LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #10

December 5, 2019

LA DWP Los Angeles Department of Water & Power

NREL Transforming ENERGY

Agenda

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

***Q&A and Discussion*

Tips for Productive Discussions

Let one person speak at a time

Help to make sure everyone gets equal time to give input

Keep input concise so others have time to participate

Actively listen to others, seek to understand perspectives

Offer ideas to address questions and concerns raised by others

Hold questions until after presentations

LA100

The Los Angeles 100% Renewable Energy Study

Initial Run Results: Overview of Today

Jaquelin Cochran, Ph.D.

December 5, 2019

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

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

Input models

What is electricity demand and customer-driven supply?

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

Main scenario model

What should LADWP build?

- Generation
- Transmission
- Distribution upgrades

Output and validation models

How do we know it's right?

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

Impact models

What are the impacts?

- Economic and workforce analysis
- Environmental analysis

Input Models (Paul Denholm)

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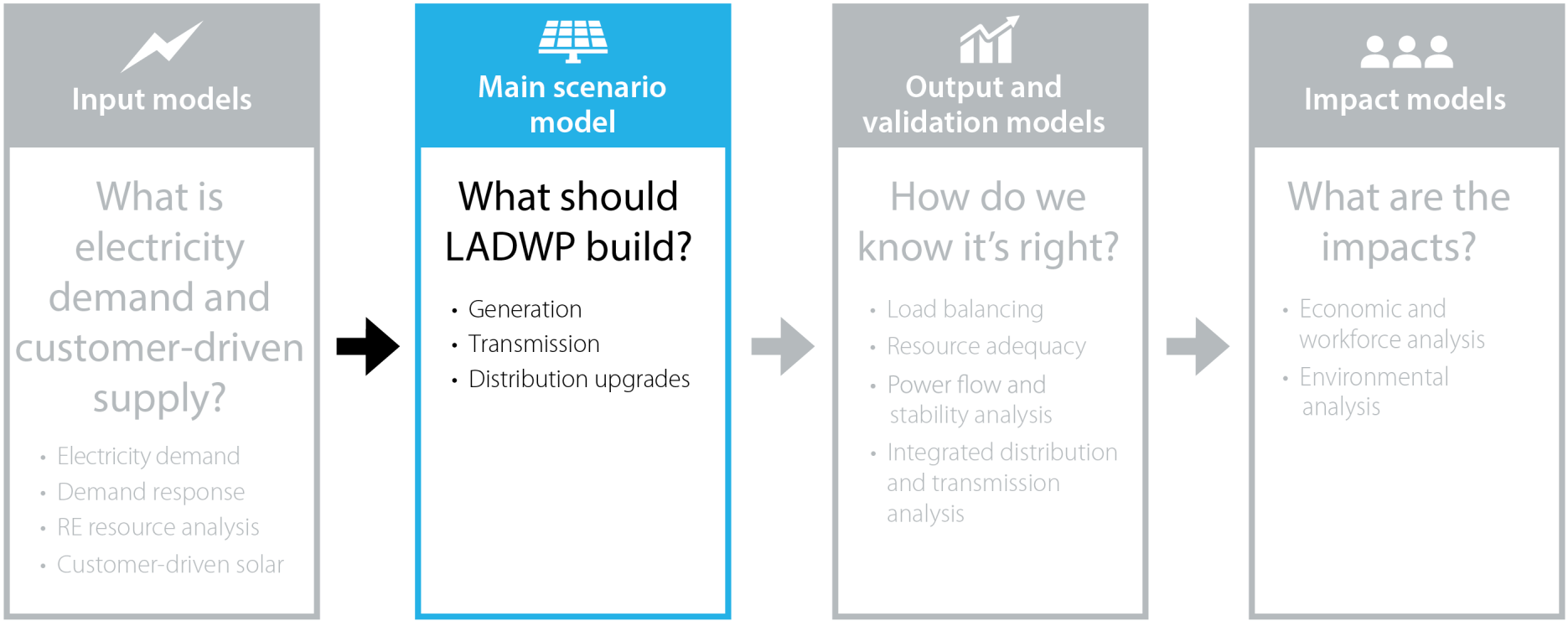
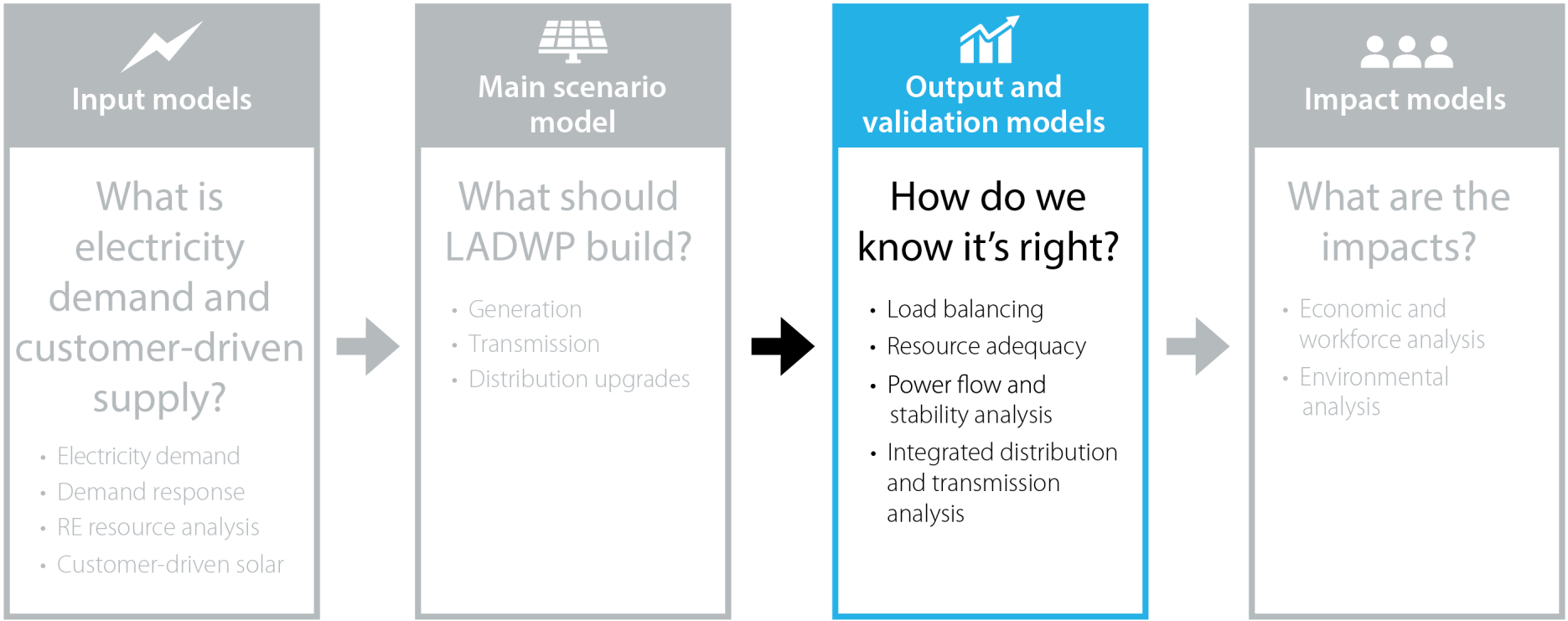
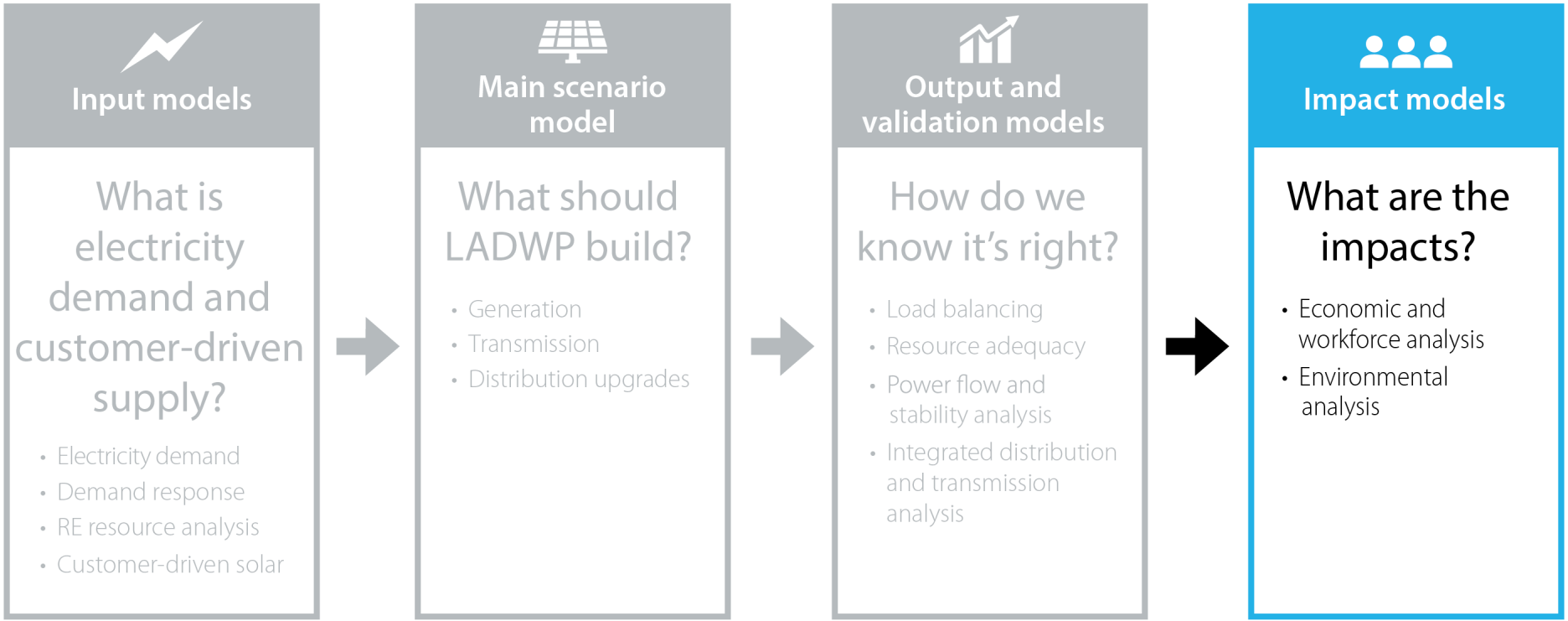
Bulk Power & Distribution Models (Dan Steinberg, Bryan Palmintier)



Output and Validation Models (Dan Steinberg)

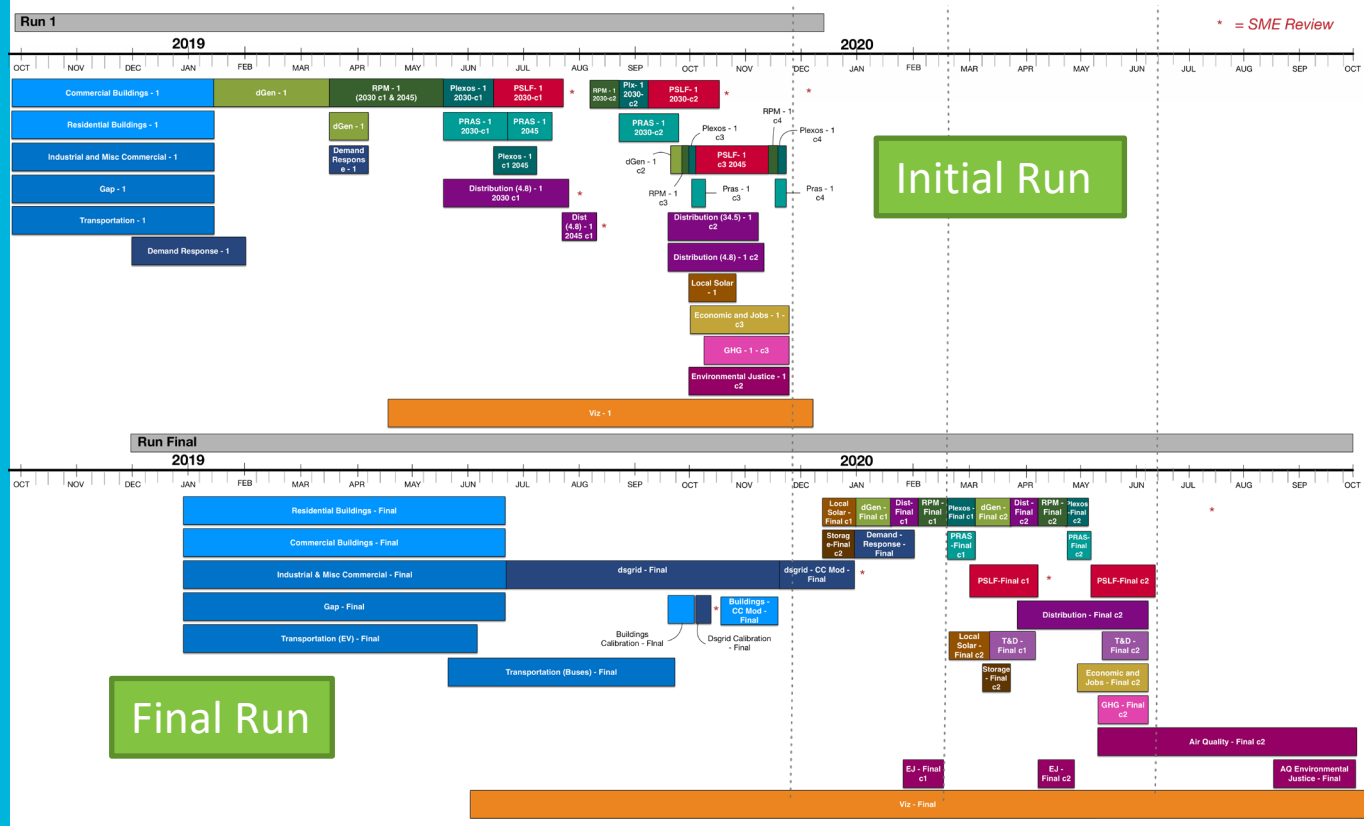


Impact Models (Jaquelin Cochran)



Today—
Present Initial Run Results

2020 AG Meetings—
Review Final Run



LA100 Scenarios (updated September 2019)

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

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

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

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	Biogas	Y	No	Y	Y	Y	No	Y	Y	Y
	Electricity to Fuel (e.g. H2)	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Natural Gas	Yes	N	N	N	Yes	N	N	N	Yes
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geo	Y	Y	Y	Y	Y	Y	Y	Y	Y
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First: In-depth Focus on SB100 to Understand One Set of Results

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Second: Review All Models to Assess Trends

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Important Considerations for Interpreting Initial Run Results

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

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

Why Are We Presenting Results That Will Change?

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

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

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

Reviews of Each Model Include A Slide That Looks Like This

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

What's Included in Initial Run

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

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

Follow-up Q&A from this Advisory Group Meeting

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

- Mark your calendars for:

  Tuesday, December 17, 2019

  10:00 AM – 11:00 AM

LA100

The Los Angeles 100% Renewable Energy Study

Initial Run Results: Input Models

All LA100 Scenarios

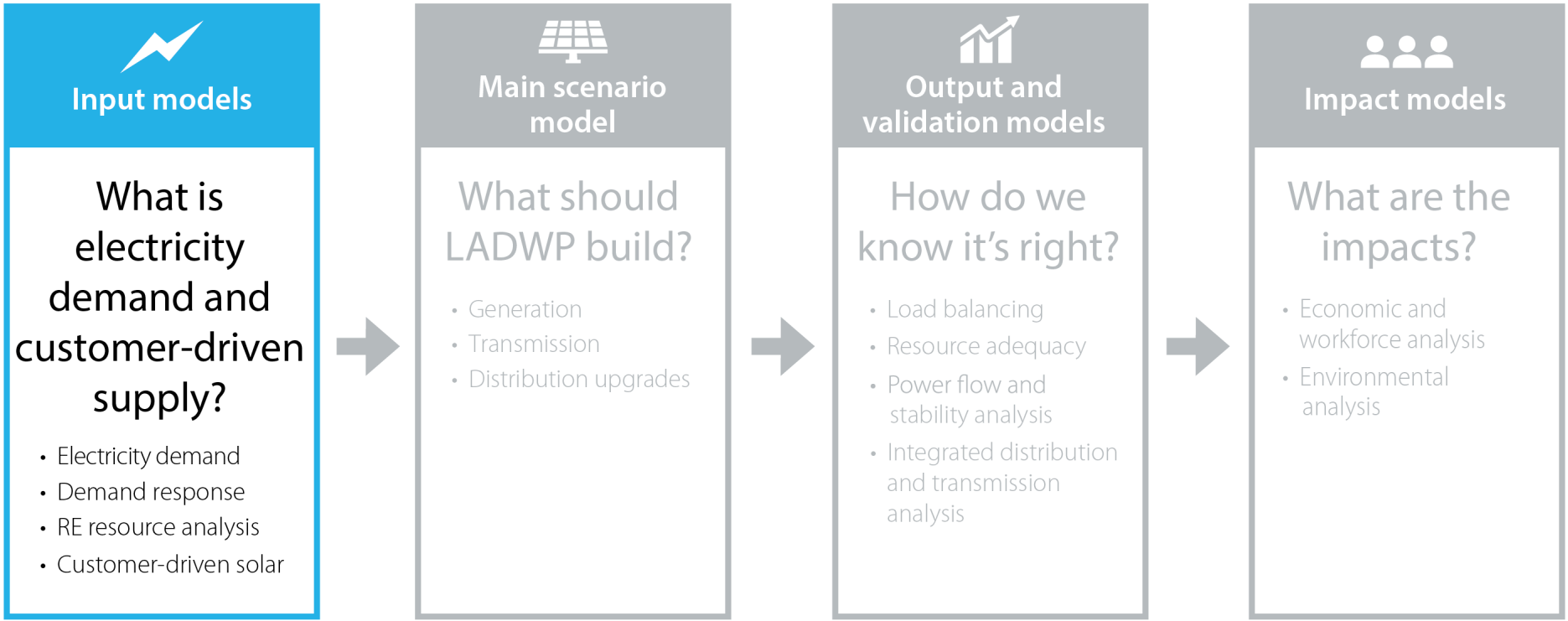
Paul Denholm

December 5, 2019

LA DWP Los Angeles Department of Water & Power

NREL Transforming ENERGY

Input Models



Agenda

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

Electricity Demand Projections

Purpose within LA100

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

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

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

What's Included in Initial Run

Projections completed in January 2019

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

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

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

Electric buses

Climate-adjusted buildings demand

Improved calibration of buildings models

More aggressive demand response

Electricity Demand Projections

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

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

Residential and Commercial Electricity Demand

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

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

ResStock ComStock

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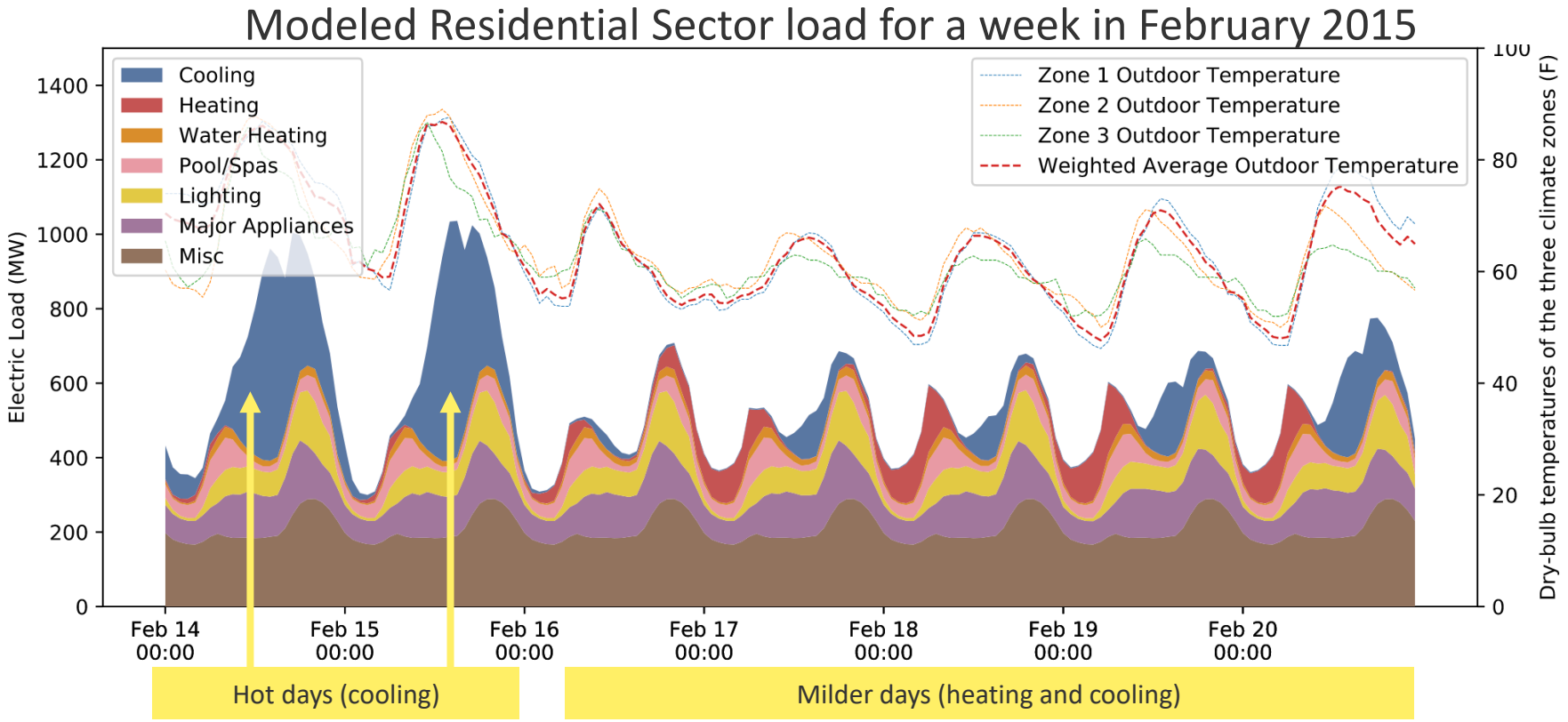
Initial Run: Example Week of Residential Demand in Base Year



Buildings Demand: Coming in March AG Presentation

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

Industrial Demand and Other Loads

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

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

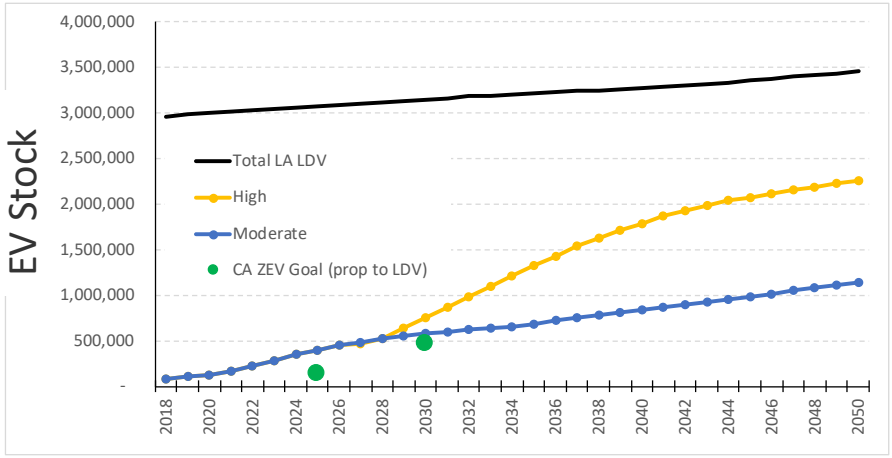
Electric Vehicle Charging Demand

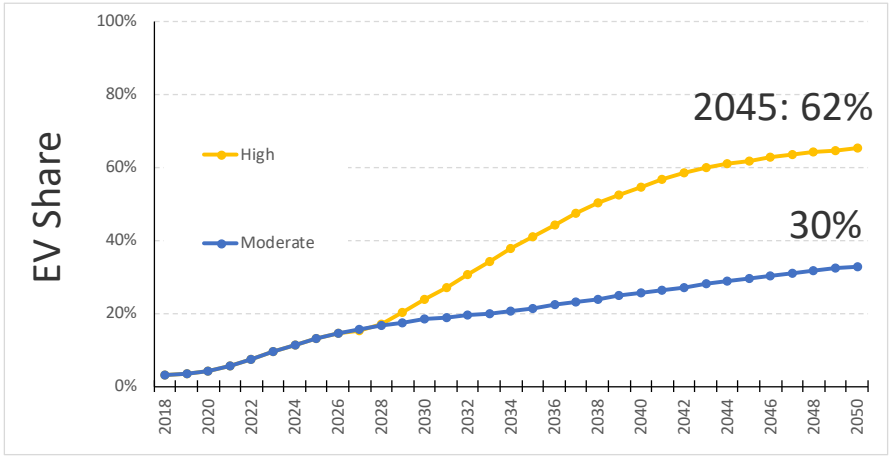
How will electric vehicles and buses impact LADWP's need for new resources?

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

EV Scenario Design

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





Initial Run: EV Charging Simulations

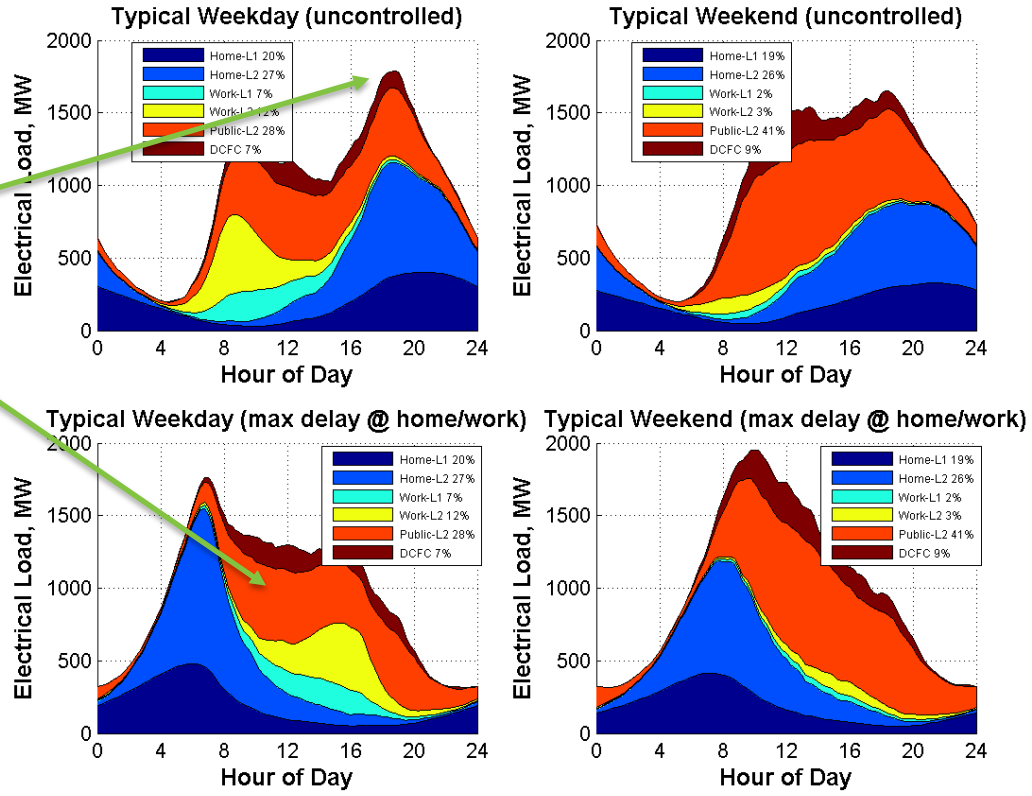
Example from Initial Run: **High** (~2 million EVs)

Arrive and plug in:
Significant charging demand during peak periods

Wait as long as possible to charge:

Demand response:
Choose charging times within this window

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



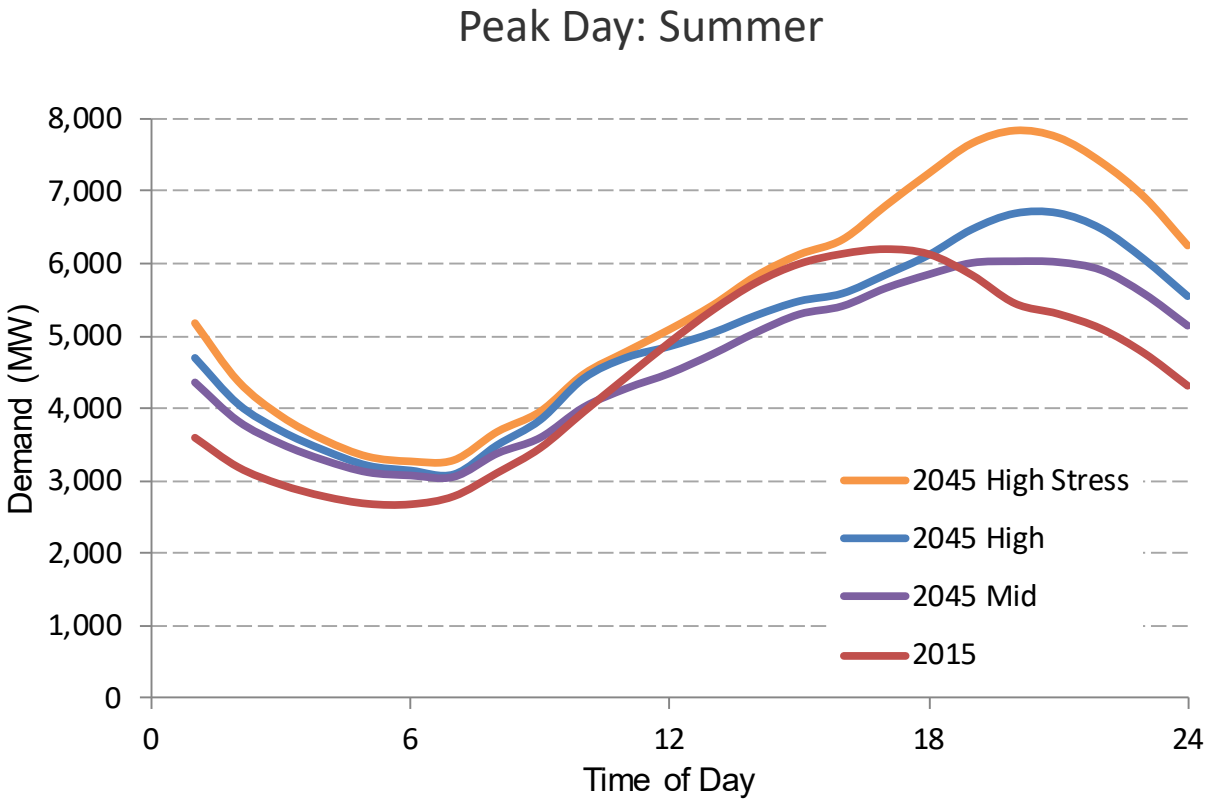
Transportation Demand: Coming in March AG Presentation

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

Demand Projections—All Sectors

Initial Run: Annual Electricity Demand Projections (All Sectors)

All years (including 2015) use 2012 weather data



Demand Response

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

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

Demand Response Programs

Interruptible Load

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

Energy-Shifting

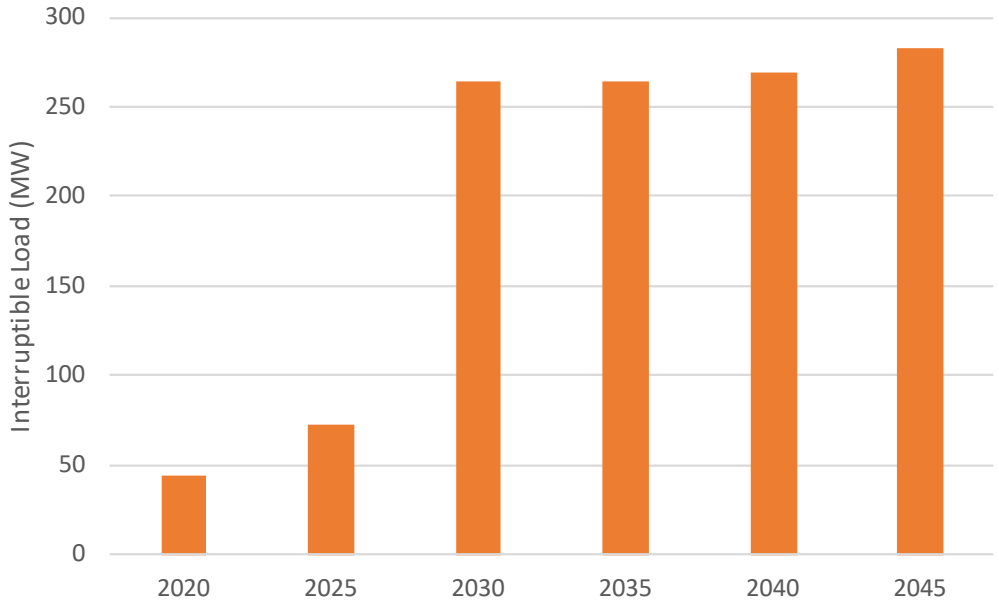
- Generalized Summer Shift Program (also CII)
- Residential Cooling (based on programmable communicating thermostats)
- Schedulable Electric Vehicle Charging
- Residential Hot Water and Heating
- Commercial Cooling and Heating

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

Moderate, High

High

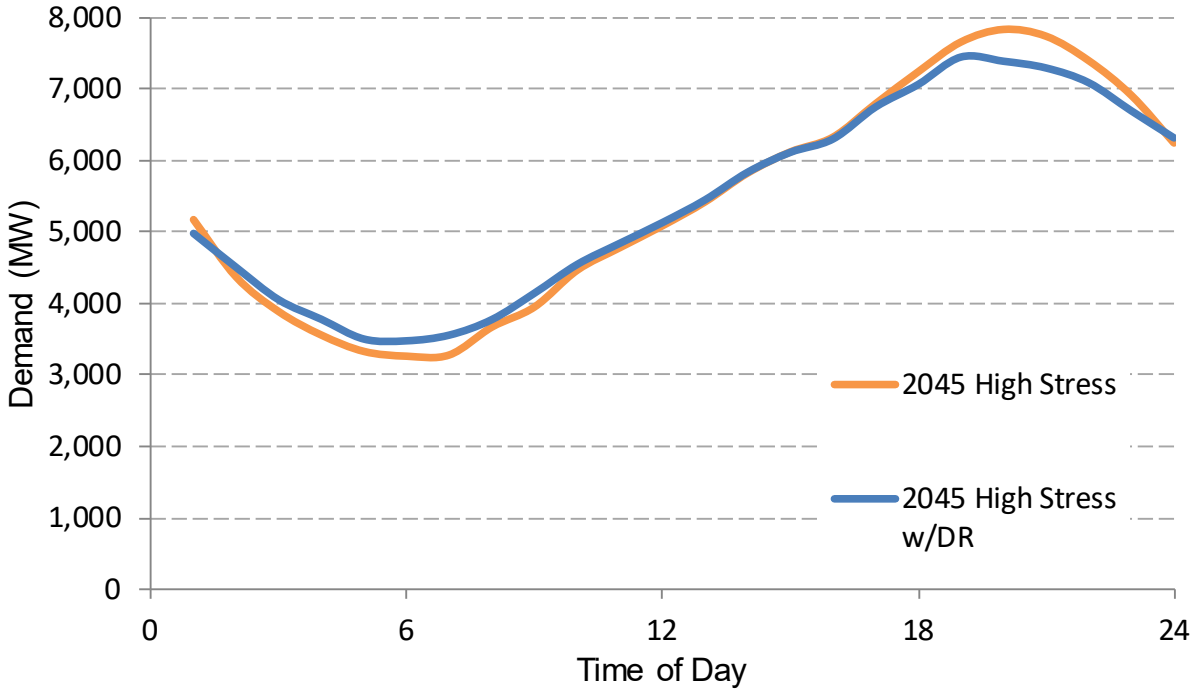
Initial Run Demand Response: Interruptible Load



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

Assumed for All Initial Run Demand Response Projections

Initial Run Demand Response: Energy Shifting



Reduction in peak demand due to energy shifting—

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

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

Demand Response: Coming in March AG Presentation

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

Questions Related to Loads?

Renewable Energy Resource Assessment

Purpose within LA100

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

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

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

What's Included in Initial Run

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

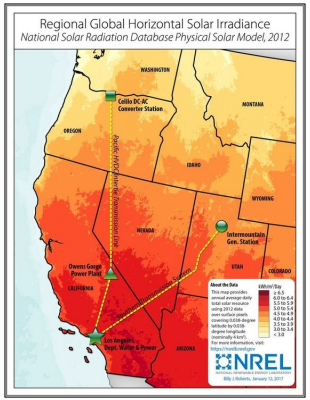
What's Not Included Today but Will Be in Final Run

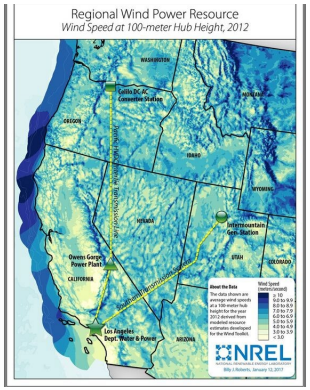
10 years of renewable resource profiles for wind and solar

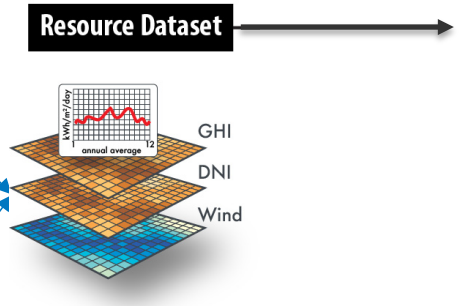
Process for Creating Renewable Generation Profiles

Inputs:

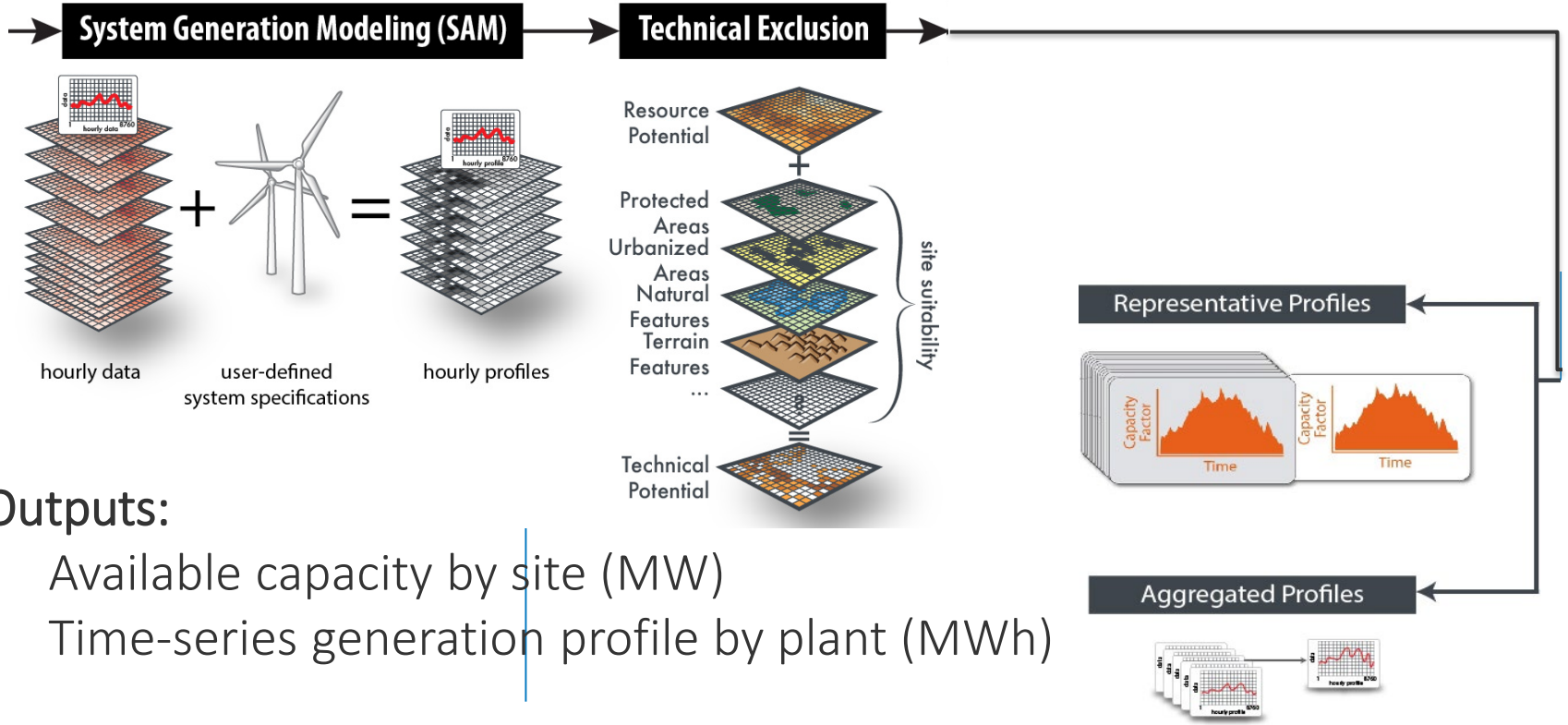
- Weather data
- Land characteristics
- Biomass, hydro, and geothermal resource availability
- Renewable plant operating characteristics







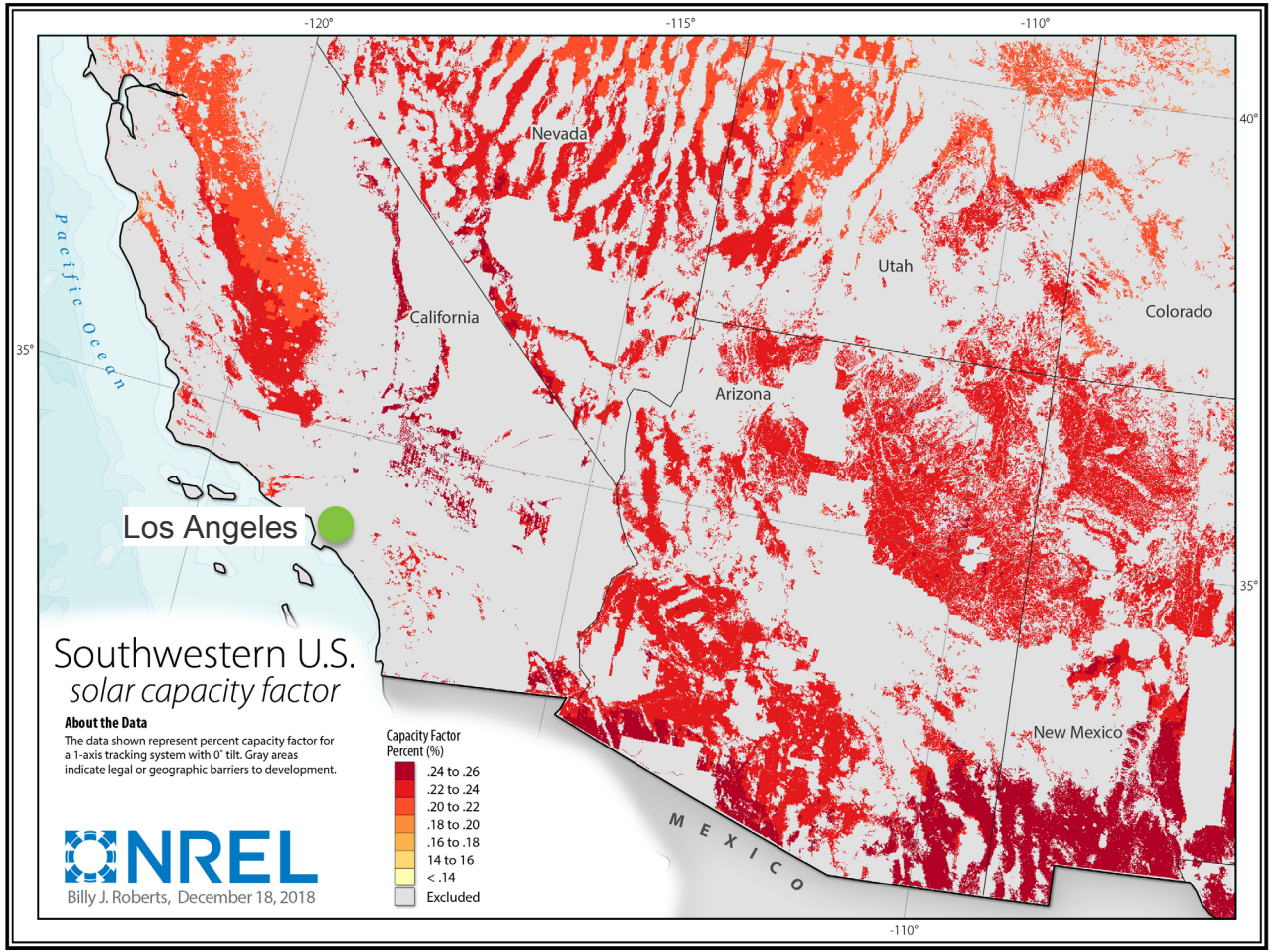
Process for Creating Renewable Generation Profiles



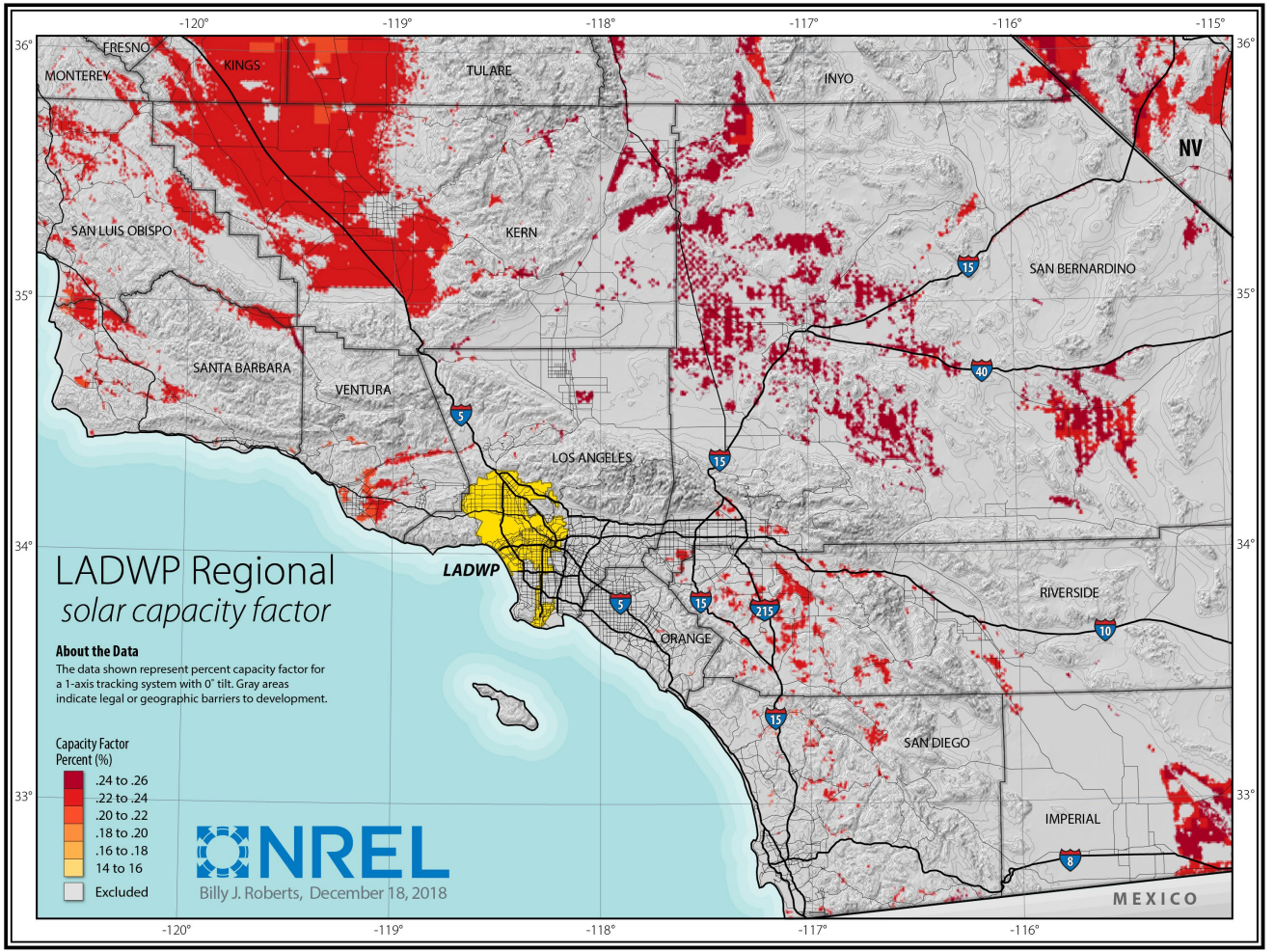
Outputs:

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

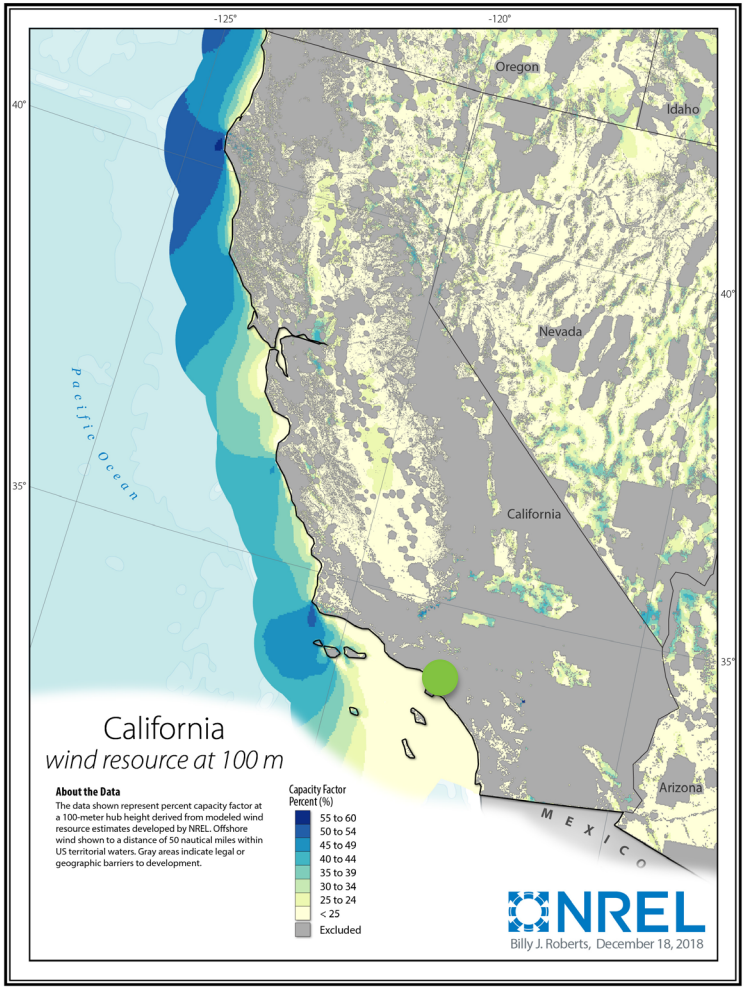
Utility-Scale PV Resource



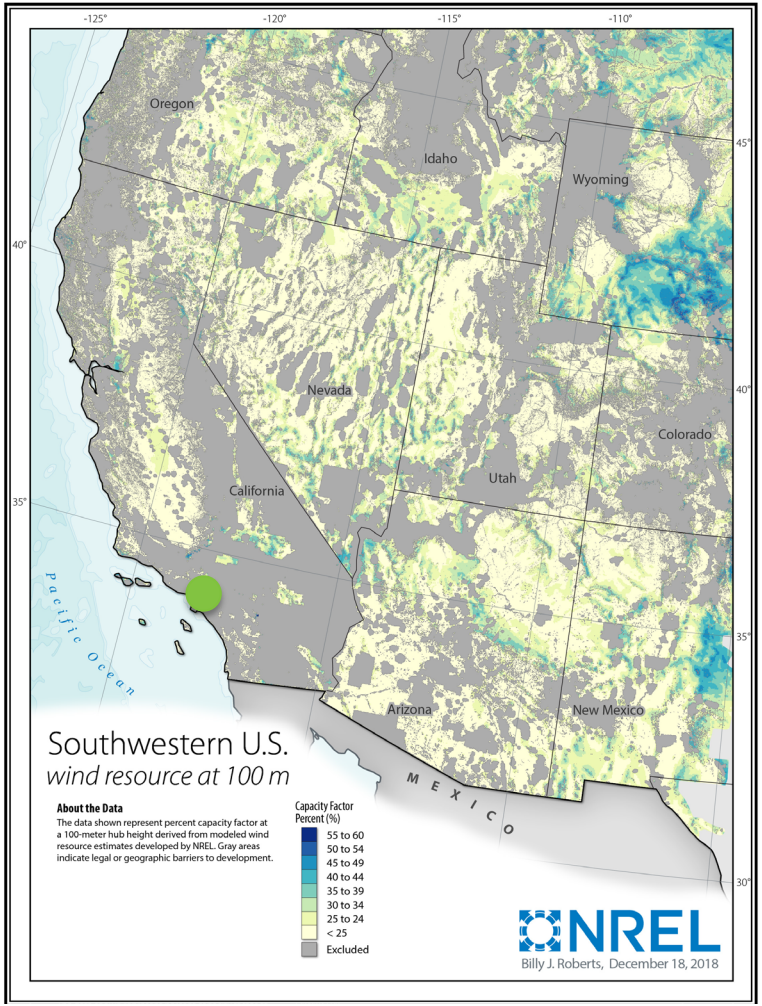
Utility-Scale PV Resource: Southern California



California Wind Resource: Including Offshore



Western U.S. Wind Resource



Resource Assessment: Coming in March AG Presentation

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

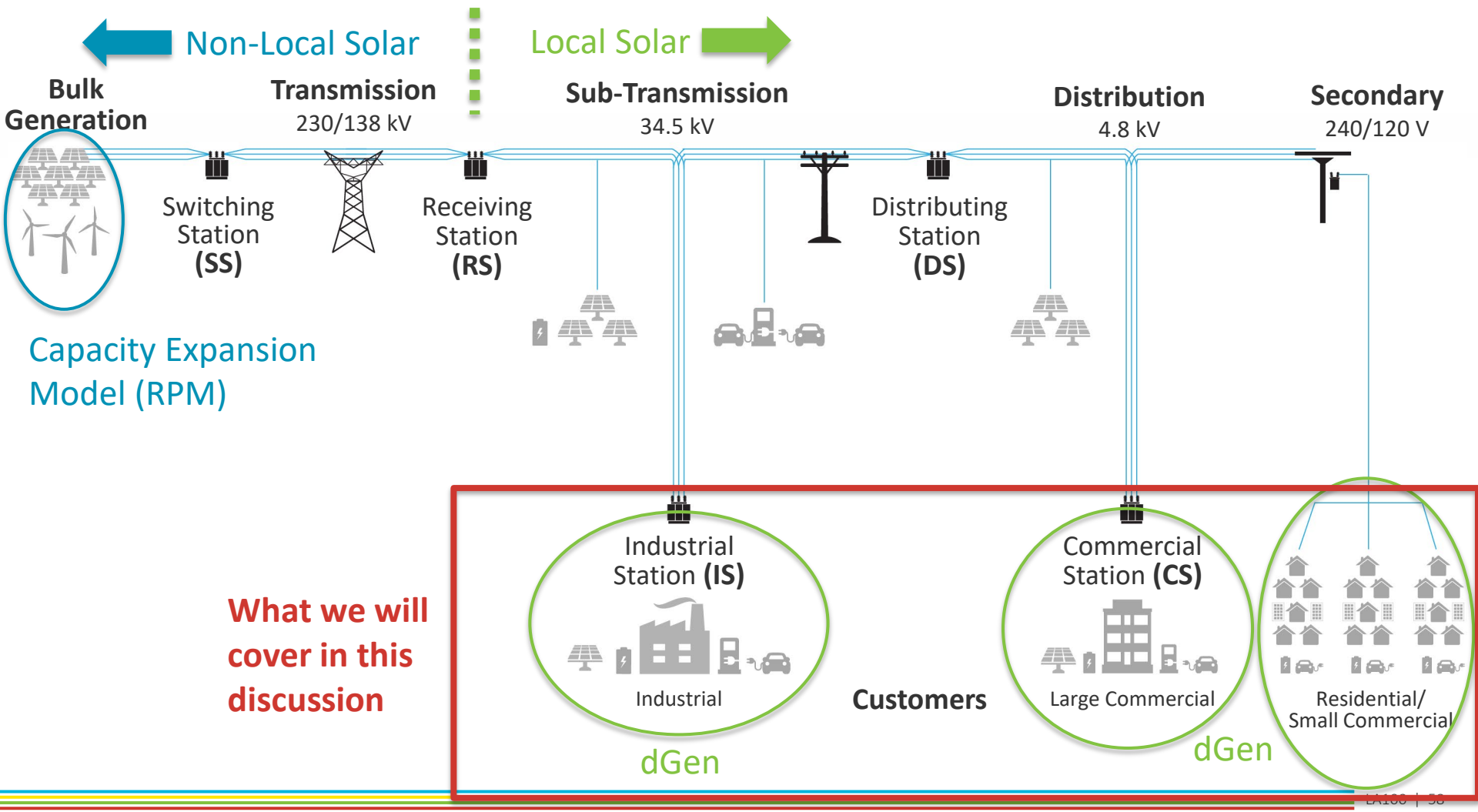
Questions Related to Renewable Resource Estimates?

Customer-Driven Solar (Rooftop Photovoltaics)

Purpose within LA100

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

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


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

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

What's Included in Initial Run

Customer projections for rooftop solar

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

Local ground-mounted and carport solar

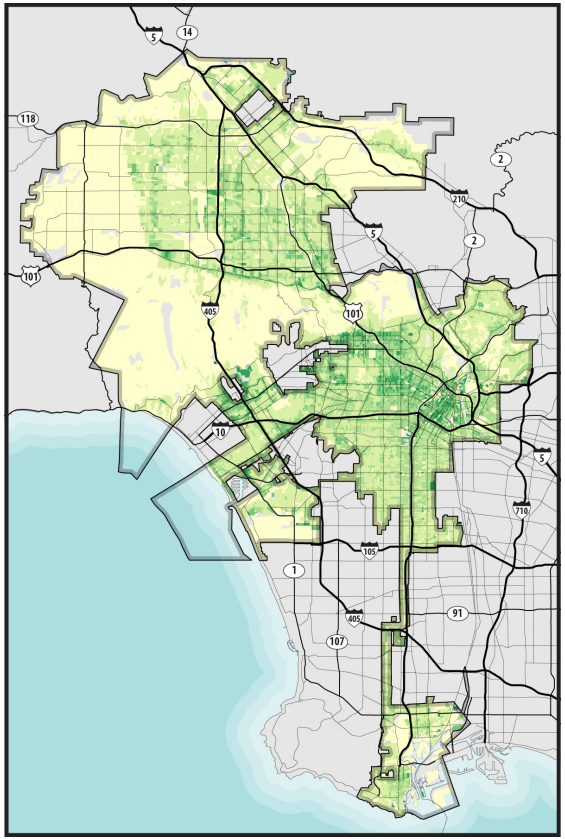
Local storage (customer and utility-scale)

Changes to rooftop solar estimates based on changes to demand

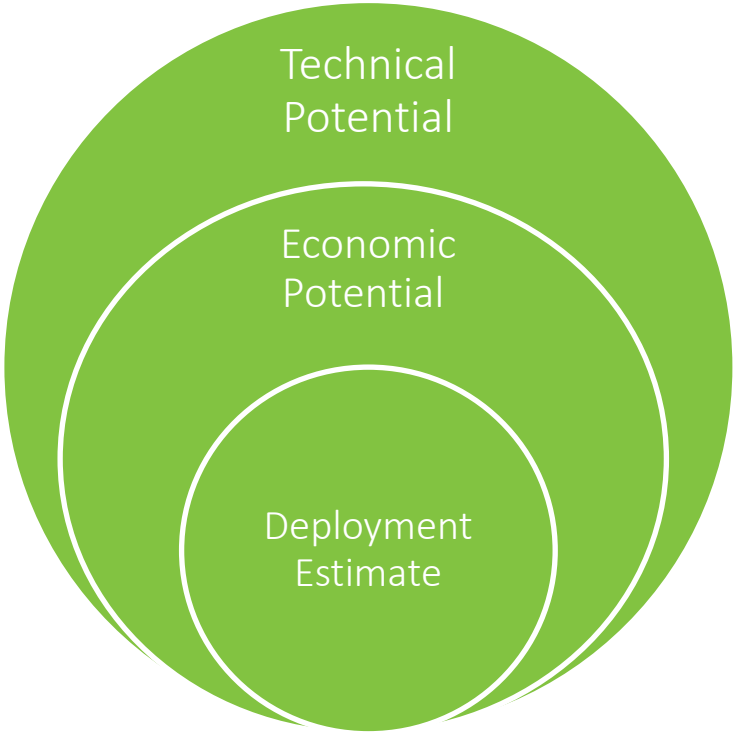
Further calibration to the dGen model

Initial Run – Quick Recap of Methods

How much rooftop solar will customers adopt?



Rooftop Solar: Framework for Projecting Adoption

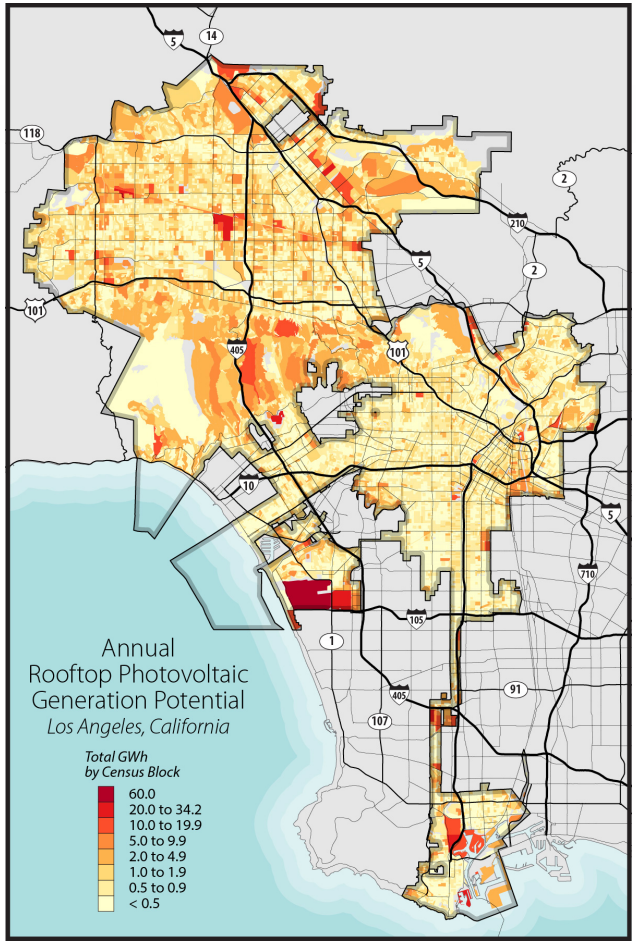


- **Technical potential:** Maximum feasible amount of capacity
- **Economic potential:** For which customers is rooftop solar cost effective?
- **Deployment**: Of the above, who might adopt?

Assess Rooftop Suitability for Solar

Rooftop Solar Generation

Technical Potential



Energy potential – Annual generation per census block

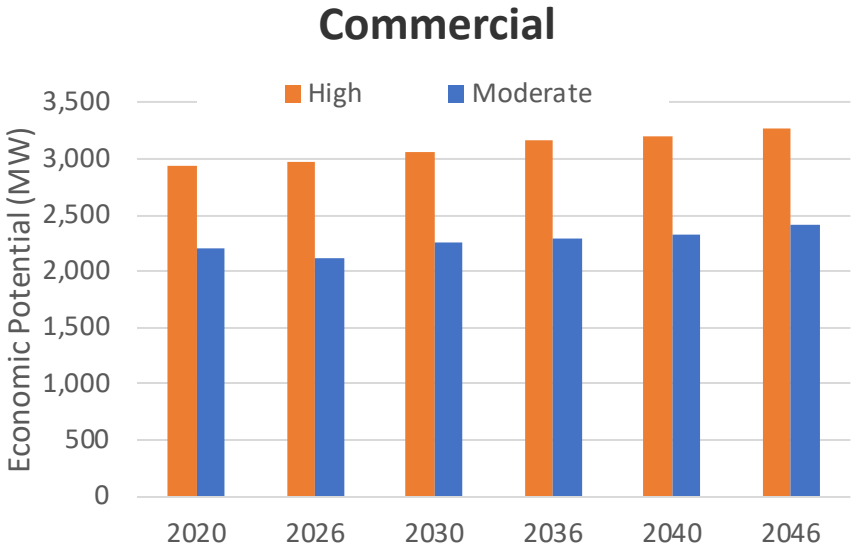
Rooftop Technical Potential Results

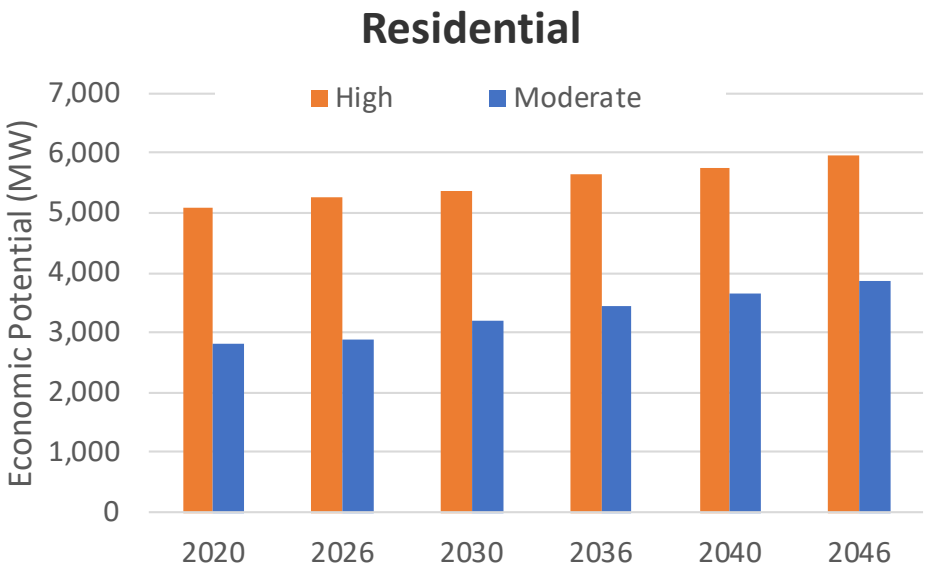
- Approximately **10.5 GW_{DC} of technical potential for rooftops** in LADWP
- Most is in the **residential sector**, followed by manufacturing and commercial
- Nearly half is in census tracts designated as **disadvantaged communities**

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

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

Initial Run: Economic Potential Results

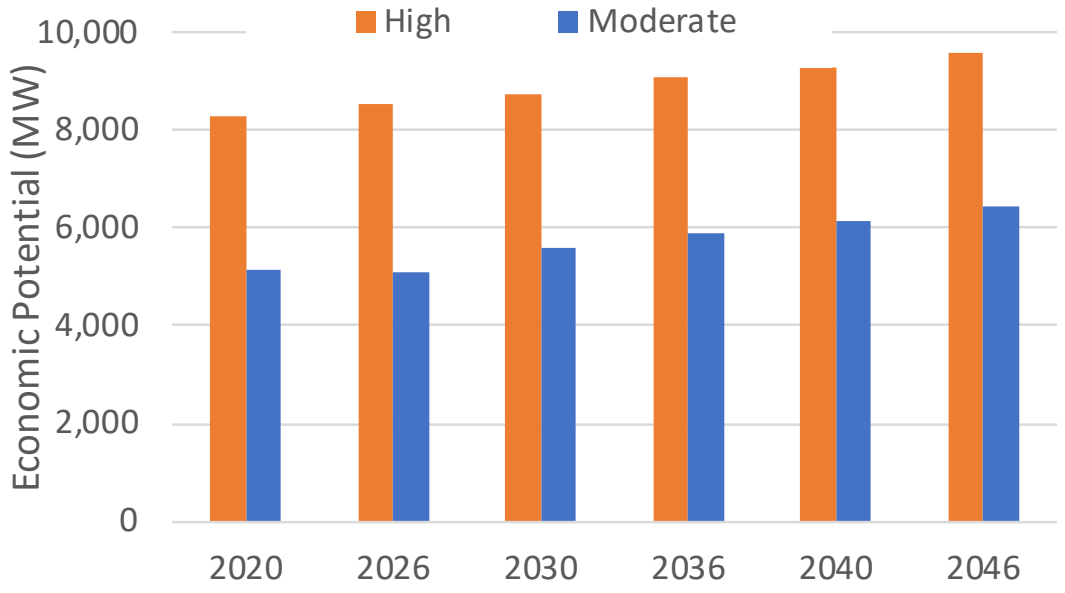




Based on discounted cash flow analysis that includes:

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

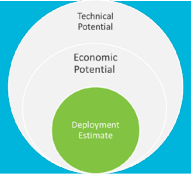
Initial Run: Total Economic Potential

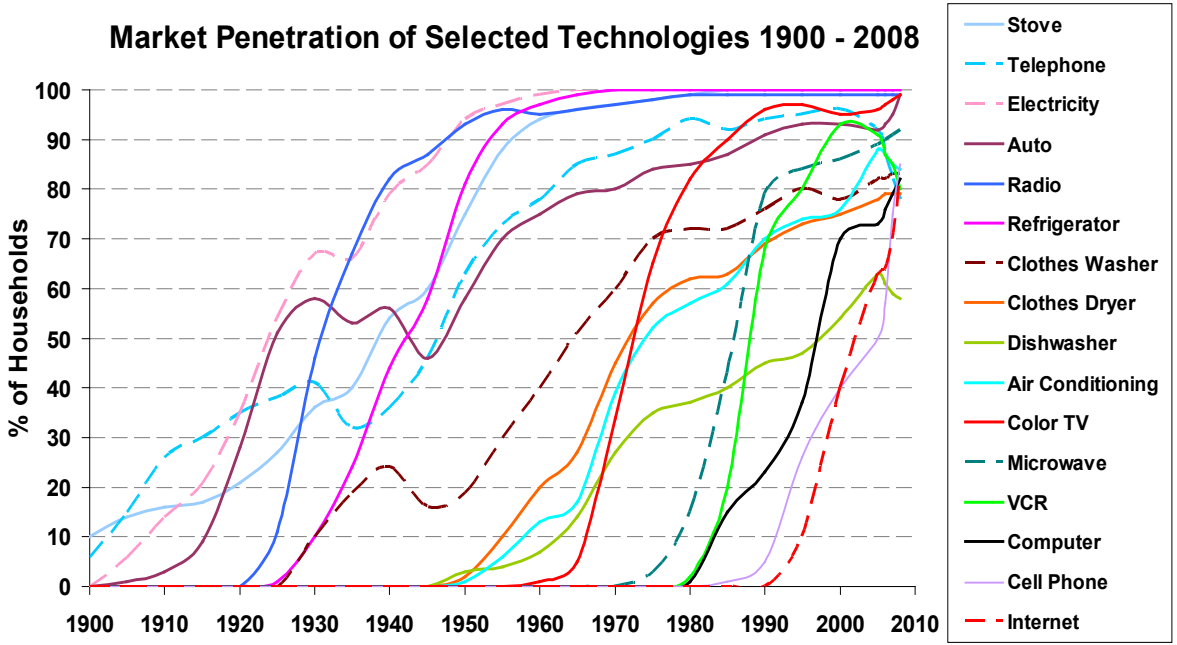


Economic potential **grows slightly** due to:

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

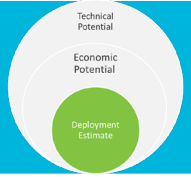
Where Are We on the Adoption Curve?

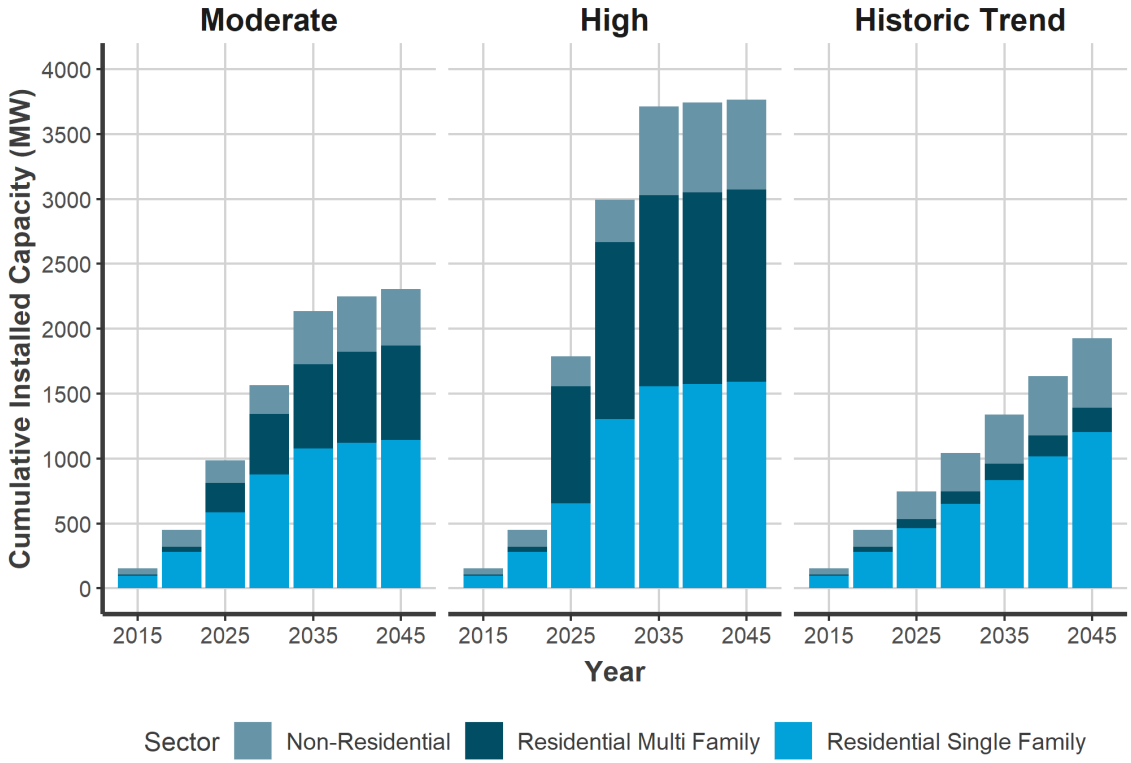




- Technology adoption shows characteristic S-curve driven by innovators & imitators
- Different technologies show unique adoption: 60% for dishwashers, 100% for refrigerators; different thresholds for when adoption 'takes off'
- No technology is a perfect analog

Initial Run: Rooftop Solar Deployment Estimates





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

Calibration of this part of the model still underway

Conversations about solar adoption on multi-family buildings are ongoing

Local Solar + Storage: Coming in March AG Presentation

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

Questions?