The Los Angeles 100% Renewable Energy Study

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #10

Thursday, December 5, 2019, 8:45 a.m. to 3:45 p.m.

Meeting Summary[1]

Meeting Notes Compiled by Kearns & West

Location

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

Attendees

Advisory Group Members

Adam Lane, Los Angeles Business Council
Agustin Cabrera, RePowerLA (LAANE)
Andy Shrader, Council District 5
Armando Flores, Valley Industry Commerce Association
Bonny Bentzin, University of California, Los Angeles
Camden Collins, Office of Public Accountability (Rate Payer Advocate)
Christos Chrysiliou, Los Angeles Unified School District
Clara Karger, Central City Association
Dan Kegel, Neighborhood Council Sustainability Alliance
Danielle Mills, American Wind Energy Association
David Graham-Caso, Council District 11
Debarshi Das, Los Angeles Cleantech Incubator
Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Frank Lopez, SoCal Gas
Fred Pickel, Office of Public Accountability (Rate Payer Advocate)
Hilary Firestone, Natural Resources Defense Council
Jack Humphreville, Greater Wilshire Neighborhood Council
Jason Douglas, Department of City Planning
Jean-Claude Bertet, City Attorney
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies (CEERT)
Jin Noh, California Energy Storage Alliance

[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

Kendal Asuncion, Los Angeles Chamber of Commerce
Luis Amezcua, Sierra Club
Martin Marrufo, International Brotherhood of Electrical Workers (IBEW) Local 18
Matt Hale, Council District 2
Michael Christensen, Los Angeles World Airports
Mike Webster, Southern California Public Power Authority
Priscila Kasha, City Attorney
Rebecca Rasmussen, Office of the Mayor
Salem Afeworki, Value Sustainability
Shaouki Aboulhosn, Port of Los Angeles
Tony Wilkinson, Neighborhood Council — LADWP MOU Oversight Committee

LADWP Staff

Amanuel Selassie
Armen Saiyan
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Carol Tucker
Cindy Parsons
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Eric Hy
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James Barner
Jason Rondou
Jay Lim
Jodean Giese
Joseph Avila
Julie Van Wagner
Leilani Johnson
Louis Ting
Luis Martinez
Nicholas Matiasz
Robert Hodel
Scott Moon
Stephanie Spicer
Steve Swift

Project Team

Bryan Palmintier, National Renewable Energy Laboratory (NREL)
Daniel Steinberg, NREL
Doug Arent, NREL
Jaquelin Cochran, NREL
Paul Denholm, NREL
Christian Mendez, Kearns & West
Jack Hughes, Kearns & West
Jenna Tourje, Kearns & West
Joan Isaacson, Kearns & West
Taylor York, Kearns & West

Observers
Adam Procell, Lime Energy
Bruce Tsuchida, The Brattle Group
Debarshi Das
Duane Muller, University of California, Los Angeles
Jason Douglas
Mabell Paine, Lime Energy
Michael Christensen
Salem Afeworki
V. John White

Call to Order and Agenda Overview

Joan Isaacson, Advisory Group meeting facilitator from Kearns & West, welcomed members to the tenth meeting. She thanked Advisory Group members for their efforts, provided an overview of the agenda (see Appendix A). She noted that the meeting would address results from the Initial Run of the Los Angeles 100% Renewable Energy Study (Study), highlighting that results from the Final Run would be different. Isaacson introduced LADWP and NREL leadership for opening remarks.

Greg Huynh, LADWP Manager of 100% Clean Energy Innovation, thanked Advisory Group members and introduced himself and role in the Study. He noted that this tenth Advisory Group meeting was the first since the project scope change, and that Advisory Group members would begin to see the culmination of more than two years' work. Jason Rondou, LADWP Director of Clean Grid LA Strategy, thanked Advisory Group members for their contributions and noted that the tenth meeting marked a big milestone and an important step in completing the Study.

Doug Arent, NREL Deputy Associate Lab Director, remarked that NREL is excited to partner with LADWP on the Study. He noted that this project is providing an example of leadership for thinking about and planning decarbonization pathways for municipalities and for the broader energy economy around the world.

Isaacson then invited Advisory Group members to introduce themselves in roundtable fashion. After introductions, Isaacson reminded Advisory Group members that only primary members from each member organization should sit at the table and participate in question and answer discussion.

Initial Run Overview
See Appendix B for Initial Run Results: Overview of Today slides.
Jaquelin Cochran, NREL LA100 Project Lead, introduced the context for presenting the Initial Run results and explained how they are being used in preparing for the Final Run. The Initial Run results also show some general trends related to four important aspects of the Study:

- Input models: What could be electricity demand and customer-driven supply?
- Main scenario model: What does LADWP build?
- Output and validation models: How do we know it's right?
- Impact models: What are the impacts?

Presenting Initial Run results also enables the Advisory Group to better understand the LA100 Study modeling and to provide feedback.

Cochran provided an overview of the Study scenarios, noting that the only change since the September 2019 Advisory Group meeting was addition of the reference case. The Initial Run results presented at this meeting are for the five scenarios that represent each scenario type. Importantly, the results from the Initial Run will change in the Final Run, based on several factors:

- Changes in electricity demand projections, including higher vehicle electrification, higher electricity projections due to climate change, and consideration of demand response.
- Further analysis of reliability, particularly in the context of extreme conditions and over multiple weather years.
- While the NREL team has a lot of data on wind and solar, further consideration of other non-variable renewable energy generation sources is needed.
- Further consideration of the cost and constructability of both local solar and transmission assets, including capturing the nuances of solar cost on certain types of property.

Reviews of each model during the Advisory Group meeting included 1) considerations in the Initial Run and 2) considerations not included in the Initial Run but that would be included in the Final Run. The considerations would be outlined at the beginning of each presentation at today's meeting, explained Cochran.

Advisory Group members were prompted to ask questions and provide feedback that can inform the Final Run.

Major Themes from Advisory Group Member Questions and Discussion

- The project team needs to be clear that the Study is not locking in a specific course, but rather presenting a series of building blocks that could be used to address a future power system.

Initial Run Results: Input Models

See Appendix B for Initial Run Results: Input Models slides.

Paul Denholm, NREL Technical Lead, presented an overview of the input modeling used to inform the Initial Run. Specific aspects reviewed by Denholm included electricity demand projections, demand response, renewable energy resources, and customer-driven solar (rooftop photovoltaics).

Electricity Demand Projections

Electricity demand projections show how electricity usage patterns and levels will change between now and 2045. The Initial Run incorporated projections completed in January 2019 and "high" projections that are lower than what will be in the Final Run. The Final Run will include "high" efficiency and electrification projects that align with LA's Green New Deal, climate-adjusted and improved calibration of building models, and more aggressive demand response.

The LA100 Study uses three projections of demand to explore three different energy futures:

- Moderate: Moderate increase in demand above 2017 LADWP Power Integrated Resource Plan (IRP)
- High: Significantly higher demand due to electrification partially offset by improvements in energy efficiency
- High Stress: High electrification combined with low energy-efficiency improvements

To project these energy futures, NREL used the ResStock and ComStock models to study how the residential and commercial building stock use power and how power use will change in the future, based on a set of assumptions. The models also considered industrial demand and other loads, including industrial manufacturing, water system loads, Los Angeles International Airport and the Port of Los Angeles, the motion picture industry, as well as consideration of impacts of electric vehicle charging.

Denholm provided a review of results, including examples of residential demand in the base year, which can be found on slide 30 of the presentation. He noted that Initial Run projections show a 30% electric vehicle share for moderate load and a 62% electric vehicle share for high load in 2045. This is projected to have a significant impact on demand during peak hours. More detailed results, including peak day demand projections, can be found on slide 38 of the presentation.

Demand Response

Denholm talked about the potential role that demand response could play in helping to reduce the need for expensive peaking capacity. Denholm overviewed two different types of demand response – interruptible load and energy-shifting. Further analysis of demand response is needed, and a more detailed discussion will occur at the March 2020 Advisory Group meeting.

Renewable Energy Resource Assessment

The renewable energy resource assessment identifies the most cost-effective renewable resources that can meet LADWP's needs. The Initial Run analysis included renewable resource assessments for all technologies across the Western US for one weather year. The Final Run analysis will consider renewable resource profiles for wind and solar over a 10-year period and will generate multiple years of forecasts and sub-hourly data sets. Inputs to renewable generation profiles include historic weather data; land characteristics; biomass, hydro, and geothermal resource availability; and renewable plant operating characteristics. Modeling outputs include available capacity by site (megawatts) and time-series generation profile by plant (megawatt hours). Denholm shared maps and visualizations depicting the Initial Run results (slides 50–53 of the presentation).

Customer-Driven Solar

Next, Denholm explained that the goal of the customer-driven solar analysis is to establish projections that represent realistic adoption rates. The analysis incorporates two methods for compensating customers for energy supplied to the system:

- Moderate: Based on use of net billing, which has compensates exported energy based on value of energy at that time
- High: Based on use of net metering, which compensates at retail tariffs, regardless of timing of the exports

Projecting adoption of rooftop solar is a three-step process:

- Technical Potential: Maximum technically feasible amount of capacity, does not account for economic feasibility or constructability
- Economic Potential: For which customers is rooftop solar cost effective?
- Deployment Estimate: Of those customers for whom rooftop solar is technically feasible and cost effective, who is likely to adopt?

Modeling shows approximately 10.5 GW of technical potential for rooftops currently, mostly in the residential sector and nearly half in census tracts designated as disadvantaged communities. Potential grows slightly, due to declines in installation costs but is offset by declining value due to increased deployment. More detailed results of economic and adoption potential can be found on slides 64-68 of the presentation. Further work is needed to address how rooftop solar targets can be achieved, and discussion about multi-family solar adoption is ongoing. The March 2020 Advisory Group presentation will address local solar such as ground-mounted and carport, consumer-adopted storage, and continued refinement of assumptions.

Major Themes from Advisory Group Member Questions and Discussion

- Electric load has declined over the last decade, and increases in efficiency may continue. Is this accounted for?
- Will demand response only be assessed on a programmatic basis, or will capacity expansion be considered? Is historical demand response data being used to inform optimizations?
- Why is NREL not considering electric trains coming in from other regions? The East Coast has some experience with this.
- Does the Study assume a 1:1 replacement of gasoline vehicles with electric vehicles? We need to consider that there is a trend of reducing the number of cars on the road.
- How will the Study address evolving targets for Electric Vehicle penetration?
- Does demand modeling consider reduced loads in commercial areas during non-business hours?
- Despite lack of data, the scenarios should include some consideration of heavy-duty electrification beyond buses. This electrification will have a big impact on criteria emission reduction.
- Can we show tradeoffs between greenhouse gas reduction in the power and transportation sectors?
- Are incremental costs of adopting new technologies, such as electric vehicle and solar, considered in the modeling?
- The Study is heavy with engineering detail but leaves out some fundamental economic issues. If the cost of electricity rises to match the cost of gasoline, it makes electric vehicle adoption less desirable, making electric vehicle penetration goals challenging to accomplish.
- Is the cost of offshore wind declining?
- Is there an opportunity to consider cost efficiencies, such as installing solar on new or replacement roofs?
- How much housing growth does the consumer-driven solar modeling assume?
- Does rooftop solar make economic sense considering local feed-in tariff models?
- If net billing and net metering rate structures are only being used to forecast solar adoption, behind-the-meter solar generation may not be included.

LA100 SB100 Scenario, Initial Run Results: Bulk Power Models

See Appendix B for SB100 Scenario, Initial Run Results slides.

Daniel Steinberg, NREL Senior Analyst and Group Manager, provided an overview of Initial Run results for the bulk power models for the SB100 scenario. He addressed generation and transmission expansion needs, investment pathways, and system reliability considerations related to load balancing, resource adequacy, and power flow and stability.

Steinberg provided a review of the bulk system modeling approach and noted that modeling will help identify a set of bulk system investment pathways to 2045 and ensure that the future system is operable, resource-adequate, and physically stable. Modeling runs are based on the Initial Run electricity demand projections initial cost and performance assumptions, and initial resource assessments. Analysis was conducted for one weather year, and considers the impacts of short-duration outages of generation and transmission on resource adequacy. The Final Run will include evaluation of long-duration outages, final cost and performance assumptions, limits on transmission upgrades, and evaluation of power flow under different conditions. The Final Run will address multiple weather years.

Steinberg reviewed the definition of the SB100 scenario, clarifying that renewable energy certificates (RECs) are available for a portion of compliance through 2045, and that all scenarios assume retirement of once-through-cooling infrastructure by 2030, and operation of natural gas generation through 2045 (when offset through the use of RECs). He also provided an overview of the three renewable portfolio standards categories:

- Category 1: Time-synchronous RECs and energy delivered to the LADWP balancing area
- Category 2: RECs and energy that cannot be delivered without technology substitution; firmed and shaped contracts
- Category 3: Unbundled RECs (no energy purchased)

Investment Pathway: Capacity Expansion Model

Steinberg provided an overview of total needed capacity, noting significant expansion of wind and solar generation. Because a significant portion of wind and solar generation is occurring out-of-basin, transmission infrastructure will be a key investment. Detailed results of the Initial Run can be found on slides 13, 14, and 18–20 of the presentation.

Operations/Energy Balancing

Steinberg reviewed hourly dispatch results for the SB100 scenario for a set of representative days over the 2045 solve year. Steinberg noted that wind and solar serve a high portion of the load and generate excess power during the day that can charge storage. During peak load conditions, or during times of low renewable resource output, the Initial Run results show that the system will rely on increased output from storage, geothermal, and natural gas (in addition to available wind, solar, hydro, and nuclear) to meet demand.

Resource Adequacy

Resource adequacy, explained Steinberg, measures the ability of the bulk-scale generation and transmission system to serve electricity demand under all but the most extreme conditions. Under this study, resource adequacy is estimated using the Normalized Expected Unserved Energy (NEUE) metric, which effectively measures both frequency and magnitude of losses. Initial Run results for the SB100 Scenario indicate that resource adequacy that is well below the NEUE target of 10 parts per million for a single weather year, but this result could change when more weather years are analyzed in the Final Run.

Power Flow Analysis

Next, Steinberg described how the power flow analysis indicates whether the system is stable under normal operating conditions and following contingencies (unexpected outages). The objective is to evaluate the reliability of the system and identify if changes in generation and transmission investments are required to maintain reliability.

System Costs

Steinberg reported that the system costs analyzed for the bulk system in the Initial Run include capital, fuel, fixed operations and maintenance (O&M), and variable O&M. Costs that have not been analyzed include existing debt on capital expenses, distribution system costs, capital costs and O&M for customer-owned distributed generation, and cost of energy efficiency and demand response programs. Distribution system costs for upgrades, as well as capital cost and O&M for customer-owned distributed generation will be included in the Final Run. For the Initial Run for the SB100 scenario, bulk system generation and transmission cost is estimated to be $10 billion between 2021 and 2030, and $26 billion between 2031 and 2045, for a total of $36 billion. Steinberg noted that of the cost categories analyzed in the Initial Run, capital costs had the largest share, reflecting the absence of fuel costs for renewable generation. Steinberg also noted that NREL expects these results to change during the Final Run.

Major Themes from Advisory Group Member Questions and Discussion

- Is the $36 billion on top of costs in the current LADWP long-range plan?
- Many of the sources of generation identified in the Study have startup costs on top of capital and O&M costs. Are these accounted for in the Study?
- What is the primary in-basin generation source?
- Are any of the Initial Run results surprising for LADWP or NREL?
- Is the NREL team developing a balance sheet and cashflow numbers in kW/hr?
- Are the analyzed costs realistic, in terms of generating rates, because they do not include costs of existing system resources, cost of RECs, and cost of load curtailment?
- There are questions about whether the use of natural gas and RECs meet SB100's intent for zero-carbon sources.
- Do initial results differentiate between on- and off-shore wind generation?
- How much of the $36 billion investments would still be required if LADWP wasn't planning for a 100% renewable system?
- Can 8760 dispatch results from PLEXOS be made available?
- Is there a way to account for fossil fuel subsidies, and to consider the impacts if they are removed?
- Is an expenditure of $2 billion a year realistic? Is it possible to develop a matrix that illustrates the types of investment needed?

LA100 SB100 Scenario Initial Run Results: Distribution Models

See Appendix B for Initial Run Results: Distribution Models SB100 Scenario slides.

Bryan Palmintier, NREL Manager Grid-Connected Energy Systems Modeling Group, explained the purpose and method of the distribution analysis in the Study and presented the Initial Run results for distribution models in the SB100 Scenario. This included describing the approaches being used for both "Impact Analysis"—for a specific integration scenario, such as those in this study—and for "Hosting Capacity"—which attempts to find the range of generic distributed energy resource (DER) installation levels above which upgrades are required. He then previewed what would be covered in future Advisory Group meetings. The distribution analysis will ultimately help determine the types of distribution upgrades LADWP should make to reach 100% renewable energy.

Impacts of Distribution-Connected Solar

Palmintier explained that the analysis seeks to determine the impacts on the distribution system from 1) future electricity demand changes, and 2) distributed generation from residential and commercial rooftop solar and larger ground-mounted and carport solar. He indicated that his presentation would focus only on Initial Run results for the SB100 scenario for the year 2045, using initial loads for 4.8 kV solar. Based on two time points: "peak demand" and "high solar with low demand," NREL examined potential violations from load changes in the year 2045, differences in violations from local solar in 2045, and the combined load and solar impact.

NREL modeled specific customer adoption patterns and ran detailed power flow simulations to test for four types of violations: under and over voltages and overloads in the lines and transformers. Palmintier discussed violations and the types of needed feeder upgrades to accommodate increased loads, additional solar, and the combined impact of increased loads and solar. The 2045 load-only result estimated the most common projected violations are due to under voltages, with over voltages being the next most common violation. Eighty-six percent of the feeders operated well with 2045 loads and most of those remaining required only a few upgrades. The impacts of adding new solar did not produce a drastic increase in violations. Most feeders decreased in type of violations with a few increases, mostly in transformer overload. Looking at the combined load and solar impact analysis, no upgrades were needed in 78% of feeders and only 2.3% of feeders would require potentially more expensive line upgrades. In summary, he noted that these results will change in the Final Run.

Forthcoming Analyses

Palmintier wrapped up by highlighting distribution modeling topics for upcoming meetings. At the next Advisory Group meeting in March 2020, NREL will expand the distribution analysis results to cover initial upgrade cost estimates for 2030 and analysis of large-scale local solar on 34.5 kV lines. At the June 2020 Advisory Group meeting, NREL will share distribution analysis and upgrade costs for 2030 and 2045 based on revised loads, including electric vehicles, busses, and fast charging; local storage; and full time-series analysis for impacts and curtailments.

Major Themes from Advisory Group Member Questions and Discussion

- Do strategies include upgrading from a 4.8 kV system to 34.5 kV system?
- Did NREL use socioeconomic data for specific neighborhoods? More affluent neighborhoods are able to pay for things like electric vehicles and air conditioning.
- Will NREL study upgrading distribution circuits to 10 kV?
- What is the average age of the 4.8 kV system components?
- What percent of feeders currently operate without problems?
- Problems with cross arms and other maintenance challenges should be considered in the modeling."
- Are smart inverter requirements being assumed?
- Is NREL considering line upgrades, reconducting voltage changes, or both?
- There are hidden increases in the use of air conditioning. Many who haven't used it now do – or will – due to rising temperatures related to climate change.
- Please explain the assumptions used for the distribution of load growth.
- The public will have questions about assumption, like the load growth in different parts of the city, and therefore the Advisory Group needs to understand the assumptions behind the maps.

Highlights and Learnings from Additional Pathways: Initial Run Results of All LA100 Scenarios

Cochran and Palmintier reviewed Initial Run results for five of the LA100 Scenarios, including investment pathways, operations, distribution analysis, and environmental analysis. Cochran noted that the Initial Run results included a single weather year, initial cost and performance assumptions, and initial constraints on in-basin resources. Results also only evaluated the impacts of short duration outages of generation and transmission on resource adequacy.

Cochran explained that of the five Initial Run scenarios she would focus on in this meeting, the SB 100 scenario and Transmission Renaissance had moderate load electrification projections and LA Leads and High Electrification Energy Future had high load projections. The final high load scenario was the High Stress scenario.

Key Learnings from LA100 Scenarios

See Appendix B for Highlights and Learnings from Additional Pathways, Initial Run Results of LA100 Scenarios slides.

Cochran reviewed six key insights from the Initial Run results for all Study scenarios. First, substantial renewable energy additions both within and outside the LA basin are required to achieve the 100% target, irrespective of pathway. The scenarios differed slightly on some aspects such as whether renewable energy certificates or biofuel generation were allowed. For instance, some scenarios adopted more biofuel while others added more concentrated solar power. In others, geothermal was added more. Cochran shared observations that substantial investment in new renewable resources will be required to meet the 100% renewable target, wind and photovoltaic were built across all scenarios, and scenarios that do not allow generation from natural gas and/or biofuel require either non-variable renewable generation or longer-duration storage.

Second, high use of variable generation is associated with high rates of economic curtailment. In scenarios that do not allow contributions from natural gas or biofuel, further building of solar photovoltaic capacity is required but during many times of the year results in excess energy if it cannot be sold or used in another way. There could be options for using curtailed energy in the future, such as using it to operate desalination plants or converting electricity to storage fuel.

Third, because renewable sources do not always produce energy when it is needed, storage plays a critical role in shifting variable generation on a daily basis. All scenarios relied on storage, but the model built different mixes of battery, pumped hydro, utility photovoltaic and battery, and compressed air energy storage for different scenarios. For scenarios that do not allow contributions from natural gas or biofuel, longer-duration storage becomes more valuable. Cochran noted that siting extensive storage within the basin could be difficult.

Fourth, in scenarios that did not allow RECs, capacity not reliant on variable resources is highly valuable. This is because RECs allow the use of associated natural gas generation offset by credits. This energy is used in peak times when variable sources of energy, like wind and solar-photovoltaic, may not generate enough to meet load, so other types of non-variable resources like biofuel, geothermal, and mid- to long-duration storage become desirable substitutes.

Fifth, although substantial transmission capacity is available to carry energy into the basin, longer duration transmission outages (both in- and out-of-basin) could be challenging in the absence of mitigating options.

Sixth, changes in the eligibility of compliance options can have substantial implications for total costs. Differences in technology eligibility and other scenario requirements lead to differences in bulk generation and transmission costs, leading to a 30% increase in bulk system costs from the Highly Distributed to LA Leads scenarios.

Cochran concluded by reiterating that the results in the Final Run may change substantially. This is because load will change substantially. Also, NREL is refining representation of the transmission system, analyzing both short- and long-run duration outages, and continuing to develop resource constraints and cost assumptions.

Distribution GRID Analysis for All Scenarios

Palmintier presented on the distribution grid analyses for the 4.8 kV system. Since load and estimated rooftop solar adoption will change substantially in the Final Run, only significant trends in the Initial Run results should be noted. Aggressive rooftop solar requires more widespread upgrades, but still for a minority of feeders. The most common upgrade was for the service transformers; however, more feeders need line upgrades with increased rooftop solar. Rooftop solar adoption seems to have a larger impact on distribution upgrade needs than increasing loads only.

Environmental Analysis

Next, Cochran discussed how the five scenarios compare in terms of lifecycle greenhouse gas emissions, and she presented the results for rooftop solar deployment in environmental justice communities. In the Initial Run, all five scenarios had reduced greenhouse gas emissions compared to the status quo with High Load Stress having the most reduction and LA Leads the least. High Load Stress and the SB100 scenario had the most emissions due to natural gas combustion.

Cochran concluded by giving an update on rooftop solar adoption projections for environmental justice. Thirty-nine percent of rooftop solar deployment is in Cal EnviroScreen-identified disadvantaged communities, with the share of technical potential being 42%.

Major Themes from Advisory Group Member Questions and Discussion

- How will a $41 billion expenditure on bulk systems impact rates?
- The Initial Run results show much less storage than expected.
- Why does the LA Leads scenario have more transmission and geothermal generation, and less wind generation, than other featured scenarios? Does the Transmission Renaissance scenario show the same trend?
- Offshore wind generation is more constant than other variable sources; should it be differentiated from other types of wind energy generation?
- What surprises did NREL see when comparing scenarios? What was unanticipated?
- The Initial Run results seem to point to storage of several types.
- In-basin storage needs to be protected from disruption by fire.
- There seems to be a lack of seasonal storage. Every 25 years there is a hydro shortage in the West.
- Why isn't NREL looking into hydrogen for seasonal storage?
- Seasonal storage could help in cases where there is a transmission outage. How does the RPM model address this?
- The LA Leads scenario does not allow any type of gas-fired generation - this exclusion is a political choice rather than a decision based on comparing costs.
- It is important to look at greenhouse gas reduction to understand all benefits from the investment.
- The costs are spread out over 24 years. Also, the money must be spent now or later to meet greenhouse gas reduction goals.
- What kinds of building data are used for commercial buildings, and how are buildings that are good candidates for electrification being identified?
- Is NREL taking into consideration City of Los Angeles planning targets and goals?
- Are the suggestions for line upgrades in addition to upgrades already planned by LADWP?
- The challenges of being a load balance authority need to be considered.
- When will the 34.5 kV analysis be finished?
- Line upgrades are required with higher solar penetration. Is prohibiting export of rooftop solar a mitigation strategy?
- Which greenhouse gases are considered in the Study: CO2, CF6, and/or methane?
- If ratepayers are asked to fund installation of fast charging stations to electrify vehicles and reduce greenhouse gases, they should get credits for reduction in another economic sector.
- Is rooftop solar a benefit to environmental justice communities or a burden?
- Improving air quality is an environmental justice issue. It is a humanitarian crisis. The most appropriate place to expand rooftop solar is South LA.
- Rooftop solar can help to reduce power bills.
- Communities in lower economic brackets often miss economic opportunities like installation of rooftop solar; access to opportunities is what is meant by environmental justice.

Final Run Updates

See Appendix B for LA100 Final Run Updates slides.

Cochran gave an update on the Reference Case and the status of the Final Run. NREL has added a Reference case in response to an LADWP Board request. The Reference Case is based upon the latest Board-approved set of projections from the 2017 Integrated Resource Plan and includes repowering the coastal once-though cooling units. Using a consistent set of assumptions and bulk power modeling tools will make comparing costs and reliability through 2036 possible. This Reference Case does not include the same end year as the other LA100 Study scenarios and therefore it is not included among pathways to reach 100% renewable energy. It will use "moderate" load projections to be consistent with the moderate set of scenarios.

Cochran clarified that the Reference Case does not serve as the basis for the Study scenarios. The LA100 scenarios remain the same as before, and none of the scenarios include repowering once-through-cooling units. Costs for LA100 scenarios and the Reference Case can only be compared through 2036, even though LA100 scenarios continue through 2045. Costs for the Reference Case will not be compared to 2045 scenarios.

Cochran concluded by giving an update on the Final Run progress and previewing the agenda for the next Advisory Group meeting in March 2020 during which NREL will present results for 2030 Buildout which represents an in-depth look at investments (bulk power and distribution grid) that can replace the once-through-cooling units. NREL will also review the Final Run results for electricity demand projections, local solar and storage, and options for demand response.

Major Themes from Advisory Group Member Questions and Discussion

- Cost curves for greenhouse gases for each scenario would be helpful.
- There is a lot of interest in the upcoming public health analysis, mortality, and morbidity results.
- The number one cause of children not attending school is asthma. Absences cost schools funding.
- Advisory Group members will be taking the results to the community and explaining what they mean, and the team needs to equip the Advisory Group members.
- The public will have important input on greenhouse gas implications, electrifying transportation, and ongoing cost for hydropower. Communicating these issues before the Study is complete in September 2020 seems important, so that the public's input can be considered.
- When will results be presented to stakeholder communities?
- There is a page on the LADWP website devoted to the Study, and the City and LADWP have been transparent about doing the Study. The public can submit comments to LADWP at any time.

Wrap-up and Next Steps

A follow-up webinar scheduled for December 17, 2019 for Advisory Group Members will serve as a forum for additional questions and discussion. The next Advisory Group meeting date is in March 2020.

The Los Angeles 100% Renewable Energy Study

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Advisory Group Meeting #10

Thursday, December 5, 2019, 8:45 a.m. to 3:45 p.m.

Appendix A

Agenda

The Los Angeles 100% Renewable Energy Study

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

Thursday, December 5, 2019

8:45 am – 3:45 pm

Los Angeles Department of Water and Power, Room 1514

Meeting Purpose: The purpose of the Advisory Group is to guide the Los Angeles 100% Renewable Energy Study (LA100) and provide input and review throughout the study. At this point of the study, the National Renewable Energy Laboratory (NREL) has completed its initial modeling runs and has transitioned to the final set of runs. The Advisory Group's feedback and questions received during this meeting will help to fine-tune NREL's assumptions and investigations for these final runs.

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

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

9:05 – 9:25 am **Advisory Group Roundtable Introductions**
LADWP: Greg Huynh, Manager of 100% Clean Energy Innovation
NREL: Jaquelin Cochran, Ph.D., Manager, Grid Systems Group

9:25 – 10:15 am **Initial Run Results: Input Models**

- Electricity Demand (Load) Projections
- Renewable Energy Resource Assessment
- Customer-Adopted Solar (Rooftop Photovoltaics)
- Discussion/Q&A

NREL: Paul Denholm, Ph.D., Principal Engineer

10:15 – 10:30 am **Break**

10:30 – 12:00 pm **LA100 SB100 Scenario, Initial Run Results, Bulk Power Models**

- Pathway to 2045: Retirements and New Investments, Including Costs
- Load Balancing and Resource Adequacy
- Power Flow and System Stability
- Discussion/Q&A

NREL: Dan Steinberg, Manager, Economics and Forecasting Group

12:00 – 12:30 pm **Lunch Served**

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

12:30 – 1:30 pm	**LA100 SB100 Scenario, Initial Run Results, Distribution Models** • Hosting Capacity and Impacts of Distribution-Connected Solar • Forthcoming Analyses • Discussion/Q&A NREL: Bryan Palmintier, Ph.D., Manager Grid-connected Energy systems Modeling Group
1:30 – 1:45 pm	**Break**
1:45 – 3:00 pm	**Highlights and Learnings from Additional Pathways, Initial Run Results of All LA100 Scenarios** • Key Learnings from LA100 Scenarios • Discussion/Q&A NREL: Dan Steinberg
3:00 – 3:30 pm	**Final Run Updates** • Reference Case • Status of Final Run • Expectations for 2020 Advisory Group Meetings NREL: Jaquelin Cochran
3:30 – 3:45 pm	**Wrap-up and Next Steps** • All feedback welcome; please send to: Ashkan.Nassiri@ladwp.com • Next meeting date: March 5, 2020 K&W: Joan Isaacson

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #10

Thursday, December 5, 2019, 8:45 a.m. to 3:45 p.m.

Appendix B

Presentation Slides

LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #10

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Agenda

- Call to Order
- Introductions
- All LA100 Scenarios, Input Models **
- SB100 Scenario, Bulk Power Models **
- Lunch
- SB100 Scenario, Distribution Models **
- All LA100 Scenarios, Output Models **
- LA100 Final Run Updates **
- Wrap-up and Next Steps

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

Tips for Productive Discussions

- Let one person speak at a time
- Help to make sure everyone gets equal time to give input
- Keep input concise so others have time to participate
- Actively listen to others, seek to understand perspectives
- Offer ideas to address questions and concerns raised by others
- Hold questions until after presentations

The Los Angeles 100% Renewable Energy Study

Initial Run Results: Overview of Today

Jaquelin Cochran, Ph.D.

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Today's Plan: Use "Initial Run" to Walk through These Questions

Input models

What is electricity demand and customer-driven supply?

- Electricity demand
- Demand response
- RE resource analysis
- Customer-driven solar

→

Main scenario model

What should LADWP build?

- Generation
- Transmission
- Distribution upgrades

→

Output and validation models

How do we know it's right?

- Load balancing
- Resource adequacy
- Power flow and stability analysis
- Integrated distribution and transmission analysis

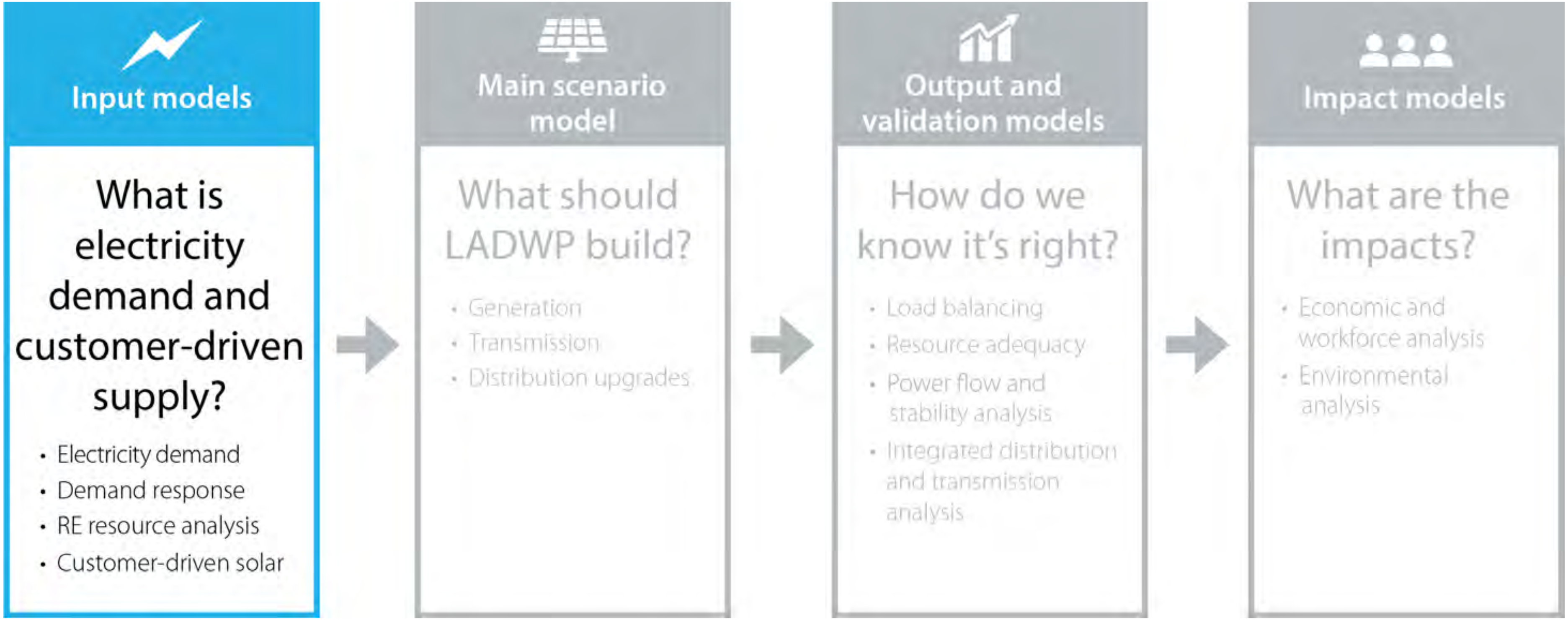
→

Impact models

What are the impacts?

- Economic and workforce analysis
- Environmental analysis

Input Models (Paul Denholm)



Bulk Power & Distribution Models (Dan Steinberg, Bryan Palmintier)

Input models

What is electricity demand and customer-driven supply?

- Electricity demand
- Demand response
- RE resource analysis
- Customer-driven solar

→

Main scenario model

What should LADWP build?

- Generation
- Transmission
- Distribution upgrades

→

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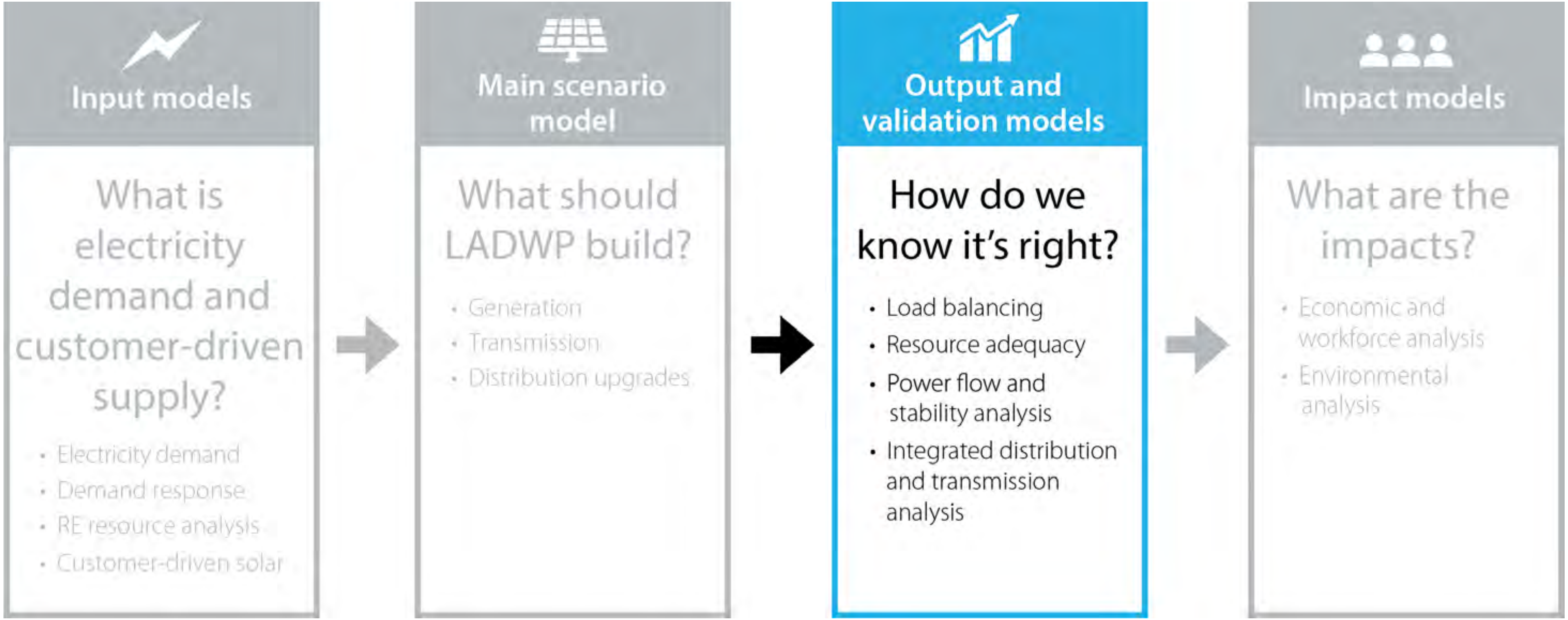
→

Impact models

What are the impacts?

- Economic and workforce analysis
- Environmental analysis

Output and Validation Models (Dan Steinberg)



Impact Models (Jaquelin Cochran)

Input models

What is electricity demand and customer-driven supply?

- Electricity demand
- Demand response
- RE resource analysis
- Customer-driven solar

→

Main scenario model

What should LADWP build?

- Generation
- Transmission
- Distribution upgrades

→

Output and validation models

How do we know it's right?

- Load balancing
- Resource adequacy
- Power flow and stability analysis
- Integrated distribution and transmission analysis

→

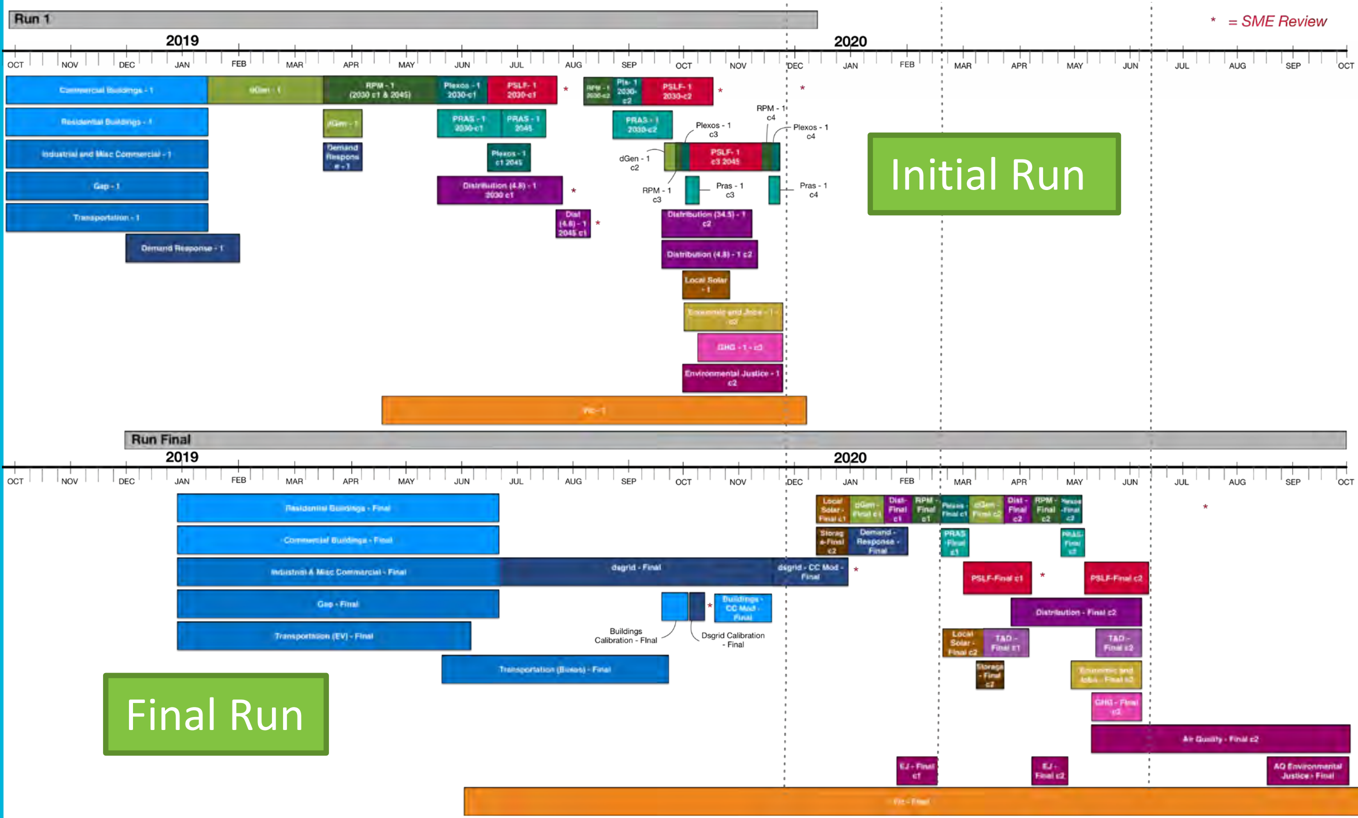
Impact models

What are the impacts?

- Economic and workforce analysis
- Environmental analysis

Today—
Present
Initial Run
Results

2020 AG Meetings—
Review
Final Run



LA100 Scenarios (updated September 2019)

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

Note, the study also includes a reference case (2017 IRP with minor updates). This case extends through 2036.

Today's Focus: One of Each Scenario Type (Final Run Includes Both Moderate and High Load Levels For Each Type)

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

Note, the study also includes a reference case (2017 IRP with minor updates). This case extends through 2036.

First: In-depth Focus on SB100 to Understand One Set of Results

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

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Second: Review All Models to Assess Trends

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load
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Technologies Eligible in the Compliance Year	Biomass	Y	No	Y	Y	Y	No	Y	Y	Y
	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
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	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
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WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Note, the study also includes a reference case (2017 IRP with minor updates). This case extends through 2036.

Important Considerations for Interpreting Initial Run Results

Today's results **will change** for Final Run

- Electricity demand projections due to:
  - Higher electrification estimates (e.g., EVs, buses)
  - Higher electricity projections due to hotter temperatures
  - Demand response that can better manage extreme periods of stress
- Further analysis of reliability, particularly in the context of extreme conditions (long-duration transmission outages) and over multiple weather years
- Further consideration of non-variable renewable energy generation options for in-basin capacity
- Further consideration of the cost and constructability of both local solar and transmission assets

Why Are We Presenting Results That Will Change?

- We still can **learn general trends**, e.g., what types of investment may be required when in-basin thermal generation is not available, for example in the LA Leads scenario
- Reviewing current results enables the Advisory Group to **better understand** the LA100 modeling and provide feedback

How Will Today's Results Fit Into Overall Study Process?

- The Advisory Group uses the Initial Run results to:
  - **Ask questions** about what you are seeing
  - Better **understand general trends** and the broad technical challenges associated with achieving the 100% goal
  - **Provide feedback** on modeling approach, data, and assumptions (but less important is feedback on specific results, like costs, which will change)
- LA100 Study Team will incorporate learnings from today (e.g., what is unclear, which assumptions need updating) to incorporate into the Final Run

Reviews of Each Model Include A Slide That Looks Like This

Initial Run (Today) vs. **Final Run** (to be presented at the March or June AG Meeting, depending on the model)

What's Included in Initial Run

What's Not Included Today but Will Be in Final Run

These slides are included with each set of modeling results to help communicate how the results will continue to change

Follow-up Q&A from this Advisory Group Meeting

- Need time to digest and ask questions for the day?
- Like last two AGs, we will hold a webex-based Q&A after two weeks

- Mark your calendars for:

  Tuesday, December 17, 2019

  10:00 AM – 11:00 AM

LA100

The Los Angeles 100% Renewable Energy Study

Initial Run Results: Input Models

All LA100 Scenarios

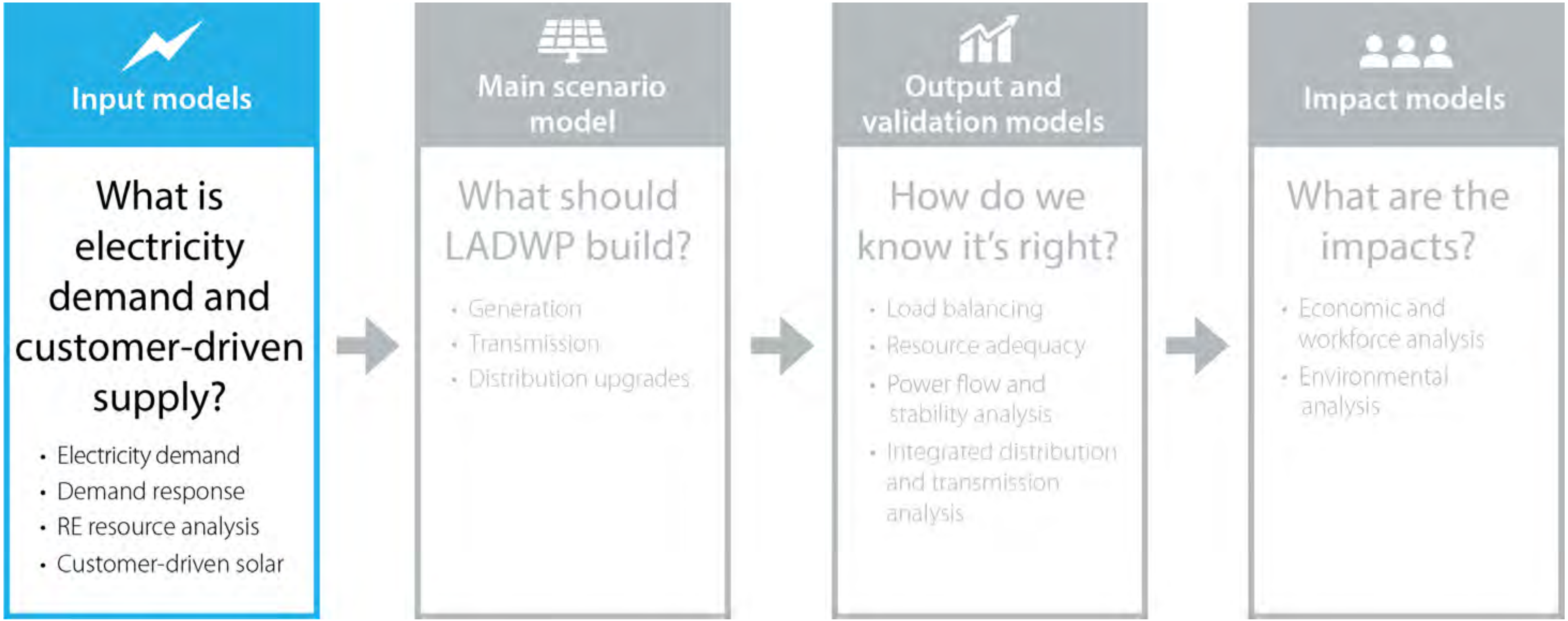
Paul Denholm

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Input Models



Agenda

1. Electricity Demand Projections
2. Renewable Energy Resource Assessment
3. Customer-Driven Solar (Rooftop Photovoltaics)
4. Discussion/Q&A

Electricity Demand Projections

Purpose within LA100

What will the demand for electricity be between now and 2045?

- Includes electricity demand from:
  - Residential and commercial buildings
  - Industrial and other loads
  - Electric vehicles
- Preliminary demand response also included, although these assumptions will change significantly for Final Run

Initial Run (Today) vs. Final Run (March AG Presentation)

What's Included in Initial Run

Projections completed in January 2019

"High" projections that are lower than what we have in Final Run

What's Not Included Today but Will Be in Final Run

"High" efficiency and electrification projections that align with LA's Green New Deal

Electric buses

Climate-adjusted buildings demand

Improved calibration of buildings models

More aggressive demand response

Electricity Demand Projections

LA100 uses three projections of demand to indicate three different futures to assess how this affects pathways to meet 100% renewable energy:

1. **Moderate**: Modest increase in demand above 2017 IRP
2. **High**:
   - Initial Run (today): Higher than moderate
   - Final Run (March): Significant increase in demand due to high electrification of end uses, transportation
3. **High Stress**: High electrification combined with low ("reference") energy-efficiency improvements

Residential and Commercial Electricity Demand

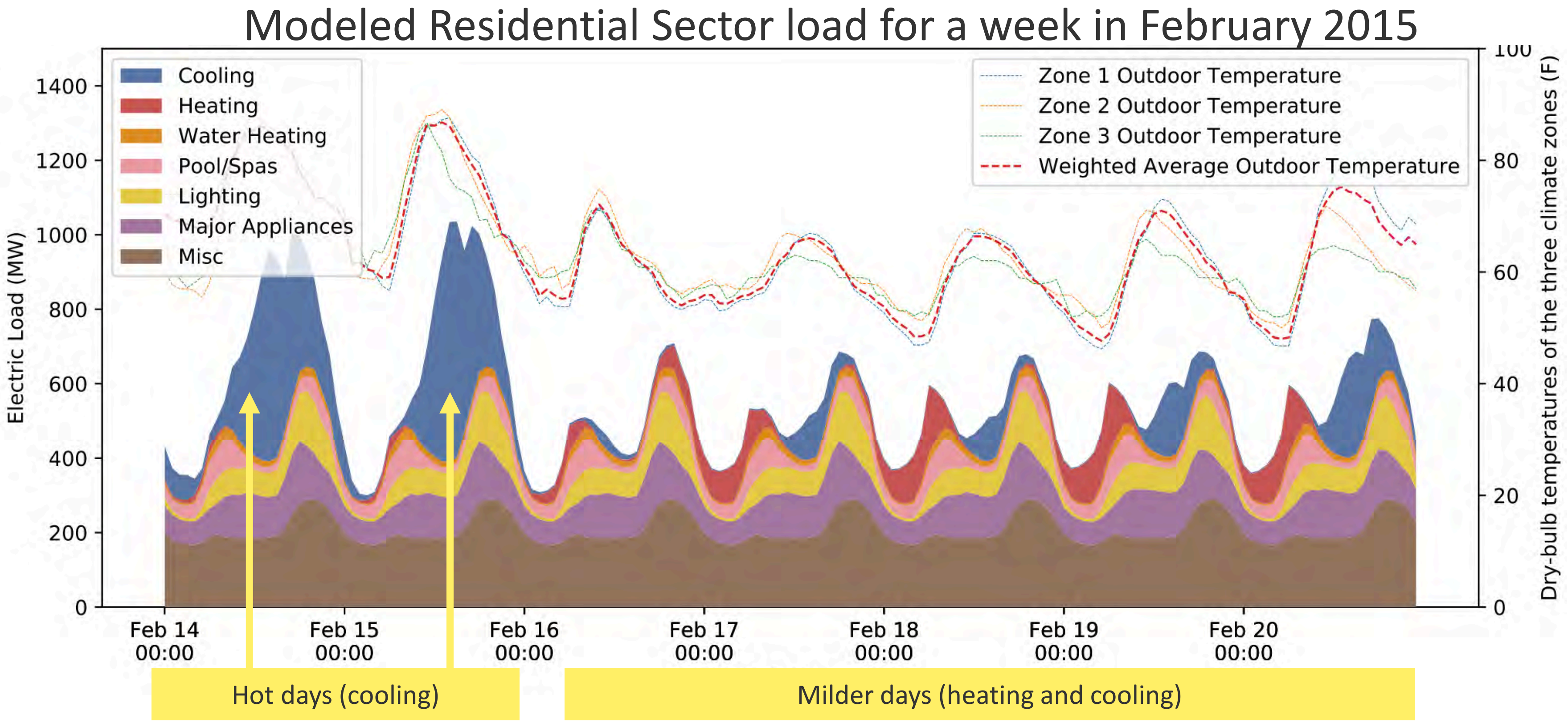
How will residential and commercial buildings impact LADWP's need for new resources?

- How will the building stock change?
- What types of end uses will be electrified?
- How energy efficient will buildings and appliances be?
- What will the demand for electricity (heating, cooling, appliances, etc.) be at each hour of the day each year?

ResStock ComStock

Highly granular modeling of local, regional, and national building stocks

Initial Run: Example Week of Residential Demand in Base Year



Buildings Demand: Coming in March AG Presentation

- Higher “high” electrification and efficiency projections that match LA’s Green New Deal
- Hotter expected temperatures reflected in residential and commercial electricity demand
- Results that reflect additional calibration to ResStock and ComStock

Industrial Demand and Other Loads

How will electricity demand change for major commercial and industrial customers?

- All industrial manufacturers
- Water system loads
- LAX
- Port of LA (including some electrification)
- Motion picture and video industry
- Unmetered outdoor lighting
- Owens Valley

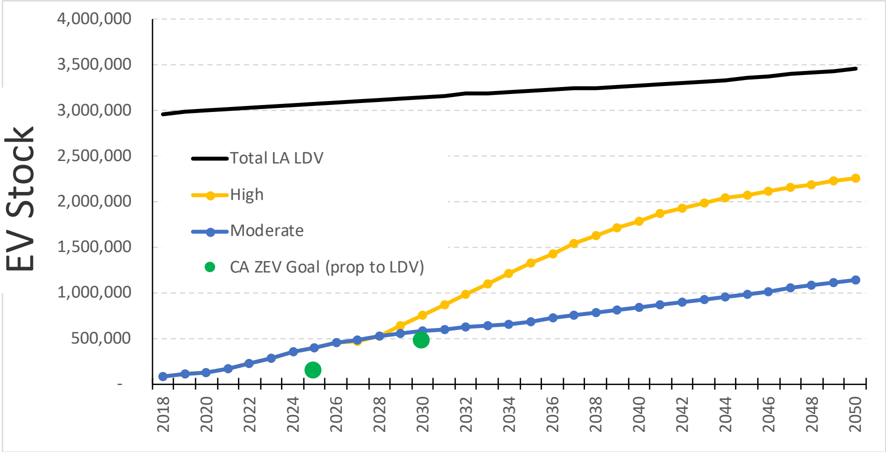
Electric Vehicle Charging Demand

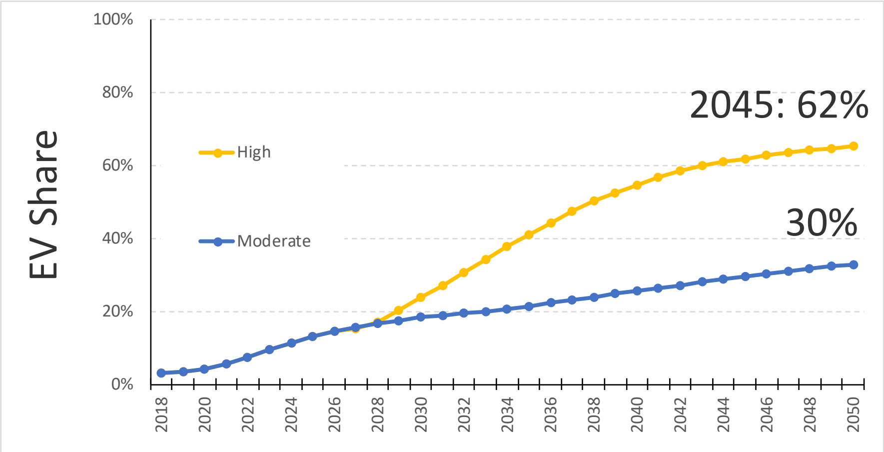
How will electric vehicles and buses impact LADWP's need for new resources?

- How many cars will be electrified? What types of cars will they be (with what range)?
- How many miles do the drivers need to reach between charges?
- What type and where will the chargers be?
- When and for how long will the cars charge?
  - If drivers charge as soon as they arrive at home/work
  - If drivers can delay charging as long as possible

EV Scenario Design

Share of Light-Duty Vehicles that are Electrified (Initial Run)





Initial Run: EV Charging Simulations

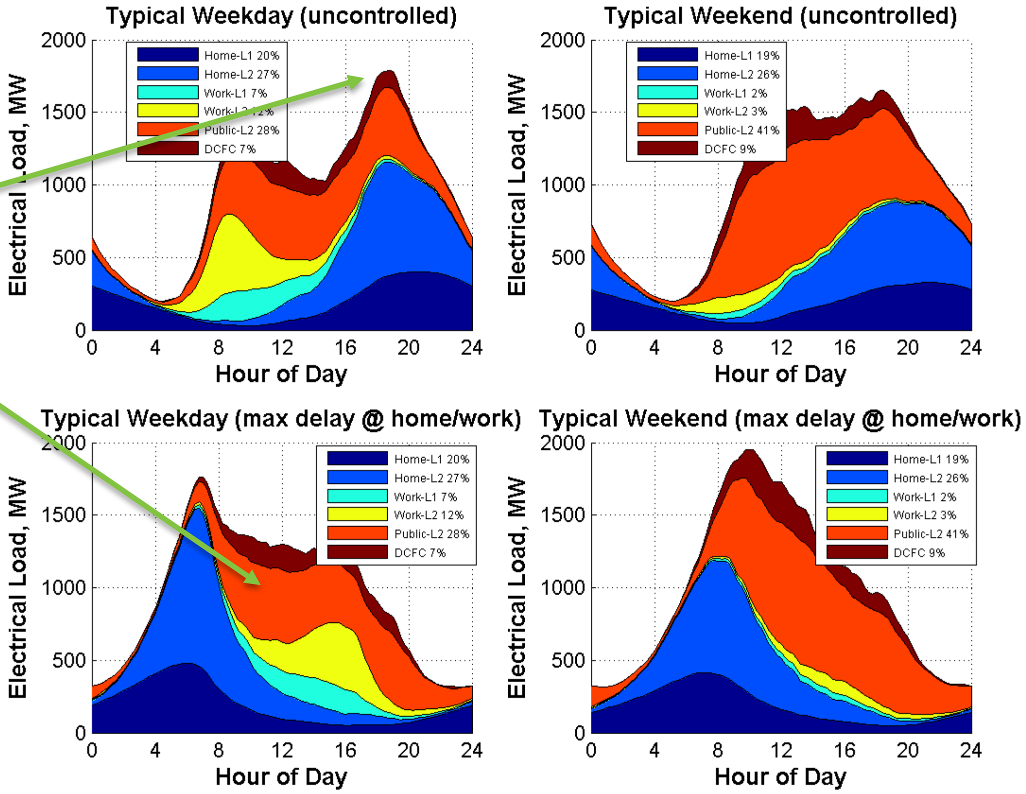
Example from Initial Run: **High** (~2 million EVs)

Arrive and plug in:
Significant charging demand during peak periods

Wait as long as possible to charge:

Demand response:
Choose charging times within this window

Flexibility helps avoid the need for new capacity and better match demand with RE supply

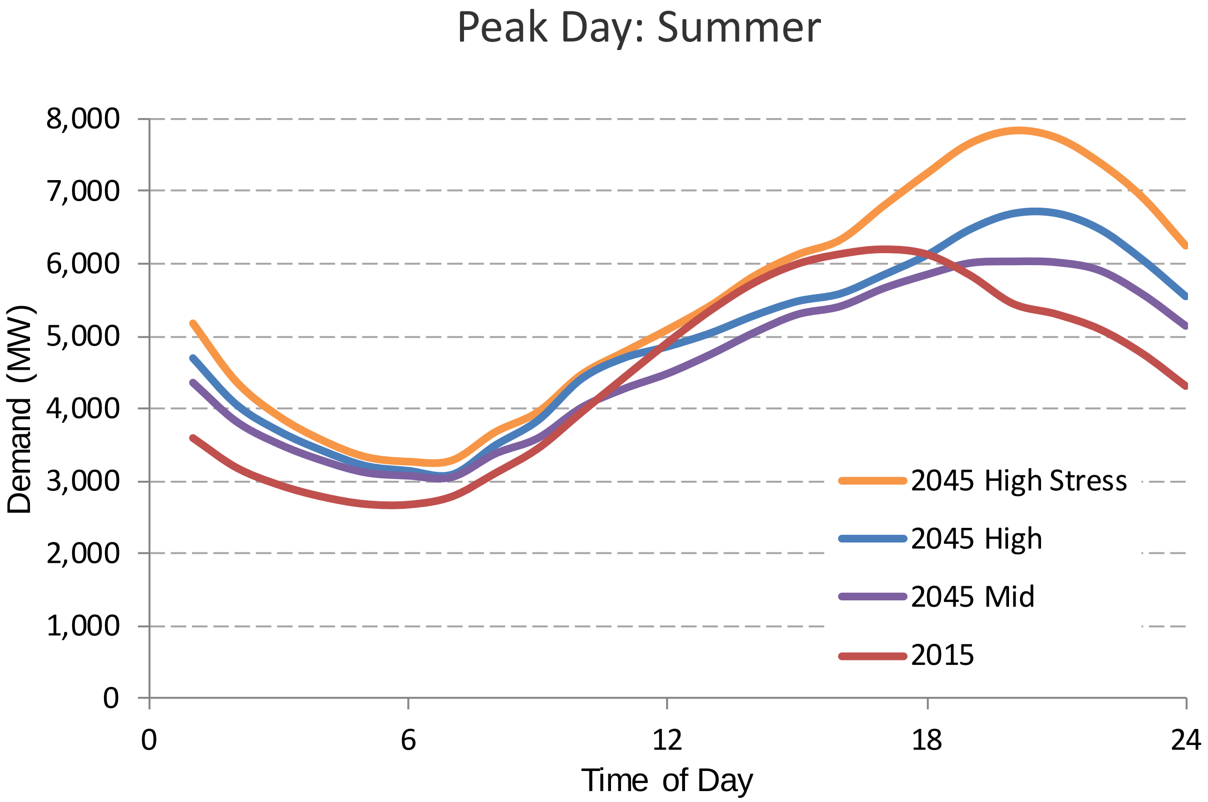


Transportation Demand: Coming in March AG Presentation

- Electric buses: 100% electrification of LADOT, LA Metro, school
- Higher “high” EV projections that are closer to LA’s Green New Deal
  - 80% stock in 2045, which would yield 100% stock by 2055

Demand Projections—All Sectors

Initial Run: Annual Electricity Demand Projections (All Sectors)



All years (including 2015) use 2012 weather data

Demand Response

Where can demand response help match demand to renewable supply and avoid the need for expensive peaking capacity?

- What is the potential for demand to be shifted or deferred?
- How well does this potential align with when renewables are available or not available?

Demand Response Programs

Interruptible Load

- Commercial, Institutional, and Industrial (CII, modeled on current program)
- Critical Peak Pricing (starting by 2030)

Energy-Shifting

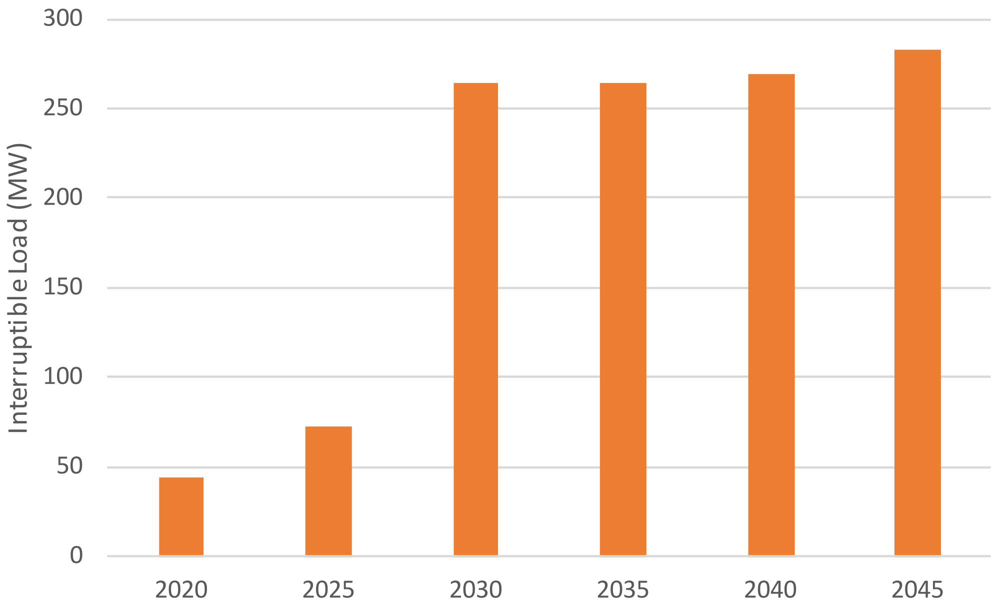
- Generalized Summer Shift Program (also CII)
- Residential Cooling (based on programmable communicating thermostats)
- Schedulable Electric Vehicle Charging
- Residential Hot Water and Heating
- Commercial Cooling and Heating

Modeled in all Scenarios (Moderate, High, High Load Stress)

Moderate, High

High

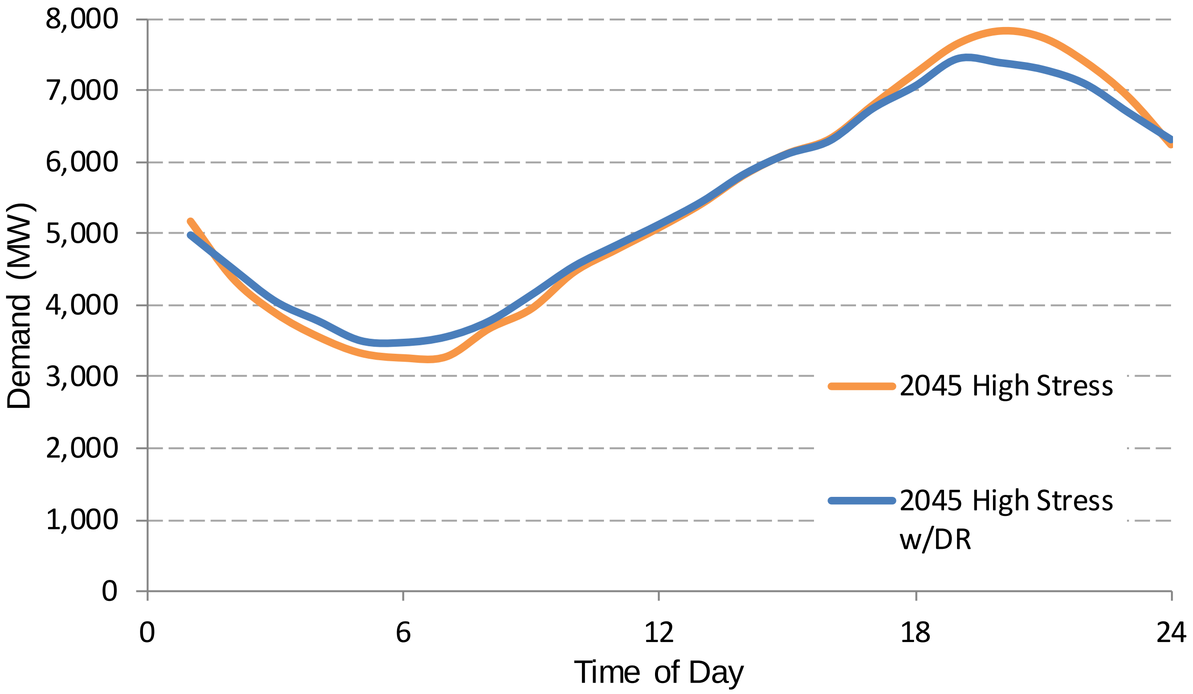
Initial Run Demand Response: Interruptible Load



Up to about 5% of load on a hot summer day

Assumed for All Initial Run Demand Response Projections

Initial Run Demand Response: Energy Shifting



Reduction in peak demand due to energy shifting—

Moderate: 200 MW
High: 600 MW
High Stress: 400 MW

Peak demand can be reduced by both interruptible load and shiftable load

Demand Response: Coming in March AG Presentation

- More detailed characterization of demand response resources
- Explore new sources for demand response

Questions Related to Loads?

Renewable Energy Resource Assessment

Purpose within LA100

Where are the most cost-effective renewable resources that can meet LADWP’s need for new resources?

- Where are the best renewable energy resources?
- If you build generation plants, what are the generation profiles over the course of a year? Over 10 years?
- Where are the best locations relative to existing transmission?

Initial Run (Today) vs. Final Run (March AG Presentation)

What's Included in Initial Run

Renewable resource assessments for all technologies across the West (one weather year)

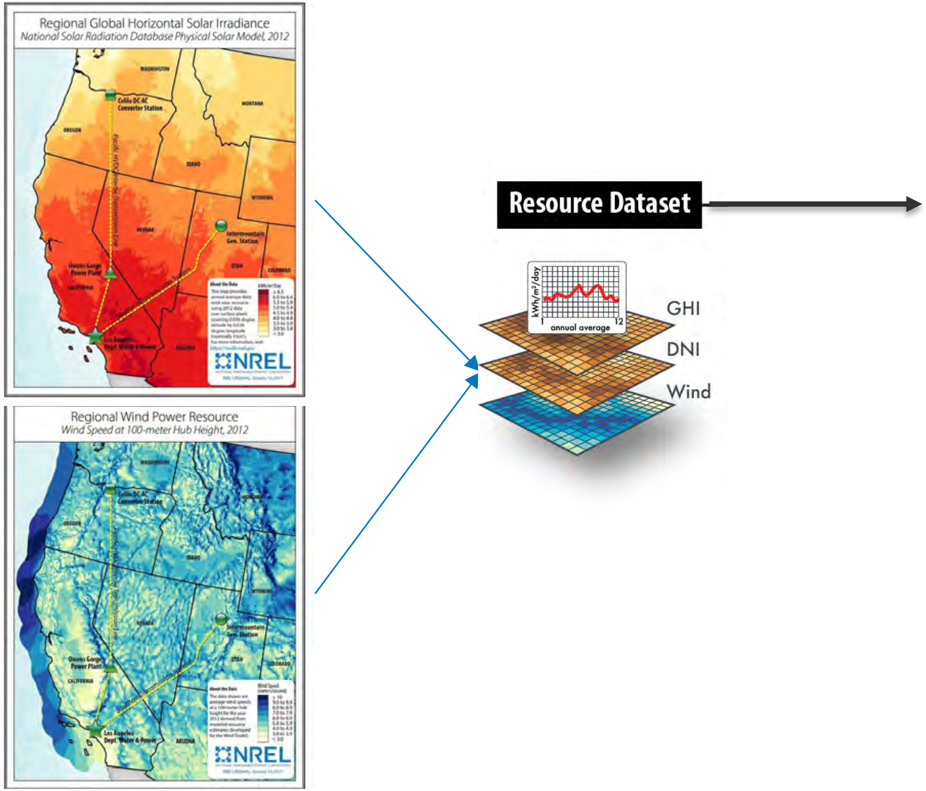
What's Not Included Today but Will Be in Final Run

10 years of renewable resource profiles for wind and solar

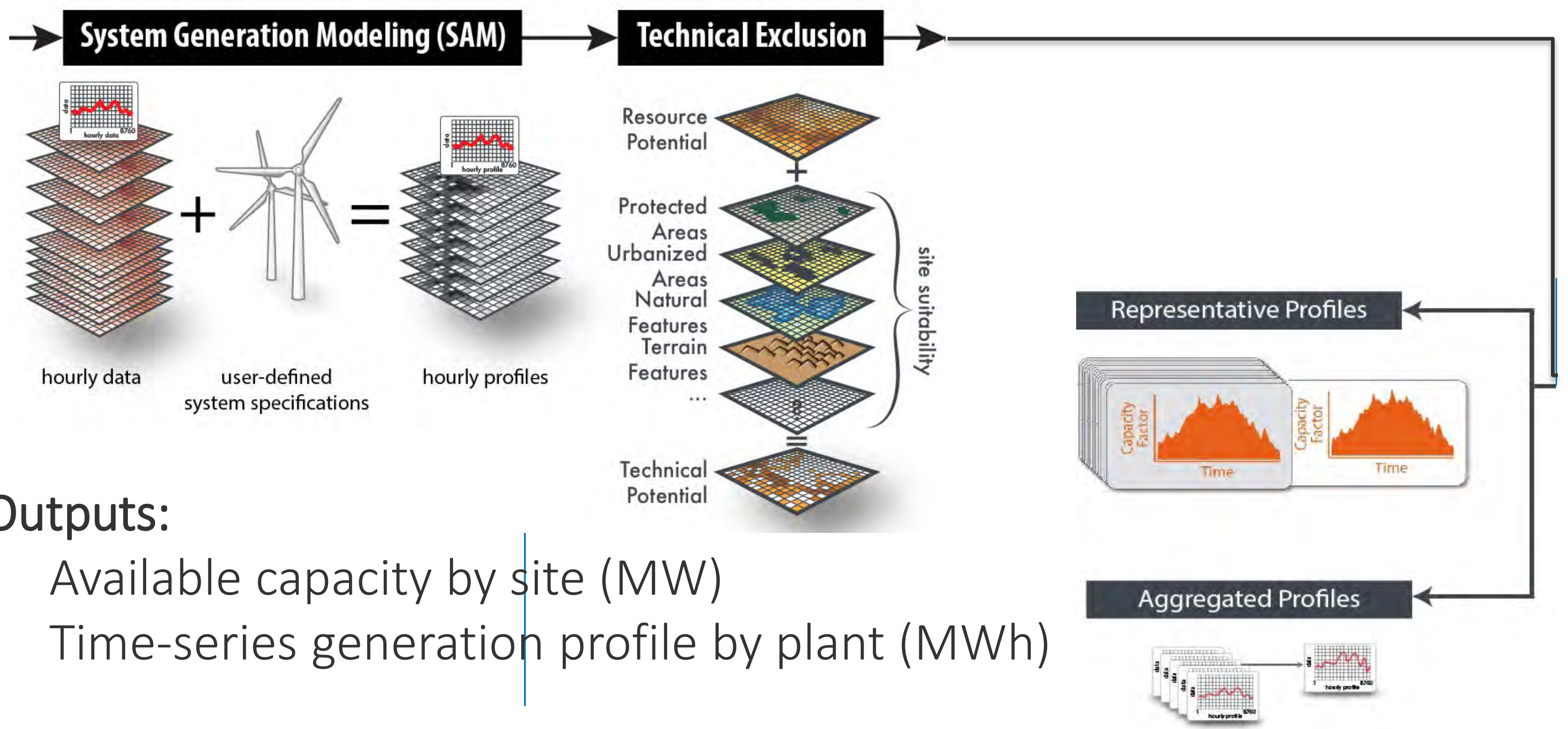
Process for Creating Renewable Generation Profiles

Inputs:

- Weather data
- Land characteristics
- Biomass, hydro, and geothermal resource availability
- Renewable plant operating characteristics



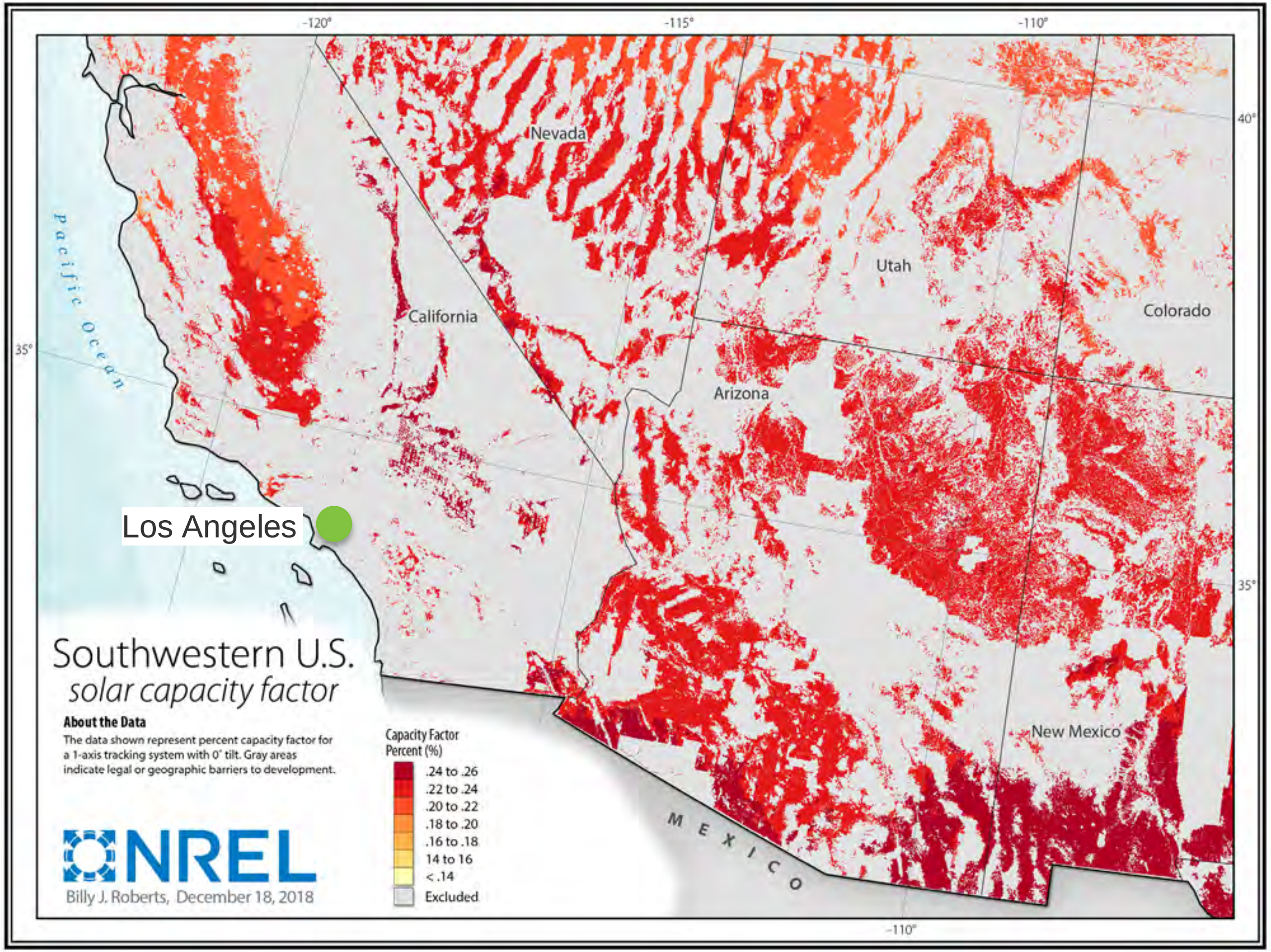
Process for Creating Renewable Generation Profiles



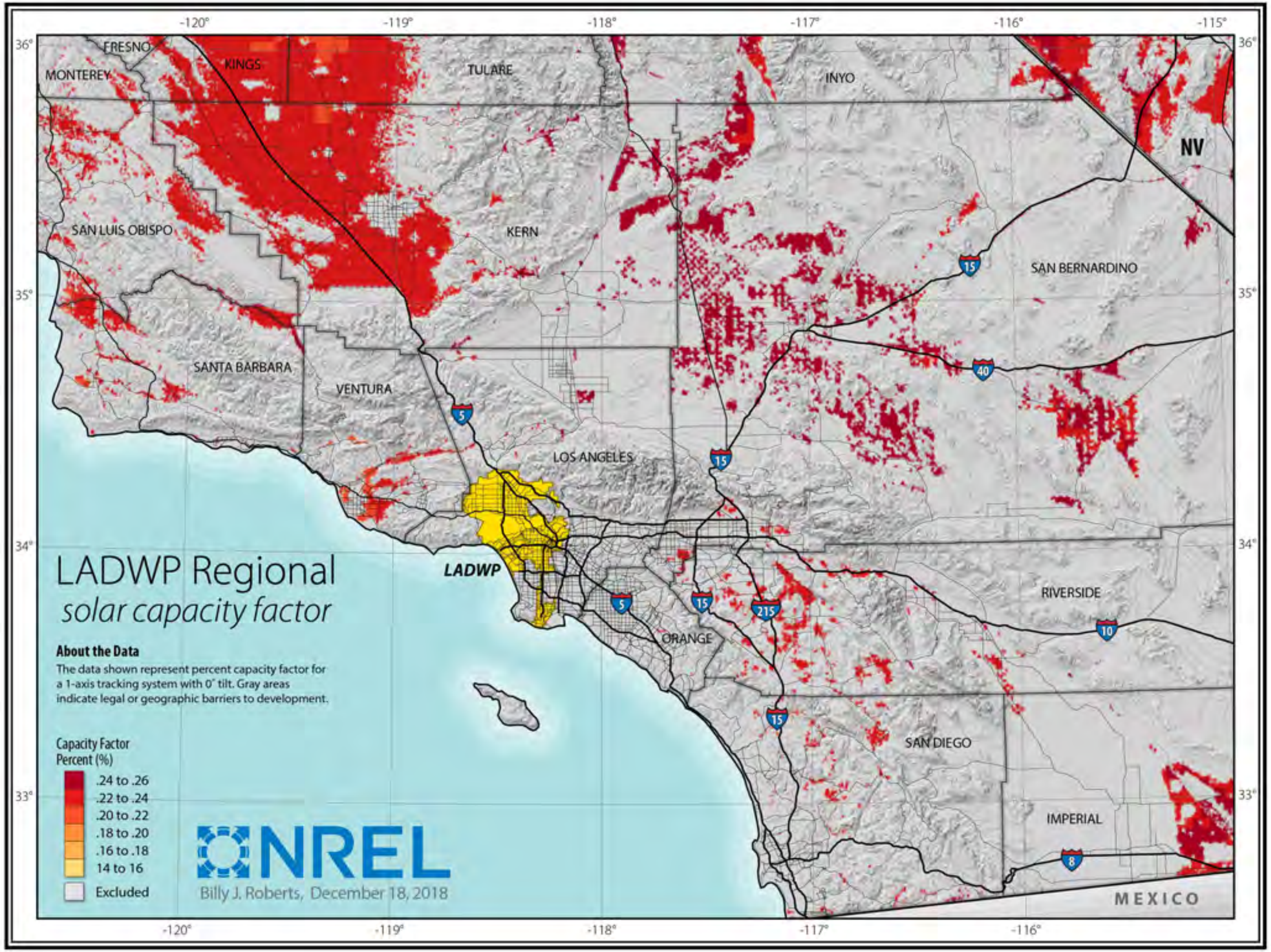
Outputs:

- Available capacity by site (MW)
- Time-series generation profile by plant (MWh)

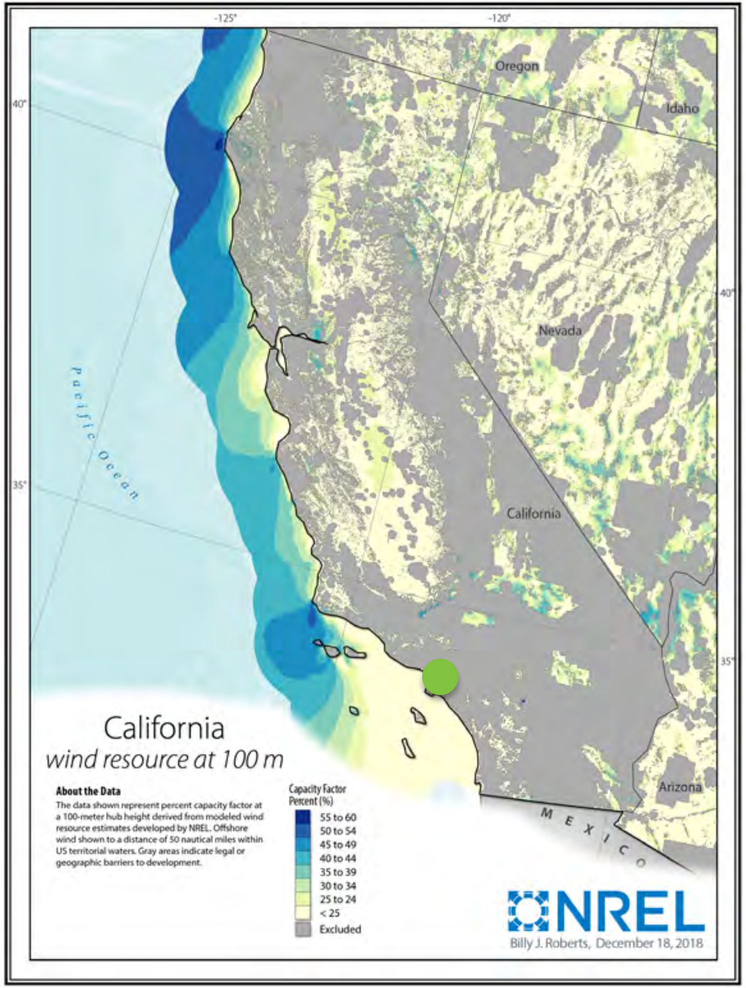
Utility-Scale PV Resource



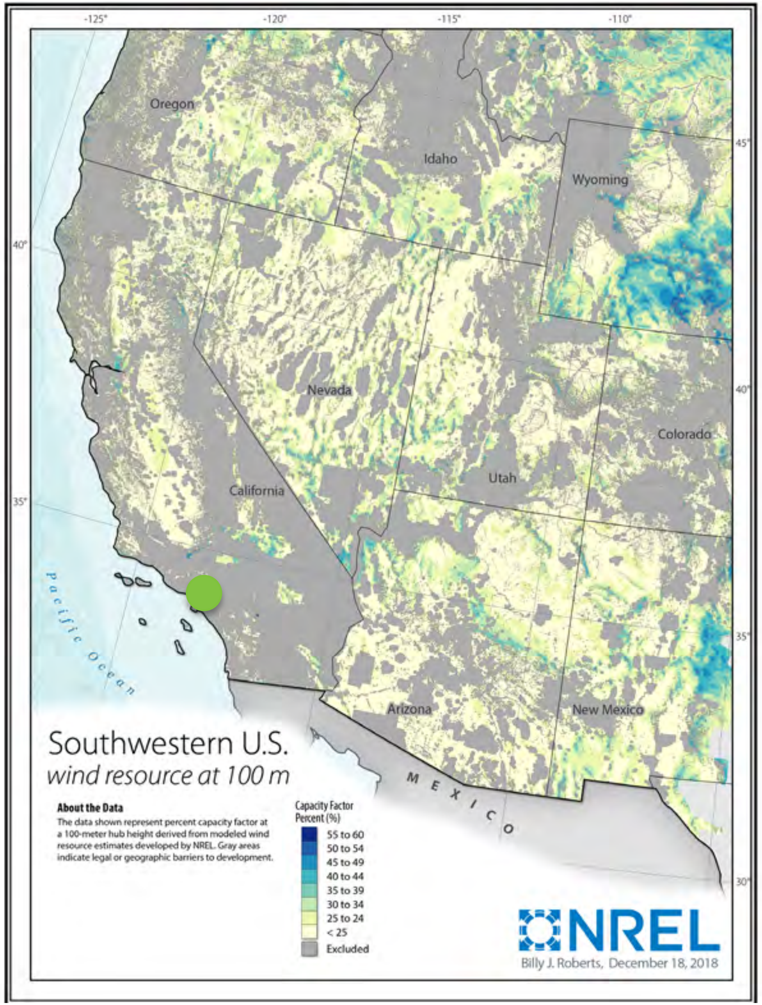
Utility-Scale PV Resource: Southern California



California Wind Resource: Including Offshore



Western U.S. Wind Resource



Resource Assessment: Coming in March AG Presentation

- Repeat exercise for 10 years of data to include in analyses of resource adequacy (i.e., how confident are we that we have enough renewable generation to meet load?)
- Generate multiple years of forecasts and sub-hourly data sets

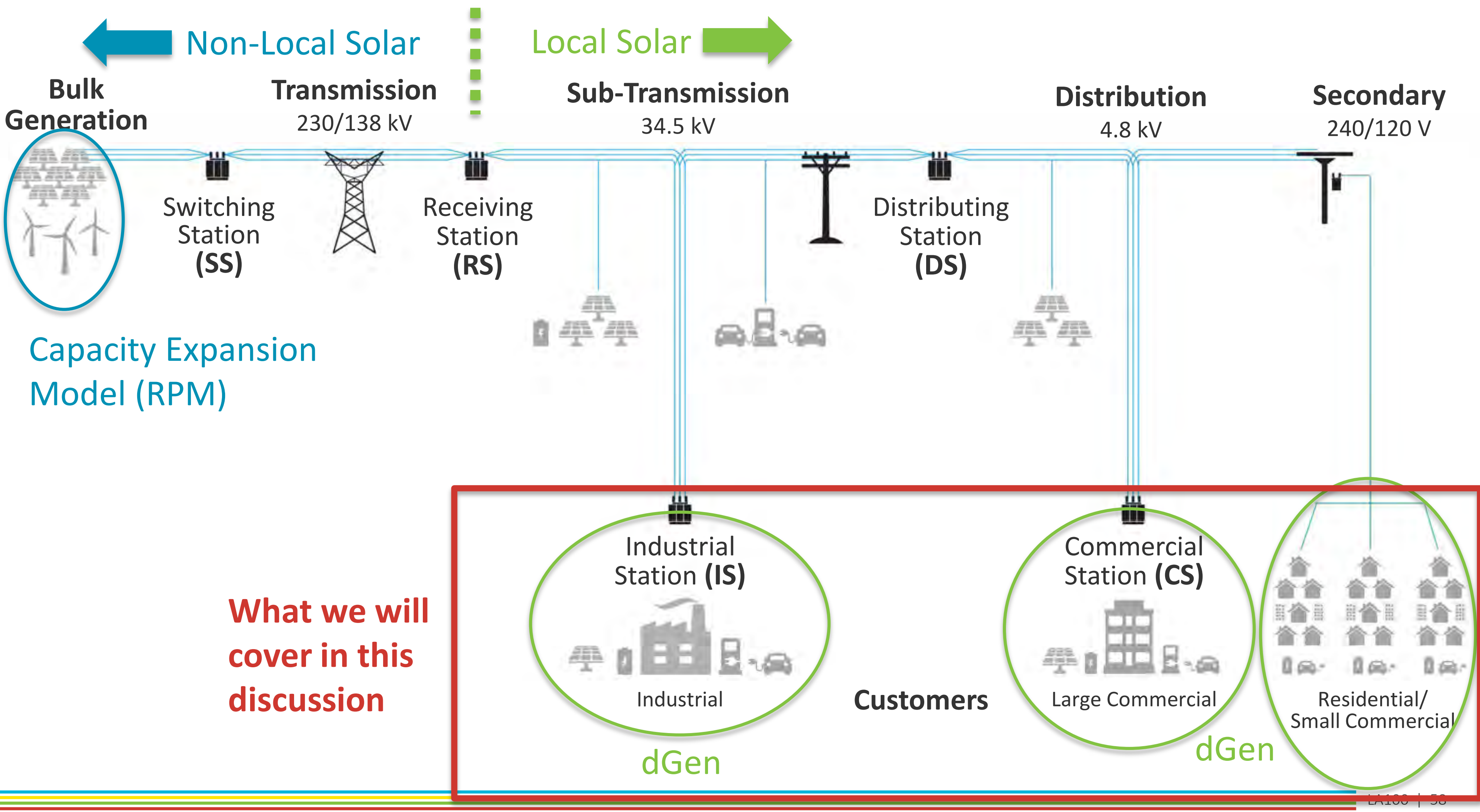
Questions Related to Renewable Resource Estimates?

Customer-Driven Solar (Rooftop Photovoltaics)

Purpose within LA100

What will be the customer-driven demand for rooftop solar?
How will this affect what LADWP needs to build (renewable energy; distribution upgrades)?

- Goal: Create two projections that represent realistic adoption rates:
  1. **Moderate** projections (based on lower compensation of net billing)
  2. **High** projections (based on higher compensation of net metering)
- Purpose is not to evaluate policy (net billing vs. net metering) but to create two different customer adoption trends


Non-Local Solar
Local Solar
Bulk Generation
Transmission
230/138 kV
Sub-Transmission
34.5 kV
Distribution
4.8 kV
Secondary
240/120 V
Switching Station (SS)
Receiving Station (RS)
Distributing Station (DS)
Capacity Expansion Model (RPM)
What we will cover in this discussion
Industrial Station (IS)
Industrial
dGen
Customers
Commercial Station (CS)
Large Commercial
dGen
Residential/ Small Commercial

Initial Run (Today) vs. Final Run (March AG Presentation)

What's Included in Initial Run

Customer projections for rooftop solar

What's Not Included Today But Will Be in Final Run

Local ground-mounted and carport solar

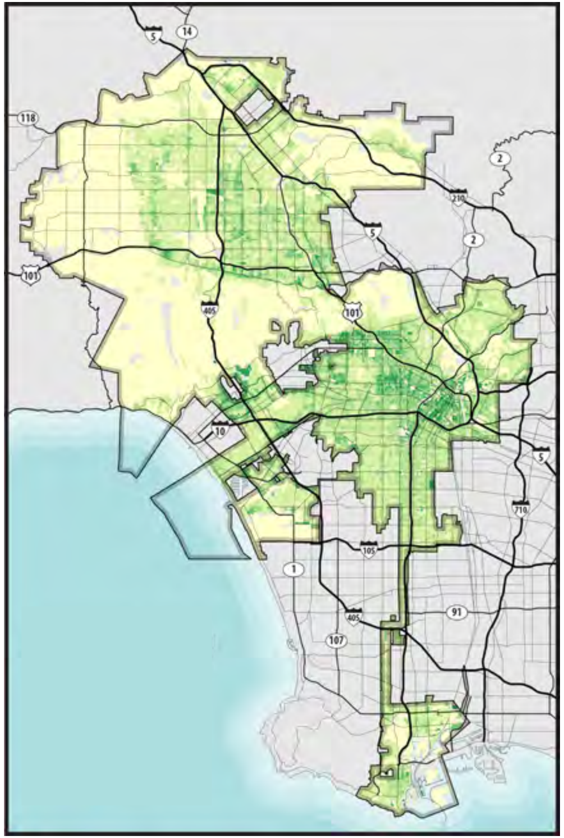
Local storage (customer and utility-scale)

Changes to rooftop solar estimates based on changes to demand

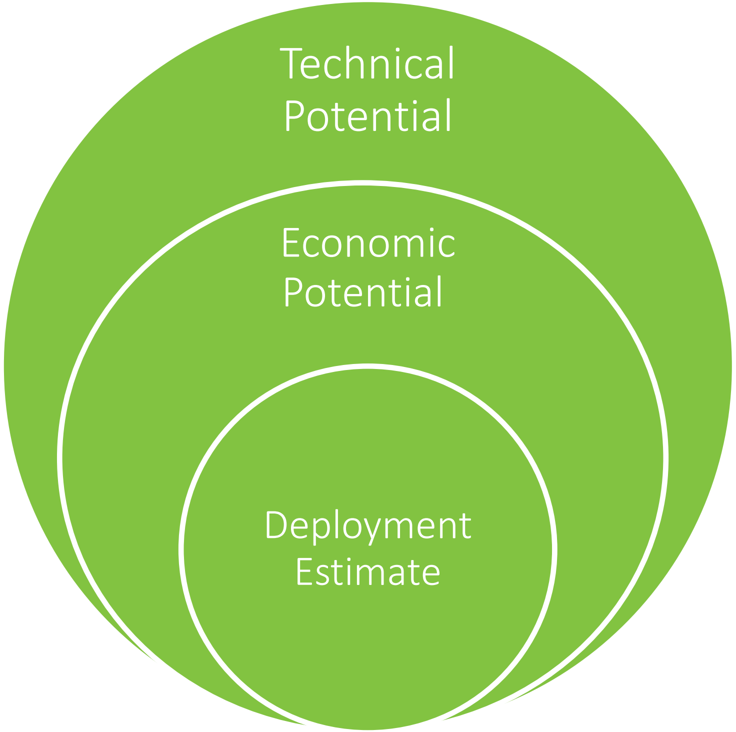
Further calibration to the dGen model

Initial Run – Quick Recap of Methods

How much rooftop solar will customers adopt?

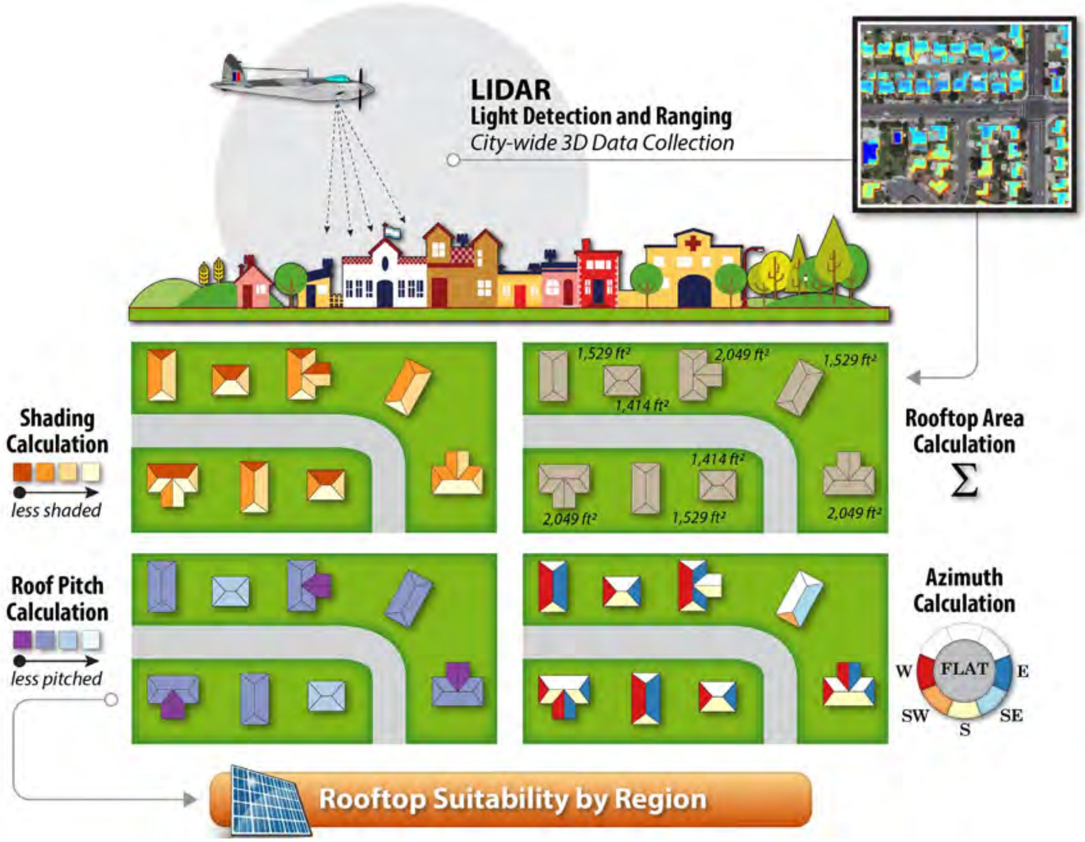


Rooftop Solar: Framework for Projecting Adoption



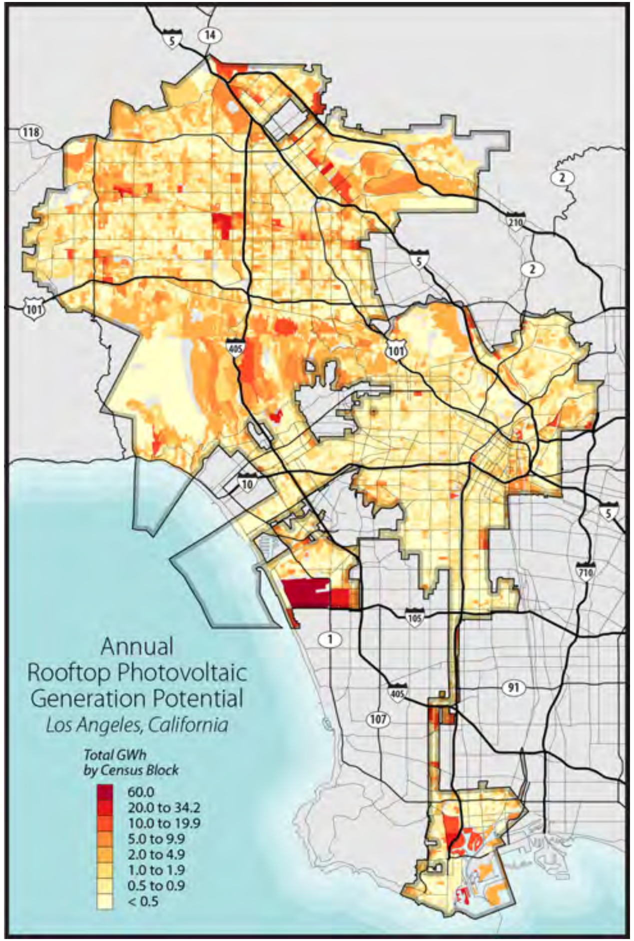
- **Technical potential:** Maximum feasible amount of capacity
- **Economic potential:** For which customers is rooftop solar cost effective?
- **Deployment**: Of the above, who might adopt?

Assess Rooftop Suitability for Solar



Rooftop Solar Generation

Technical Potential



Energy potential –
Annual generation per census block

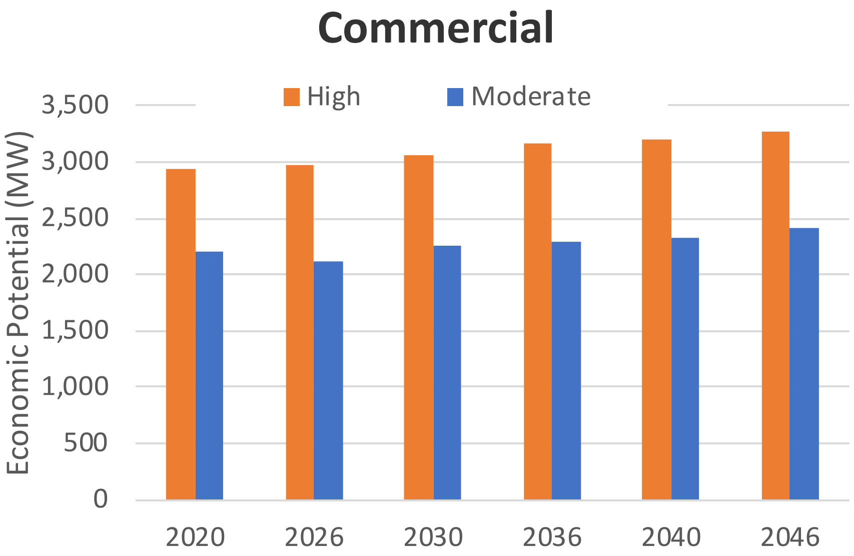
Rooftop Technical Potential Results

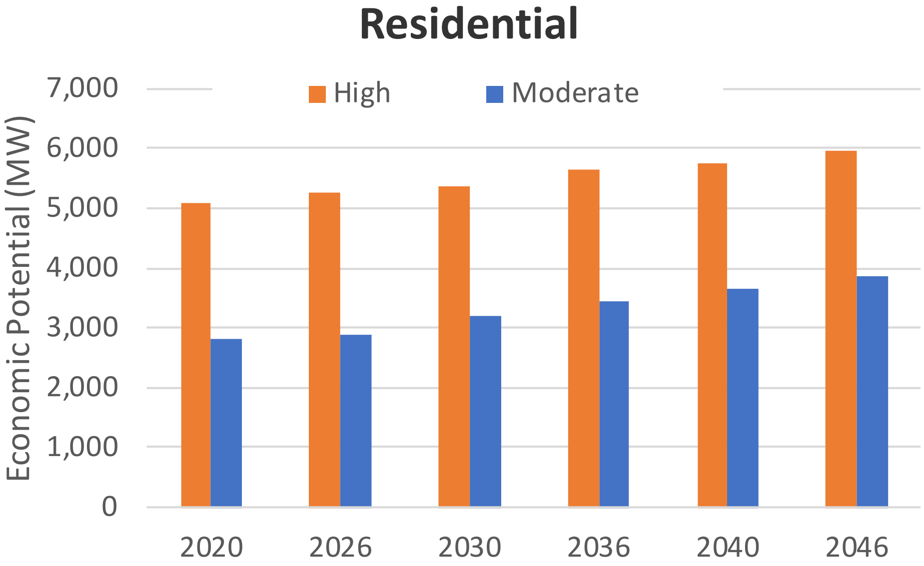
- Approximately **10.5 GW_{DC} of technical potential for rooftops** in LADWP
- Most is in the **residential sector**, followed by manufacturing and commercial
- Nearly half is in census tracts designated as **disadvantaged communities**

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

Summary of technical potential study results (from September AG meeting)

Initial Run: Economic Potential Results

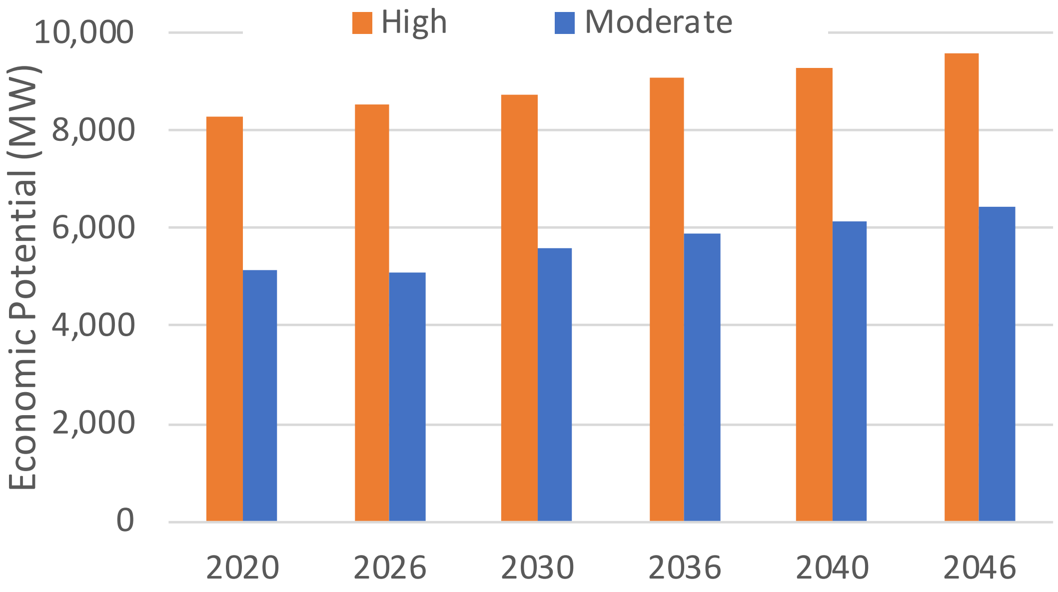




Based on discounted cash flow analysis that includes:

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

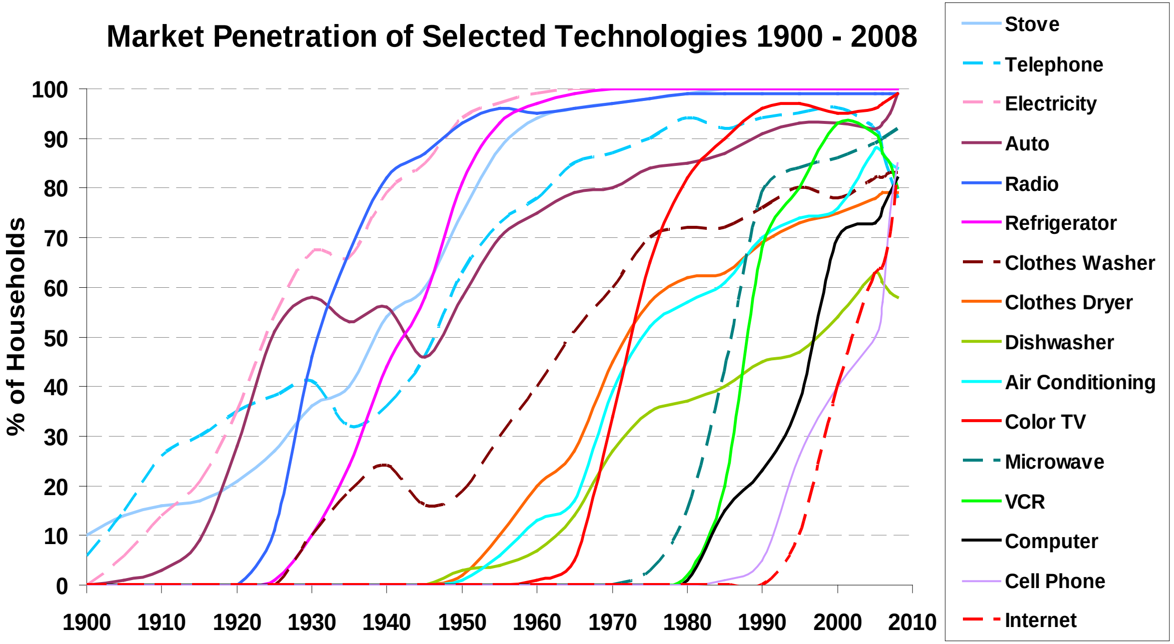
Initial Run: Total Economic Potential



Economic potential **grows slightly** due to:

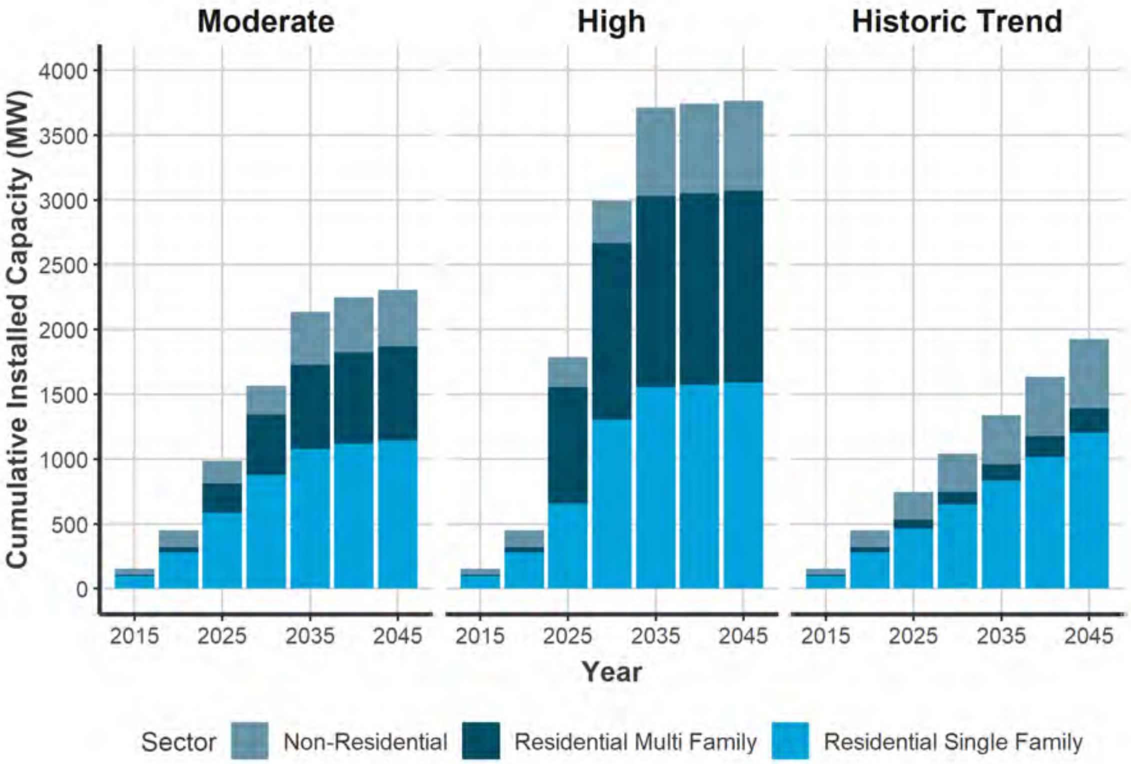
- Decline in PV **installation costs**
- Offset by **declining value** due to increased deployment

Where Are We on the Adoption Curve?



- **Technology adoption shows characteristic S-curve driven by innovators & imitators**
- **Different technologies show unique adoption: 60% for dishwashers, 100% for refrigerators; different thresholds for when adoption ‘takes off’**
- **No technology is a perfect analog**

Initial Run: Rooftop Solar Deployment Estimates



Note:
Further work needed to address whether and how these targets could be achievable in practice (e.g., constructability)

Calibration of this part of the model still underway

Conversations about solar adoption on multi-family buildings are ongoing

Local Solar + Storage: Coming in March AG Presentation

- Technical potential for local solar (ground-mount and car ports) and storage
- Deployment estimate for customer-adopted storage
- Continued refinement of assumptions

Questions?

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

SB100 Scenario, Initial Run Results

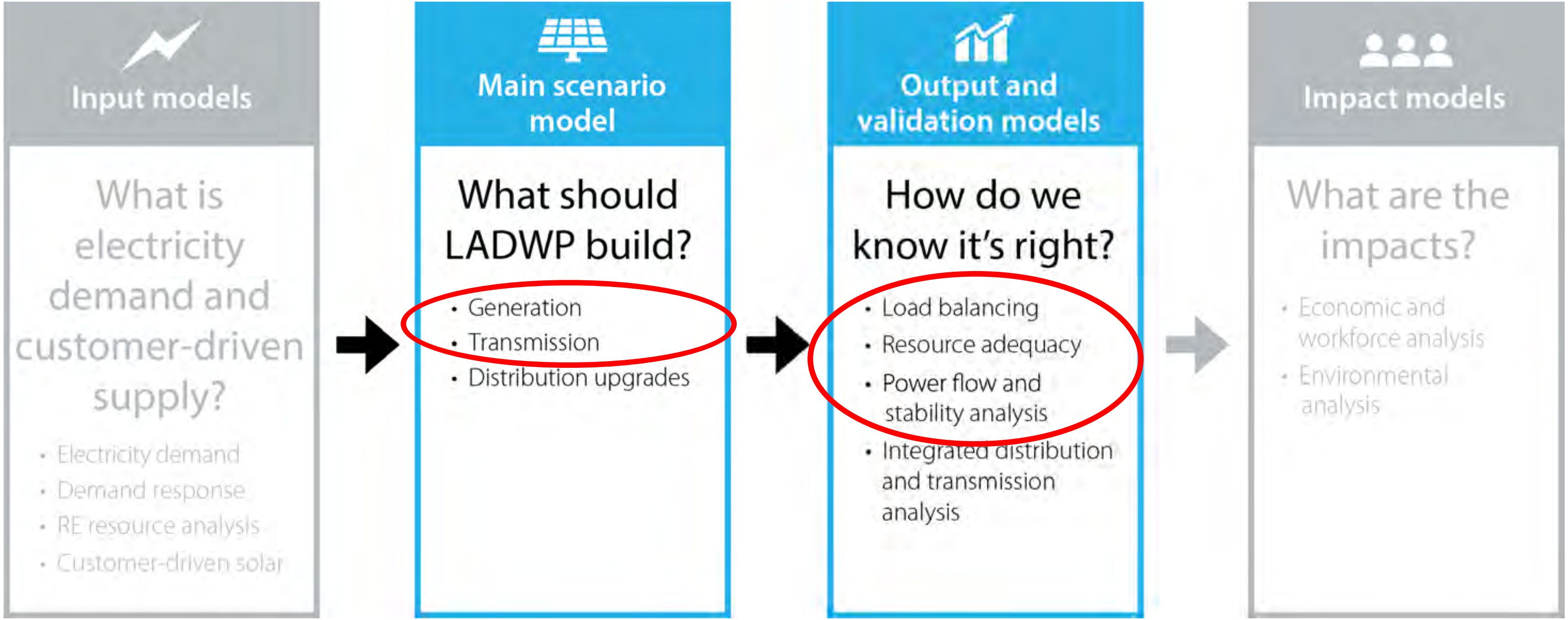
Daniel Steinberg

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

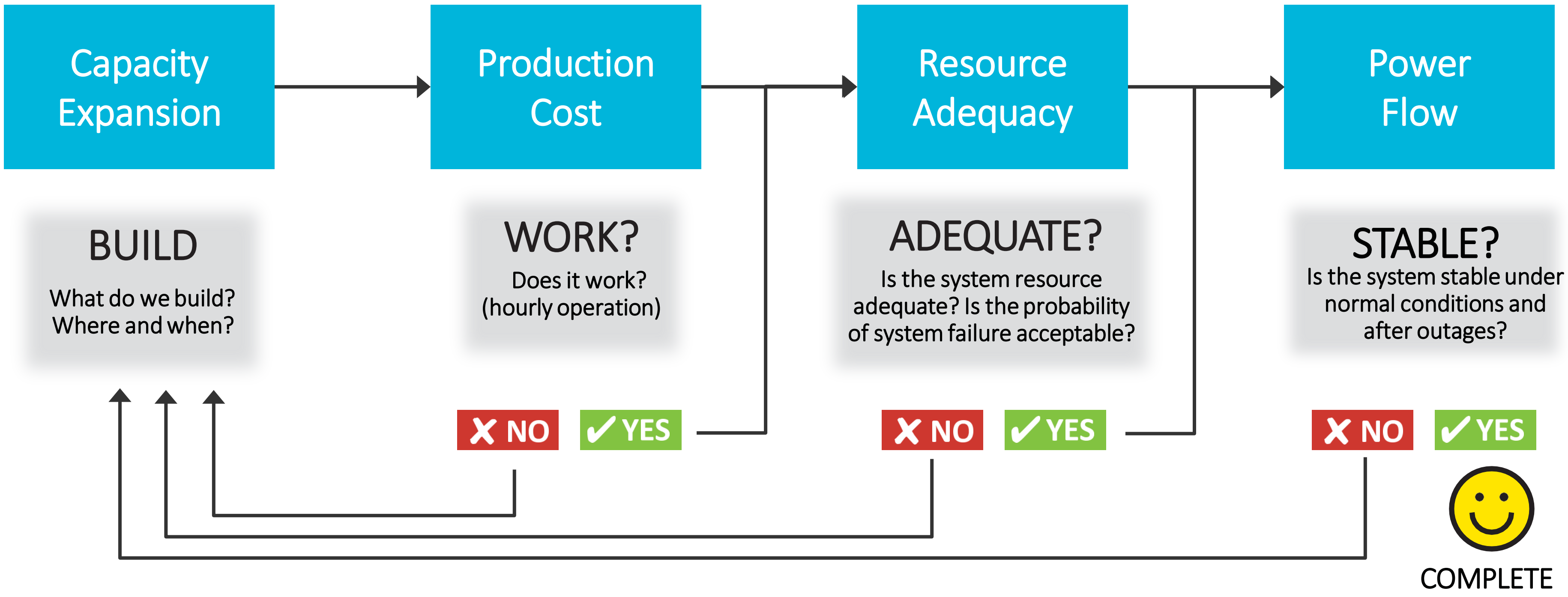
Bulk Power Models



Agenda for This Session

- Review bulk system modeling approach
- Pathway to 2045: SB100 Scenario, Initial Results:
  - Investment pathway
  - Operations: load balancing and resource adequacy
  - Power flow and system stability

Bulk System Modeling Approach: Estimate, Then Refine



Purpose within LA100

- Identify a set of bulk-system investment pathways to 2045
- Ensure that each identified future system is:
  - Operable
  - Resource adequate
  - Physically stable

Initial Run (Today) vs. Final Run (June AG Presentation)

What's Included in Initial Run

Electricity Demand: **Initial** Run

Evaluation of the impacts of **short-duration** outages of generation and transmission on resource adequacy

Single weather year

Initial cost and performance assumptions; **initial** constraints on in-basin resources

What's Not Included Today but Will Be in Final Run

Electricity Demand: **Final** Run

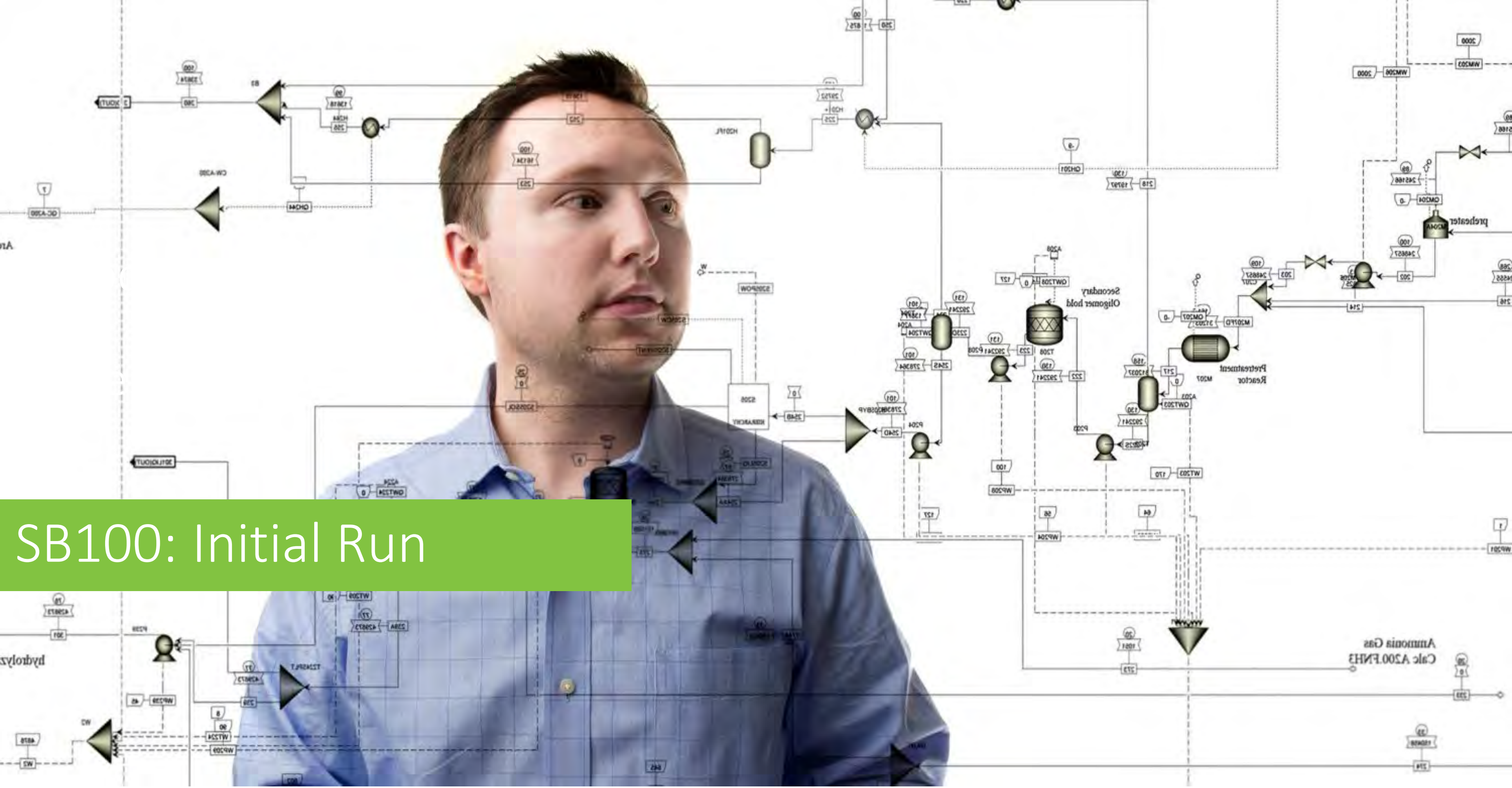
Evaluation of **long-duration** outages of generation and transmission on resource adequacy and system operations

Multiple weather-years

Final cost and performance assumptions; **revised** constraints on in-basin resources

Limits on transmission upgrades and new builds

Evaluation of power flow under steady-state and transient conditions



SB100: Initial Run

SB100 Scenario Specifics

- Energy targets are specified as a portion of **demand** (not supply):
  - 60% renewable energy by 2030
  - 100% carbon-free energy by 2045
- Renewable Energy Certificates (RECs) allowed for a portion of compliance through 2045
  - Must follow Compliance Period 3 Content Category Requirements: at least 75% Category 1 and no more than 10% Category 3
- OTC Units are ***retired*** by 2030; however, the non-OTC units, Apex, and IPP conversion remain online through 2045 (3 GW)

California RPS Content Categories

- **Category 1**: Time-synchronous RECs and energy delivered to the LADWP balancing area
- **Category 2:** RECs and energy that cannot be delivered without technology substitution; firmed and shaped contracts
- **Category 3:** Unbundled RECs (no energy purchased)

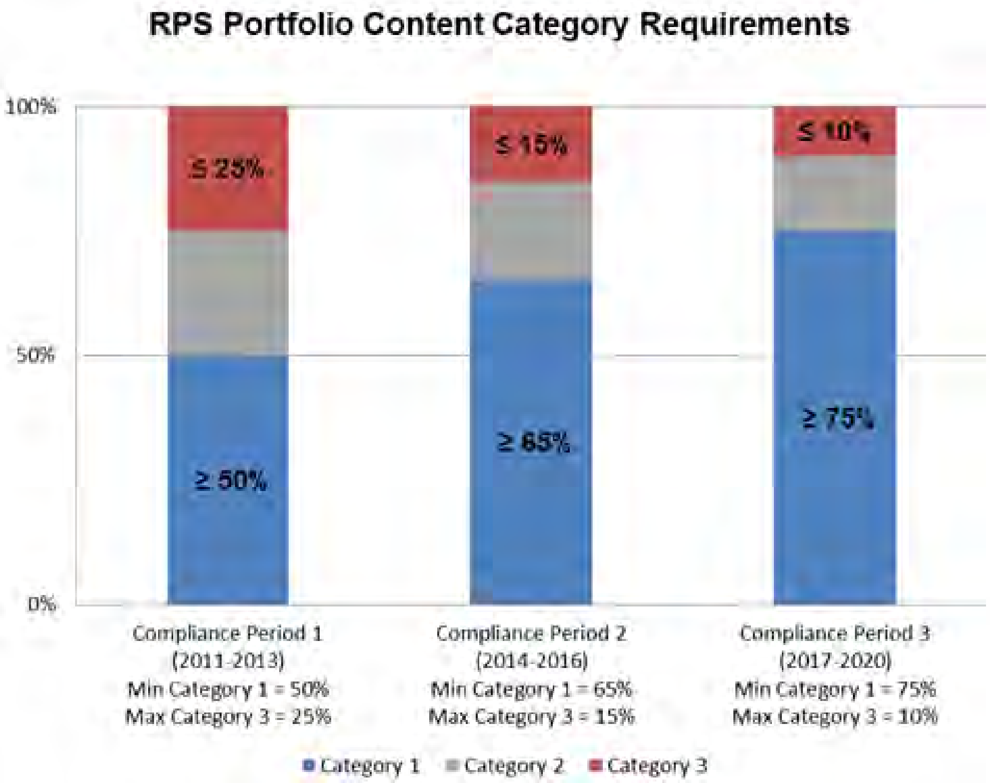
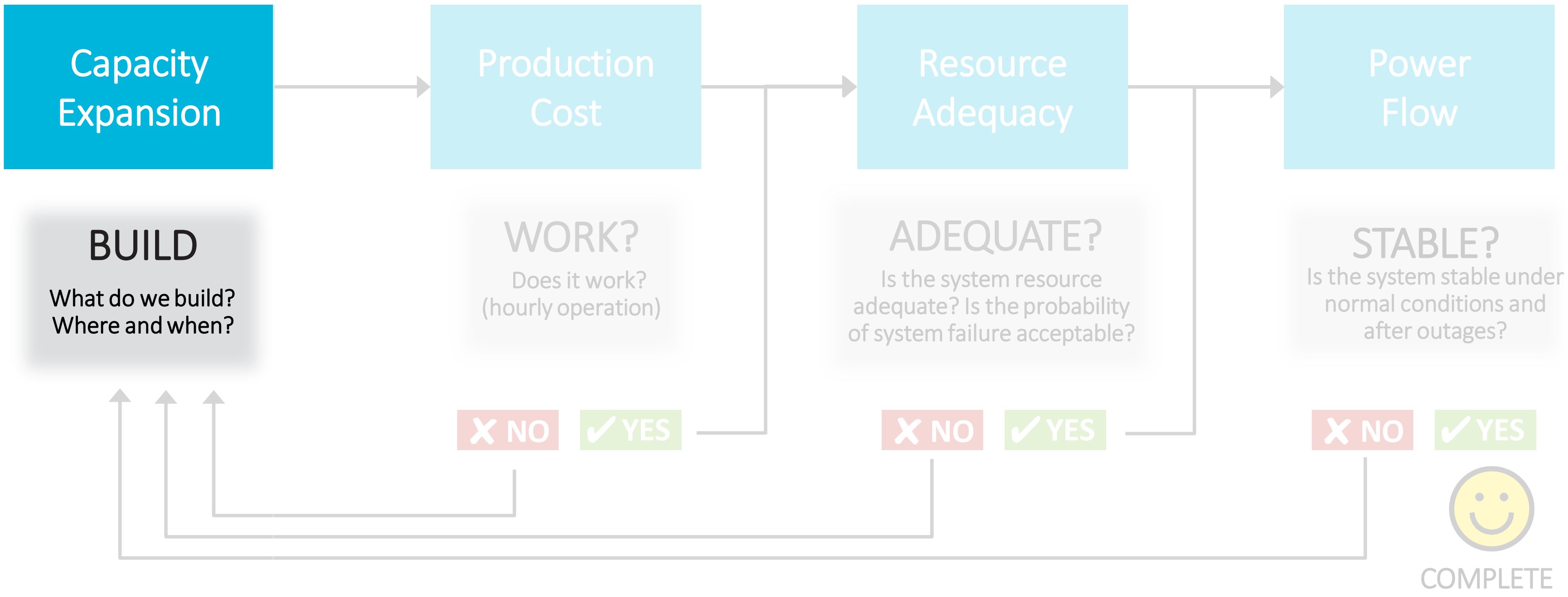


Figure Source: https://www.cpuc.ca.gov/RPS_Procurement_Rules_50/

Investment Pathway:

Capacity Expansion Modeling

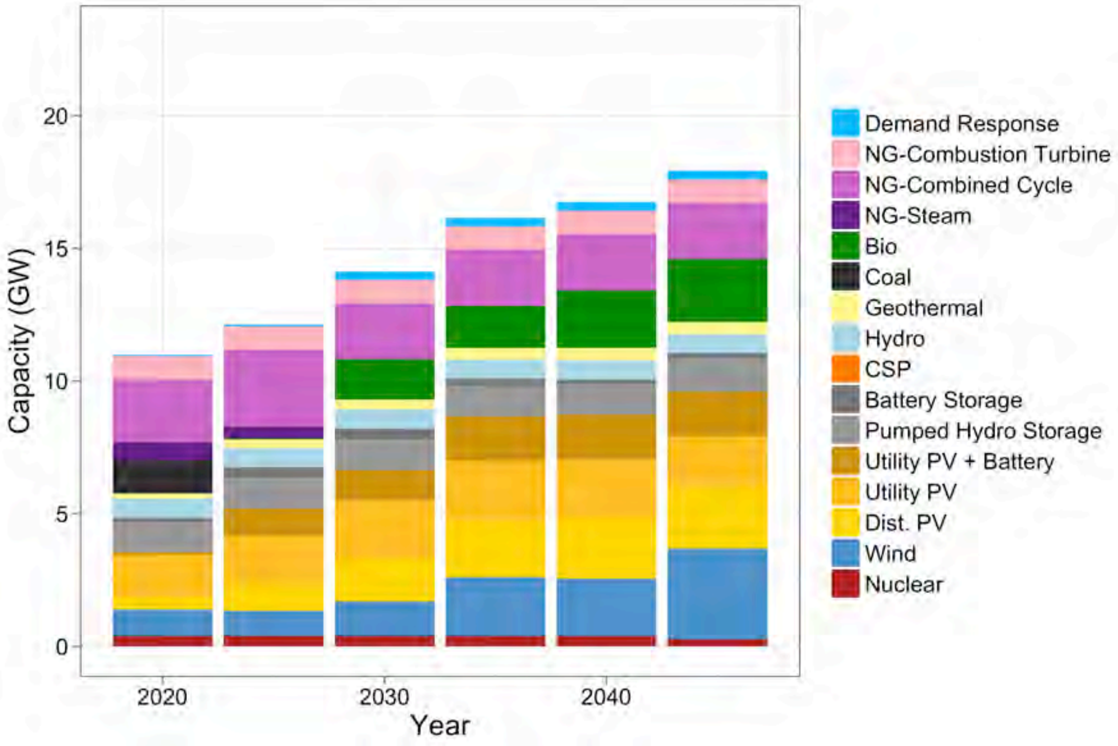
Bulk System Modeling Approach: Estimate, Then Refine



Generation Investment

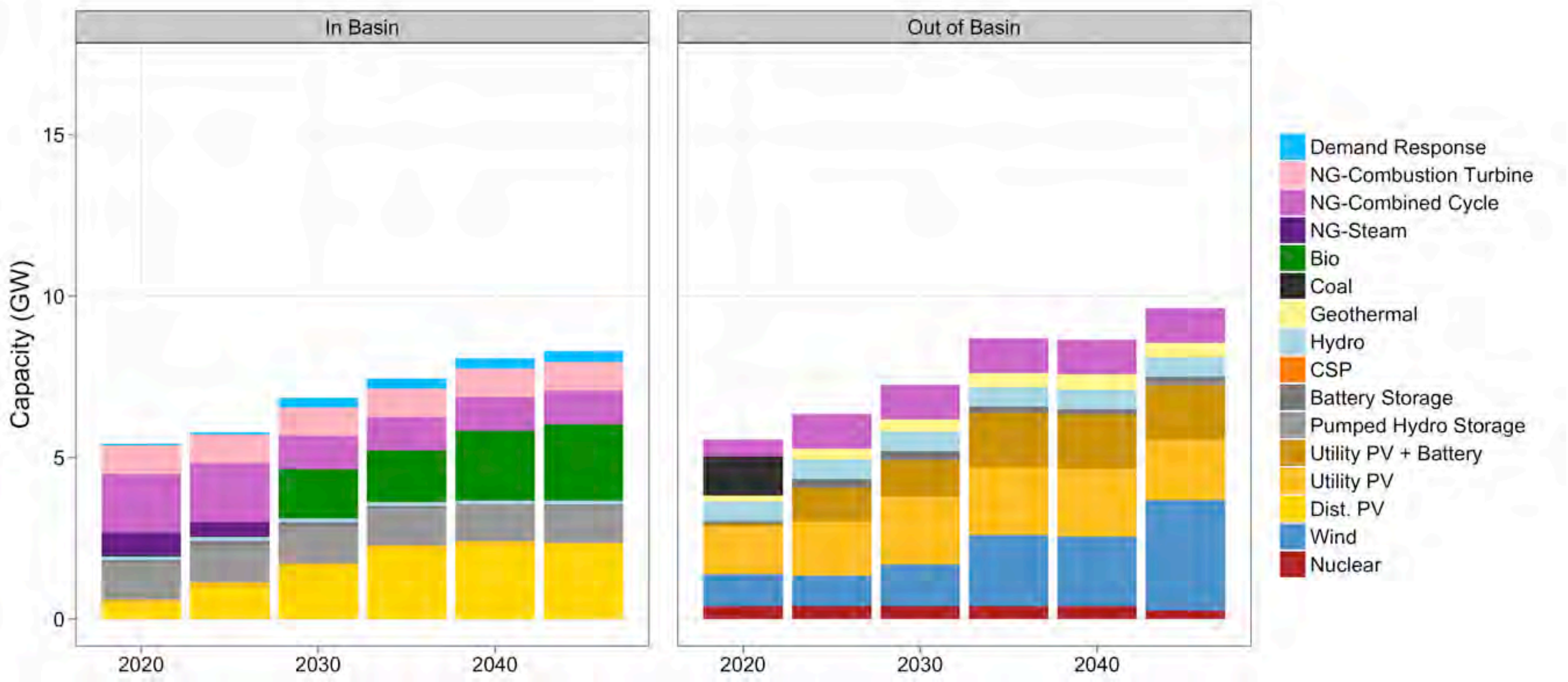
SB100 Initial Run: Total Capacity

	2030	2045
Natural Gas	3 GW	3 GW
Wind	1.3 GW	3.4 GW
PV *(portion w/ storage)*	3.4 GW *(1.1 GW)*	3.6 GW *(1.7 GW)*
Bio and Geo	1.9 GW	2.3 GW
Dedicated Storage	1.6 GW	1.5 GW



Initial Run For Discussion Purposes Only; Subject to Change

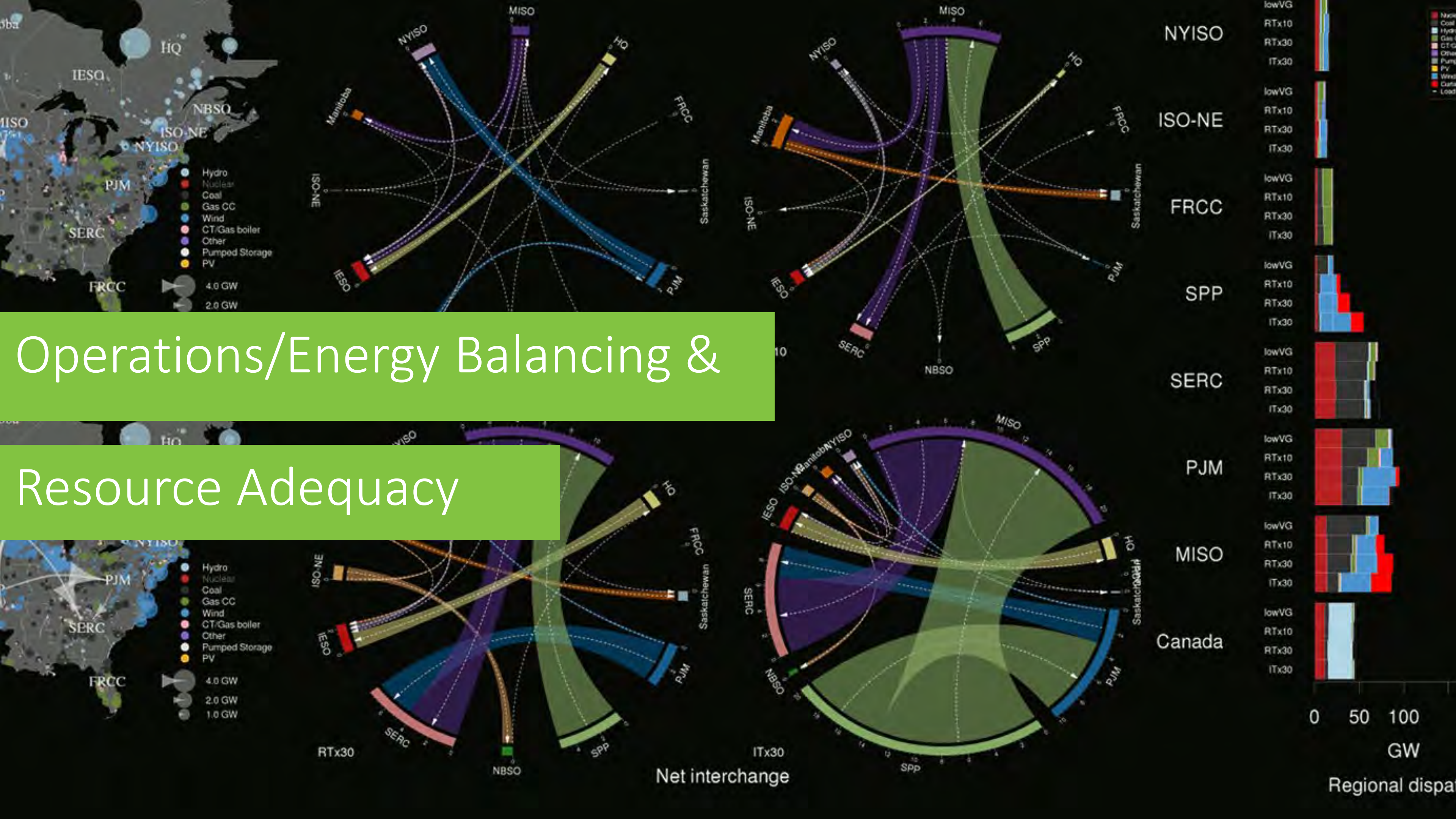
SB100 Initial Run: Basin-level Capacity



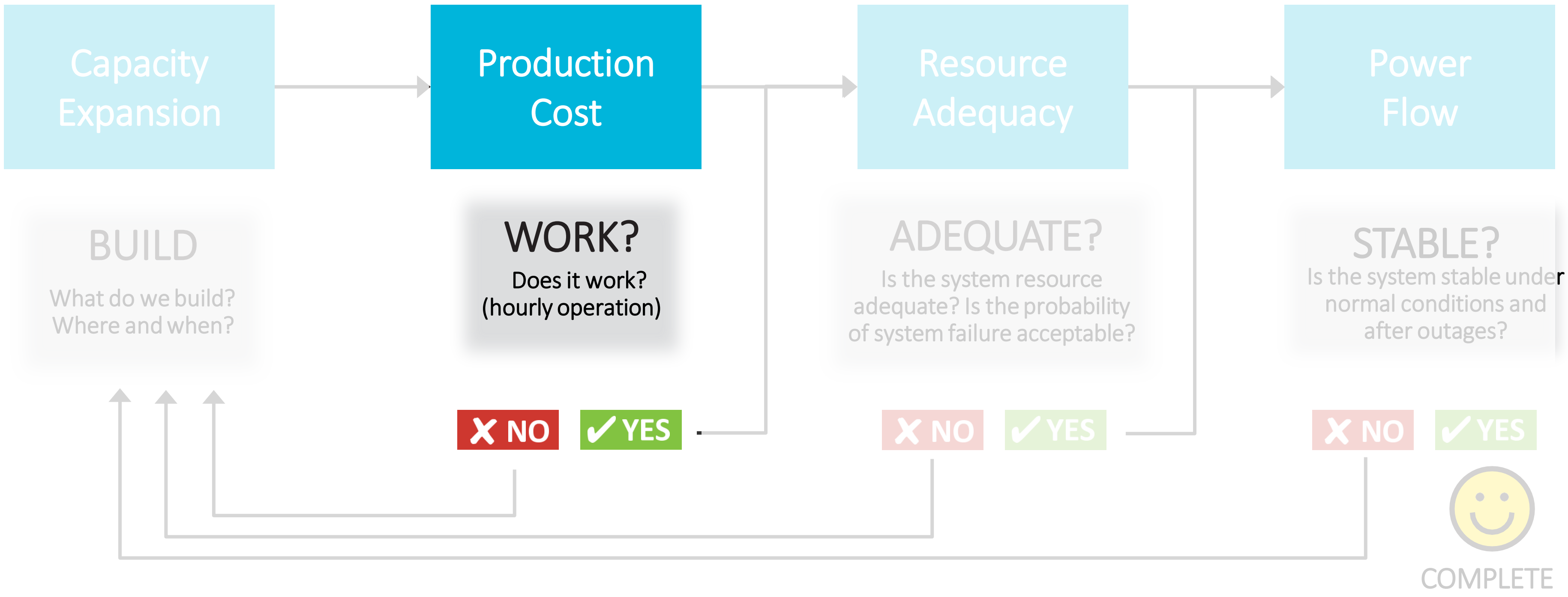
Initial Run For Discussion Purposes Only; Subject to Change

Transmission Investment

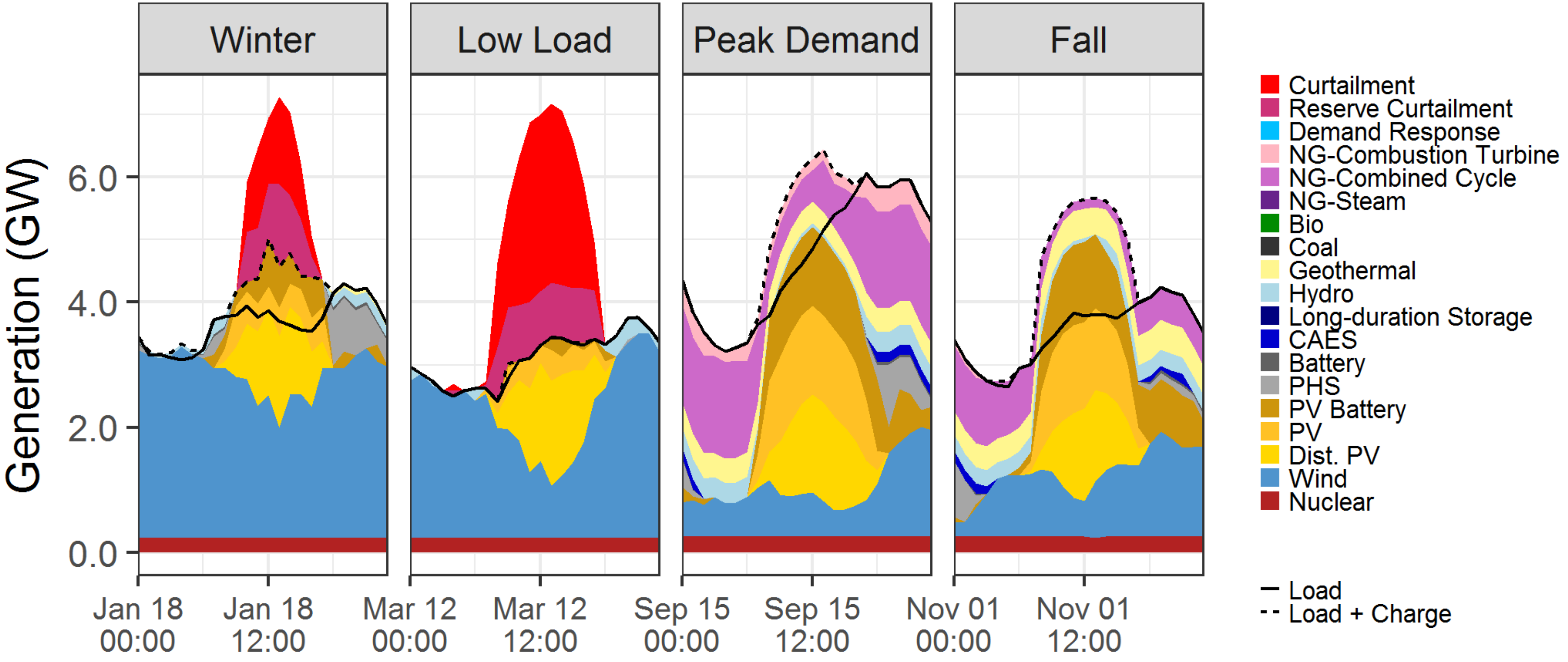
Operations/Energy Balancing & Resource Adequacy



Bulk System Modeling Approach: Estimate, Then Refine

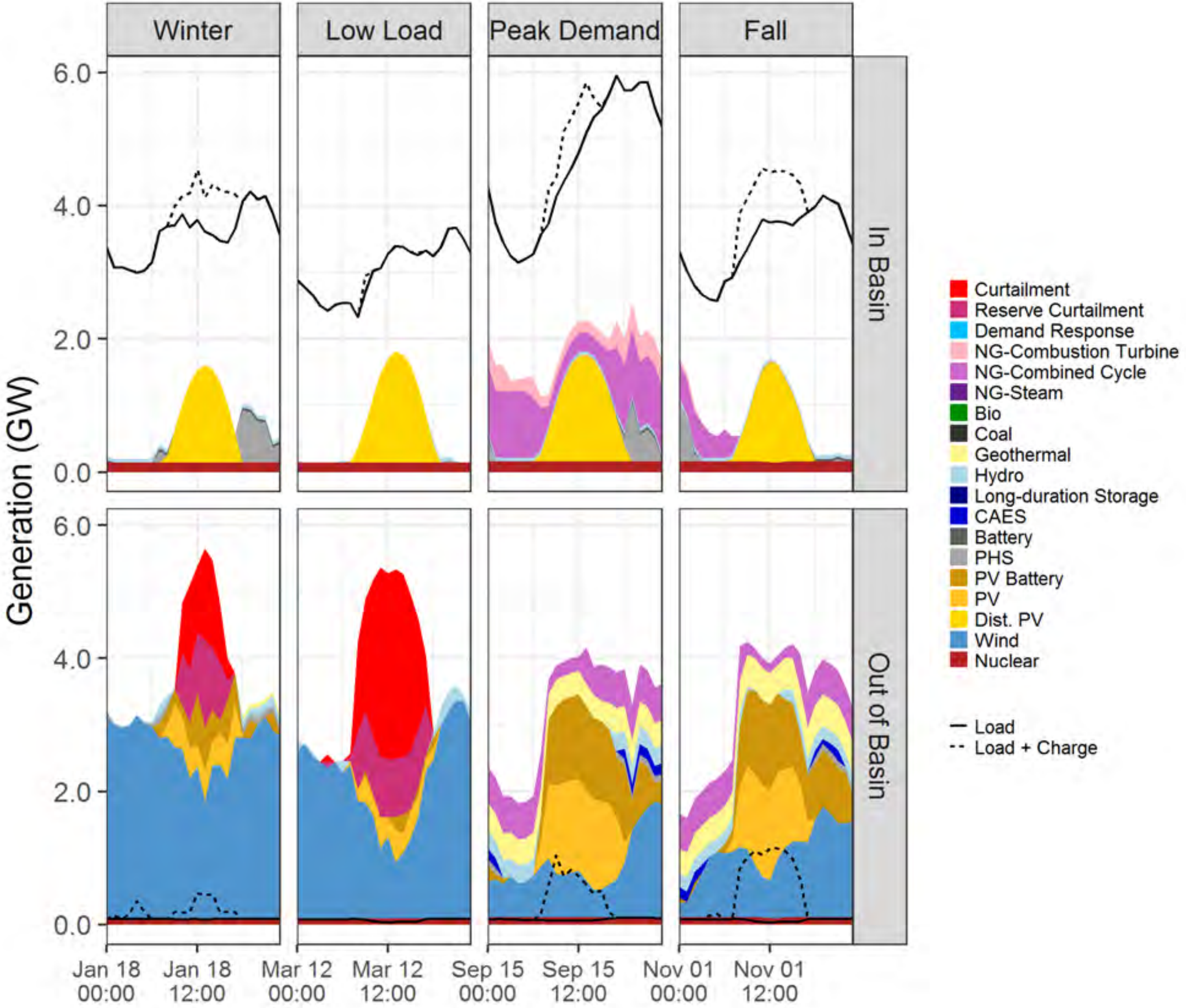


SB100 Initial Run: Operations, 2045



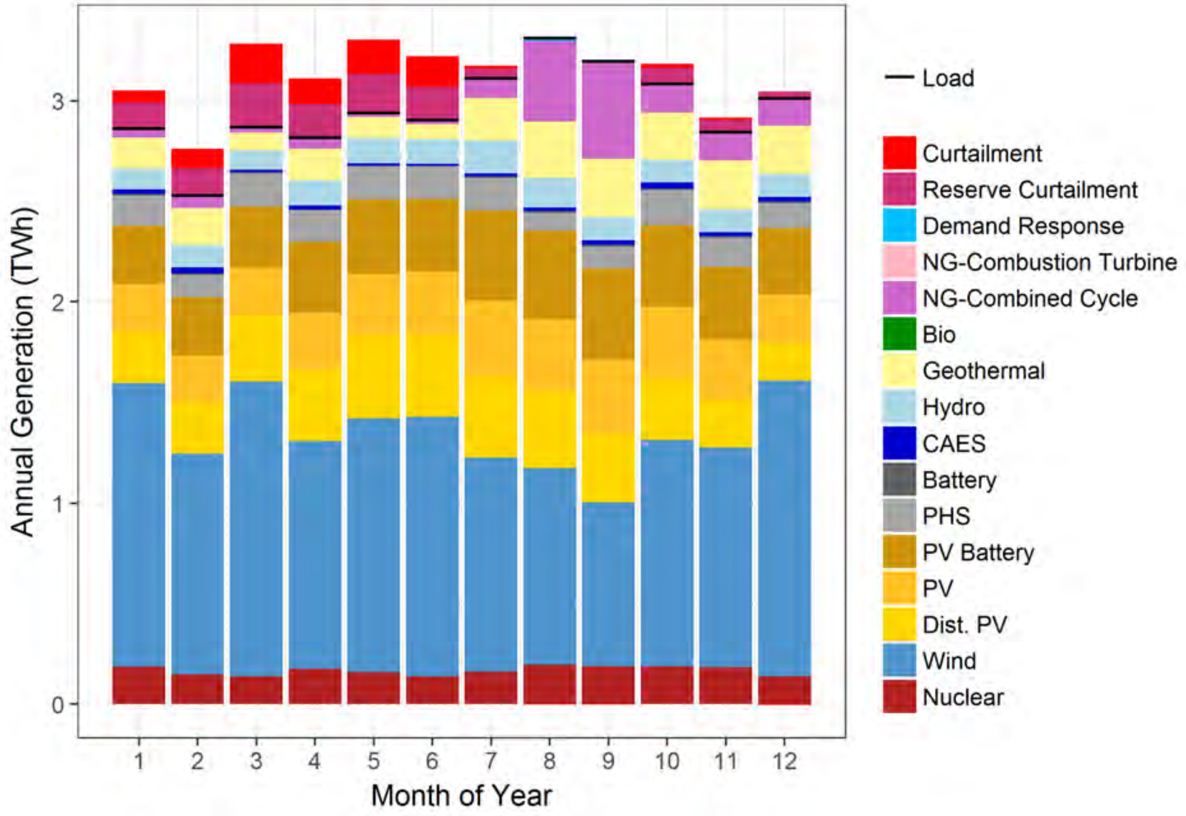
*Note, load shown has load shifting embedded

SB100 Initial Run: Operations, 2045, Basin-Level



Initial Run For Discussion Purposes Only; Subject to Change

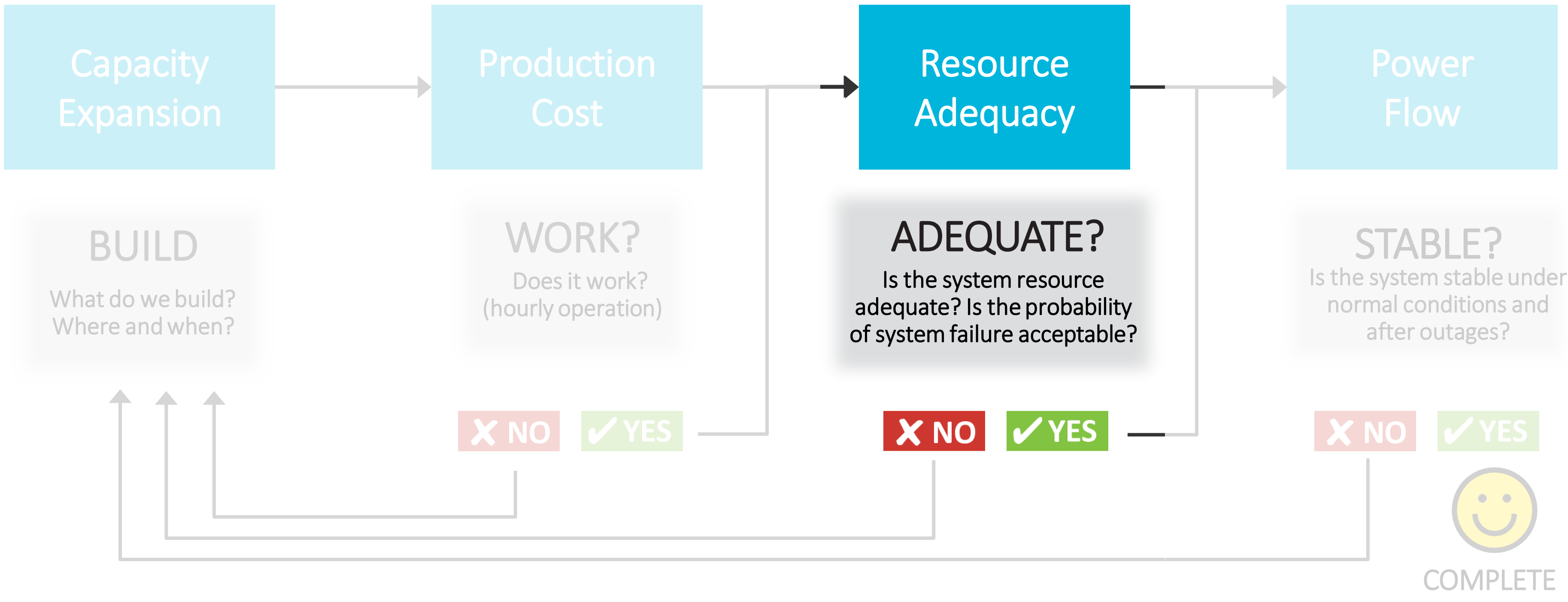
SB100 Initial Run: Monthly Dispatch, 2045



Initial Run For Discussion Purposes Only; Subject to Change

Visualization of Operations

Bulk System Modeling Approach: Estimate, Then Refine



What is Resource Adequacy?

Measures the ability of the bulk-scale generation and transmission system to serve electricity demand under all but the most extreme circumstances

**Note: most customer outages occur as a result of distribution system failures*

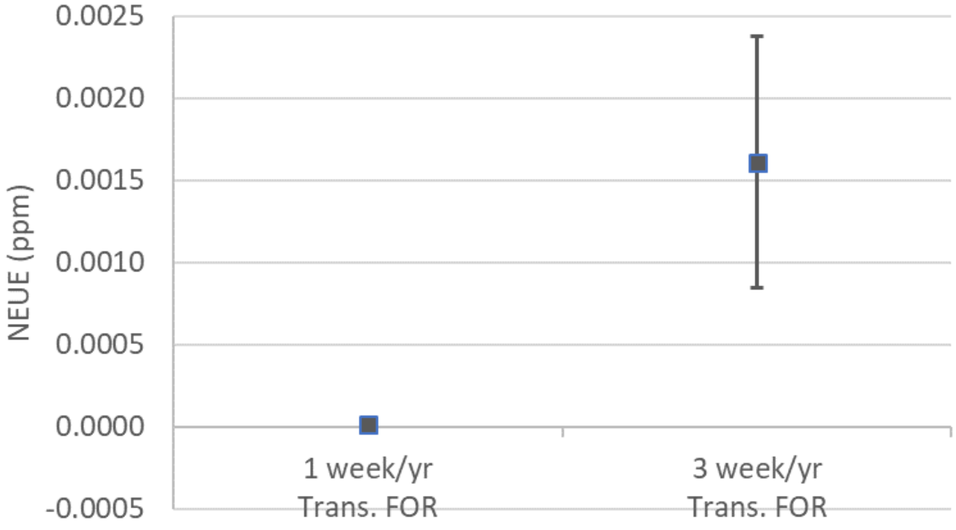
SB100 Initial Run: Resource Adequacy Metrics

Normalized Expected Unserved Energy (NEUE):

- Effectively measures both the **frequency** and **magnitude** of losses—i.e., how many customers and for how long
- Measured in parts per million (PPM)
- Our target is 10 PPM
  - This is equivalent to having 10 average customers out of every 1 million without power due to generator or transmission failures
  - Also means that on average, any individual customer will lose power for an hour every 11 years

SB100, 2045 Initial Run: Resource Adequacy

Target: stay below 10 ppm



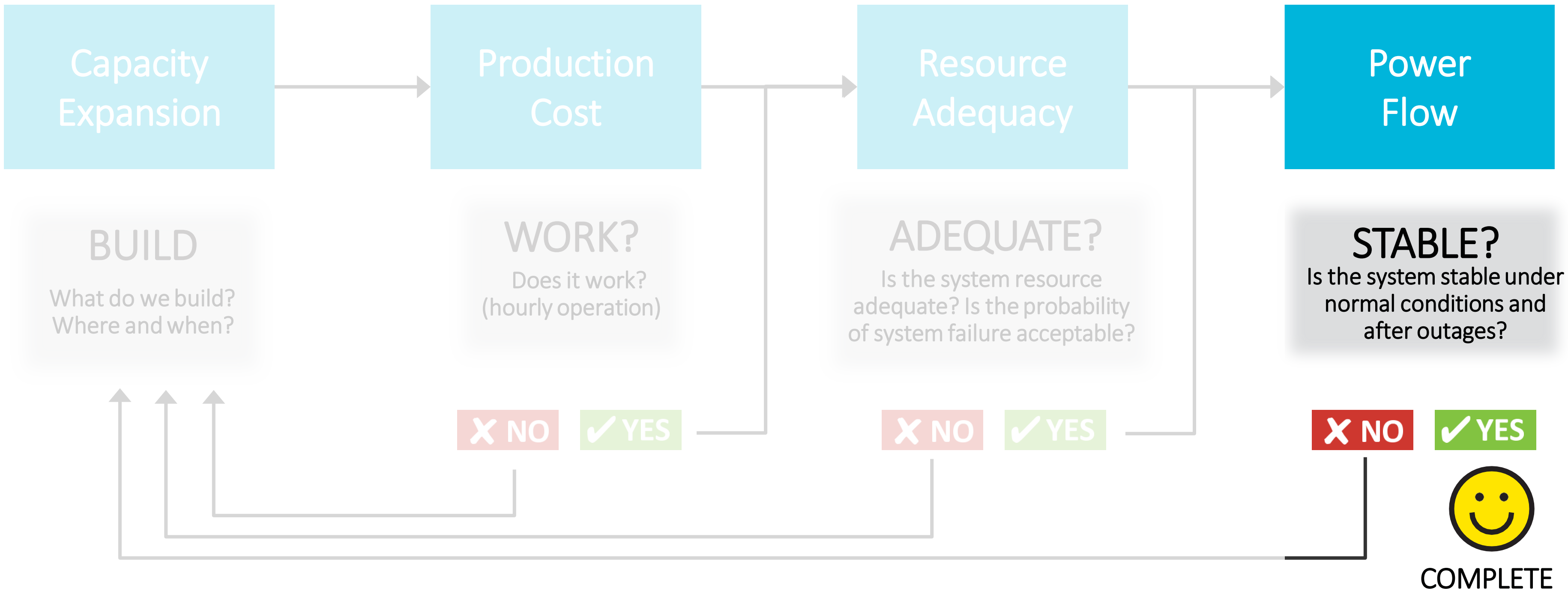
- Well below target of 10 ppm
- Only considers single weather year
- Initial load projections

Initial Run For Discussion Purposes Only; Subject to Change

Is the System Stable?

Power Flow Analysis

Bulk System Modeling Approach: Estimate, Then Refine



Objective

- Evaluate the **reliability of the system** designed by RPM and dispatched by PLEXOS
  - Evaluate under steady state, as well as post-contingency
- Identify if **changes in generation and/or transmission investments** are required to relieve any reliability violations

System Costs

Cost Categories

- **Capital** – capital and associated financing costs of new infrastructure
- **Fixed Operations and Maintenance (FOM)** – fixed costs of operating and maintaining assets
- **Fuel** – cost of fuel, including natural gas, uranium, coal, biofuel
- **Variable O&M (VOM)** – non-fuel variable costs of operating and maintain assets

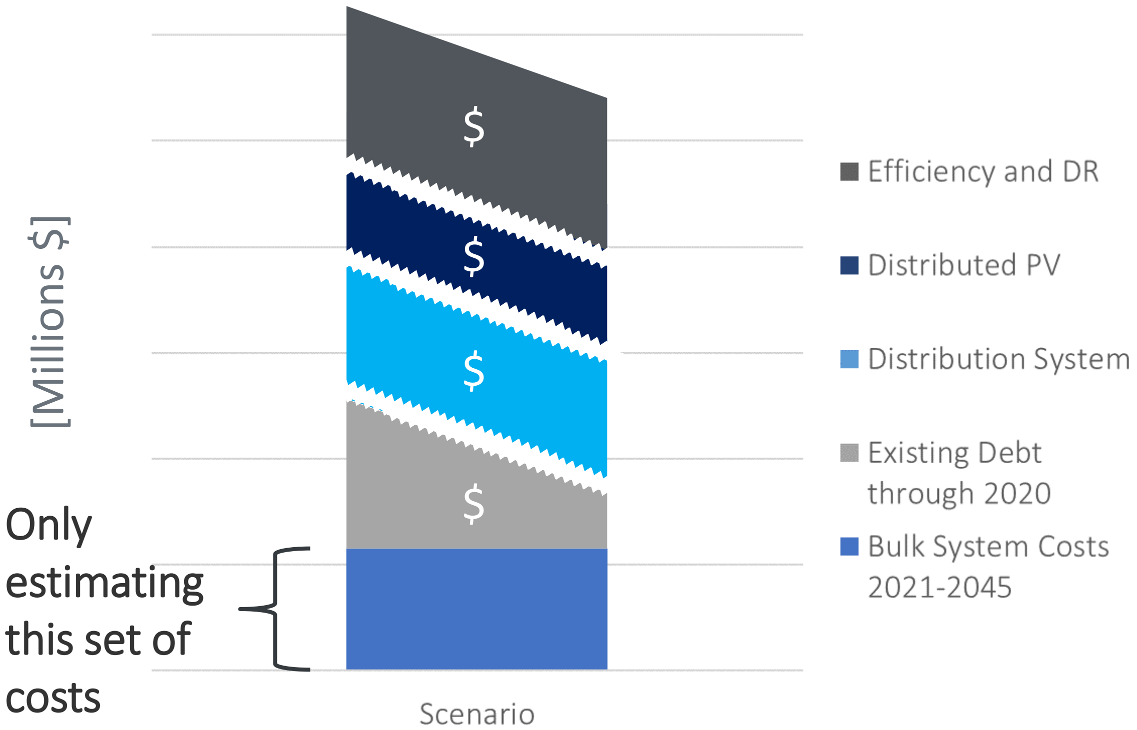
Bulk Costs (To Date):

- **Includes:**
  - Bulk system (generation and transmission):
    - Capital and financing costs for new investments (2021-2045)
    - Fuel, VO&M, and FO&M for all assets
- **Excludes:**
  - Existing debt on capital expenses (made before 2021)
  - Distribution system costs (upgrades* and O&M)
  - Capital cost and O&M for customer-owned distributed generation*
  - Costs of energy efficiency and demand response programs

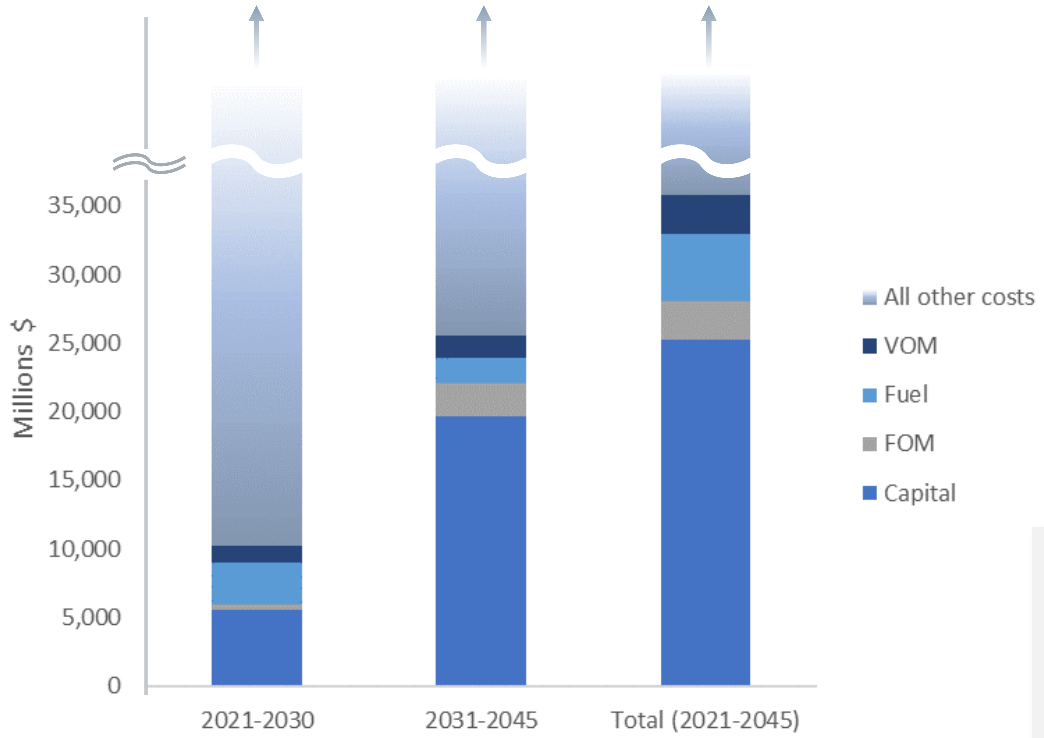
* Will be included in Final Results

Illustrative Cost Stack

Estimates only include capital and operational costs for bulk system generation and transmission



SB100 Initial Run:
2021-2045 Annualized Bulk System-Only Costs



Bulk system generation and transmission cost*

- 2021-2030: $10 B
- 2031-2045: $26 B
- **Total: $ 36 B**

Note that these represent only a portion of total system costs; see slide 36

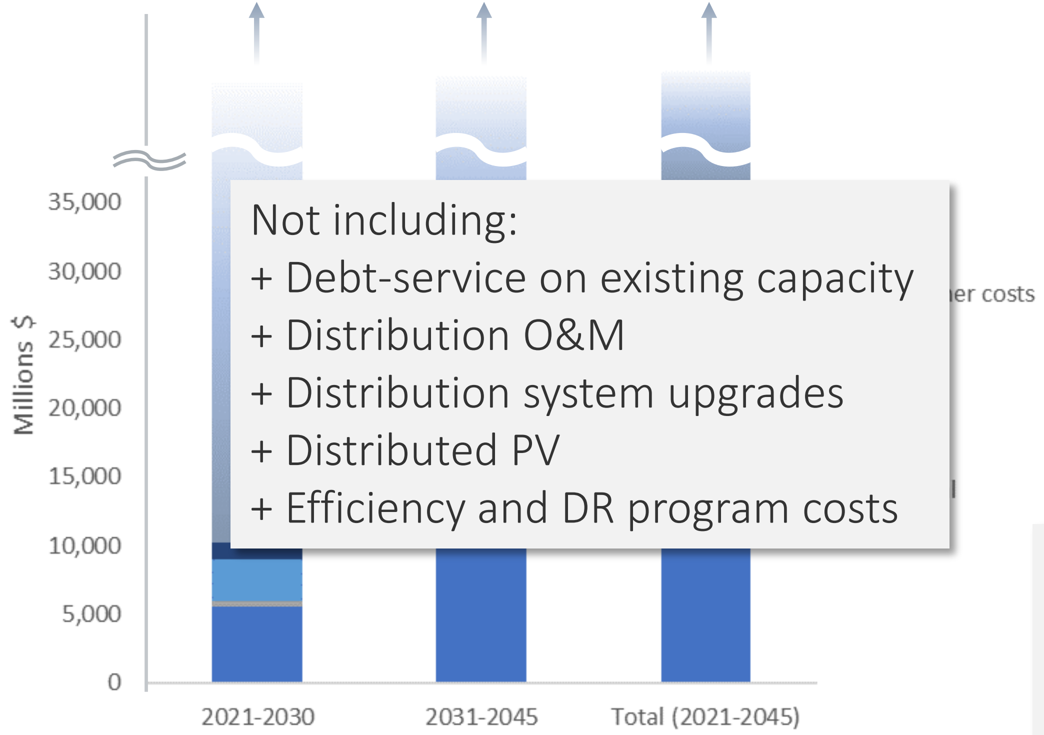
Key Assumptions:

- Financial lifetime of 20 years for all assets
- WACC of 5.5%, real

[Assumptions will be updated with parameters from DWP]

Initial Run For Discussion Purposes Only; Subject to Change

SB100 Initial Run: 2021-2045 Annualized Bulk System-Only Costs



Not including:
+ Debt-service on existing capacity
+ Distribution O&M
+ Distribution system upgrades
+ Distributed PV
+ Efficiency and DR program costs

Note that these represent only a portion of total system costs; see slide 36

Bulk system generation and transmission cost*

- 2021-2030: $10 B
- 2030-2045: $26 B
- **Total: $ 36 B**

Key Assumptions:
- Financial lifetime of 20 years for all assets
- WACC of 5.5%, real

[Assumptions will be updated with parameters from DWP]

Initial Run For Discussion Purposes Only; Subject to Change

Summary, SB100 Initial Run

- Growing energy needs, driven by increasing requirements for renewables and increasing load, are met with a **diverse set of renewable resources** (solar, wind, geothermal, and bio)
  - Feasibility of utility-scale biofuel generation has not been evaluated in depth
- Storage is used to **shift surplus generation** during mid-day hours to evening, night, and morning hours
- Remaining in-basin natural gas generation is relied on during **hours of low renewable resource quality** and during **hours of stress**
- Initial resource adequacy tests have **not identified any substantial issues** associated with short-duration outages

Summary, SB100 Initial Run

- Future bulk-system costs are dominated by **capital costs associated with new generation, storage, and transmission capacity**; fuel costs decline as energy needs are increasingly met with renewable resources
  - Capital costs may be realized as either capital expenditures or variable costs depending on how new energy and storage assets are procured (e.g., owned assets vs. PPAs)
- Results will likely change:
  - **Changes in load projections** may lead to changes in required resources
  - Further operational, adequacy, and power flow simulations required to **validate system reliability**

Thank you

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Initial Run Results: Distribution Models

SB100 Scenario

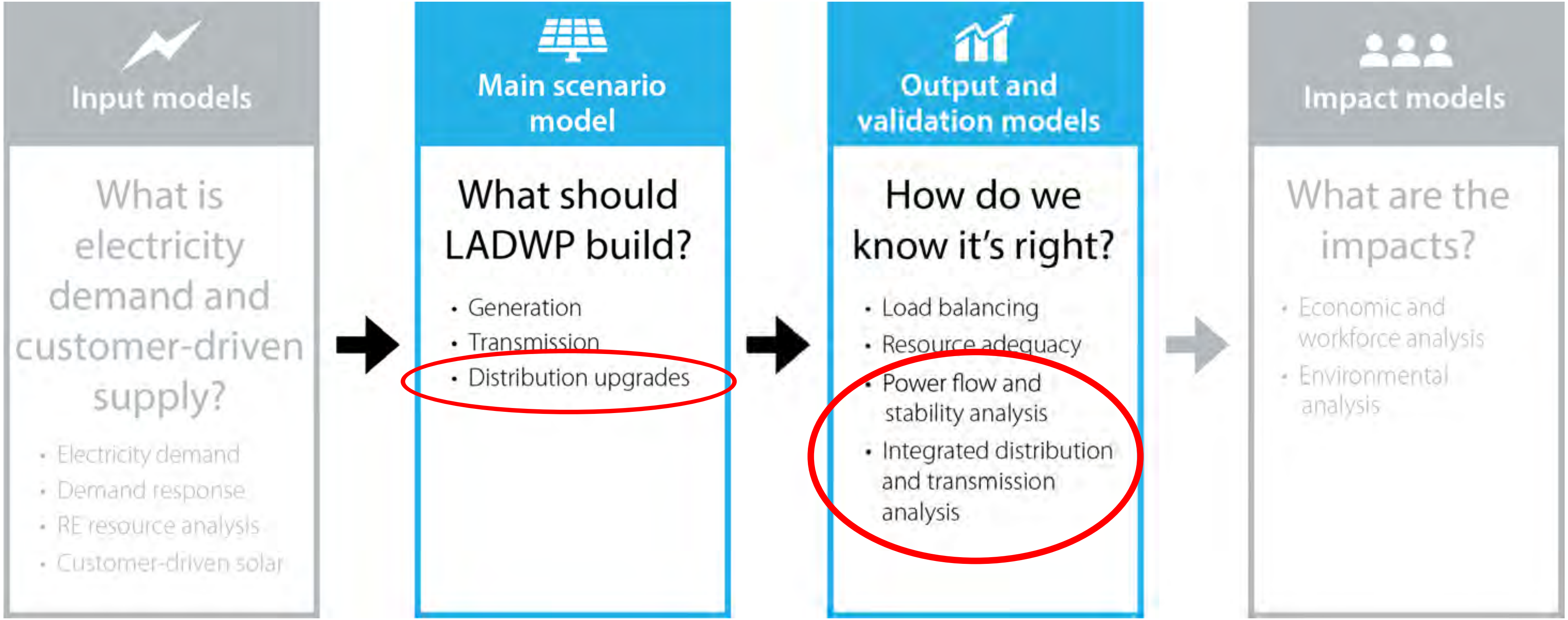
Bryan Palmintier, Ph.D.

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Bulk Power and Distribution Models



Agenda

Output Models, Part 2: Distribution System

1. Analysis Overview
2. Methods Introduction
3. Initial Run Results (4.8kV)
4. Discussion/Q&A

Distribution System Analysis

Overview

Purpose within LA100

What are the impacts on the distribution system of:

- Future electricity demand changes?
- Distributed generation?

Approximately how much would required distribution upgrades cost LADWP?

- Includes distributed generation from:
  - Residential and commercial rooftop solar
  - Larger ground-mounted and carport solar
- Analysis conducted only for 2030 & 2045

Initial Run (Today/March) vs. Final Run (June AG)

What's Included in Initial Run (Today)

2045 analysis

Initial loads (electricity demand)

4.8kV rooftop solar

Two time periods: peak load and high solar with low load

Initial Run results at March AG

Upgrade cost estimates (2030)

34.5kV large-scale local solar (2030)

What's Not Included Today but Will Be in Final Run

2030 & 2045 analysis

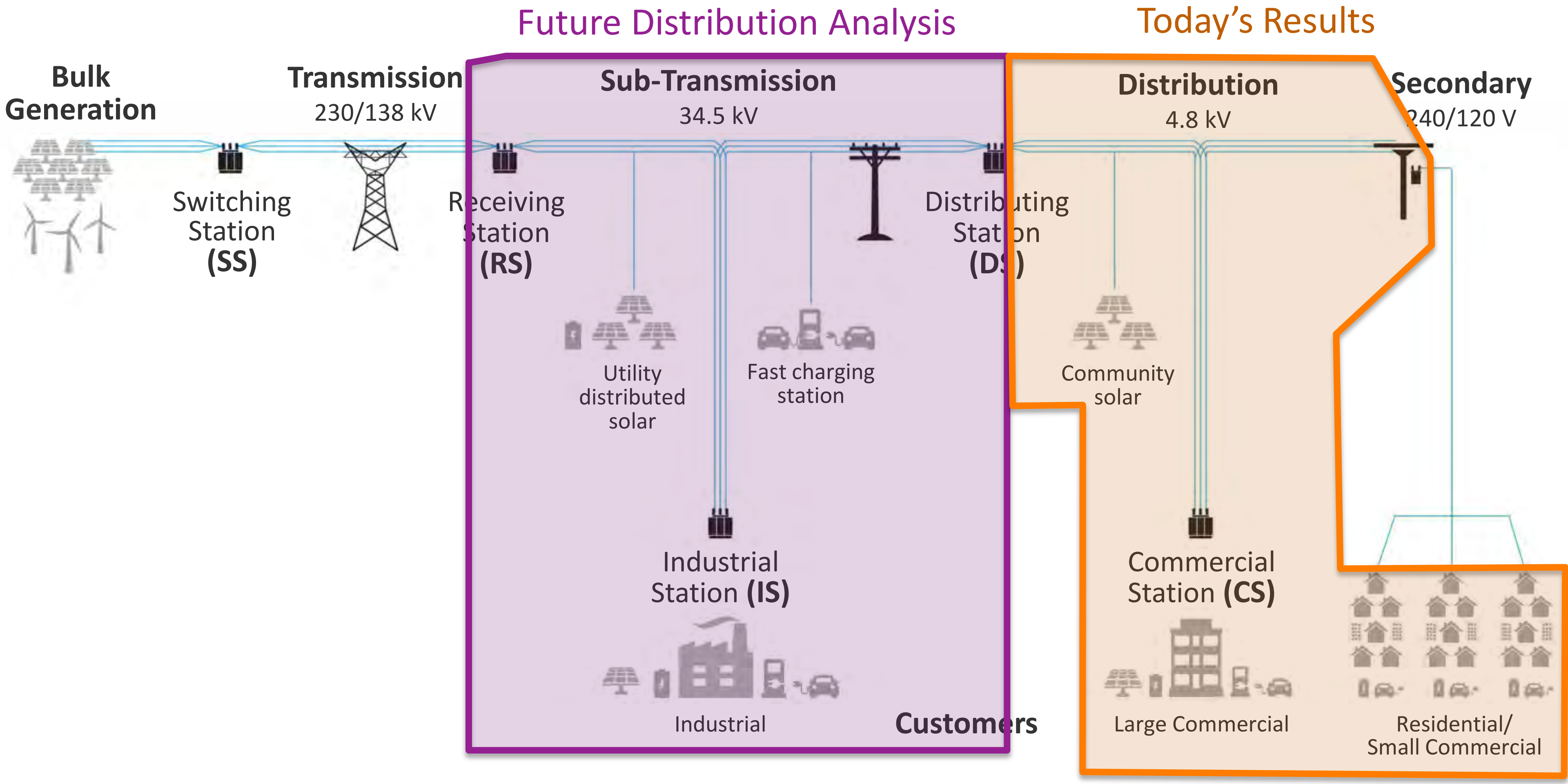
Revised loads, including EVs, buses, fast charging

Distribution upgrade cost estimates

34.5kV large-scale local solar

Local storage

Time-series analysis for impacts and curtailments


Future Distribution Analysis
Today's Results
Bulk Generation
Transmission
230/138 kV
Sub-Transmission
34.5 kV
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Distributing Station (DS)
Utility distributed solar
Fast charging station
Community solar
Industrial Station (IS)
Commercial Station (CS)
Industrial
Customers
Large Commercial
Residential/ Small Commercial

LA100 Distribution Modeling Efforts: Load and Solar

1 Today → There are some circuits that already have known overloading or voltage challenges (data from LADWP)

2 2030 Load-only
2045 Load-only
→ Distribution impacts of load changes due to electric vehicle adoption, energy efficiency, demand response, and other sources

Then add solar:

3 2030 with solar*
2045 with solar*
→ Distribution impacts of both rooftop and utility-scale local solar
* For Final Run: add storage

LA100 Distribution Modeling Efforts: Analysis Types

Rooftop solar adoption
(dGen)

System-wide expansion plan for ~1-5 MW local solar at 34.5kV
(RPM)

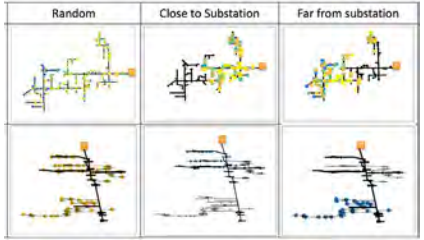
Projection of customer adoption on each roof
5 samples/feeder

Distribution Impact Analysis

Power flow analysis to look for voltage violations and thermal impacts of customer-adopted solar

Aggregated up and input to capacity expansion model

Random solar deployments



Hosting Capacity Analysis

- Snapshot hosting capacity —all feeders
- Dynamic hosting capacity — select feeders

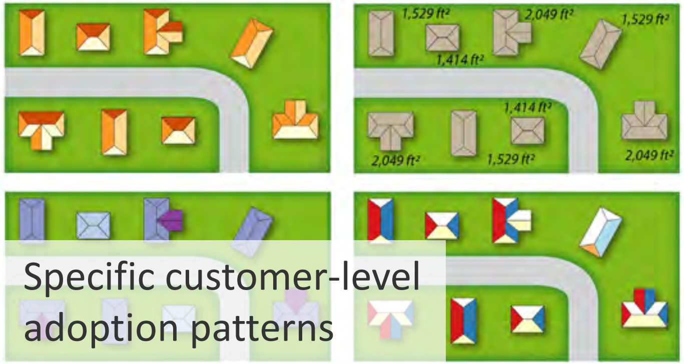
What is Impact Analysis?

Distribution power-flow study of future operations to check for violations, including:

- **Voltages:**
  - Under: typically from high loads
  - Over: typically from distributed generation (e.g. solar)*
- **Overloads:**
  - Transformers
  - Lines

Two approaches:

1. **Absolute:** Are upgrades needed?
2. **Relative:** How do things change?



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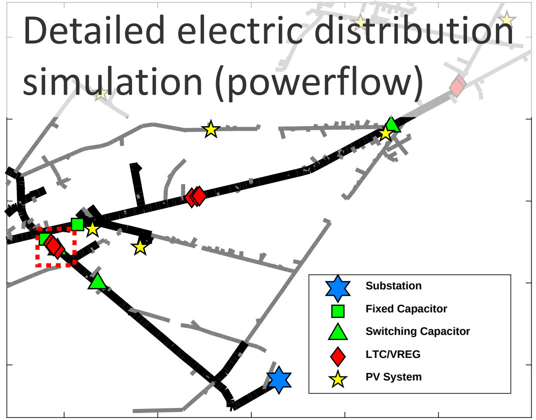


**Note: Advanced inverters can help manage both over & under voltages*

What Is Hosting Capacity? And How Is It Computed?

The amount of solar that can be added to a feeder without causing operational changes

Key Items:

- Voltage violations
- Overloads
  - Transformers
  - Lines

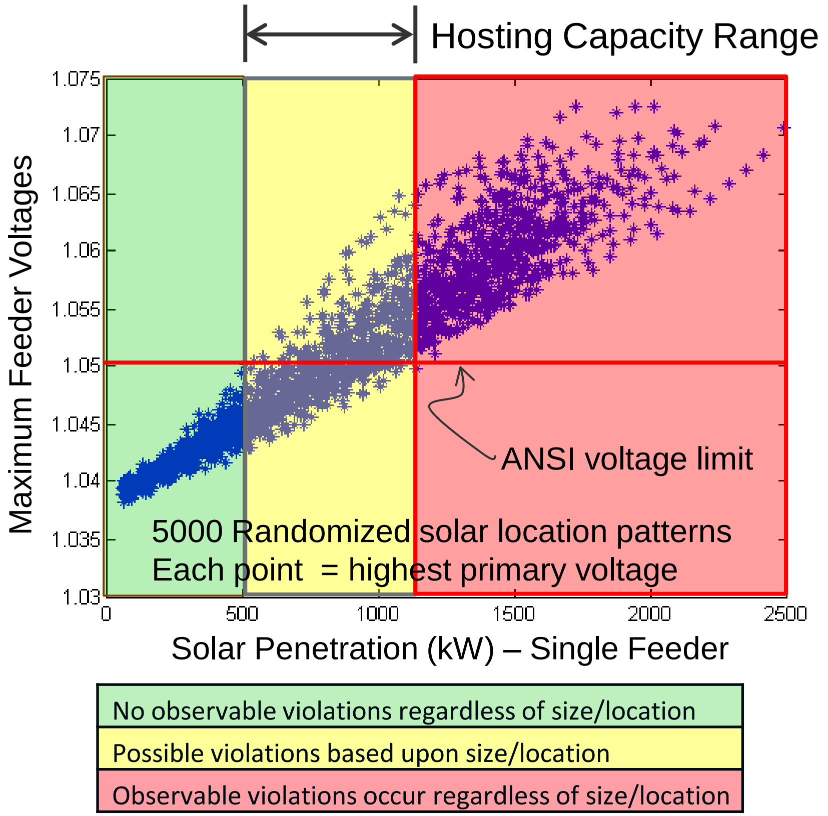


Figure Adapted from: Jeff Smith, EPRI, "Alternative Screening Methods solar Hosting Capacity in Distribution Systems", Presented at HiPen Solar Forum 2013, Feb 13-14, San Diego, CA.

What Is Hosting Capacity? And How Is It Computed?

The amount of solar that can be added to a feeder without causing operational changes

Key Items:

- Voltage violations
- Overloads
  - Transformers
  - Lines

Key Points:

- Up to a certain point, integrating distribution-connected solar is “free”
- Location matters ... a lot
- Advanced inverters can boost hosting (e.g., 2-3x)
  - Included for all new solar in LA100
- Hosting capacity is not a hard limit ... but we have to pay for upgrades

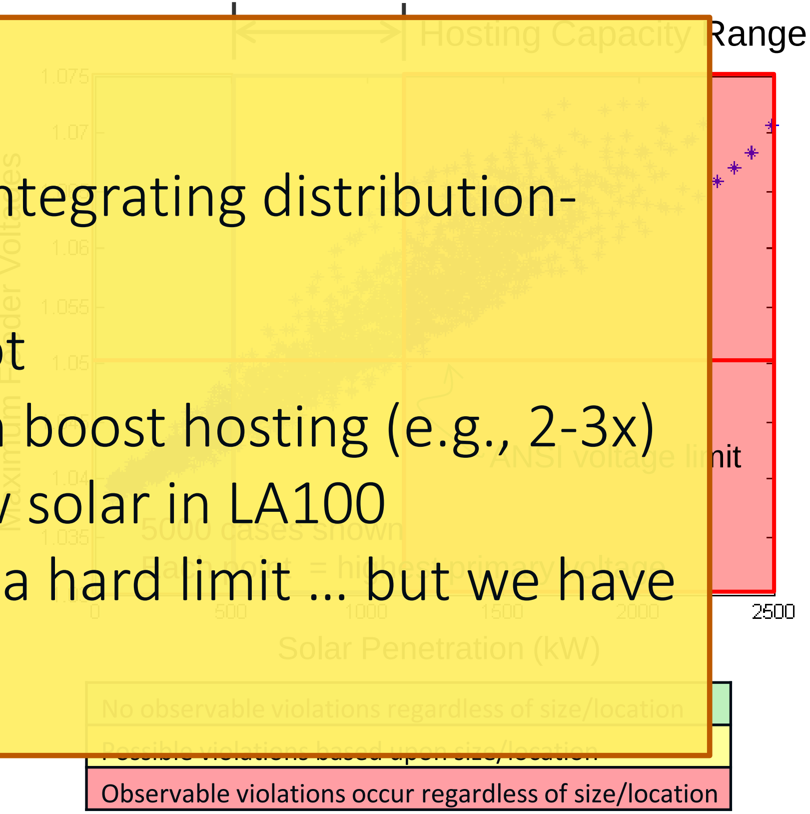
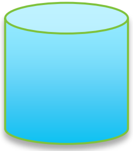


Figure Source: Jeff Smith, EPRI, “Alternative Screening Methods solar Hosting Capacity in Distribution Systems”, Presented at HiPen Solar Forum 2013, Feb 13-14, San Diego, CA.

Distribution System Analysis

Methodology

Step 1: Build Electric Models of LA’s Distribution System

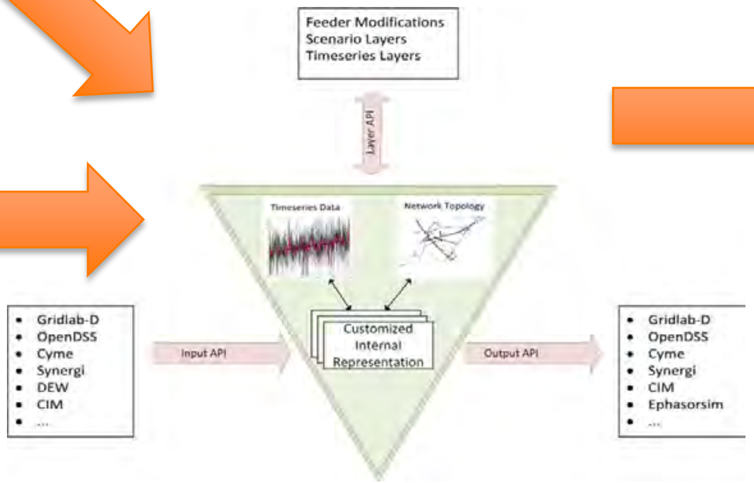


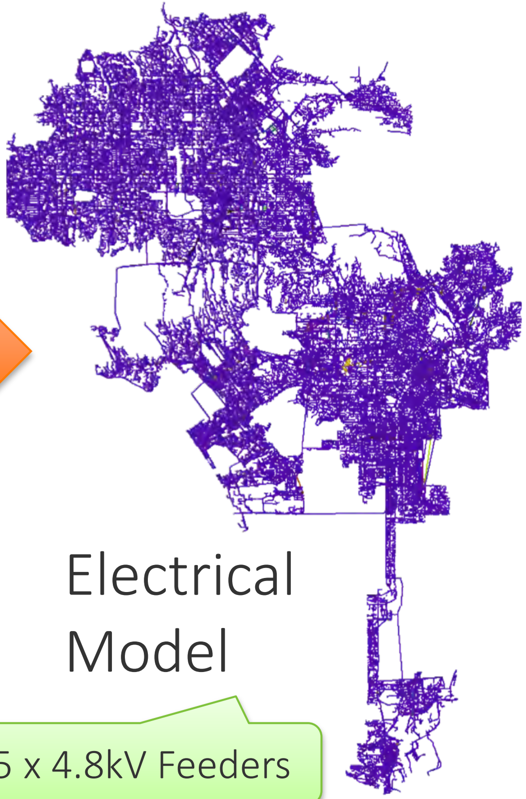
Geospatial and Equipment Data

Typical Technical Parameters

DiTTo

Github.com/NREL/ditto





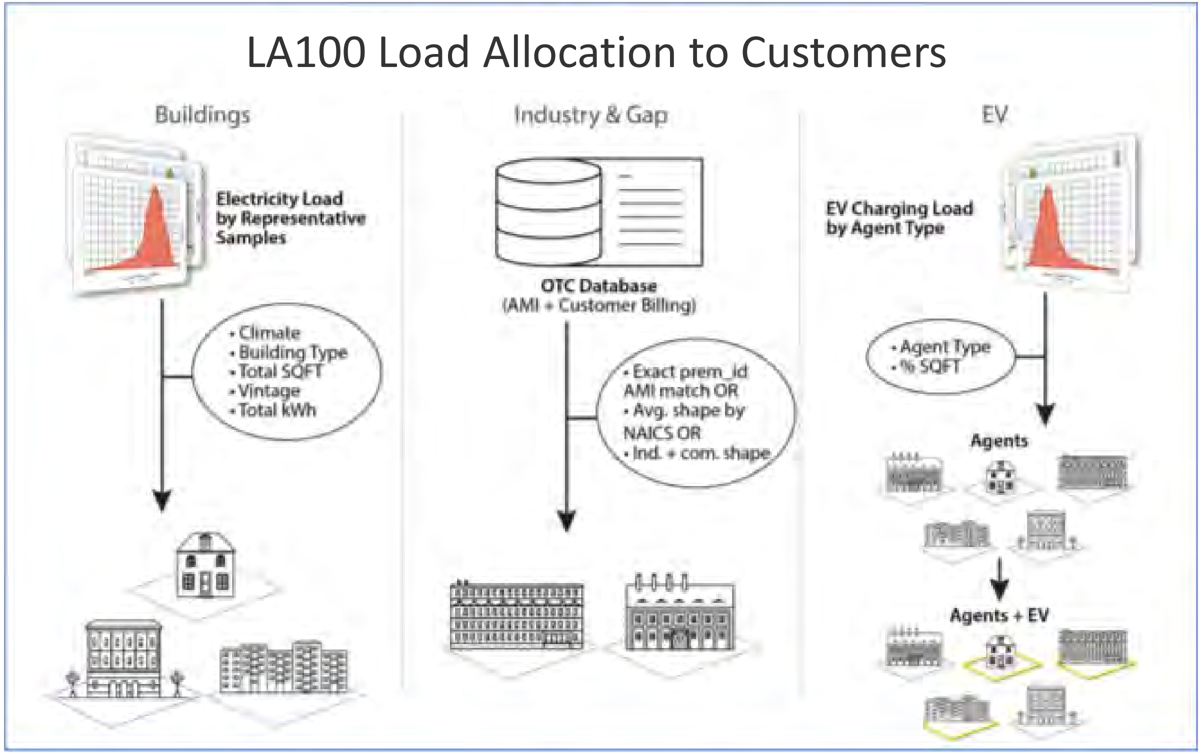
Electrical Model

1,675 x 4.8kV Feeders

Step 2: Add Loads and Solar

Matched to individual customers:

- Building loads
- Electric vehicle loads
- Distributed solar adoption
- Customer storage (soon)



Step 3: Lots of Computations

500,000+ Powerflows

Pre-Processing
- Powerflow with PyDSS → Identify Items to Fix

DiTTO
- Feeder Model Creation
- dGen Solar Deployments

Hosting Capacity Setup
- Hosting Capacity Solar Deployments → Config File Creation

Impact Analysis Setup
- Config File Generation

DISCO
- Model Input Creation → Configure Model Inputs → Run Powerflow with PyDSS
- Post Processing Layer 1: Impact and Hosting Capacity Analysis
- Post Processing Layer 2: Create Summary Dataframes

DISCO
Distribution grid Integration Solution COst

Data Analysis
LA100-specific Jupyter Notebooks, scripts, etc.

- Interactive Data Analysis

Step 3: Lots of Computations–What We Evaluate Today

Based on two time points: "peak demand" and "high solar with low demand"

1. **Violations because of 2045 load changes:**
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. **Differences in violations due to 2045 local solar**
   - Impact analysis: customer deployments
3. **Combined load and solar impact analysis:**
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare **2045 load-only** impacts to **today**

Compare 2045 **with** and **without solar**

May be better or worse with solar

Compare **2045 load** + **solar** to **today**

Distribution System Analysis

Initial Run Results (4.8kV)

SB100-Moderate Load 2045

Reminder: Load and Solar Adoption Levels

- Peak 4.8kV Load = 3.2 GW
  - Bottom-up Building Models (moderate efficiency)
  - Light-duty Electric Vehicles (moderate adoption)
- Total 4.8kV Rooftop Solar = 2.1 GW
  - Based on dGen results (moderate adoption)

Initial Run: **Load** Analysis, 2045 Compared to Today

Based on two time points: “peak demand” and “high solar with low demand”

1. **Violations because of 2045 load changes:**
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. Differences in violations due to 2045 local solar
   - Impact analysis: customer deployments
3. Combined load and solar impact analysis:
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare 2045 load-only impacts to today

Compare 2045 with and without solar

Compare 2045 Load + Solar to today

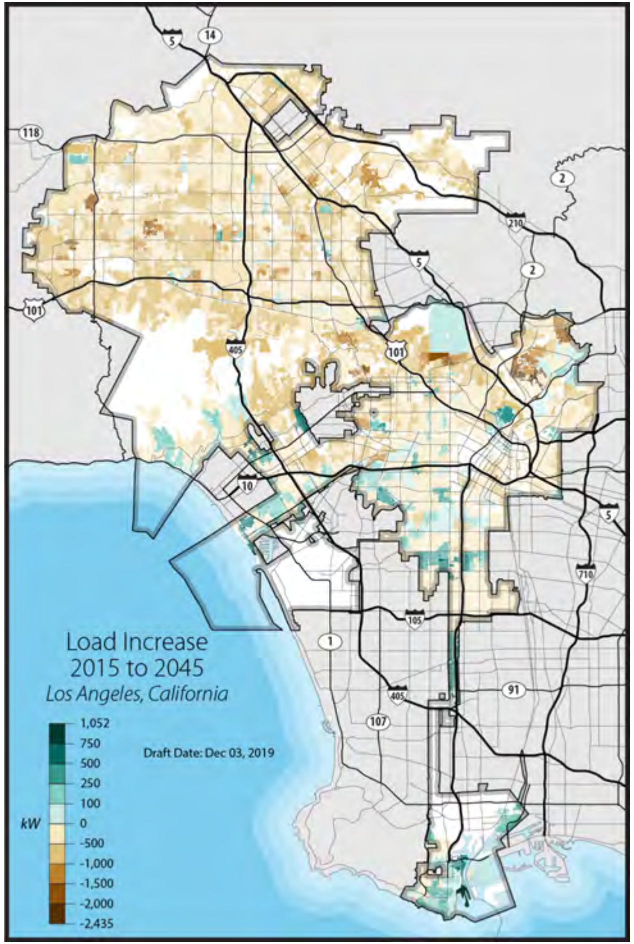
Initial Run
4.8kV

Distribution Impacts of **Load-only**

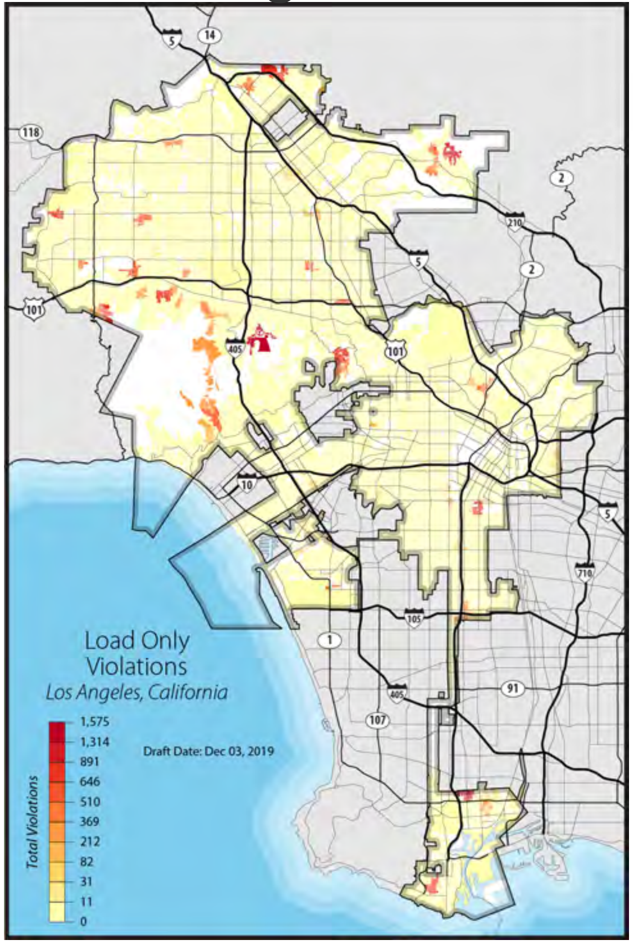
(2045 SB100 Moderate)

Note: Loads do not include demand response shifts

2045 Load Increase



Resulting Violations

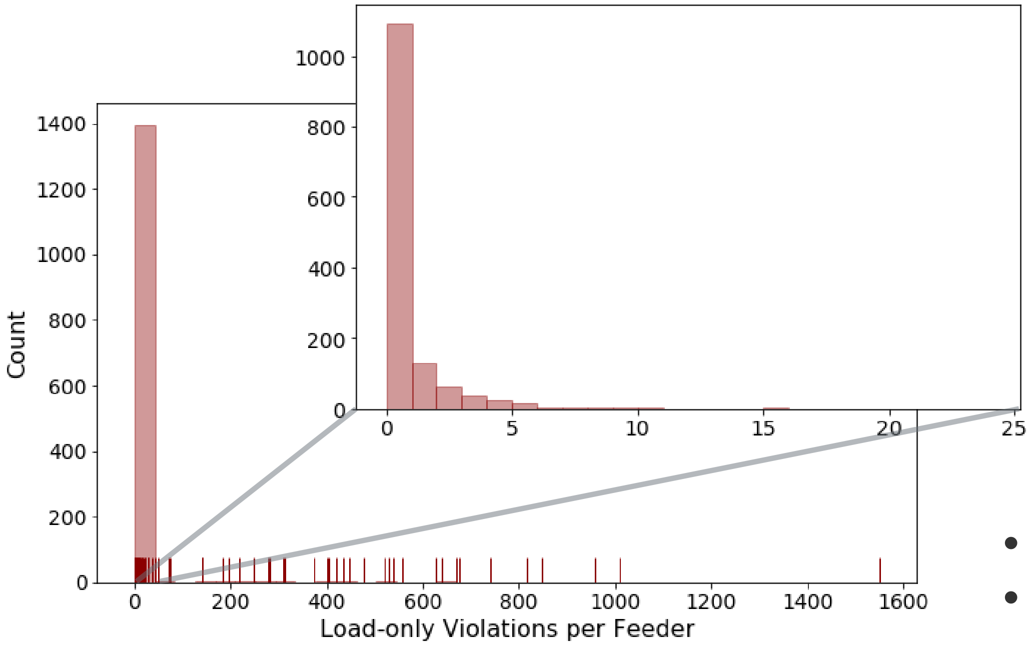


Initial Run – For Discussion Purposes Only; Subject to Change

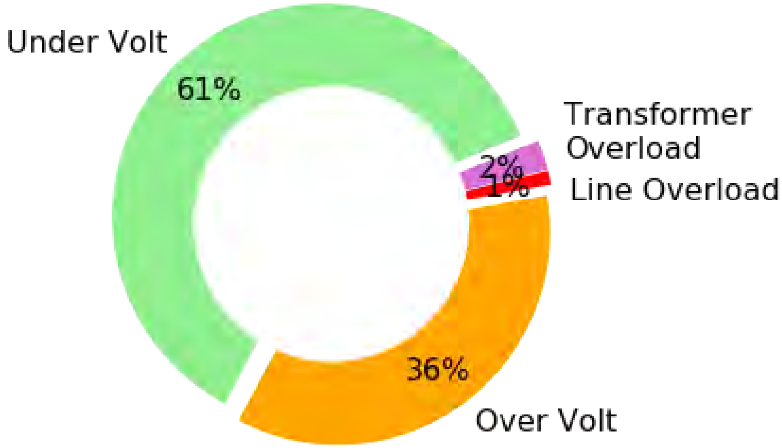
Initial Run: Distribution Impacts of 2045 **Load-only** (continued)

4.8kV, 2045 SB100-Moderate

Violations per Feeder (Load-only)



Violation Type Breakdown



- 86% of feeders OK with new loads
- Most remaining require only few upgrades

Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run: **Solar** Analysis, 2045 With and Without Solar

Based on two time points: “peak demand” and “high solar with low demand”

1. Violations because of 2045 load changes:
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. Differences in violations due to 2045 local solar
   - Impact analysis: customer deployments
3. Combined load and solar impact analysis:
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare 2045 load-only impacts to today

Compare 2045 with and without solar

May be better or worse with solar

Compare 2045 Load + Solar to today

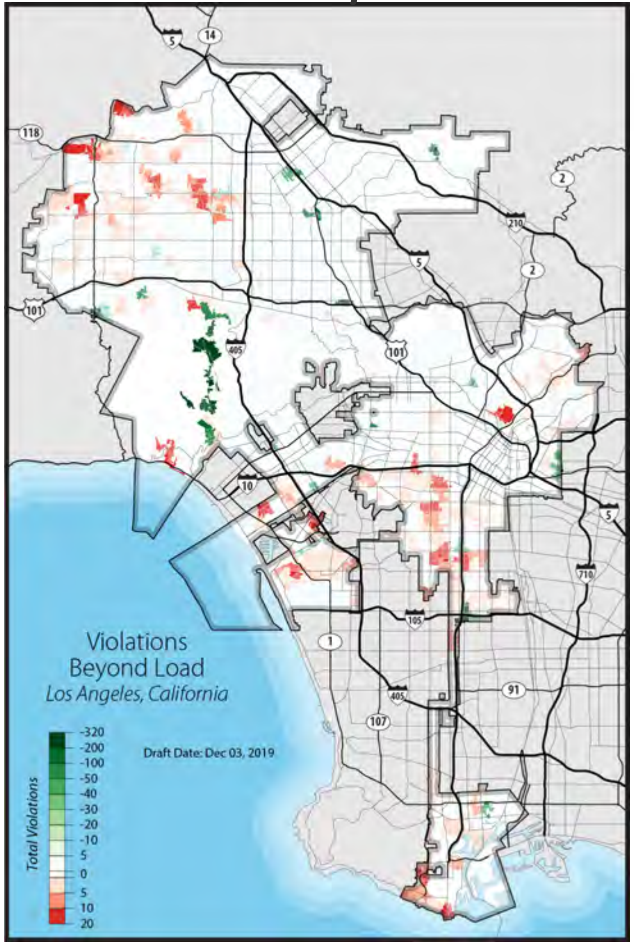
Initial Run
4.8kV

Distribution Impacts of **Rooftop Solar**

(2045 SB100 Moderate)

Note: Loads do not include demand response shifts

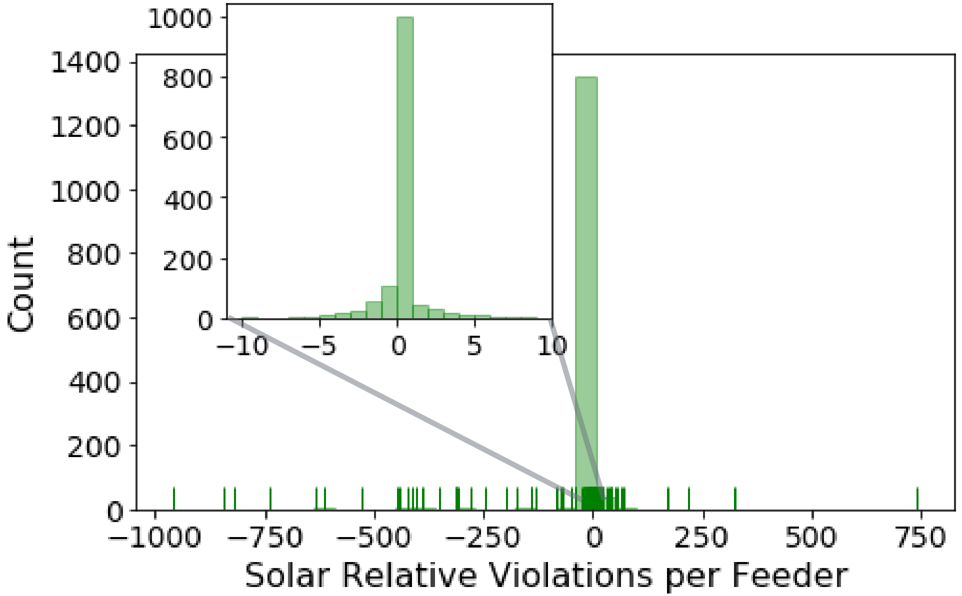
Violations Beyond Load

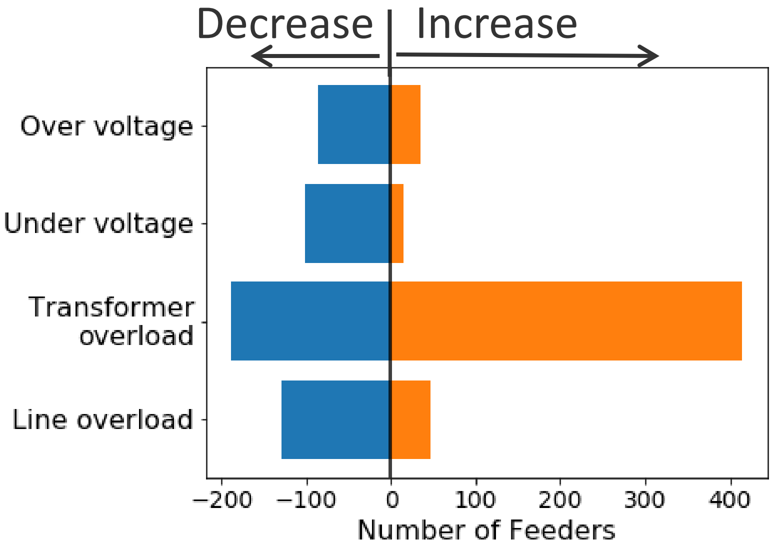


Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run: Distribution Impacts of 2045 **Rooftop Solar** (continued)

Violation Change with Solar vs. Load-only





Total Violation Count:

- Up: 14% of Feeders
- Down: 18%
- The same: 69%

Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run: **Load and Solar** Analysis, 2045—Will It Fit?

Based on two time points: “peak demand” and “high solar with low demand”

1. Violations because of 2045 load changes:
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. Differences in violations due to 2045 local solar
   - Impact analysis: customer deployments
3. Combined load and solar impact analysis:
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare 2045 load-only impacts to today

Compare 2045 with and without solar

Compare 2045 Load + Solar to today

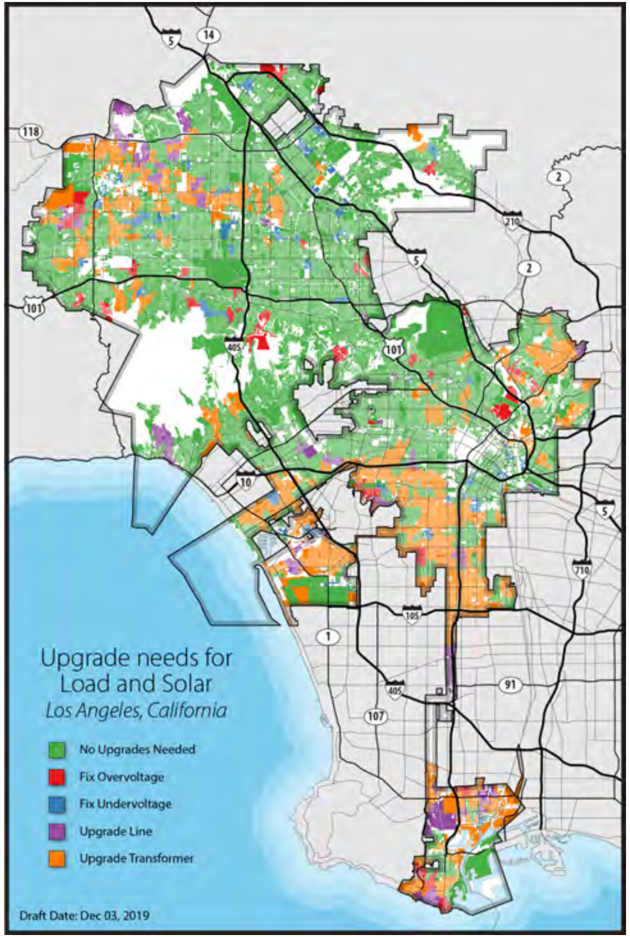
Are Upgrades Needed?

2045 SB100-Moderate

Initial Run 4.8kV

Are upgrades needed to accommodate estimated **load + rooftop solar**? If not, how hard will it be to upgrade?

Note: Loads do not include demand response shifts

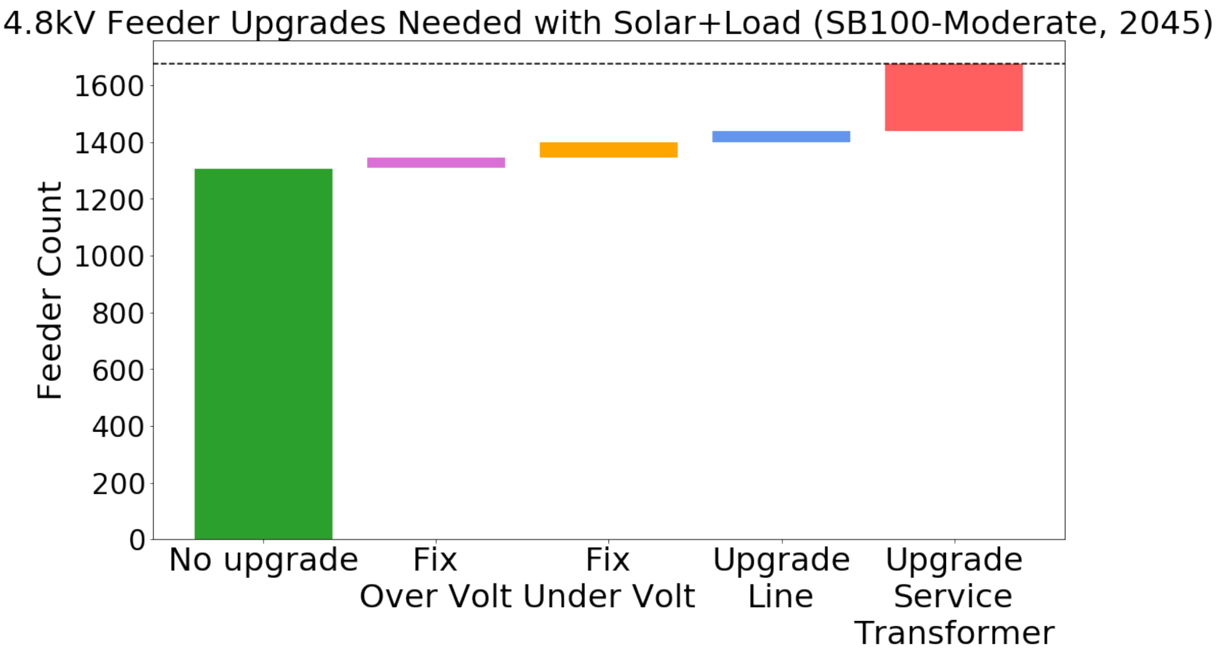


- No upgrades needed
- Fix overvoltage, typically from solar ($-$$)
- Fix undervoltage, typically from load ($-$$)
- Line upgrade ($$$+)
- Service transformer upgrade ($-$$)

Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run: Are Upgrades Needed with **Loads and Rooftop Solar?**

4.8kV, 2045 SB100-Moderate



- No upgrades needed in 78% of feeders with new loads and solar
- Only 2.3% of feeders would require line upgrades ($$$)

Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run Summary for SB100 Moderate

- **Expected load changes are OK for most (86%) 4.8kV feeders**
  - Most common concern = undervoltage
- Adding rooftop solar can both:
  - Increase violations (14% of feeders) and
  - Decrease violations (18% of feeders)
- **Most 4.8kV feeders (78%) are OK with both solar and rooftop PV**
- But these results will change for Final Run

Coming Up

March

- Distribution analysis and upgrade cost estimates for 2030, including:
  - Analysis of large-scale local solar on 34.5kV lines

June

- Distribution analysis and upgrade costs for 2030 and 2045 based on:
  - Revised loads, including EVs, buses, and fast charging
  - Local storage
  - Full time-series analysis for impacts and curtailments

Questions?

LA100

The Los Angeles 100% Renewable Energy Study

The Los Angeles 100% Renewable Energy Study

Highlights and Learnings from Additional Pathways, Initial Run Results of LA100 Scenarios

Daniel Steinberg, Bryan Palmintier, Jaquelin Cochran

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Agenda for This Session

Review results and initial insights from the full set of LA100 scenarios

- Investment pathways
- Operations
- Distribution analysis
- Environment analysis

Initial Run (Today) vs. Final Run (June AG Presentation)

What's Included in Initial Run

Electricity Demand: **Initial** Run

Evaluation of the impacts of **short-duration** outages of generation and transmission on resource adequacy

Single weather year

Initial cost and performance assumptions; **initial** constraints on in-basin resources

What's Not Included Today but Will Be in Final Run

Electricity Demand: **Final** Run

Evaluation of **long-duration** outages of generation and transmission on resource adequacy and system operations

Multiple weather-years

Final cost and performance assumptions; **revised** constraints on in-basin resources

Limits on transmission upgrades and new builds

Evaluation of power flow under steady-state and transient conditions

Today's Focus

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

Initial Insights: LA100 Scenarios

Preliminary Insights

1. Substantial renewable energy additions both within and outside of the LA basin are required to achieve the 100% target, irrespective of the pathway
2. Associated with high penetrations of variable generation are high rates of *economic* curtailment
3. Storage plays a critical role in shifting variable generation diurnally
4. In the absence of eligibility of RECs (and associated natural gas generation), capacity that does not rely on variable resources (bio, geo, mid- to long-duration storage) is highly valuable
5. Although substantial transmission capacity is available to carry energy into the basin, in the absence of mitigating options, longer-duration transmission outages (both in- and out-of-basin) could be challenging
6. Changes in the eligibility of compliance options can have substantial implications for total costs

Preliminary Insights

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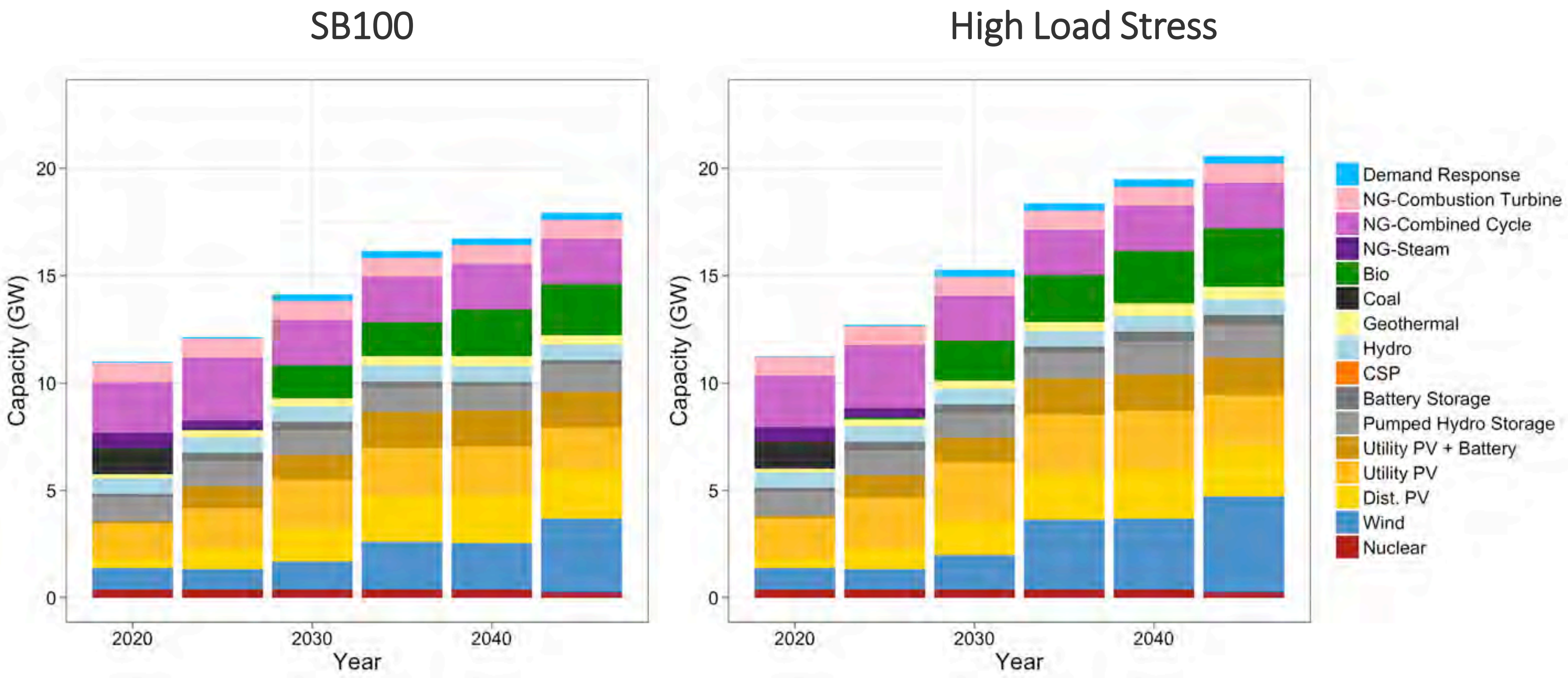
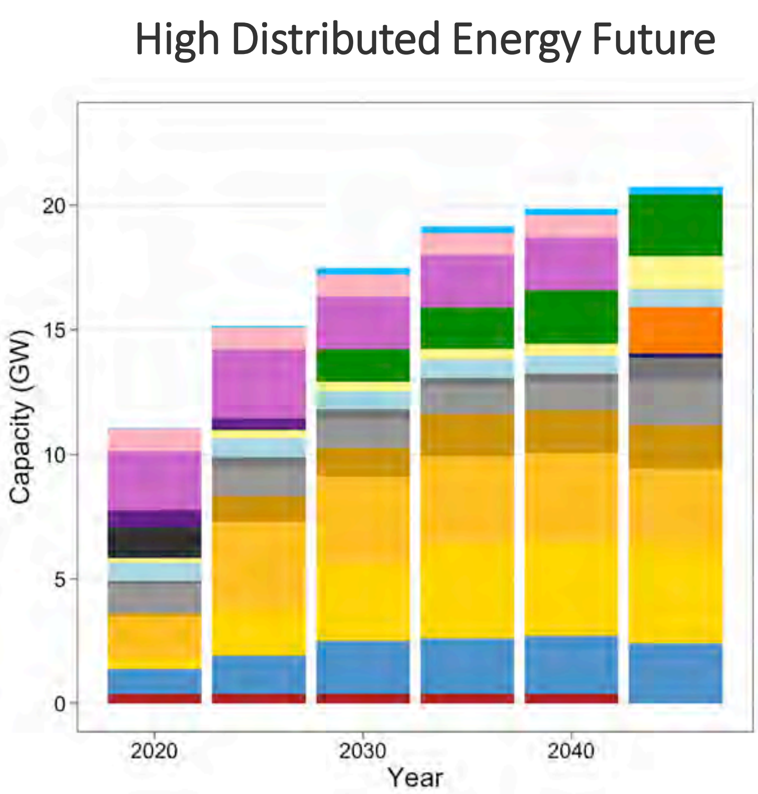
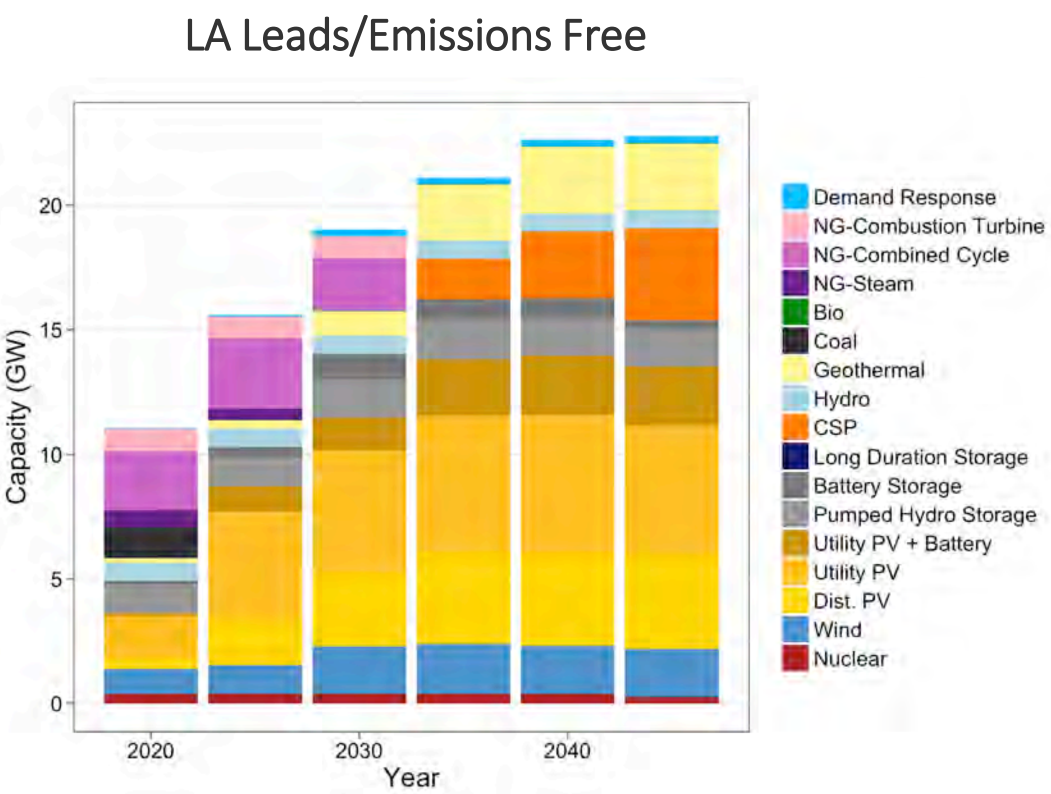
Initial Run, Capacity: **SB100** and **High Load Stress**



Initial Run – For Discussion Purposes Only; Subject to Change

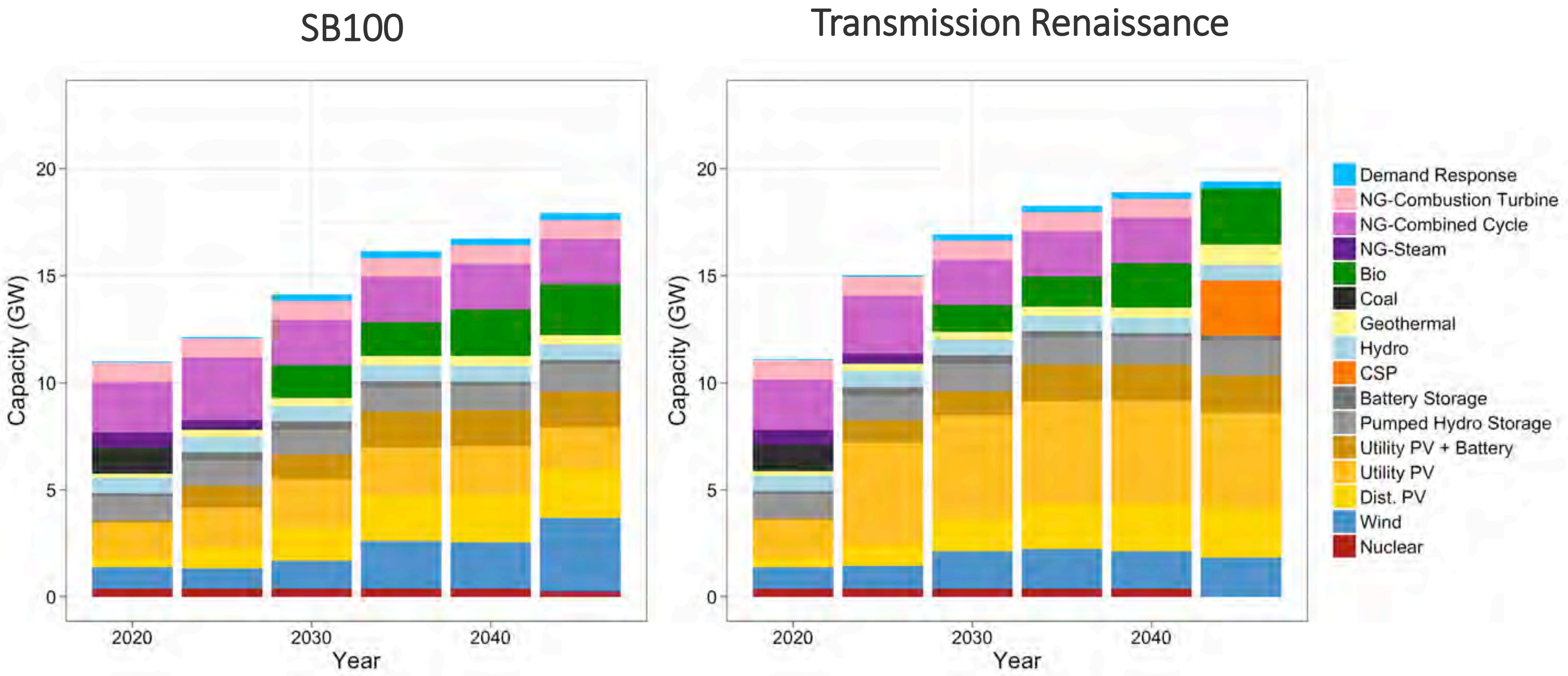
Initial Run, Capacity: **High Distributed Energy Future** and **LA Leads**



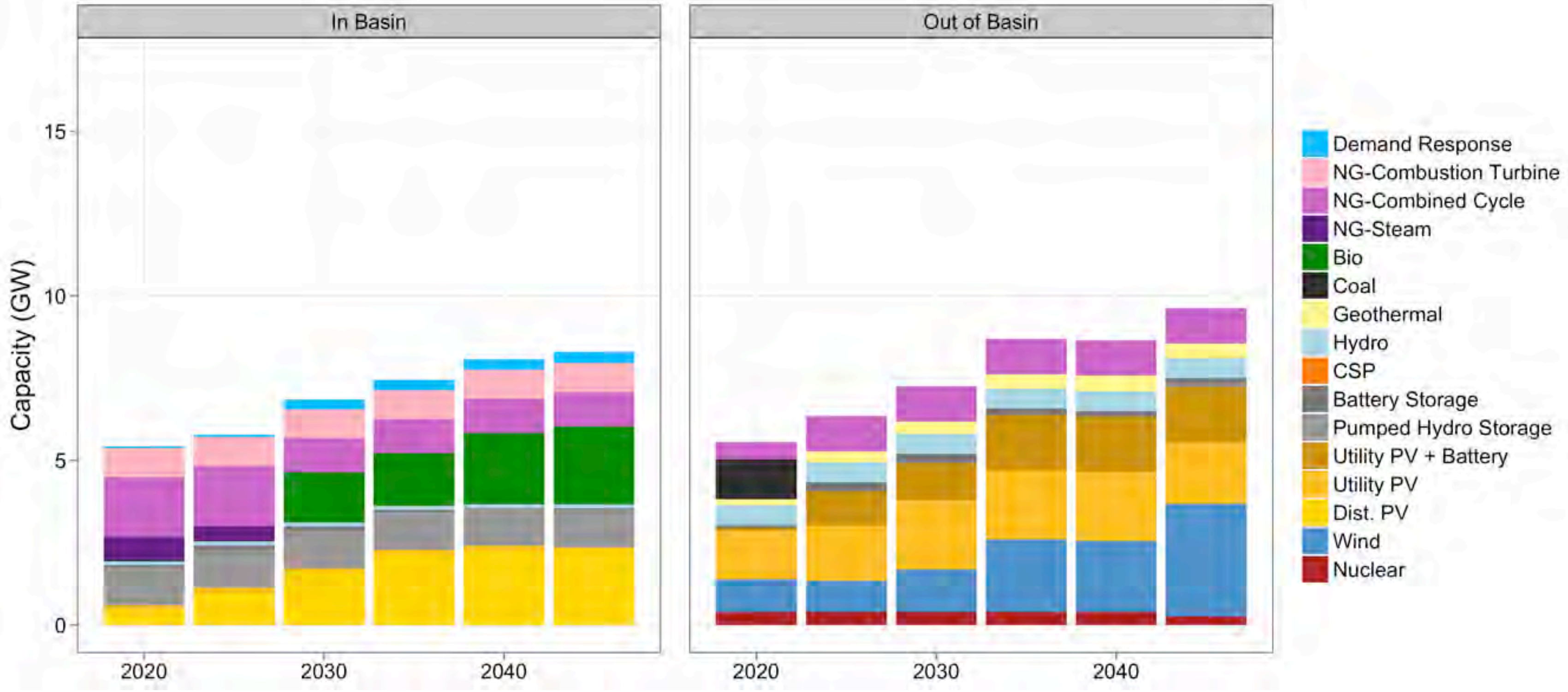


Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, Capacity: **SB100** and **Transmission Renaissance**

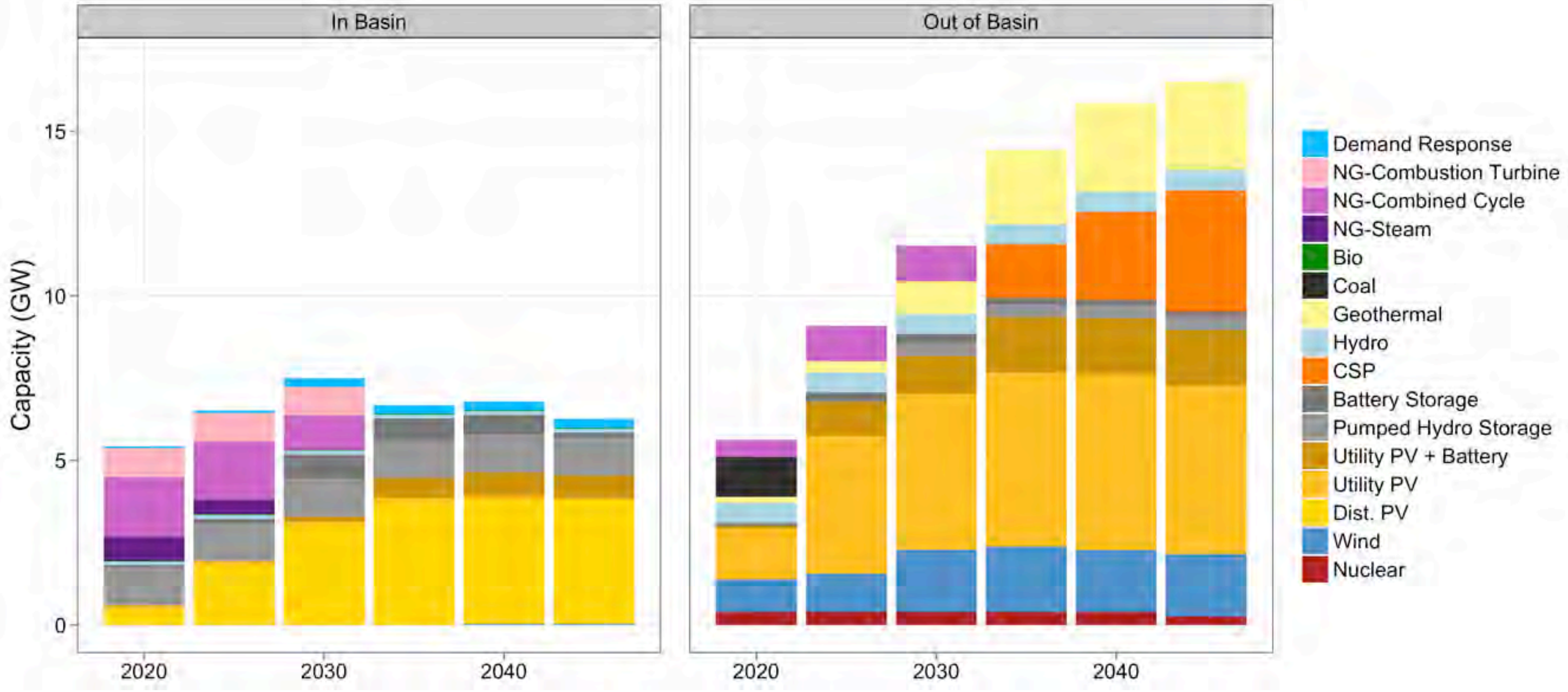


Initial Run Insights: **High Stress**, Basin-Level Capacity



Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run Insights: **LA Leads**, Basin-Level Capacity



Initial Run – For Discussion Purposes Only; Subject to Change

Summary: Renewable Resources

- **Substantial investment in new renewable resources** will be required to meet the target
- **Wind and PV are built across all scenarios**
- Scenarios that do not allow generation from natural gas and/or biofuel require either **non-variable renewable generation** (such as geothermal) or **longer-duration storage**

Preliminary Insights

1. Substantial renewable energy additions both within and outside of the LA basin are required to achieve the 100% target, irrespective of the pathway
2. Associated with high penetrations of variable generation are high rates of *economic* curtailment
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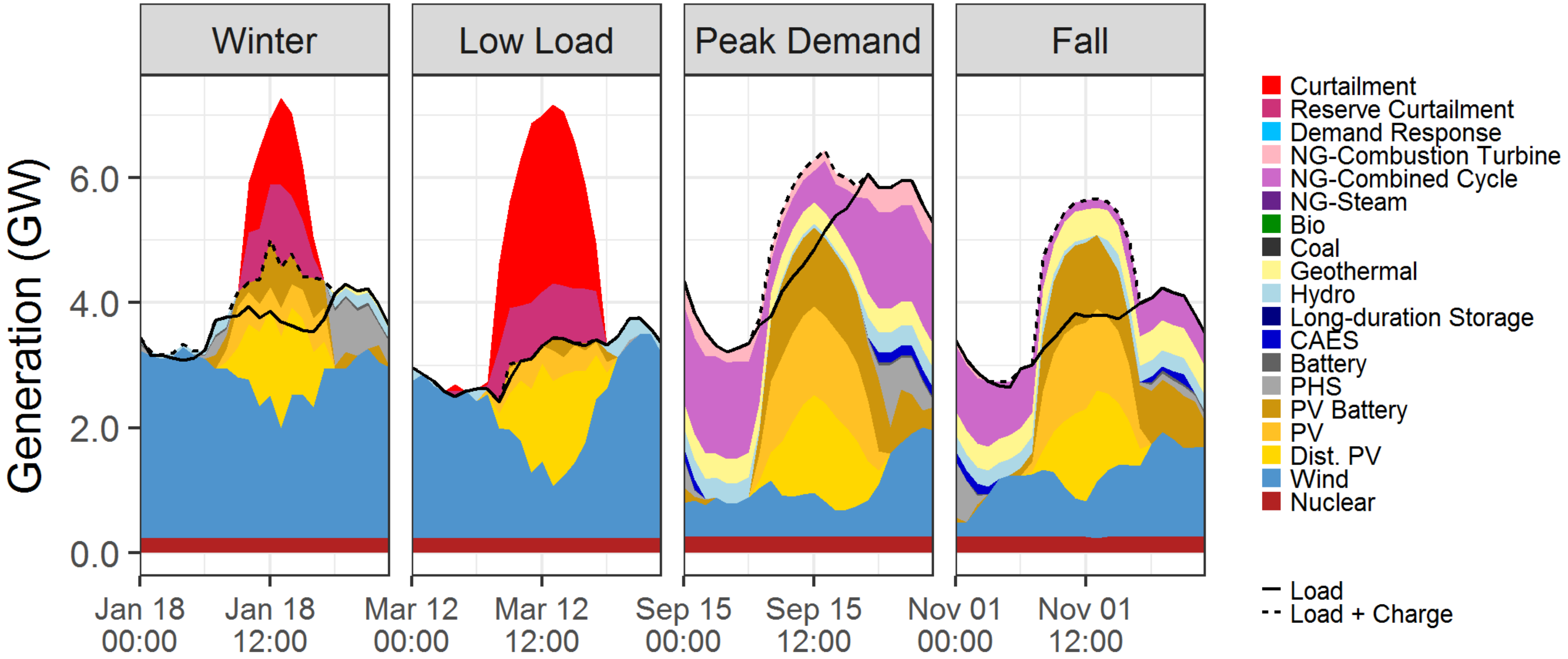
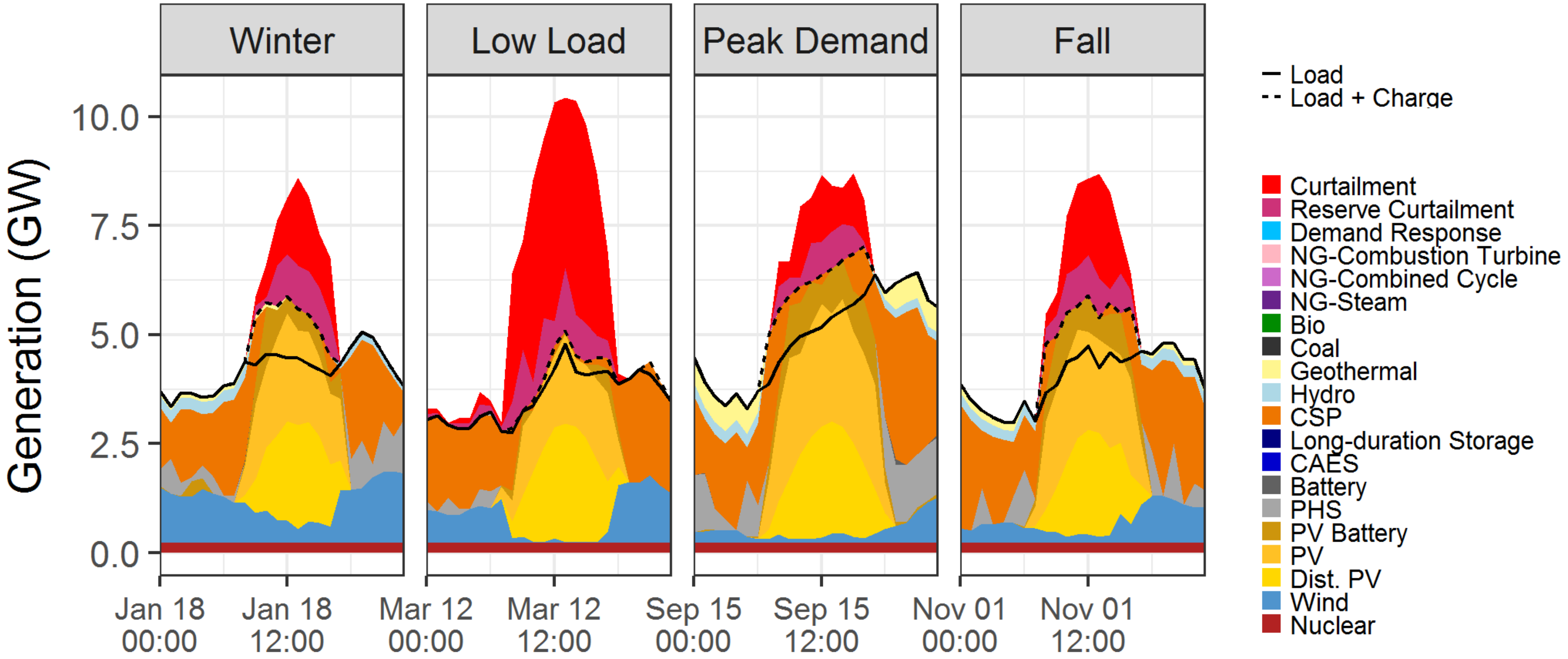
Initial Run, **SB100**: Curtailment largely during low-load and high resource quality days



Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, **LA Leads**: Higher penetrations of solar capacity leads to substantially greater levels of curtailment



Initial Run – For Discussion Purposes Only; Subject to Change

Summary: Curtailment

- In cases that do not allow contributions from natural gas or biofuel, further "overbuilding" of solar photovoltaic capacity leads to **higher rates of curtailment**
- Trade-offs between:
  - Overbuilding and curtailing variable generation
  - Storage
  - Non-variable renewable resources
  - Transmission

Preliminary Insights

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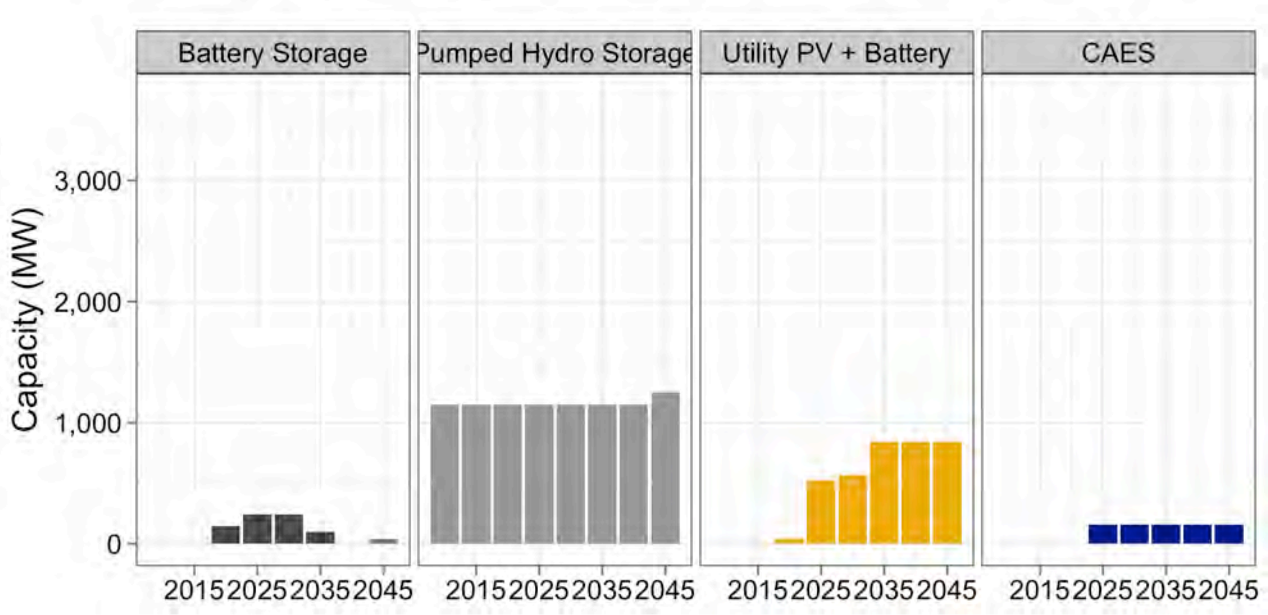
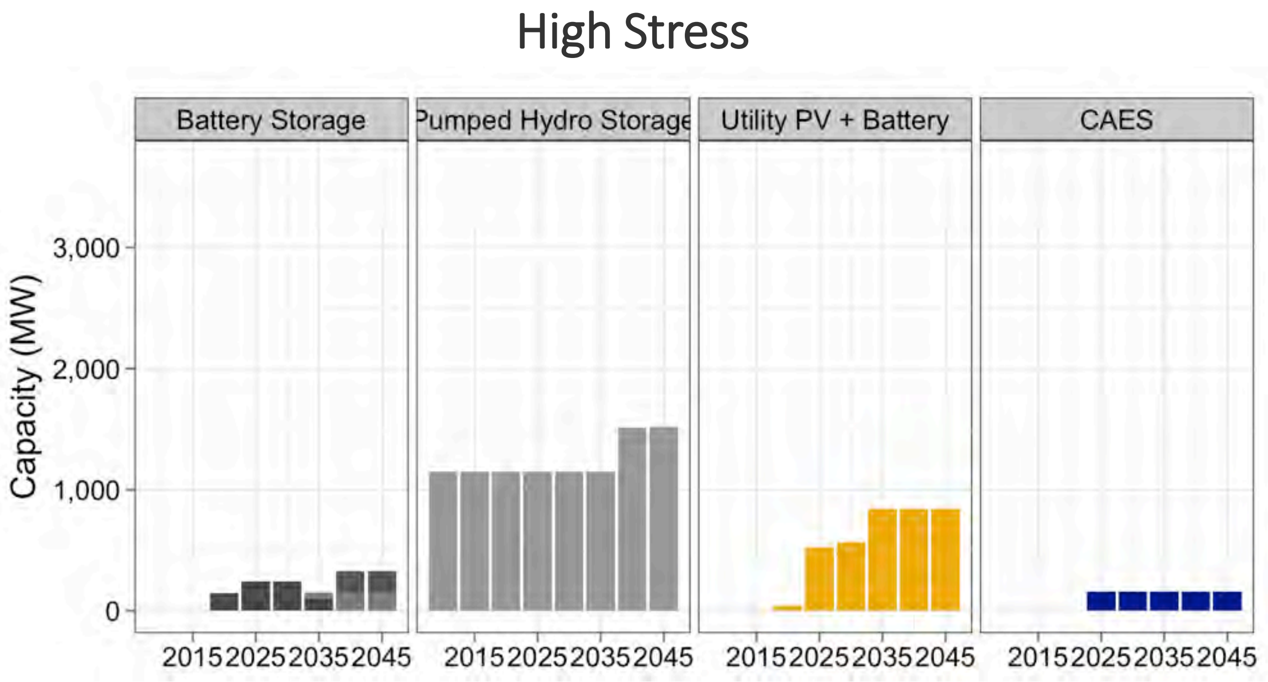
Storage is crucial to all scenarios

SB100



Initial Run – For Discussion Purposes Only; Subject to Change

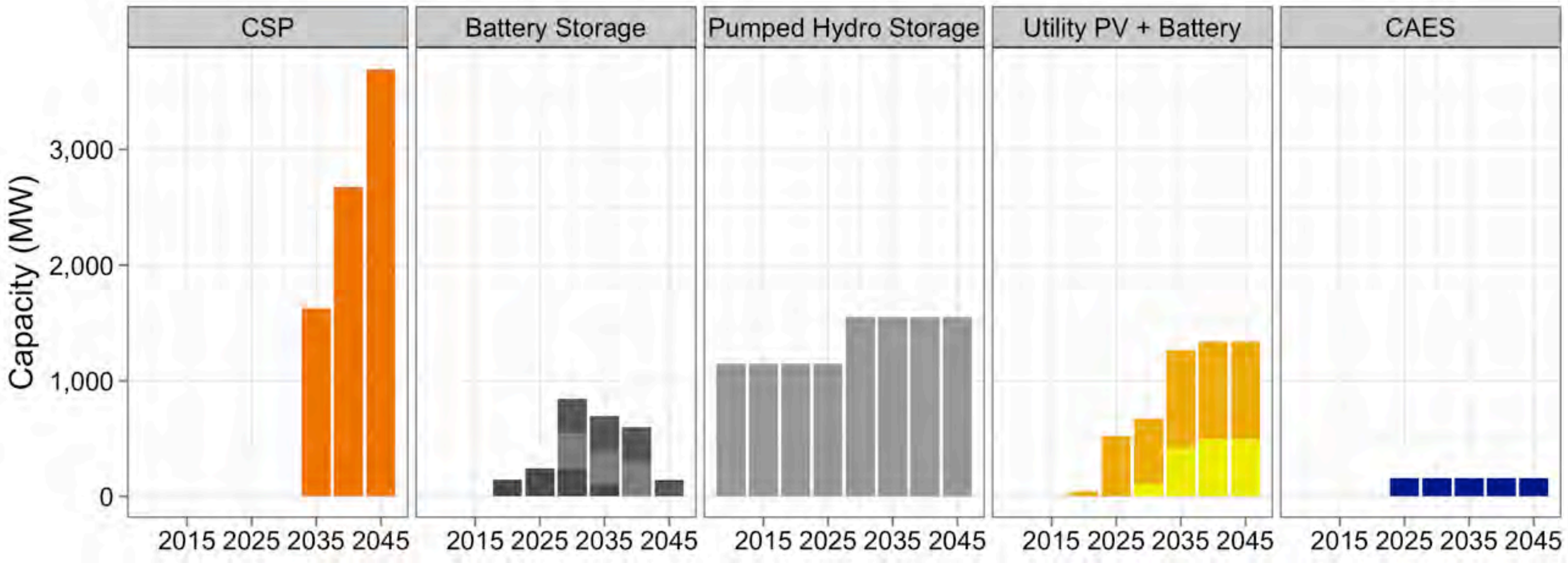
Storage is crucial to all scenarios



Initial Run – For Discussion Purposes Only; Subject to Change

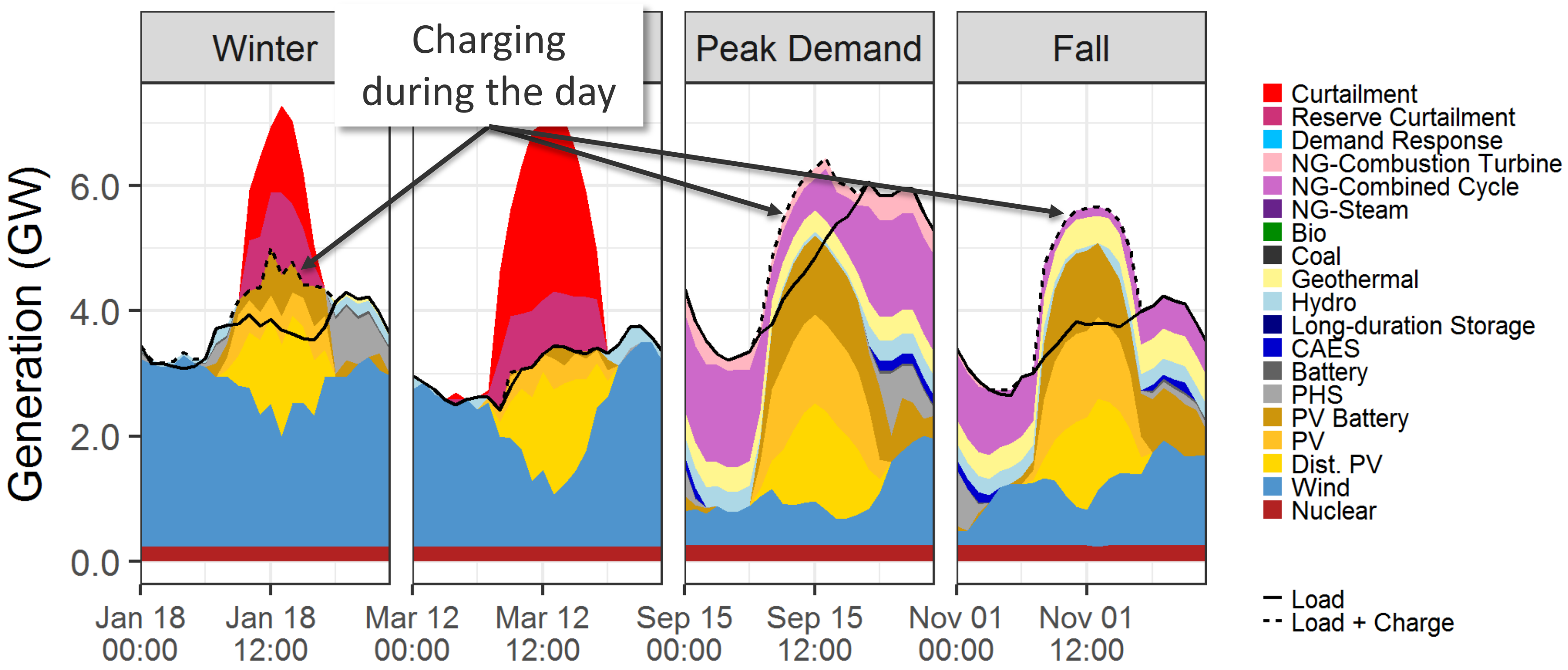
Storage is crucial to all scenarios

LA Leads



Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, **SB100**: Storage—Battery, PV+battery, pumped storage, CAES used to shift excess renewable generation



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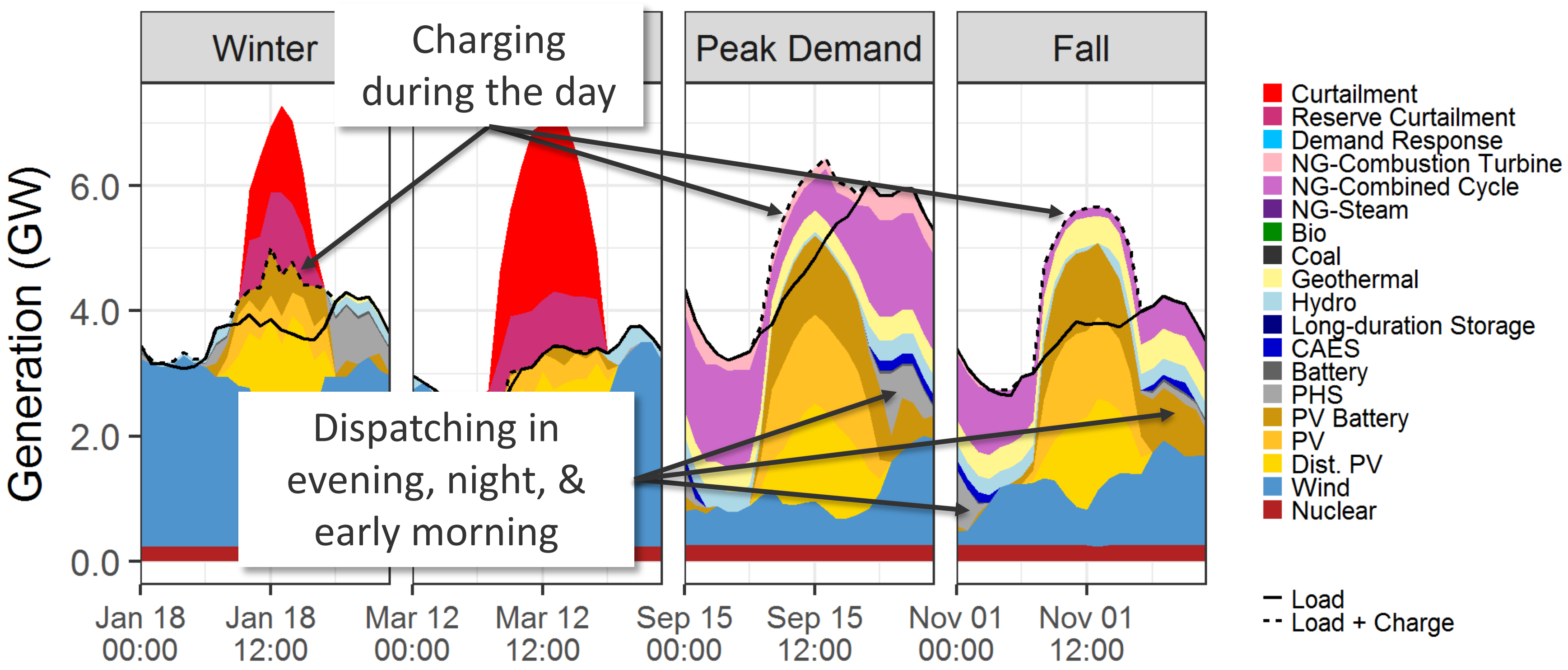
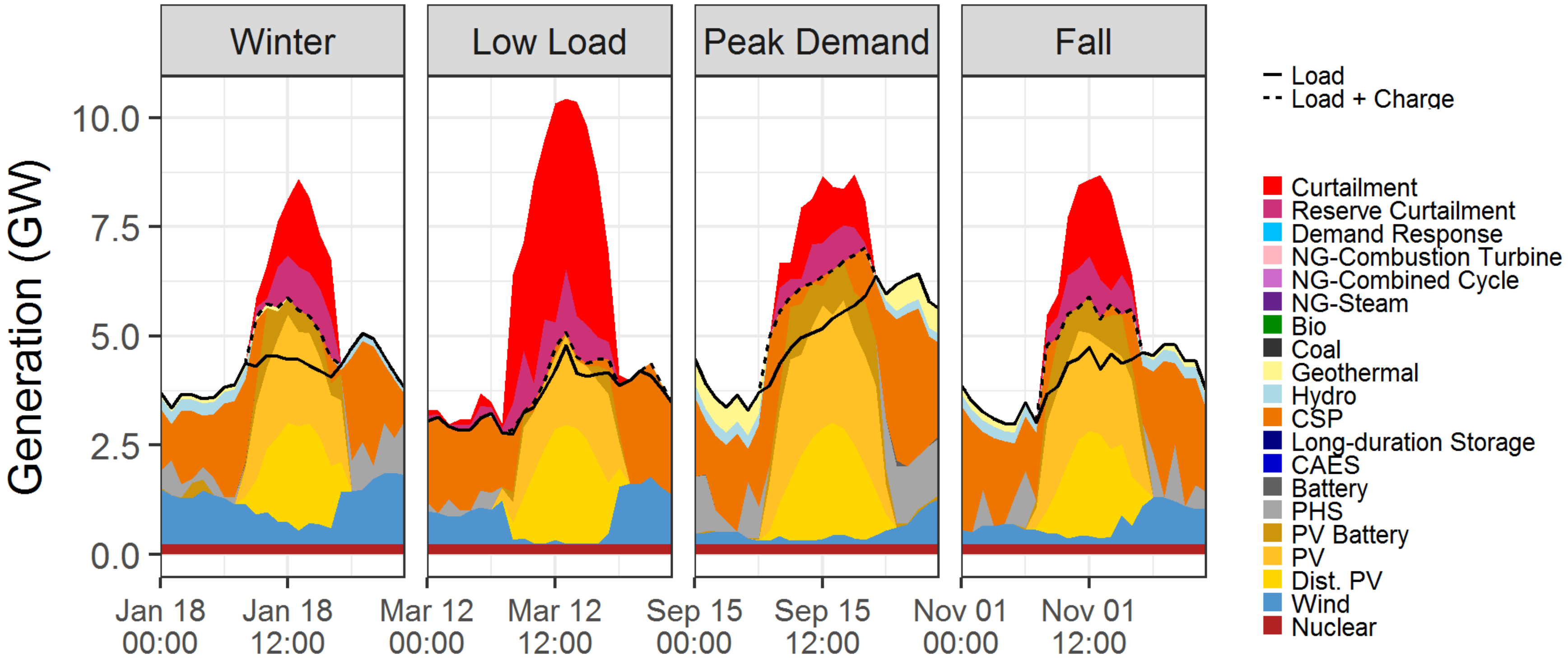


Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, **LA Leads**: CSP with 8-hour storage is used to serve a substantial portion of energy during night hours



Battery siting within the city could pose challenges

Summary: Storage

- The **lowest-cost** options (on a levelized basis) to produce renewable energy are **wind and PV technologies**
- These technologies have **variable resources** and therefore do not always produce energy when it is needed
- **Storage allows re-dispatch** of the variable energy
- Under scenarios that do not allow contributions from natural gas or biofuel, **longer-duration storage becomes more valuable**
- **Storage siting in-basin** could present challenges

Preliminary Insights

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2. Associated with high penetrations of variable generation are high rates of *economic* curtailment
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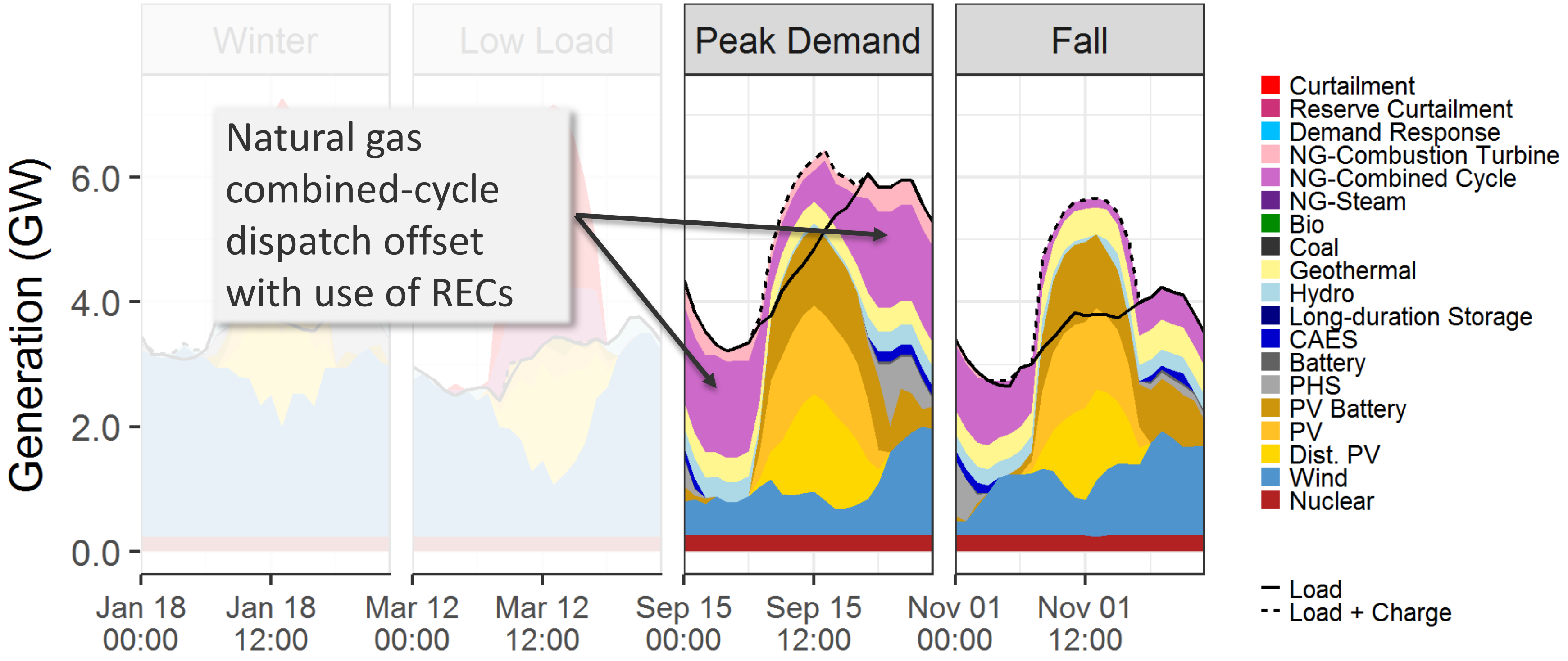
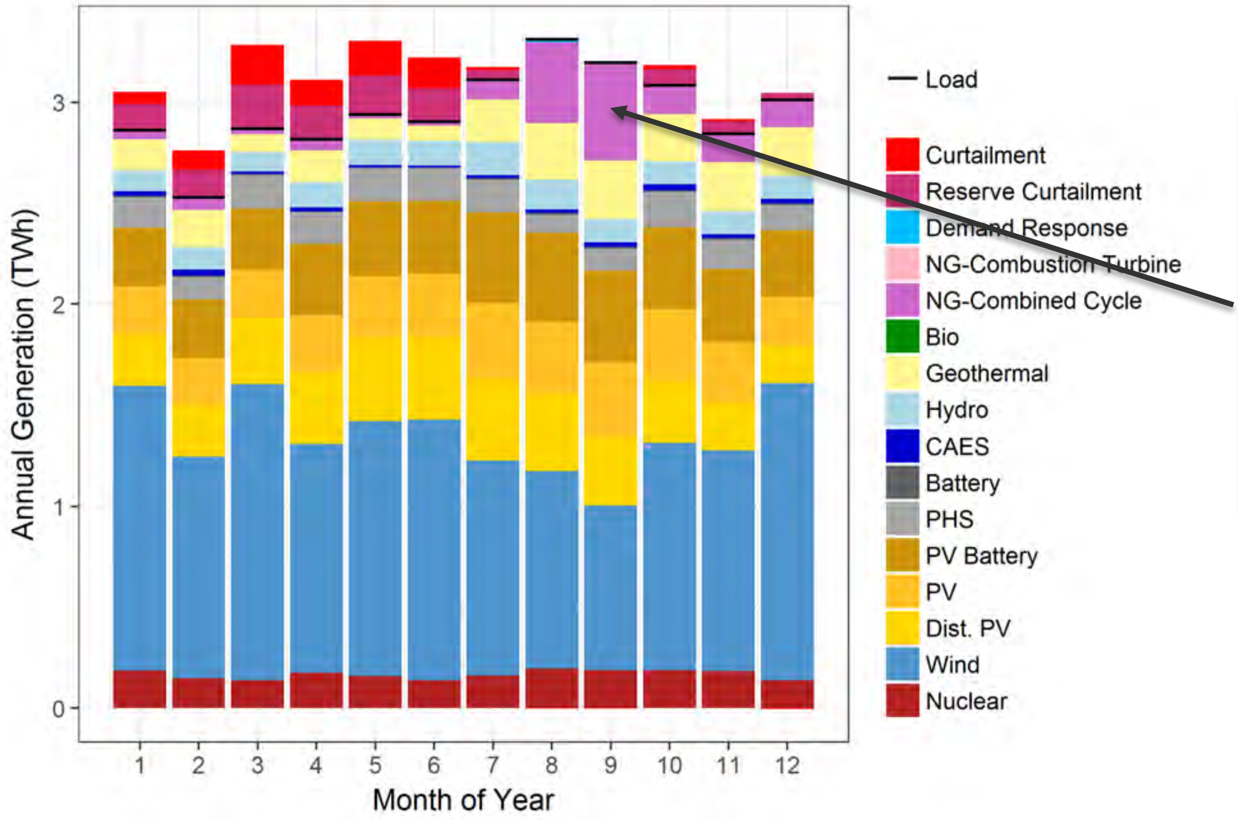
6. Changes in the eligibility of compliance options can have substantial implications for total costs

Initial Run: Eligibility of RECs allows use of existing in-basin natural gas generation during times stress or low renewable resource



Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, **SB100**: Natural gas combined-cycle accounts for ~6% of total generation

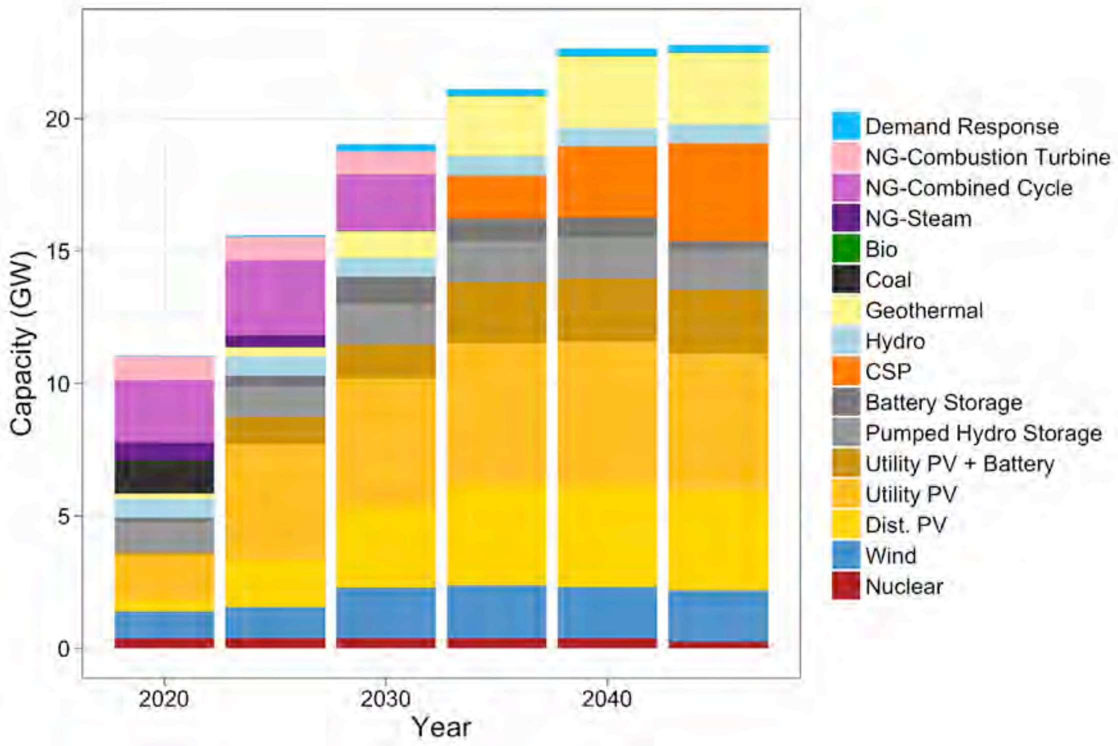


Substantial contributions during peak months, but overall usage is minimal over the year

Initial Run – For Discussion Purposes Only; Subject to Change

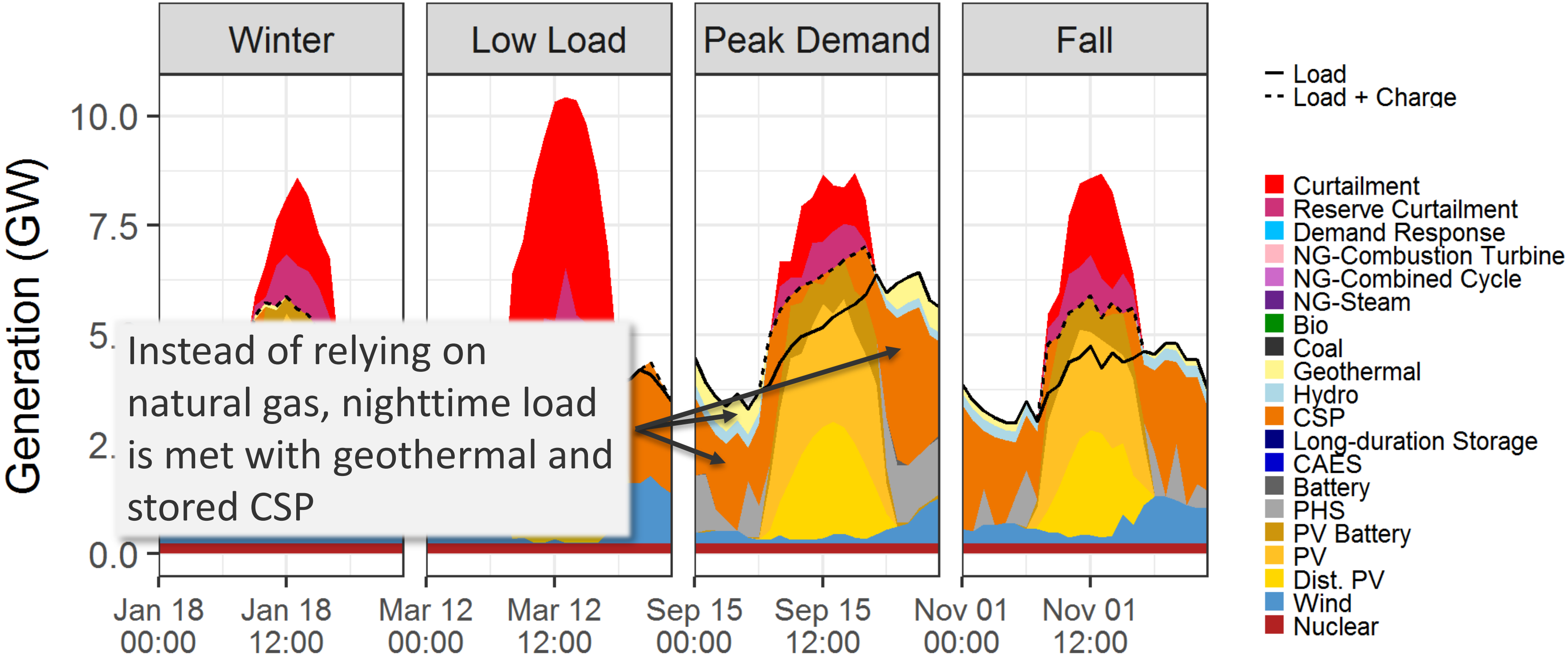
Restricting the eligibility of natural gas and biomass requires reliance on storage and other dispatchable renewable generation

LA Leads



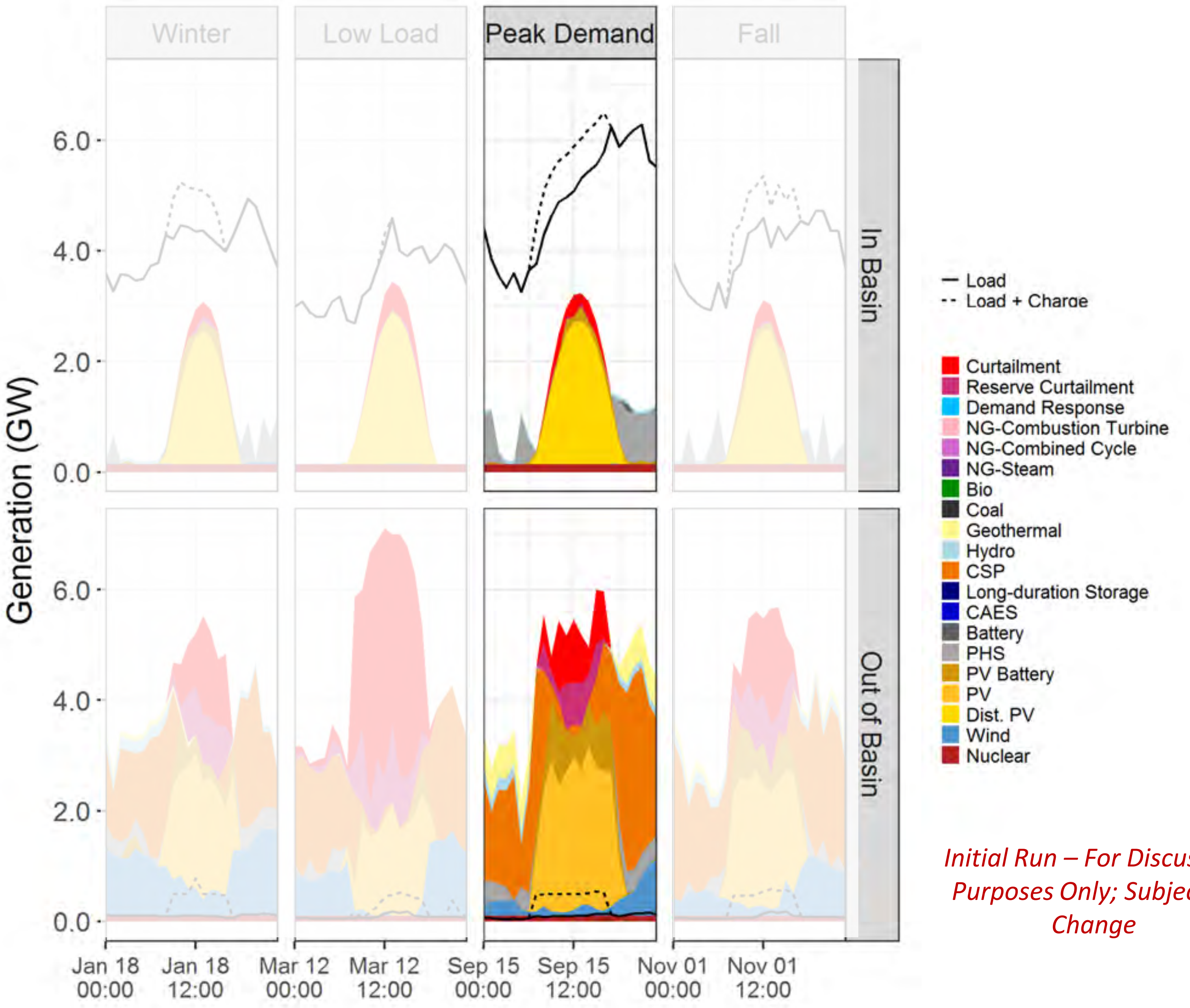
Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, **LA Leads**: Morning, evening, and night hours met with wind, storage, and geothermal



Initial Run – For Discussion Purposes Only; Subject to Change

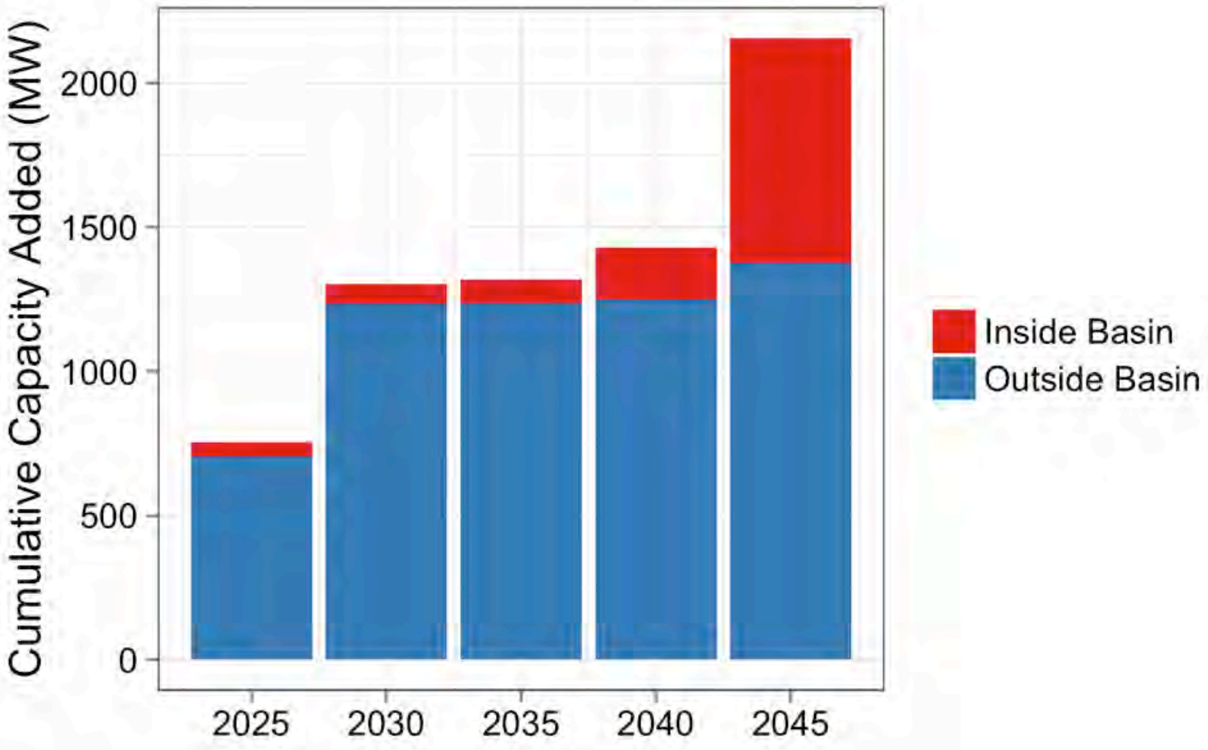
Initial Run, **LA Leads**: Relying on a greater share of out-of-basin storage resources during morning, evening, night hours



Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run, *LA Leads*: Greater reliance on out-of-basin resources requires more out- and in-basin transmission

LA Leads, Transmission Upgrades



Summary: RECs

- RECs and associated natural gas generation:
  - Provide energy during times of **stress** (e.g., high load) and during times of **low renewable resource quality**
  - **Reduce the amount of higher-cost dispatchable renewable generation or storage** (e.g., bio, geothermal, 8-hour storage)

Preliminary Insights

1. Substantial renewable energy additions both within and outside of the LA basin are required to achieve the 100% target, irrespective of the pathway
2. Associated with high penetrations of variable generation are high rates of *economic* curtailment
3. Storage plays a critical role in shifting variable generation diurnally
4. In the absence of eligibility of RECs (and associated natural gas generation), capacity that does not rely on variable resources (bio, geo, mid- to long-duration storage) is highly valuable
5. **Although substantial transmission capacity is available to carry energy into the basin, in the absence of mitigating options, longer-duration transmission outages (both in- and out-of-basin) could be challenging**
6. Changes in the eligibility of compliance options can have substantial implications for total costs

Preliminary Insights

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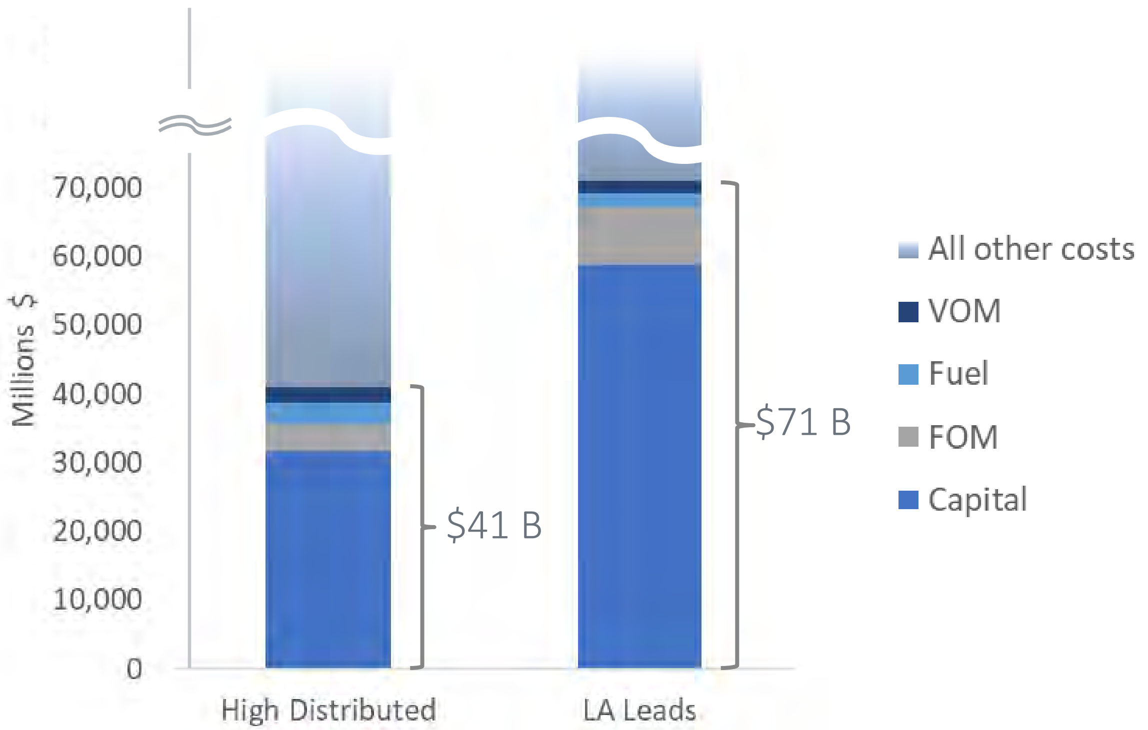
6. Changes in the eligibility of compliance options can have substantial implications for total costs

Initial Run Insights: Bulk system costs

Differences in technology eligibility and other scenario requirements lead to differences in bulk generation and transmission costs: **>30% increase in bulk system costs (2021–2045) from Highly Distributed to LA Leads**

Not including:
+ Debt-service on existing capacity
+ Distribution O&M
+ Distribution system upgrades
+ Distributed PV
+ Efficiency and DR program costs

2021-2045 Generation and Transmission Costs



Initial Run – For Discussion Purposes Only; Subject to Change

Summary

- **Substantial renewable energy additions** both within and outside of the LA basin are required to achieve the 100% target irrespective of the pathway
- **Storage plays a critical role** in shifting variable generation diurnally
- In the absence of eligibility of RECs (and associated natural gas generation), **dispatchable capacity** (bio, mid-to long duration storage) is highly valuable
- Although substantial transmission capacity is available to carry energy into the basin, in the absence of mitigating options, **longer-duration transmission outages** (both in- and out-of-basin) **could be challenging**
- Changes in the **eligibility of compliance options** can have substantial implications for total costs

Summary (continued)

- Results may change substantially
- Why?
  - Load will change substantially
  - Continuing to refine representation of the transmission system
  - Only have completed test runs of power flow
  - Will be further analyzing both short- and long-run duration outages
  - Continuing to refine resource constraints and cost assumptions

Questions?

The Los Angeles 100% Renewable Energy Study

Distribution Grid Analyses

All Scenarios

Preliminary 4.8kV Distribution Insights

1. Aggressive rooftop solar requires more widespread upgrades, but only for a minority of feeders

2. Rooftop solar adoption seems to have a larger impact than load difference on distribution upgrade needs

Caveats:

- *Modeled load data will change for Final Run*
- *Estimated rooftop solar adoption will change for Final Run*

DG and Load Are Key Differentiators for Distribution Analyses

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

Preliminary 4.8kV Distribution Insights

1. Aggressive rooftop solar requires more widespread upgrades, but only for a minority of feeders

2. Rooftop solar adoption seems to have a larger impact than load difference on distribution upgrade needs

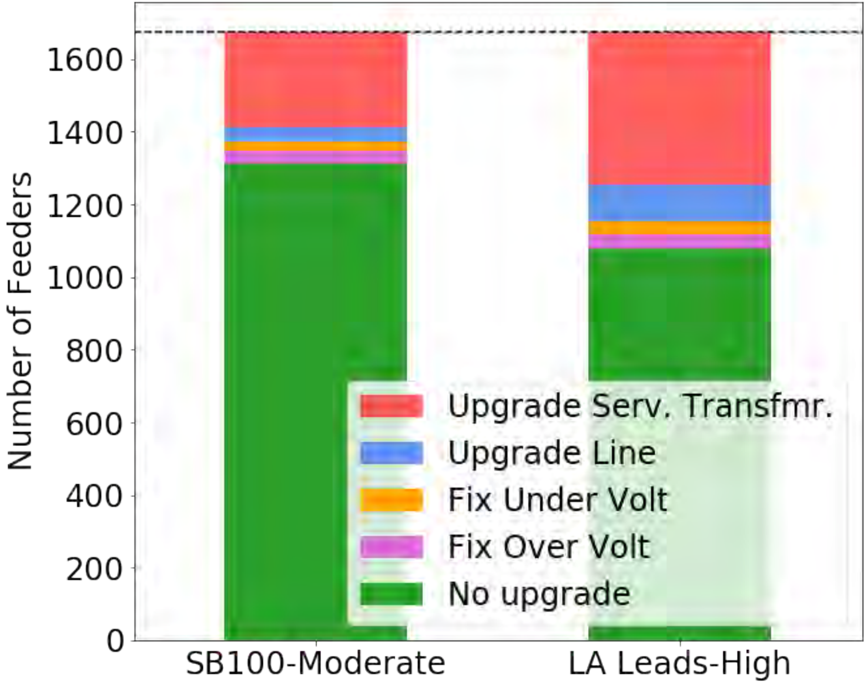
Caveats:

- *Modeled load data will change for Final Run*
- *Estimated rooftop solar adoption will change for Final Run*

Aggressive DG requires more upgrades, but only for a minority of feeders

4.8kV-only, 2045

Most common upgrade needs with Load+Solar



Upgrades Required:

- SB100: **22%** of feeders
- LA Leads: **36%** (highest)

Most common upgrade (for both):

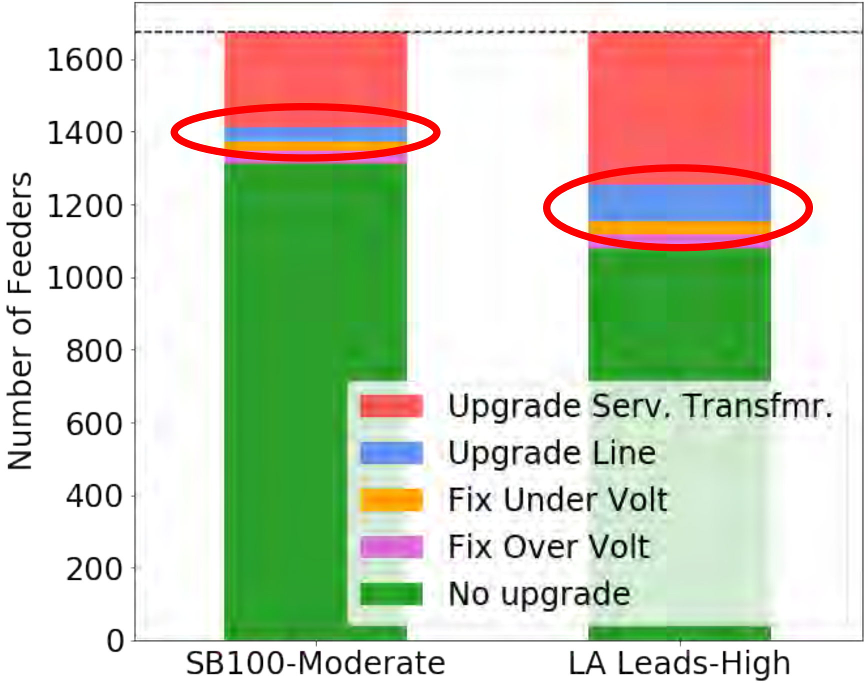
- Service transformer ($-$$)

Initial Run – For Discussion Purposes Only; Subject to Change

Aggressive DG requires more upgrades, but only for a minority of feeders

4.8kV-only, 2045

Most common upgrade needs with Load+Solar



Upgrades Required:

- SB100: **22%** of feeders
- LA Leads: **36%** (highest)

Most common upgrade (for both):

- Service transformer ($-$$)

However, considerably more feeders need line upgrades ($$$+) with increased rooftop solar

Initial Run – For Discussion Purposes Only; Subject to Change

Preliminary 4.8kV Distribution Insights

1. Aggressive rooftop solar requires more widespread upgrades, but still only for a minority of feeders

2. Rooftop solar adoption seems to have a larger impact than load difference on distribution upgrade needs

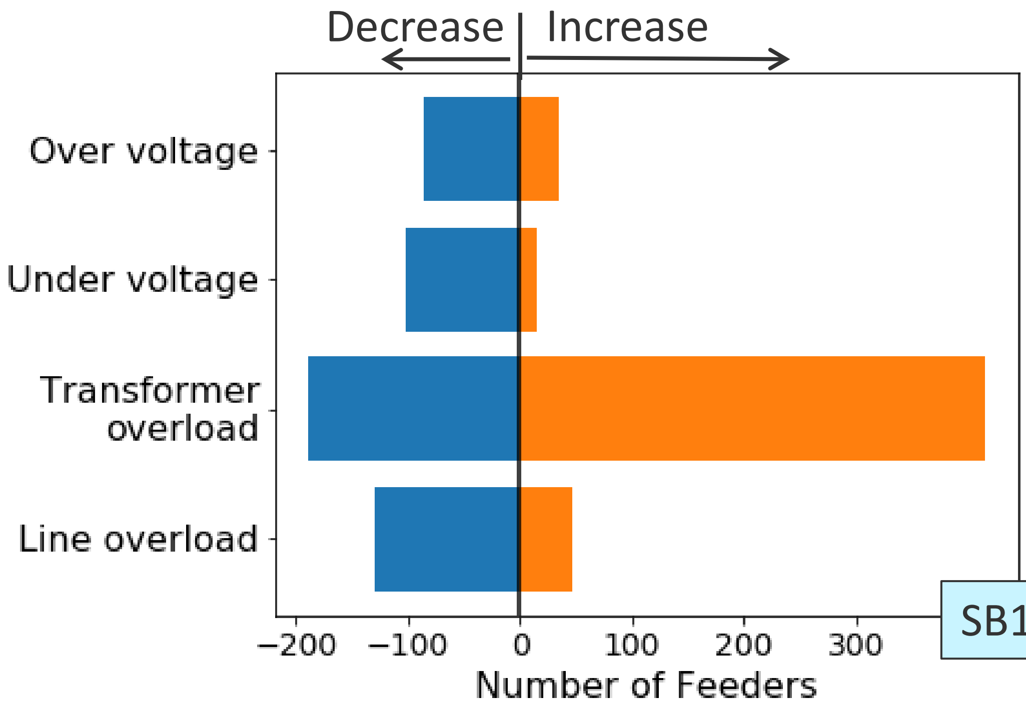
Caveats:

- *Modeled load data will change for Final Run*
- *Estimated rooftop solar adoption will change for Final Run*

Reminder: Solar may help or hurt distribution impacts compared to load alone

4.8kV-only, 2045

Violation Change with Solar vs. Load-only



SB100-Moderate

Initial Run – For Discussion Purposes Only; Subject to Change

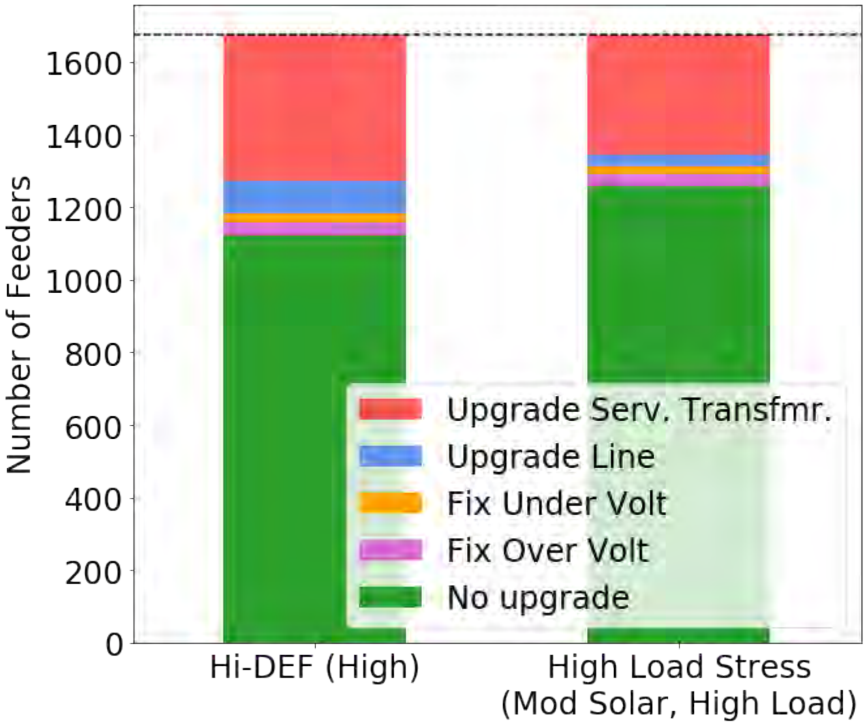
Not much difference in upgrades even with very high load levels

4.8kV-only, 2045

Upgrades Required:

- SB100: **22%** of feeders
  - Load: Mod., Solar: Mod.
- High Load Stress: **25%**
  - Load: Very High, Solar: Mod.

Most common upgrade needs with Load+Solar



Initial Run – For Discussion Purposes Only; Subject to Change

But even with (somewhat) lower loads, a switch to high rooftop solar makes a big difference

4.8kV-only, 2045

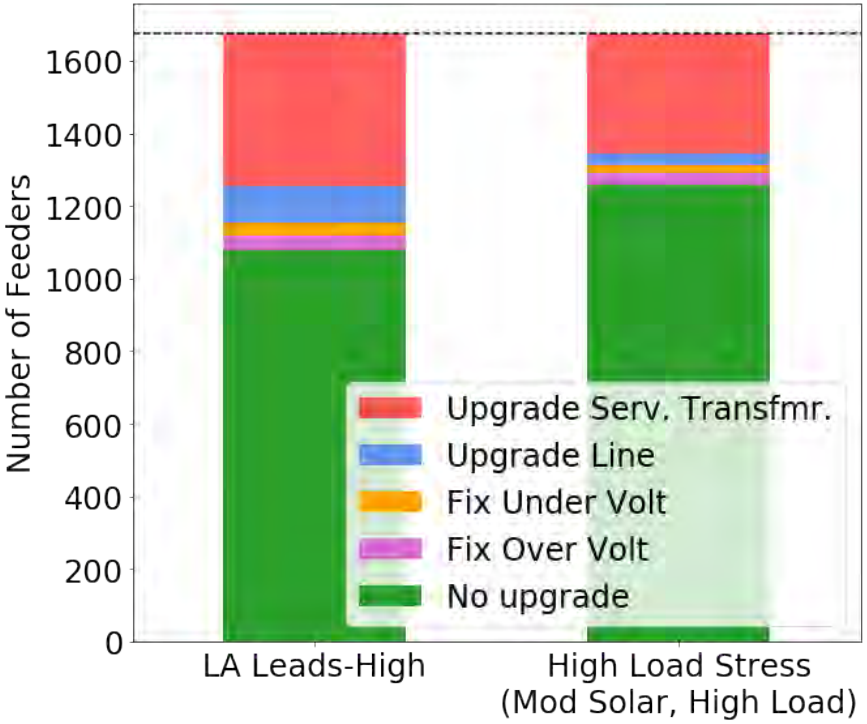
Upgrades Required:

- SB100: **22%** of feeders
  - Load: Mod., Solar: Mod.
- High Load Stress: **25%**
  - Load: Very High, Solar: Mod.
- Highly Distributed Energy Future (Hi-DEF): **33%**
  - Load: High, Solar: High

Line upgrades ($$$+) more common with increased solar (vs. load-only), but for fewer feeders than need transformer upgrades

- SB100: **2.2%**, High Load Stress: **1.8%**
- Hi-DEF: **5.3%**

Most common upgrade needs with Load+Solar



Initial Run – For Discussion Purposes Only; Subject to Change

Preliminary 4.8kV Distribution Insights

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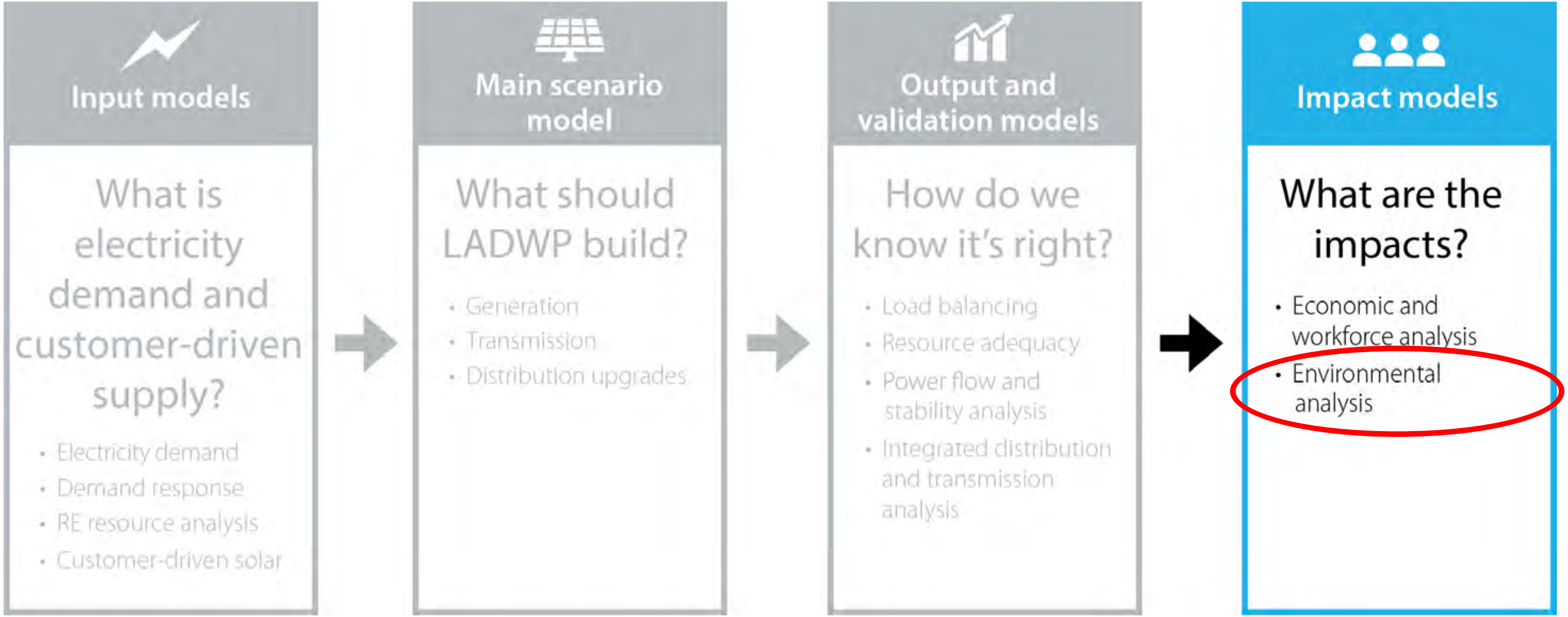
2. Rooftop solar adoption seems to have a larger impact than load difference on distribution upgrade needs

Caveats:

- *Modeled load data will change for Final Run*
- *Estimated rooftop solar adoption will change for Final Run*

Questions?

Initial Run: Impacts–Environment Analysis



Greenhouse Gas (GHG) Emissions

Purpose within LA100

How do the scenarios compare in terms of lifecycle GHG emissions?

Greenhouse Gas Emissions Analysis

Methodology

- Life cycle GHG emissions from all four life cycle phases, not just combustion
- Literature-sourced, phase-specific emissions factors for each technology

Assumptions

- Electric sector only; does not consider other GHG emissions (e.g., vehicles, buildings)
- Does not consider GHG emissions from other electric infrastructure (e.g., transmission lines, distribution lines, substations)

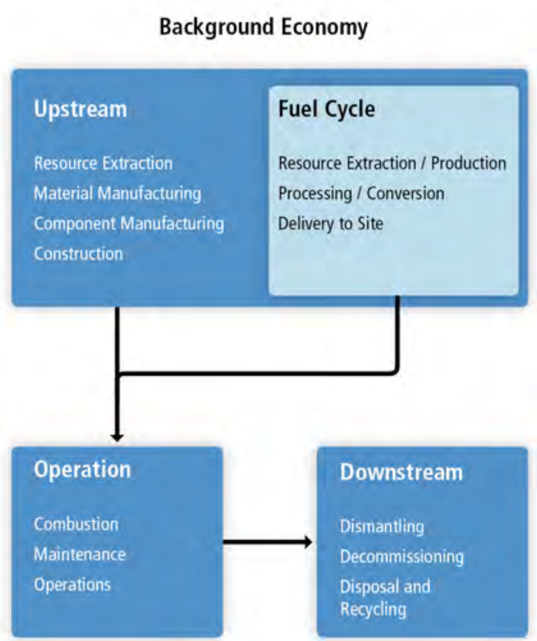
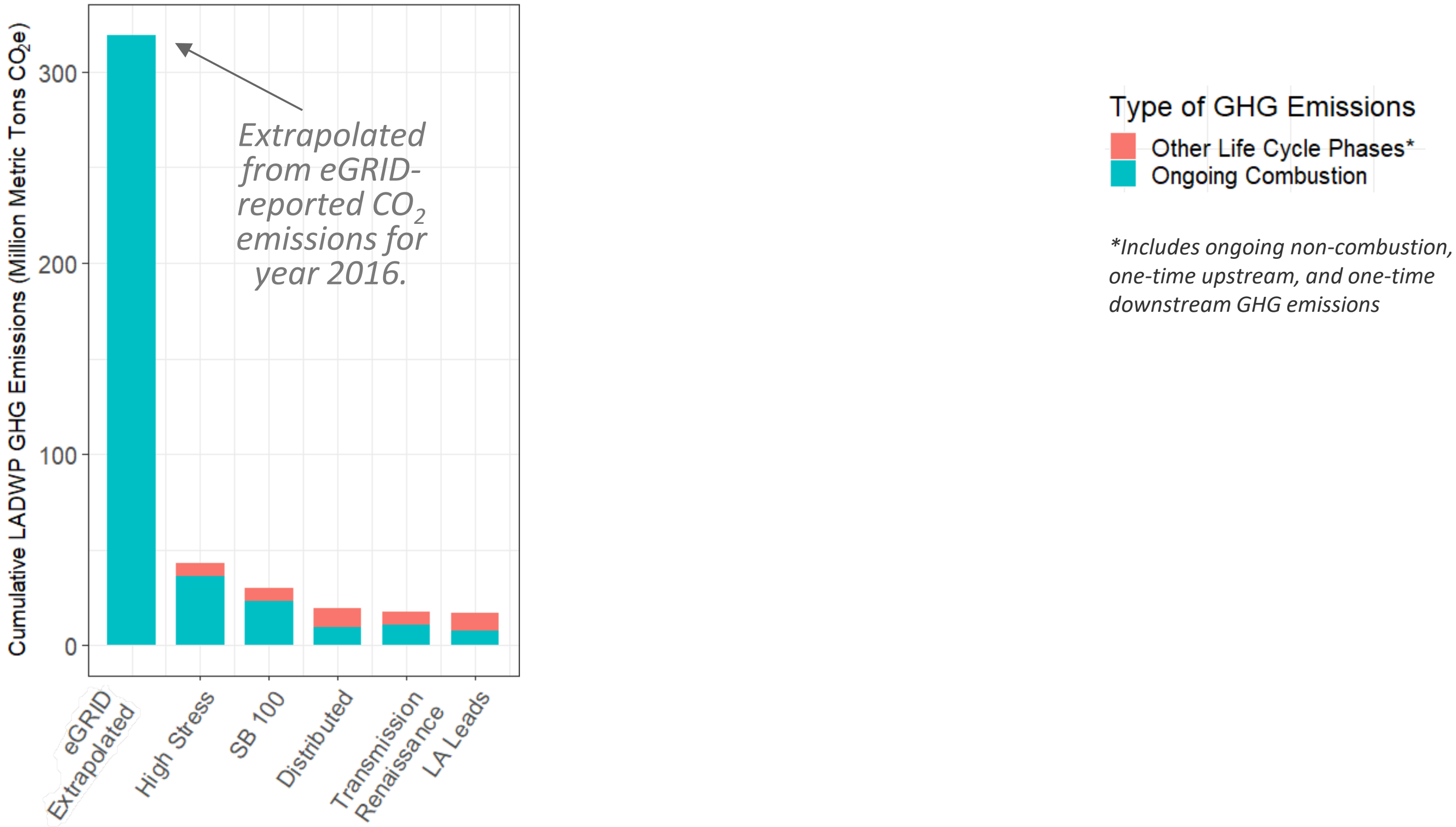


Figure from: Sathaye, J., Lucon, O., Rahman, A., Christensen, J., Denton, F., Fujino, J., ... & Shmakin, A. (2011). Renewable energy in the context of sustainable development.

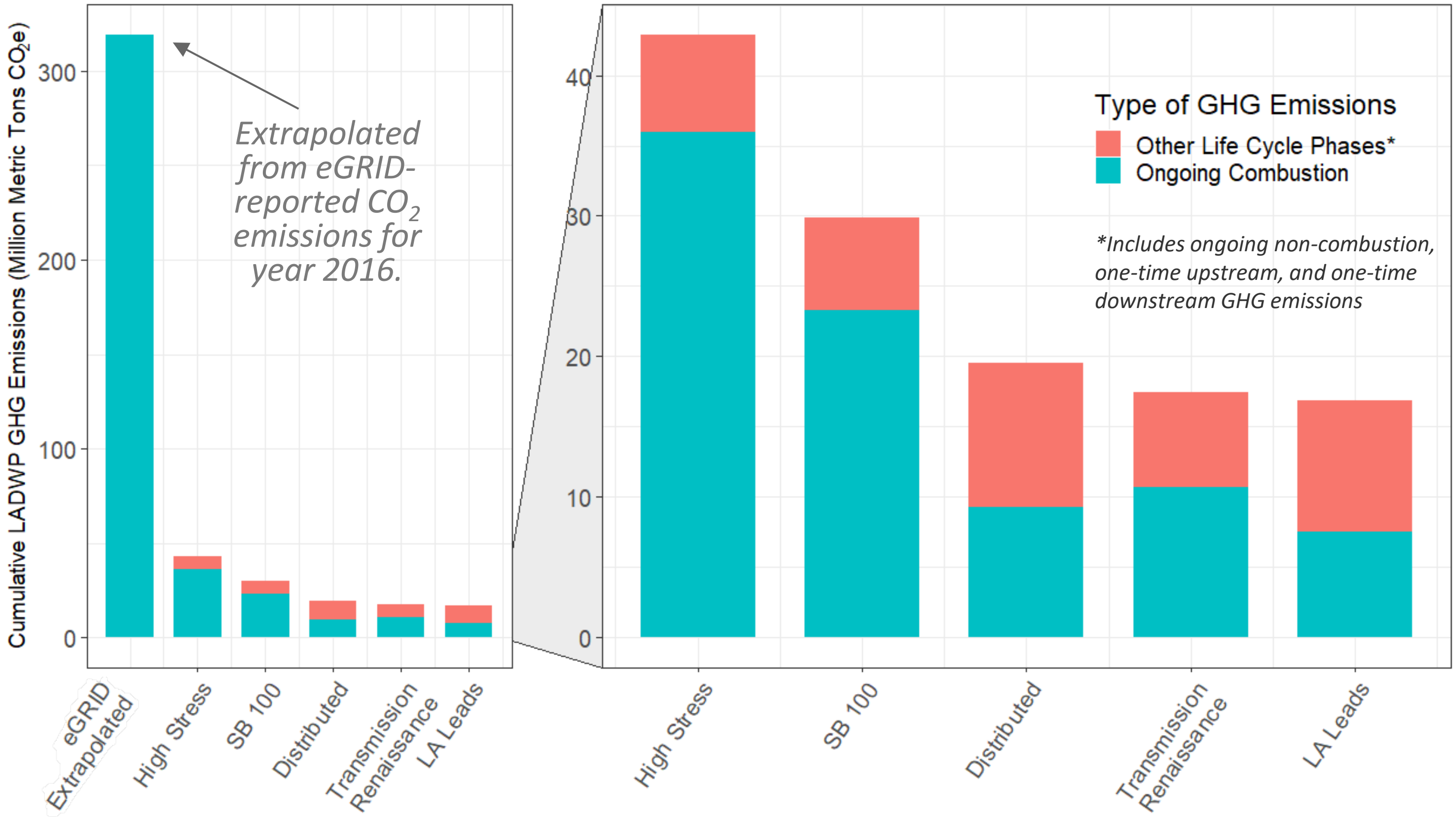
Life Cycle GHG Emission Phase	Examples	Relevant Metric	Combustion-Only GHG Analysis	Full Life Cycle GHG Analysis
1) Ongoing **combustion**	CO_2 from fuel burned in a power plant	Fuel burn (BTU)	✓	✓
2) Ongoing **non-combustion**	Extraction of fossil fuel (e.g. NG); plant O&M	Generation (MWh)	X	✓
3) One-time **upstream**	Building a new power plant	Capacity (MW)	X	✓
4) One-time **downstream**	Decommissioning an old power plant	Capacity (MW)	X	✓

Initial Run: Cumulative LADWP Lifecycle GHG Emissions, 2020–2045



**Includes ongoing non-combustion, one-time upstream, and one-time downstream GHG emissions*

Initial Run: Cumulative LADWP Lifecycle GHG Emissions, 2020–2045



Coming Soon:

- GHG breakdown for each lifecycle phase
- GHG breakdown by generator/ fuel type
- GHG impacts from increased part-loading / startup / shutdown

Initial Run – For Discussion Purposes Only; Subject to Change

Environmental Justice (EJ)—Technology Deployment

Rooftop Solar Deployment

Purpose within LA100

How much of rooftop solar is being adopted in disadvantaged communities?

We compare rooftop solar adoption levels (installed capacity, MW) in EJ and non-EJ tracts in LADWP service territory

Initial Run (Today) vs. Final Run (June – Dec AG)

What's Included
in Initial Run

EJ deployment:
Rooftop solar

What's Not Included Today But Will be in Final Run

EJ analysis of:

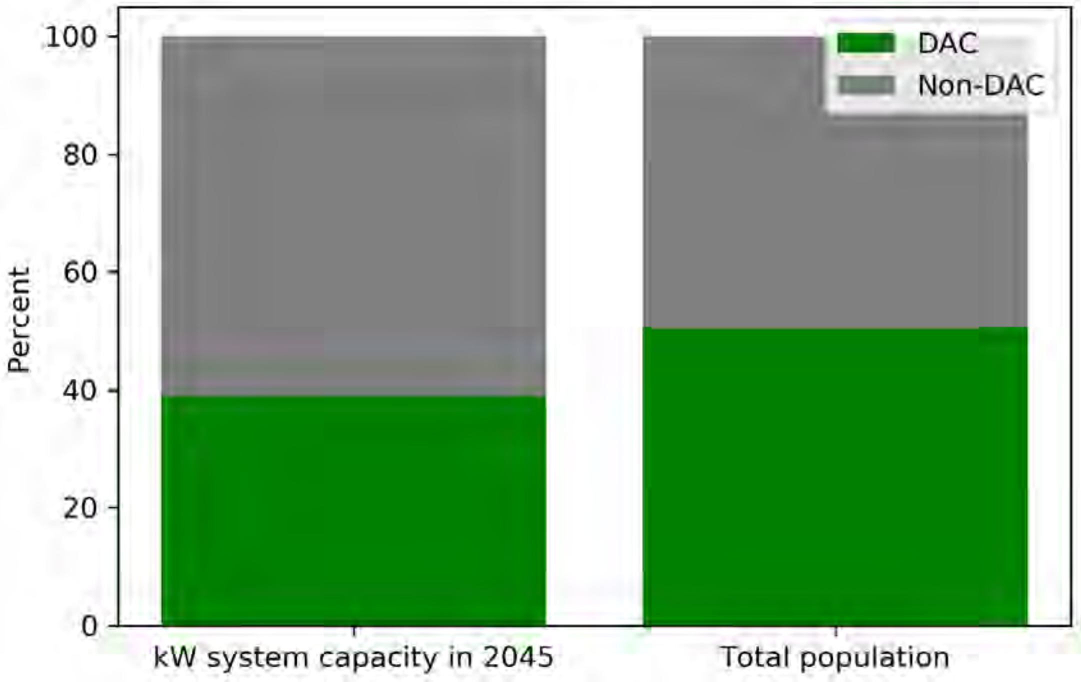
1. Air quality and public health
2. Deployment based on:
    - Energy use intensity in buildings
    - EV adoption and DC fast charging

Initial Run: EJ Deployment—Rooftop Solar by Population

39% of rooftop solar deployment is in Cal EnviroScreen-identified Disadvantaged Communities (DAC)

DAC represents **50%** of LADWP population

Share of rooftop solar in disadvantaged communities compared to share of population

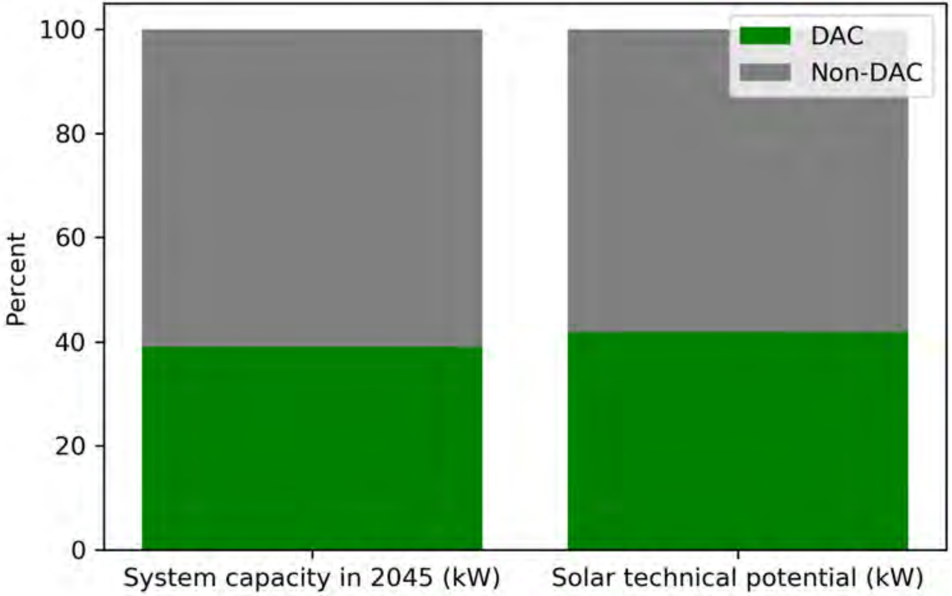


Initial Run – For Discussion Purposes Only; Subject to Change

Initial Run: EJ Deployment—Rooftop Solar by Technical Potential

39%: Share of **rooftop solar** in disadvantaged communities

42%: Share of **technical potential** in disadvantaged communities



Initial Run – For Discussion Purposes Only; Subject to Change

Upcoming AG Presentations

EJ analysis based on:

- Air quality
- Health improvements
- Deployment based on:
  - Energy use intensity in buildings
  - EV adoption and DC fast charging

Questions?

LA100

The Los Angeles 100% Renewable Energy Study

The Los Angeles 100% Renewable Energy Study

LA100 Final Run Updates

Jaquelin Cochran, Ph.D.

December 5, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Agenda for This Session

- Reference Case
- Status of Final Run
- Expectations for 2020 AG Meetings

Reference Case

LA100 Scenarios (updated September 2019)

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

Note, the study also includes a reference case (2017 IRP with minor updates). This case extends through 2036.

Reference Case: Purpose and Plan

- Inclusion of a reference case responds to LADWP Board request to do so to **increase transparency**
  - IRP 2017 reflects the latest Board-approved set of projections

- **Benefit:** Using a consistent set of assumptions and bulk power modeling tools allows us a basis to compare costs and reliability through 2036

- **Limitation:** This case does not include the same end year as LA100 scenarios and therefore is not included among pathways to reach 100% RE

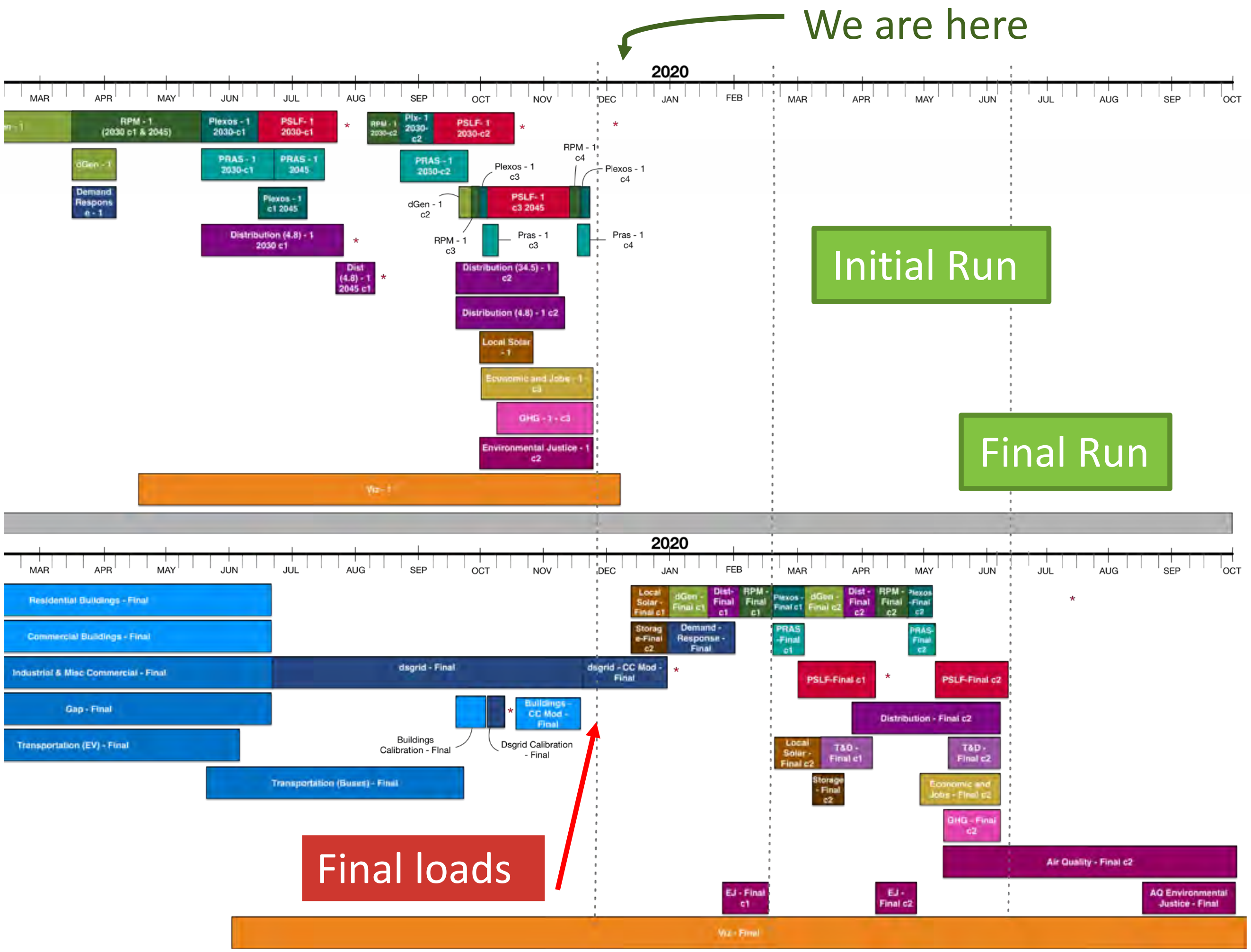
Reference Case: Key Points

- The Reference Case (including repowering OTC units) **does not serve as the basis for the LA100 scenarios**
  - LA100 scenarios remain the same as before
  - No LA100 scenario includes repowering OTC
- Costs for LA100 scenarios and the Reference Case **can only be compared through 2036**, even though LA100 scenarios continue through 2045
  - Costs for the Reference Case will not be compared to 2045 scenarios
- The Reference Case will use **“moderate” load projections** to be consistent with the moderate set of scenarios

Questions on Reference Case?

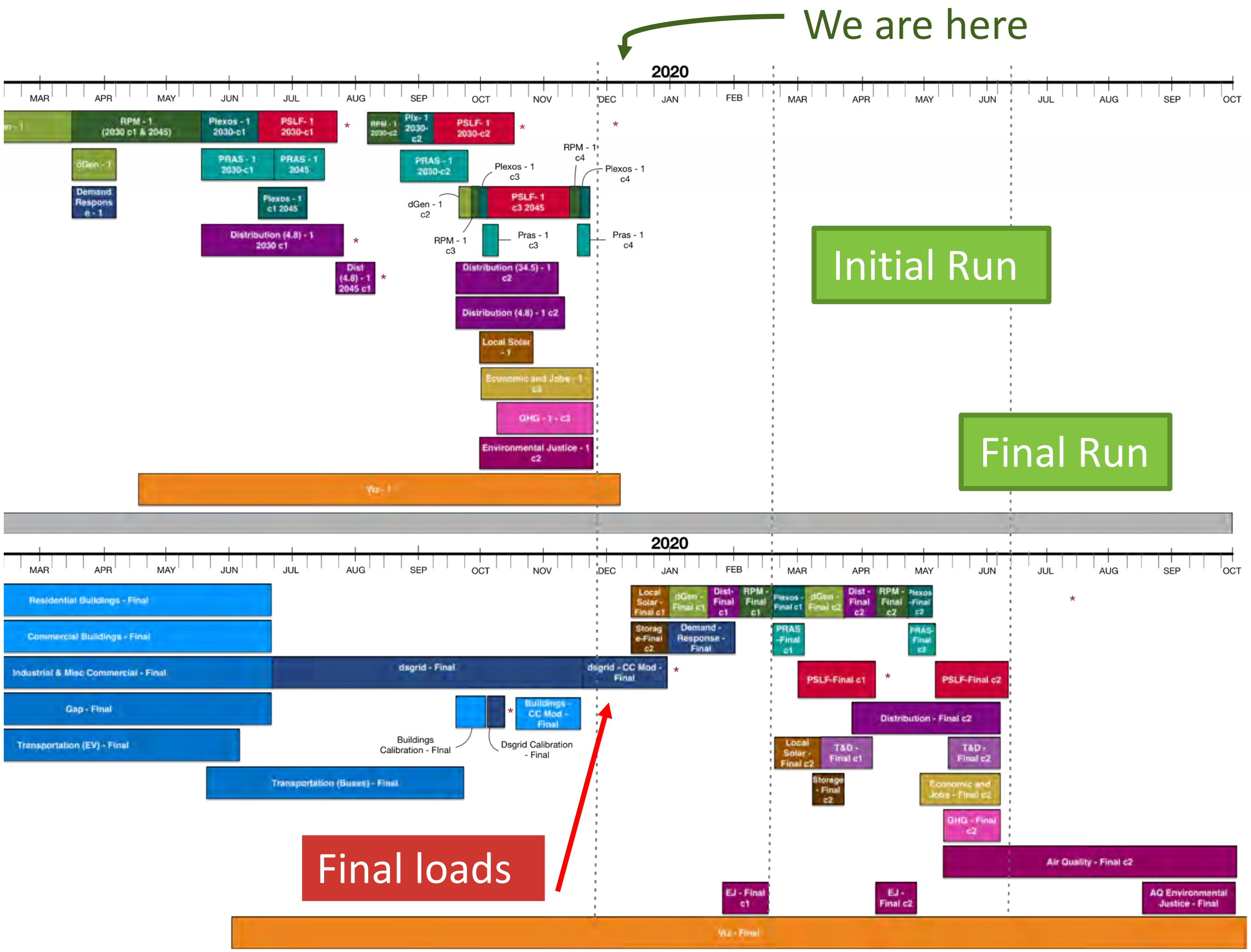
Status of Final Run

We Are Now Focused on the Final Run



Final Run

- Buildings models have been rerun with higher temperatures
- In the process of assigning demand data to each building
- Adding local storage
- Output models continue to be improved



Expectations for 2020 AG Meetings

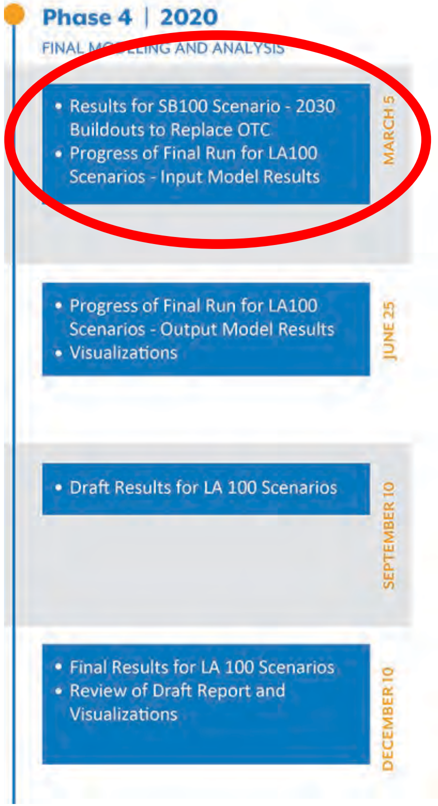
AG Timeline

- COMPLETED MEETINGS/TASKS
- PLANNED MEETINGS/TASKS

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

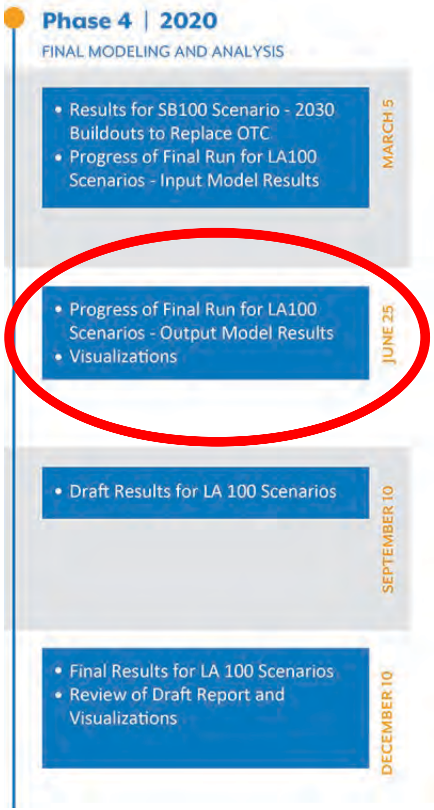
AG: March 2020

- **Results for 2030 Buildout (Focus on SB100)**
  - Represents an in-depth look at investments (bulk power and distribution grid) that can replace the OTC units
  - Will look at metrics of cost and reliability, including compared to Reference Case
- **LA100 Scenarios (2021-2045), Input Model Results**
  - Will review Final Run results:
    - Electricity demand projections (including buildings, EVs, and buses)
    - Local solar and storage (sites and ranking)
    - Options for demand response



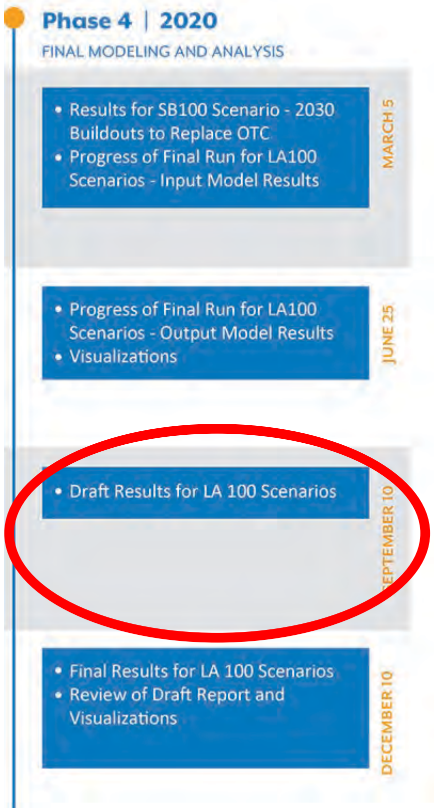
AG: June 2020

- **LA100 Scenarios (2021-2045), Output Model Results in Progress**
  - Review all output models; first look at investment pathways with final loads
  - Present on emissions inventory
  - Present progress on visualizations
- **June Feedback Goal:** Incorporate your feedback about additional questions that we can analyze based on results (without rerunning models)



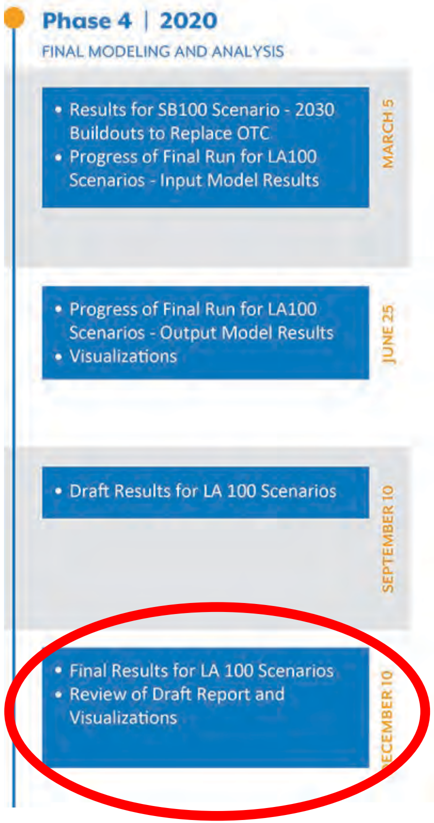
AG: September 2020

- **Draft Results for All Scenarios**
  - Results for all models except air quality will be complete
    - What are your questions?
  - Focus will be on finalizing how we communicate information, including improvements to our interactive visualizations



AG: December 2020

- **Final Results: Air Quality and Environmental Justice**
- **Distribution of Draft Report and Visualizations**
  - Request feedback and comments on the report
  - Types of feedback that will be most helpful:
    - Questions that we can answer but haven't
    - Caveats that we should add to the study (e.g., assumptions that might be out of date)
    - Key points that should be better emphasized
    - Explanations that can be improved
- **Presentation by LADWP Financial Service Office**



Follow-up Q&A from this Advisory Group Meeting

- Need time to digest and ask questions for the day?
- Like last two AGs, we will hold a webex-based Q&A after two weeks

- Mark your calendars for:

  Tuesday, December 17, 2019

  10:00 AM – 11:00 AM

Questions?

The Los Angeles 100% Renewable Energy Study