Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #8

Thursday, June 13, 2019, 7:45 a.m. to 2:30 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
Allison Smith, Southern California Gas
Alvin Kusumoto, Metropolitan Transportation Agency
Andy Shrader, Council District 5
Agustin Cabrera, RePowerLA
Bonny Bentzin, University of California, Los Angeles
Camden Collins, Office of Public Accountability (Ratepayer Advocate)
Jim Caldwell, Center for Energy Efficiency and Renewable Technologies
Chaouki Aboulhosn, Port of Los Angeles
Christos Chrysiliou, Los Angeles Unified School District
Dan Kegel, Neighborhood Council Sustainability Alliance
David Graham-Caso, Council District 11

[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.

Ernie Hidalgo, Neighborhood Council Sustainability Alliance
Fred Pickel, Ratepayer Advocate
Gina Palencar, RePowerLA
Hilary Firestone, Natural Resource Defense Council
Jack Humphreville, Greater Wilshire Neighborhood Council
Jasmin Vargas, Food and Water Watch
Jin Noh, California Energy Storage Alliance
Katya English, Sierra Club
Kendal Asuncion, Los Angeles Chamber of Commerce
Luis Amezcua, Sierra Club
Martin Marrufo, International Brotherhood of Electrical Workers (IBEW) Local 18
Matt Gregori, Southern California Gas Company
Matthew Thomas, Los Angeles Unified School District
Michael Webster, Southern California Public Power Authority
Michele Knab Hasson, Natural Resource Defense Council
Nikhil Schneider, California State University, Northridge
Priscila Kasha, City Attorney
Randy Krager, Southern California Public Power Authority
Stuart Waldman, Valley Industry Commerce Association
Tony Wilkinson, Neighborhood Council
Virginia Cormier, International Brotherhood of Electrical Workers (IBEW) Local 18
Walker Foley, Food and Water Watch

LADWP Staff

Ann Santilli
Armen Saiyan
Ashkan Nassiri
Brian Hwang
Dawn Cotterell
Eric Montag
Jay Lim
Julie Van Wagner
Louis Ting
Luis Martinez
Melanie Kwong
Nancy Sutley
Reiko Kerr
Robert Hodel
Scott Moon
Steve Swift
James Barner

Project Team

Jaquelin Cochran, National Renewable Energy Laboratory (NREL)
Daniel Steinberg, NREL
Paul Denholm, NREL
Ramin Faramarzi, NREL
Scott Haase, NREL
Rob Leland, NREL
Jack Hughes, Kearns & West
Jenna Tourje, Kearns & West
Joan Isaacson, Kearns & West

Observers

Alexandra Nagy, Food and Water Watch
Aris Hovasapian, Los Angeles Community College District
Bianca Linares, University of Southern California
Bruce Tsuchida, The Brattle Group
Craig Reiter, Metropolitan Transportation Agency
Dominique Hargreaves, Office of the Mayor
Duane Muller, University of California, Los Angeles
Giovanni Damato, Electric Power Research Institute
Haresh Kamath, Electric Power Research Institute
Jack Brouwer, University of California, Irvine
Katie Goldman, Office of the Mayor
Marjorie Phan, Los Angeles World Airports
Mike Swords, Los Angeles Cleantech Incubator

Welcome Remarks

Reiko Kerr, Assistant General Manager for Power Systems, Engineering, Planning, and Technical Systems for LADWP, provided welcoming remarks. She thanked the Advisory Group for attending the meeting and for their commitment of time. She noted that the March Advisory Group meeting was postponed because the team needed time to consider the implications of the mayor's announcement to not repower the coastal generating stations. This affected both the Los Angeles 100% Renewable Energy Study (hereafter LA100) and the SLTRP process. She said that the Advisory Group would soon hear about the Clean Grid LA program for moving forward. She concluded by saying that the Advisory Group's input is more important now than ever before.

Eric Montag, Senior Manager of Strategic Initiatives and Resource Development for LADWP, welcomed the Advisory Group members and congratulated them for reaching the two-year mark of LA100 and Advisory Group. He noted that Aaron Bloom, NREL's lead for LA100 has moved on and has been replaced by Jaquelin Cochran, manager, Grid Systems group. He also introduced Scott Moon, new to LADWP's LA100 team, and Steve Swift, who is the new LADWP project manager for LA100.

Call to Order and Agenda Overview

Joan Isaacson, lead facilitator from Kearns & West, welcomed members to the eighth meeting of the Advisory Group for LA100. She provided an overview of the agenda (see Appendix A), highlighting two presentations from LADWP— one on updates for Clean Grid LA and LADWP's Strategic Long-Term Resource Plan (SLTRP), the other on financial planning—and three presentations from the NREL team; the first provided LA100 updates, the second was on interpreting modeling outputs from long-term scenario analyses, and the third focused on bottom-up load modeling for residential and commercial sectors. All agenda items incorporated ample time for Advisory Group discussion.

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

Clean Grid LA and Strategic Long-Term Resource Plan

Nancy Sutley, LADWP Chief Sustainability Officer, gave a presentation that explained how LADWP was responding to the mayor's announcement to not repower the coastal generating units with natural gas with its new initiative Clean Grid LA. Clean Grid LA will support 100% renewables by 2045 and LADWP-wide carbon neutrality by 2050. These goals will be achieved by investing in local transmission and distribution to enhance grid reliability, seeking out innovative and new technologies, and phasing out local fossil fuel generation.

As part of Clean Grid LA, the Scattergood Units and other in-basin power plants may be repowered with clean alternatives. LADWP is currently determining the need for further studies about factors such as distributed energy resources and energy supply needs, as well as a number of environmentally focused questions about the grid and generation. LADWP has submitted a request to the State Water Resources Control Board to align all ocean water cooling deadlines to 2029.

Additionally, the 2018 SLTRP was postponed, and the next SLTRP will be developed in 2020, with inputs from LA100. LA100 will be finalized in 2020. See slides 1 through 14 for more information on the presentation.

Major Themes from Advisory Group Member Questions and Discussion

- When will the next Integrated Resource Plan (IRP) be developed? Can the 2018 Interim IRP be accessed?
- Will the final Once Through Cooling (OTC) Study be made available?
- Please provide information about the public outreach process for Clean Grid LA.
- The reference to workforce development as part of Clean Grid LA is appreciated. When will data be available?
- How does Clean Grid LA interact with LA100?

LA100 Recap and Updates

Jaquelin Cochran, NREL Manager, Grid System Groups and LA100 lead, recapped the LA100 objectives, unique aspects of the study, and significant events that occurred since the previous Advisory Group meeting in November 2018, and gave a modeling status update. The significant events include SB 100 going into effect, the downgrading of PG&E investor-owned utilities' bond ratings (which affected the solar companies supplying renewable energy to PG&E), and additional new renewable energy targets announced by states in the western U.S. Her list of important events for LA100 also includes the mayor's decision to not repower the coastal OTC units with natural gas and LA's Green New Deal pLAn (pLAn).

In order to address the mayor's decision regarding the OTC units, NREL removed repowering assumptions from the scenarios and is in the process of identifying replacement options using reliable, clean generation. In response to pLAn, NREL will electrify 100% of Los Angeles Department of Transportation, Metro, and school buses in the scenarios; align high-electrification building projections with pLAn targets; and evaluate pathways to local solar targets. Cochran noted that NREL updated the November 2018 scenario matrix by removing the repowering reference cases in order to focus on the new pathways to 100% renewable energy and remove any repowering assumptions.

The study's timeline has been extended by 6 months and is now scheduled to release the draft report to the Advisory Group by the end of 2020. The September 2019 Advisory Group meeting will cover more information on how to interpret modeling outputs. NREL will present the initial results of the LA100 scenarios for feedback at the December meeting. Slides 19 through 28 detail the above information.

Cochran reported on NREL's progress in the modeling process. Slides 31 through 40 show the basic modeling framework, a detailed framework showing data handoff between models, and a timeline of modeling. She gave some updates on specific aspects of the study, including load data allocation to downstream models, rooftop solar technical potential, projections of light-duty electric vehicle adoption by scenario, and projections of light-duty electric vehicles charging profiles. Please see slides 41 through 47 to view the charts. At the time of the meeting, the initial run of the capacity expansion modeling was completed, and NREL was starting the process of reviewing outputs. She also reported that the initial runs for load balancing and reliability were underway.

Major Themes from Advisory Group Member Questions and Discussion

- Dropping the reference scenarios makes it harder to see the incremental costs of switching to 100% renewable energy.
- Is NREL considering electric vehicles as an energy-storage tool (i.e., as a vehicle-to-grid technology)?
- How are the renewable energy pursuits of others states in the Western Electricity Coordinating Council (WECC) addressed in the modeling?
- Is NREL considering the sites currently occupied by the OTC units for other types of generation? LADWP should be doing option 11 or 12 from the OTC study right now.
- The social cost of carbon needs to be examined.
- Supply has to match demand at all times, and overbuilding more renewables is cheaper than building storage.
- Is transmission upgrade implementation included in the study?
- Is NREL considering how deenergizing during periods of high wildfire risk affects the grid?
- What are the rate impacts for individuals, homeowners, and business? There should be more public discussion about costs of alternatives.
- Has there been any outreach as a result of the rooftop solar potential analysis to let customers know of potential sites? Have the potential rooftop sites been analyzed for seismic sensitivity?

- Questions about cost sensitivity in the modeling and the anticipation of soliciting Advisory Group input on cost assumptions were raised.
- Has NREL overlaid the rooftop solar potential with LADWP grid capacity?
- Is the rooftop solar potential overlaid with low-income communities to identify opportunities for incentive programs?
- Did NREL assume workplace charging was available everywhere?
- 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?

Interpreting Modeling Outputs of Long-Term Scenarios

Daniel Steinberg, NREL Senior Analyst and Group Manager, provided an overview of long-term scenario modeling, including future pathways, keys assumptions, cost models, and learning to date. He described that LA100 is representing the 100% target as a clean energy standard. He then went on to define a clean energy standard in detail, noting that within LA100 the scenarios vary which technologies qualify under a clean energy standard. In all LA100 scenarios except SB100, the target is established based on both end-use consumption and system loss. Under the SB100 scenario the target is based on end-use consumption or sales. In some scenarios, a portion of compliance can be met with Renewable Energy Certificates (RECs). A REC is a market-based instrument that represents the property rights to the environmental, social, and other non-power attributes of renewable electricity generation. For the study, load must be met with clean energy at all times unless RECs are allowed. Two of the eight scenarios in the study allow RECs.

Review key considerations around 100% target representation

Steinberg explained that for modeling assumptions regarding coordination with other entities, LA100 assumes that LADWP plans for self-sufficiency in terms of capital investments but can allow coordination with other entities for balancing (scheduling and dispatch). NREL's Annual Technology Baseline provides a consistent set of cost and performance projections for renewable and conventional generation and storage technologies from present day to 2050. Costs covered included capital (including financing costs), fixed and variable (non-fuel O&M). Assumptions for technology and cost are provided at Constant, Mid, and Low. Steinberg shared that assumptions for fuel costs are based on LADWP's existing contracts with fuel providers.

Use scenario testing to interpret modeling results

The general approach to evaluate and validate 100% RE pathways, Steinberg explained, is to use a capacity expansion model to identify investments, followed by detailed load balancing, resource adequacy, and power flow models to validate operational feasibility and identify constraints and solutions to any reliability issues identified.

Preliminary insights show at a high level that getting to 100% renewable will include leveraging diverse resources. Resources will include new wind and solar capacity and increased transmission to access these resources, storage to manage diurnal and seasonal variability, and—in scenarios where eligible—use of RECs. Insights also show that with high penetrations of variable resources come increased economic curtailment of renewable energy.

Major Themes from Advisory Group Member Questions and Discussion

- Should the study consider both retail sales and system losses for clean generation, or should the SB 100 standard regarding reliance on retail sales be used? Defining clean generation as solely retail sales allows for fossil fuel generation to make up for system losses.
- How are storage investments made—are they optimized over multiple days?
- What are the differences in the timeline to achieve 100% renewable energy between SB 100 and this study?
- Curtailment assumes that there will be no technological improvements. What sensitivities will be run for broad changes in technology? For example, the solar prices decreased much faster than anticipated ten years ago, while storage technology has been slower to evolve.
- Economic curtailment could have several implications—are the environmental and social costs being considered?
- Is it possible to remove biomass and nuclear from the scenarios?
- Where is the social cost of carbon reflected, and what is the reach by 2030?
- Is there a social discount rate?
- There are communities outside of LA that feel like they are "batteries for LA"—will renewable energy development impacts to outlying communities be considered as part this study?
- How will climate change and temperature changes be incorporated into the study? The City Council motion directing LA100 was intended to address climate change.
- How will the cost/benefit of decentralized strategies be balanced?
- How is the study assessing resiliency? What are the health impacts to communities when power is shut down to reduce wildfire risks?
- Will new solar programs incorporate public and/or private investments with multiple benefits? Do these capture indirect investments (like local jobs)?
- Hydrogen can be considered long-term storage. It can transmit energy and address resiliency.

LA100—Bottom-up Load Modeling for Residential and Commercial Sectors–Assumptions and Early Results

Eric Wilson, NREL Senior Research Engineer, gave a presentation to familiarize the Advisory Group with the methodology for building sector bottom-up load modeling by explaining how the buildings in Los Angles were modeled and how NREL made projections for building stock and electricity consumption. He reviewed sample results of these projections. The presentation focused on residential and commercial building consumption, exclusive of changes that will be modeled separately, such as rooftop solar, electric vehicle charging, demand response, and large industry/special loads. The building loads affect all downstream models.

Methodology for Buildings Sector Load Modeling

NREL created virtual models of 75,000 building categories that represent two million buildings in Los Angeles. These models are used to represent the diversity of building stock in Los Angeles and how it will change in the future. NREL uses ResStock and ComStock models, which were developed with support of the U.S. Department of Energy to model the national building stock. A statistical sampling technique using building stock characteristics data supplied the 75,000 representative building models. NREL then constructed physics-based computer models for those representative buildings to determine how and when they use energy.

NREL made building load projections by considering types and numbers of units, square footage, future building electrification, and future efficiency levels. Load projections cover a range of outcomes, including reference, moderate, high, and stress, in terms of energy efficiency, demand response, and electrification. NREL compared adoption rates and building stock turnover to pLAn to ensure that the scenarios cover the range of outcomes the Advisory Group is interested in seeing. Outcomes are independent of any market context (e.g., gas versus electricity tariffs that impact electrification rates) or policy implementation (e.g., incentives that might be needed to achieve efficiency projections). Slides 97 through 100 review how the different scenarios characterize load and the assumptions for the load projection outcomes. Wilson gave examples of projections resulting from the initial run. All projections use the same building stock growth assumption and weather, as well as assume natural turnover of equipment using standard lifetimes and commercial renovation rates, meaning there is no assumption of early replacement.

To make building stock growth projections, which were the same across all scenarios, NREL used California Department of Finance data and modeled demolitions and new construction by vintage (year built) and building type from 2015 to 2045. NREL used projections by Dodge Data and Analytics that made predictions through 2022 and extrapolated those predictions to 2045. Building stock growth predictions are the same for all scenarios. It is projected that by 2045, 25–30% of all residential units will have been constructed. Multifamily homes are projected to increase by 300,000 units. For commercial building stock growth projections, the largest growth is projected to be in education, hotels, healthcare, and other buildings.

Initial Run Sample Results

Wilson shared some results from the initial, uncalibrated model run. The load profile from February 2015 for the whole residential sector can be seen on slide 113. NREL has profiles for every one of the 75,000 buildings they modeled. Building profiles can be placed anywhere on the grid to learn the impacts to the distribution system, as well as the potential of sites for rooftop solar or electric vehicle charging.

NREL has gone through a process of calibration and validation of its modeling in preparation for the final run. Initial run snapshots of peak day and average winter day profiles can be viewed on slides 119 and 120.

Major Themes from Advisory Group Member Questions and Discussion

- How does the City of Los Angeles goal of zero net renewable energy by 2030 factor into this analysis?
- How does NREL factor in adoption projections for Title 24?
- Consider simplifying the analysis by creating energy indices for buildings by taking into account energy efficiency and renewables.
- Back-casting may assume targets that are not realistic—e.g., in the high case, the commercial building had an unrealistically high energy efficiency standard. Can the model test for scenario viability given that NREL worked backwards from the goal?
- In general, gas power is cheaper, so why assume everything will be electrified?
- Why is NREL not modeling future load increases due to increased cooling loads from AC due to a warmer climate?

- How does input account for buildings built to current codes and buildings that need to be retrofitted?
- How is NREL accounting for the additional load associated with new multi-family housing development?
- Does the modeling take into account fluctuations in the housing market, such as a crash?

LADWP Financial Services Organization

Overview of Financial Planning Criteria to Support Borrowing

Ann Santilli, LADWP Chief Financial Officer, gave a presentation on LADWP's competitive rates, revenue requirements, financial planning and metrics, credit rating, independent assessment, and financial strategy moving forward. Currently, LADWP has competitive residential energy rates at 17.2 cents per kilowatt hour. Energy conservation has reduced load and sales in the past few years, and that trend could continue into 2020. However, accelerated and expanded electric vehicle adoption, or fuel switching and electrification, could reverse that trend.

Slide 137 displays LADWP's financial planning criteria to maintain its good bond rating of AA. A lower bond rating would result in increased project costs and potentially increased rates for customers.

Once LA100 is complete, and LADWP knows what asset investments are needed, then cash flow needs can be assessed to determine cost and rate impacts. Navigant will provide an independent report to assess the cost-benefit impact, financial planning metric impact, rate impact, and customer bill impact. Navigant will work with the Office of Public Accountability on the analysis as directed by the City Council.

Major Themes from Advisory Group Member Questions and Discussion

- Who will supervise the Navigant Study? When will the Navigant report be released?
- This is a study that predicts 25 years into the future. It is important to consider that 25 years ago, LADWP's planned debt ratio was a debt percentage of zero, and many other assumptions that did not come true. The challenge is to think broadly about what could happen in the future.
- Does governance of LADWP pose challenges for innovative financing opportunities?
- The SB 100 legislative mandate is that 100% renewable energy should meet retail sales. System loss does not have to come from renewable energy. Until LADWP gets public input and integrates it into the IRP, the SB 100 assumption should be adopted.
- Not all pathways to 100% to renewable energy are possible.
- If no action to advance renewables is taken soon, LADWP will have an unreliable system and high rates.
- The Advisory Group needs to take these issues to constituents to foster more public discussion.
- Materials and information about LA100 should be simplified so that they are easier to share with a broader audience.

Wrap-up and Next Steps

When wrapping up, the project team asked the Advisory Group for feedback on the meeting formats. Comments indicate that the Advisory Group generally thinks that the predominant format of round-table discussions is productive and preferred. There were suggestions for greater communication between the team and Advisory Group in between meetings, use of webinars, and distribution of materials before meetings earlier than the current practice. The NREL team offered to host a follow-up Q&A on the AG8 materials later in June.

The next Advisory Group meeting date is September 19, 2019.

Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #8

Thursday, June 13, 2019, 7:45 a.m. to 2:30 p.m.

Appendix A

Agenda

The Los Angeles 100% Renewable Energy Study

City of Los Angeles 100% Renewable Energy Study (LA100)
Thursday, June 13, 2019
7:45 am – 2:30 pm
Los Angeles Department of Water and Power, Room 1514

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

7:45 – 8:00 am	**Arrive at LADWP / Networking / Continental Breakfast**
8:00 – 8:05 am	**Call to Order and Agenda Overview** Kearns & West (K&W): Joan Isaacson, Facilitator
8:05 – 8:15 am	**Welcome Remarks** LADWP: David Wright, General Manager
8:15 – 8:25 am	**Advisory Group Roundtable Introductions** LADWP: Eric Montag, Senior Manager, Strategic Initiatives and Resource Development NREL: Jaquelin Cochran, Manager, Grid Systems Group
8:25 – 9:00 am	**CleanGridLA and Strategic Long-Term Resource Plan** LADWP: Nancy Sutley, Chief Sustainability Officer • Presentation • Discussion/Q&A

9:00 – 10:10 am	**LA100 Recap and Updates**
	• Integrating LA Green New Deal and Mayor's No-Repowering Decision into LA100
	  o Updates to align with pLAn
	  o Replacing once-through cooling units
	  o Advisory Group schedule
	  o Scenario adjustments
	• Modeling Status
	• Discussion/Q&A
	NREL: Jaquelin Cochran

Los Angeles Department of Water & Power

NREL Transforming ENERGY

10:10 – 10:20 am **Break**

10:20 – 11:45 am **LA100—Interpreting Modeling Outputs of Long-term Scenarios**

- Review key considerations around 100% target representation
- Definitions of 100% Renewable Energy and Renewable Energy Credits
- Review of data and assumptions for bulk system simulation
- Use scenario testing to interpret modeling outputs
- Discussion/Q&A

NREL: Dan Steinberg, Senior Researcher and Group Manager, Economics and Forecasting

11:45 – 12:15 pm **Lunch Served**

12:15 – 1:15 pm **LA100—Bottom-up Load Modeling for Residential and Commercial Sectors–Assumptions and Early Results**

- Methodology for buildings sector load modeling
- Buildings electrification and efficiency projections
- Initial run sample results
- Discussion/Q&A

NREL: Eric Wilson, Senior Research Engineer

1:15 – 1:25 pm **Break**

1:25 – 2:15 pm **LADWP Financial Services Organization**

- Overview of Financial Planning Criteria to Support Borrowing
- Discussion/Q&A

LADWP: Ann Santilli, Chief Financial Officer

2:15 – 2:30 pm **Wrap-up and Next Steps**

- All feedback welcome; please send to: Ashkan.Nassiri@ladwp.com
- Next meeting date: September 19, 2019

K&W: Joan Isaacson

The Los Angeles 100% Renewable Energy Study

Los Angeles 100% Renewable Energy Study

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Appendix B

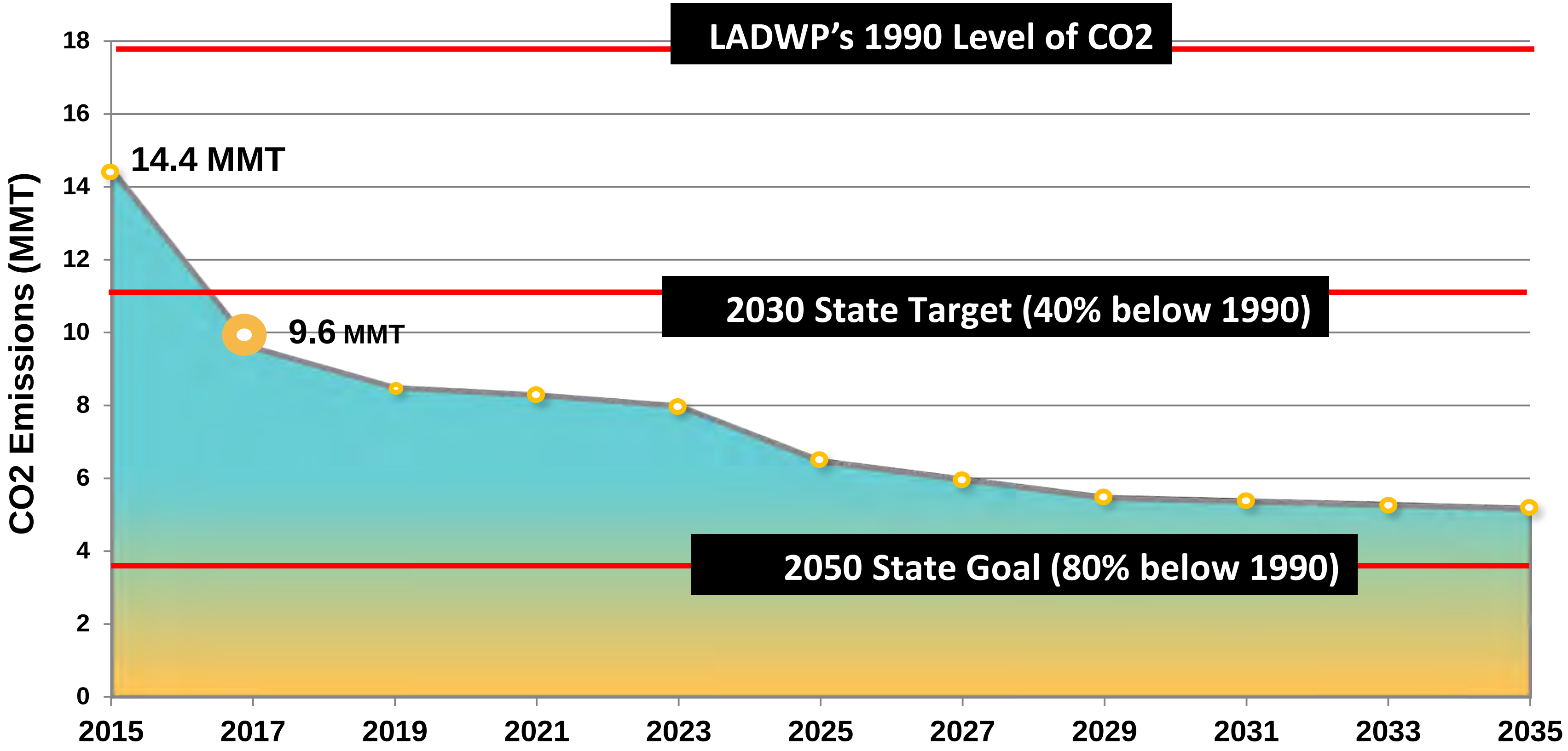
Presentation Slides

LA DWP Los Angeles Department of Water & Power

Clean Energy Future: Our Path Forward

Historical Innovations Bringing Water and Power to L.A.

Beating State GHG Targets



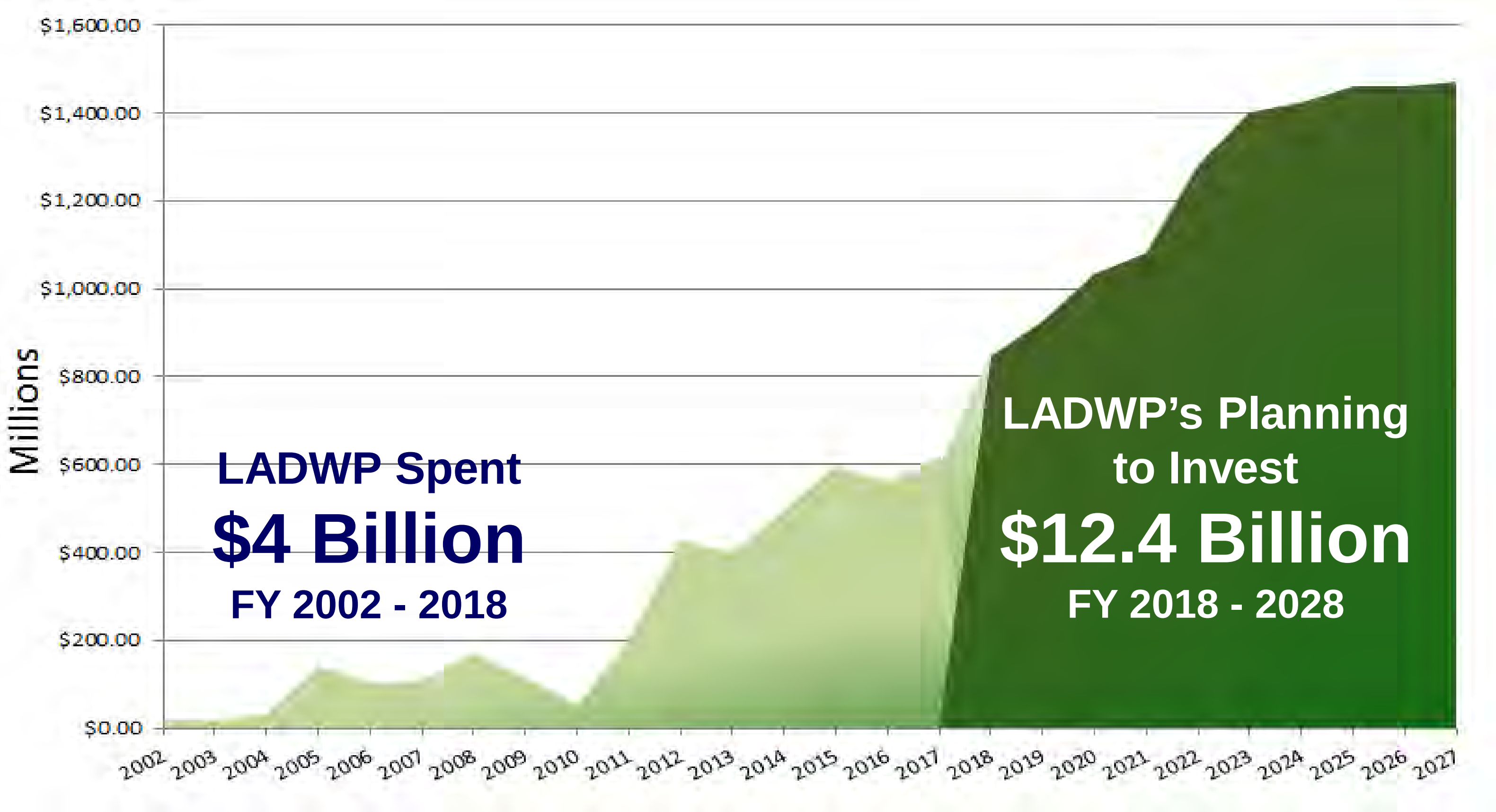
Major Renewable Projects

Pine Tree
Wind & Solar

Beacon Solar

Barren Ridge Transmission

Investing in Clean Energy



Energy Transformation is Complex!
We must be –

Green

Reliable

and Affordable

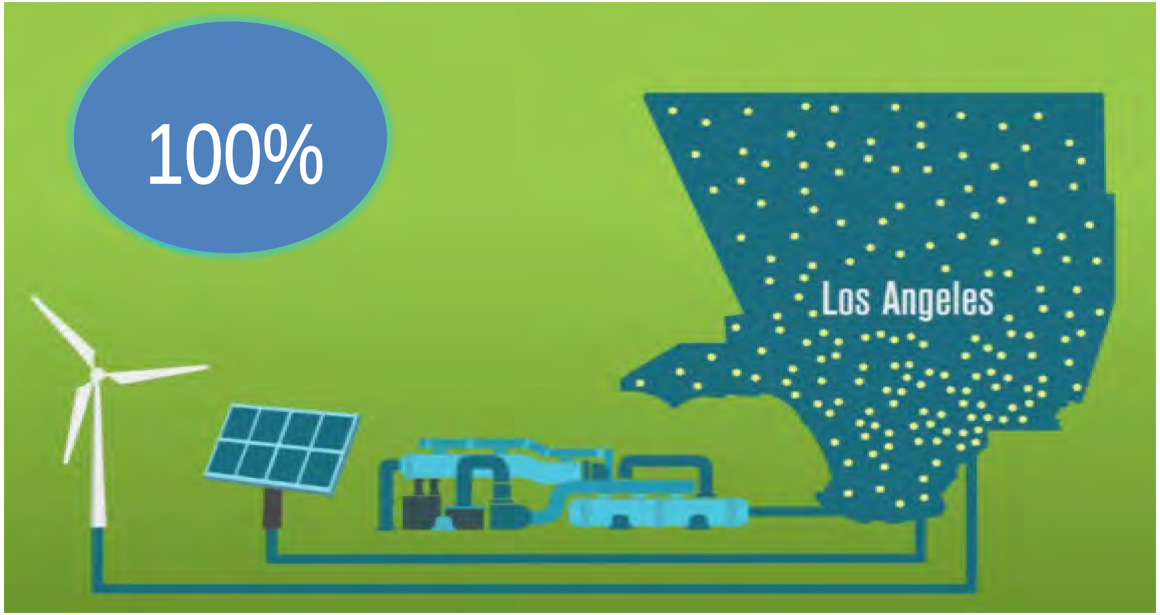
Clean Grid L.A.

Plan for Local Power Grid –Guiding Principles

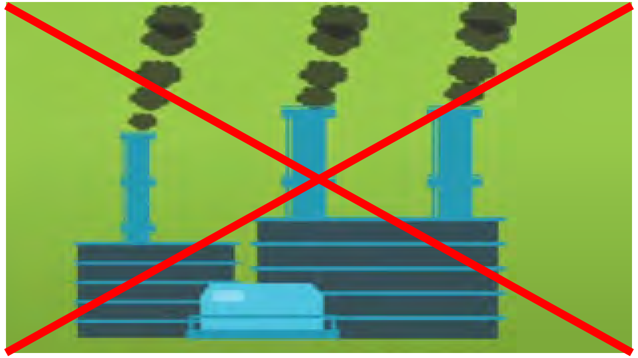
- Ensure Reliability
- Environmentally Beneficial
- Allow Flexibility
- Sensitive to Rate Impacts

Clean Grid L.A. Goals

L.A's Clean Grid will support 100% renewables by 2045 and carbon neutrality by 2050.



We Will Achieve These Goals Through–



- Investing strategically in local transmission and distribution to enhance grid reliability
- Seeking out innovative and new technology
- Ensuring all Angelenos benefit
- Phasing out local, fossil fuel generation
- Checkpoints to ensure grid reliability

Next Steps

- Request to align all Ocean Water Cooling deadlines to 2029
- Shift focus on repowering Scattergood and other in-basin power plants to clean repowering alternatives

  Issue RFI for new Distributed Resources (i.e. Solar, Demand Response, Energy Storage, Microgrid)
- Convene Transmission Working Group
- Work with neighbor utilities to maximize resources

Finalize Clean Grid L.A. Plan by 2020

- Complete and incorporate findings of 100% Renewable Study
- Identify investments to upgrade local transmission and distribution
- Update goals and budget to maximize energy efficiency
- Plan grid-scale energy storage
- Plan upgrade of pollution control equipment
- Issue RFP for expanding distributed energy resources
- Develop accelerated electrification strategy
- Evaluate in-depth path to carbon neutrality by 2050
- Provide complete financial analysis and rate review

Clean Grid L.A. Investments

Renewables

in basin &
out-of-basin **solar**

wind

geothermal

Storage

battery/energy storage
new technology

Distributed Energy Resources

energy efficiency

demand response

rooftop solar

Transmission

increased capacity on external transmission

in-basin transmission system **upgrades**

Partnerships and Public Engagement

- Postpone 2018 Strategic Long Term Resource Plan and merge into 100% Renewable Advisory Group
- Form Transmission-focused advisory group
- Partner with Labor, Private-Sector, Energy Experts, State Agencies
- Public outreach and workshops


ladwp.com/CleanEnergyFuture

LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group 8

June 13, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Agenda

- Call to Order
- Welcome Remarks
- Introductions
- Clean Grid LA and Strategic Long-Term Resource Plan
- LA100 Recap and Updates **
- LA100—Interpreting Modeling Outputs of Long-term Scenarios**
- Lunch
- LA100—Bottom-up Load Modeling for Residential and Commercial Sectors–Assumptions and Early Results**
- LADWP Financial Services Organization: Overview of Financial Planning Criteria to Support Borrowing**
- 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

LA100 Recap and Updates

Jaquelin Cochran, Ph.D.

June 13, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Refresh: LA100 Objectives

LA100 aims to address the full suite of questions and issues raised in three recent Los Angeles City Council Motions:

- Determine what **investments** can be made to achieve 100% RE power system
- Examine the impacts on **local jobs** and **economic development**
- Understand the **electricity rate, air quality,** and **health impacts** of achieving a 100% RE system
  - Identify **environmental justice neighborhoods** to be the first beneficiaries of improvements

LA100: What Is Unique?

LADWP must balance electricity supply and demand <u>at all times</u>

Most scenarios go beyond SB100, including:

- RE-only, not just clean energy with RECs
- Meeting all generation, not just retail consumption

First-of-its-kind modeling

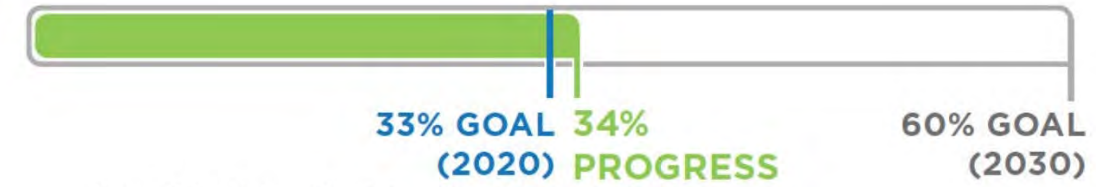
Objective, transparent, stakeholder-based analysis of pathways to 100% RE

- LA100 does <u>not</u> present recommendations or suggest policies
- LA100 does <u>not</u> evaluate implementation, such as difficulty of transmission upgrades

What's New Since Last AG?

- **SB100** in effect (January 1, 2019)
- **PG&E bankruptcy** (January 29, 2019); investor-owned utilities' bond ratings downgraded; solar companies supplying PG&E also downgraded by ratings or fallen stock value
- **Mayor's decision** to not repower remaining once-through cooling units (February 12, 2019)
- **Clean Grid LA** initiative established by LADWP (February 12, 2019)
- **New state RE targets**: New Mexico 100% carbon-free by 2045 (March 22); Nevada—RPS 50% by 2030 (April 22); Washington carbon neutral (2030), carbon-free retail by 2045 (May 7); Colorado goal carbon-free by 2050 (May 30)
- **LA's Green New Deal "pLAn"** (introduced April 29, 2019), and broader national discussions about 100% RE futures, costs

Estimated 2018 CA Renewables Portfolio Standard Progress



Source: California Energy Commission, staff analysis November 2018

Integrating Mayor's Decisions into LA100

- **LA's Green New Deal (2019 Updates to Sustainable City pLAn):**
  - Add bus electrification (LADOT, LA Metro, school buses)
  - Align high electrification projections with pLAn targets (residential & commercial buildings, light-duty vehicles)
  - Evaluate pathways to local solar targets, including community solar and virtual net metering for multifamily buildings
- **No repowering:**
  - Remove repowering assumption from each scenario
  - Identify options for reliable, clean generation to replace OTC units (in-depth modeling focus on 2030) [pending LADWP approval]
- **Timeline extended 6 months** as a result of these changes
  - Impacts AG schedule

AG Timeline (prior version)

QUARTER	Phase 1 | 2017 LAUNCH AND ORGANIZATION		Phase 2 | 2018 SCENARIOS		Phase 3 | 2019 ANALYSIS AND MODELING		Phase 4 | 2020 FINAL REPORT	
Q1	COMPLETED MEETINGS/TASKS PLANNED MEETINGS/TASKS		• Advisory Group Meeting Plan • Preliminary Scenarios and Sensitivities • Field Trip Itinerary • Power Strategic Long-Term Power Resources Plan • Once-Through Cooling Study Update	FEBRUARY 15	• Preliminary Scenario Tests • Environmental Analysis II • LADWP Financial Office	MARCH 28	• Final Results	MARCH 5
Q2	• Advisory Group Launch • City Council Motion: 100% Renewable Energy Study	JUNE 23	FIELD TRIP April 26 • Draft 100% Papers: Framing, Data, Methods • Final Scenarios and Sensitivities • Once-Through Cooling Study Update	JUNE 7	• Load Analysis • Jobs & Economic Analysis II • Advanced Engineering Concepts	JUNE 27	• Final Report • Final Presentation	JUNE 25
Q3	• Advisory Group Charge and Operating Protocols • Introduction to NREL and 100% Renewable Energy Study	AUGUST 3	• 100% Data • 100% Methods • Environmental Analysis I • Once-Through Cooling Study Update	AUGUST 16	• Preliminary Electric System Results • Preliminary Visualizations	SEPTEMBER 19		
Q4	• Defining Clean Energy and Renewable Energy • Considerations for Study • Once-Through Cooling Study Overview • Public Outreach Overview	NOVEMBER 16	• Methods for Calculating Investment & Operating Cost • Jobs & Economic Analysis I	NOVEMBER 15	• Preliminary Economy & Jobs Results • Preliminary GHG & Air Pollution Results	DECEMBER 5		

LA DWP Los Angeles Department of Water & Power

NREL NATIONAL RENEWABLE ENERGY LABORATORY

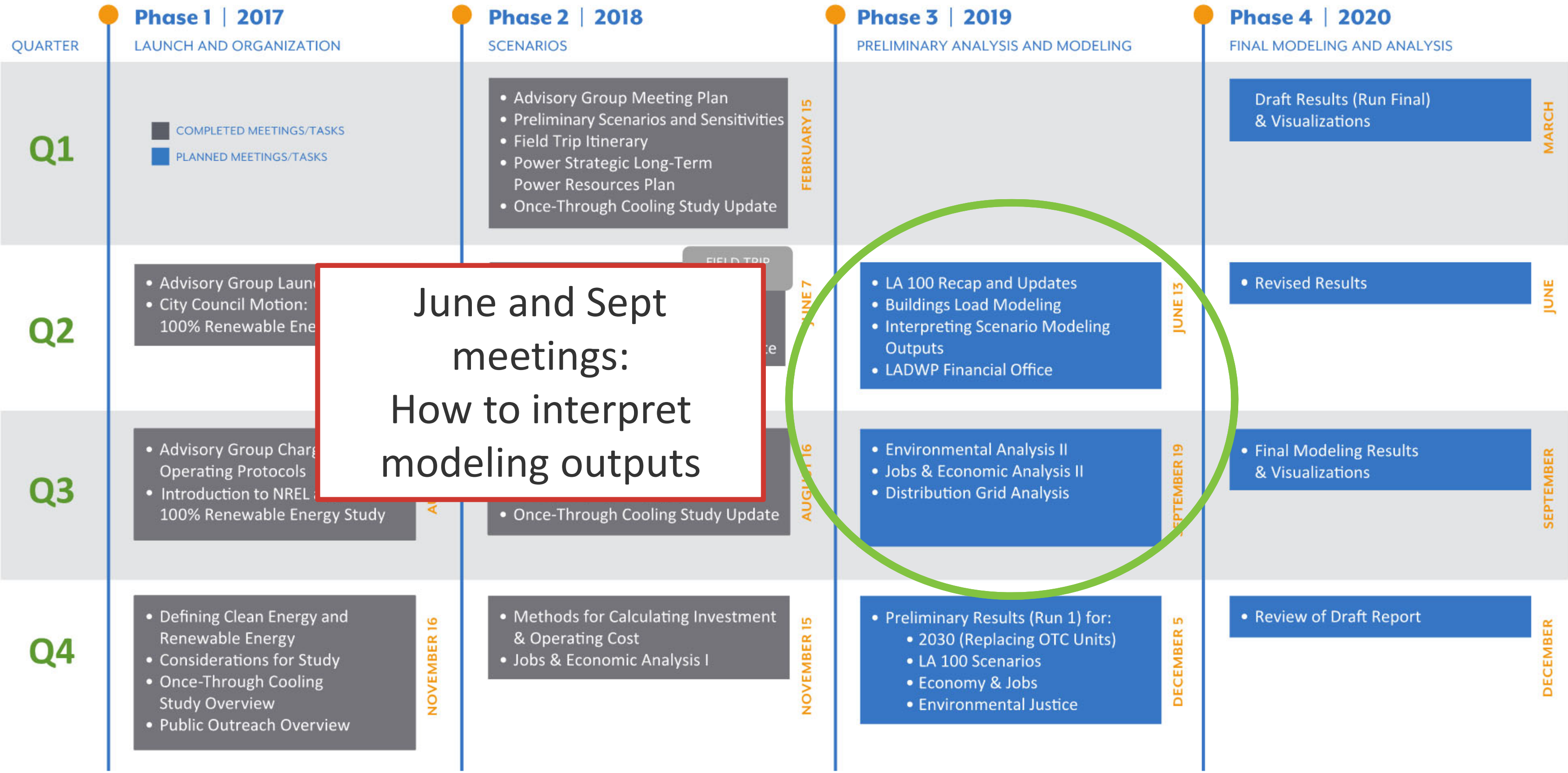
New AG Timeline

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 Draft Results (Run Final) & Visualizations
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 13 • LA 100 Recap and Updates • Buildings Load Modeling • Interpreting Scenario Modeling Outputs • LADWP Financial Office	JUNE • Revised Results
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 • Environmental Analysis II • Jobs & Economic Analysis II • Distribution Grid Analysis	SEPTEMBER • Final Modeling Results & Visualizations

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
			• Preliminary Results (Run 1) for:
			  • 2030 (Replacing OTC Units)
			  • LA 100 Scenarios
			  • Economy & Jobs
			  • Environmental Justice
				DECEMBER
				• Review of Draft Report

New AG Timeline



New AG Timeline

QUARTER	Phase 1 | 2017 LAUNCH AND ORGANIZATION	Phase 2 | 2018 SCENARIOS	Phase 3 | 2019 PRELIMINARY ANALYSIS AND MODELING	Phase 4 | 2020 FINAL MODELING AND ANALYSIS
Q1	■ COMPLETED MEETINGS/TASKS ■ PLANNED MEETINGS/TASKS	• Advisory Group Meeting Plan • Preliminary Scenarios and Sensitivities • Field Trip Itinerary • Power Strategic Long-Term Power Resources Plan • Once-Through Cooling Study Update FEBRUARY 15		Draft Results (Run Final) & Visualizations MARCH
Q2	• Advisory Group Launch • City Council Motion: 100% Renewable Energy Study JUNE 23	FIELD TRIP April 26 • Draft 100% Papers: Framing, Data, Methods • Final Scenarios and Sensitivities • Once-Through Cooling Study Update JUNE 7	• LA 100 Recap and Updates • Buildings Load Modeling • Interpreting Scenario Modeling Outputs • LADWP Financial Office JUNE 13	• Revised Results JUNE
Q3	• Advisory Group Charge and Operating Protocols • Introduction to NREL and 100% Renewable Ene… AUGUST 3	• 100% Data • 100% Methods • Environmental Analysis I • …te AUGUST 16	• Environmental Analysis II • Jobs & Economic Analysis II • Distribution Grid Analysis SEPTEMBER 19	• Final Modeling Results & Visualizations SEPTEMBER

Q4	• Defining Clean Energy… Renewable Energy
	• Considerations for St…
	• Once-Through Coolin… Study Overview
	• Public Outreach Over…
		…nt
		…VEMBER 15
			• Preliminary Results (Run 1) for:
			  • 2030 (Replacing OTC Units)
			  • LA 100 Scenarios
			  • Economy & Jobs
			  • Environmental Justice
			DECEMBER 5
				• Review of Draft Report
				DECEMBER

December meeting: Initial (first run) results presented for feedback

Scenario Matrix (Presented November 2018)

		Reference		LA100						
		LADWP 2017 SLTRP *Recommended Case*	SB 100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
				All LA100 cases reach 100% Net Renewable Energy by 2030						
	Compliance Year:	2045	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies Eligible in the Compliance Year	Biomass		Y	Y	Y	Y	N	Y	Y	Y
	Biogas		Y	Y	Y	Y	N	Y	Y	Y
	Electricity to Fuel (e.g. H2)		Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells		Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing		Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	Matches 2017 SLTRP Technology Mix	N	N	N	N	N	N	N	N
	Hydro - Upgrades		Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas		Y	N	N	N	N	Y	N	N
	Nuclear - Existing		Y	Y	N	N	Y	Y	N	N
	Nuclear - New		N	N	N	N	N	N	N	N
	Wind, Solar, Geo		Y	Y	Y	Y	Y	Y	Y	Y
	Storage		Y	Y	Y	Y	Y	Y	Y	Y
DG	Distributed Adoption	Reference	Balanced	High	Low	High	Balanced	Balanced	Balanced	Balanced
RECS	Financial Mechanisms (RECS/Allowances)	Y	Y	N	N	N	N	Y	N	N
Load	Energy Efficiency	Reference	Moderate	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	Moderate	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	Moderate	High	Moderate	High	Moderate	High	High	Moderate
Transmission	New or Upgraded Transmission Allowed?	Matches 2017 SLTRP	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	High

New Scenario Matrix

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

Removed reference cases

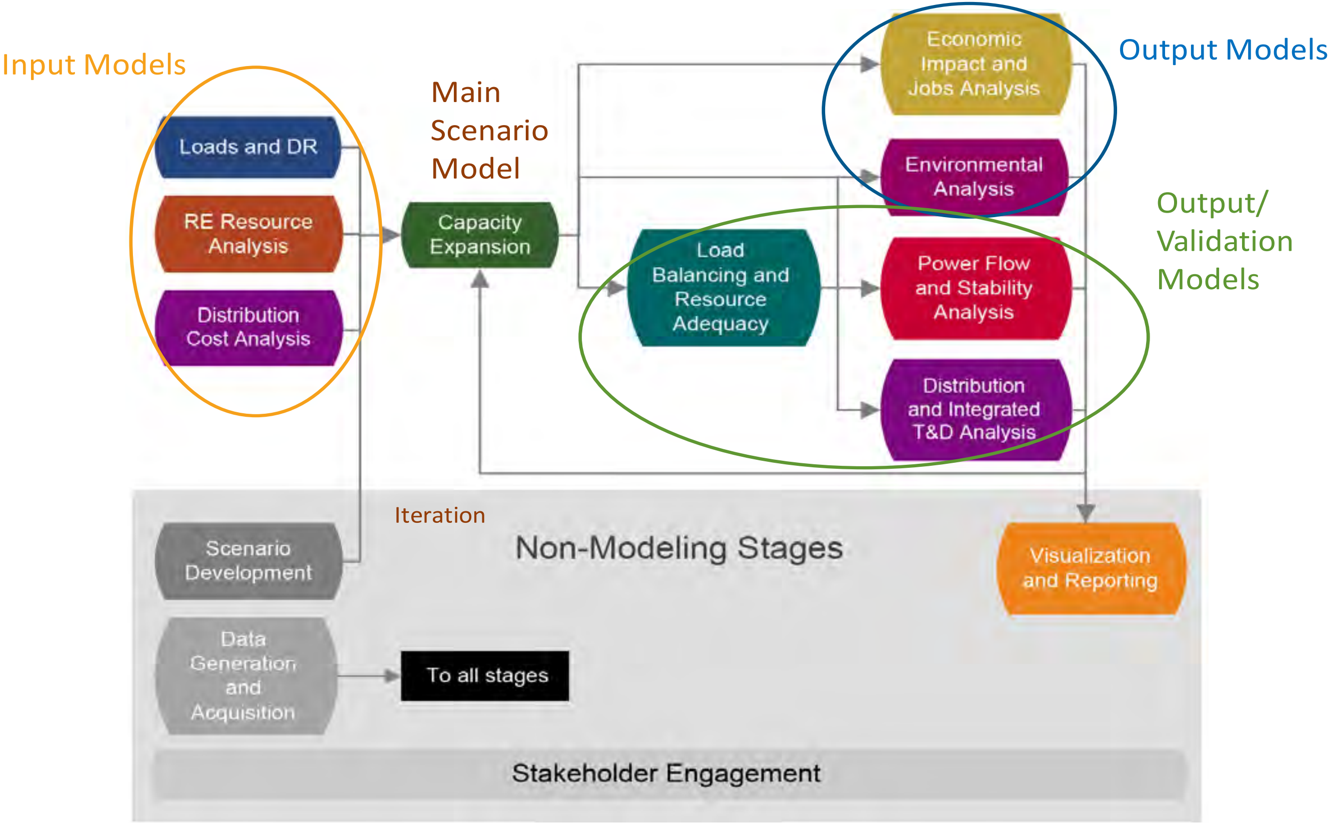
SB100 incorporated as one of the LA100 scenarios

All scenarios assume no repowering

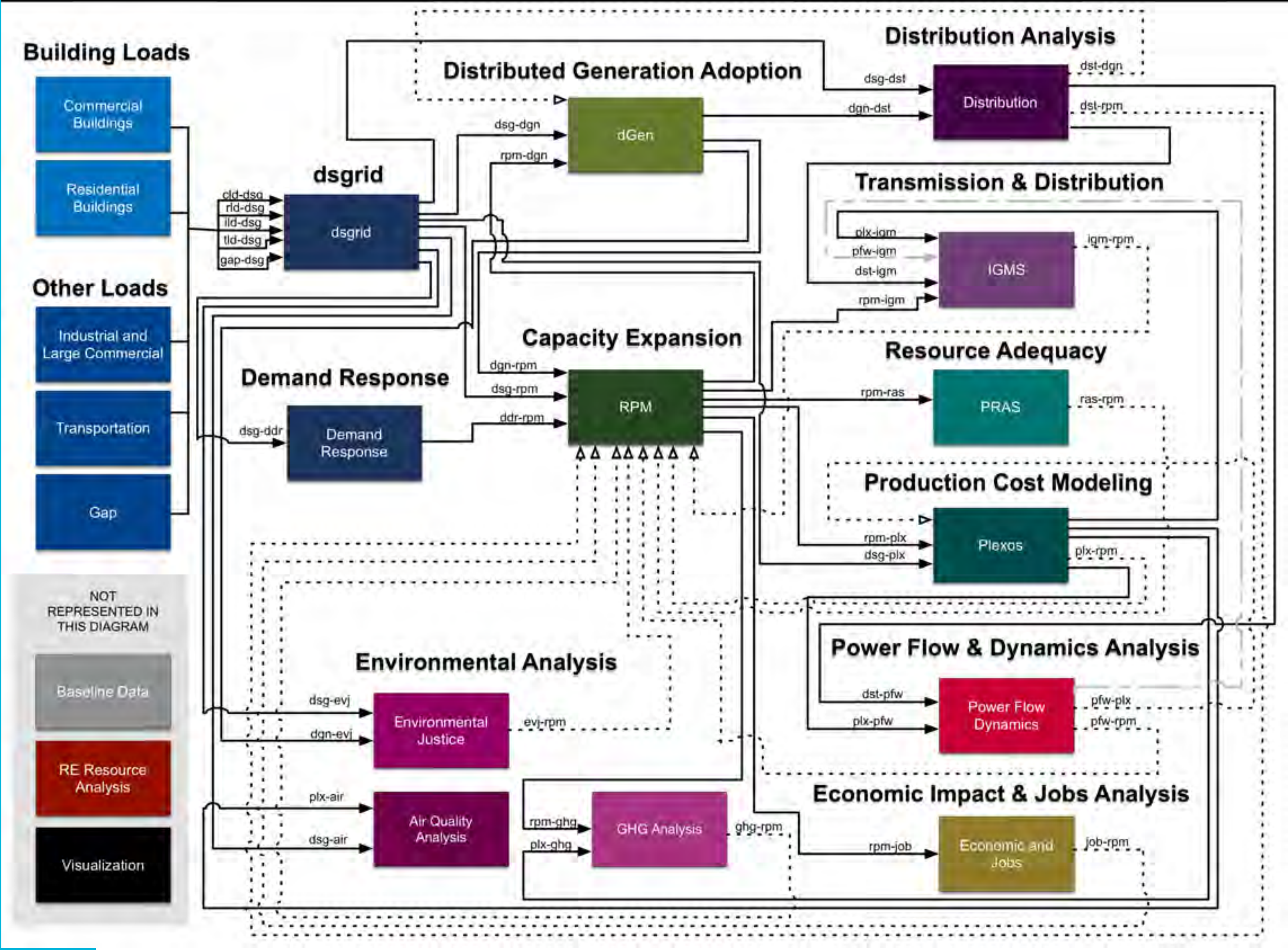
Questions?

LA100: Modeling Overview & Status

Modeling Framework

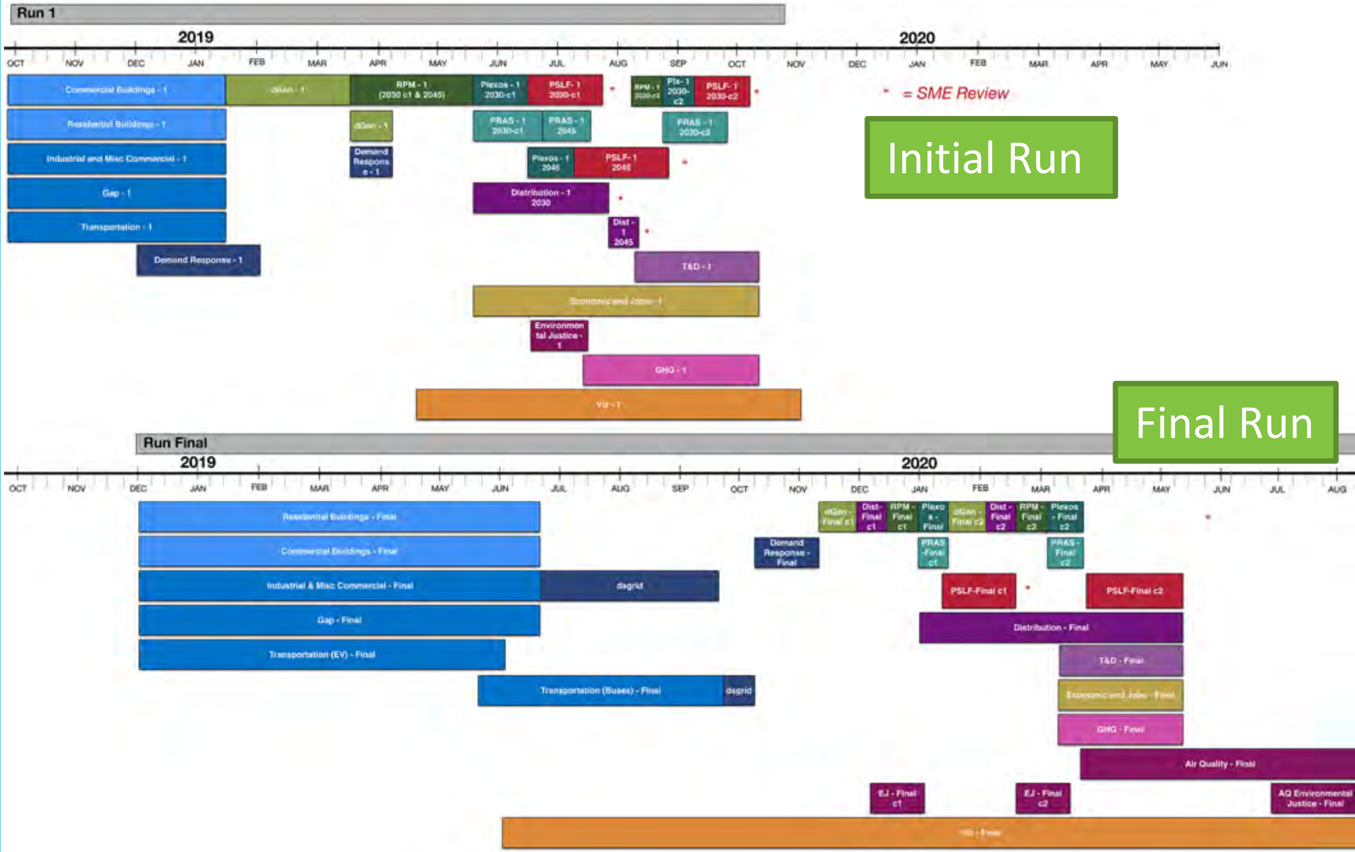


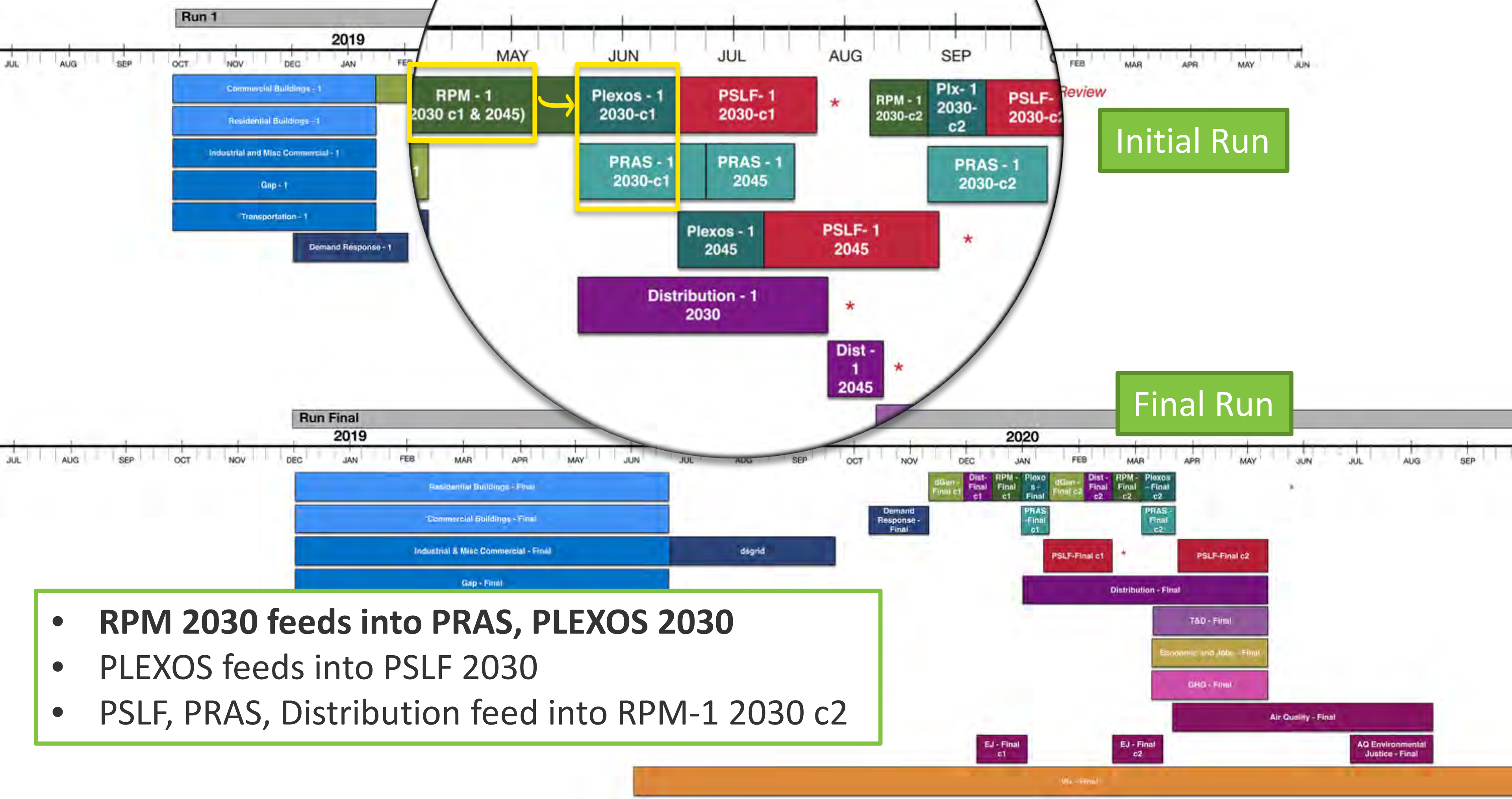
Detailed Modeling Framework Showing Data Handoffs Between Models



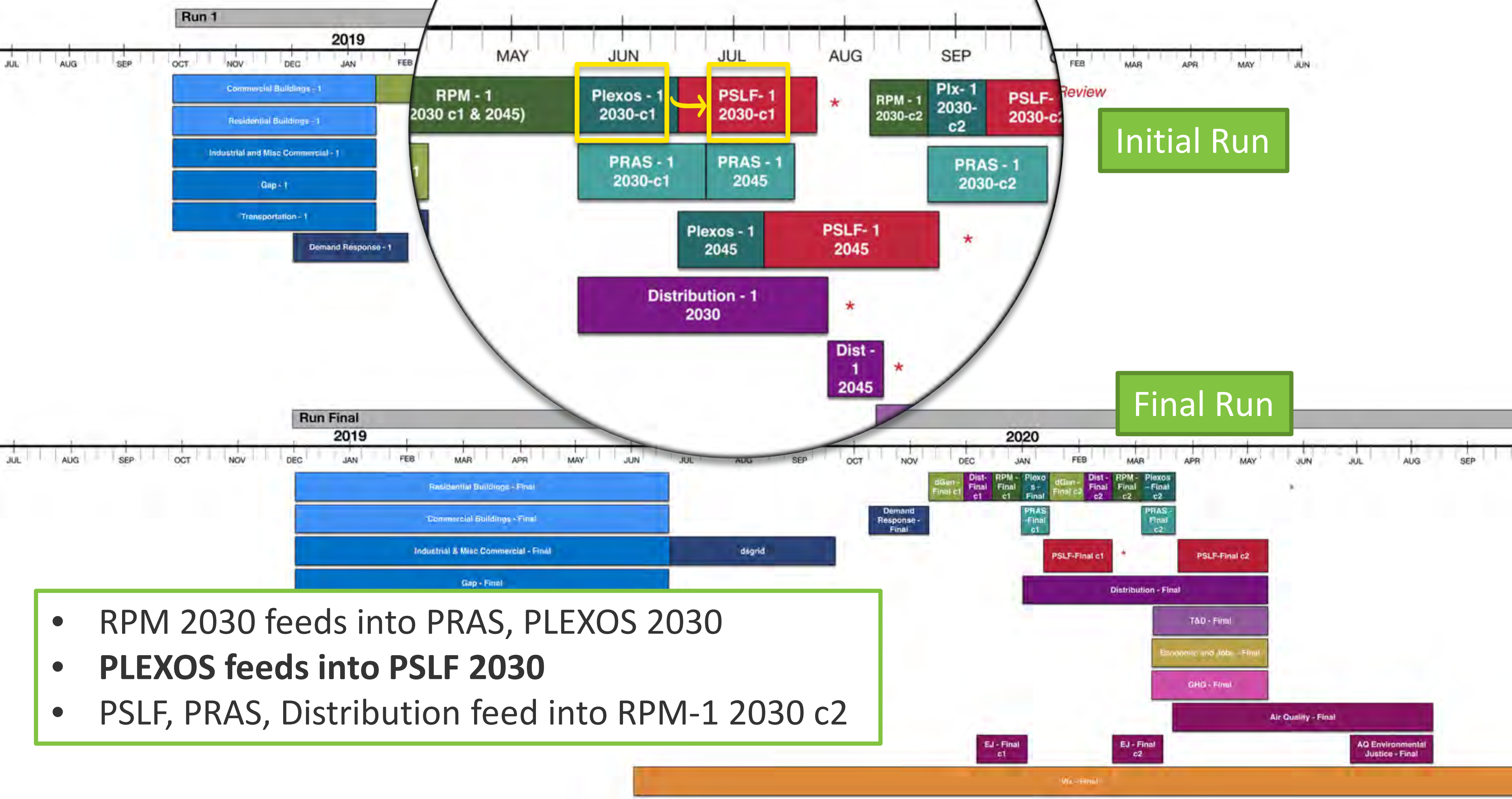
Our Timeline of Modeling Dependencies

Results from first round feed into second round of modeling
e.g., If power flow shows reliability violations, updates are made to capacity or operations

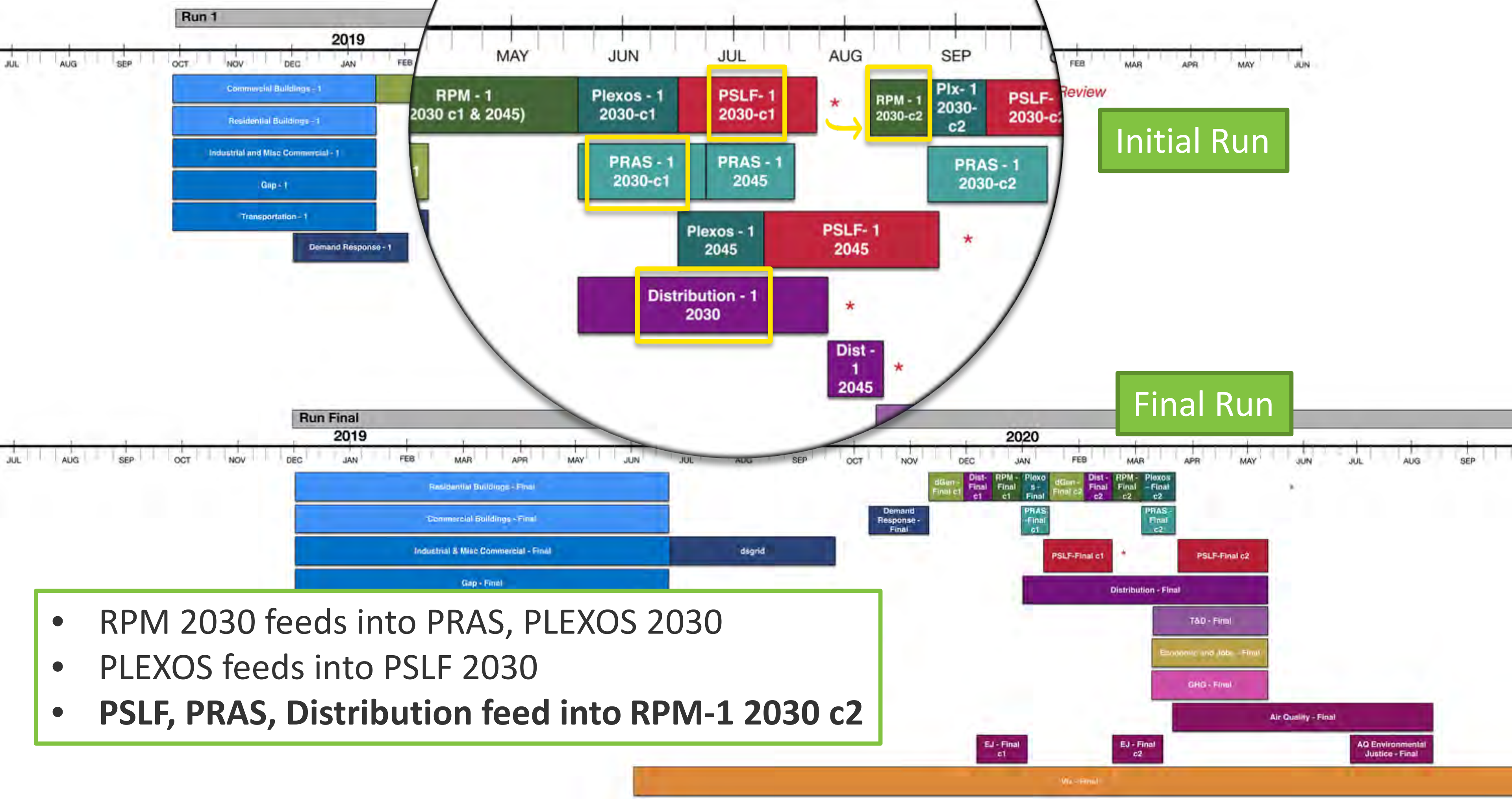




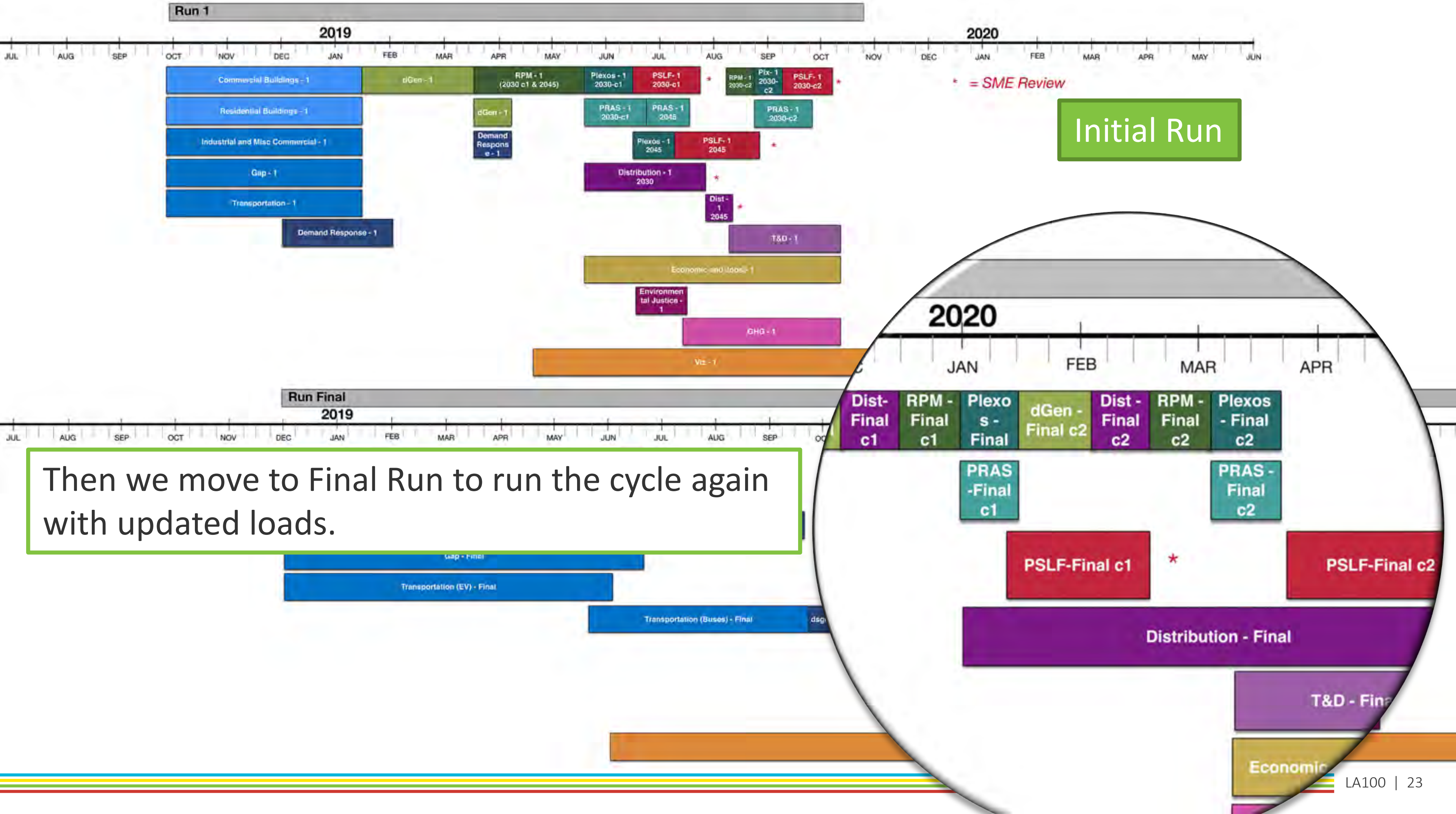
- **RPM 2030 feeds into PRAS, PLEXOS 2030**
- PLEXOS feeds into PSLF 2030
- PSLF, PRAS, Distribution feed into RPM-1 2030 c2



- RPM 2030 feeds into PRAS, PLEXOS 2030
- **PLEXOS feeds into PSLF 2030**
- PSLF, PRAS, Distribution feed into RPM-1 2030 c2

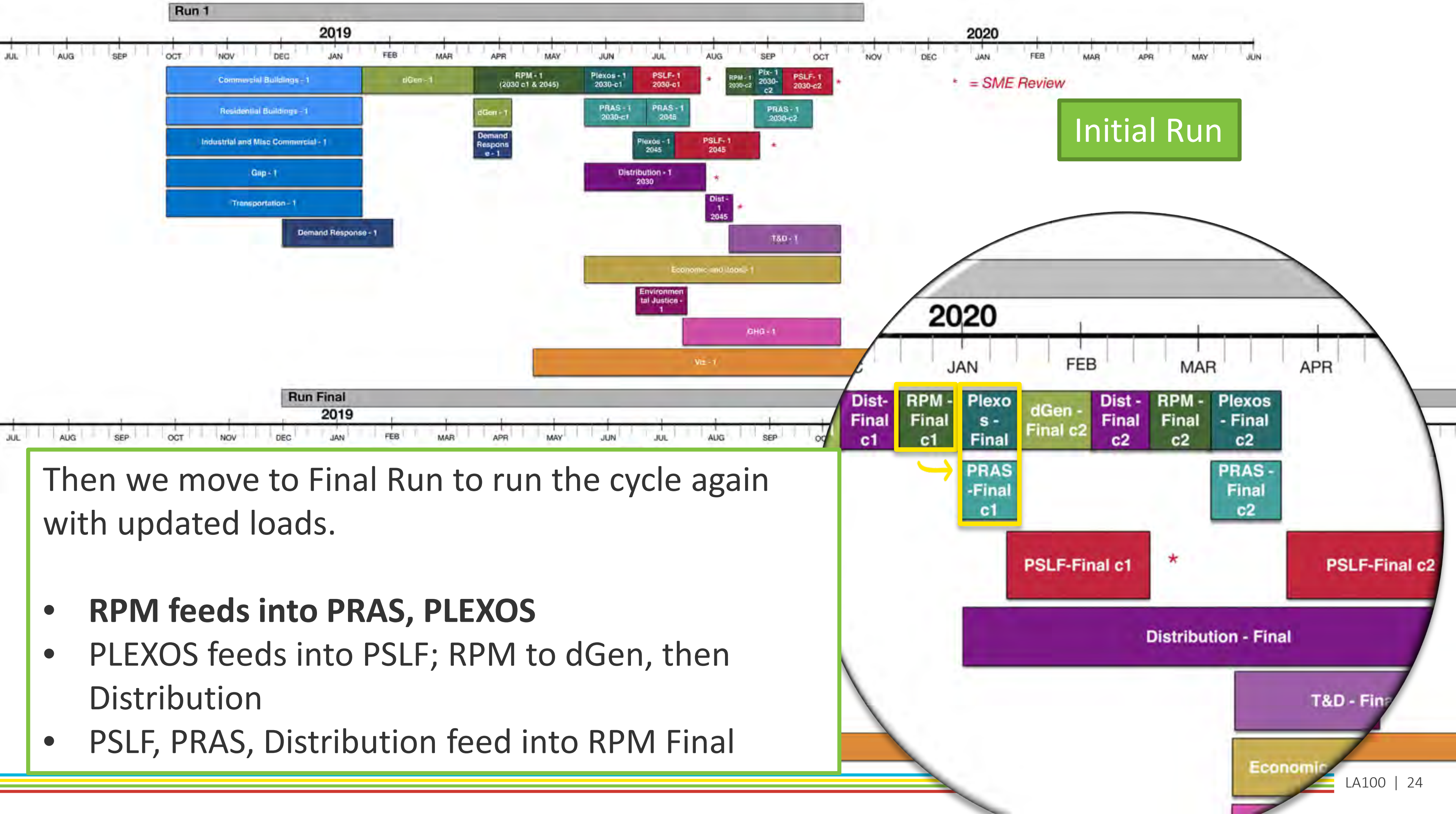


- RPM 2030 feeds into PRAS, PLEXOS 2030
- PLEXOS feeds into PSLF 2030
- **PSLF, PRAS, Distribution feed into RPM-1 2030 c2**



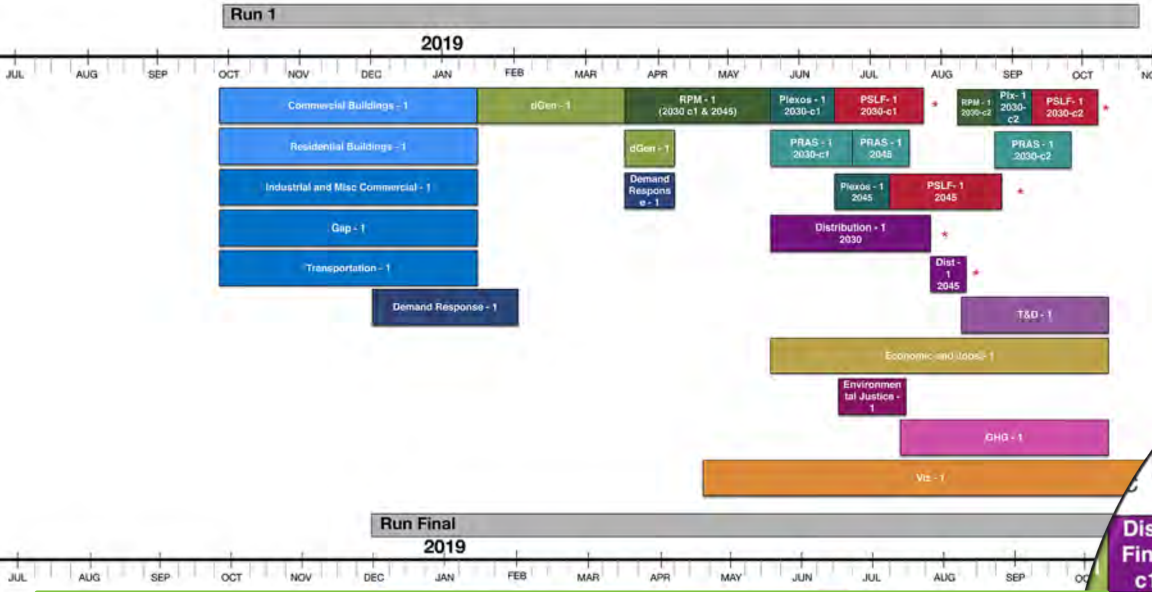
Initial Run

Then we move to Final Run to run the cycle again with updated loads.

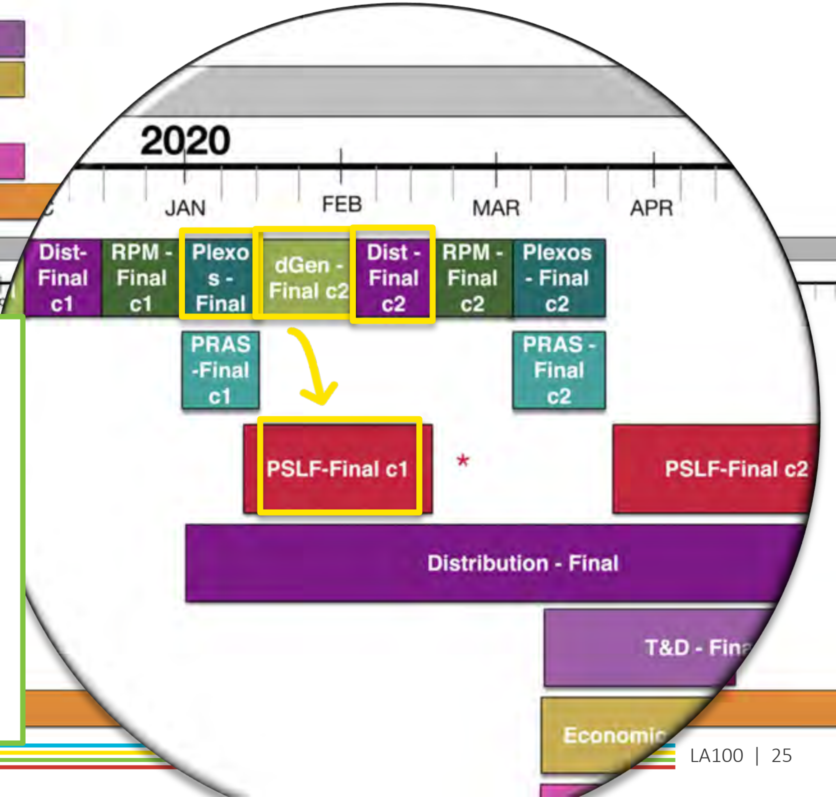


Then we move to Final Run to run the cycle again with updated loads.

- **RPM feeds into PRAS, PLEXOS**
- PLEXOS feeds into PSLF; RPM to dGen, then Distribution
- PSLF, PRAS, Distribution feed into RPM Final

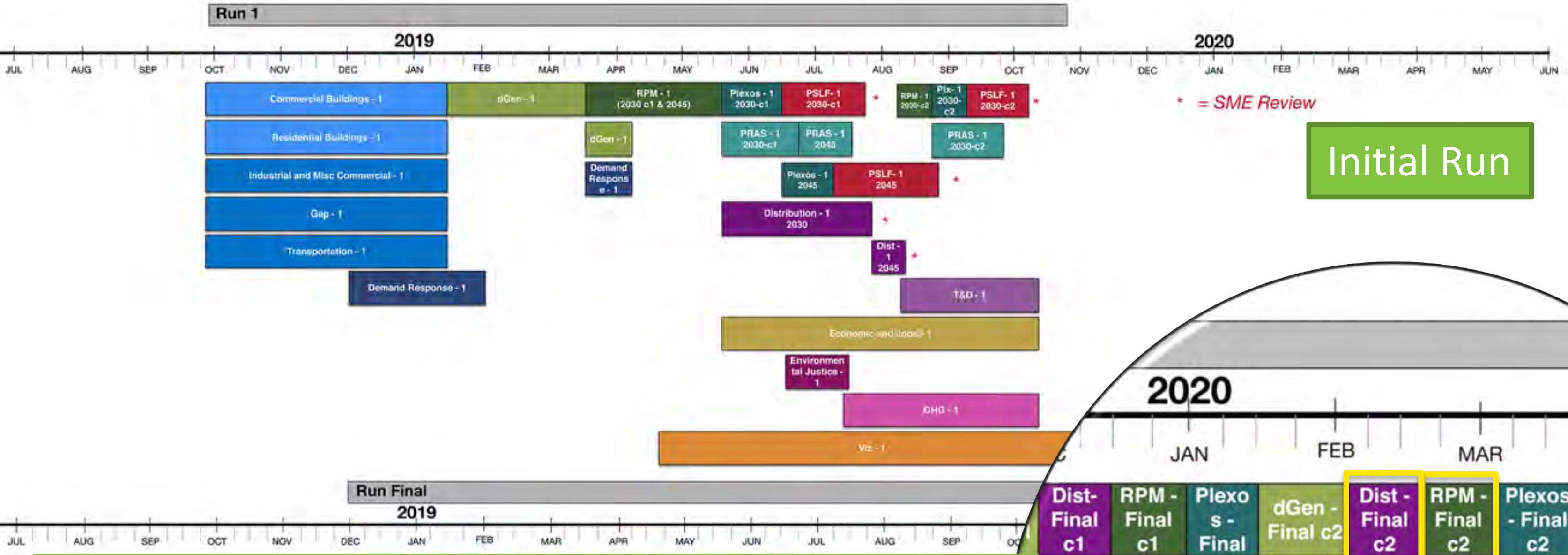


Initial Run

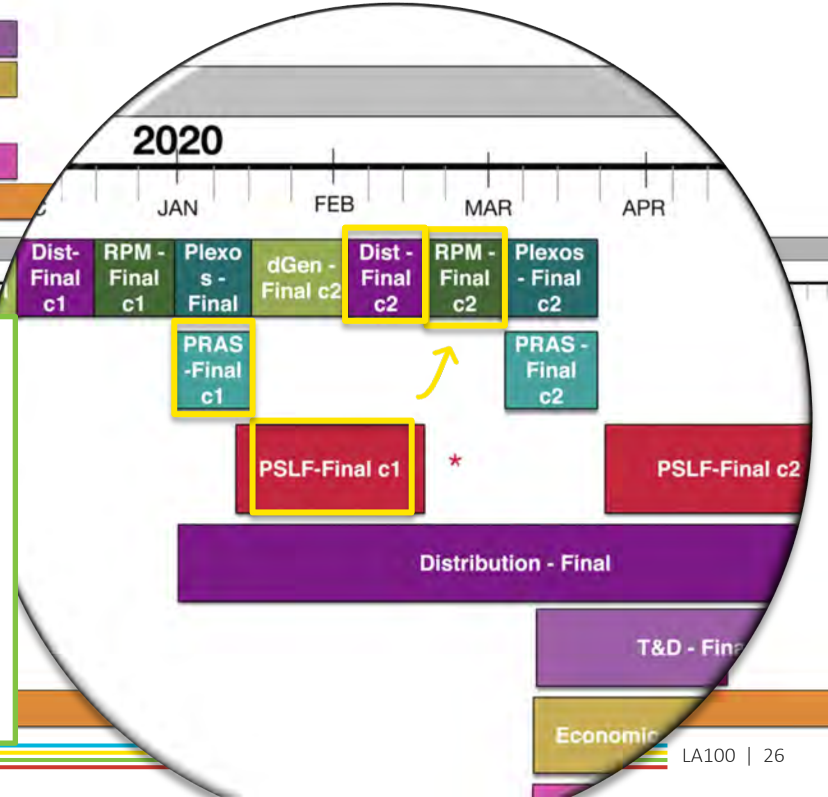


Then we move to Final Run to run the cycle again with updated loads.

- RPM feeds into PRAS, PLEXOS
- **PLEXOS feeds into PSLF; RPM to dGen, then Distribution**
- PSLF, PRAS, Distribution feed into RPM Final



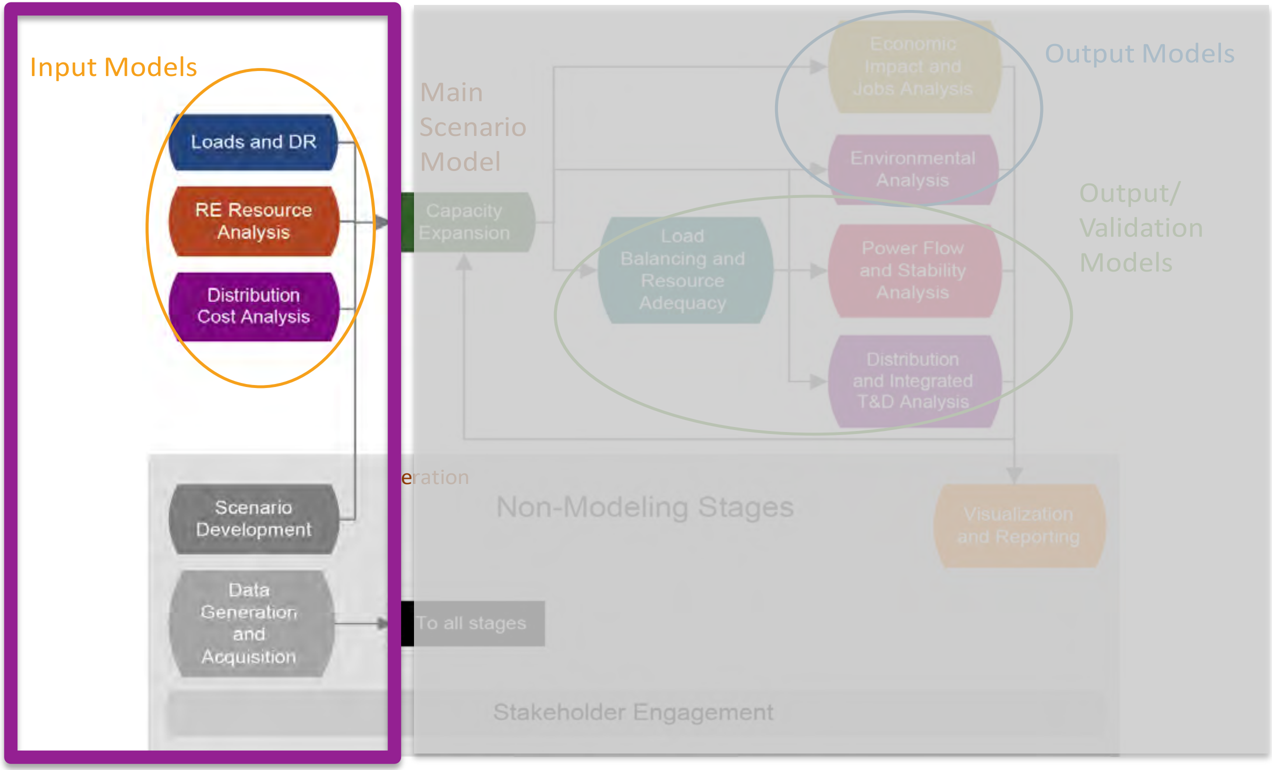
Initial Run



Then we move to Final Run to run the cycle again with updated loads.

- RPM feeds into PRAS, PLEXOS
- PLEXOS feeds into PSLF; RPM to dGen, then Distribution
- **PSLF, PRAS, Distribution feed into RPM Final**

Input Models—Status Update



Complete:

- Final Run: Load modeling, except electric buses (new)
- Energy efficiency assumptions
- RE generation profiles

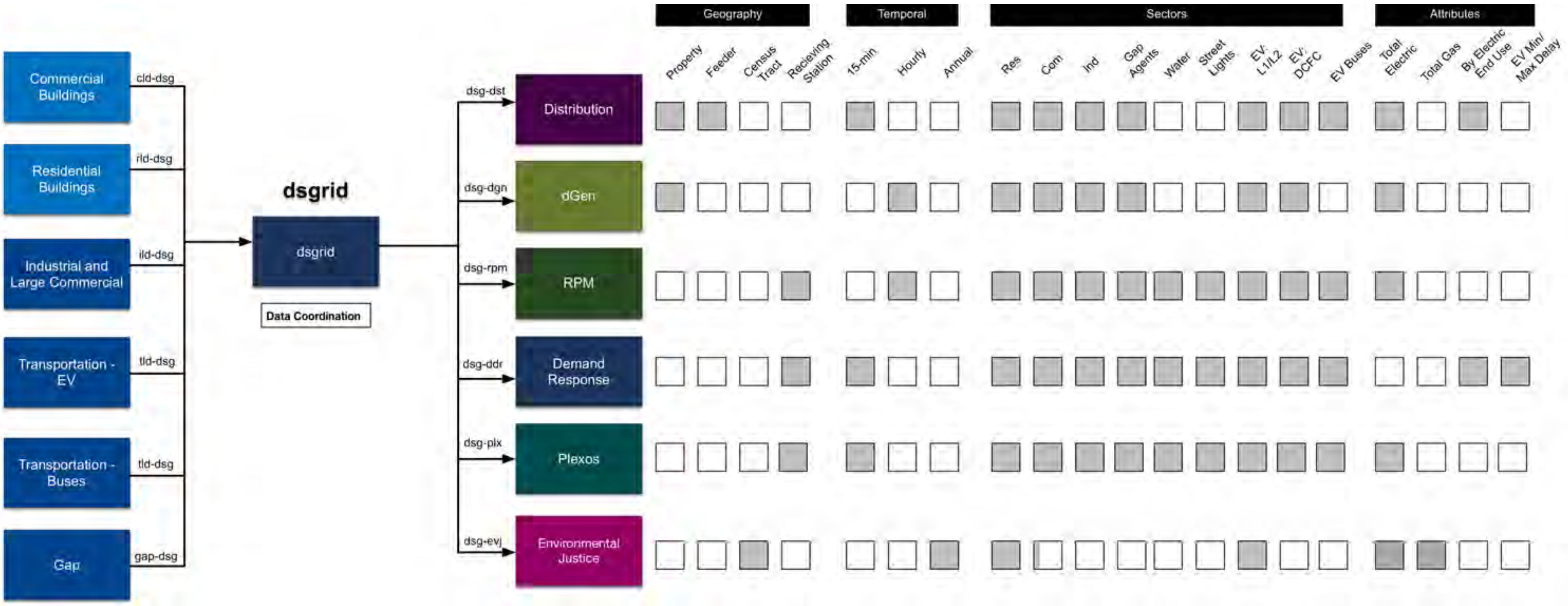
Ongoing refinement:

- Rooftop PV availability
- Data management between models

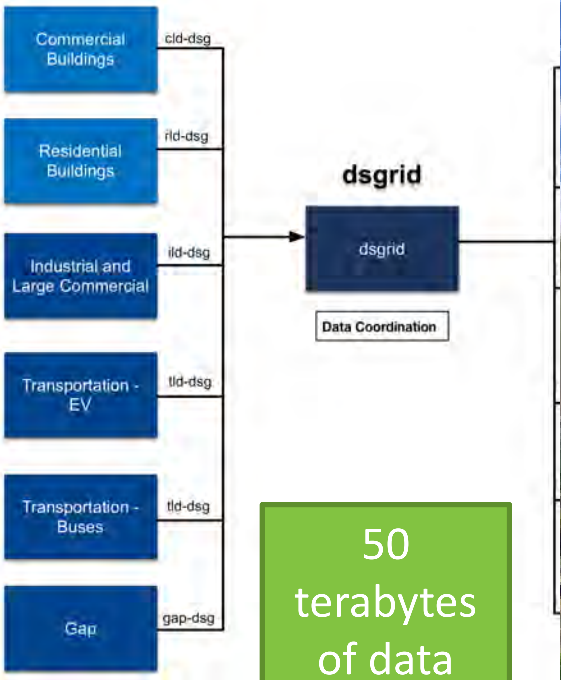
In development:

- Distribution network—modeling and costs
- Electric bus (school, transit) charging profiles

Progress Update: Load Data Allocation to Downstream Models



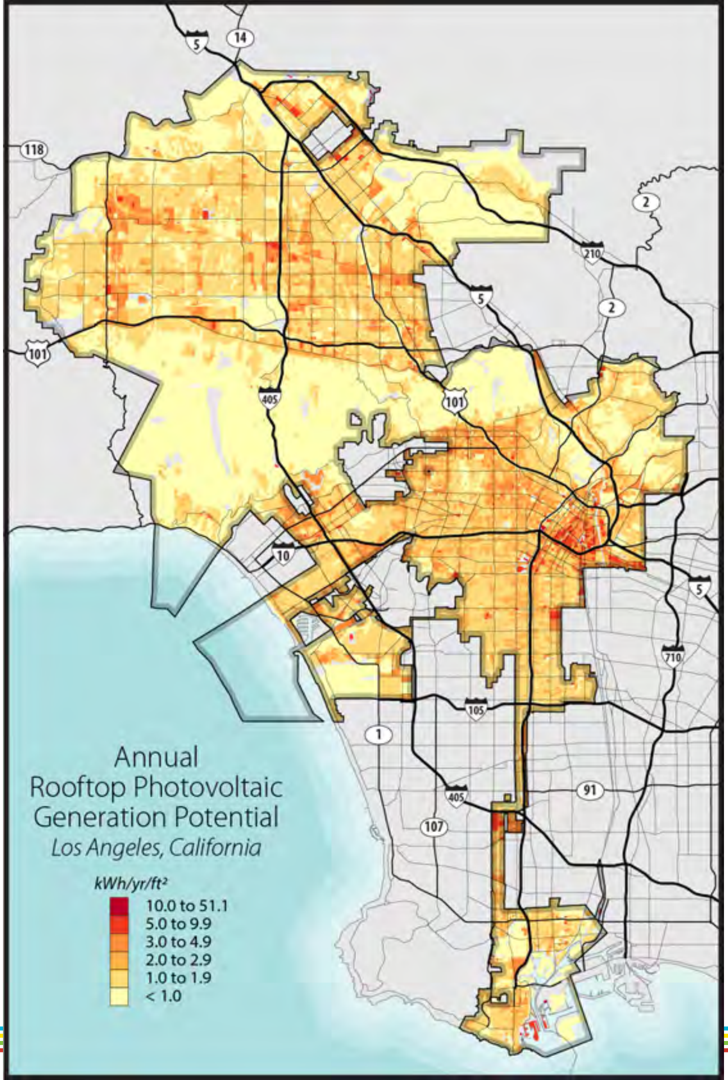
Progress Update: Load Data Allocation to Downstream Models



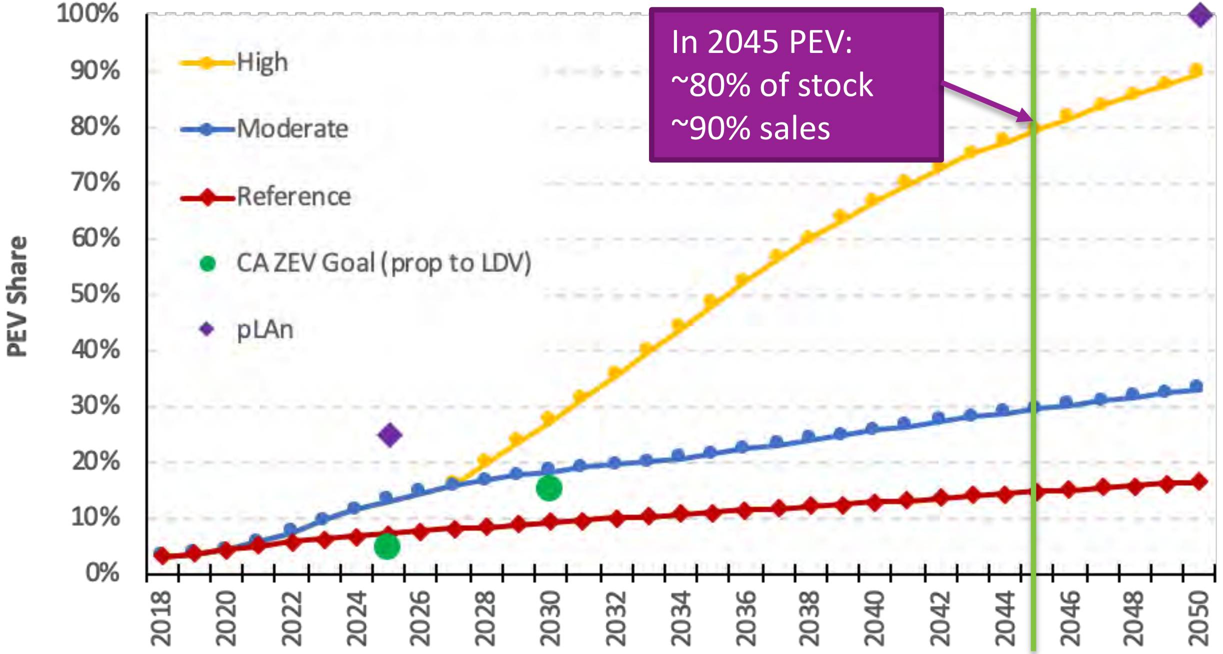
50 terabytes of data

Progress Update: Analysis of 2045 Rooftop Solar

Technical Potential



Progress Update: Projections of Light-Duty Electric Vehicles Adoption, by Scenario

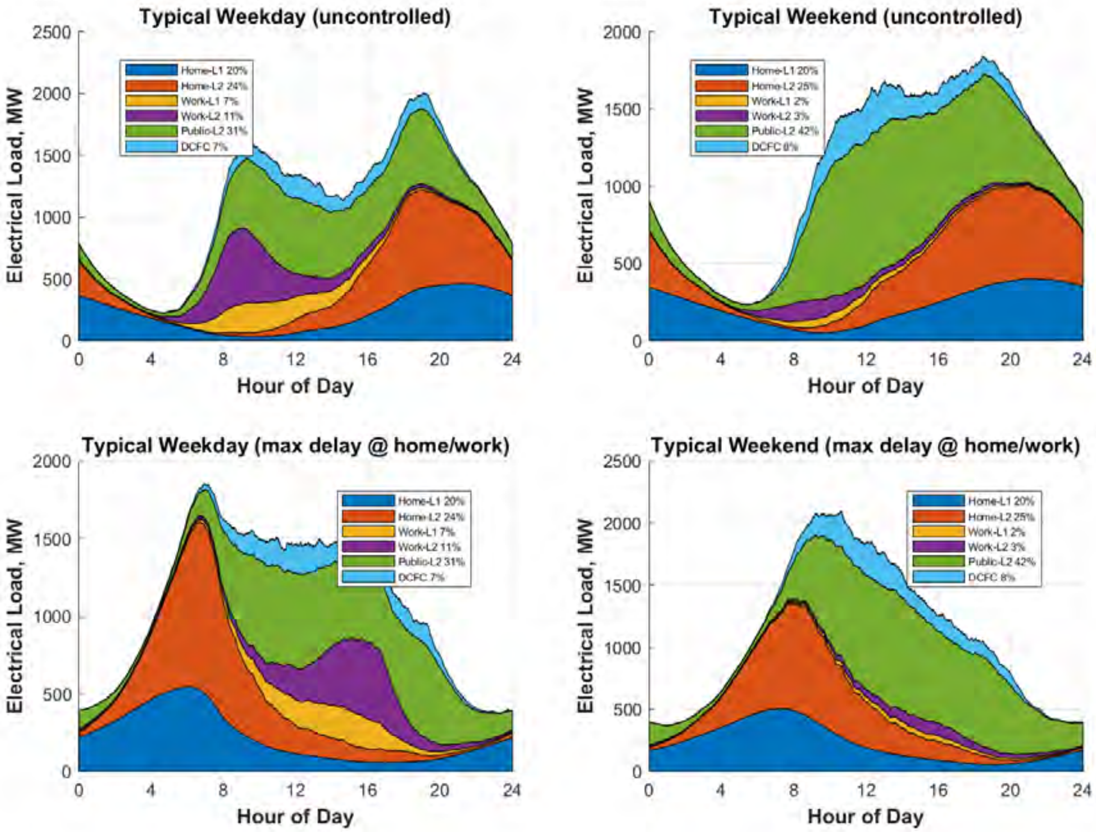


Plug-in EV Share by Projection: Moderate: 30% of Stock
High: 80% in 2045; 90% in 2050

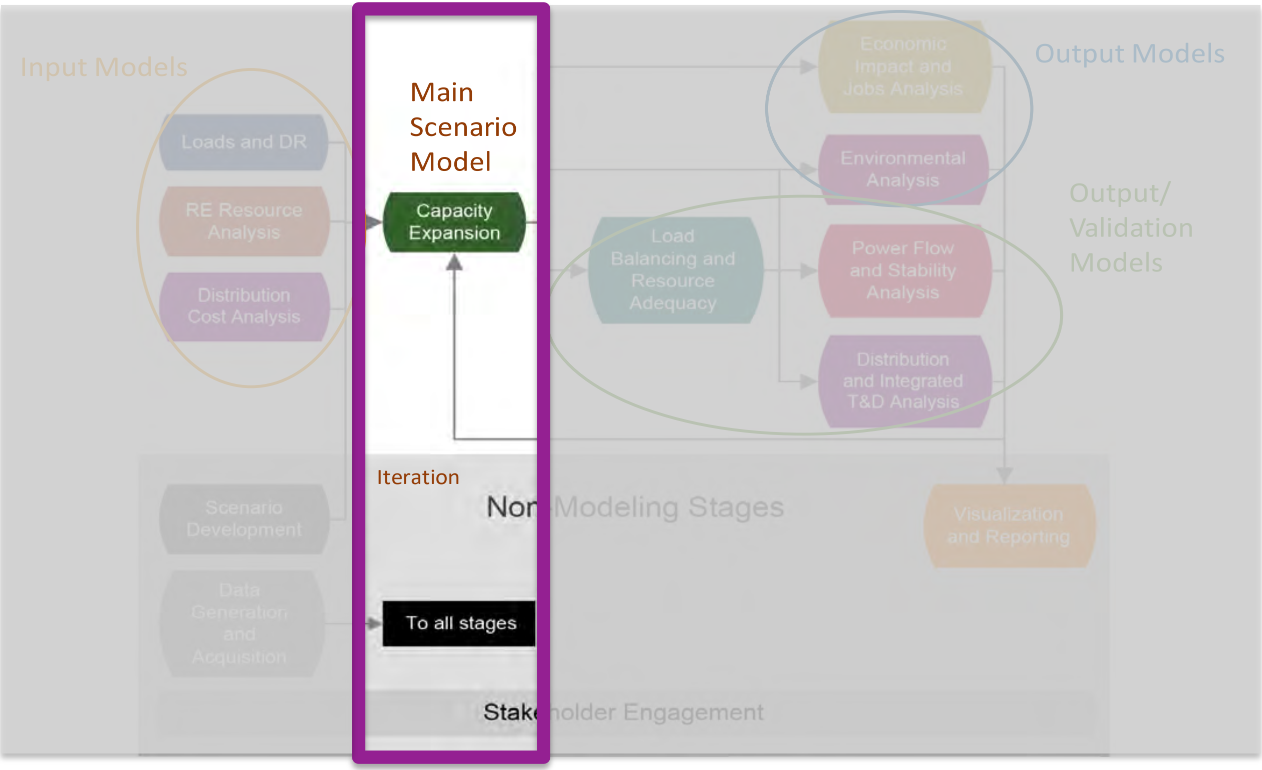
Progress Update: Projections of Light-Duty Electric Vehicles Charging Profiles

High Electrification

- 2.6M EVs in 2045
- 60% access to residential charging
- 50% access to workplace charging



Capacity Expansion: Initial Scenario Modeling



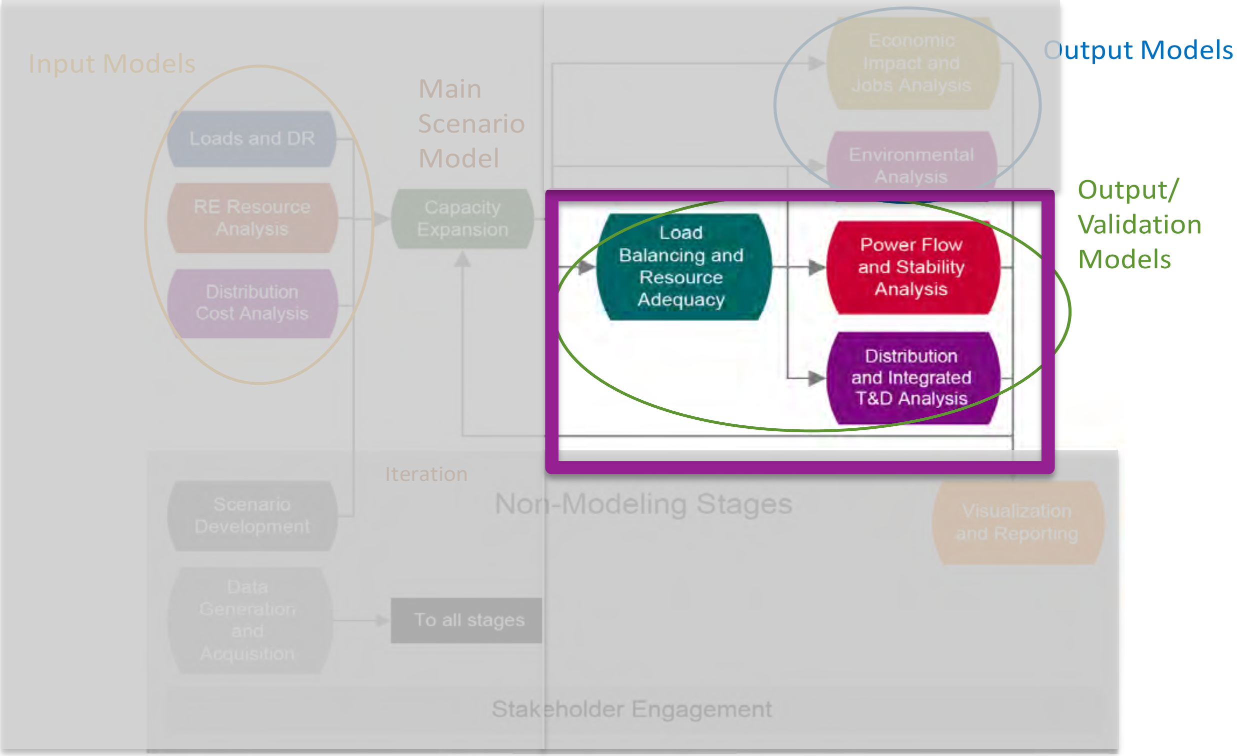
Complete:

- LADWP initial feedback on characterization of generation and transmission (modeling inputs)
- Initial Run modeling of all scenarios
  - Will be previewing outputs following this presentation

In development:

- Final Run
- Replacement options to exclude repowering
- Evaluation of additional technologies (e.g., undersea cables)

Load Balancing and Stability: Refining Assumptions, Testing



Complete:

- 2017 SLTRP case tested (PCM, Power flow)
- LADWP initial feedback on assumptions (e.g., hydro operations, reserves, contingencies)

Underway:

- Initial Run modeling of all scenarios

In development:

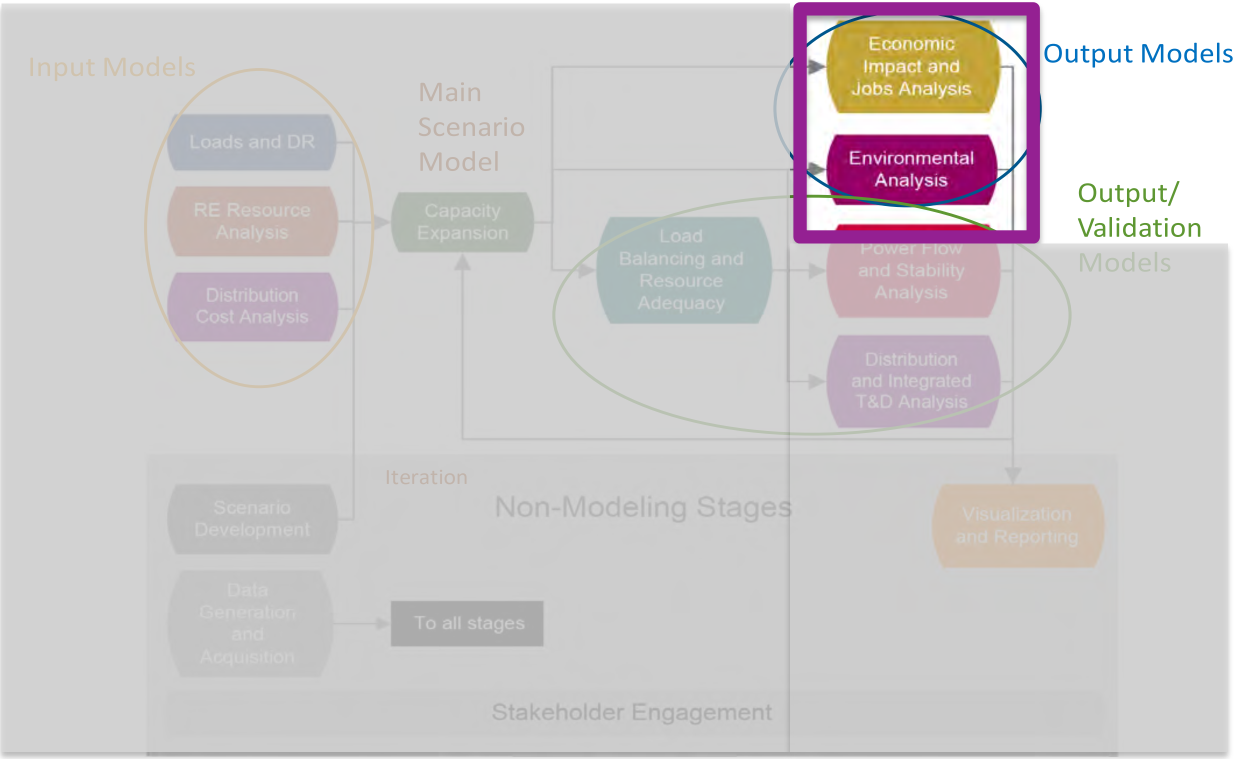
- RE forecast profiles

Reliability Check as Part of Validation Process

Approach:

- 2017 SLTRP is the most recent projection that has been vetted by an Advisory Group and deemed achievable and reliable
- 2017 SLTRP projects to 2037 and had been one of our reference scenarios, but was removed because it includes repowering of OTC units
- As part of our validation process, we will use 2017 SLTRP (extended to 2045, in line with SB100) as a basis to evaluate reliability of our LA100 scenarios

Economic and Environmental Impacts: Modeling Methods Developed; Awaiting Initial Run Results



Complete:

- Models (economic impacts, air quality) calibrated for LA

Under development:

- Public health model
- Environmental justice analysis

Questions?

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Bulk Power System Modeling:
Key Considerations, Working Assumptions, and Ongoing Exploration

Daniel Steinberg, NREL

Advisory Group Meeting

June 13, 2019

Los Angeles Department of Water & Power

NREL Transforming ENERGY

Session Goals

1. Review the formulation of a 100% clean or renewable energy standard
2. Review key bulk-system modeling assumptions
3. Understanding outputs from capacity expansion and production cost models
4. Bulk power system pathways to 100%—what have we been learning?

Defining a Clean Energy Standard: Clean Generation

$$Clean\ Gen = Load$$

Defining a Clean Energy Standard: Clean Generation

$$Clean\ Gen = Load$$

- *Clean Generation* includes generation for all qualifying clean technologies (what qualifies as clean depends on scenario)

Defining a Clean Energy Standard: Load

$$Clean\ Gen = End\ Use\ Consumption + System\ Losses$$

- *Clean Generation* includes generation for all qualifying clean technologies
- *End Use Consumption* is the energy consumed at the point of end use: plug loads
- *System Losses* are the losses associated with transmission and distribution

Defining a Clean Energy Standard: Time

$$Clean\ Gen_t = End\ Use\ Consumption_t + System\ Losses_t$$

- Over what time period is this evaluated?

Defining a Clean Energy Standard: RECs

$$Clean\ Gen_t + RECs_t = End\ Use\ Consumption_t + System\ Losses_t$$

- Whether renewable energy certificates (***RECs***) are allowed to contribute toward compliance and restrictions on the types and quantities of RECs allowed depends on the scenario

Interpretation for Current Results Shown

- Load must be met with clean energy at all times unless RECs are allowed
- Exported clean energy does not count towards compliance; cannot offset natural gas generation with surplus renewable generation unless RECs are allowed

Key Assumptions for Bulk System Modeling and Analysis

Two of eight scenarios allow the use of RECs for a portion of compliance

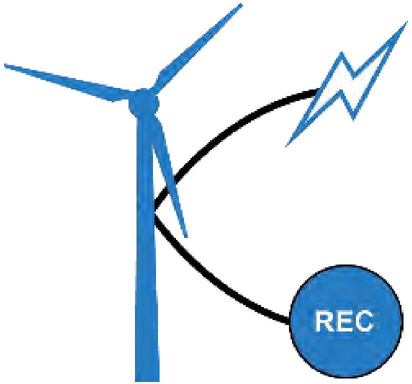
		SB100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
		LA100 Scenarios							
	2030 RE Target	60%	100% Net Renewable Energy						
	Compliance Year for 100%	2045	2035/2040	2045	2045	2045	2045	2045	2045
Technologies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

Defining RECs

A renewable energy certificate (REC) is a market-based instrument that represents the property rights to the environmental, social, and other non-power attributes of renewable electricity generation. **RECs are issued when one megawatt-hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy resource.**

Use of RECs in Making RE Claims

- Every MWh of RE output generates two valuable assets:



Electricity
RE output may be used to reduce the customer's grid demand, sold into wholesale markets, or sold directly to a supplier via bilateral contract

RECs
RECs are used by customers to make RE use claims or sold into REC markets

- RECs are uniquely numbered and tracked;
- For compliance purposes (e.g., with a renewable portfolio standard), RECs are "retired" by obligated entities
- REC tracking and certification systems prevent double-counting

Modeling Assumptions: RECs

The LA100 study assumes that the CA SB 350 RPS REC usage restrictions apply in all scenarios that allow partial compliance with RECs

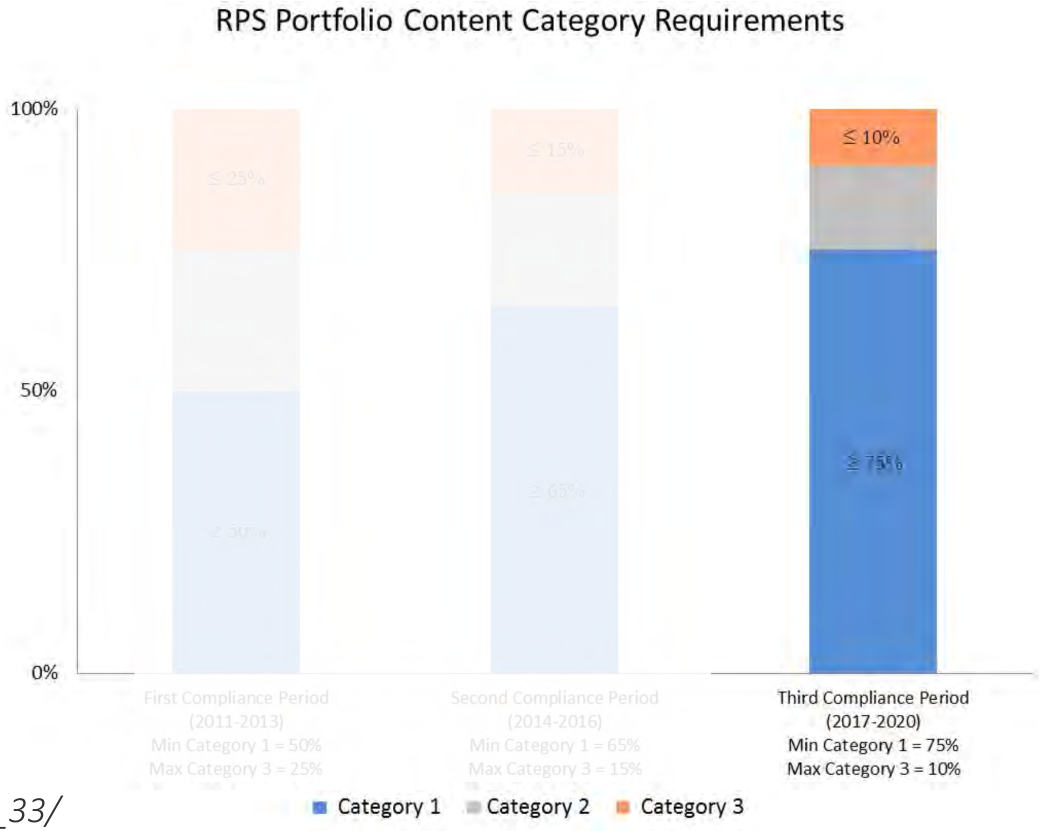


Figure from the California PUC: https://www.cpuc.ca.gov/RPS_Procurement_Rules_33/

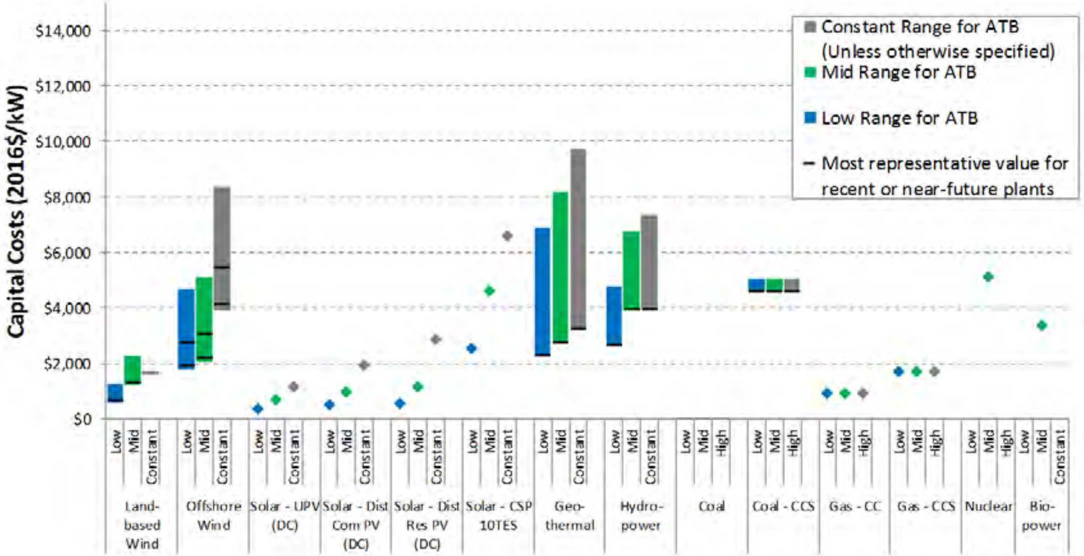
Modeling Assumptions:
Coordination with Other Entities

- **Planning/investment (RPM)**: LADWP system designed for *self-sufficiency*: all electricity services (energy, capacity, planning reserves, and operating reserves) must be met with LADWP owned or contracted assets
- **Dispatch/operations (PLEXOS)**: examine both dispatch based solely on LADWP-owned or -contracted assets, **and** *fully coordinated* dispatch

Assumptions: Technology Costs and Performance

NREL's Annual Technology Baseline (ATB)

- The ATB provides a consistent set of cost and performance projections for renewable and conventional generation and storage technologies from present day to 2050
- Costs covered: capital (including financing costs), fixed and variable (non-fuel) O&M



2018 ATB CAPEX range by technology for 2050

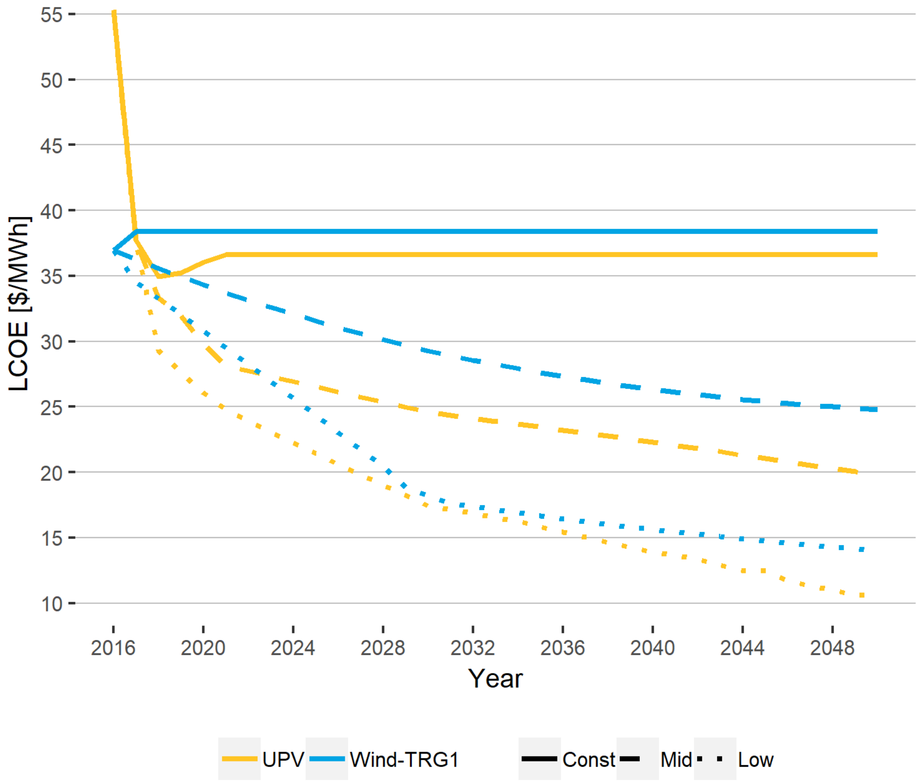
Source: National Renewable Energy Laboratory Annual Technology Baseline (2018), http://atb.nrel.gov

Assumptions: Technology Costs and Performance

- **Constant:** Current technology costs held constant; represents limited/no technology improvement; No additional R&D

- **Mid:** Improvements characterized as “likely” or “not surprising;” continued public and private R&D; continued deployment and market growth

- **Low:** Improvements at the “limit of surprise”; not an absolute low bound; increased public and private R&D, breakthroughs; accelerated market growth



Assumptions: Technology Prices Sources of Base Year (2016)

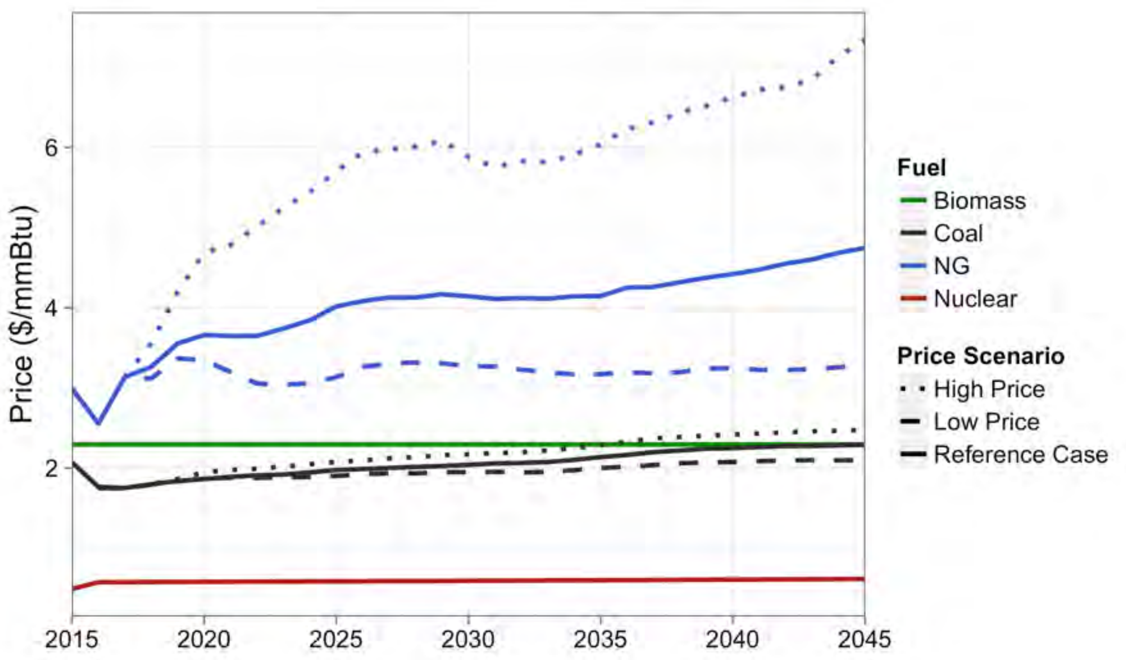
Technology	Methods	Main Sources
Wind - Land-based - Offshore	Use of market data Bottom-up modeling	2016 Wind Technologies Market Report (LBNL 2017) 2016 Cost of Wind Energy Review (NREL 2017) Assessment of Economic Potential of Offshore Wind in the United States (NREL 2017)
Solar Photovoltaics (PV) - Utility - Commercial and industrial - Residential	Market data Bottom-up model	Utility-Scale Solar 2016 (LBNL 2017) Tracking the Sun 10 (LBNL 2017) U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017 (NREL 2017)
CSP	Market data Unpublished data Bottom-up model	Utility-Scale Solar 2016 (LBNL) On the Path to SunShot (DOE/NREL 2016) Survey of in-development projects (DOE unpublished)
Hydropower - New stream-reach - Non-powered Dams	Market data Bottom-up model	Hydropower Baseline Cost Modeling (ORNL 2015)
Geothermal - Binary and flash - EGS	Bottom-up model	Geothermal Energy Technology Evaluation Model (DOE 2016)
Fossil, Nuclear, and CCS	Engineering estimates	AEO2018 assumptions (EIA 2018)

Assumptions: Technology Prices Sources of Projections

Technology	Methods	Main Sources
Wind - Land-based - Offshore	Expert elicitation Bottom-up model Expert assessment	Expert elicitation survey on future wind energy costs (LBNL 2016) SMART Wind (NREL 2017)
Solar PV - Utility - Commercial and industrial - Residential	Literature survey Bottom-up model	Internal analysis (Feldman/NREL 2018) On the Path to SunShot (DOE/NREL 2016)
CSP	Market data Unpublished data Bottom-up model	Internal analysis (Kurup/NREL 2018) On the Path to SunShot (DOE/NREL 2016)
Hydropower - New stream - Non-powered Dams	Expert assessment Learning	Hydropower Vision (DOE 2016) NEMS (EIA 2017)
Geothermal - Binary and flash - EGS	Bottom-up model	Same as ATB 2017. Will be updated after Geothermal Vision Study is published.
Fossil, Nuclear, and CCS	Learning	AEO2018 outputs (EIA 2018)

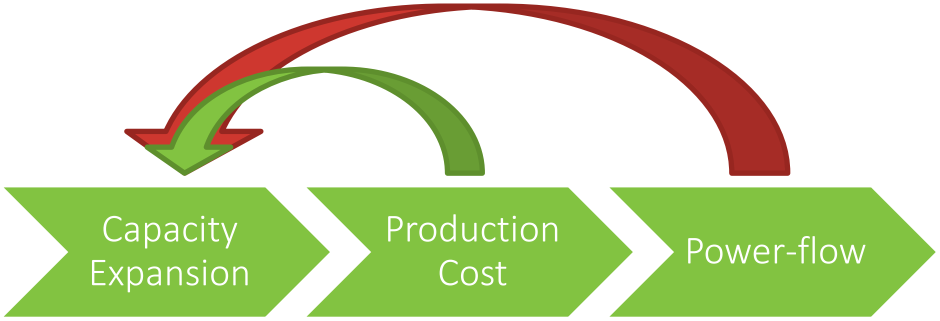
Assumptions: Fuel Prices

- **Current and near-term** (through 2020) fuel prices are based on LADWP's existing contracts with fuel providers
- **Future** fuel prices (2020–2045) are based on projections used within LADWP's SLTRP analyses, and standard projections for power sector delivered fuel prices from the U.S. Energy Information Administration's Annual Energy Outlook (AEO2018)



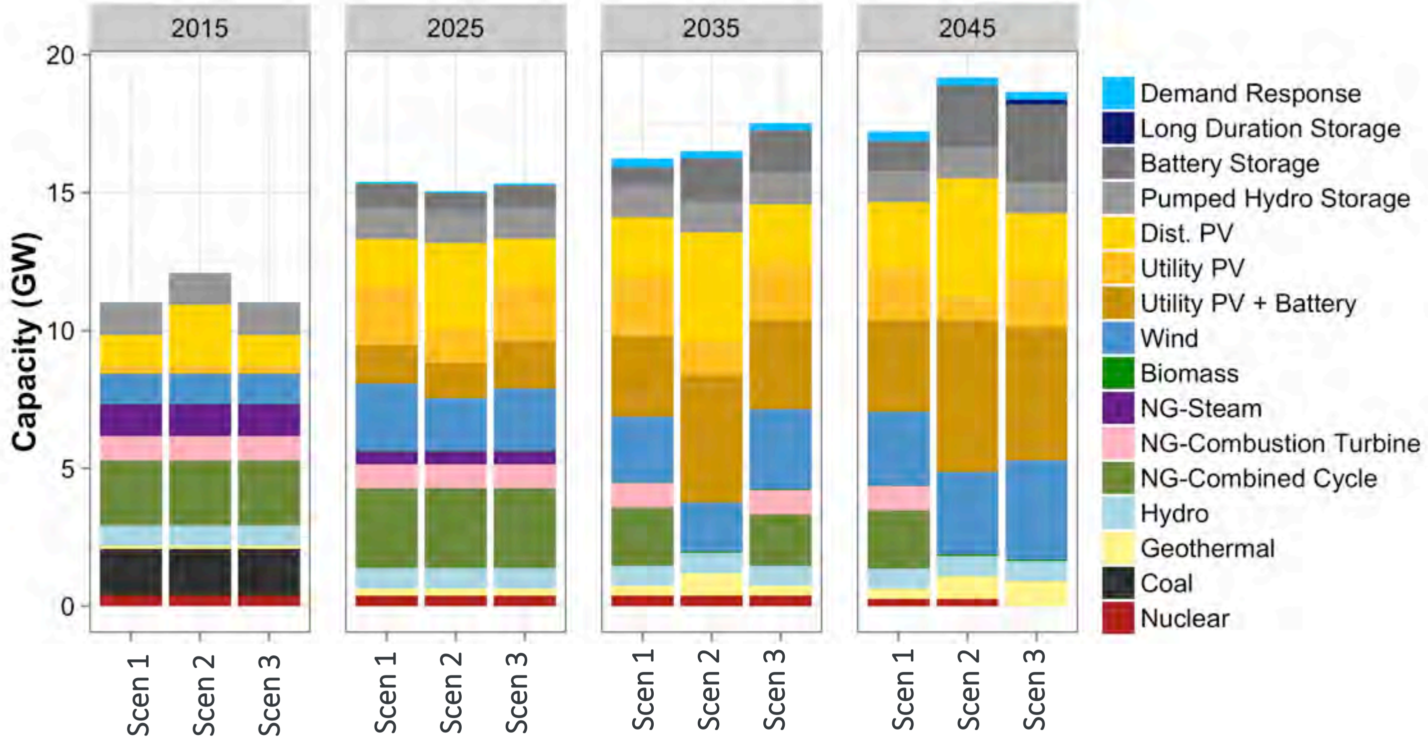
What kind of plots are we going to see?

General Approach: Estimate, Then Refine



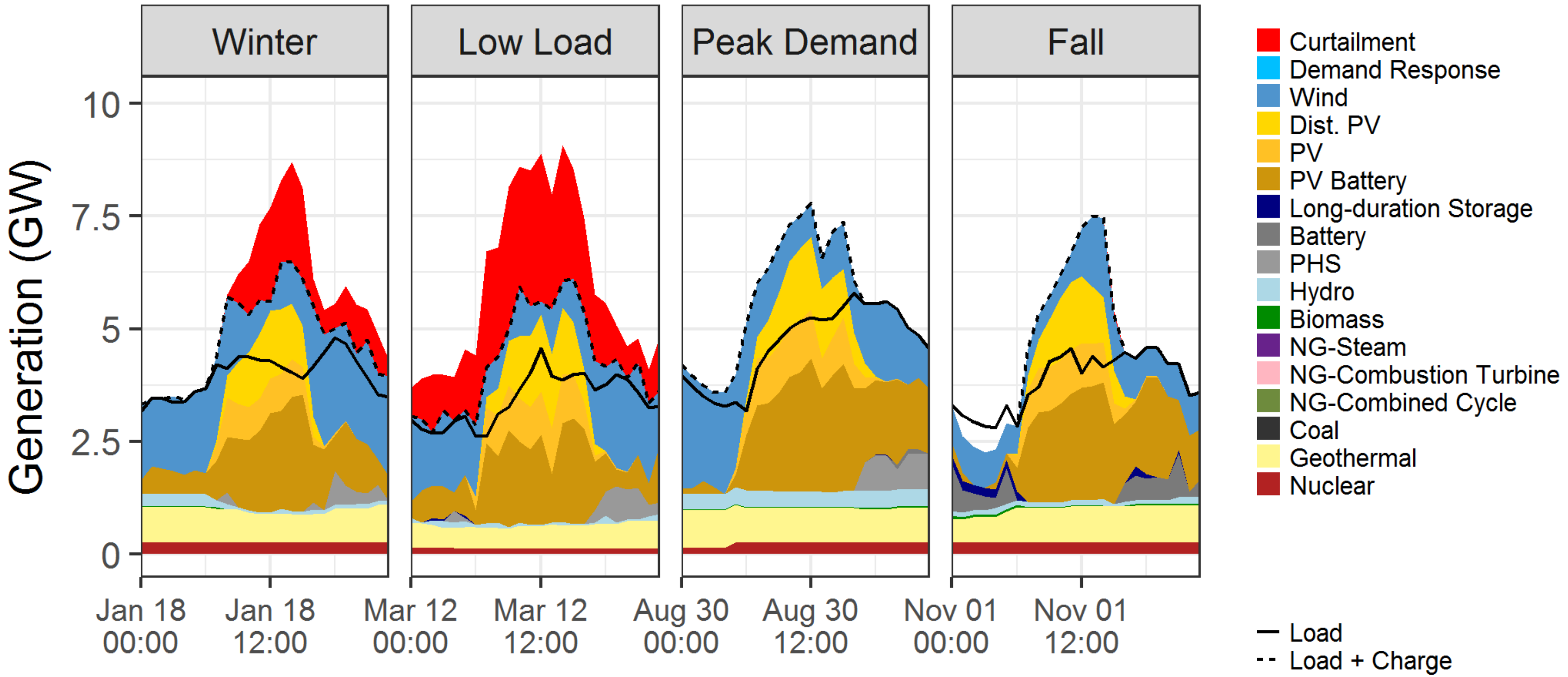
Capacity Expansion	Production Cost	Power-flow
Estimate investment & reduced-form operational costs	Calculate detailed operational costs; identify additional investments needed to address congestion	Identify any other necessary infrastructure to mitigate power-flow issues

Capacity Expansion/Evolution

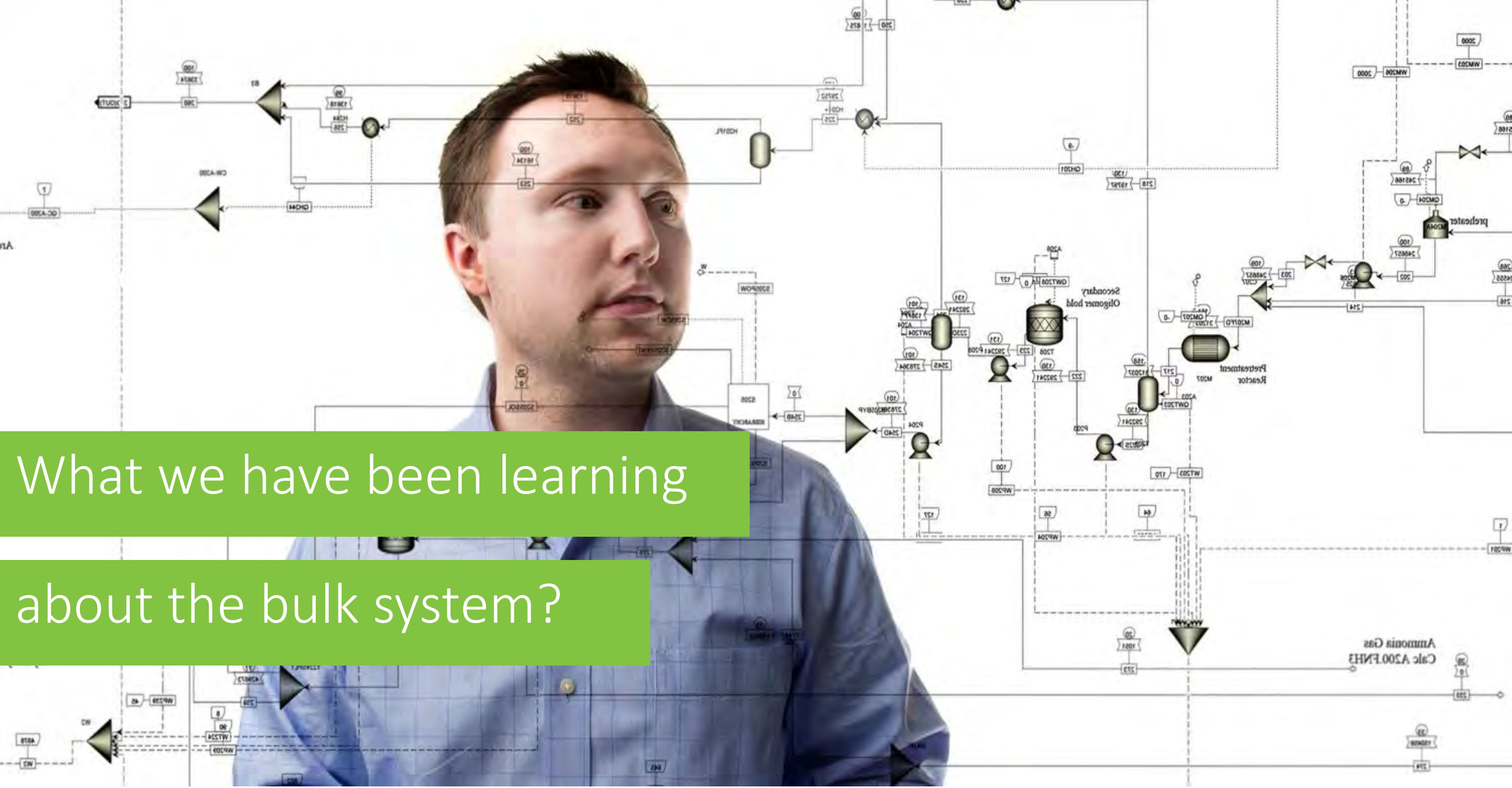


Example figure for demonstration purposes only

Dispatch (Hourly Generation)



Example figure for demonstration purposes only

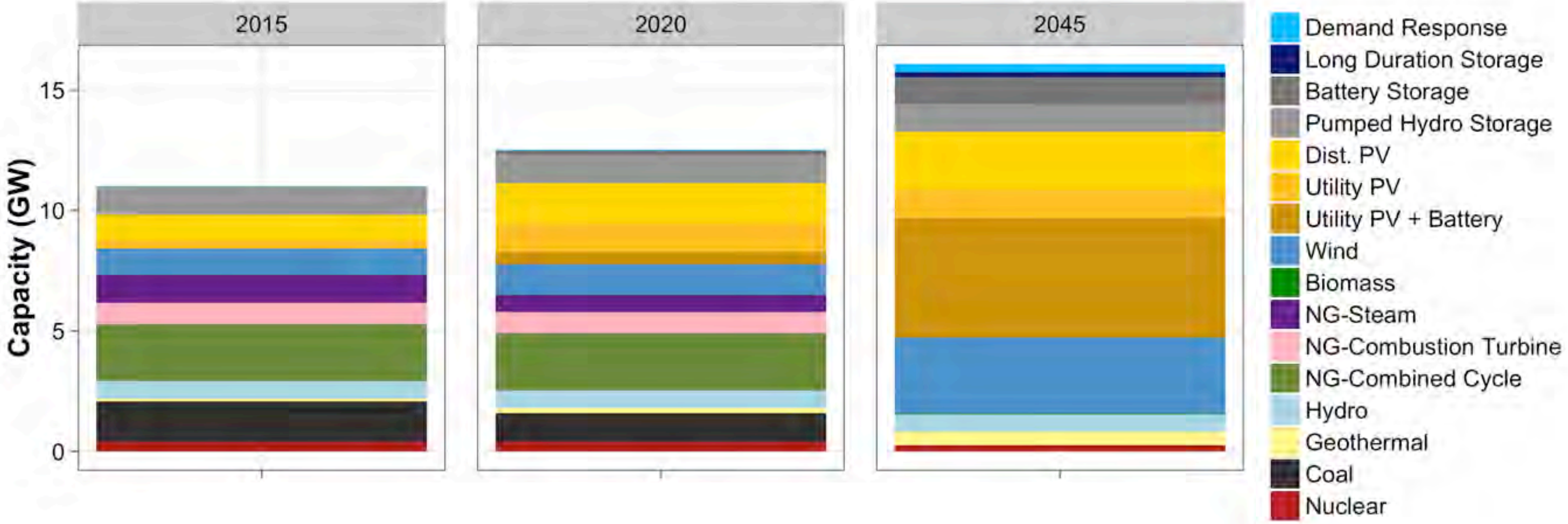


What we have been learning about the bulk system?

Getting to 100% Means Leveraging a Diverse Set of Power System Technology Options

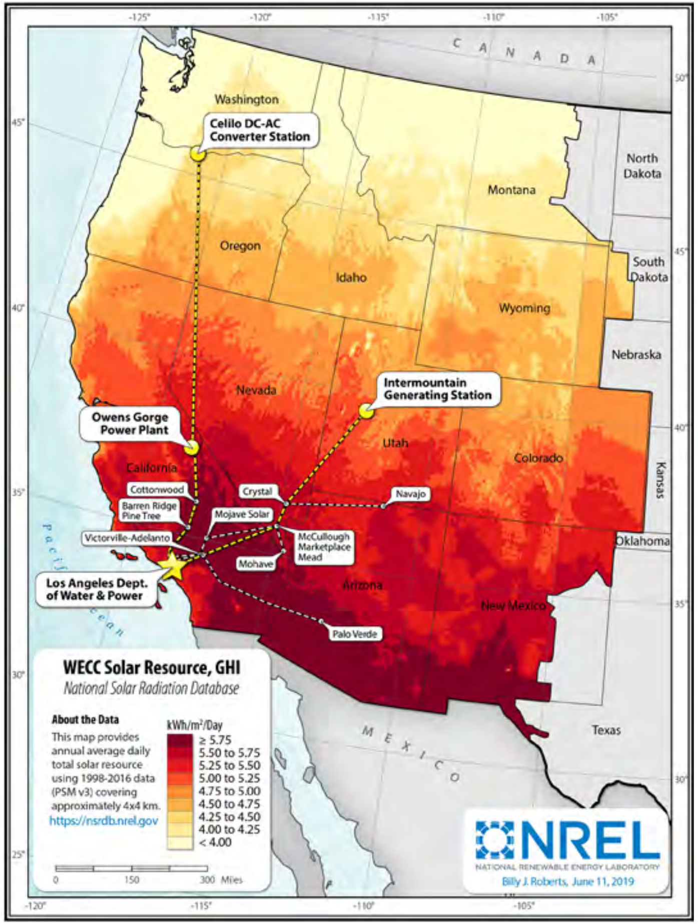
- New wind and solar **capacity** is crucial
- **Storage** is needed to manage diurnal and, in cases without the option to leverage of thermal generation, seasonal variability
- Eligibility of **RECs** allows usage of non-eligible generation during hours of stress
- With high penetrations of variable resources comes increased economic **curtailment**

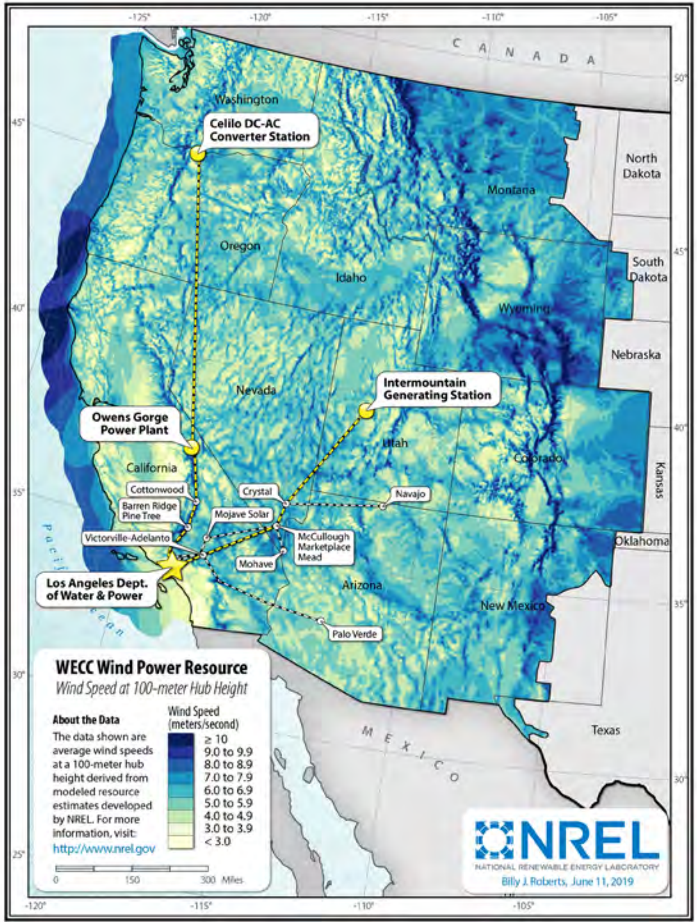
New Renewable Capacity Is Required



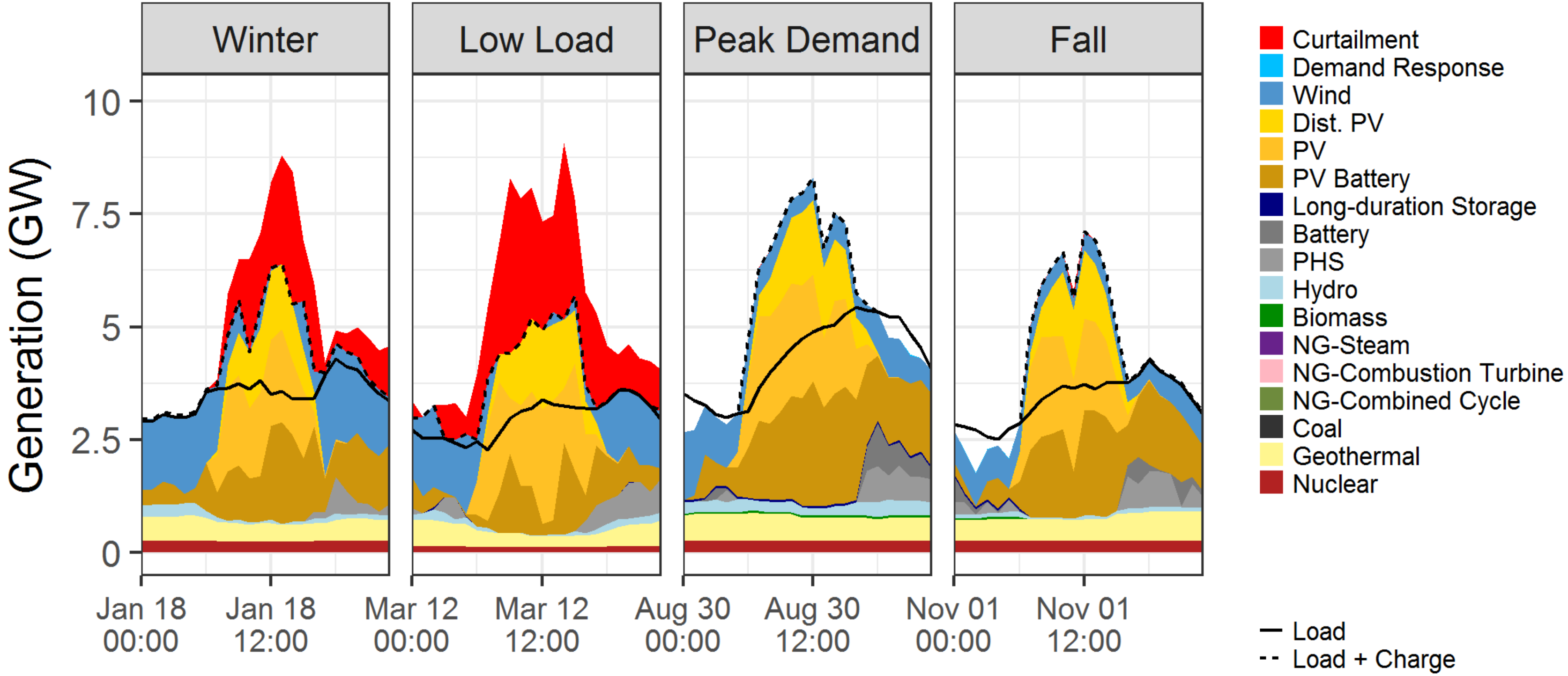
Preliminary Insights—for Discussion Purposes Only

New Renewable Capacity Is Required



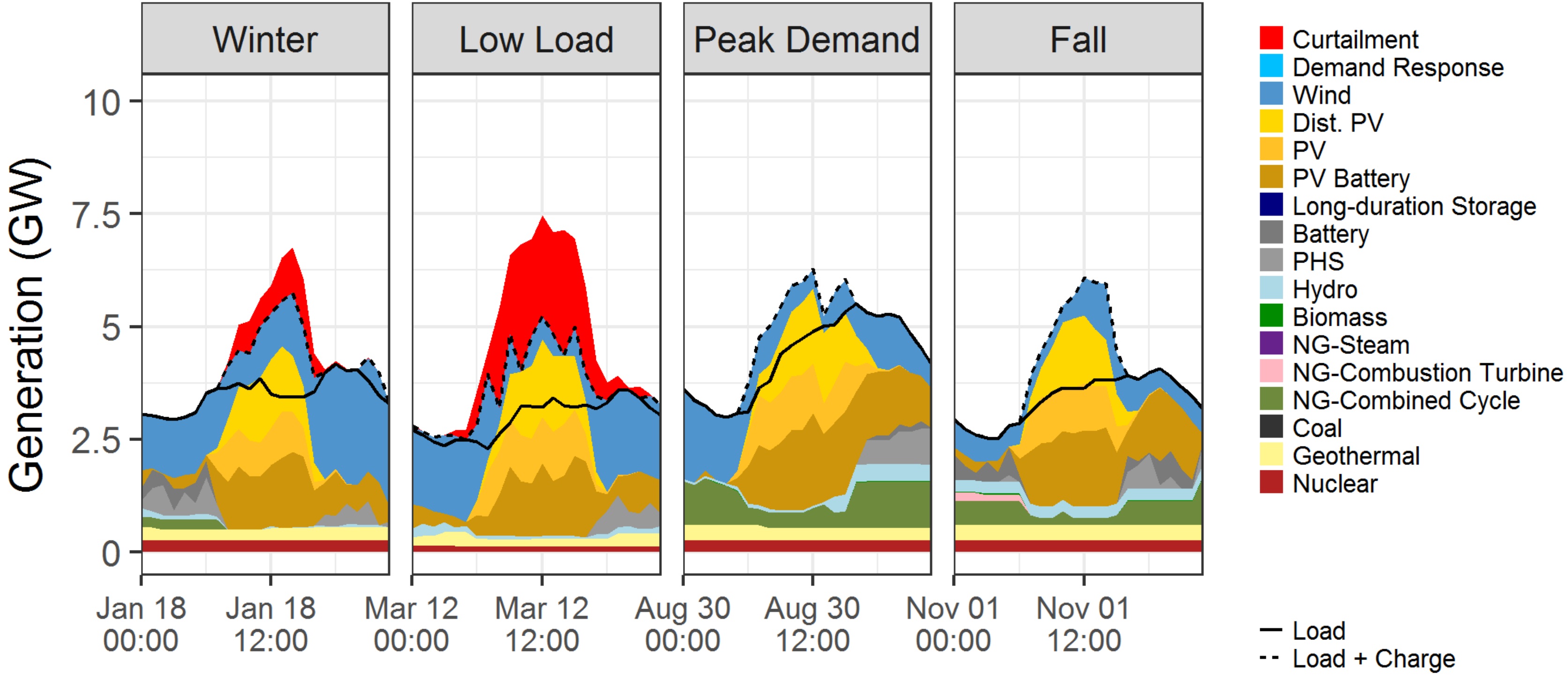


Storage Is Crucial to Manage Variability

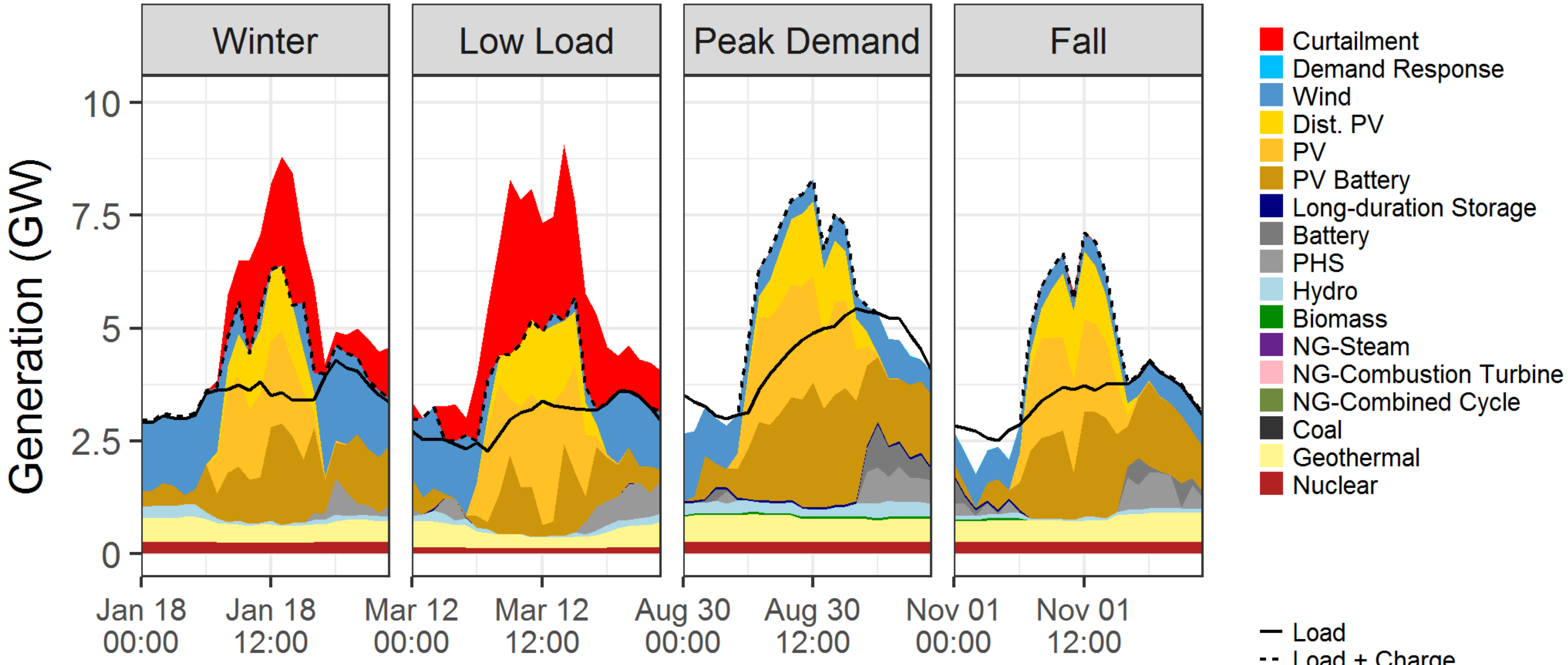


Preliminary Insights for Discussion Purposes Only—Do Not Cite or Distribute

RECs Allow Flexibility to Leverage Thermal Capacity in Times of System Stress



At 100% Renewable, Curtailment Is Also High



Thank you

The Los Angeles 100% Renewable Energy Study

LA100

The Los Angeles 100% Renewable Energy Study

Buildings Sector Bottom-up Load Modeling

Eric Wilson

Advisory Group Meeting, June 13, 2019

Los Angeles Department of Water & Power | NREL Transforming ENERGY

Session Goals

1. Become familiar with methodology for buildings sector load modeling

2. Review buildings electrification and efficiency load projections

3. Review sample results

Definition of Buildings Sector Load

For today's presentation:

Included

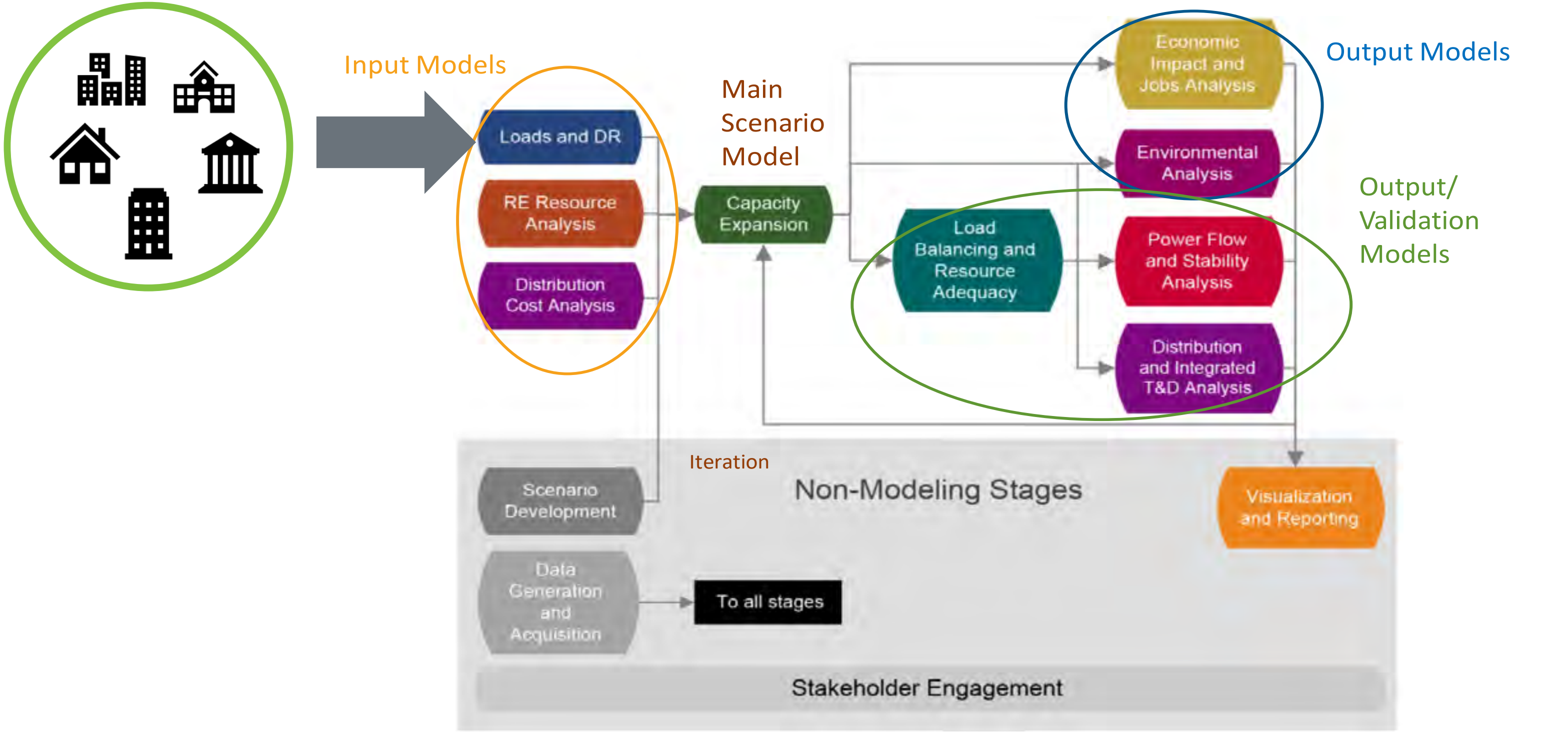
- Residential buildings
- Commercial buildings

Not included

- Distributed solar PV
- Electric vehicle charging
- Demand response
- Industry/special loads

Context: How does load modeling fit in?

Buildings load impacts all downstream models



Building Stock Simulation

ResStock ComStock

Building stock characteristics database + Physics-based computer modeling + High-performance computing

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

ResStock ComStock

Building stock characteristics database + Physics-based computer modeling + High-performance computing

Building Characteristics

EIA	**Res/Com Energy Consumption Survey**
NAHB	**Homebuilder Surveys**
IECC	**Historical Energy Codes**

Other national, regional, and local audit databases

Census Data

Census	**American Community Survey (ACS)**

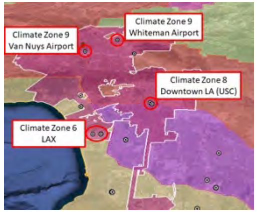
Costs

EIA	**Electricity and fuel costs**
NREL	**OpenEI.org Utility Rate Database**
NREL/Navigant	**Measure Cost Database**

Climate Locations

NREL	**TMY3 weather data**

Customization for Los Angeles



Los Angeles City/County

- Los Angeles Region Imagery Acquisition Consortium (LAR-IAC)
- LA County GIS Data Portal - various
- Los Angeles County Assessors Database
- LA DBS Existing Buildings Energy & Water Efficiency Program'
- Dodge Data and Analytics – Metropolitan Construction Insight

California (filtered to LA/DWP when possible)

- California Title 24 (current and historical building energy codes)
- California Database for Energy Efficiency Resources (DEER)
- California End Use Survey (CEUS)
- California Commercial Saturation Survey - Report for the California Public Utilities Commission
- 2009 California Residential Appliance Saturation Study (RASS), 2012 California Lighting and Appliance Saturation Survey (CLASS)
- Report on Complete Schools & 2015 Student Audit - California Department of Education
- California Department of Finance Population Projections for LA County
- Weather data from multiple weather stations covering LA microclimates

ResStock ComStock

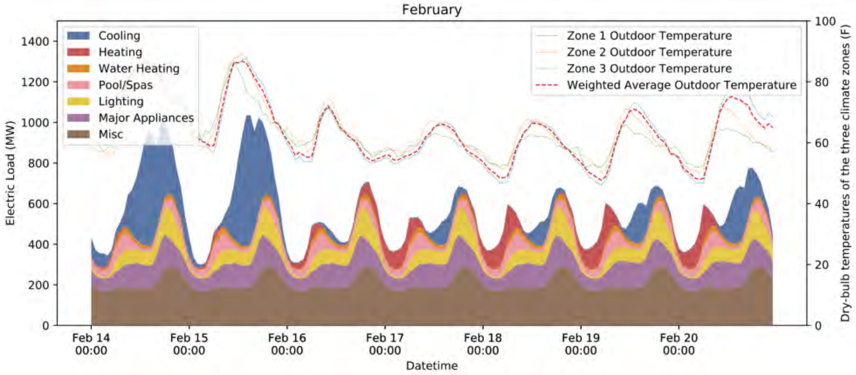
Building stock characteristics database + Physics-based computer modeling + High-performance computing

U.S. DOE Tools

OpenStudio

EnergyPlus

Detailed sub-hourly energy simulations



ResStock ComStock

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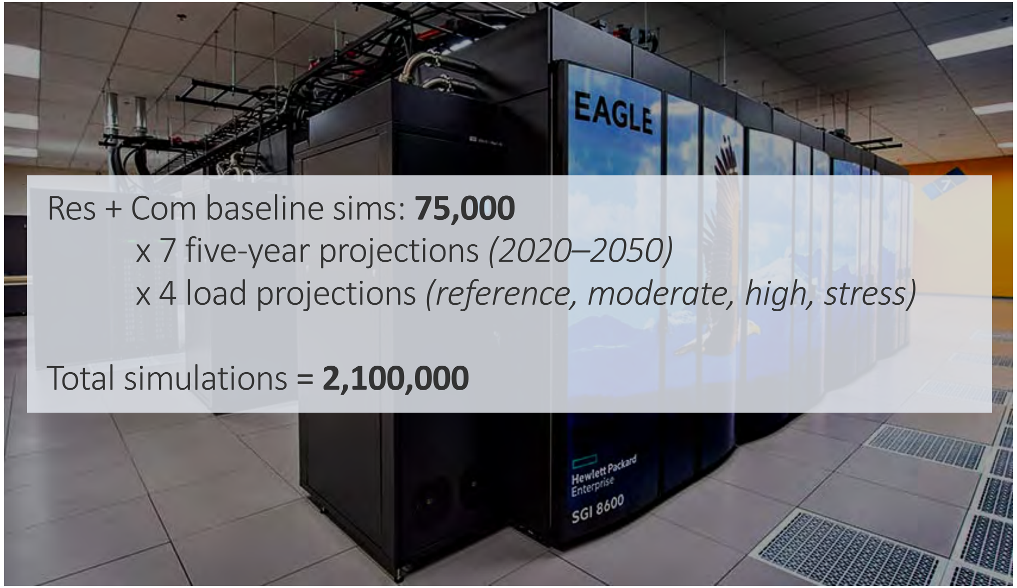

Res + Com baseline sims: **75,000**

x 7 five-year projections *(2020–2050)*

x 4 load projections *(reference, moderate, high, stress)*

Total simulations = **2,100,000**

ResStock ComStock

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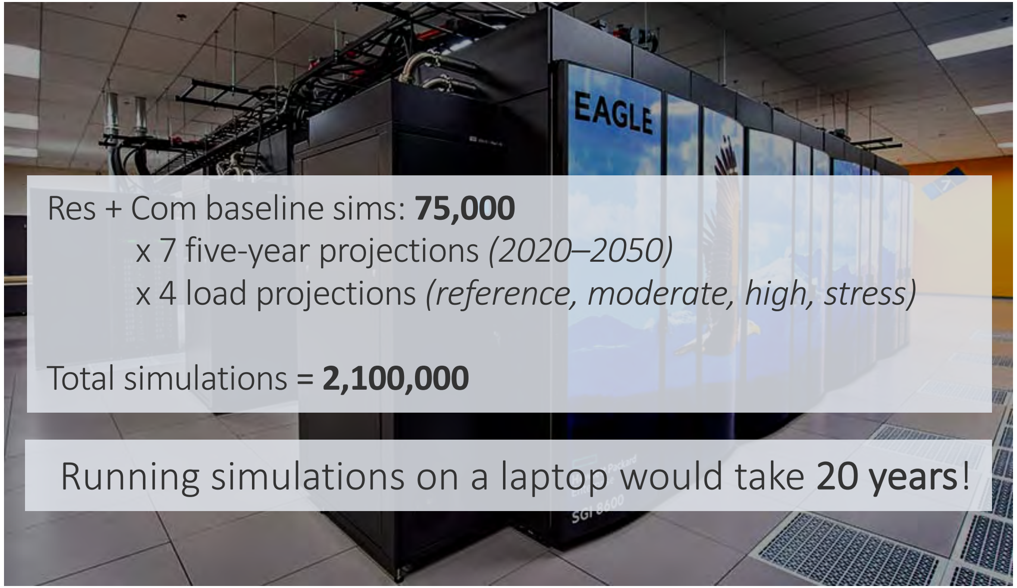

Res + Com baseline sims: **75,000**

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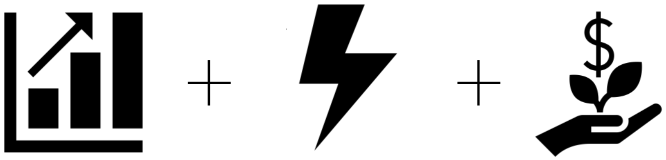
Total simulations = **2,100,000**

Running simulations on a laptop would take **20 years**!

Buildings Sector Load Projections



Load Projection Design Philosophy

- Load projections cover a **range of outcomes:**
  reference, moderate, high, stress

- Outcomes used to **back-cast** electrification and efficiency adoption rates

- Outcomes are **independent of market context and policy implementation** (e.g., prices or incentives)

How Each Scenario Characterizes Load

		LA100 Scenarios							
		SB100	LA-Leads	Transmission Renaissance	High Distributed Energy Future	Emissions Free	High Load Stress	Load Modern-ization	Western Initiatives
Load	Energy Efficiency	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Demand Response	Reference	High	Moderate	High	Moderate	Reference	High	Moderate
	Electrification	Reference	High	Moderate	High	Moderate	High	High	Moderate
		R	H	M	H	M		H	M

For all but one LA 100 scenario, the three dimensions vary together:

- **Reference**
- **Moderate**
- **High**

The name indicates the level of energy efficiency, electrification, and demand response.

How Each Scenario Characterizes Load

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		R	H	M	H	M	S	H	M

For all but one LA 100 scenario, the three dimensions vary together:

- **Reference**
- **Moderate**
- **High**

The name indicates the level of energy efficiency, electrification, and demand response.

The "High Load Stress" scenario uses a fourth load projection:

- **Stress** (combines **High electrification** and **Reference efficiency**)

Buildings Sector Load Projections

Projection Name		Residential Buildings	Commercial Buildings
Reference	Electrification	Low electrification (matches SLTRP[1] projections)	
	Efficiency	Designed to match 2017 SLTRP 10-year efficiency goals	
Moderate	Electrification	Low-hanging fruit electrification	
	Efficiency	Sales shares distributed across available efficiency levels	Moderate adoption of above-code efficiency levels (80% adoption of Title 24[3] code 5 yrs ahead of schedule)
High[2] GREEN NEW DEAL pLAn	Electrification	100% electric sales share by 2030 100% electric homes by 2050	100% electric sales by 2030 (HVAC and water heating) 100% electric buildings by 2050 (almost)
	Efficiency	100% sales share of highest efficiency levels (currently available technology)	Substantial adoption of above-code efficiency levels (70% adopt est. Title 24 code 15 yrs ahead of schedule)

- All projections use the same building stock growth assumption
- All projections assume natural turnover of equipment using standard lifetimes and commercial renovation rates (no early replacements)
- All projections use the same weather (2012)

[1] SLTRP = 2017 Final Power Strategic Long-Term Resource Plan

[2] High projection is based on our interpretation of of LA's Green New Deal Sustainable City pLAn 2019 (100% net zero carbon buildings by 2050; energy use intensity reduced by 44% by 2050)

[3] LA100 estimates projections of Title 24 (California's Building Energy Efficiency Standards) for 2022–2050

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Stress	Electrification	**High** electrification	
	Efficiency	**Reference** efficiency	

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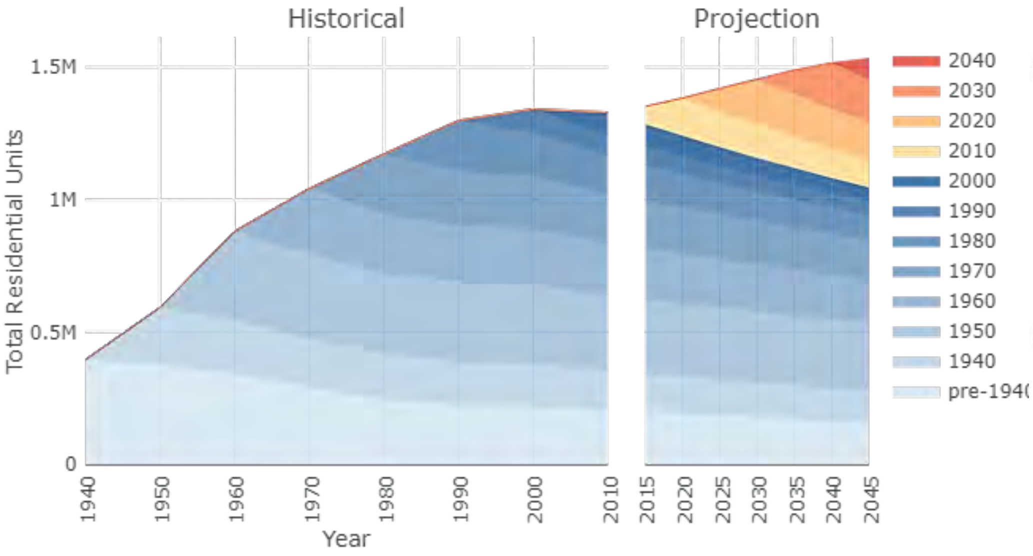
Building Stock Growth Projections

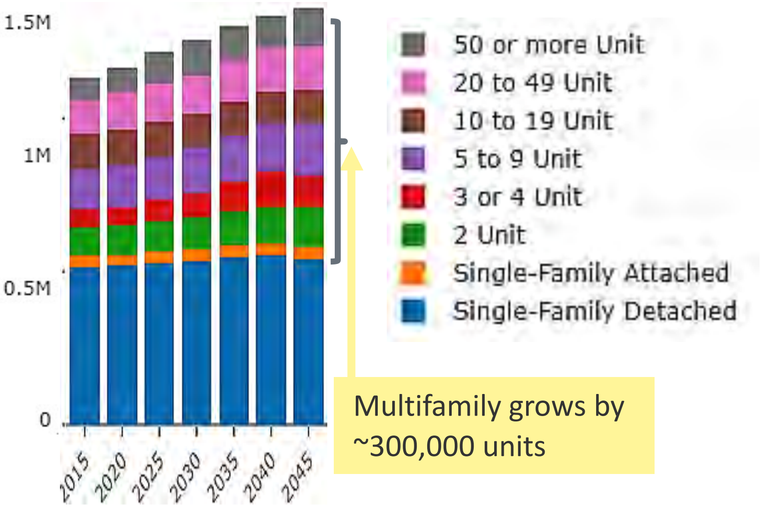
Residential Building Stock Growth Projections

- Using projections from California Department of Finance
- Demolitions and new construction modeled by vintage and building type
- Growth held constant across all load projection cases

Vintages

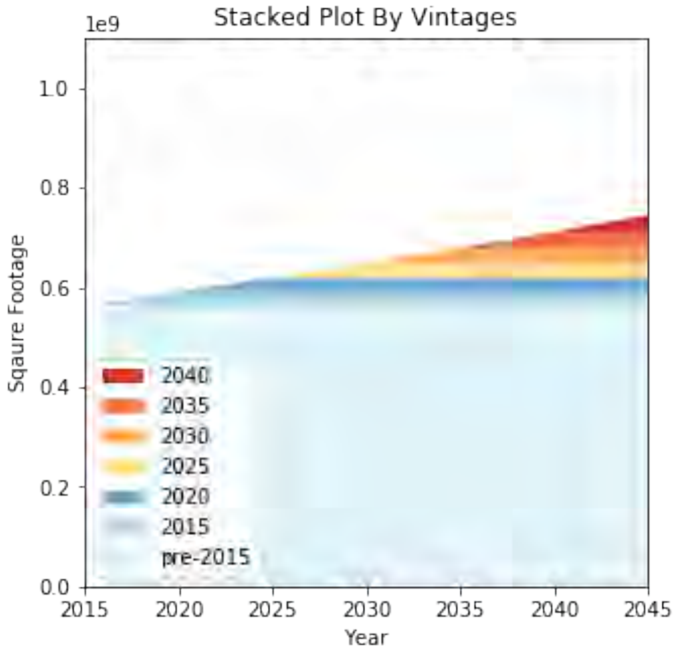


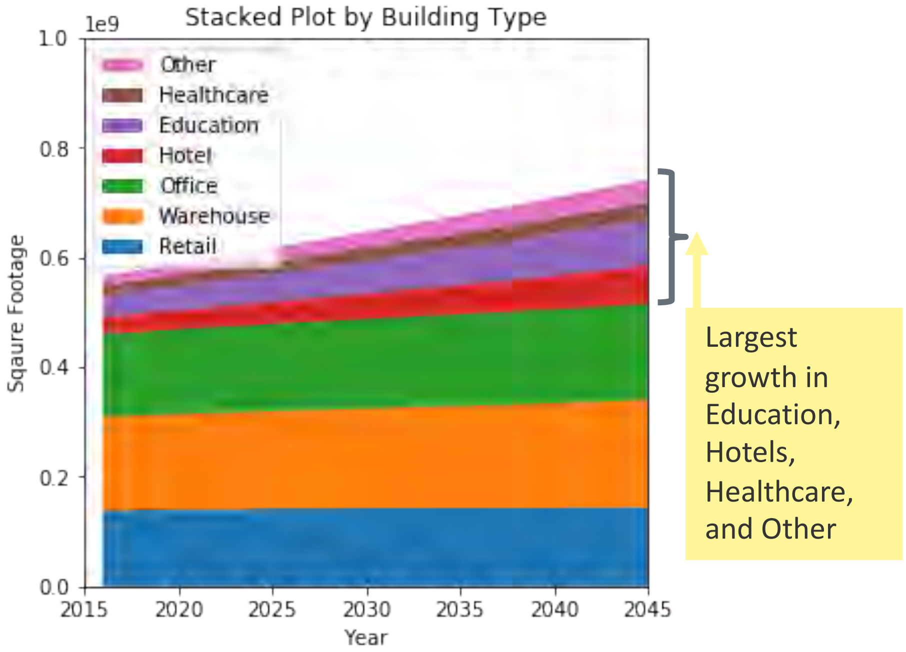
Building Types



Commercial Building Stock Growth Projections

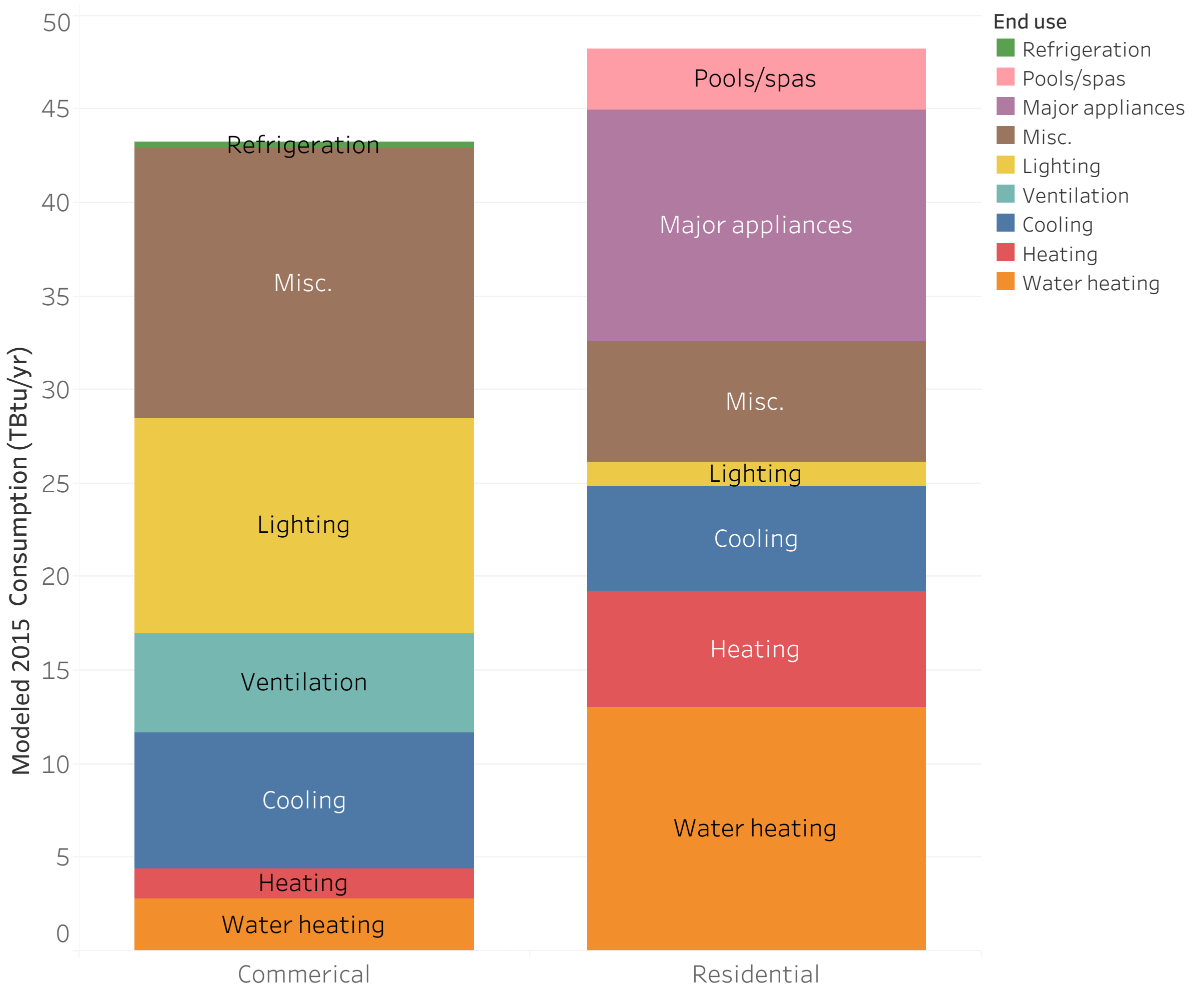
- Using projections through 2022 from Dodge Data and Analytics – Metropolitan Construction Insight
- Growth held constant across all scenarios





Electrification Adoption Projections

Which end uses are most important for **buildings electrification?**



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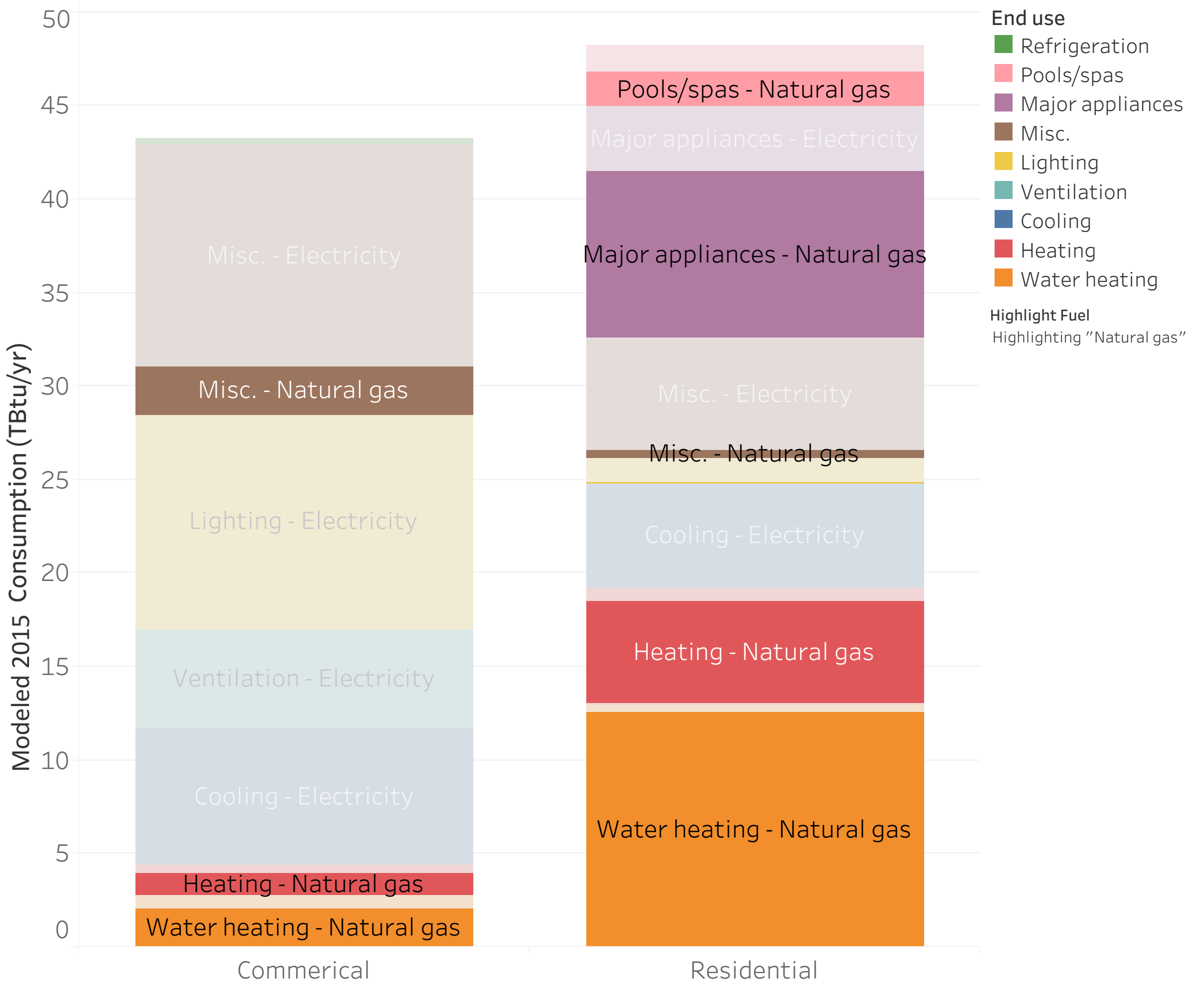
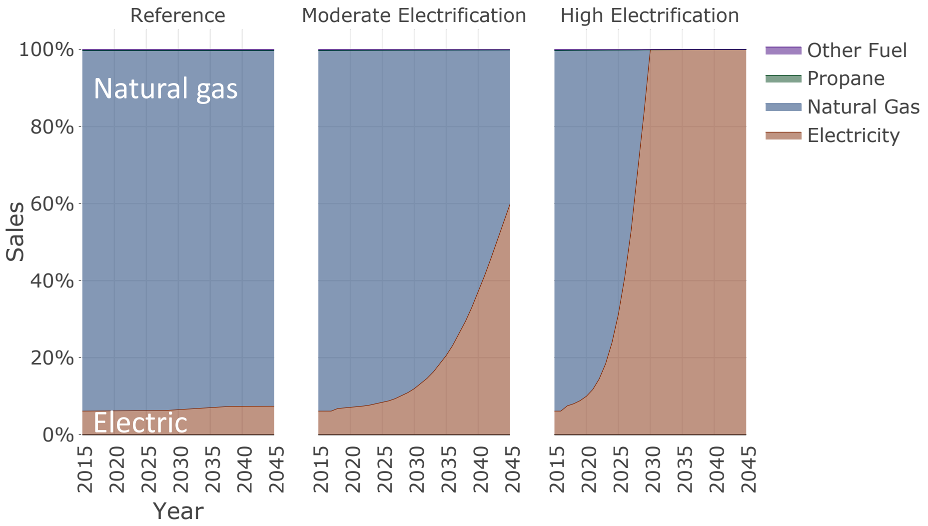


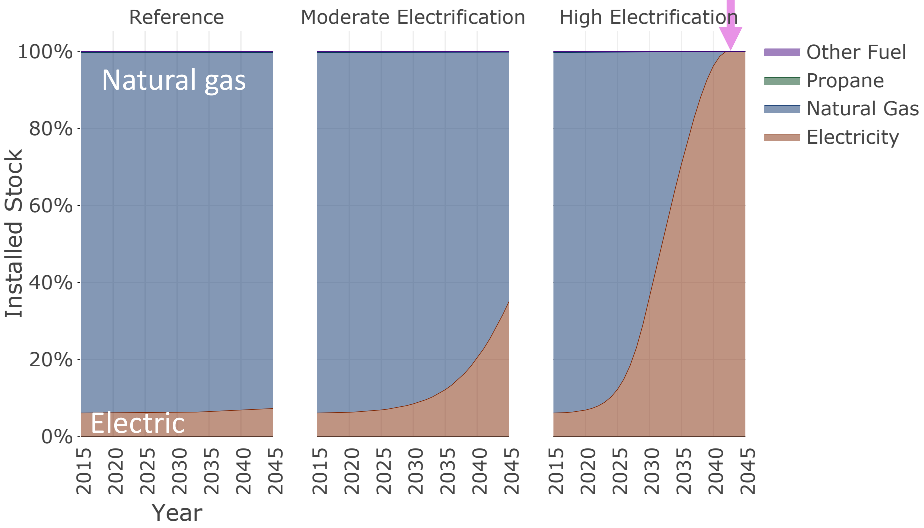
Residential Water Heaters

100% electric water heating by 2030

Equipment Sales



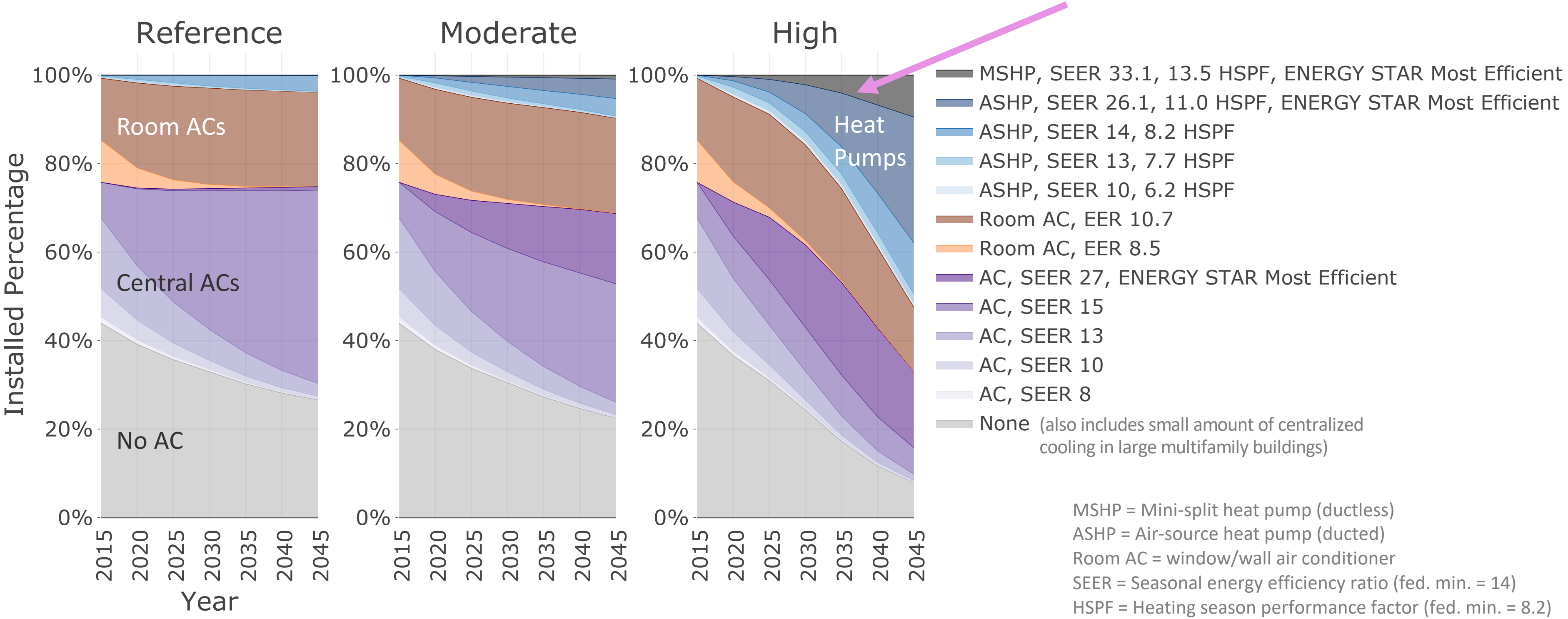
Installed Stock



Efficiency
Adoption Projections

Residential Air Conditioning

Large increase in fraction of homes with heat pumps



MSHP = Mini-split heat pump (ductless)
ASHP = Air-source heat pump (ducted)
Room AC = window/wall air conditioner
SEER = Seasonal energy efficiency ratio (fed. min. = 14)
HSPF = Heating season performance factor (fed. min. = 8.2)

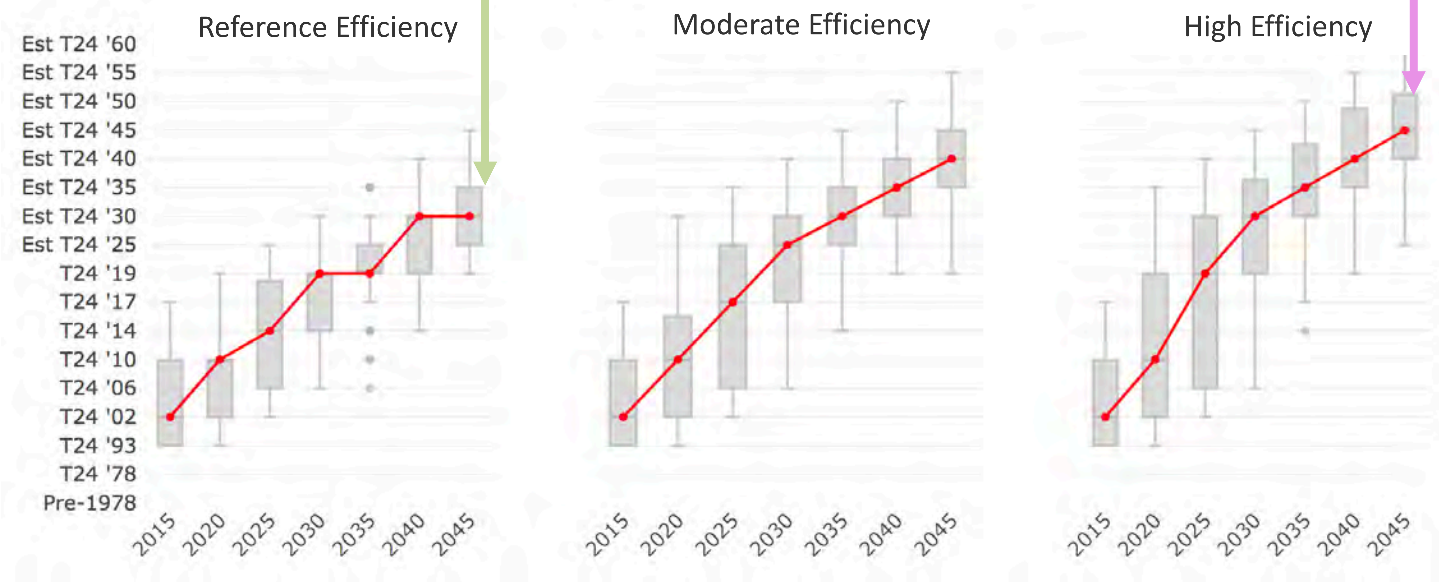
Commercial HVAC Efficiency

Historic and projected[1] Title 24 HVAC efficiency

Average projected installed code is 2030

Average projected installed code is 2045

GREEN NEW DEAL PLAN



Analysis does not quantify incentives or other mechanisms that would drive these levels of beyond code adoption

[1] LA100 estimates projections of Title 24 (California's Building Energy Efficiency Standards) for 2022–2050

Sample Results

Where are we now?

Complete:

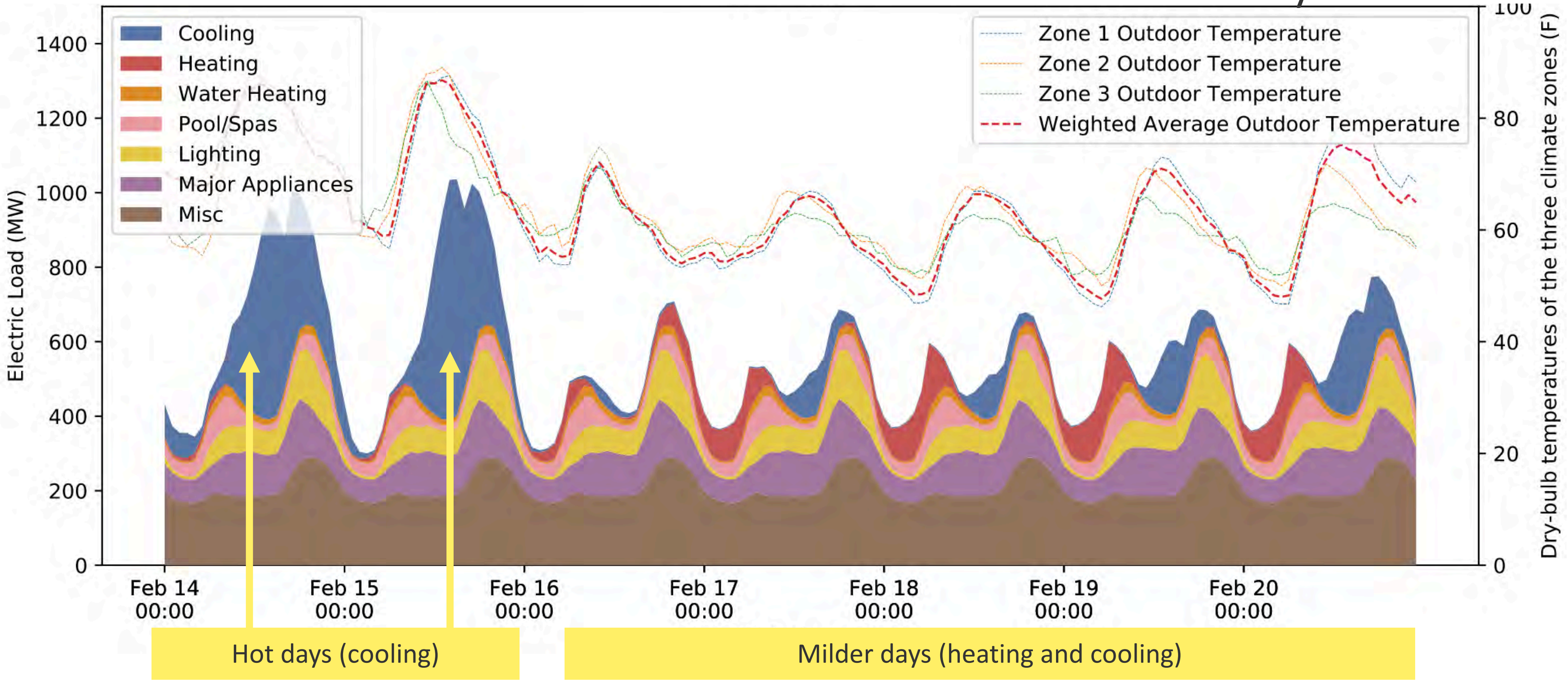
- Validation/calibration
- Final Run "High" projection updated to reflect pLAn
- Final Run modeling

In progress:

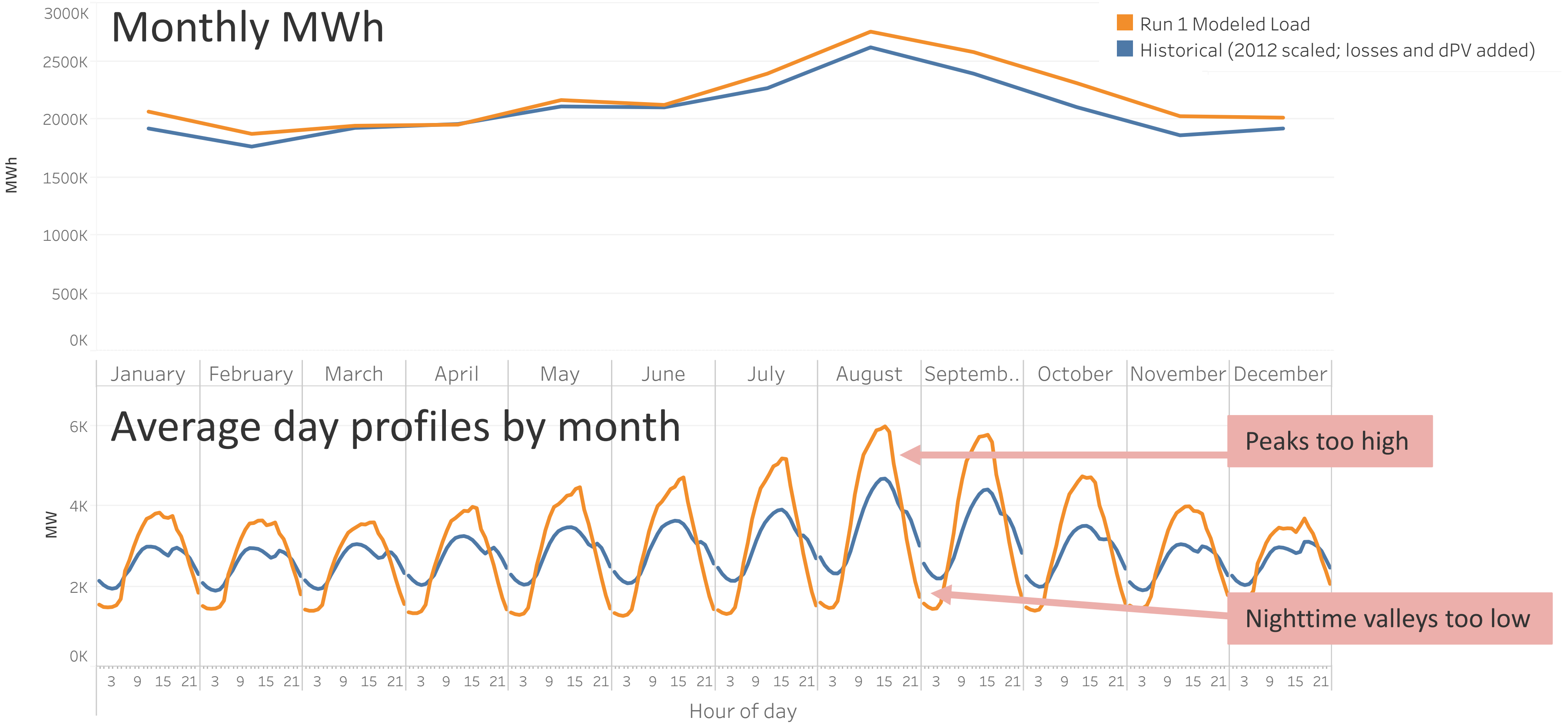
- Processing and interpreting Final Run results

What do results look like?

Modeled Residential Sector load for a week in February 2015



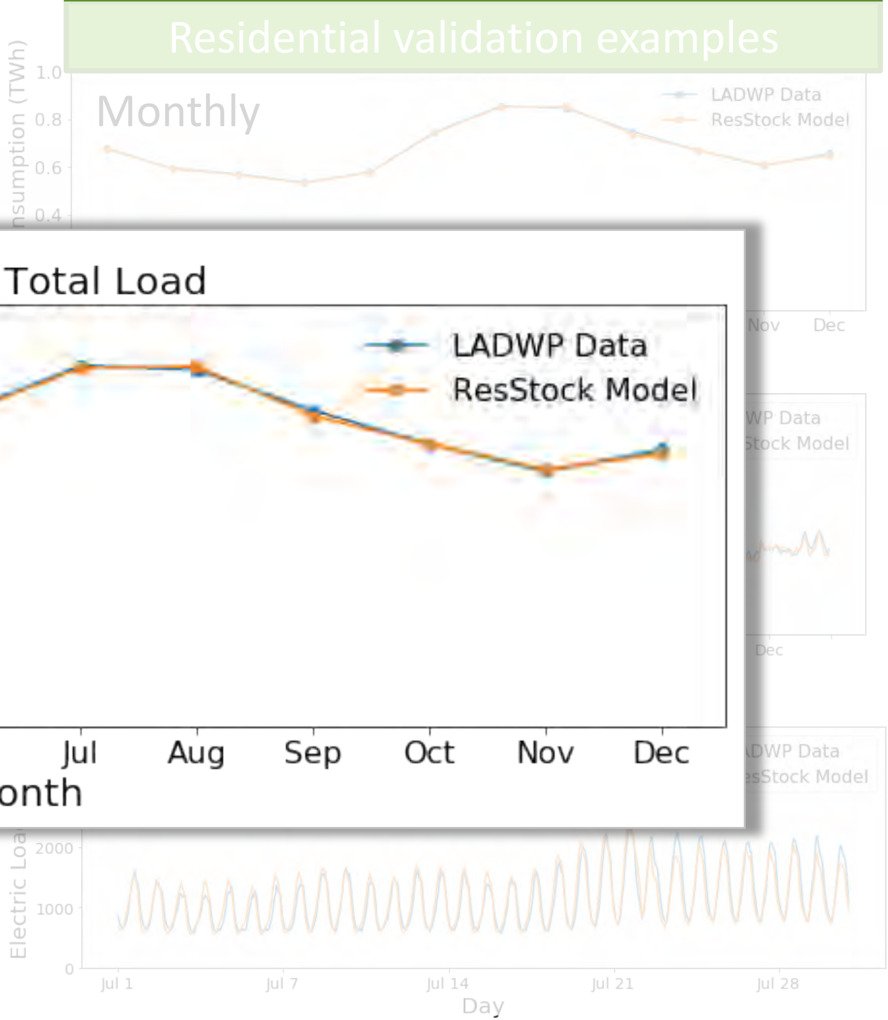
What have we learned? Initial Run Results vs. Reality

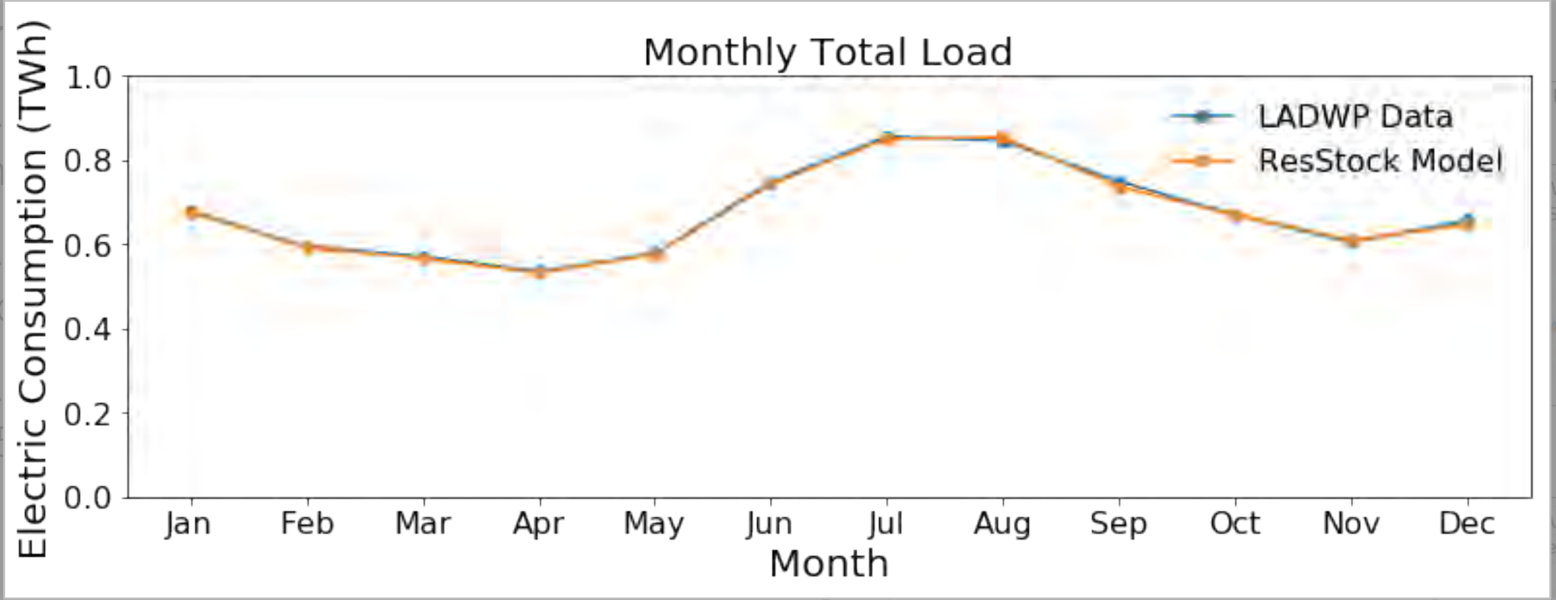


Calibration and Validation

Calibr

- LA (m
- LA (h
- LA (1



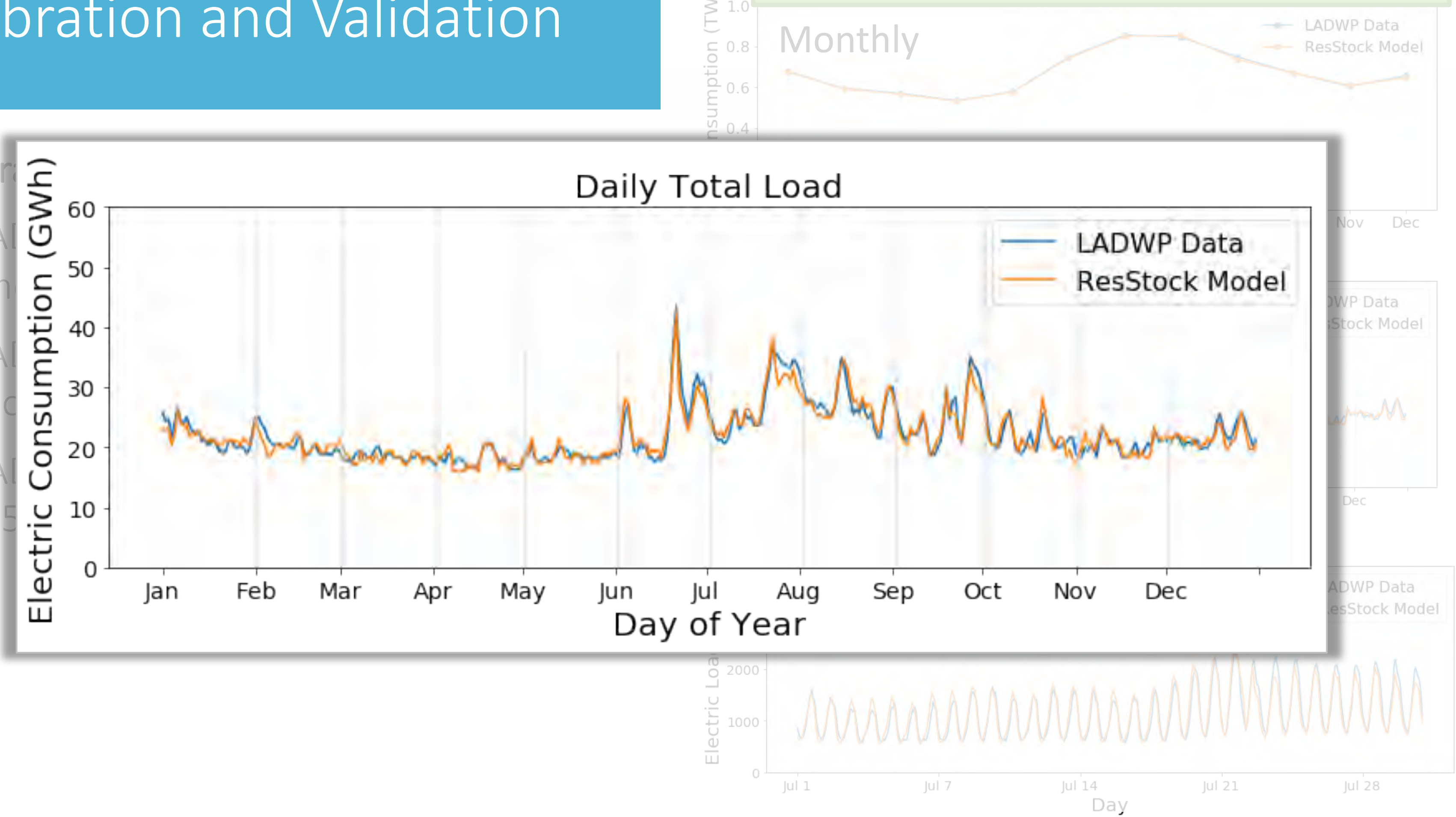


Calibration and Validation

Residential validation examples

Calibr

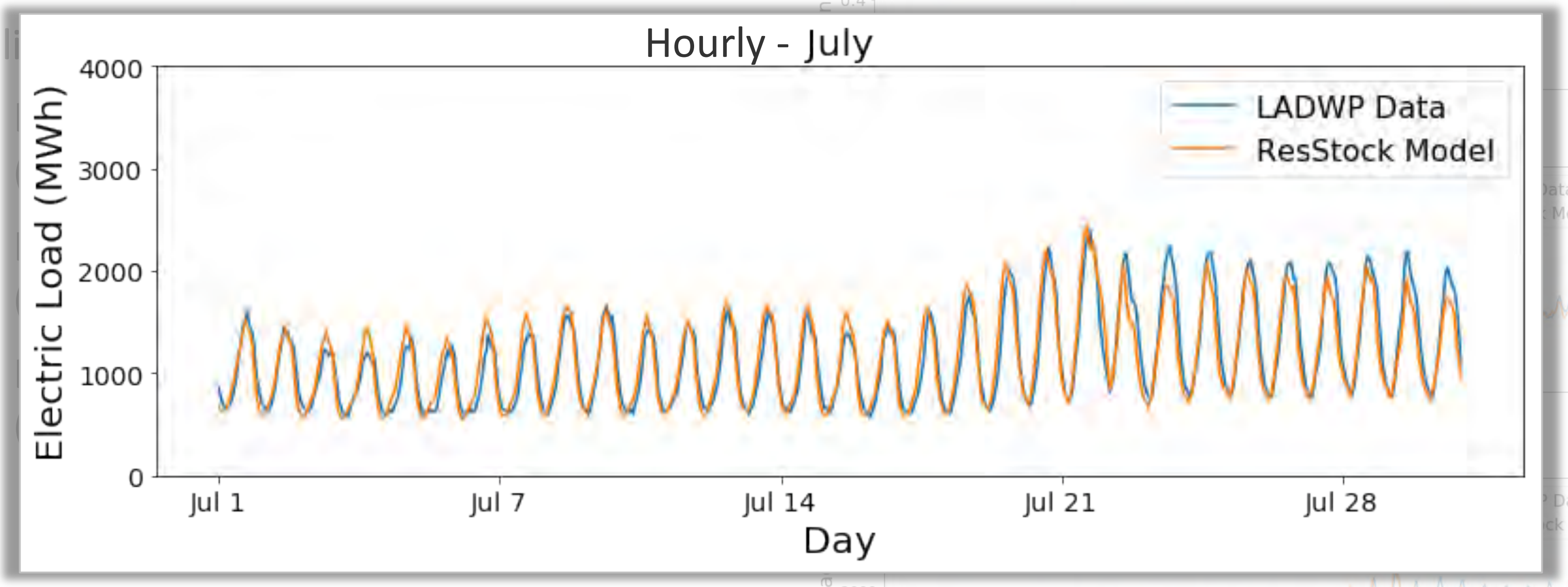
- LAI (m
- LAI (h
- LAI (15



Calibration and Validation

Residential validation examples

Cali

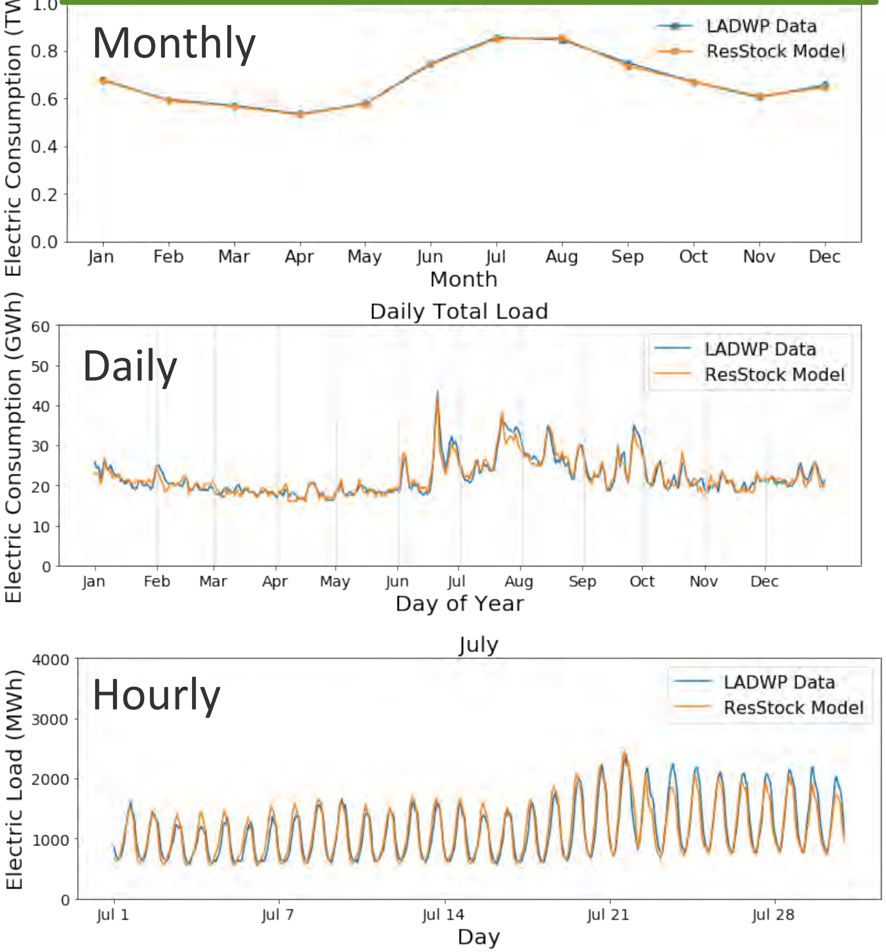


Calibration and Validation

Calibration/validation data sources

- LADWP **customer billing data** (monthly; all customers)
- LADWP **load research data** (hourly; residential/commercial sectors)
- LADWP **smart meter data** (15-minute; subset of customers)

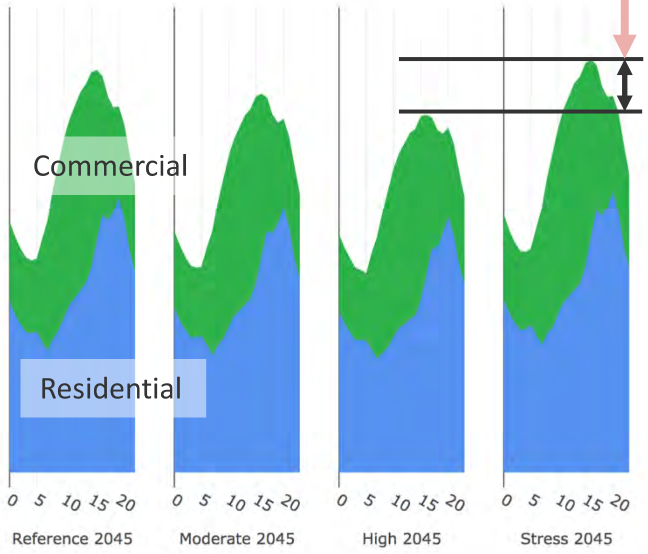
Residential validation examples



Initial Run Snapshot: Peak Day, Average Winter Day Profiles

E.g., 10% higher buildings load in 2045 Stress vs. High

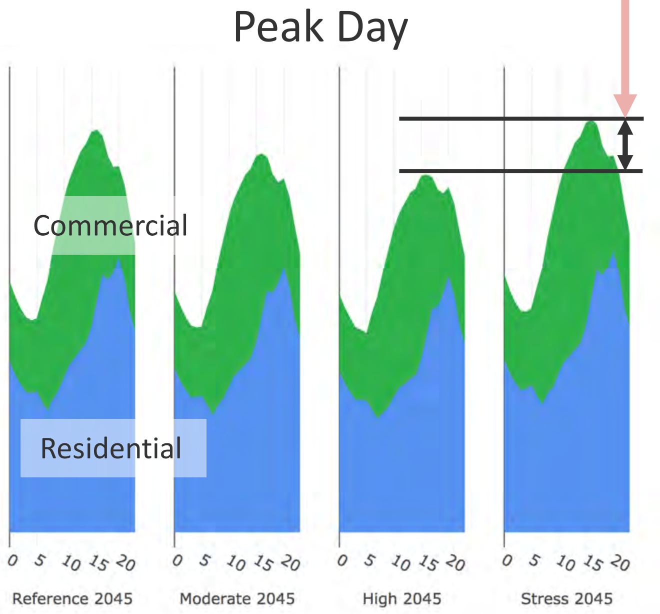
Peak Day

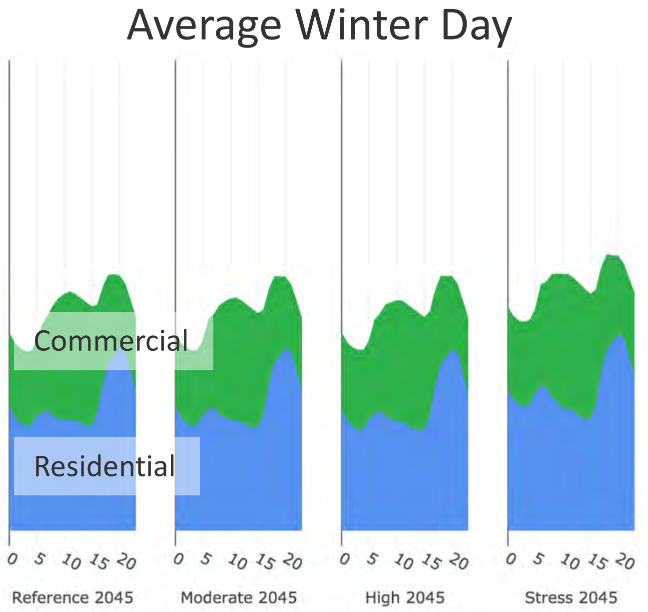


<u>Example</u> Initial Run results; <u>buildings load only</u>; Final Run results will reflect updates (e.g., pLAn)

Initial Run Snapshot: Peak Day, Average Winter Day Profiles

E.g., 10% higher buildings load in 2045 Stress vs. High





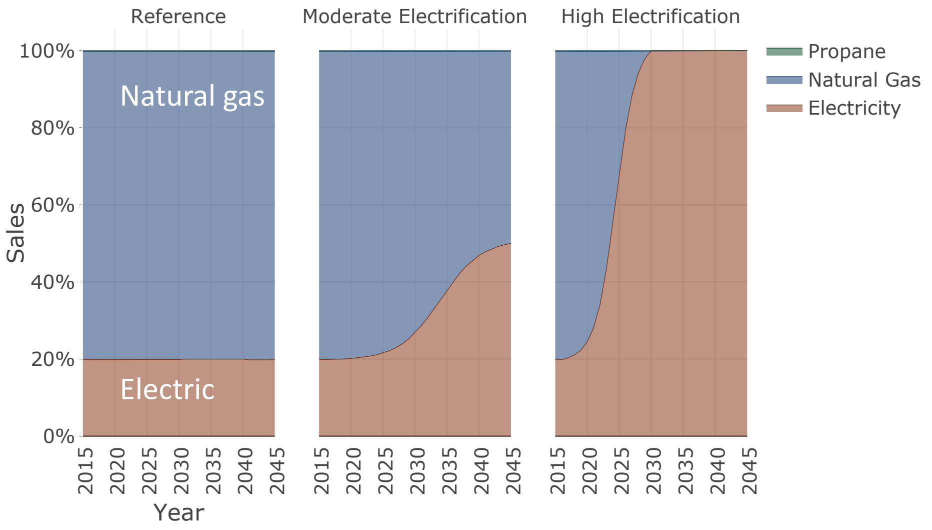
Example Initial Run results; buildings load only; Final Run results will reflect updates (e.g., pLAn)

Q&A

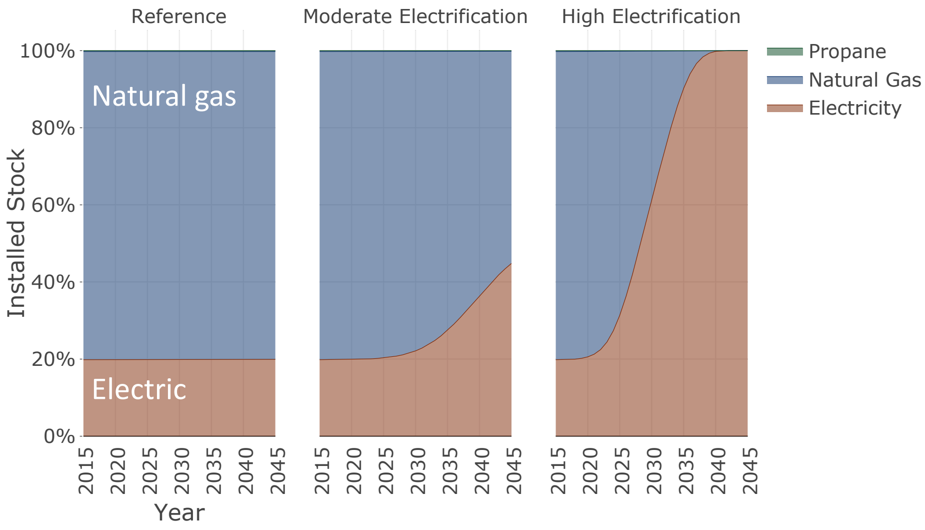
The Los Angeles 100% Renewable Energy Study

Residential Cooking Ranges

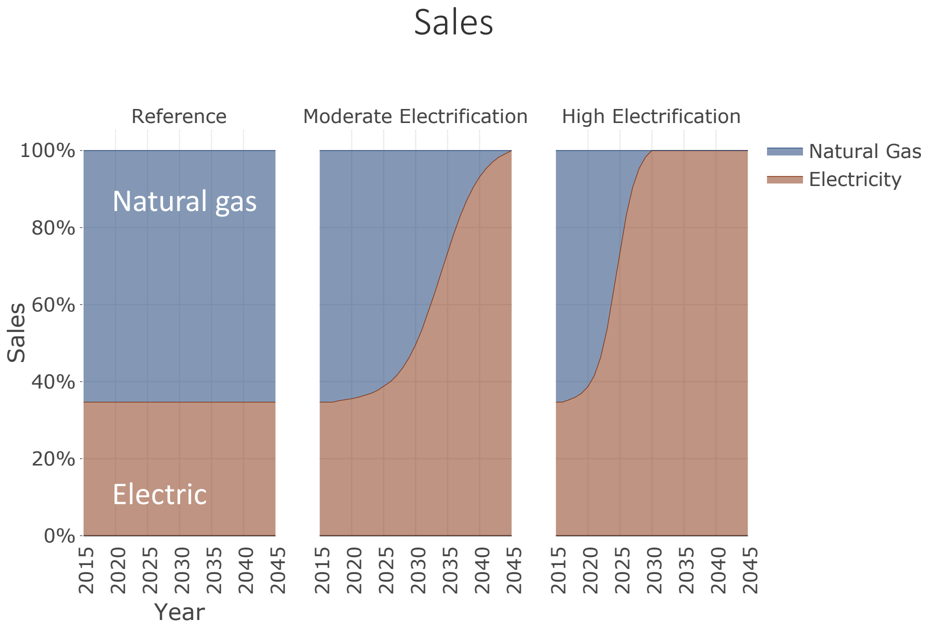
Sales

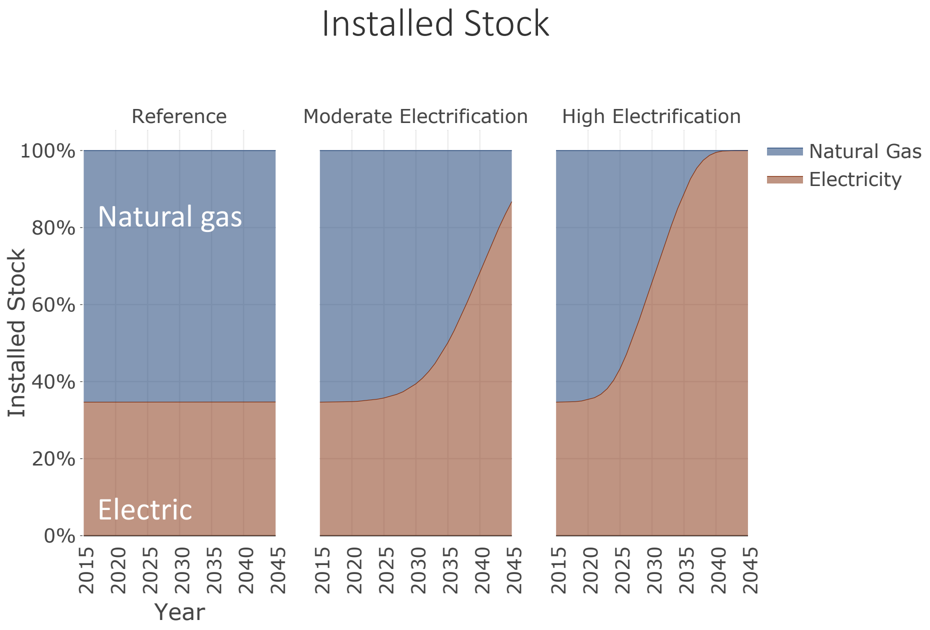


Installed Stock

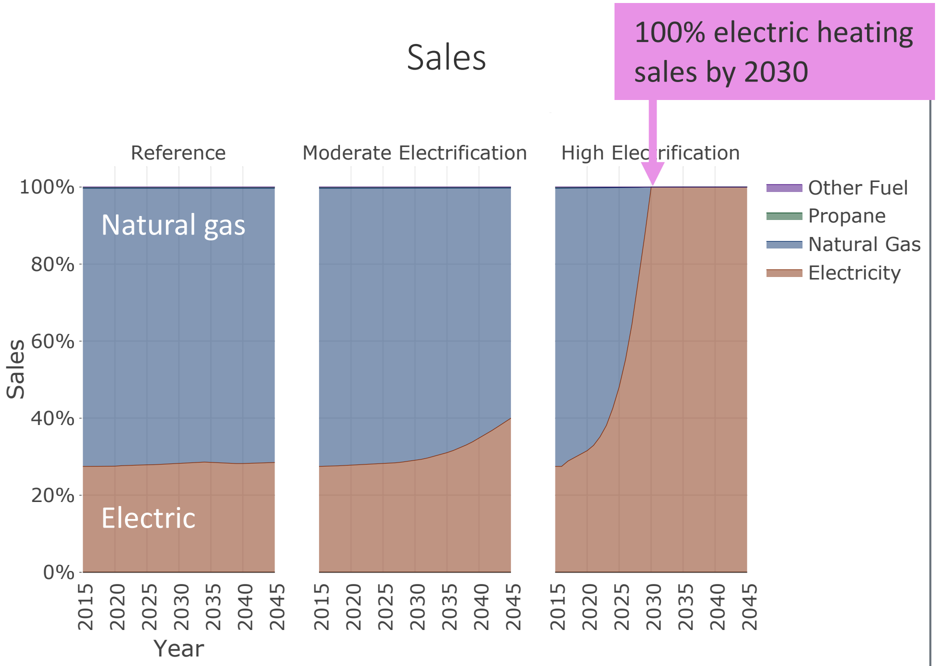


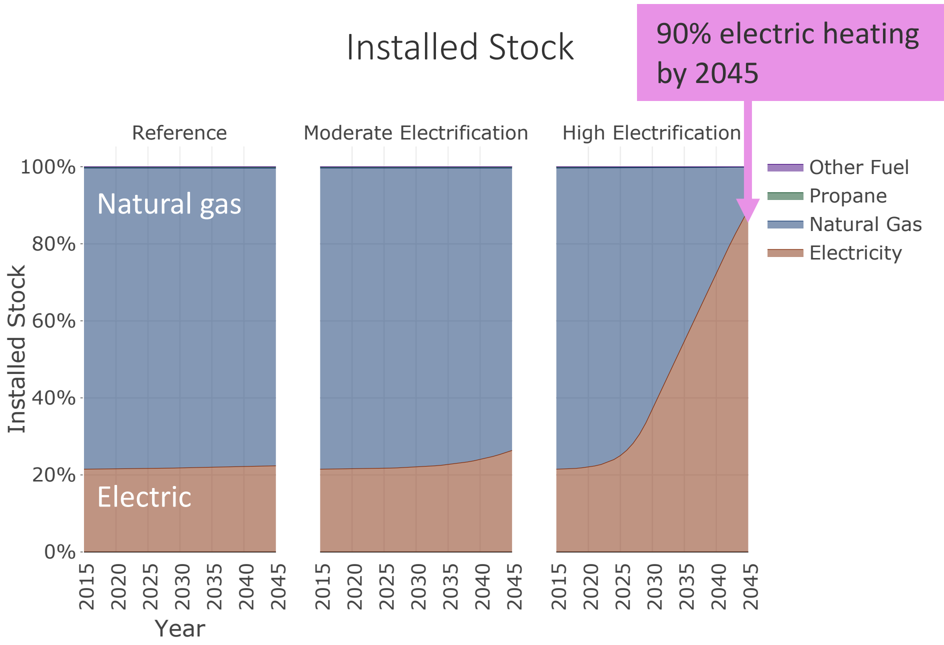
Residential Clothes Dryers





Residential Space Heating

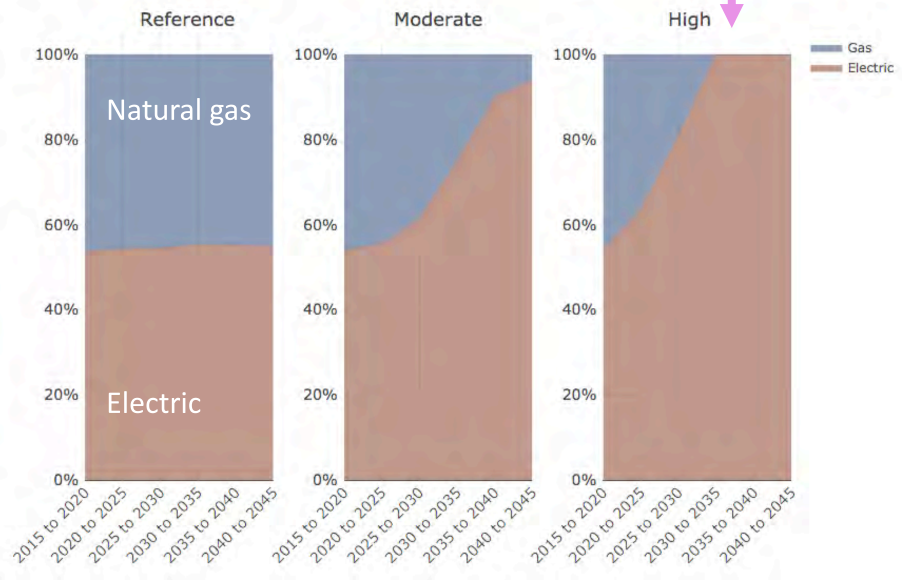




Commercial HVAC

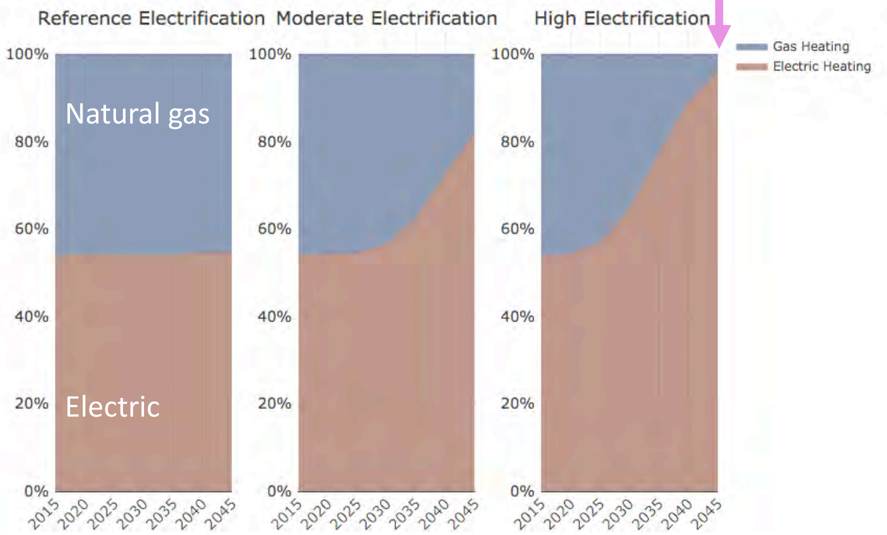
Sales Fraction

100% electric heating sales by 2030



Installed Fraction

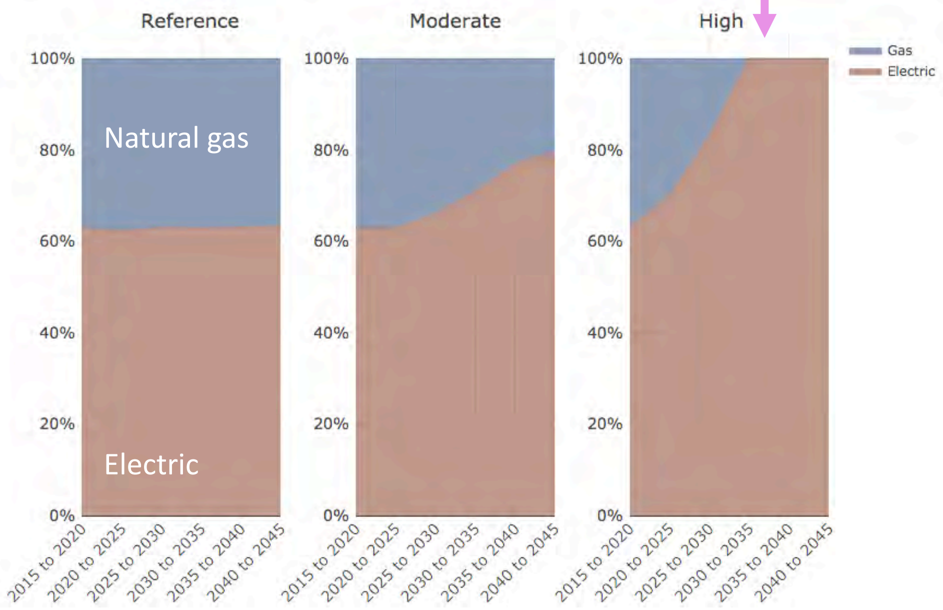
90% electric heating by 2045



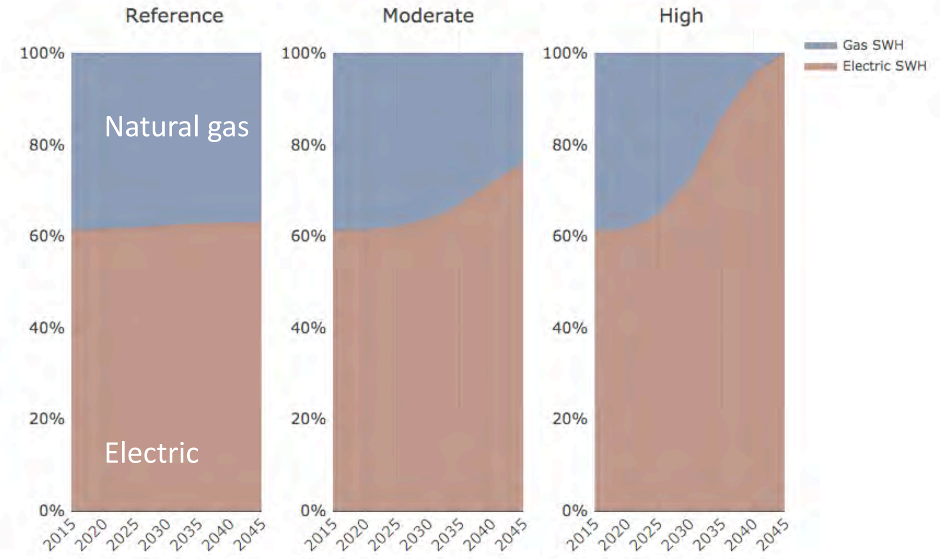
Commercial Water Heaters

Sales Fraction

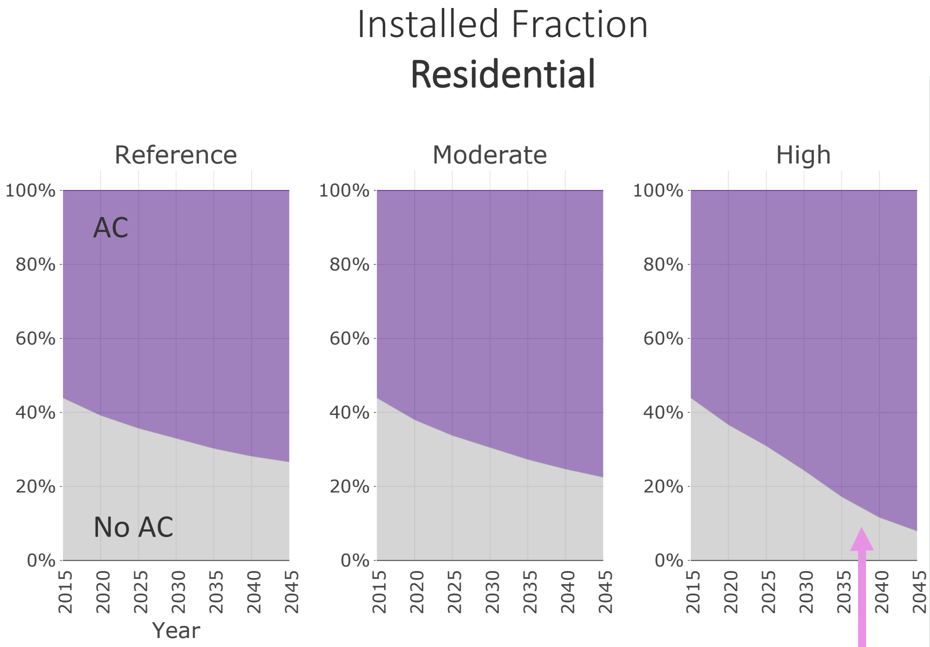
100% electric water heating sales by 2030

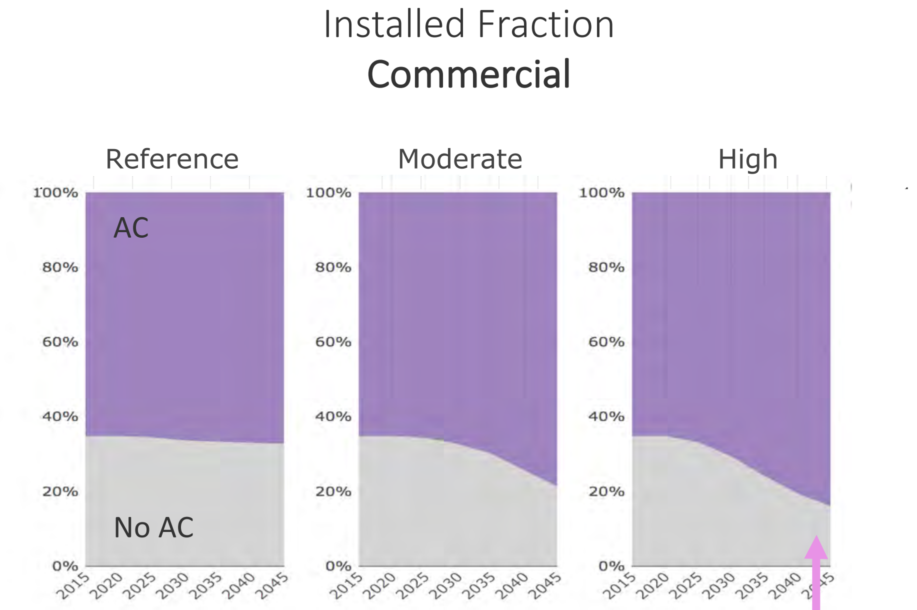


Installed Fraction



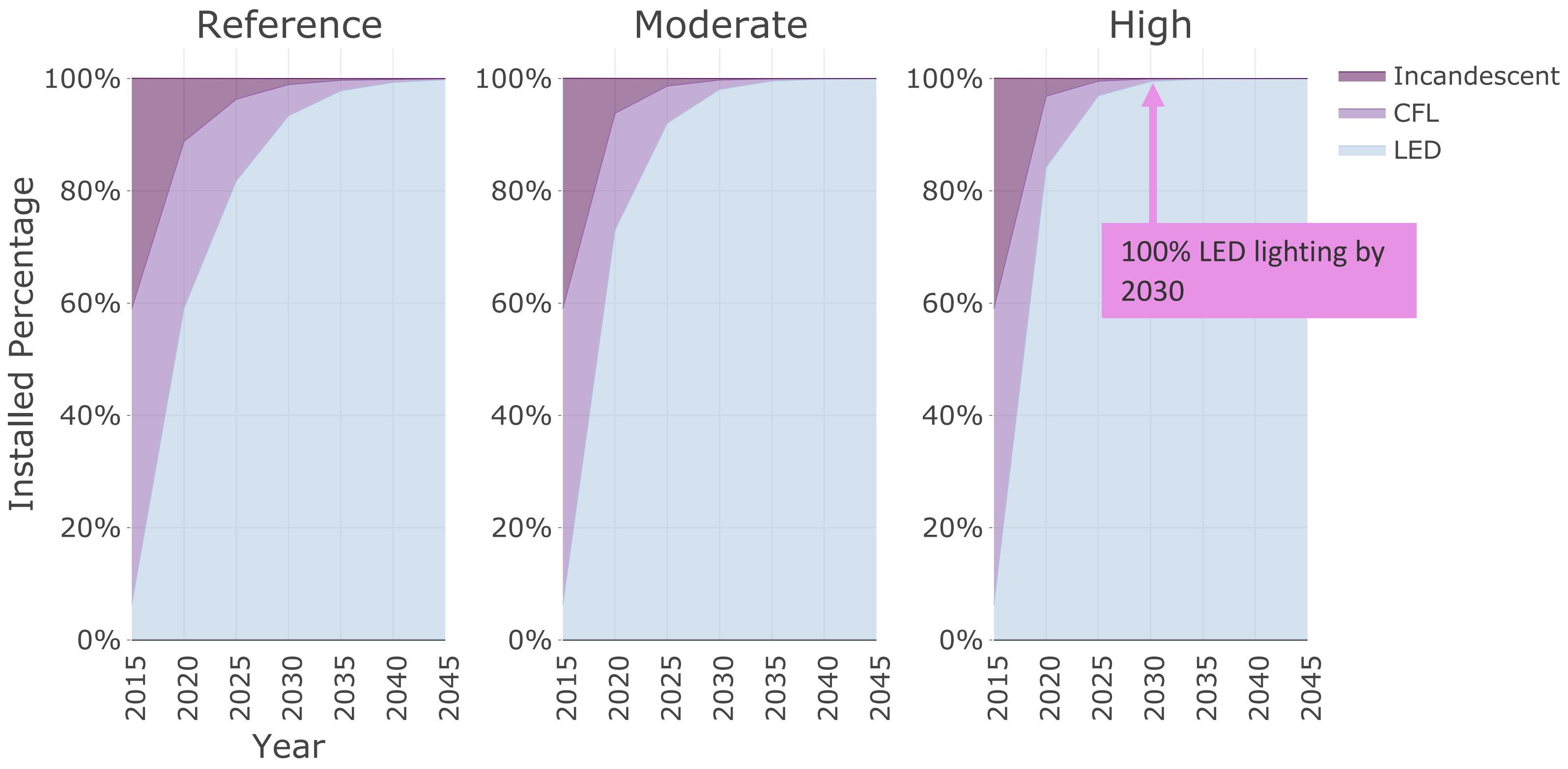
Growth in air conditioning



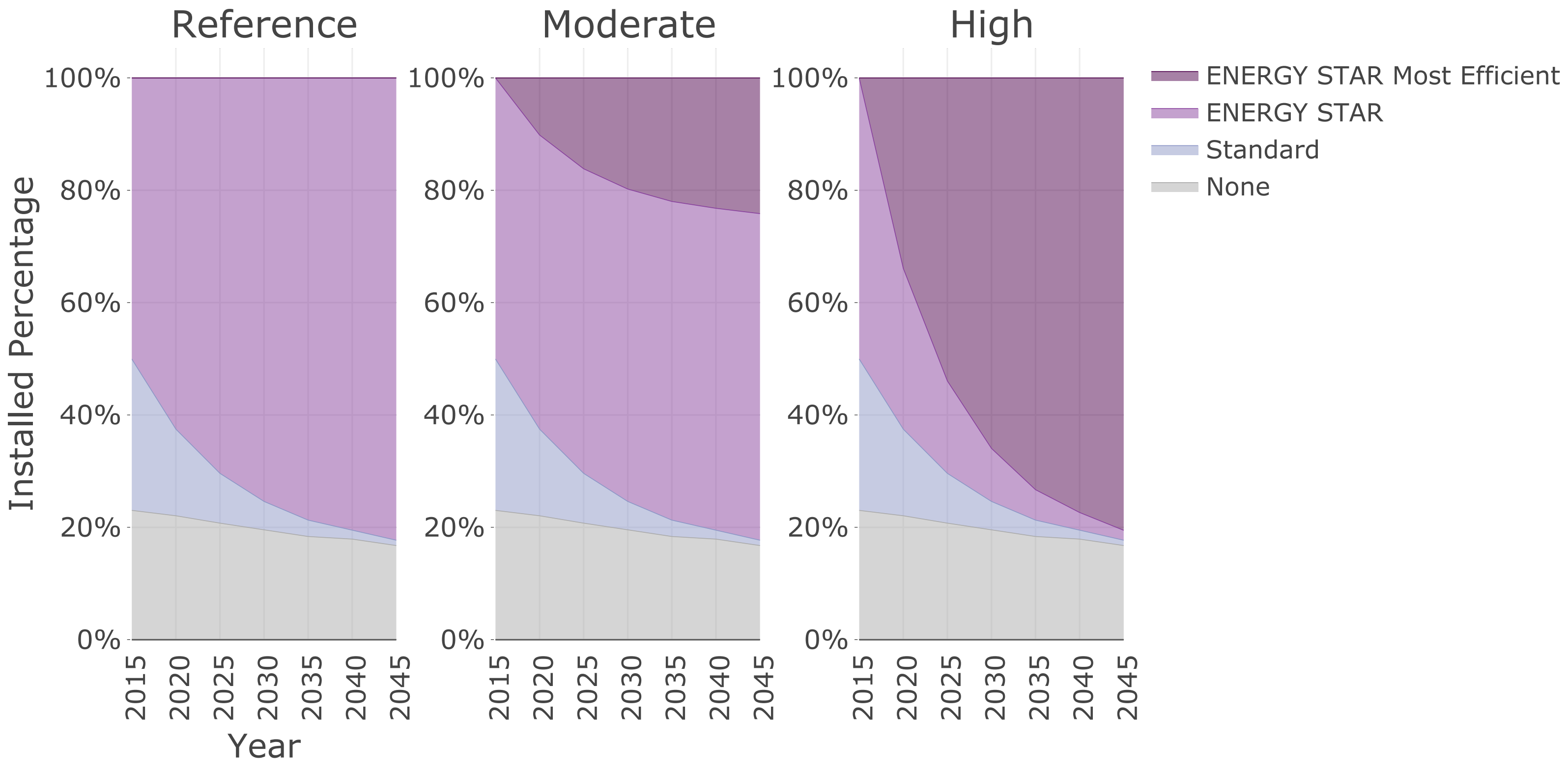


More buildings have AC in High projection because of heat pumps

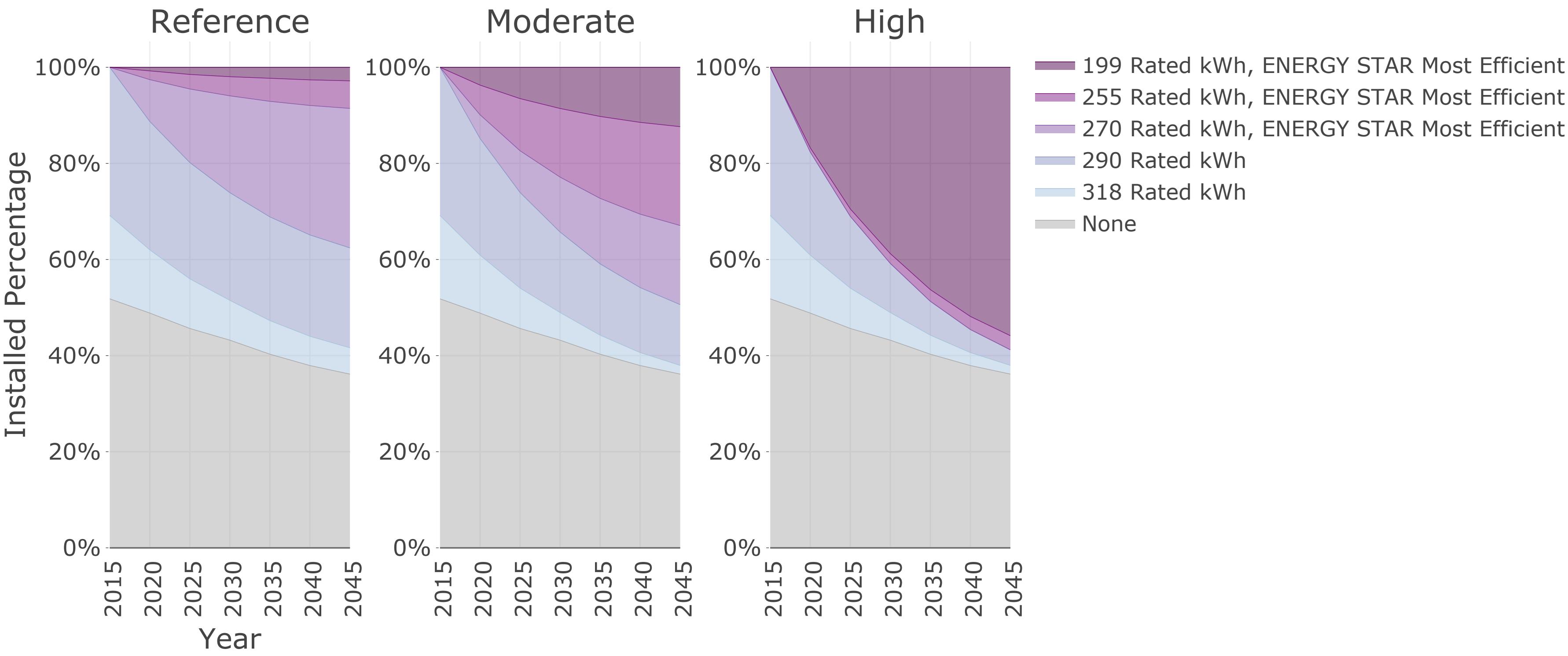
Residential Lighting



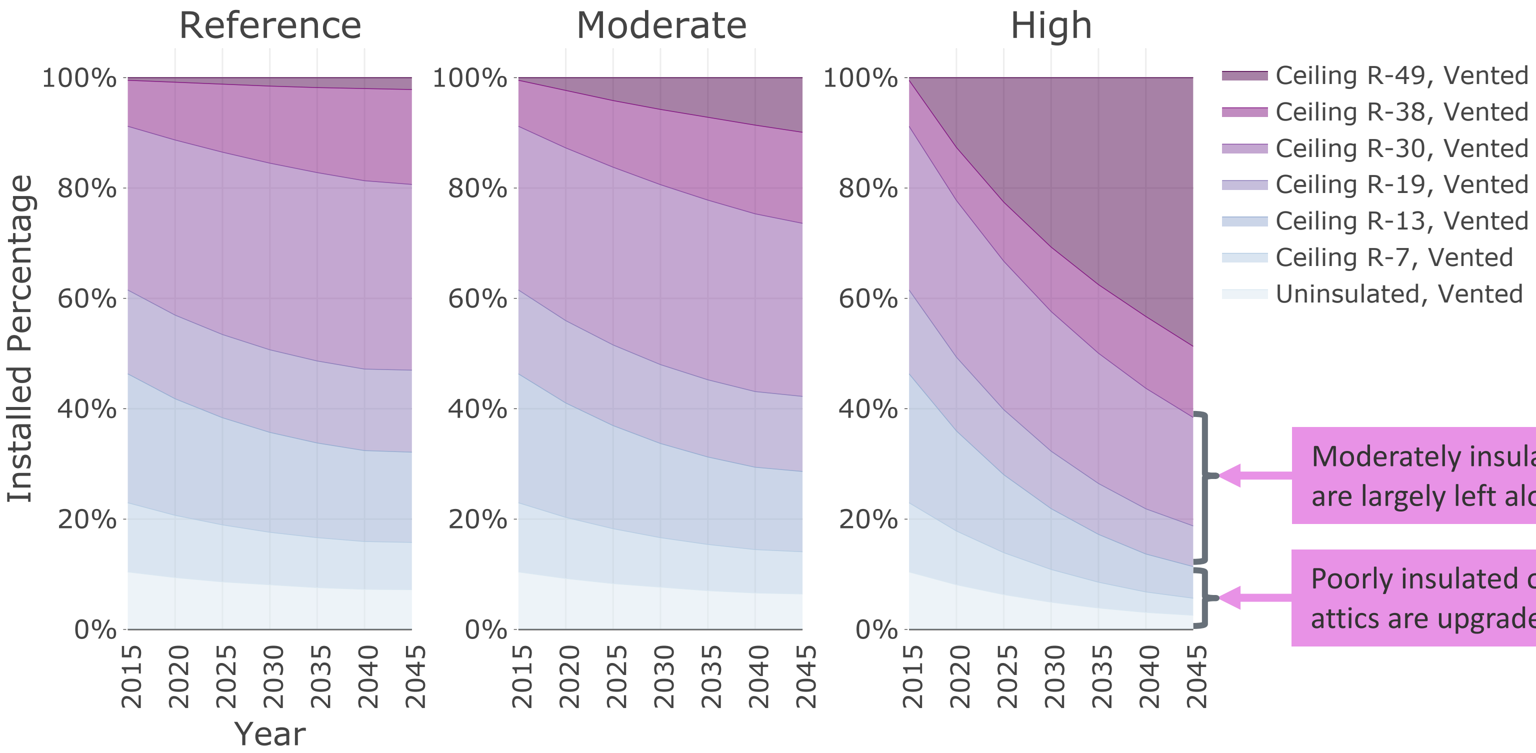
Residential Clothes Washers



Residential Dishwashers



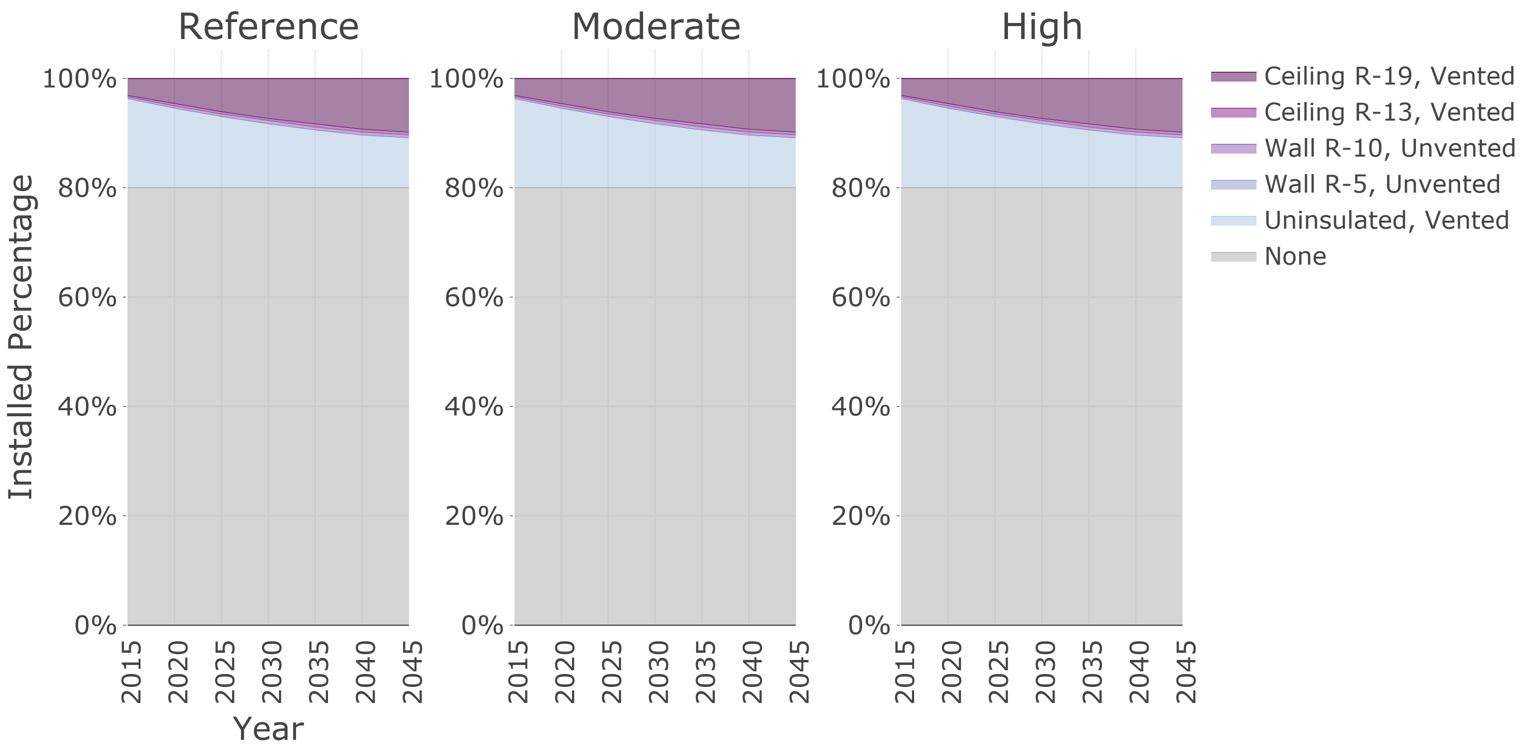
Residential Attic Insulation



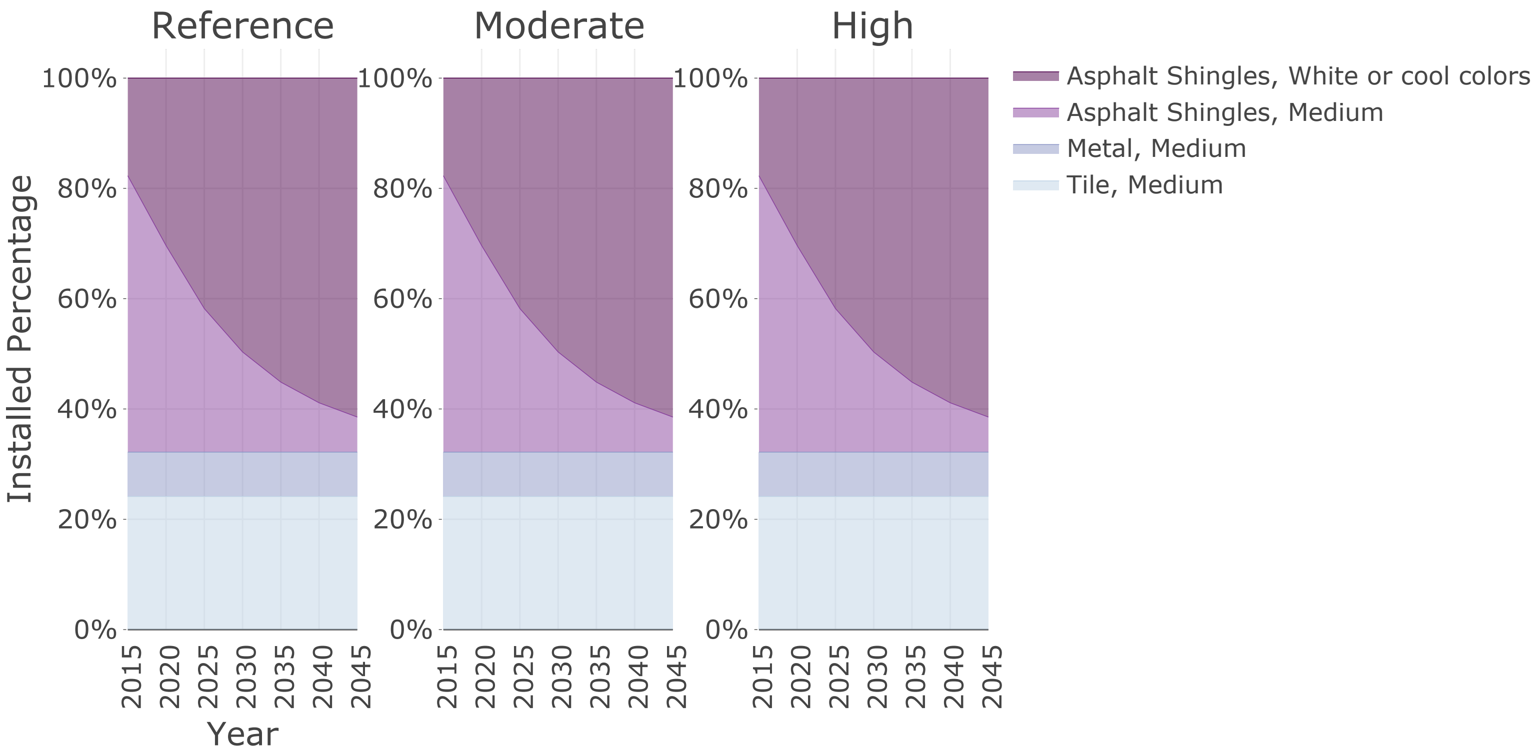
Moderately insulated attics are largely left alone

Poorly insulated or uninsulated attics are upgraded to R-38 or R-49

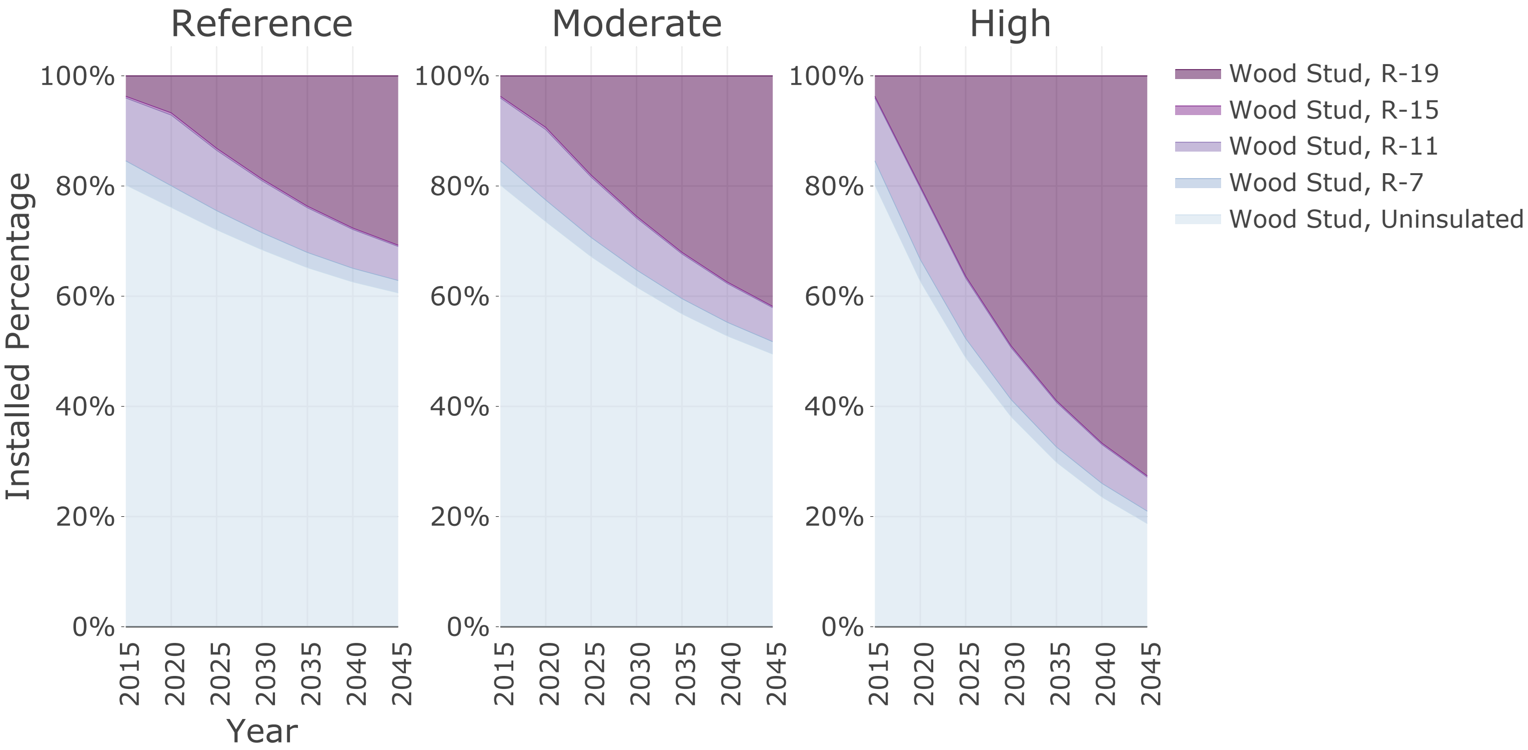
Residential Crawlspace Insulation



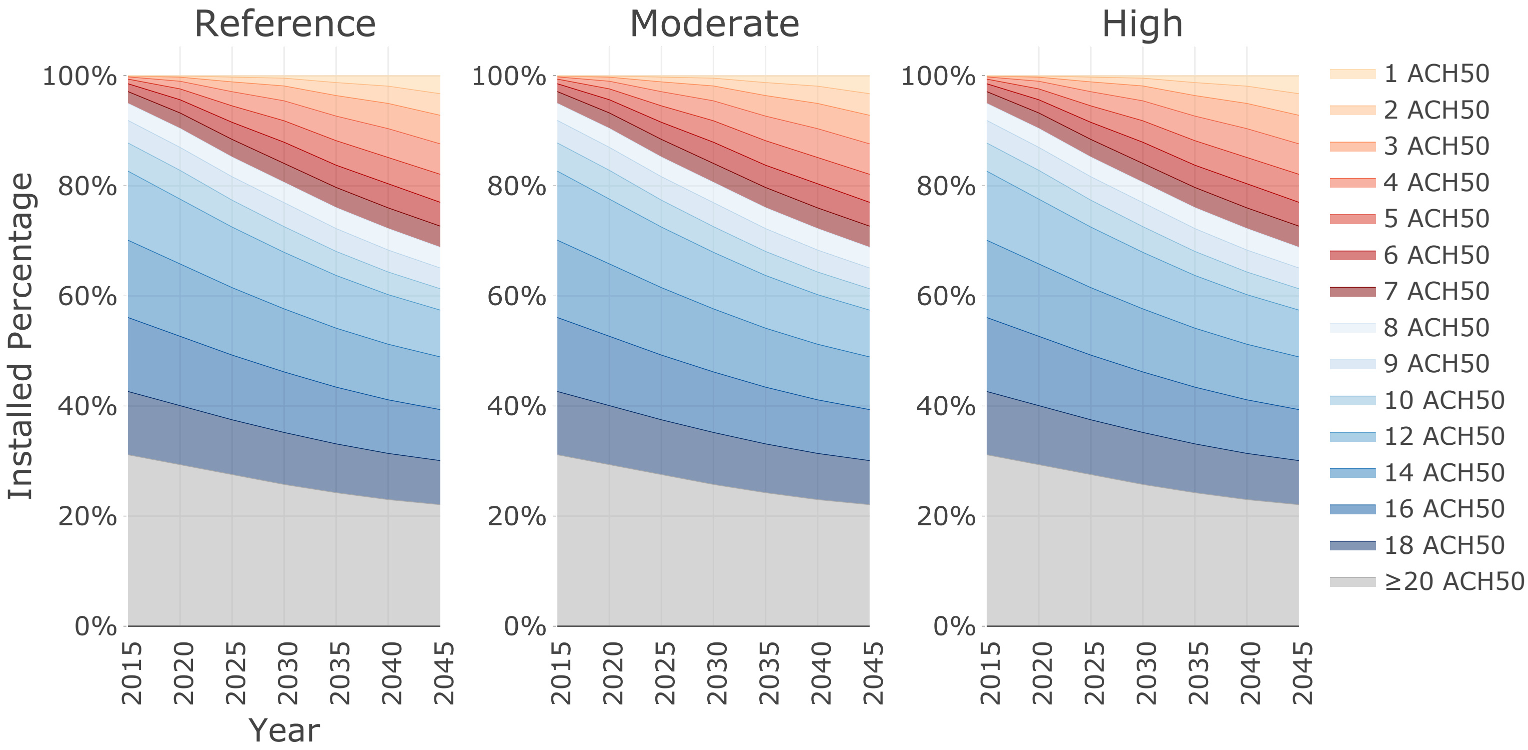
Residential Roof Material



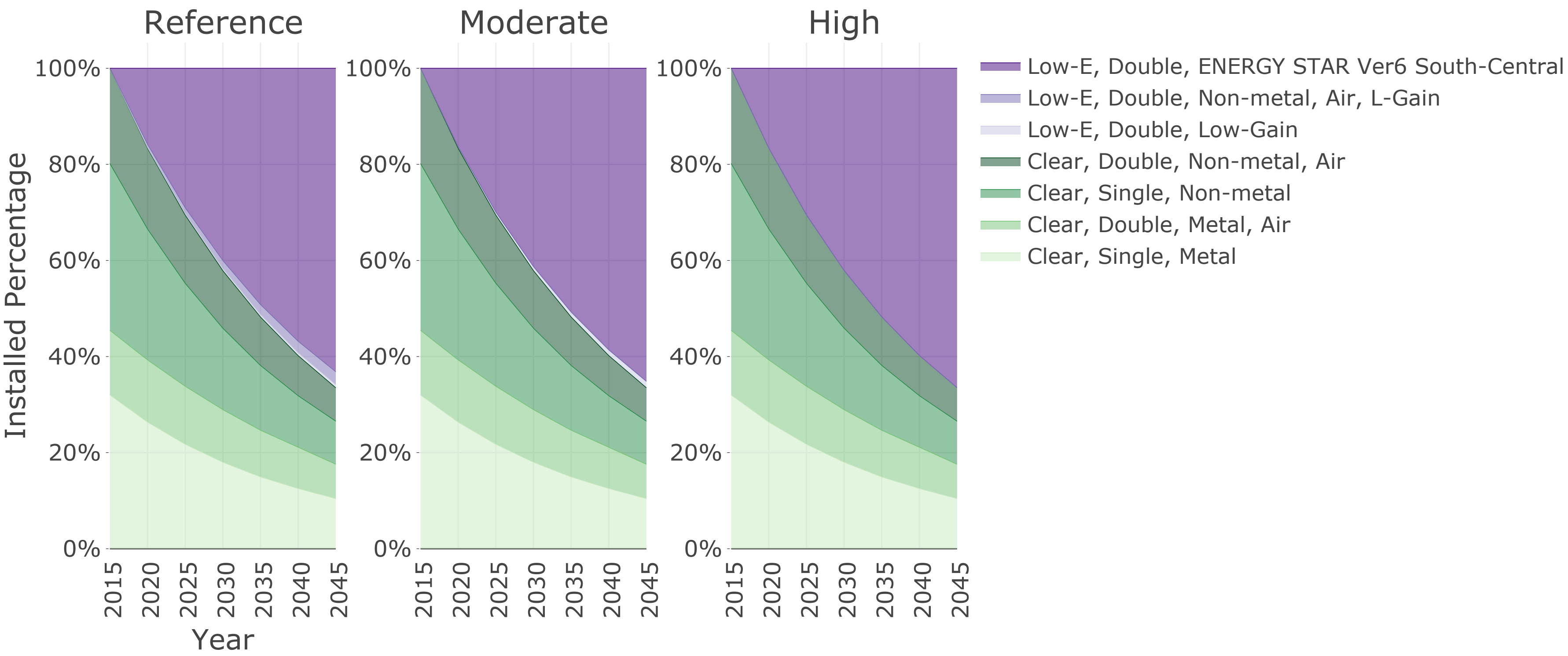
Residential Wall Insulation



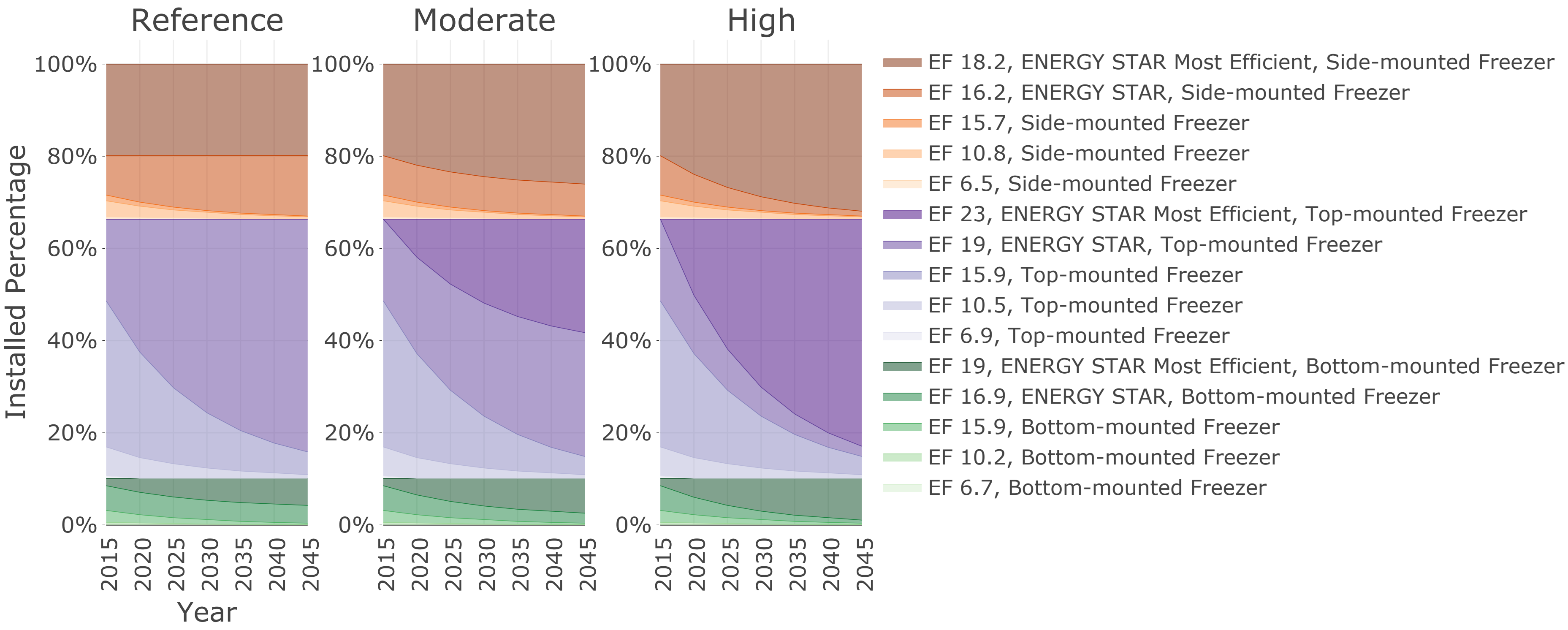
Residential Infiltration



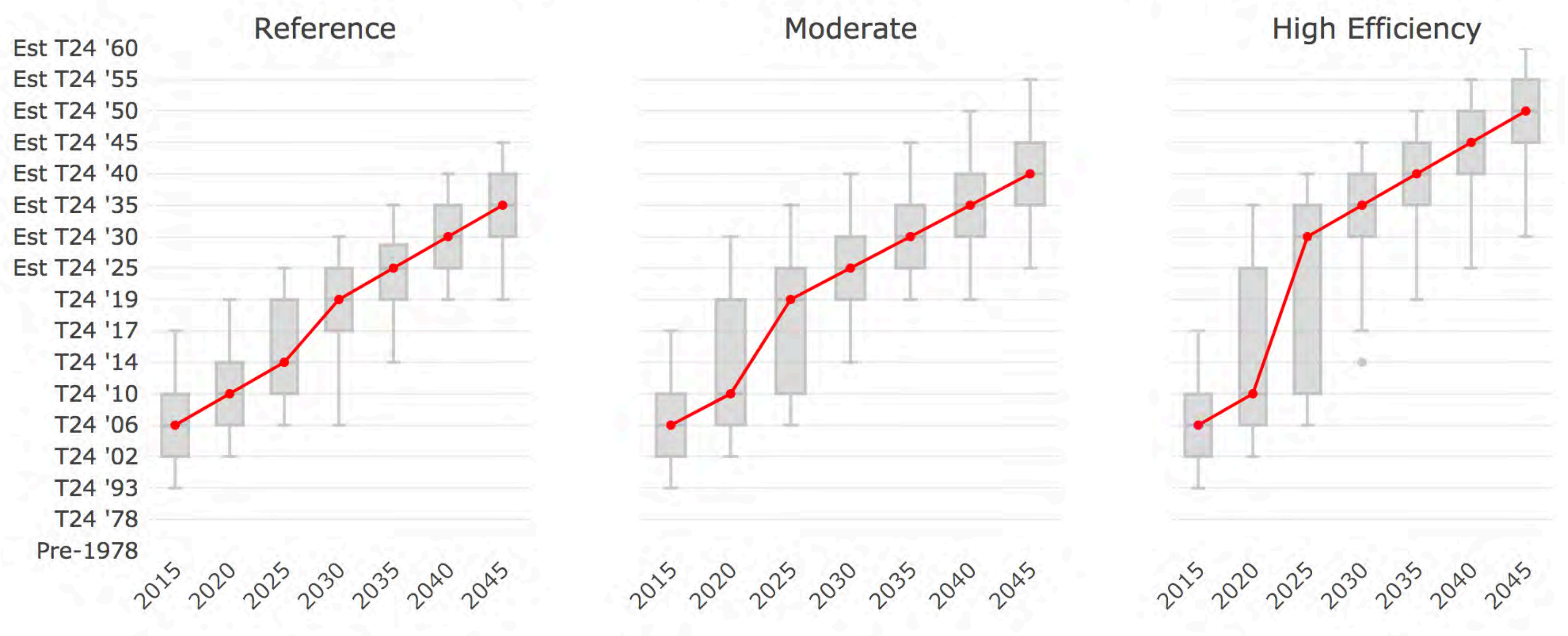
Residential Windows



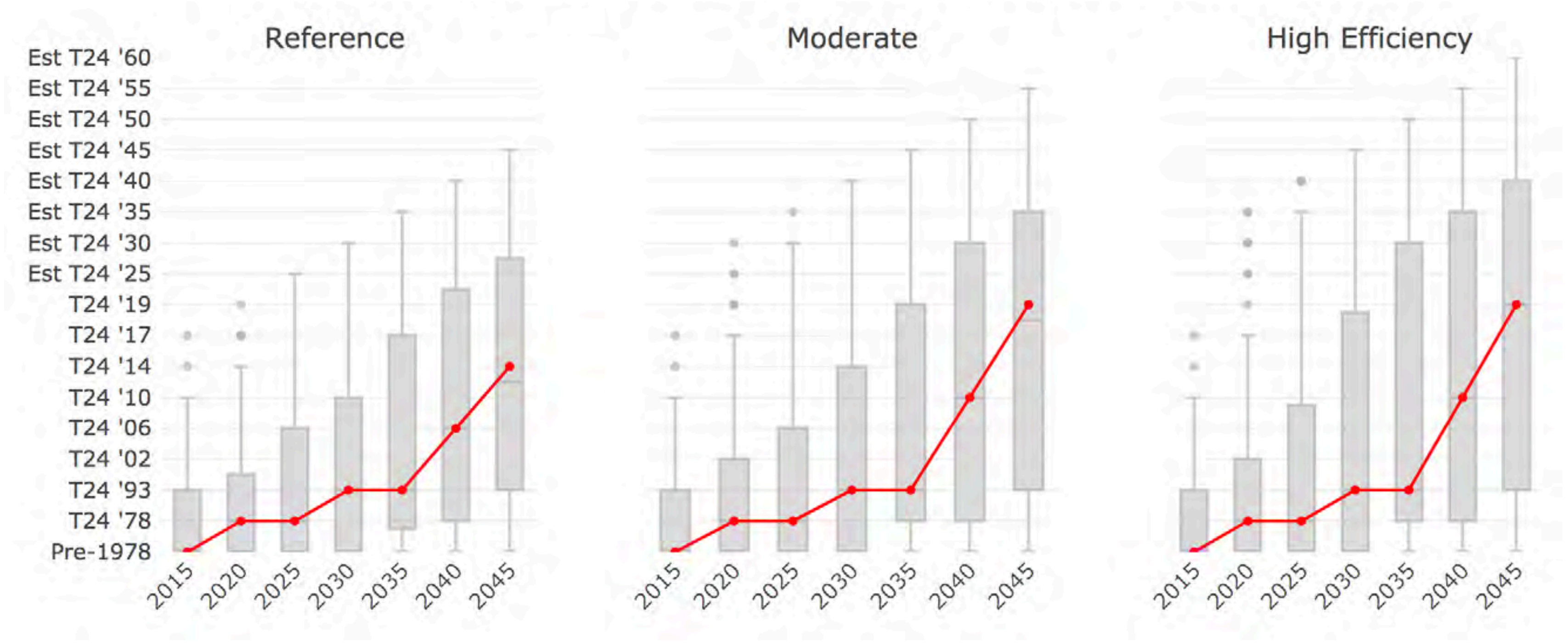
Residential Refrigerators



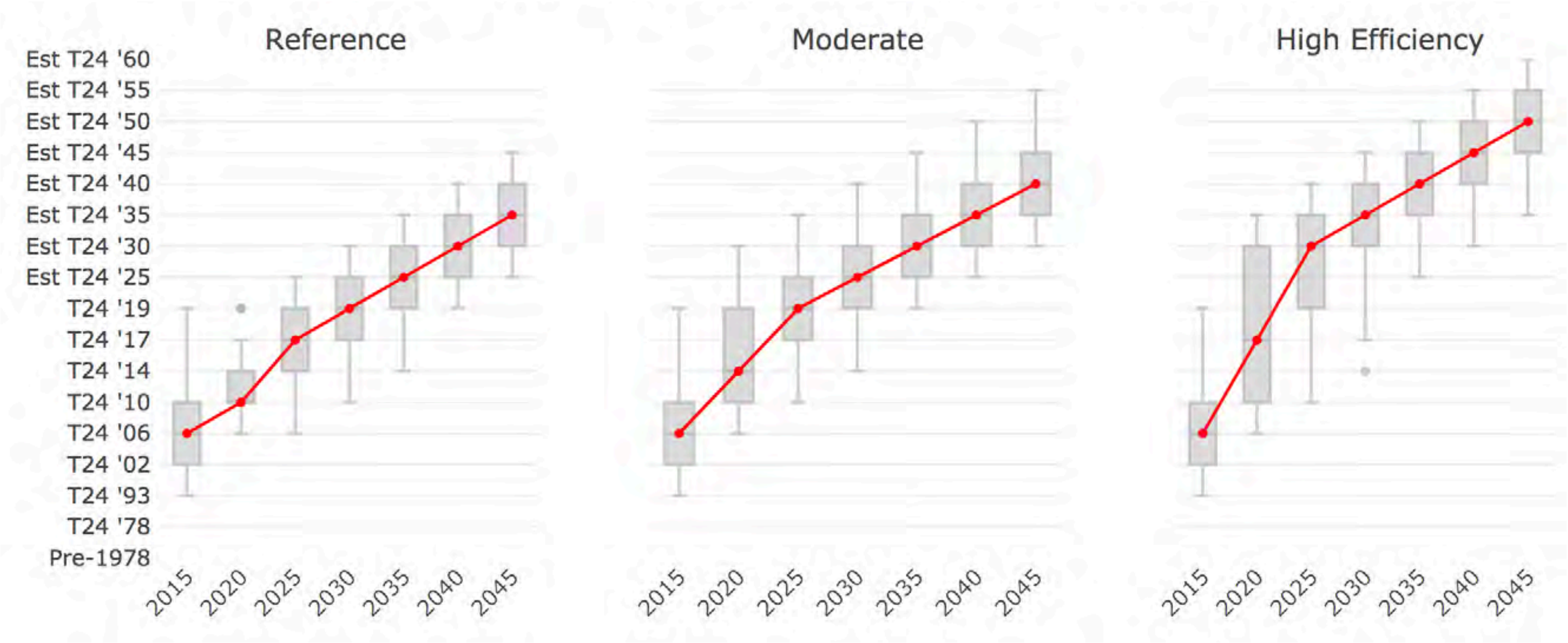
Commercial Service Water Heating Efficiency



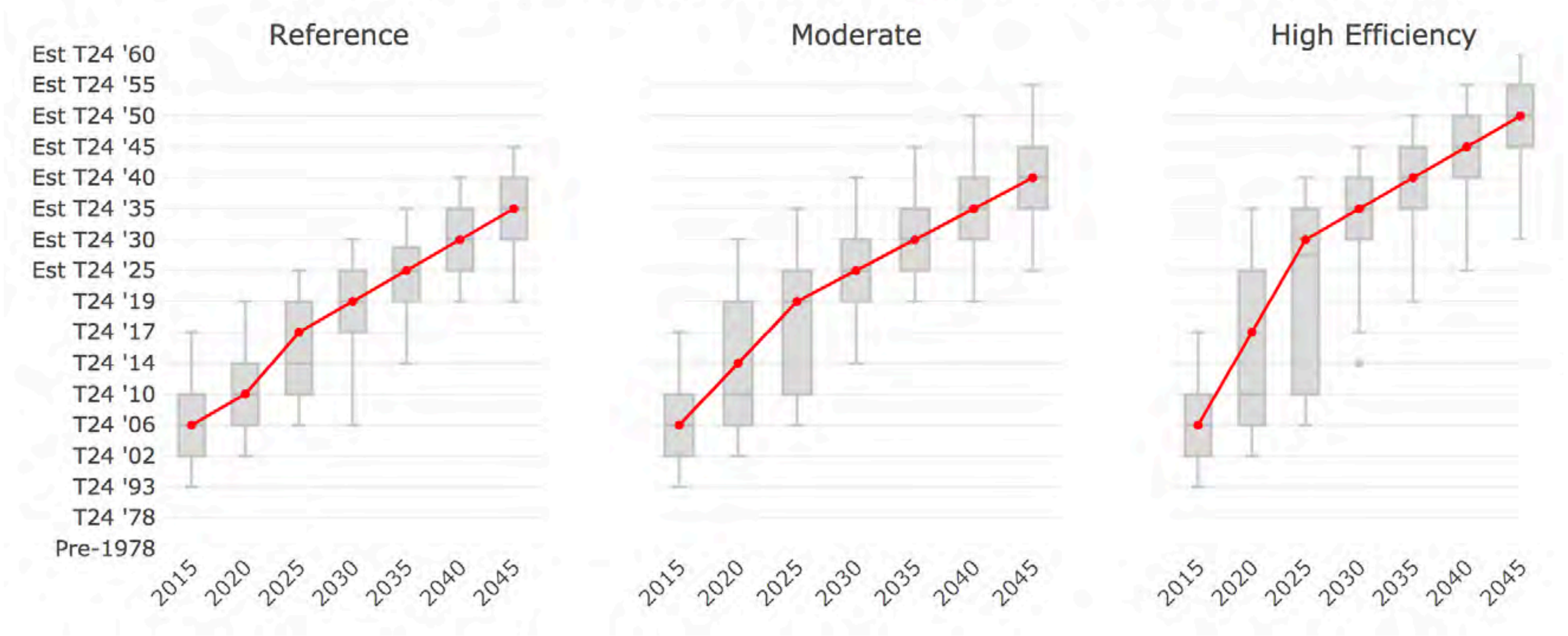
Commercial Envelope Efficiency



Commercial Interior Lighting Efficiency



Commercial Exterior Lighting Efficiency



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Financial Considerations for LA100 Investments

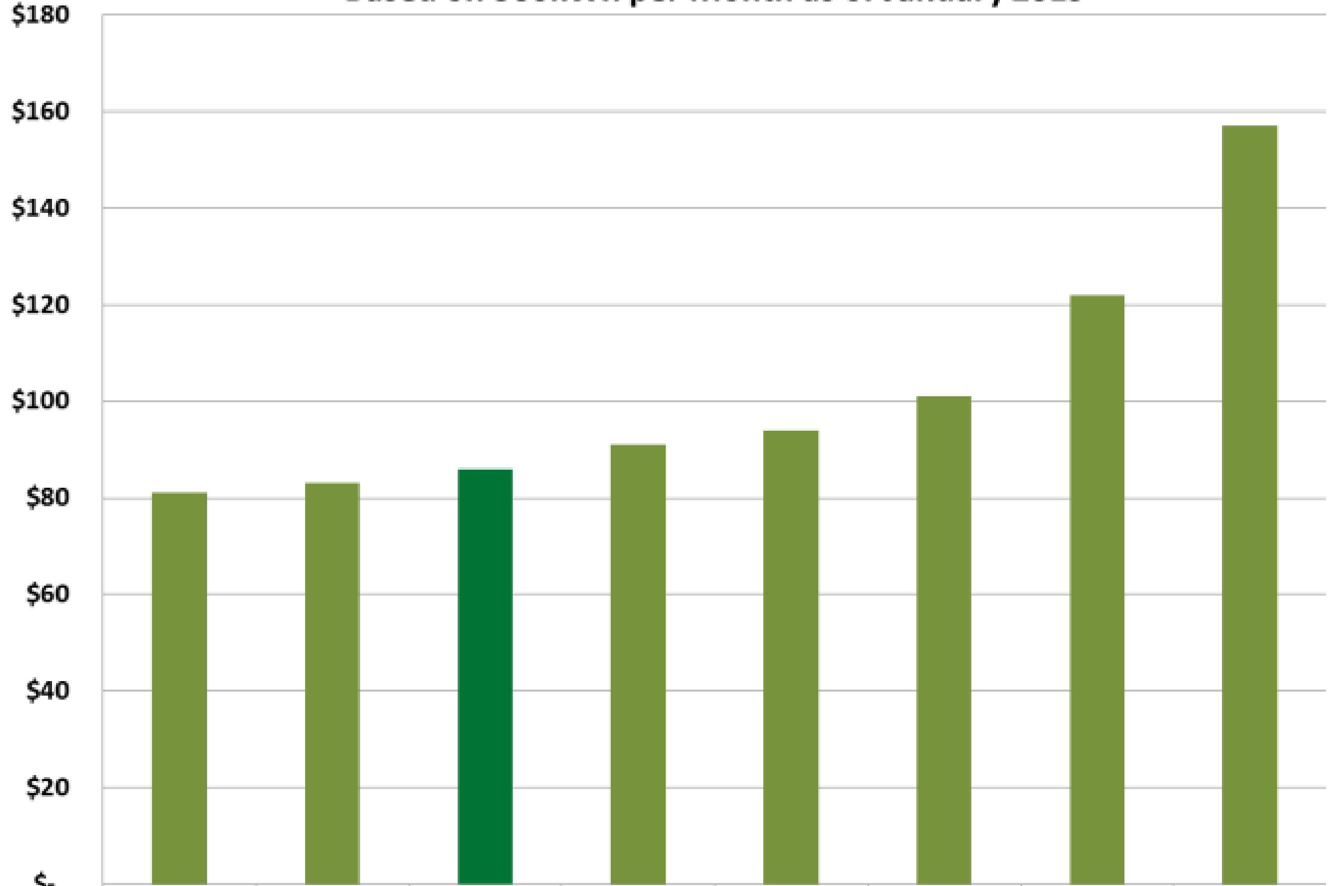
June 13 2019

Discussion Outline

- Competitive Rates
- Revenue Requirements
- Financial Planning Criteria/Financial Metrics
- Importance of credit ratings
- Independent Assessment
- Financial Strategy Moving Forward
- Discussion Q & A

Rates Remain Competitive: Residential

Comparative Residential Annualized Power Bills Excluding Tax
Based on 500kWh per Month as of January 2019



	BURBANK	SMUD	LADWP	PASADENA	GLENDALE	SCE	PGE	SDGE
Monthly Bill	$81	$83	$86	$91	$94	$101	$122	$157

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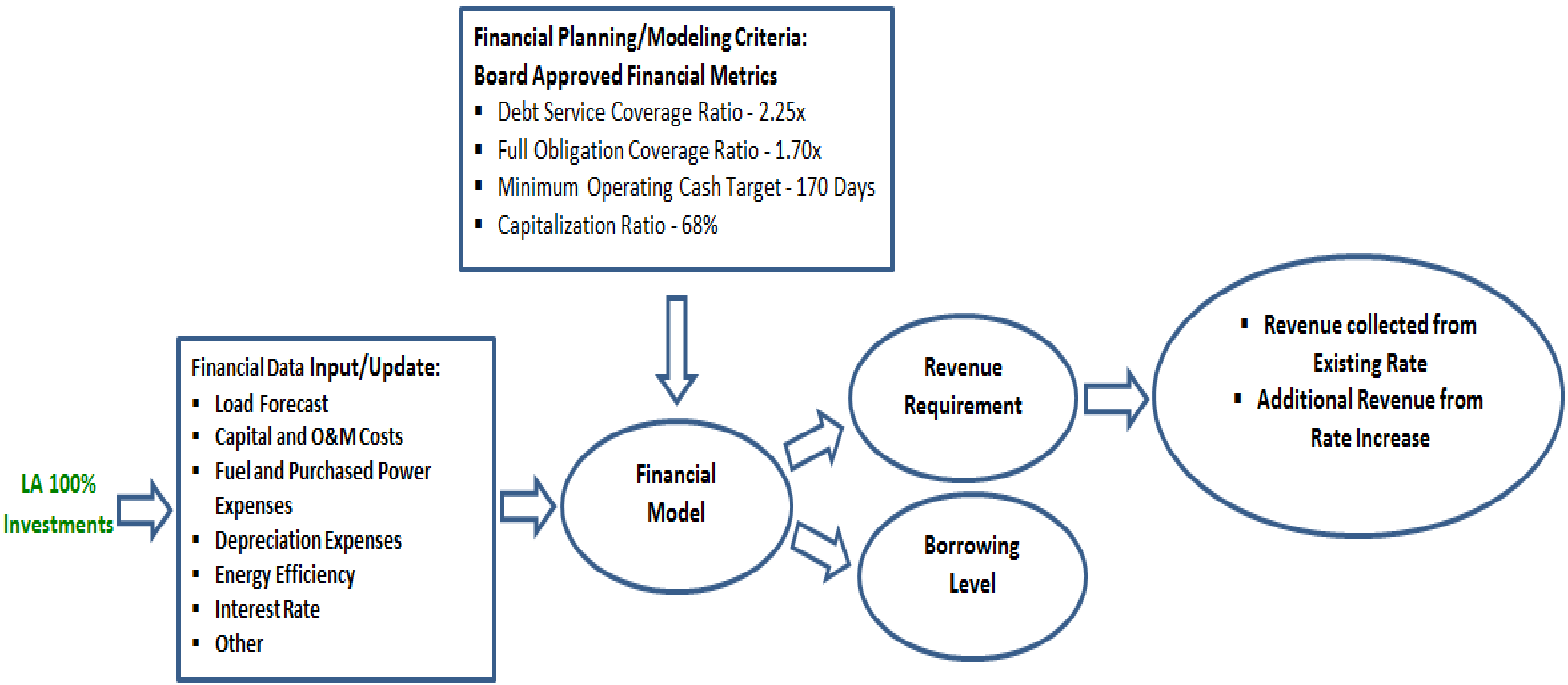
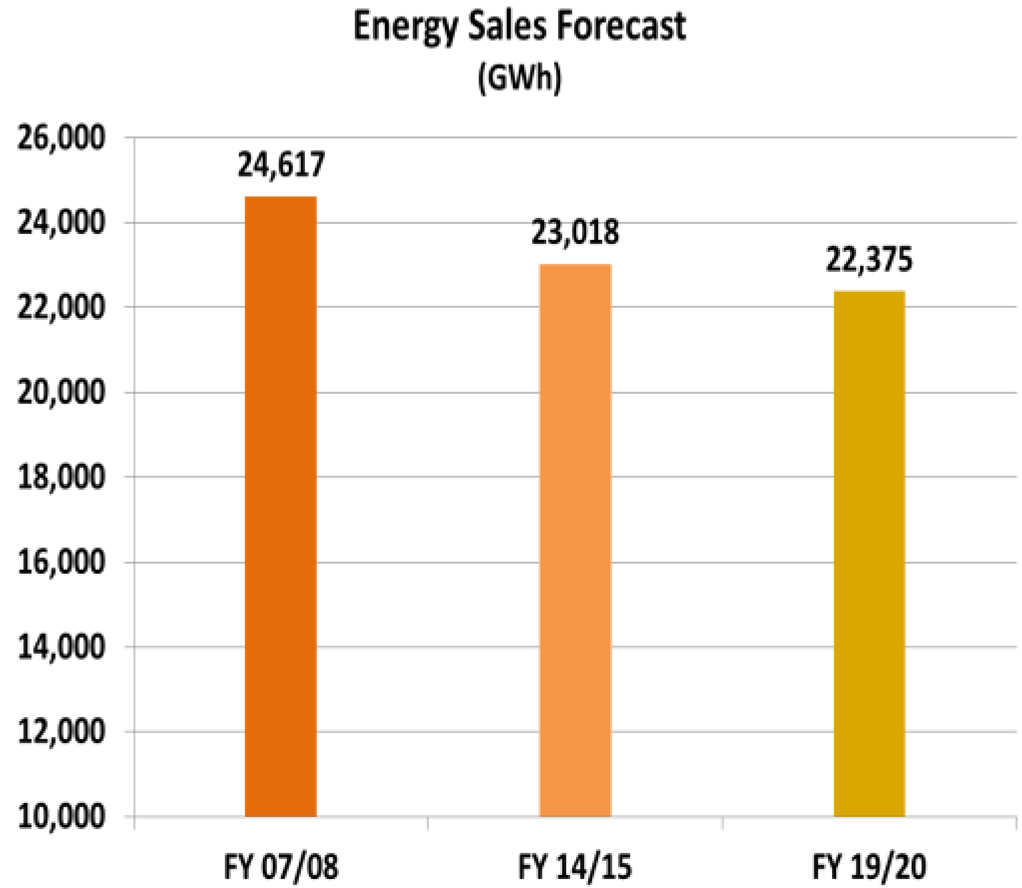
Determine Revenue Requirement



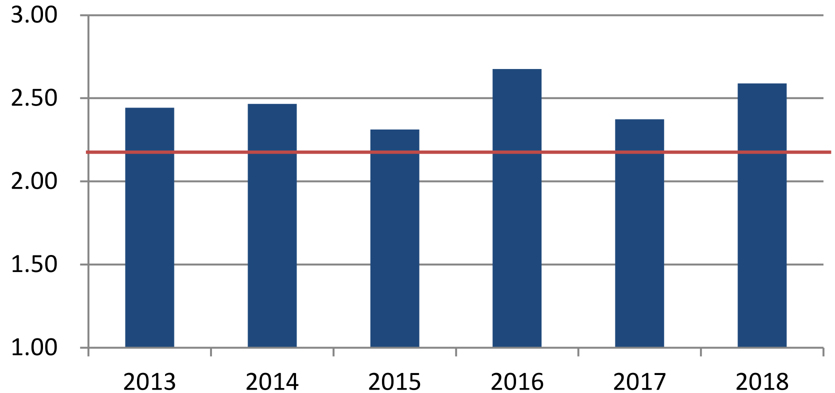
Power Demand Mitigated by Conservation

- Energy conservation is expected to continue to mitigate overall energy sales growth through 2020
- Accelerated and expanded EV adoption can reverse the trend
- Fuel switching and electrifying building stock can reverse the trend

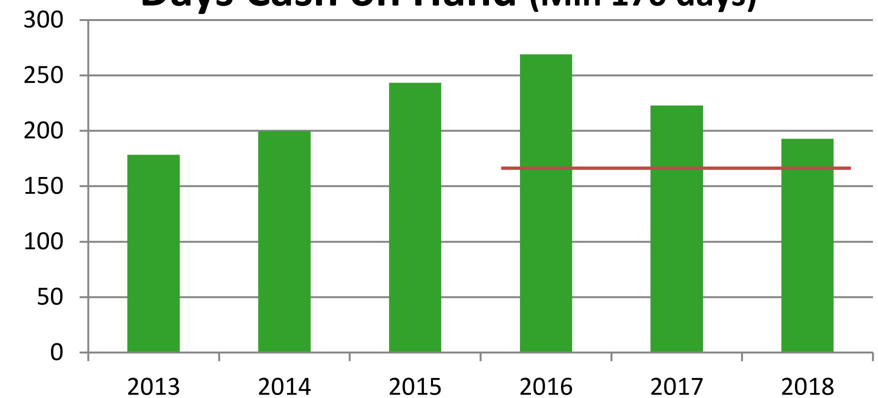


Power System Financial Overview
Historical Trends

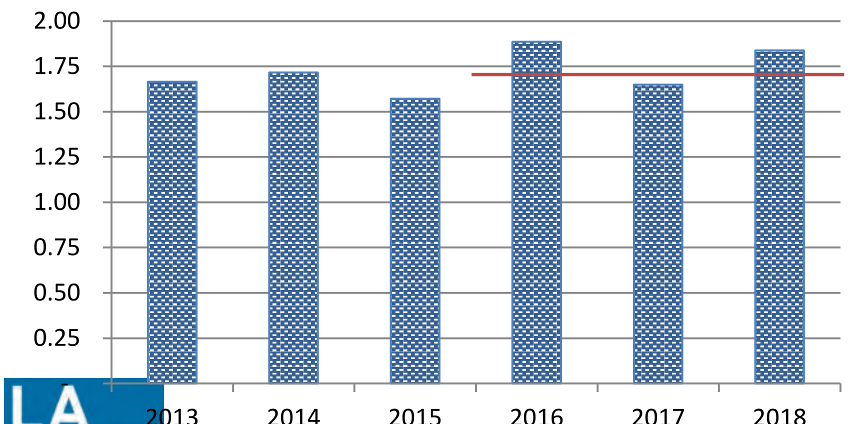
Debt Service Coverage (Min 2.25x)



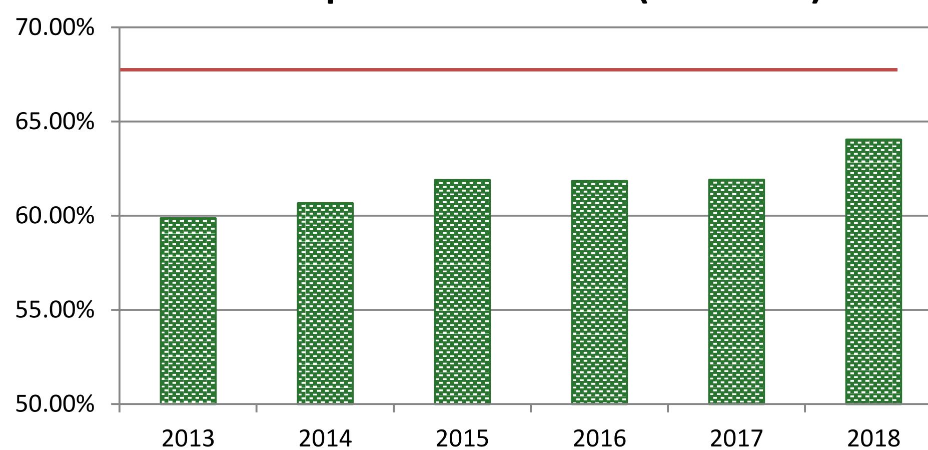
Days Cash on Hand (Min 170 days)



Full Obligation Ratio (Min 1.7x)



Debt to Capitalization Ratio (Max 68%)



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Prior to FY 2016, the Board Approved Financial Metric for Minimum Cash on Hand was $300 million.

Financial Metrics Math Explained

$$\text{Debt Service Coverage} = \frac{\text{Funds Available for Debt Service *}}{\text{Debt Service}} \quad >= 2.25$$

** Funds Available for Debt Service = Revenue – Expense before city transfer, depreciation, and debt service*

$$\text{Full Obligation Ratio} = \frac{\text{Funds Available for Debt Service} + \text{Off-balance Sheet Debt Service} - \text{City Transfer}}{\text{Debt Service} + \text{Off-balance Sheet Debt Service}} \quad >= 1.70$$

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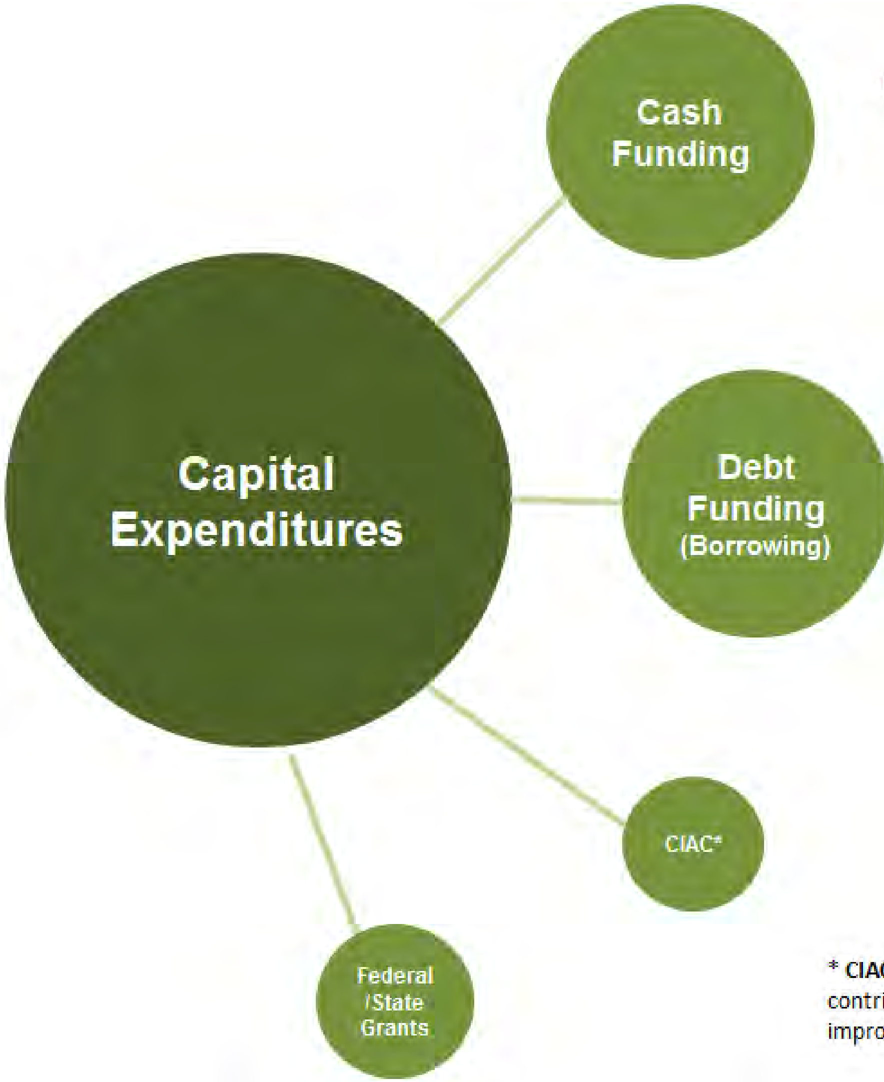
Financial Metrics Math Explained

Days Cash On Hand = Average Daily Operating Expense* x 170

** Operating Expense includes fuel, O&M expense*

$$\text{Debt to Capitalization Ratio} = \frac{\text{Long Term Debt}}{\text{Long Term Debt + Equity}} \le 68\%$$

Funding Sources for Power Capital Expenditures



- **Rate impact** - directly through rates collected from all customers

- **Rate impact** - debt Service collected from customers over a period of time

* **CIAC (Contribution in Aid of Construction)** - amounts contributed by customers for the purpose of expansion, improvement, or replacement of facilities.

Factors to Consider When Borrow for Capital Projects

- Projected Capital Projects Spending Plan
- Funds Available to Pay Debt Service
- Board Approved Capitalization Ratio
- Existing Debt Profile (Debt Outstanding)
- Additional Debt Service to be Incurred
- Maintaining Strong Bond Credit Ratings (Financial Metrics)
- Avoid Bond Credit Rating Downgrade
- Financial Market Capacity/Limitation
- Rate Impact to Customers

Power System Bond Credit Ratings

LADWP Credit Ratings		
Rating Agency	**2018 Rating**	**2015 Rating**
Standard & Poor's (S&P)	AA	AA-
Fitch Ratings	AA	AA-

S&P / Fitch	Rating Grade	Description
AAA	Prime	Highest quality with minimal risk; capacity to meet financial commitments is extremely strong
AA+ AA AA-	High Grade	Very high quality with very low risk; differs from the highest rating to only a small degree
A+ A A-	Upper Medium Grade	High quality with low risk; capacity to meet commitments is considered strong but may be susceptible to changing circumstances and economic conditions
BBB+ BBB+ BBB-	Lower Medium Grade	Medium grade; subject to moderate risk; capacity to meet financial commitments is adequate but more likely to be susceptible to changing circumstance and economic conditions

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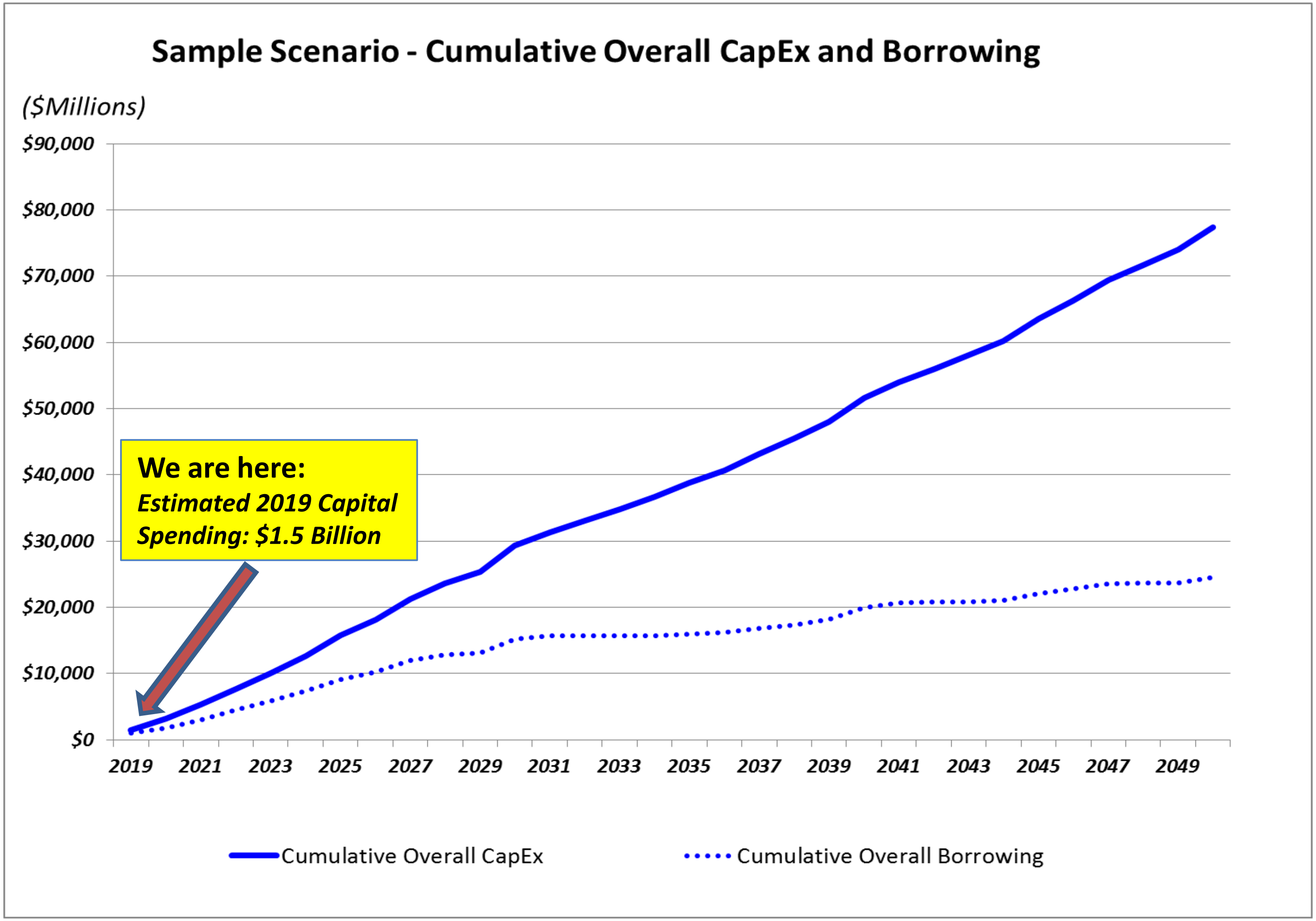
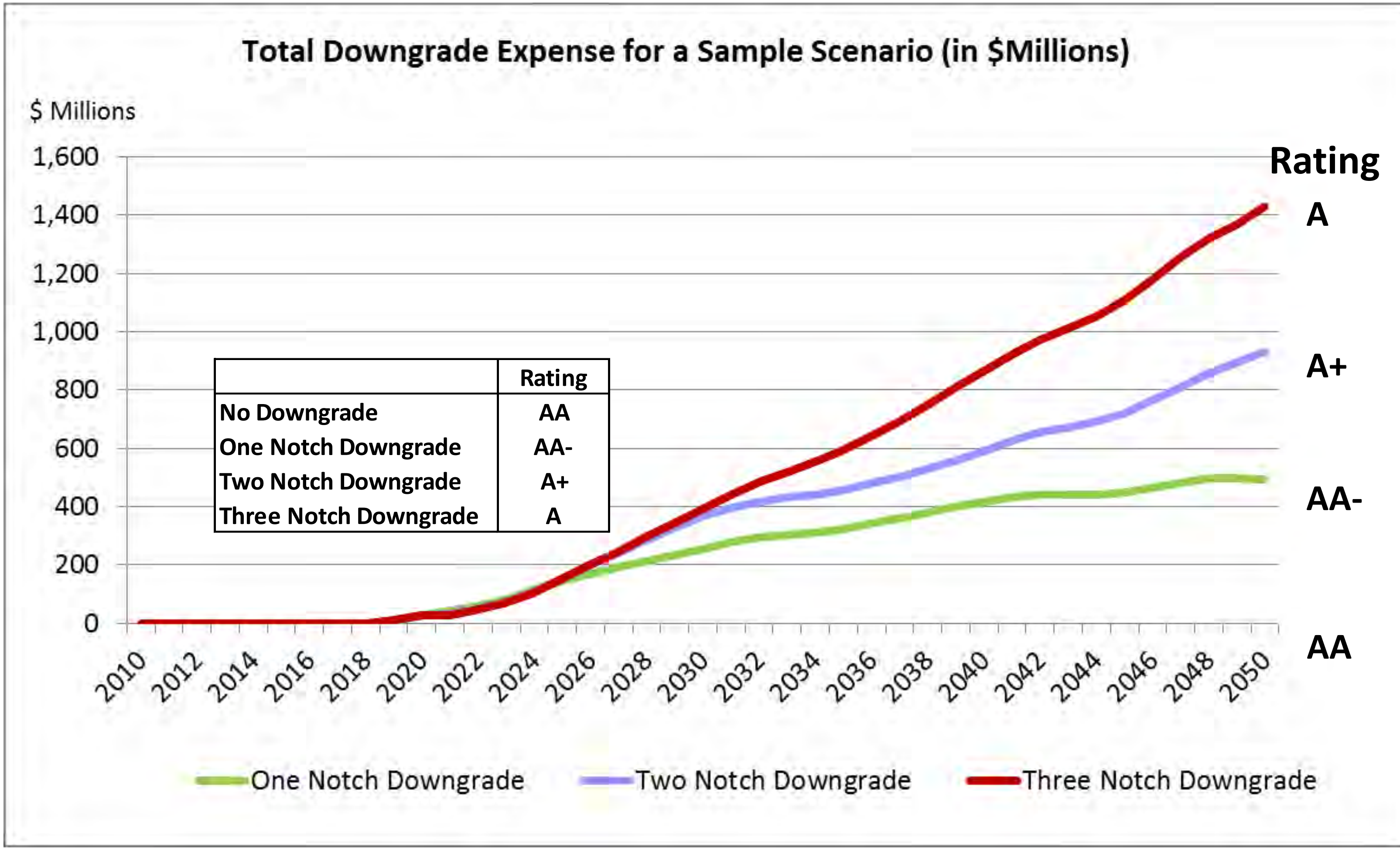
Sample Scenario – Capital Spending & Borrowing

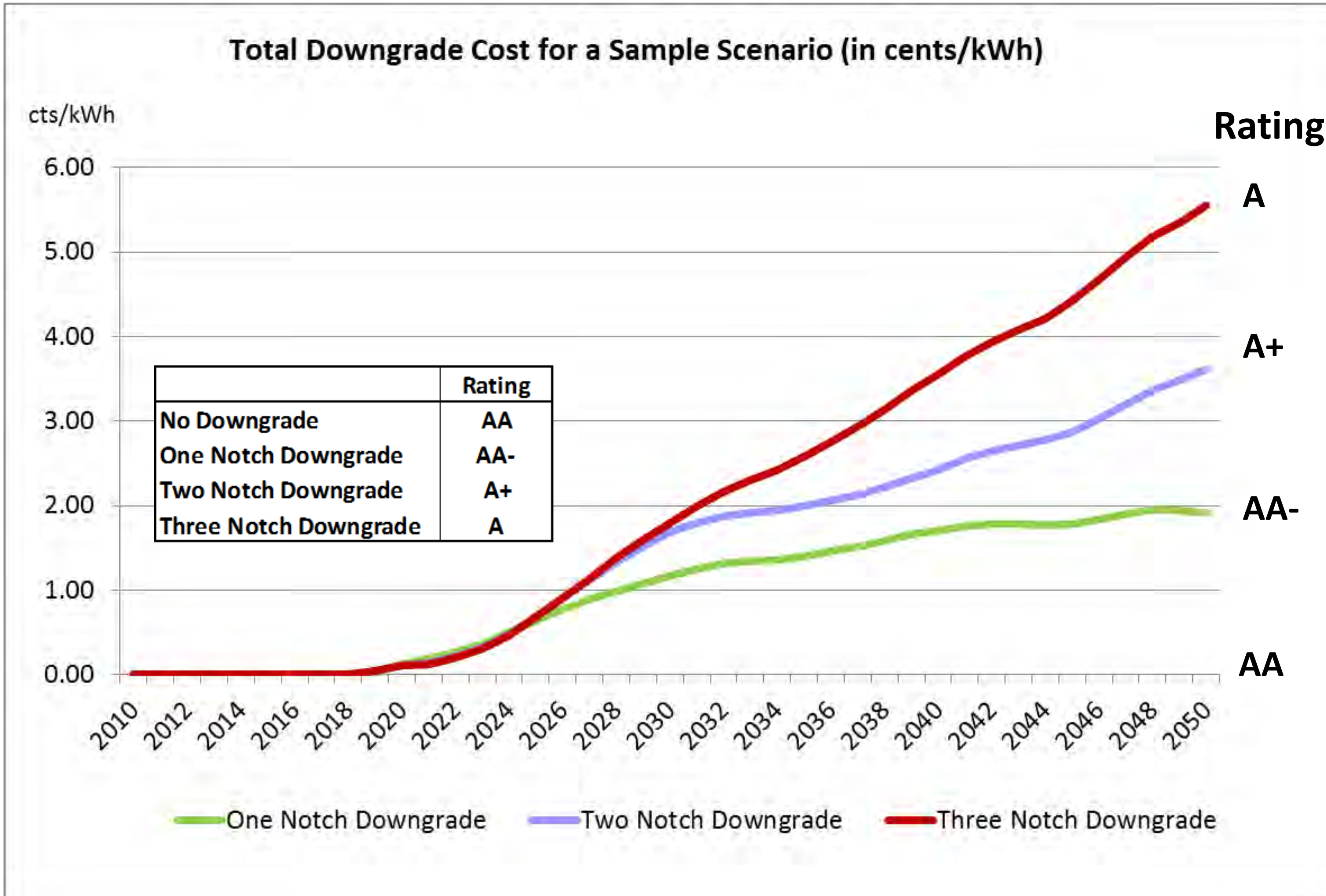


Sample Scenario - Credit Ratings Downgrade Impact



	Rating
No Downgrade	AA
One Notch Downgrade	AA-
Two Notch Downgrade	A+
Three Notch Downgrade	A

Sample Scenario - Credit Ratings Downgrade Impact

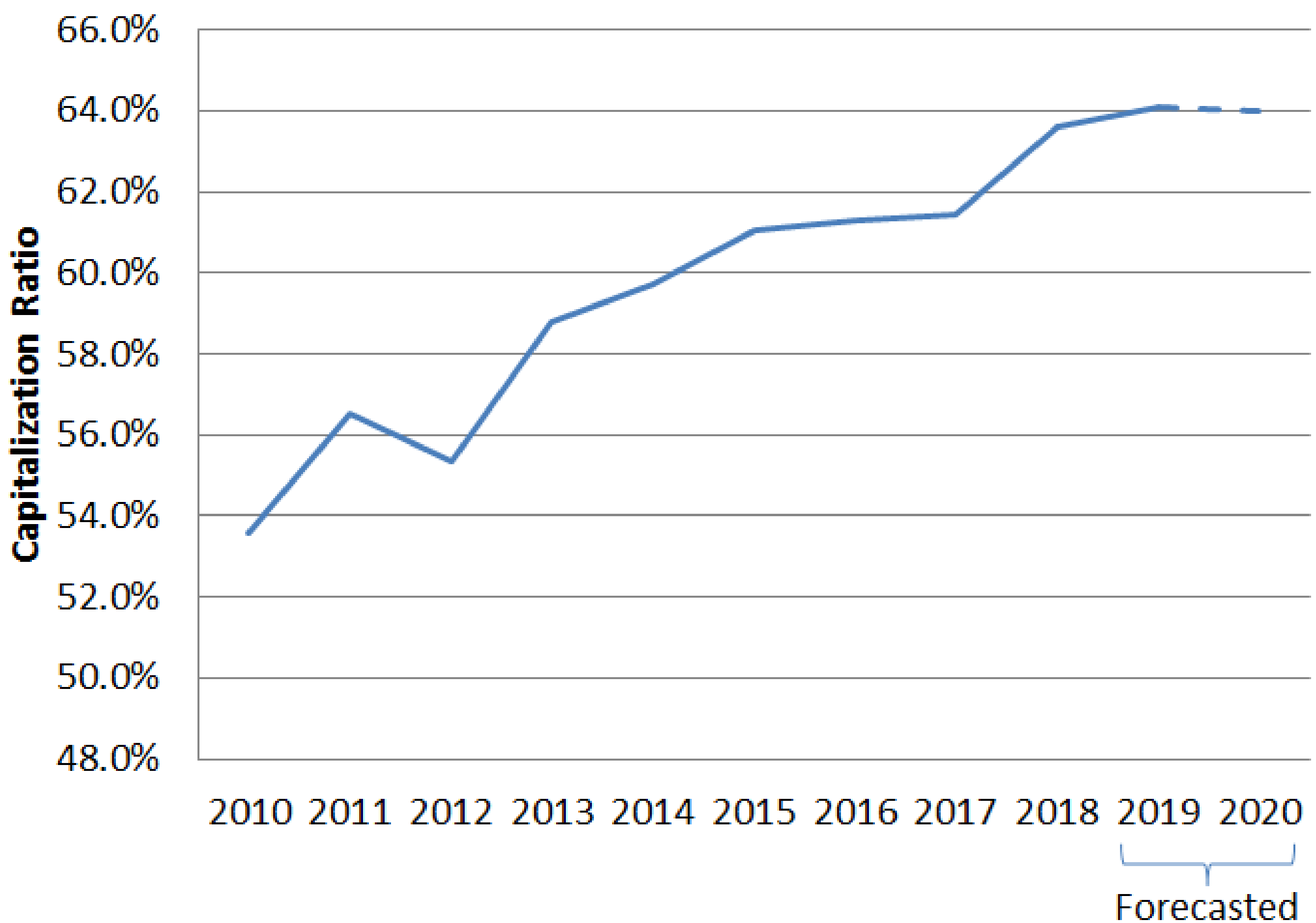


Power System Debt Profile

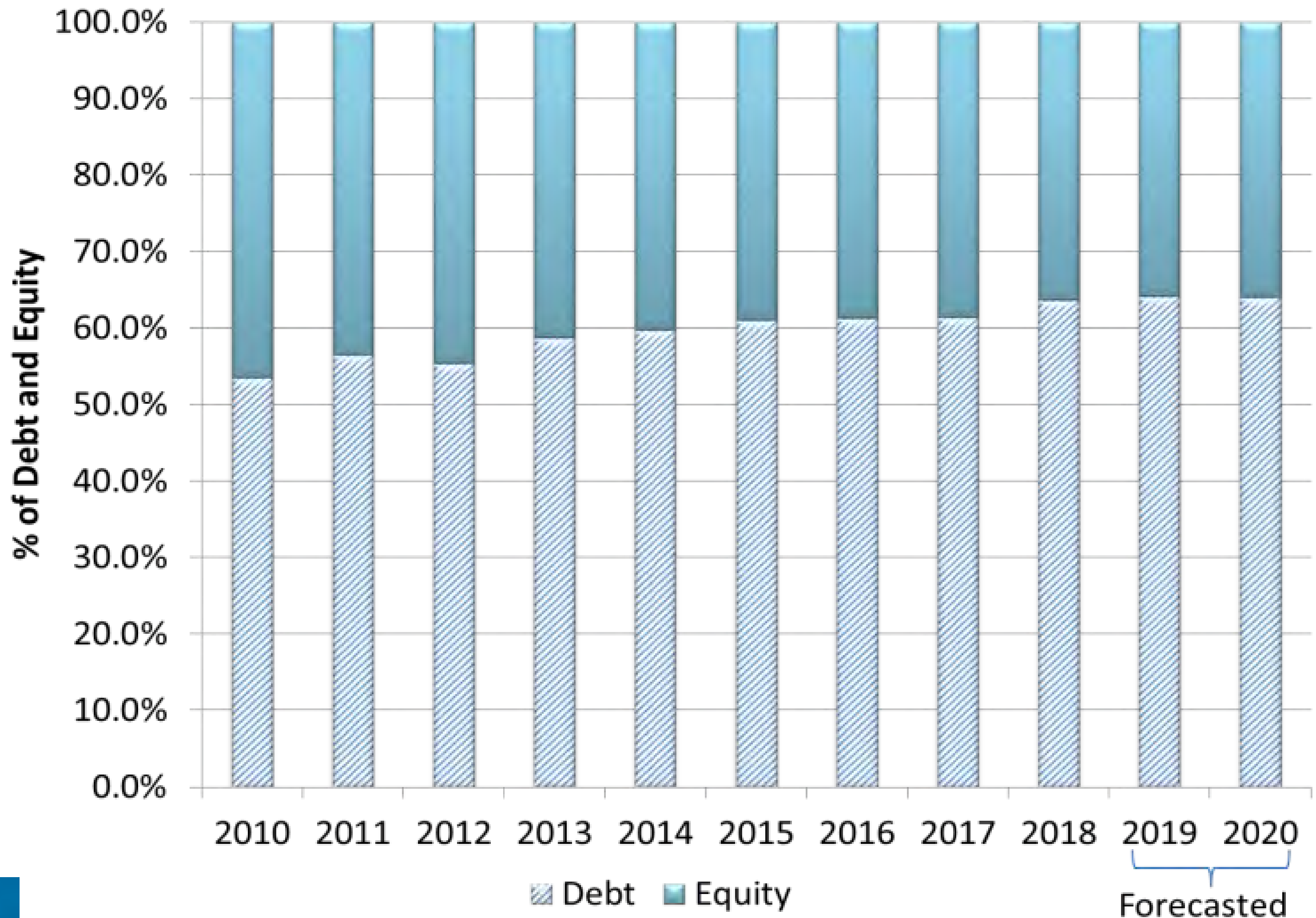
Current FY 2019 estimated Debt to Capitalization Ratio is 64.1%, or $9.46 billion in debt, which is less than Board approved target of Max 68%

Fiscal Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Debt to Capitalization Ratio	53.6%	56.5%	55.4%	58.8%	59.7%	61.0%	61.3%	61.4%	63.6%	64.1%	64.0%

Historic and Forecasted Capitalization Ratio



Historic and Forecasted % of Debt and Equity



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Validation of Financial Impacts

Navigant will provide an independent report to assess by scenario:

- The cost-benefit impact
- The financial planning metric impact
- The rate impact
- The customer bill impact

Work with Office of Public Accountability on their analysis as directed by City Council

Financial Strategy Moving Forward

Traditional Financing

- Cash funding through rates
- Traditional Revenue Bonds
- Federal/State Grants

Seeking Innovative Financing Opportunities

- Rate Reduction Bonds
- Solicit Ideas from LADWP Investment Banking Team
- Green and Sustainability Bonds
- Public-Private Partnerships

Los Angeles Department of Water & Power

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Discussion Q&A