads scenario is more sensitive to biofuel exclusion compared with speed of transition.

Major Themes from Advisory Group Member Questions and Discussion

- There was interest in an analysis of cost for consumer rooftop solar installation, demonstrating cost before and after any subsidies, as well as the break-even point.
- Interest was expressed for data showing capital expenditures for each scenario by year, generation source, transmission, and distribution.
- RE-CT could be called MRE-CT to emphasize the market aspect. Hydrogen produced by LADWP is renewable.
- Will unbundled RECs still be available as many utilities transition to 100% renewable energy? And if not, what would the implications be?
- The lower price of market-purchased hydrogen versus hydrogen produced on site caused some confusion.

- A request was made for additional data relating to the cost of acceleration in the LA Leads scenario due to the target/technology differences. A suggestion was also made that NREL could model sensitivities to all scenarios that accelerate compliance timing.
- Does storage and transfer of methane for powering turbines under these scenarios carry the same risk of environmental harm as natural gas?
- Is it correct that RECs are lower cost than renewable biofuels such as renewable natural gas?

Implications of Alternative Load Futures

Steinberg presented results by load level for the SB100 and LA Leads scenarios and noted that they do not include any sensitivities. The SB100 scenario includes moderate, high, and stress load levels, while LA Leads scenario includes moderate and high. He explained that increasing electrification across the scenarios increases costs; however, energy efficiency and demand response can mitigate cost increases.

Tradeoffs in Large-Scale Infrastructure Development

Steinberg provided an overview of the tradeoffs of large-scale infrastructure development. He noted a high level of investment across all core scenarios, as well as rapid rates of development for generation and storage assets each year. He discussed the following sensitivities to the LA Leads-High and Transmission Renaissance-High scenarios:

- **LA Leads – No In-Basin Combustion:** No new combustion turbines (Hydrogen or other fuels) or fuel cells can be sited in basin.
- **LA Leads – RE-CT:** Allows the siting of renewably fueled (e.g., biofuel) combustion turbines in basin.
- **Transmission Renaissance – No In-basin Combustion:** No new combustion turbines (H2 or other fuels) or fuel cells can be sited in basin.
- **Transmission Renaissance – No prescribed backbone:** The DC backbone is allowed to be built but is not required to be built.

Steinberg noted that the LA Leads scenario with no in-basin combustion would require a substantial increase in in-basin transmission. An LA Leads scenario that allows biofuels through 2040 would require a small increase in in-basin transmission and eliminate the need for new out-of-basin transmission. For the Transmission Renaissance sensitives, eliminating in-basin combustion would require substantially more in-basin transmission, even with a DC backbone.

Major Themes from Advisory Group Member Questions and Discussion

- Are the rates similar across the different scenarios (i.e., moderate, high, and stress)?
- Do combustion generation projections represent additional generation? Do these numbers assume decommissioning of current natural gas generation?
- Can you provide the link for the assumptions document?
- There was a request for clarifications on types of battery technologies that enable the four- and 12-hour durations outlined in the presentation.
- Does the model assume a level of availability that is not realistically attainable?
- Are the bulk of the costs for hydrogen combustion generation representative of technology or fuel costs? Can NREL provide costs for these fuels to better understand what is driving the scenarios?

Implications of Alternative Technology Futures

Steinberg presented on the implications of alternative technology futures. Alternative assumptions about the future cost and availability or eligibility of technologies can drive shifts in deployment. For example, higher

hydrogen costs result in growth in alternative sources of firm capacity, while lower hydrogen costs result in smaller changes as hydrogen is already heavily relied upon. Having no in-basin combustion or fuel cells results in more pumped hydropower storage. Higher battery costs result in more geothermal and hydrogen storage, while lower battery costs result in more medium-duration storage and less hydrogen storage. When solar is at a higher cost, there is more reliance on hydrogen storage, and when solar costs decrease, there is more reliance on it for energy. The cumulative system costs vary with future technology costs, which affects cost of compliance. Costs are sensitive to assumptions, which is particularly evident in the LA Leads scenario.

Major Themes from Advisory Group Member Questions and Discussion

- At what point does technology allow scaling up of battery storage to become more efficient?
- The height of the cost-range clusters will be most important for ratepayers. SB100 has a lower cost than other scenarios, so all others need to make a virtue argument.
- Ratepayers also care about greenhouse gas emissions, air quality, and maintaining a healthy, livable climate.
- When creating 400-500 megawatts of new capacity per year, capital costs should be the main driver.
- NREL should include data from the 2017 SLTRP in the presentation, to allow for comparison of the scenarios to current conditions.
- Can the full sensitivity results be visualized on the LA100 study website?
- Potential for economic and political changes over a long timeline (between now and 2045) presents challenges when assessing these scenarios.
- There was concern that the study does not capture the 20-25 year risk of a major Western U.S. and Canada-wide hydropower shortage.
- A request was made to allow Advisory Group members to review content as it is added to the website, allowing 2 weeks review time before the content is published.
- The website is helpful for reference after the meetings.

Wrap-up and Next Steps

Isaacson reminded Advisory Group members that there was not a meeting the following week as the October 15 session had been rescheduled to October 29. She thanked Advisory Group members for their participation and wished them a good afternoon.

Virtual Session #3

Thursday, October 22, 2020, 10:00 a.m. to 12:00 p.m.

Virtual Session #3 Attendees

Advisory Group Members

Allison Smith, Southern California Gas
Andrea Rojas, Sierra Club
Andy Shrader, Council District 5
Armando Flores, Valley Industry Commerce Association
Austin Eriksson, California State University, Northridge
Bonny Bentzin, University of California, Los Angeles
Bruce Tsuchida, The Brattle Group
Camden Collins, Office of Public Accountability (Ratepayer Advocate)
Carlos Baldenegro, Port of Los Angeles
Christos Chrysiliou, Los Angeles Unified School District
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Duane Muller, University of California, Los Angeles
Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Fred Pickel, Office of Public Accountability (Ratepayer Advocate)
Jack Humphreville, DWP Advocacy Committee
Jean-Claude Bertet, City of Los Angeles Attorney
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies
Kendal Asuncion, Los Angeles Chamber of Commerce
Loraine Lundquist, California State University, Northridge
Michael Webster, Southern California Public Power Authority
Priscila Kasha, City of Los Angeles Attorney
Rebecca Rasmussen, Office of Mayor Eric Garcetti
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Tony Wilkinson, Neighborhood Council

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James Barner
James Lin
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Louis Ting
Luis Martinez

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Joan Isaacson, Kearns & West
Taylor York, Kearns & West
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Yun Li, University of Southern California

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Bill Engels, Water and Power Associates
Frank Lopez, Southern California Gas
Johnny Huleis, Southern California Gas
Jovy Kroh, Southern California Gas
Mayte Sanchez, Los Angeles Cleantech Incubator
Megan Ross, LA Mayor's Office of Sustainability
Pablo Ruiz, The Brattle Group

Call to Order and Agenda Overview

Joan Isaacson, LA100 Advisory Group meeting facilitator from Kearns & West, welcomed the virtual meeting attendees. She explained that this was the third of four virtual sessions for Meeting #13 of the Advisory Group for the City of Los Angeles 100% Renewable Energy Study (LA100) and noted that the focus of this session was the greenhouse gas (GHG) emissions and air quality analyses.

Welcome Remarks

Greg Huynh, LADWP Manager of the 100% Clean Energy Innovation Group, said hello to the Advisory Group members, thanked them for attending, and noted that the GHG emissions and air quality analyses are primary driving factors for the LA100 study. He emphasized the importance of the Advisory Group's input in shaping the analyses and added that this input is critical in considering future benefits and possible tradeoffs. He encouraged Advisory Group members to continue providing input inside and outside of the meetings, especially on the topic of GHG emissions.

Jaquelin Cochran, NREL LA100 Principal Investigator, then overviewed the topics for the remaining sessions of the Advisory Group Meeting #13 series, noting that this current session would address GHG emissions from the power, building, and transportation sectors and provide an update on air quality modeling methods. The final

session on October 29 will address part two of the results for the 100% renewable energy pathways, with a focus on reliability. She also suggested that Advisory Group members watch two short background videos on the LA100 study website in preparation for the October 29 session.

Greenhouse Gas Emissions Impacts – Power, Buildings, and Transportation Sectors

Methods for Greenhouse Gas Analysis – Recap and Update

Garvin Heath, NREL Senior Scientist, presented on methods for the GHG emissions analysis. He noted that NREL's bulk power model directly estimates CO_2 emissions from combustion. The goal of the GHG emissions analysis is to include all attributable GHG emissions from each scenario. In addition to power sector combustion, the analysis includes three areas where GHG emissions are attributable to the LA100 scenarios:

- Construction, operation, and decommissioning of all electric generation technology
- Methane, SF6 and nitrous oxide from certain generation technologies including renewable forms of generation, such as biogas
- Fuel use in buildings and transportation, both combustion and fuel cycle (see below definition)

Heath explained that Life-Cycle Assessment (LCA) analysis, an internationally recognized method practiced for over 40 years, was used to quantify resource consumption, energy use, and emissions. The LCA provides a basis for consistent comparison of renewable and conventional energy technologies. The LCA for technologies considered in LA100 analyzes attributable GHG emissions from operation and maintenance, during which combustion of fuel takes place, as well as upstream and downstream effects. Upstream effects include resource extraction and materials/component manufacturing and facilities construction. Downstream effects include emissions related to plant decommissioning. The fuel cycle is included as a subset of the LCA for combustion technologies, which accounts for how fuels are extracted, processed and transported to their place of combustion.

Heath next outlined assumptions and caveats related to NREL's GHG emissions analysis. The power sector analysis includes the full life cycle of emissions associated with electricity generation technologies (construction, operation, and decommissioning) and fuels (combustion and fuel cycle). NREL's analysis does not consider GHG emissions from other electric infrastructure for the power sector, such as transmission lines, distribution lines, and substations. Heath noted that building sector analysis only includes residential and commercial buildings and the transportation sector only includes light-duty vehicles and buses. The analysis for those two sectors only considers emissions associated with fuel combustion and the fuel cycle and does not account for life-cycle GHG emissions associated with changes to infrastructure outside of the power sector (e.g., equipment to electrify buildings or vehicles, charging stations). Heath referred Advisory Group members to presentations from previous Advisory Group meetings or the LA100 study website for questions about load assumptions.

Heath then provided more information about the four steps generally used to estimate life-cycle GHG emissions across the LA100 study. First, power sector combustion is directly estimated based on fuel burn and fuel carbon content by the production cost model. Second, NREL's prior systematic review of LCAs on electricity generation technologies provides estimates for non-combustion GHG emissions, including non-CO_2 emissions. These life-cycle phases include: upstream (materials, manufacturing, and plant construction), downstream (plant decommissioning), and ongoing operations and maintenance as well as fuel cycle emissions. Two technologies not previously evaluated by NREL (i.e., are new to LA100) but included in the analysis are battery storage and fuel cells.

Third, Heath described buildings and transportation GHG accounting. For buildings combustion, fuel use is a result of NREL's building energy use models. The only fuel considered is natural gas; other fuels are omitted

because their use is negligible in LA. Natural gas is assumed to be 100% fossil because there is not a mandate for blending of renewable natural gas and there are no official statistics on RNG use reported to the CA Air Resources Board. For transportation combustion, the fuels evaluated are gasoline (with 2% ethanol blended) for light-duty vehicles, and gasoline, diesel (with some renewable diesel blending), and compressed natural gas for school and transit buses. Heath noted that a fraction of CNG is RNG (based on official CARB statistics). Buses are assumed to be 100% electrified by 2030. Fourth, non-combustion fuel-cycle emissions in buildings and transportation sources are estimated based on emission factors from the CARB's CA-GREET tool. These estimates account for fuel leaks in the supply chain, such as leakage of natural gas. It was noted that the leaks considered are based on the best available data for long time periods and thus are appropriate for use in long-duration studies like LA100; they do not consider specific and local infrastructure leaks.

Heath provided context for the LA100 study scenarios by outlining California's statewide GHG emissions reduction targets (40% reduction by 2030 and 80% by 2050). He noted that NREL can only compare combustion emissions to California targets, because these emissions are within California's borders within a given time frame (whereas life cycle emissions could occur outside of CA and a given year, given the methods of LCA).

Combustion and Life-Cycle Greenhouse Gas Emissions, Power and Non-Power Sectors

Heath presented the cumulative (2020–2045) life-cycle GHG emissions from the power and non-power sectors for the four core LA100 scenarios (SB100, LA Leads, Transmission Renaissance, and High Distributed Energy Future) and for different loads (Moderate, High, Stress). Overall, the LA Leads – High Load scenario has the lowest cumulative life-cycle GHG emissions while the SB100 – Moderate Load scenario has the highest life-cycle GHG emissions. In comparing the transportation, buildings, and power sectors, GHG emissions from the transportation sector account for the highest cumulative GHG emissions, ranging from 50–63% (depending on scenario).

Heath then outlined the life-cycle GHG emissions from the power and non-power sectors on an annual basis. By 2045, the LA Leads – High Load scenario has the lowest annual life-cycle GHG emissions attributable to the transportation, buildings, and power sectors, while the SB100 – Moderate Load scenario has the highest annual life-cycle GHG emissions. Heath noted that all the scenarios show a downward projection in emissions from 2020–2045, with the High Load projections seeing the largest reduction in GHG emissions.

Heath discussed combustion GHG emissions for the power and non-power sectors and compared them to California's statewide GHG emissions reduction targets. In 2030, the SB100 – Moderate Load scenario is contributing 7% of emissions reduction to the 2030 statewide target and 4% emissions reduction to the 2050 target, whereas the LA Leads – High Load scenario is contributing 9% emission reduction to the 2030 target and 7% emissions reduction to the 2050 target.

Greenhouse Gas Emissions, Power Sector

Heath described the annual life-cycle GHG emissions for the LADWP-only power sector. He noted that emissions drop significantly from 2020–2030 and then level by 2045. The LA Leads scenarios (High Load and Moderate Load) have the lowest annual life-cycle GHG emissions in 2045, about 85% lower than the SB100 scenarios (High Load, Moderate Load, and Stress Load). For cumulative life-cycle GHG emissions, the LA Leads scenarios have the lowest cumulative life-cycle GHG emissions for the power sector from 2020–2045, which is about half the emissions as the SB100 scenarios. This is due to the LA Leads scenarios reaching the 100% target 10 years earlier than the others. Heath discussed cumulative life-cycle GHG emissions by the type of GHG emissions. Power sector GHG emissions from activities outside of fossil fuel combustion, which include construction, decommissioning, and ongoing non-combustion, account for 33–58% of cumulative (2020–2045) emissions.

Heath reviewed annual combustion GHG emissions for the power sector by technology. Coal initially dominates in all scenarios but drops off after it is eliminated by 2030. After 2030, natural gas-fired plants account for the majority of combustion emissions, where allowed within LA100 scenarios. In all LA100 scenarios and load projections, LADWP's assets exceed the reductions target for its share of the statewide 40% and 80% GHG emissions for 2030 and 2050, respectively. Heath noted that results for the power sector are still in draft form.

Greenhouse Gas Emissions, Buildings Sector

Heath outlined the cumulative (2020–2045) life-cycle GHG emissions for residential and commercial buildings sector, which includes commercial and residential buildings. Due to higher levels of end-use electrification, life-cycle GHG emissions associated with natural gas consumption in the High Load projections are significantly lower than in the Moderate Load projections in the building sector. On an annual basis, reductions in natural gas usage in residential buildings in the High Load and Stress Load projections see about an 86% reduction in annual GHG emissions from 2020 to 2045. Heath noted that the commercial building results are similar. Cumulative life-cycle GHG emissions for the buildings sector are also broken out by the life-cycle phase (fuel cycle and combustion). Across all three load projections, combustion emissions account for approximately 78% of the cumulative life-cycle GHG emissions from fuel use in the residential building sector, while the remaining 22% is attributed to the fuel cycle (extraction, processing, and transport of fuels). Heath noted that commercial buildings produce similar results.

Greenhouse Gas Emissions, Transportation Sector

Heath reviewed the annual life-cycle GHG emissions for light-duty vehicles and buses as part of the overall transportation sector. Compared to 2020, the moderate electric vehicle projection reduces annual life-cycle GHG emissions from fuel used in light-duty vehicles and buses by 48% in 2045, while the high electric vehicle projections reduce GHG emissions by 85% in 2045. For life-cycle phase, the fuel cycle accounts for about 31% of the total cumulative (2020–2045) life-cycle GHG emissions from light-duty vehicles and buses in both the moderate and high electric vehicle adoption projections.

Heath reviewed the annual life-cycle GHG emissions by vehicle type (passenger cars, two weight classes of light-duty trucks, school buses, and urban buses). Passenger cars and light-duty trucks account for almost all (99%) of the annual life-cycle GHG emissions associated with fuel consumption from the vehicles considered, while school and urban buses contribute negligibly (1%).

Major Themes from Advisory Group Member Questions and Discussion

- For a nuclear plant, would the construction cycle capture the carbon emissions associated with the need for steel and concrete production?
- Would non-electric infrastructure GHG emissions be relevant if out-of-basin transmission lines vs. hyper local microgrids were under study?
- Will the life-cycle analysis for hydrogen be discussed?
- Are possible massive methane leaks, like the Aliso Canyon event, considered?
- Are CO_2 releases from wildfires that could be attributed to electricity included in these assumptions? These emissions should be considered, as the electric system can cause fires regardless of the resources used to generate electricity.
- NREL should present results of the GHG emissions impacts in two ranges, current–2035 and 2036–2045, to reflect the emissions in the year that they occur. For example, for a plant put into service in 2035, results would show GHG emissions from construction prior to 2035 and then GHG emissions from operation after 2035.

- Why was Southern California Gas' goal of utilizing 20% renewable natural gas by 2030 not considered in the buildings emissions analysis? There was concern that the analysis assumes building electrification is the only option, leading to an incomplete building GHG emissions analysis.
- Presenting GHG emissions for all sectors, including heavy-duty vehicles, could be useful for the analysis. Though heavy-duty vehicles were not considered in NREL's analysis, it is important for people to understand the scale of emissions from the different sectors and how this was addressed or not addressed in the study.
- Transition of building energy usage from natural gas to electricity is a significant input into the model, however reduction of natural gas usage is outside of DWP's control.
- A renewable natural gas goal would have provided a more holistic analysis of the building emissions profiles.
- The dangers from emissions related to natural/renewable gas leaks should be included in comparison to any GHG emissions issues related to electrification from solar and wind.

Impact of LA100 Scenarios on Air Pollutant Emissions (Update to Air Quality Modeling Methods)

Heath presented an update on the air quality modeling methods. The SB100 – Moderate Load scenario has been added to the four previous scenarios (2012 Baseline, LA Leads – Moderate Load, LA Leads – High Load, and SB100 – High Load) to act as a reference case for future scenarios. Heath noted that the SB100 – Moderate Load scenario is characterized by continued operation of natural gas power plants.

Heath presented the updated NO_x and primary particulate matter emissions results for the City of Los Angeles, now including SB100 – Moderate scenario. Significant reductions are seen from 2012–2045 across all the scenarios, and light-duty vehicles contribute the most to reductions. Heath also presented the updated annual total NO_x emissions for LADWP-owned power plants located in the South Coast Air Basin. In the updates on air quality modeling, Heath noted that the simulated $PM_{2.5}$ fits well for the 2012 baseline but that ozone concentrations are underpredicting. Simulations in future scenarios are being carried out concurrently with testing for solutions for the ozone underestimation.

Major Themes from Advisory Group Member Questions and Discussion

- The SB100 – Moderate Load scenario is a great addition to the model.
- Did NREL utilize emissions data on buses from the California Air Resources Board (CARB) EMission FACtor (EMFAC) model? There was concern that this model overstates the emissions for LA Metro, as CARB does not differentiate between the diesel standard (0.2 g/bhp) and the ultra-low NOx (0.02 g) in LA Metro's compressed natural gas fleet.

Wrap-up and Next Steps

Isaacson noted that next week's fourth session will cover part two of the final results for the 100% renewable energy pathways, with a focus on reliability. The session will take place on Thursday, October 29. She reminded Advisory Group members to view the videos on the LA100 study website in preparation for the next session.

Virtual Session #4

Thursday, October 29, 2020, 10:00 a.m. to 12:00 p.m.

Virtual Session #4 Attendees

Advisory Group Members

Adam Lane, Los Angeles Business Council
Allison Smith, Southern California Gas
Andrea Rojas, Sierra Club
Andy Shrader, Council District 5
Bruce Tsuchida, The Brattle Group
Camden Collins, Office of Public Accountability (Ratepayer Advocate)
Carter Atkins, Los Angeles World Airports
Christos Chrysiliou, Los Angeles Unified School District
Dan Kegel, Neighborhood Council Sustainability Alliance
Duane Muller, University of California, Los Angeles
Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Fred Pickel, Office of Public Accountability (Ratepayer Advocate)
Jack Humphreville, DWP Advocacy Committee
Jean-Claude Bertet, City of Los Angeles Attorney
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies
Kendal Asuncion, Los Angeles Chamber of Commerce
Martin Marrufo, International Brotherhood of Electrical Workers - Local 18
Mary Leslie, Los Angeles Business Council
Matt Hale, Council District 2
Michael Webster, Southern California Public Power Authority
Rebecca Rasmussen, Office of Mayor Eric Garcetti
Sergio Dueñas, California Energy Storage Alliance
Tony Wilkinson, Neighborhood Council
Virginia Cormier, International Brotherhood of Electrical Workers - Local 18

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Randolph Krager, Southern California Public Power Authority

Call to Order and Agenda Overview

Joan Isaacson, LA100 Advisory Group meeting facilitator from Kearns & West, welcomed the virtual meeting attendees. She explained that this was the fourth and final virtual session for Meeting #13 of the Advisory Group for the City of Los Angeles 100% Renewable Energy Study (LA100). This session's focus was reliability.

Welcome Remarks

Greg Huynh, LADWP Manager of the 100% Clean Energy Innovation Group, welcomed Advisory Group members and thanked them for accommodating a date change for this Advisory Group session as the LA100 team wanted to ensure the most accurate information was presented for discussion. He emphasized LADWP's

longstanding commitment in assuring system reliability and assured Advisory Group members that LADWP continues to view reliability as an important component of the transition to 100% renewable energy.

Doug Arent, NREL Deputy Associate Lab Director, noted that many Advisory Group meetings have focused on what to build and the portfolio of renewable energy technology. He explained that this session would provide an opportunity to discuss system reliability. He added that reliability is a significant challenge for the transition to 100% renewable energy and is a top priority for NREL and LADWP. He emphasized the utilization of new approaches to understanding reliability in 100% renewable energy systems, noting that these would be discussed at this meeting. He also encouraged Advisory Group members to continue providing feedback.

Jaquelin Cochran, NREL LA100 Principal Investigator, expanded on the meeting agenda, noting that this final session of the Advisory Group Meeting #13 series would cover part two of the final results for the 100% renewable energy pathways, with a focus on reliability. She also provided an overview of the topics for the upcoming Advisory Group Meeting #14 series which will likely occur in December, including distribution and job and economic impact results. NREL also plans to distribute completed chapters of the draft report and will continue to make updates to the LA100 study website, including adding the bulk power layer to the data viewer. Advisory Group Meeting #15, the final meeting, will take place in early 2021 and will address results for air quality, health, environmental justice, and monetization of benefits. In addition, all remaining chapters of the draft report and updates to the LA100 study website will be completed at that time.

100% Renewable Energy Investment Pathways, Part 2

Paul Denholm, Principal Energy Analyst at NREL, reviewed key points discussed during the October 8 Advisory Group session (focused on technology and cost sensitivity analysis), noting that this session would focus on how well the power system maintains its reliability during different event simulations. He provided an overview of the topics and subtopics that would be covered in the session, including components of day-to-day operations (balancing, ramping, and operating reserves), and planning for extreme events and contingencies (sufficiency of supply to meet demand at all times of the year and under different weather years, extended outages, and unexpected, rapid outages).

Day-to-Day Operations – Balancing

Denholm discussed balancing supply and demand during day-to-day operations, highlighting the differences between traditional and low-renewable energy systems and 100% renewable energy systems. Traditional and low-renewable energy systems generally have three types of operations: baseload, intermediate, and peaking. For these systems, resources like coal are supplemented by more quickly deployed resources such as hydropower or natural gas plants. Denholm noted that as more renewable energy is added, having a diversity of wind and solar locations, as well as renewable energy forecasting, becomes more important. With 100% renewable energy systems, system operators need to adjust to unusual net load shapes; storage will play a very significant role in balancing supply and demand; and careful attention must be given to scheduling of resources to ensure stored energy is available when needed.

Denholm described results for a set of example periods, including a peak demand period, a low wind period, and a low wind and solar period for the LA Leads – High Load scenario in 2045. He noted that during a peak demand period, solar mostly aligns with peak loads, and electric vehicle charging can be incentivized earlier in the day to shift the demand of electricity to greater periods of supply. During these periods of peak demand, or during low RE periods, the system relies on generation from renewably derived fuel used in combustion turbines. Denholm noted that the low wind period figure shows combustion turbines running frequently, which would not be the case when looking at results on an annual scale. Denholm directed Advisory Group members to the videos on the LA100 study website to help with further understanding low wind and solar period results.

Day-to-Day Operations – Ramping

Denholm discussed the day-to-day operations with regard to ramping, which is the change in generator output. He noted that as the demand for electricity increases in traditional and low-renewable energy systems, the required ramping changes. He explained that the system's ability to quickly ramp up to meet demand is a key concern as more renewable energy is added to the system. With 100% renewable energy systems, demand can outpace supply ramping due to the variability of wind and solar generation. Denholm suggested that the challenges associated with up-ramps, or increasing supply, need to be considered along with resource availability.

Denholm described results for the highest 3-hour up-ramp period for the High Distributed Energy Future – High Load scenario in 2045. He described the typical winter load pattern and noted that increases in demand occur in the afternoon and at sunset. Denholm suggested that the up-ramp in demand can be met if the system is designed properly and if in-basin resources are relied upon – for example, natural gas turbines can ramp up in less than an hour and battery storage can ramp up in seconds. He noted that these resources can be turned on prior to when they are needed since increases in demand during this period are predictable.

Day-to-Day Operations – Operating Reserves

Denholm discussed the operating reserves for day-to-day operations, noting that traditional and low-renewable energy systems carry contingency reserves to protect against large power plant and transmission line failures, as well as regulation reserves to protect against small random variations in demand. In addition, reserves are derived from partially loaded gas plants, pumped storage, and hydropower. Denholm noted that with 100% renewable energy, the size of the contingency to plan against is not changed, and transmission line failures still have to be prevented and addressed. There is also a small increase in regulating reserves due to increased short-term variability of wind and solar as well as a need for flexibility reserves to address sub-hourly variability. Denholm noted that reserves are derived increasingly from batteries and already curtailed wind and solar.

Denholm described results for annual operating reserve provisions for the LA100 scenarios and loads. Because fuel plants are expensive to run, maintaining reserves of energy storage using methods such as pumped hydropower plants could be a more effective resource than deployment of renewable energy combustion turbines. Wind turbine output can also be adjusted in a matter of seconds to provide reserves during times when wind is available.

Major Themes from Advisory Group Member Questions and Discussion

- The impact on total energy bills for median and lifeline customers, including a shift to electricity for transportation and building heating, is important to consider.
- Cellulosic ethanol was suggested as a cost-effective fuel, as biologically derived fuels do not necessarily contribute to a net win.
- Has LADWP considered a robust educational campaign focused on changing electricity user behaviors?
- How is the treatment of solar and wind as reserves different from curtailment? Doesn't curtailment impact the cost of solar or wind energy?
- What is the process for solar ramp up? These sources need to operate at 80%, similar to fossil fuels generation. This should be included in NREL's reporting.
- Operating reserves from wind and solar should be used only to support the variability of wind and solar. LADWP still needs to plan for operating reserves that can be utilized during times of low or no wind and solar availability.

Planning for Extremes – Sufficiency of Supply to Meet Demand All Times of the Year (Resource Adequacy)

Denholm then turned to discussing the planning for extremes in resource adequacy to ensure that physical assets are correctly placed and available when needed. In traditional and low-renewable energy systems, a simple planning reserve margin or pumped storage approach is used to build conventional capacity to the expected peak day (i.e., hot summer afternoon). This reserve margin includes building an extra 15–20% of capacity to ensure reliability against outages and unexpected events. Denholm noted that with 100% renewable energy systems, the availability of wind and solar must be considered as there is limited capacity of shorter-duration storage. This requires that all hours be considered rather than just the hottest summer afternoon.

Denholm described results for in-basin capacity, out-of-basin capacity, and total capacity for the 2045 moderate load scenarios. He discussed nominal capacity versus firm capacity, noting that a relatively small fraction of wind and solar capacity could be considered firm. Denholm noted that, from a planning reserve standpoint, generation plants are expected to be out for maintenance 5–10% of the time.

According to Denholm, in traditional and low-renewable energy systems, resource adequacy challenges in transmission-constrained regions are solved with traditional dispatchable capacity. He noted that standard probabilistic resource adequacy tools do not model transmission in detail. With 100% renewable energy systems, the availability of in-basin resources and transmission, including resources for energy dispatch, need to be considered in greater detail.

Denholm discussed results from the resource adequacy tool, noting a reliability target of 2.4 hours of outages per year. Traditional analysis shows that using the interim results the system is more reliable than needed, contributing to an over-built and costly system. He discussed transmission constraints and highlighted limitations for getting all the power into the system near Scattergood due to transmission bottlenecks in that area.

Major Themes from Advisory Group Member Questions and Discussion

- A request was made for clarification of why energy storage is not considered firm capacity. It was further noted that even under certain effective load carrying capacity approaches, some fraction of energy storage can be considered firm.
- What changes have been made to the model to address the over-reliability of the system mentioned at previous Advisory Group meetings? Will these changes have cost implications?
- Can long duration or seasonal storage help with reliability issues?
- The study does not seem to provide analysis of an 85% renewable buildout versus a 100% buildout. An 85% buildout model with gas in reserve could reduce system build-out costs.
- Concern was expressed about the system being overly reliable. When reducing reliability in-basin, reliability should be more of a worry than greenhouse gas emissions.
- Keeping natural gas as a seldom-used backup until hydrogen or other technologies become cost effective enough seems reasonable, but that may not occur until around 2030.
- Was climate variability considered over multiple years, including the relationship between drought and reduced hydropower?

Planning for Extremes – Different Weather Years

Denholm discussed planning for extremes that might occur during different weather years. Traditional and low-renewable energy systems plan around the expected hottest day of the year and consider hydropower availability, while 100% renewable energy systems need to plan around every day of the year and consider longer term variability of wind and solar. He noted that there was not a significant impact of multiple weather

years in the resource adequacy calculation results. Low wind and solar needs to be addressed in every weather year regardless of weather extremes.

Planning for Extremes – Extended Transmission Outages

Denholm discussed planning for extremes regarding extended transmission outages. Traditional and low-renewable energy systems maintain replacement reserves that can operate for days or longer while a plant or transmission line is being repaired. This is currently provided by in-basin, gas-fired units. He noted that 100% renewable energy systems need to consider the continued need for replacement reserves for the entire year, instead of just a few times of the year, especially in light of the operating characteristics of wind and solar.

Denholm described results for managing long-duration outages that are based on more than 100 types of events. He noted that a decision would be needed about how robust to build the system and the acceptable risks for extended outages. He compared scenarios for 2020 and 2045, noting that investment in the transmission system will have an impact on energy lost during severe extended outages.

Denholm discussed planning for extremes that may cause unexpected system failures, noting that LADWP currently has, or could have in the future, three sources of energy including in-basin generation, out-of-basin generation brought in by the direct current (DC) transmission network, and out-of-basin generation via the alternating current transmission network. When a transmission line fails, power from the failed line is not necessarily removed from the system but begins traveling along other existing lines, potentially causing further overload. Denholm highlighted the importance of conducting contingency analysis to assess the impacts to the rest of the system when one transmission line breaks. When planning for transmission line failures, solutions include adding more lines, upgrading to larger lines, or creating more in-basin generation.

Denholm next discussed contingency analysis. Traditional and low-renewable energy systems plan for outages by maintaining spinning contingency reserves and test for reliability using a few snapshot conditions. He noted that 100% renewable energy systems must still evaluate post-contingency events but also need to consider non-traditional sources of voltage control and frequency response (inverter-based resources). He suggested that power flow and stability analysis is needed to address deliverability issues.

Denholm discussed results from the 2,600 contingency cases NREL analyzed for the SB100 High Load Stress scenario in 2030 and the LA Leads High Load scenario in 2045. He noted that when the system is overloaded, a lot of power is brought in from out-of-basin. Denholm stated that solutions can be found to provide reliable operation under normal conditions and under many contingencies that depend on a mixture of renewable energy resources, in-basin dispatchable capacity, and transmission upgrades. He noted that standard definitions and approaches of evaluating reliability have not been sufficiently tested under different 100% renewable energy scenarios.

Major Themes from Advisory Group Member Questions and Discussion

- How frequently do extended transmission outages occur?
- A long duration outage of two major transmission lines seems unlikely.
- Keeping some once-through cooling (OTC) units as cold spares with zero usage may be an appropriate mitigation technique.
- LADWP should consider the usefulness of extra generation that provides reliability during disasters.
- Are the non-OTC gas turbines in-basin sufficient to deal with certain transmission line outages?
- Unanticipated multiyear failures have occurred on certain transmission lines.
- Could short-haul DC interties provide a solution?
- Certain components of the Transmission Renaissance scenario, such as a Victorville to Century DC line, could provide an energy path that does not travel through the San Fernando Valley.

- Are unexpected failure scenarios overlaid with periods of low solar/wind during the analysis?
- Have needed transmission upgrades been quantified (e.g., miles of transmission lines or cost)?
- It appears that the cost for reliability could be two to four times higher for a 100% renewable energy system than an 85% renewable energy system.
- Has full electrification of the entire LA economy been considered as one scenario? Could needed upgrades to accomplish electrification lead to fewer reliability problems in the system?
- Higher reliability will be expected in 20 years as society become more dependent on electricity.
- The planned fast-start replacements would take less space than existing OTC units and should be an option.

Wrap-up and Next Steps

Isaacson reported that the LA100 team is in the process of preparing summaries for each session of the Advisory Group Meeting #13 series, explaining that these will be posted to the website as one consolidated document. She reminded members of the upcoming Advisory Group Meeting #14 series in December, asked everyone to keep on the lookout for an email with the confirmed dates, and signed off with a note about looking forward to seeing everyone in December.