



The Los Angeles 100% Renewable Energy Study

Buildings Sector Bottom-up Load Modeling

Eric Wilson

Advisory Group Meeting, June 13, 2019



Session Goals



1. Become familiar with methodology for buildings sector load modeling



2. Review buildings electrification and efficiency load projections



3. Review sample results

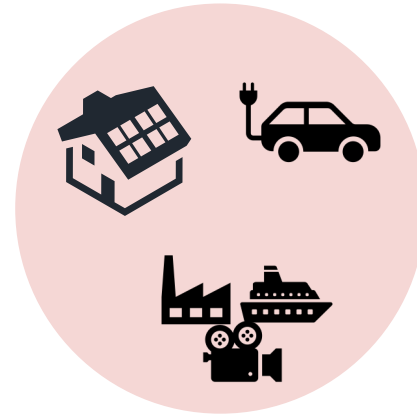
Definition of Buildings Sector Load

For today's presentation:



Included

- Residential buildings
- Commercial buildings

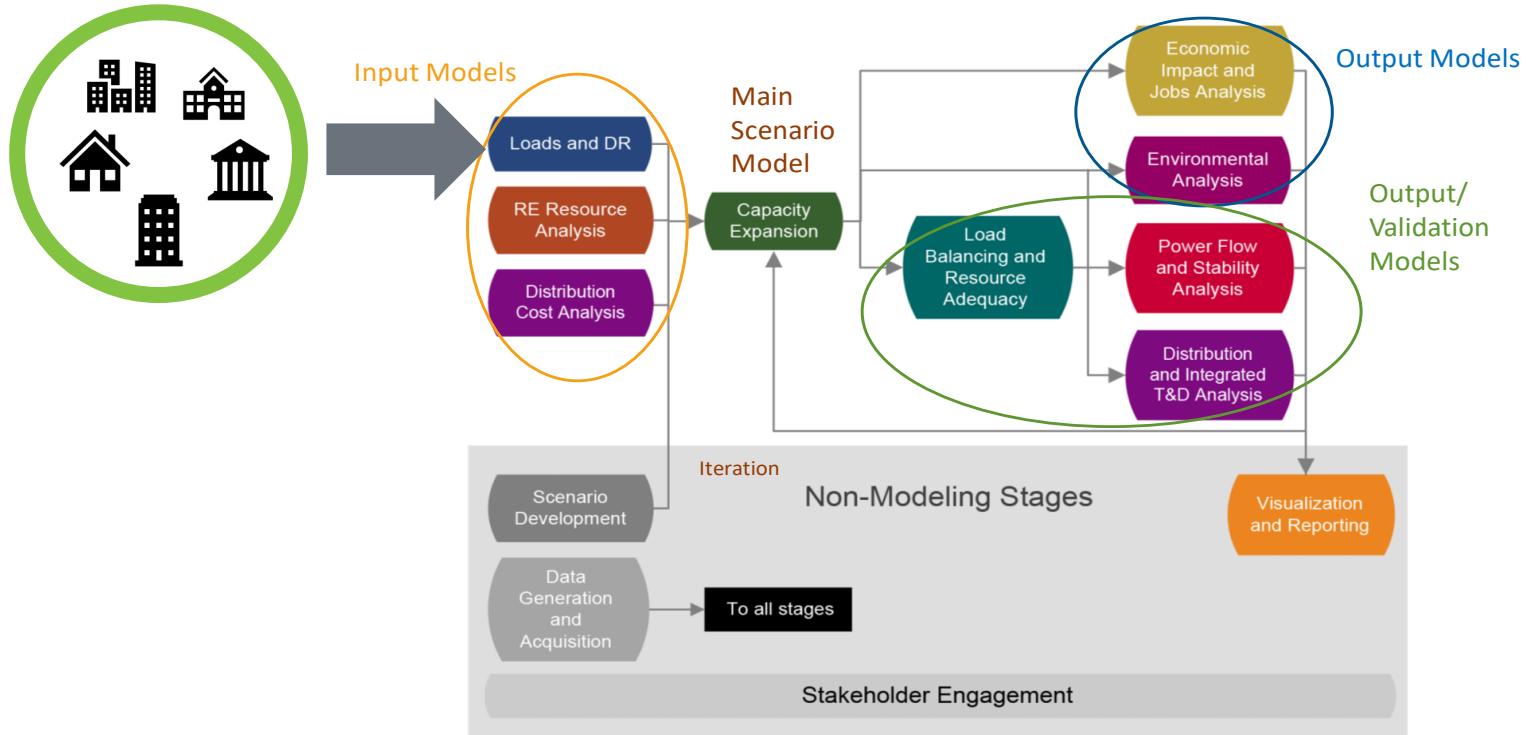


Not included

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

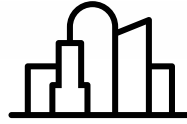
Context: How does load modeling fit in?

Buildings load impacts all downstream models

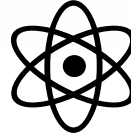


Building Stock Simulation





Building stock
characteristics
database

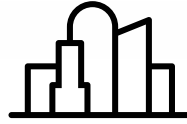


Physics-based
computer
modeling



High-performance
computing





Building stock characteristics database



Physics-based computer modeling



High-performance computing

Building Characteristics

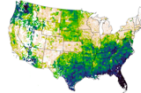


EIA
NAHB
IECC

Res/Com Energy Consumption Survey
Homebuilder Surveys
Historical Energy Codes

Other national, regional, and local audit databases

Census Data



Census

American Community Survey (ACS)

Costs



EIA
NREL
NREL/Navigant

Electricity and fuel costs
OpenEI.org Utility Rate Database
Measure Cost Database

Climate Locations



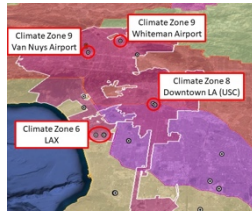
NREL

TMY3 weather data

Customization for Los Angeles



Los Angeles
Department of
Water & Power



Los Angeles City/County

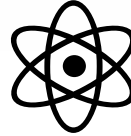
- Los Angeles Region Imagery Acquisition Consortium (LAR-IAC)
- LA County GIS Data Portal - various
- Los Angeles County Assessors Database
- LA DBS Existing Buildings Energy & Water Efficiency Program'
- Dodge Data and Analytics – Metropolitan Construction Insight

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



Building stock characteristics database



Physics-based computer modeling

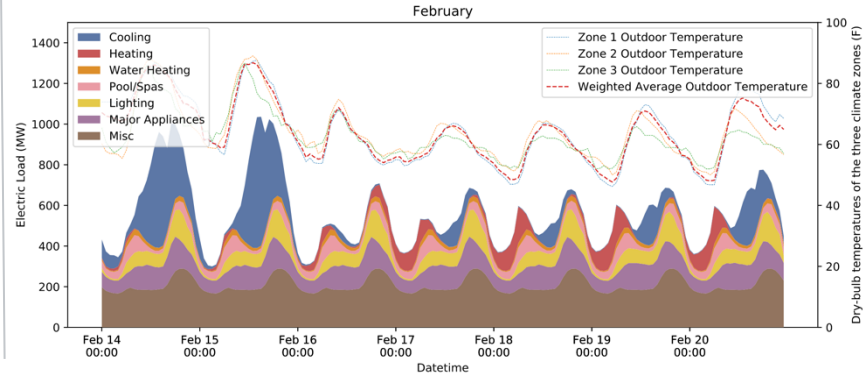


High-performance computing

U.S. DOE Tools



Detailed sub-hourly energy simulations





Building stock
characteristics
database



Physics-based
computer
modeling



High-performance
computing





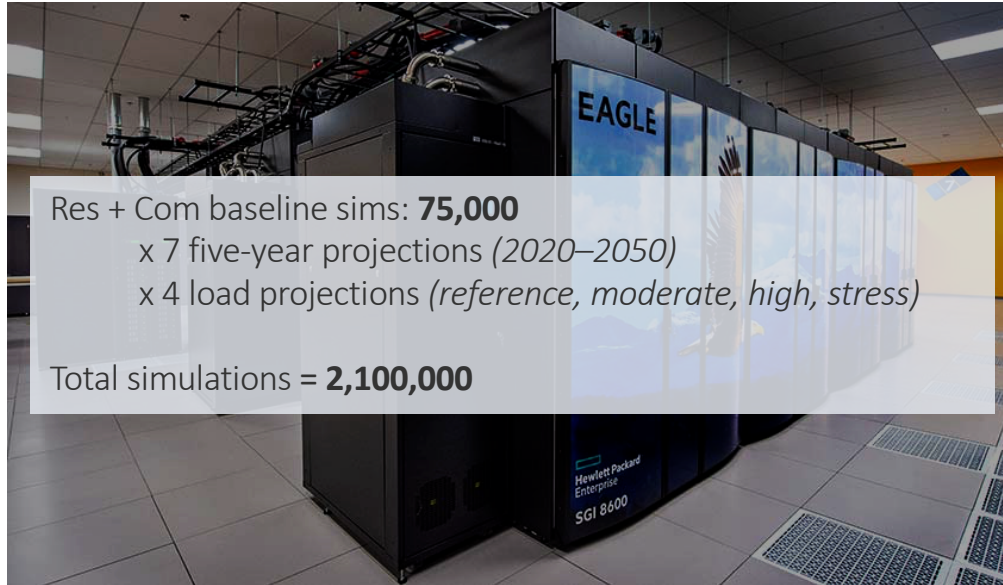
Building stock
characteristics
database



Physics-based
computer
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High-performance
computing



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**



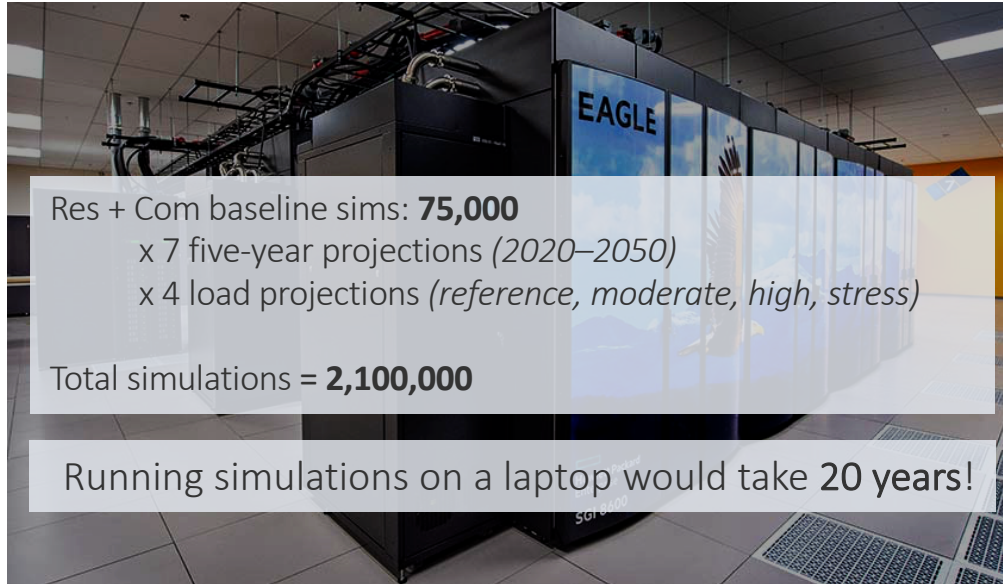
Building stock
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Physics-based
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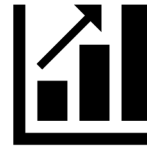


Res + Com baseline sims: **75,000**
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Total simulations = **2,100,000**

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

Buildings Sector Load Projections



Growth



Electrification



Efficiency

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 Modernization	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.

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	Electrification	Reference	High	Moderate	High	Moderate	High	High	Moderate
		R	H	M	H	M	S	H	M

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

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- **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)
High²	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



Buildings Sector Load Projections

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Stress	Electrification	High electrification	
	Efficiency	Reference efficiency	

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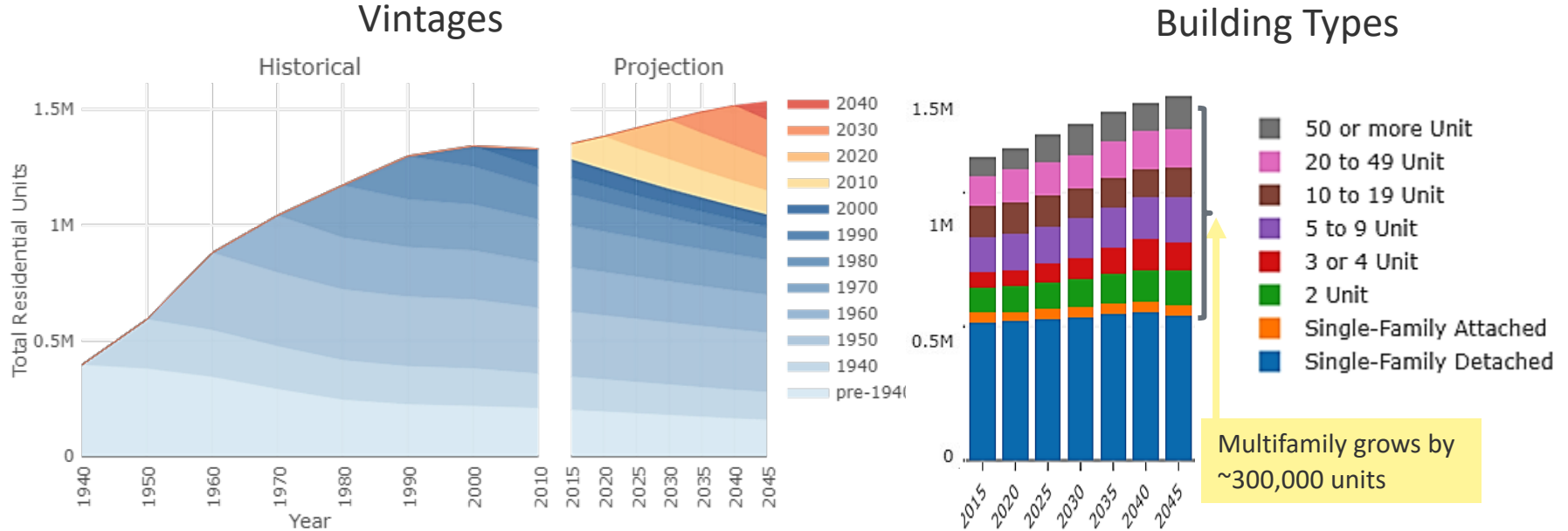
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Building Stock Growth Projections



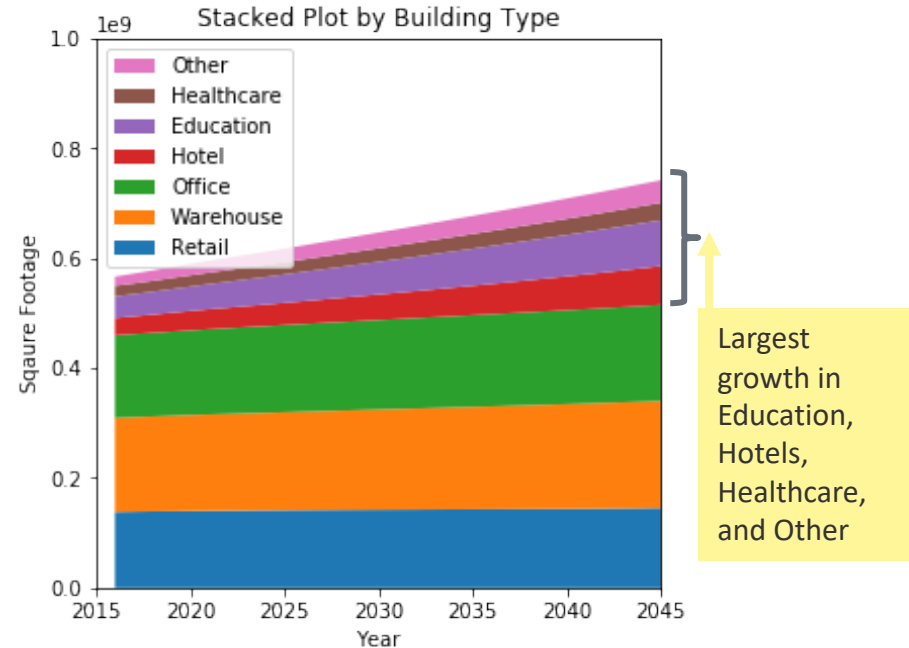
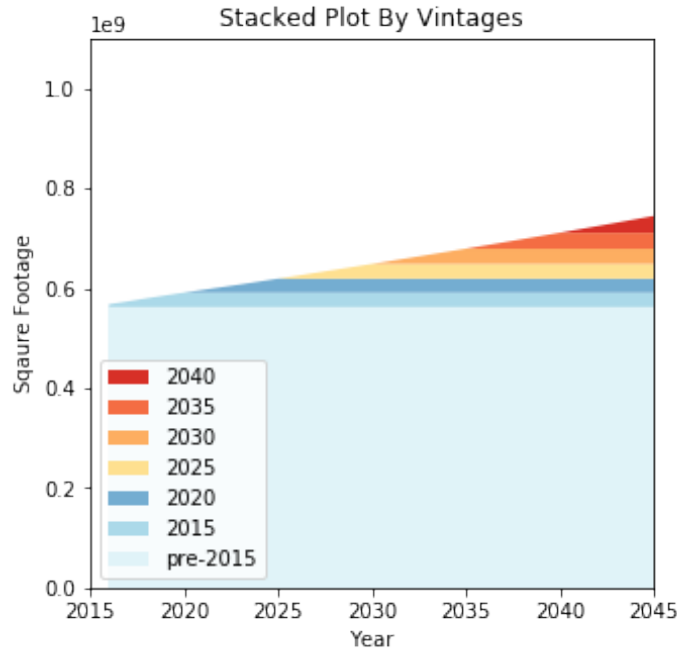
Residential Building Stock Growth Projections

- 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



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?



Which end uses are most important for buildings electrification?

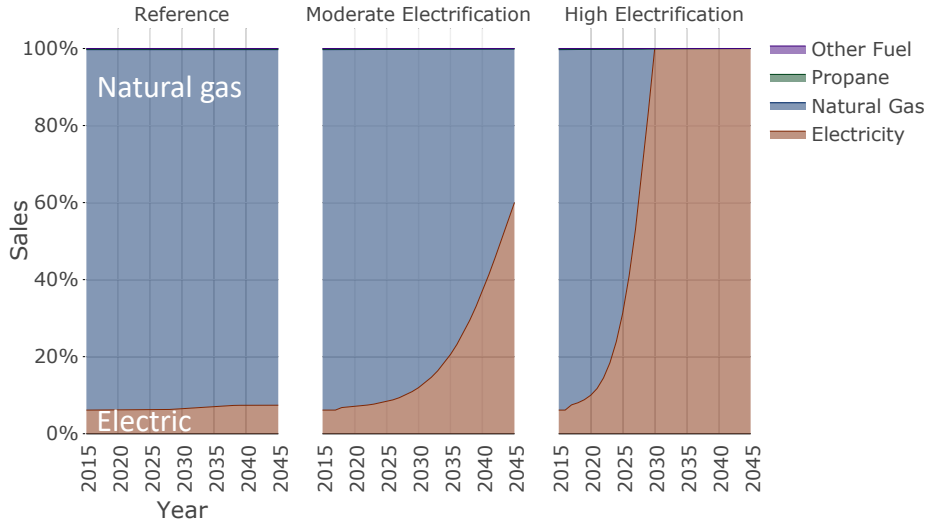


Residential Water Heaters

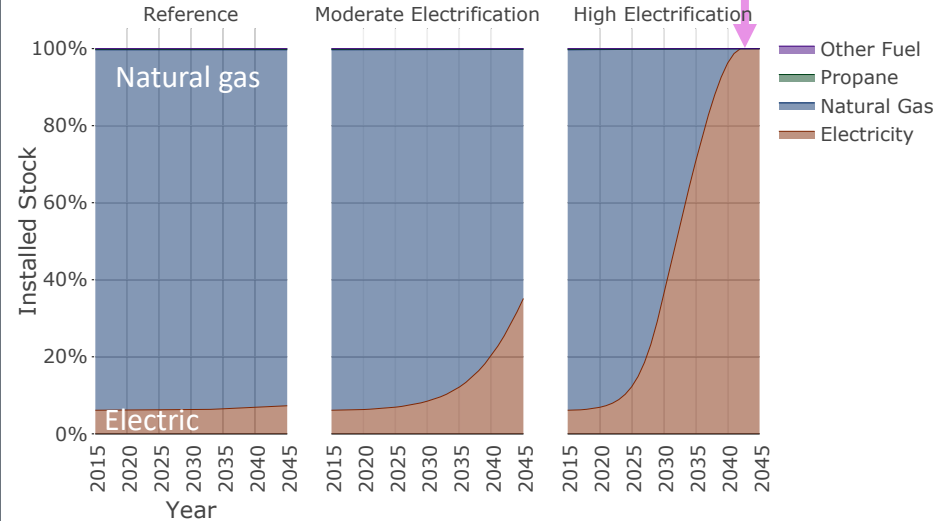
100% electric water heating by 2030



Equipment Sales



Installed Stock

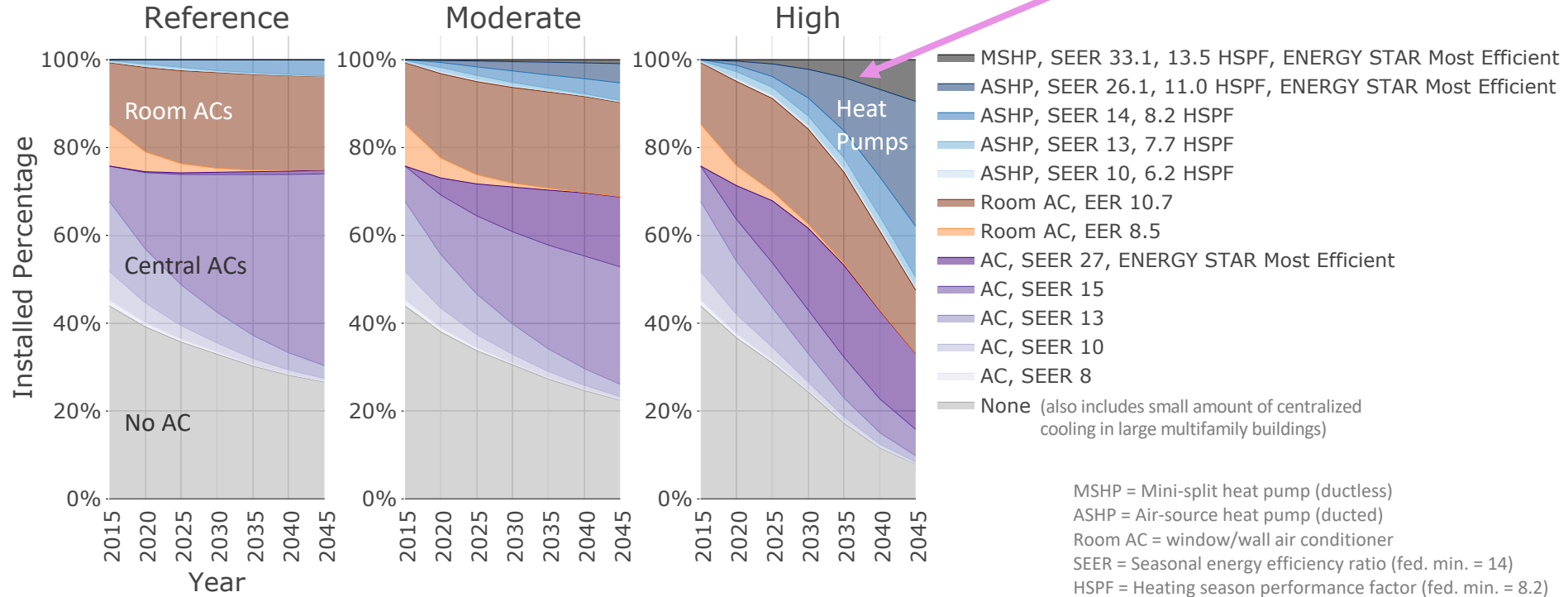


Efficiency Adoption Projections



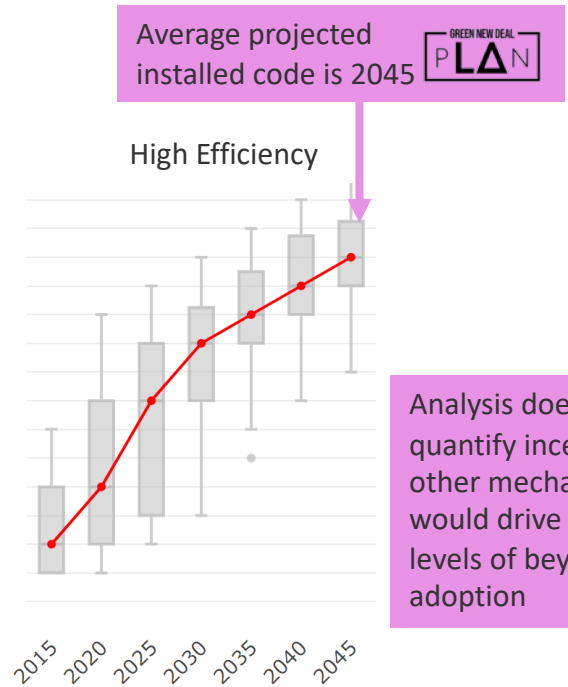
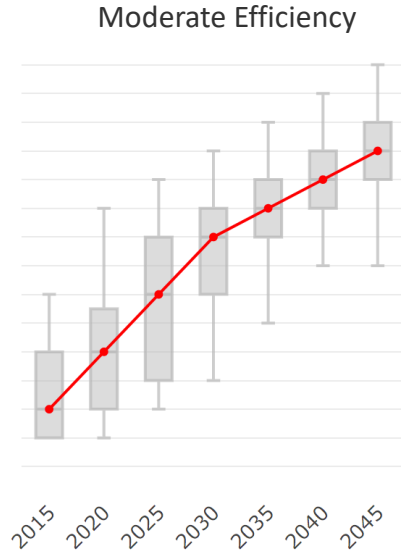
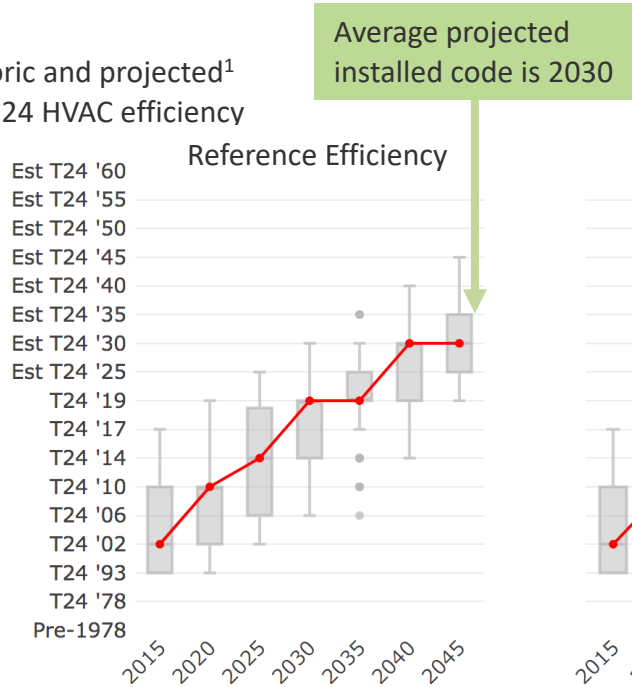
Residential Air Conditioning

Large increase in fraction of homes with heat pumps



Commercial HVAC Efficiency

Historic and projected¹
Title 24 HVAC efficiency



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:

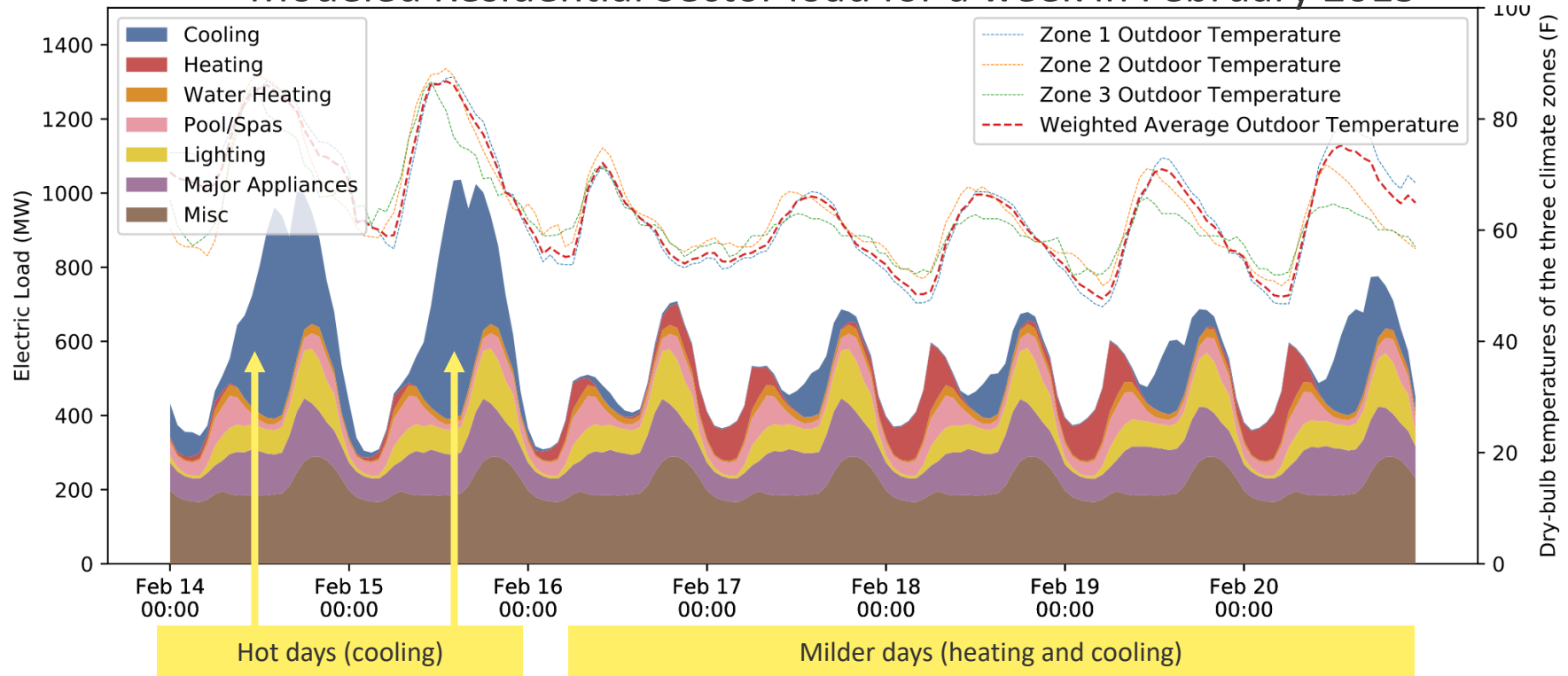
- Validation/calibration
- Final Run “High” projection updated to reflect pLAN
- Final Run modeling

In progress:

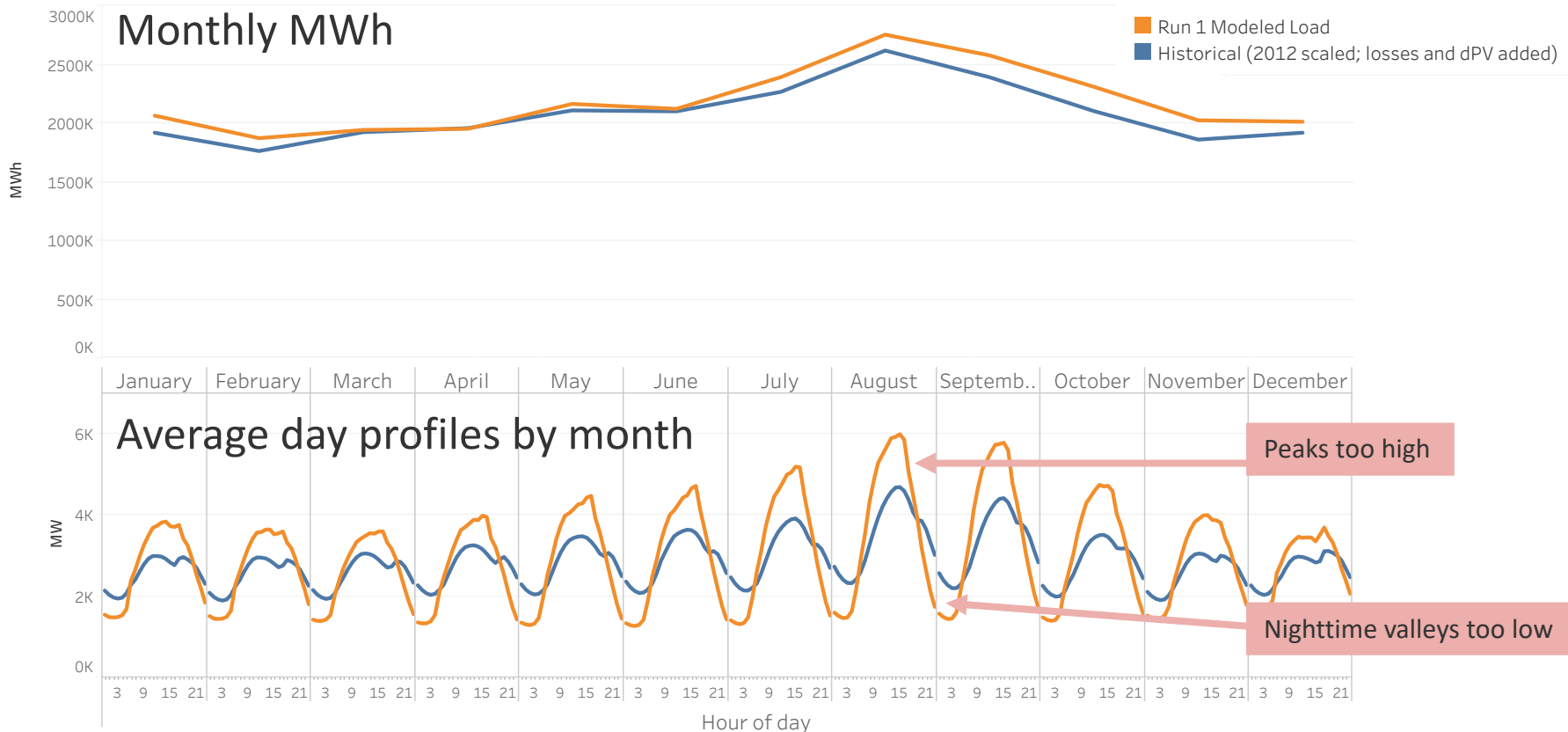
- Processing and interpreting Final Run results

What do results look like?

Modeled Residential Sector load for a week in February 2015



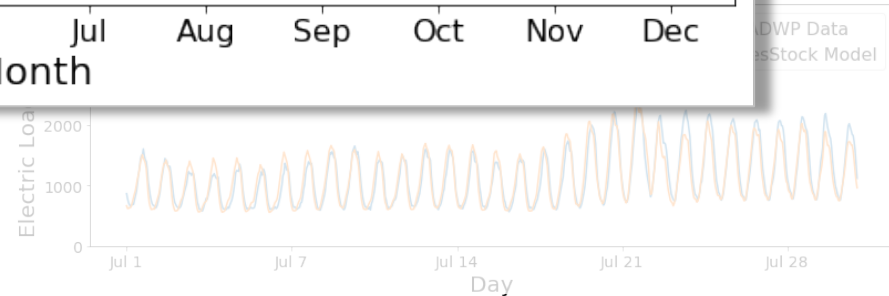
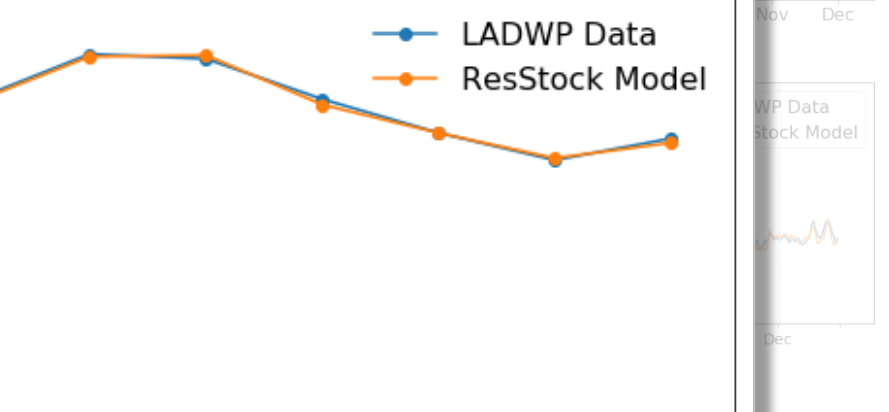
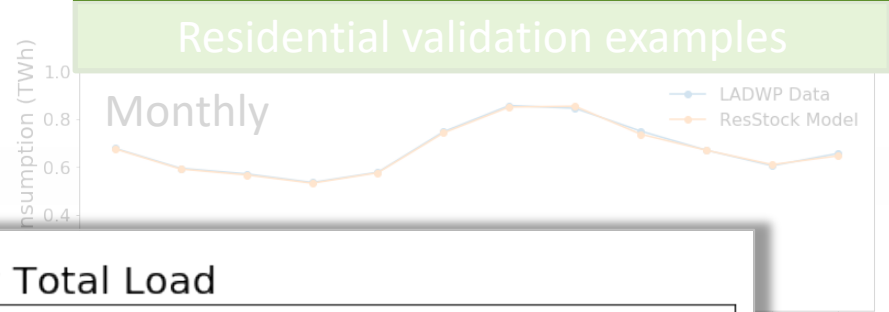
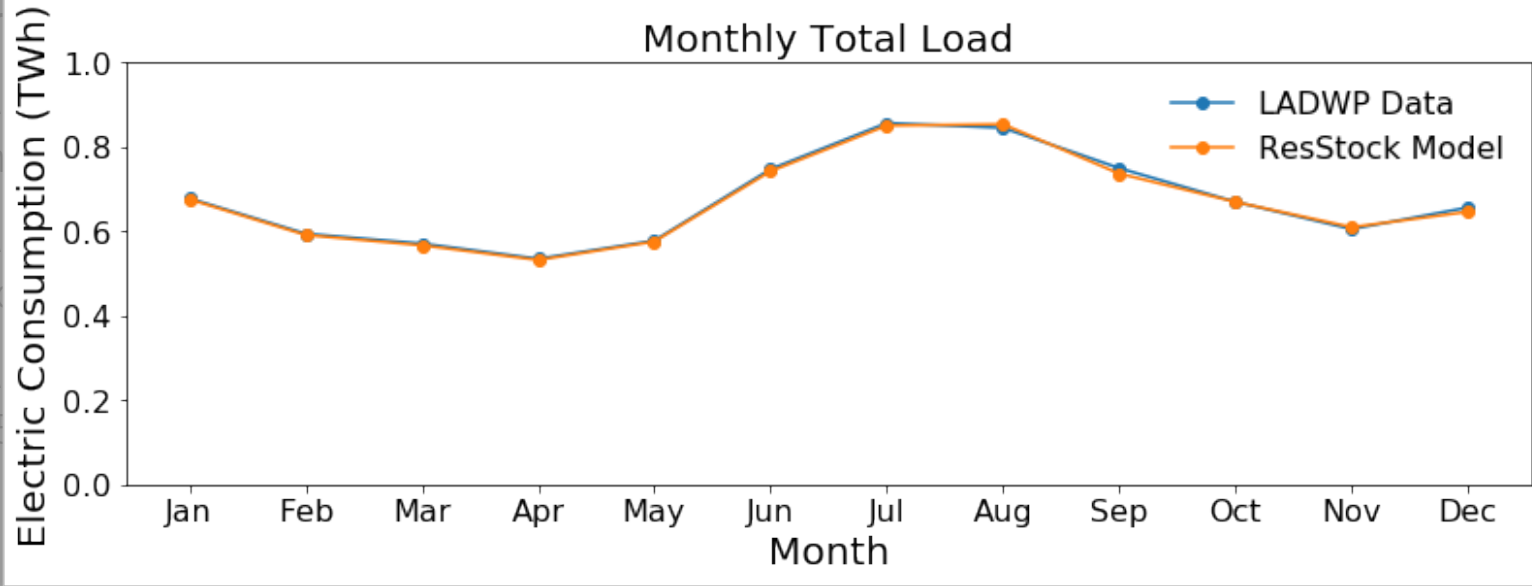
What have we learned? Initial Run Results vs. Reality



Calibration and Validation

Calibration

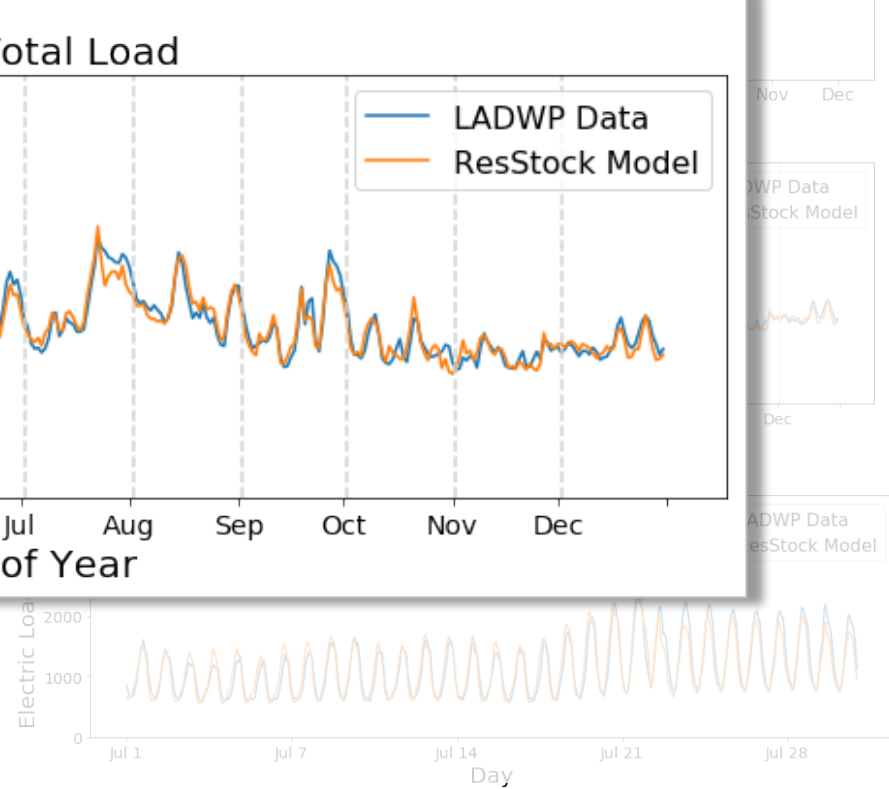
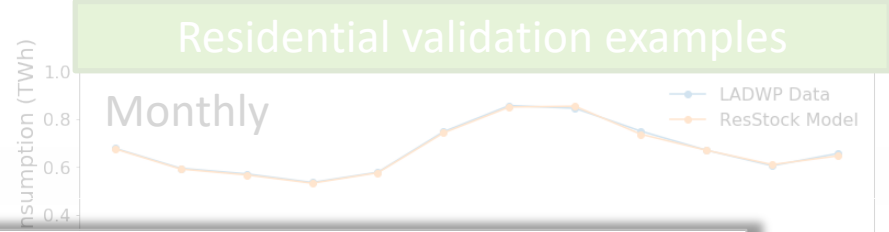
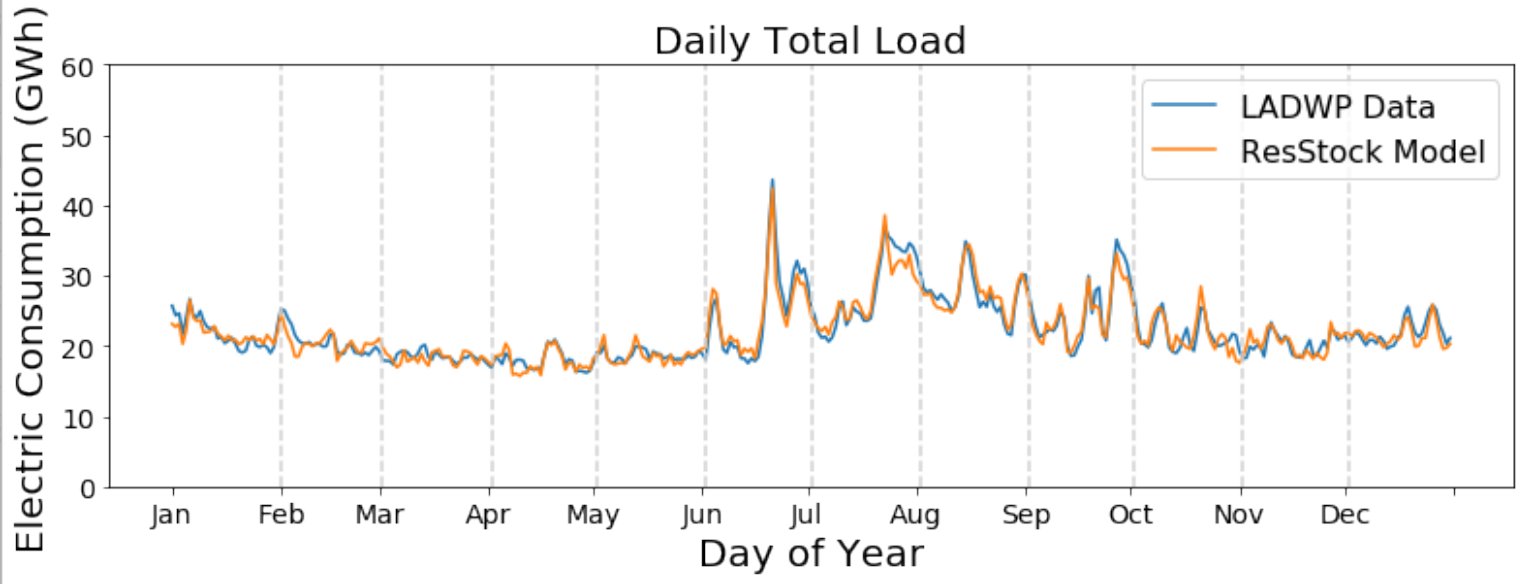
- LA (m)
- LA (h)
- LA (15)



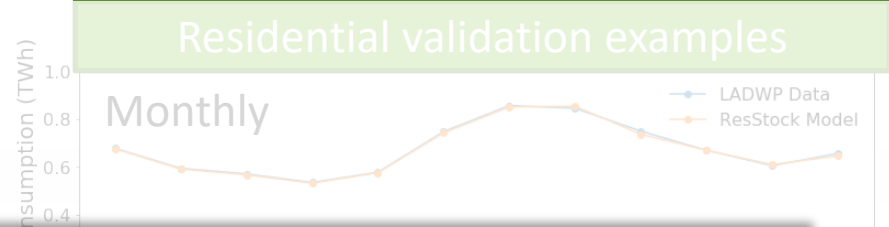
Calibration and Validation

Calibration

- LA100 (m)
- LA100 (h)
- LA100 (15)

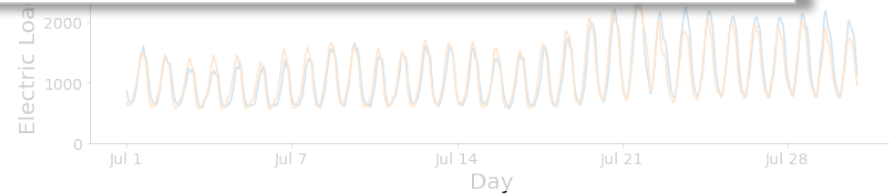
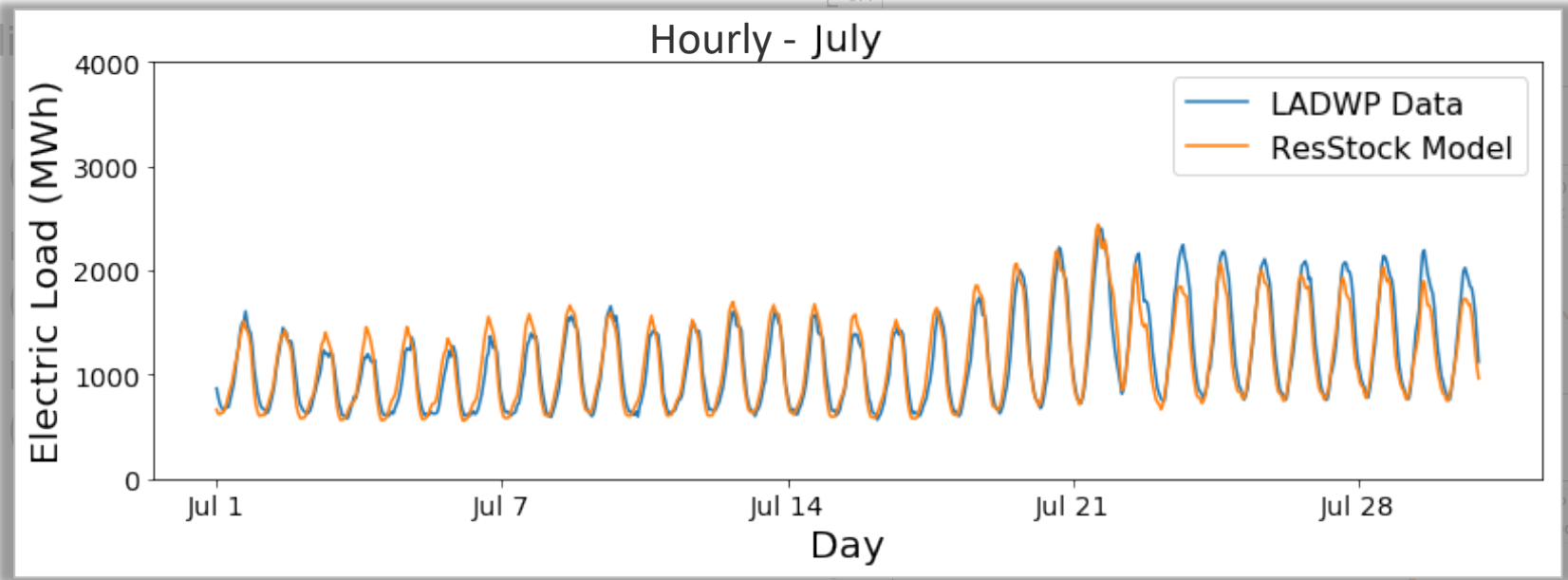


Calibration and Validation



Cali

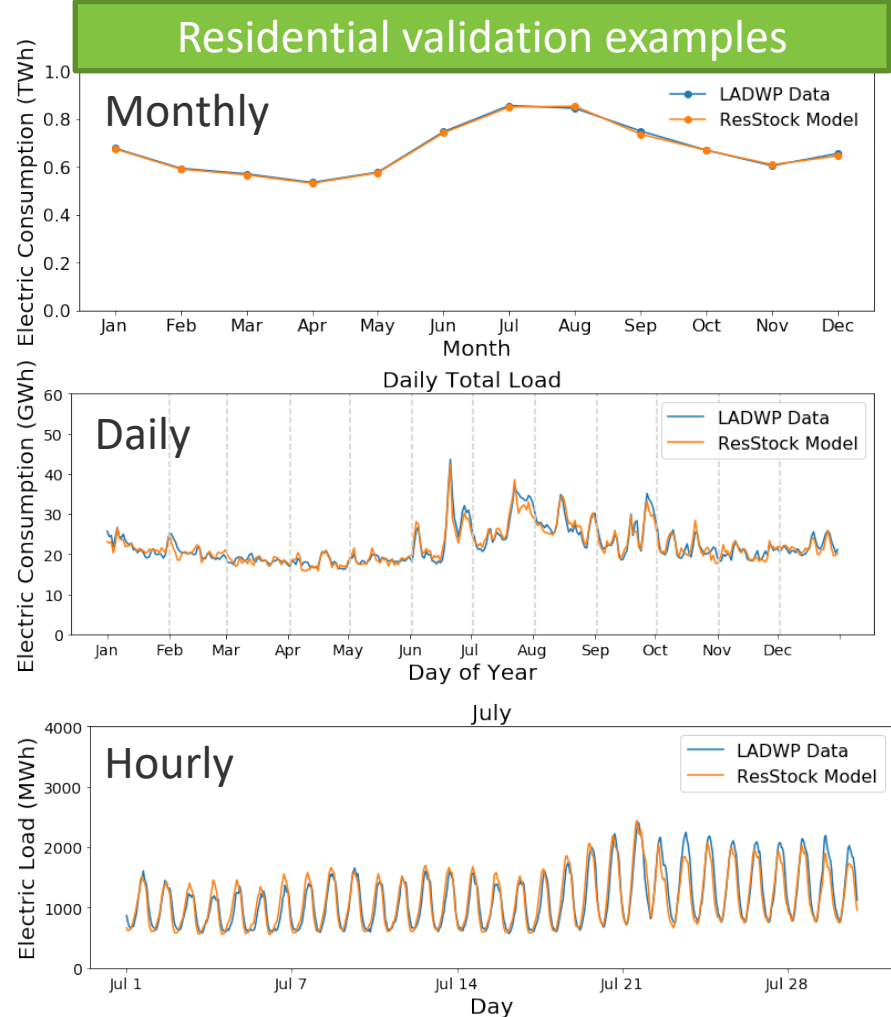
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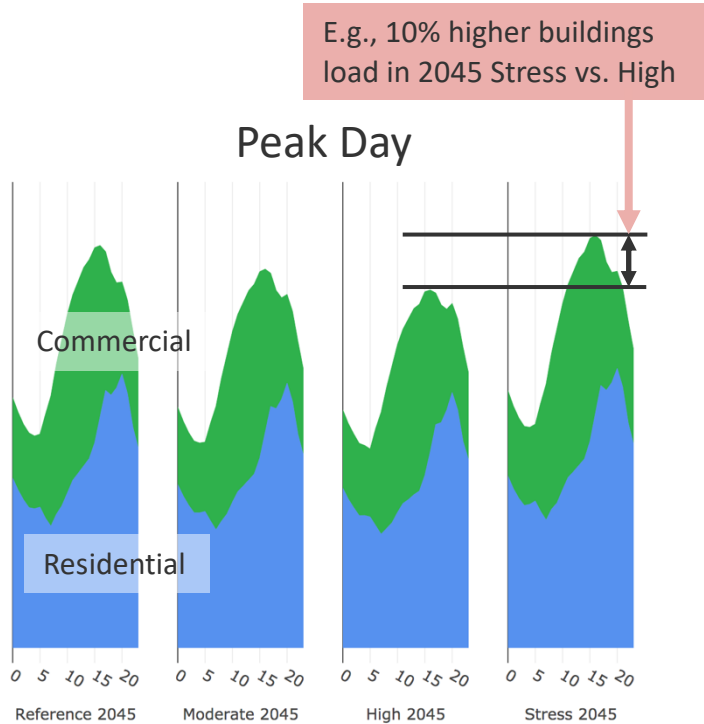
Calibration and Validation

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)

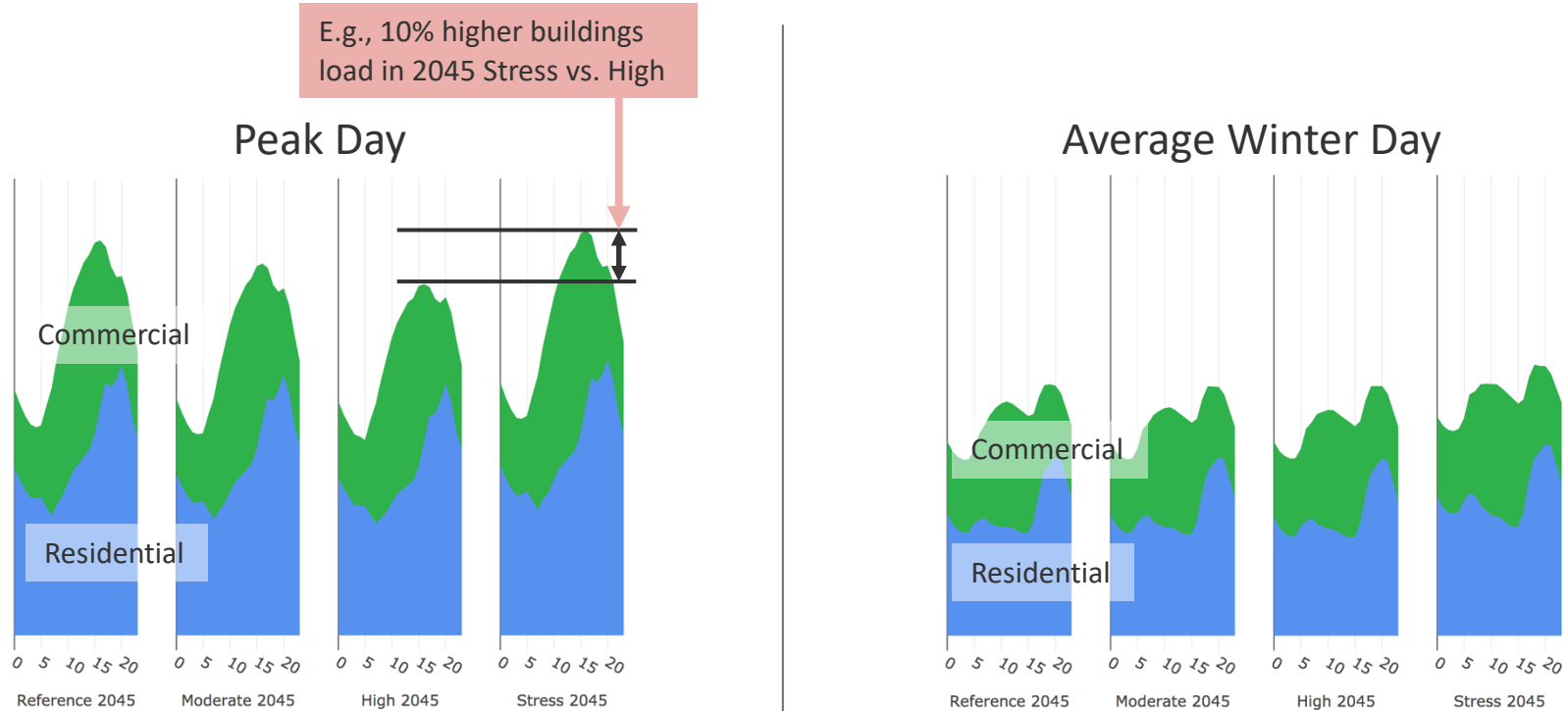


Initial Run Snapshot: Peak Day, Average Winter Day Profiles



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

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

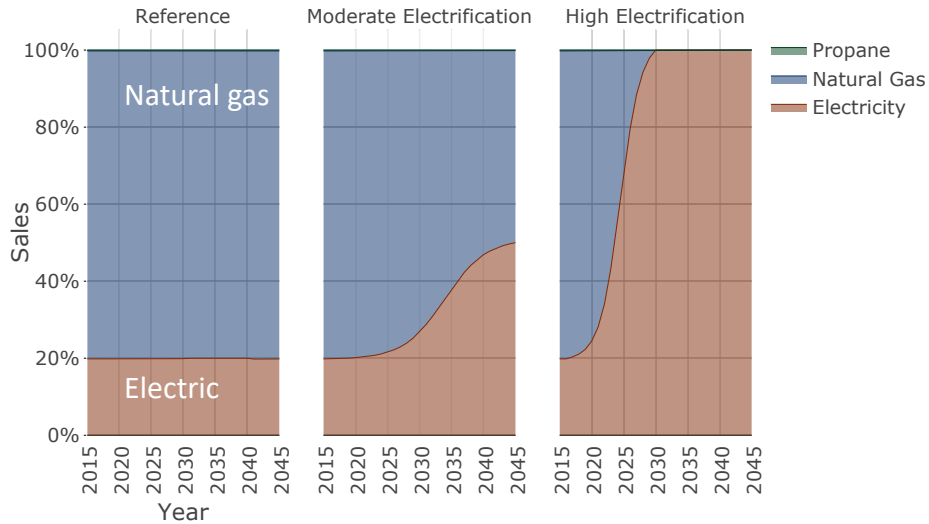
Q&A



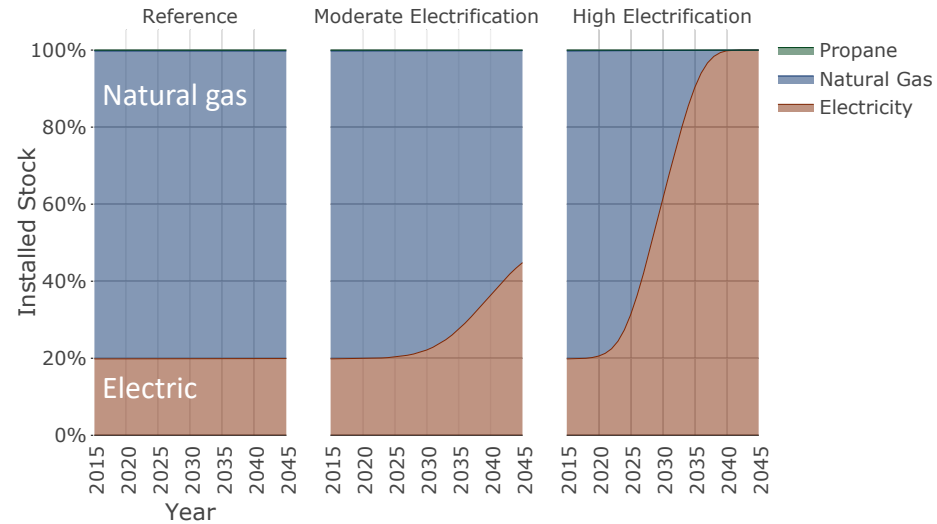
The Los Angeles 100% Renewable Energy Study

Residential Cooking Ranges

Sales

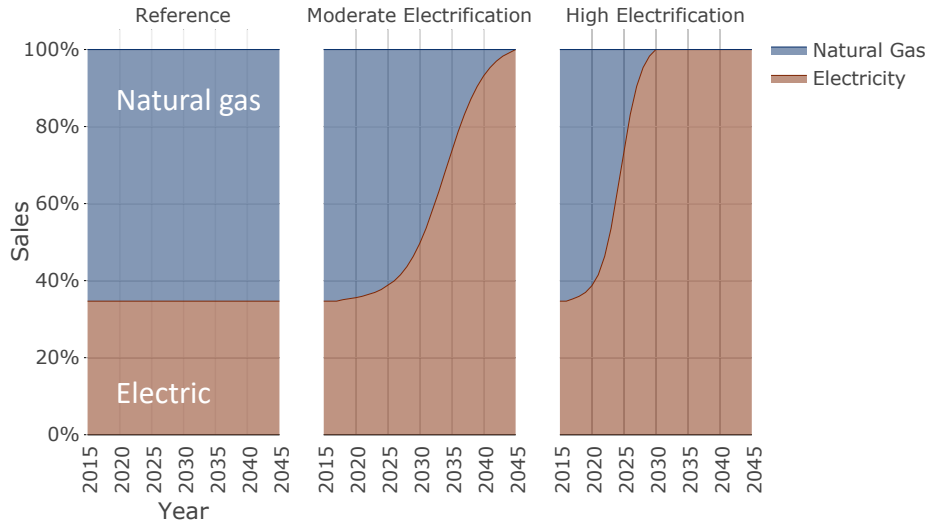


Installed Stock

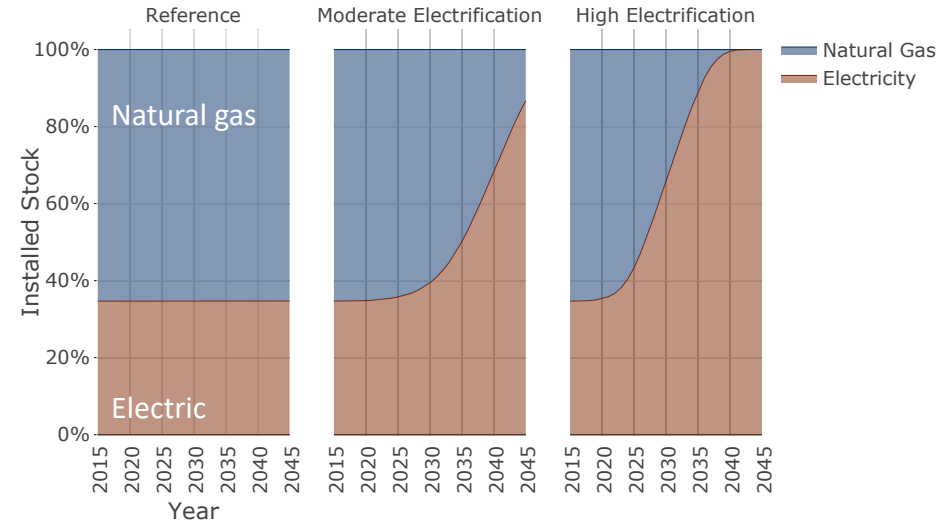


Residential Clothes Dryers

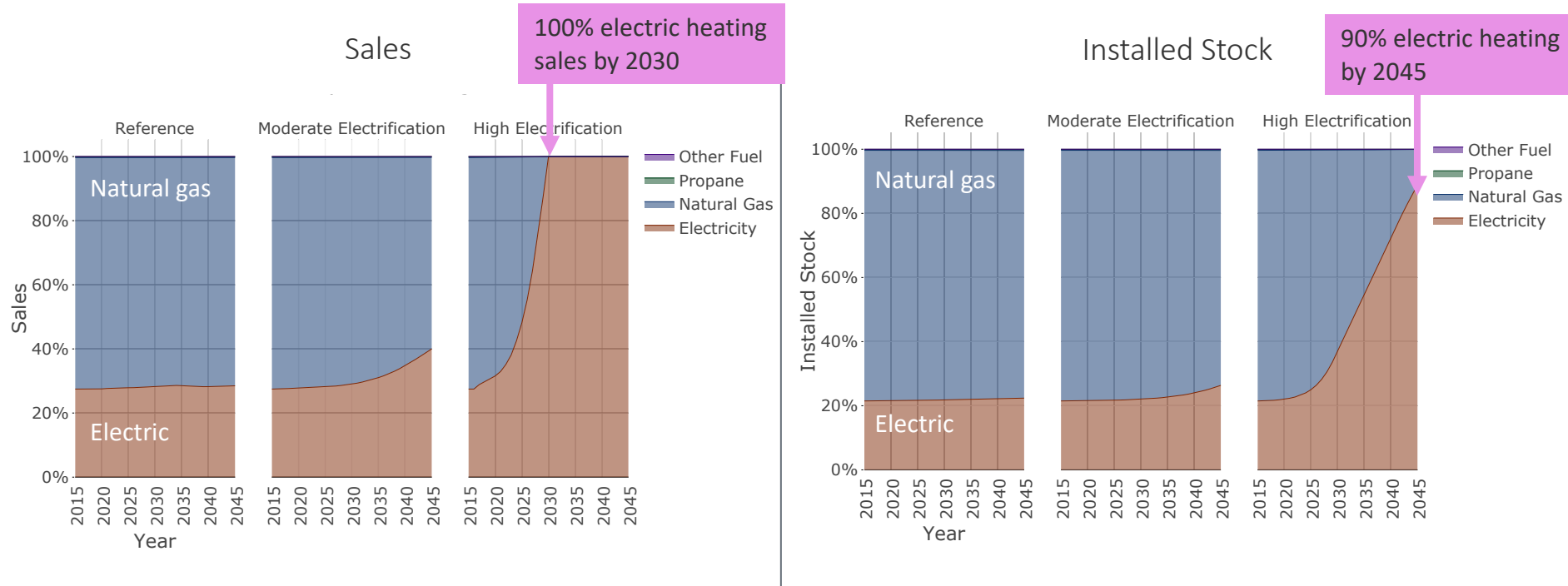
Sales



Installed Stock

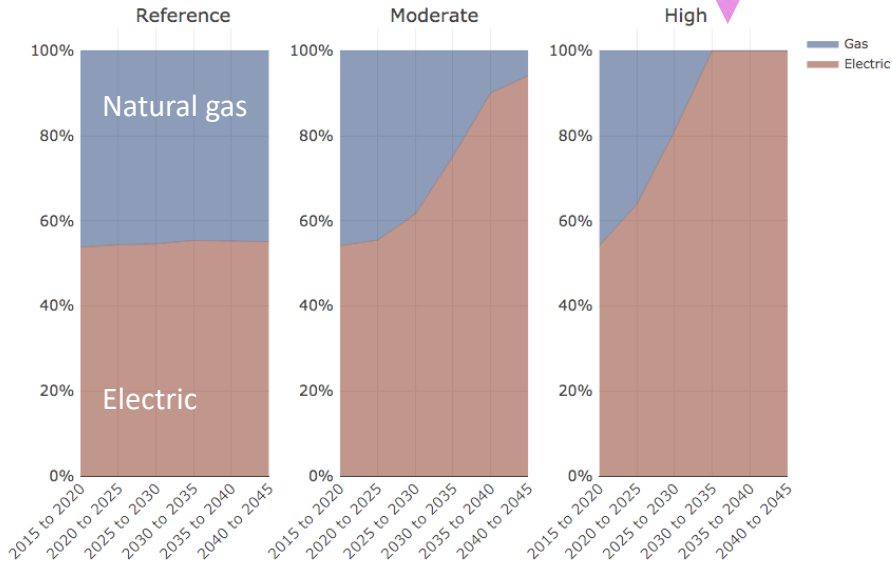


Residential Space Heating



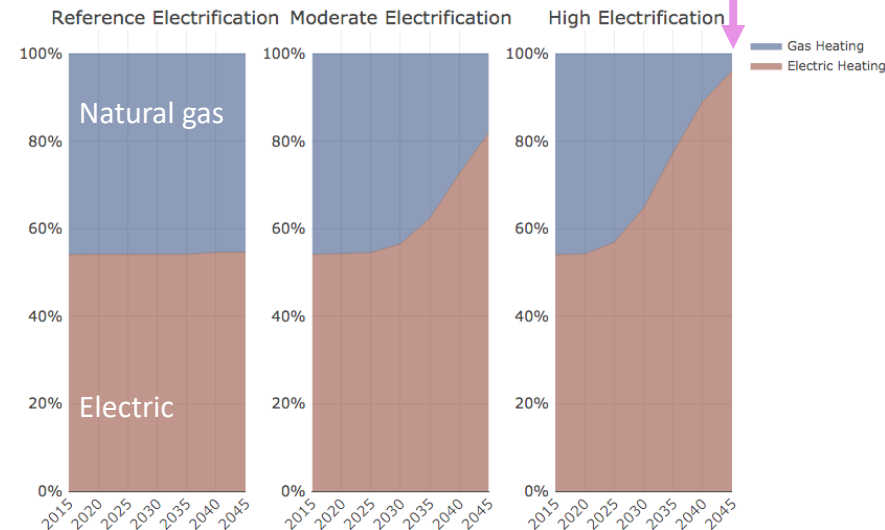
Commercial HVAC

Sales Fraction



100% electric heating sales by 2030

Installed Fraction

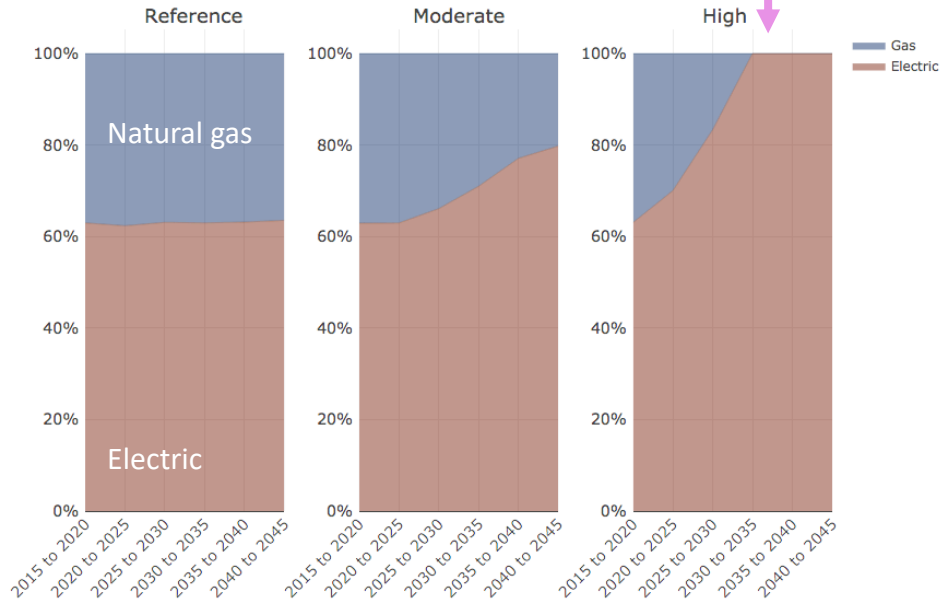


90% electric heating by 2045

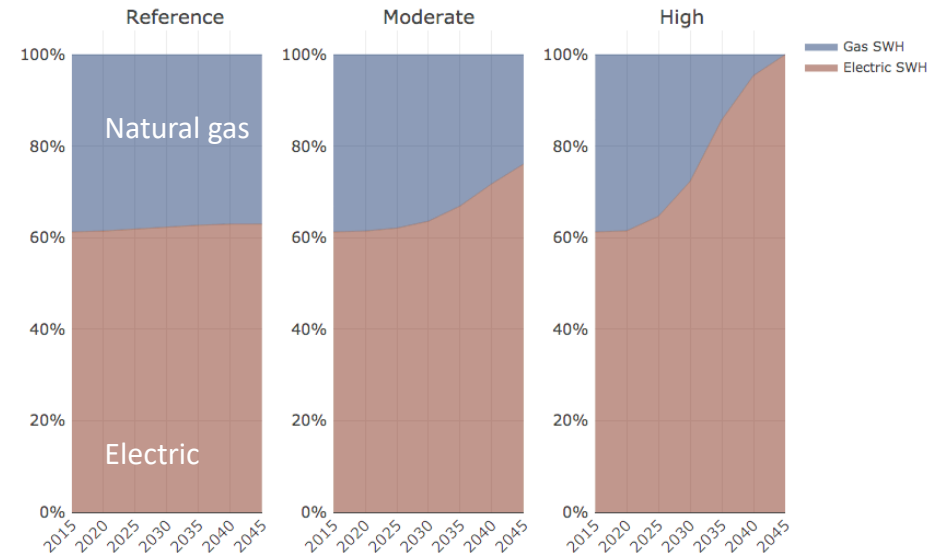
Commercial Water Heaters

Sales Fraction

100% electric water heating sales by 2030

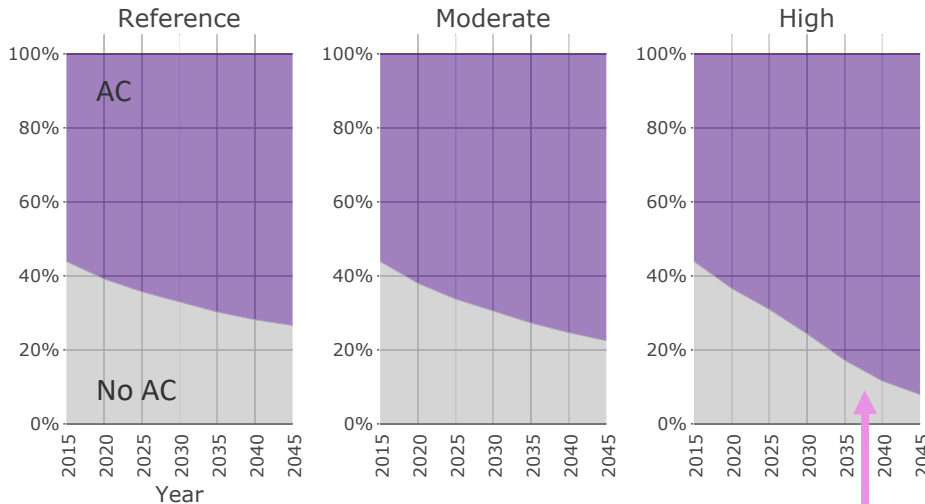


Installed Fraction

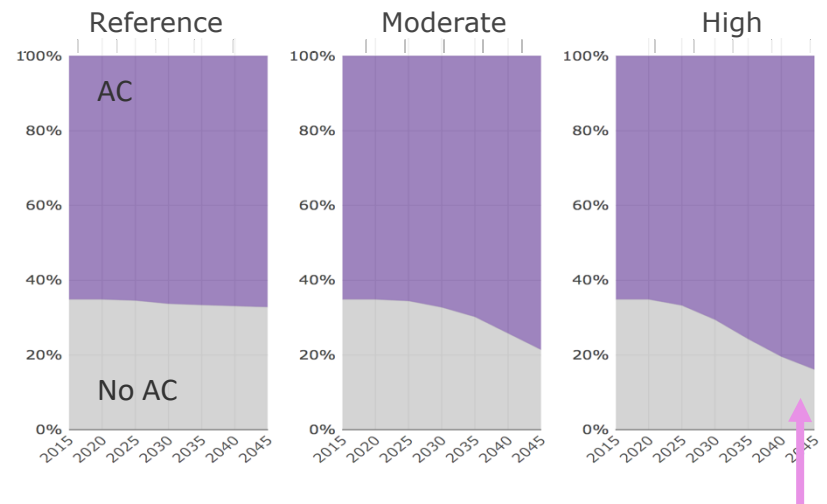


Growth in air conditioning

Installed Fraction Residential

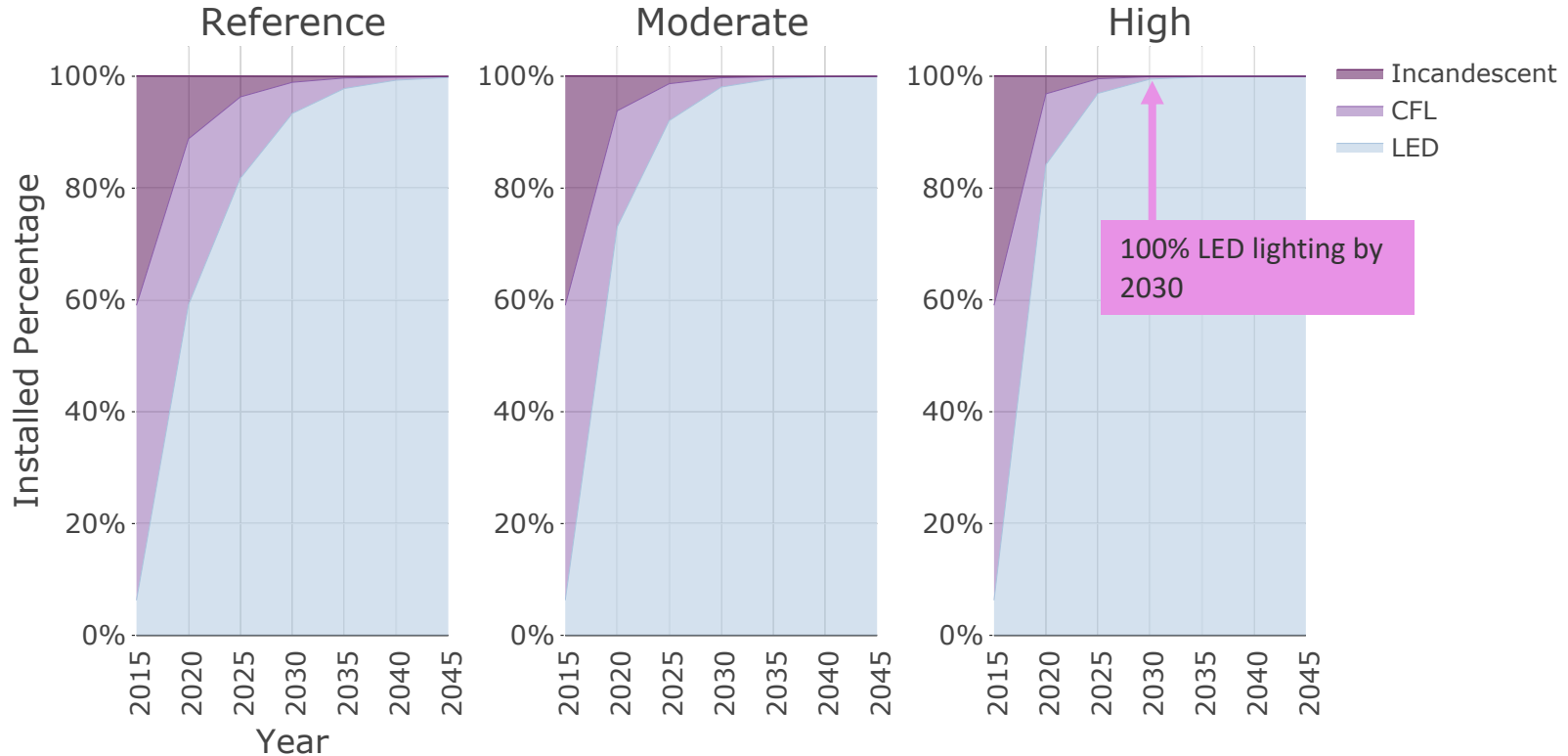


Installed Fraction Commercial

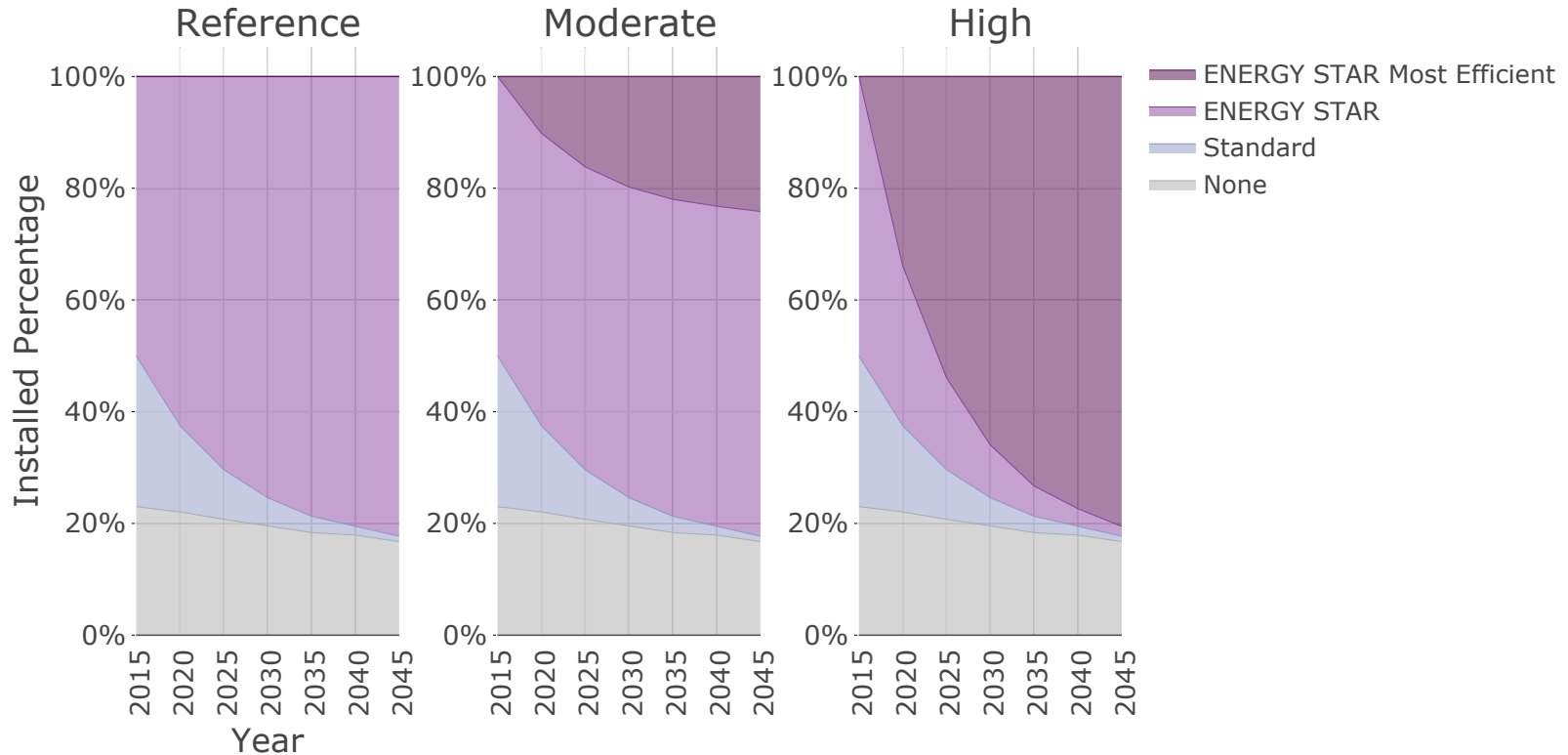


More buildings have AC in High projection because of heat pumps

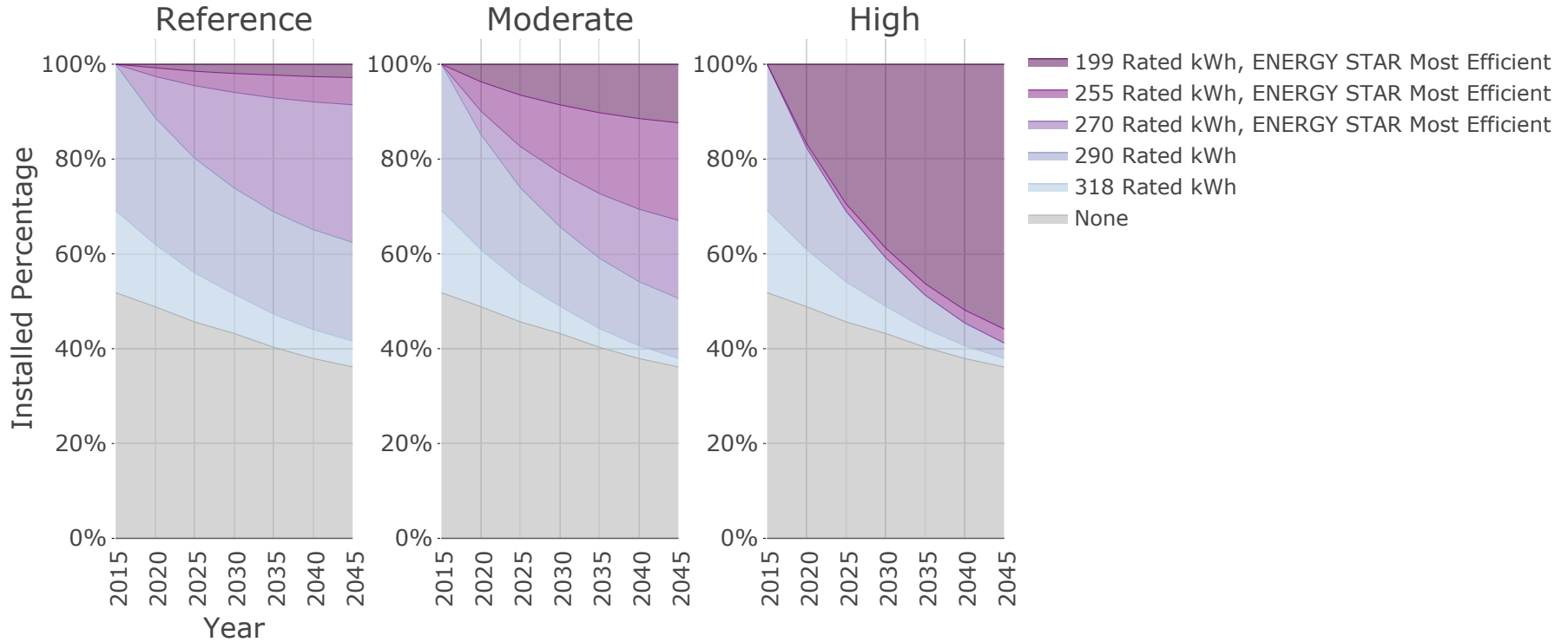
Residential Lighting



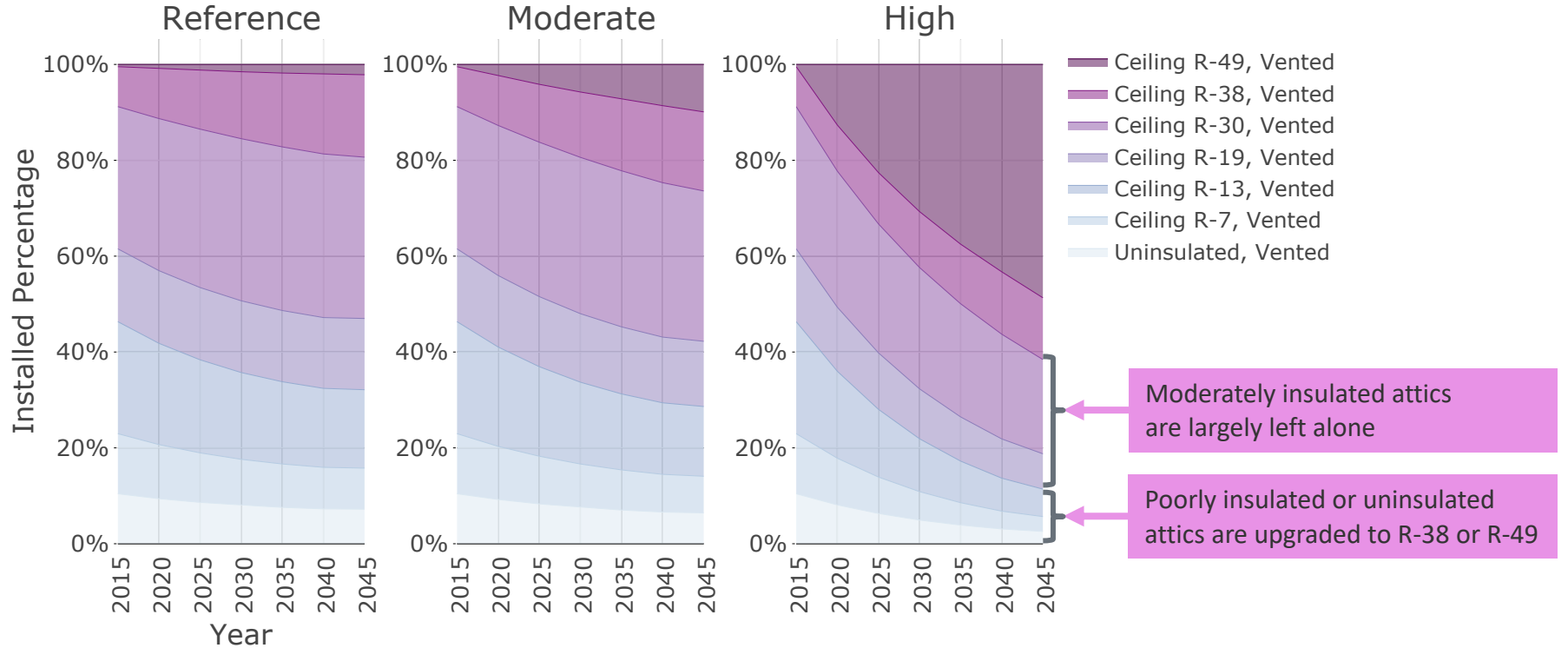
Residential Clothes Washers



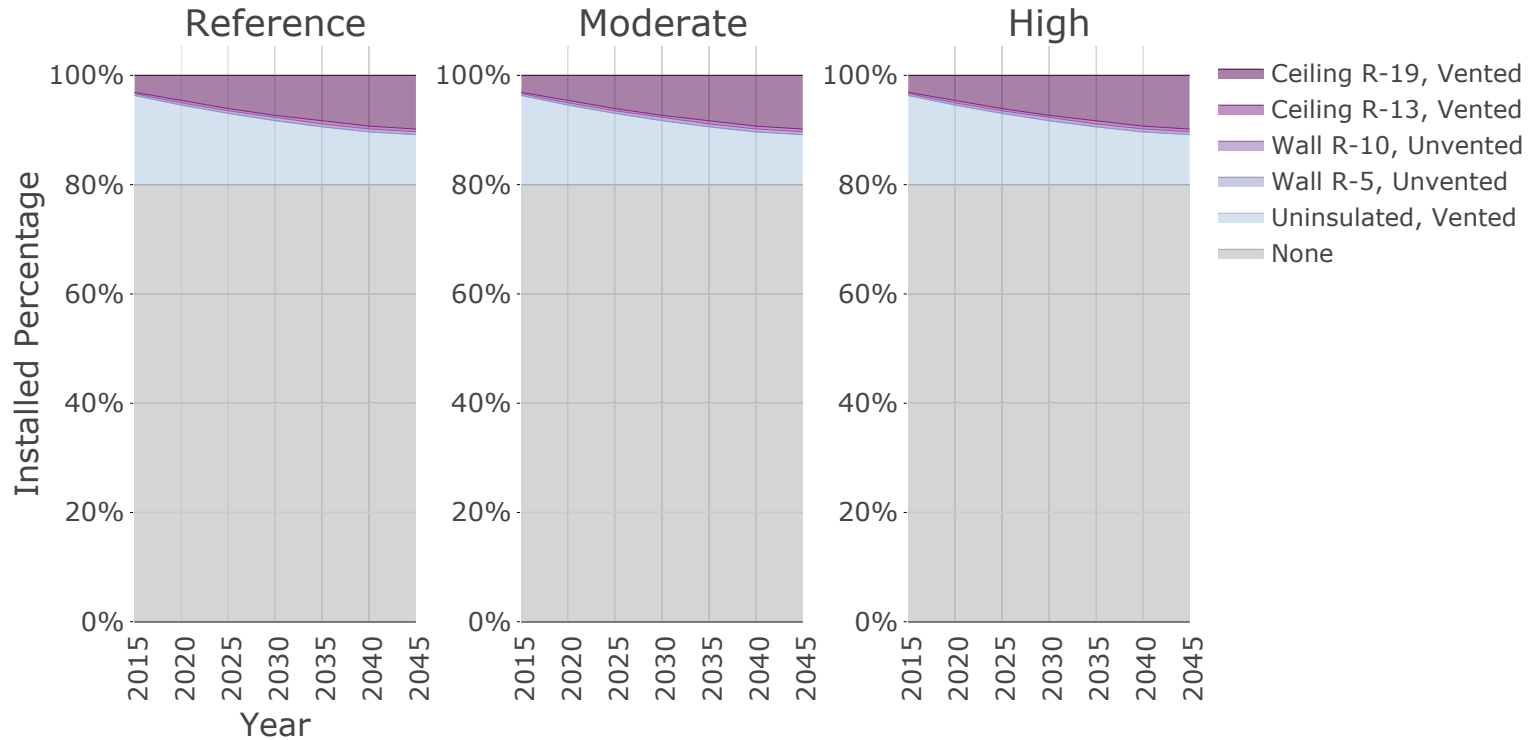
Residential Dishwashers



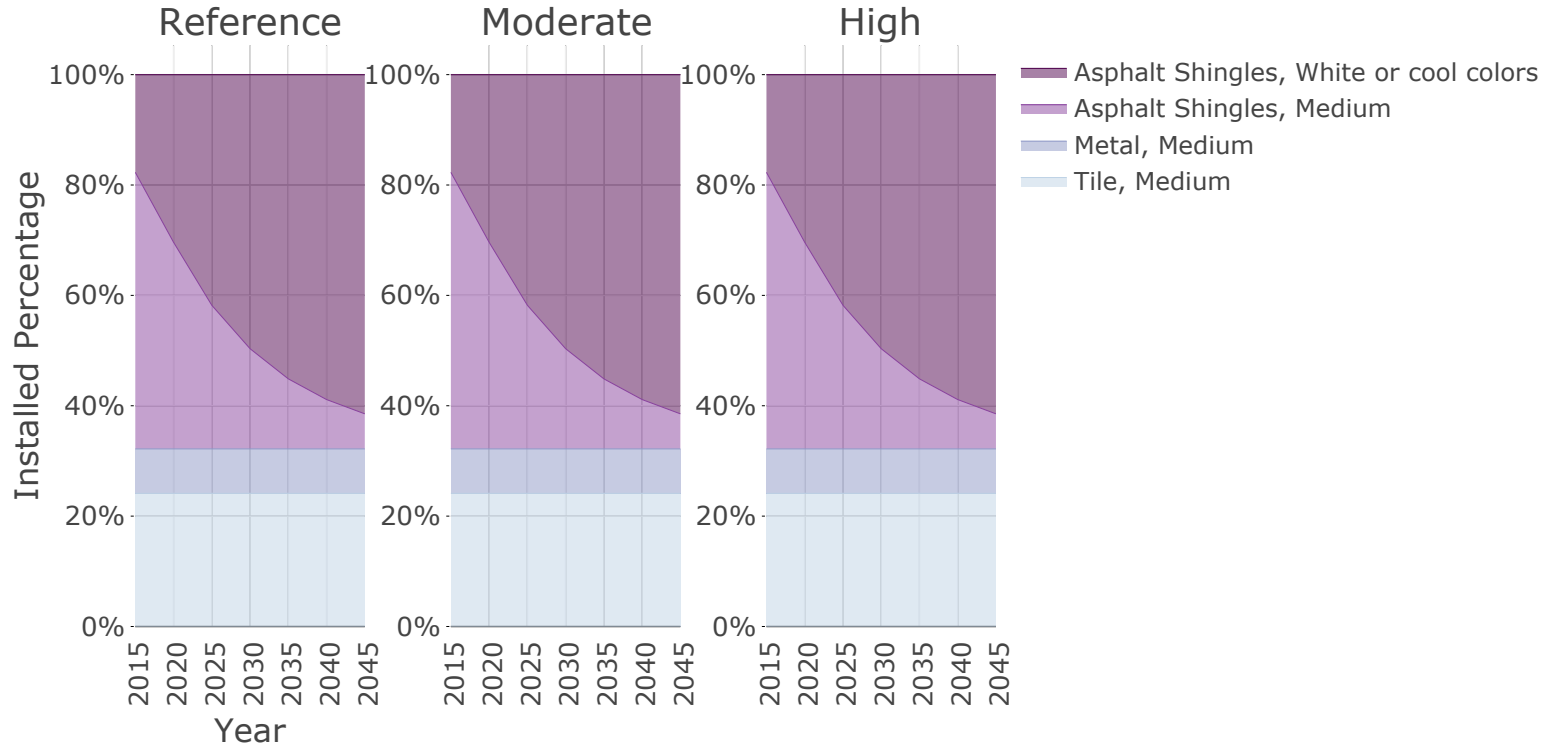
Residential Attic Insulation



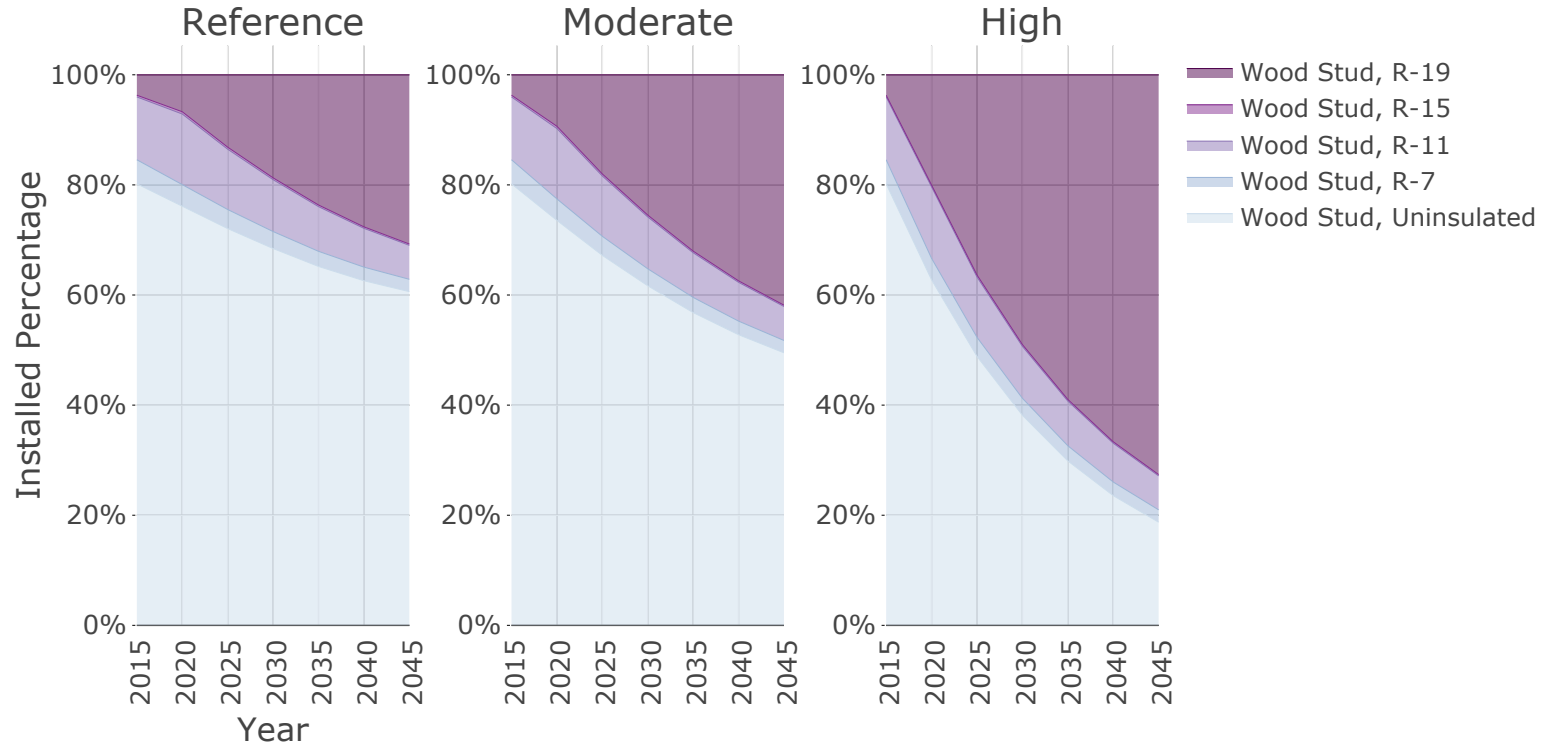
Residential Crawlspace Insulation



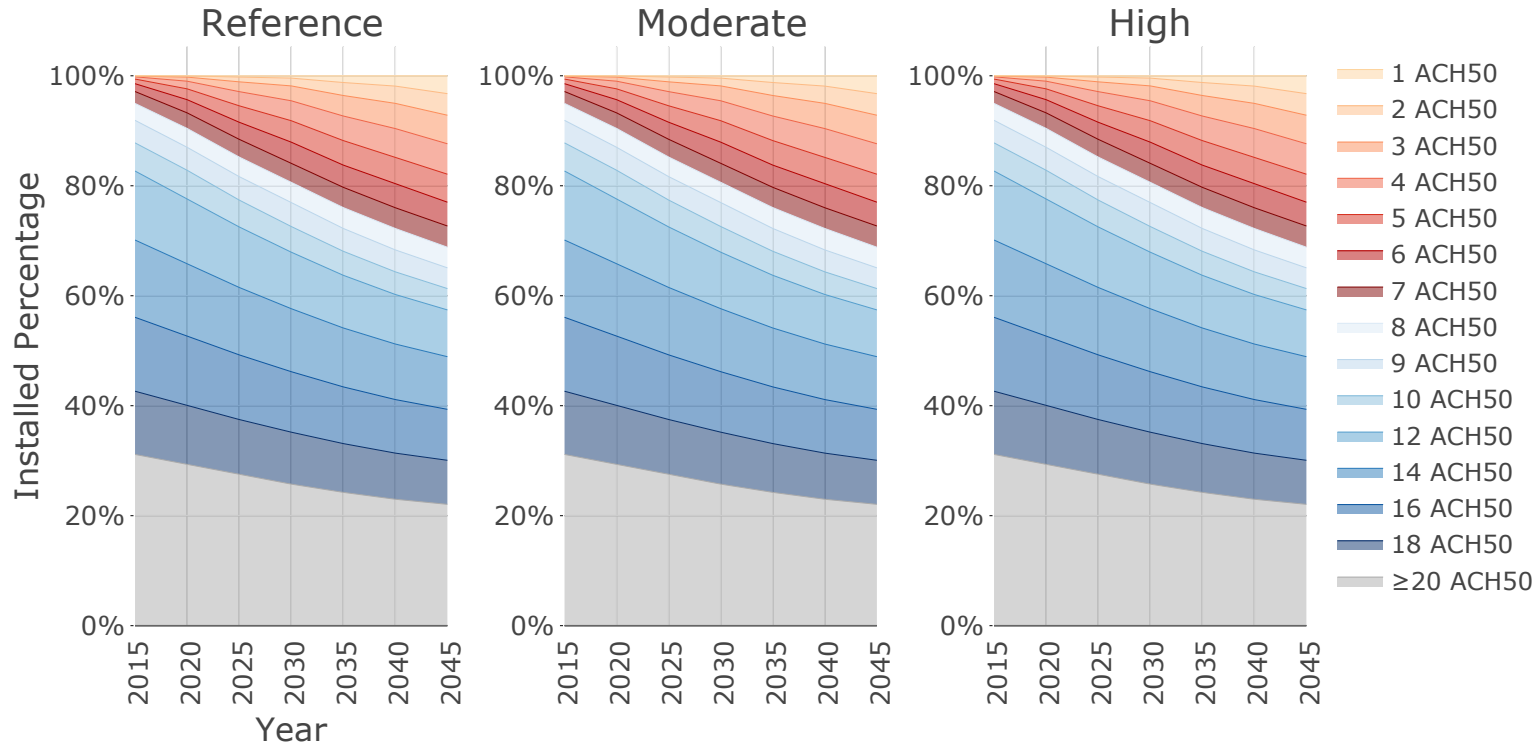
Residential Roof Material



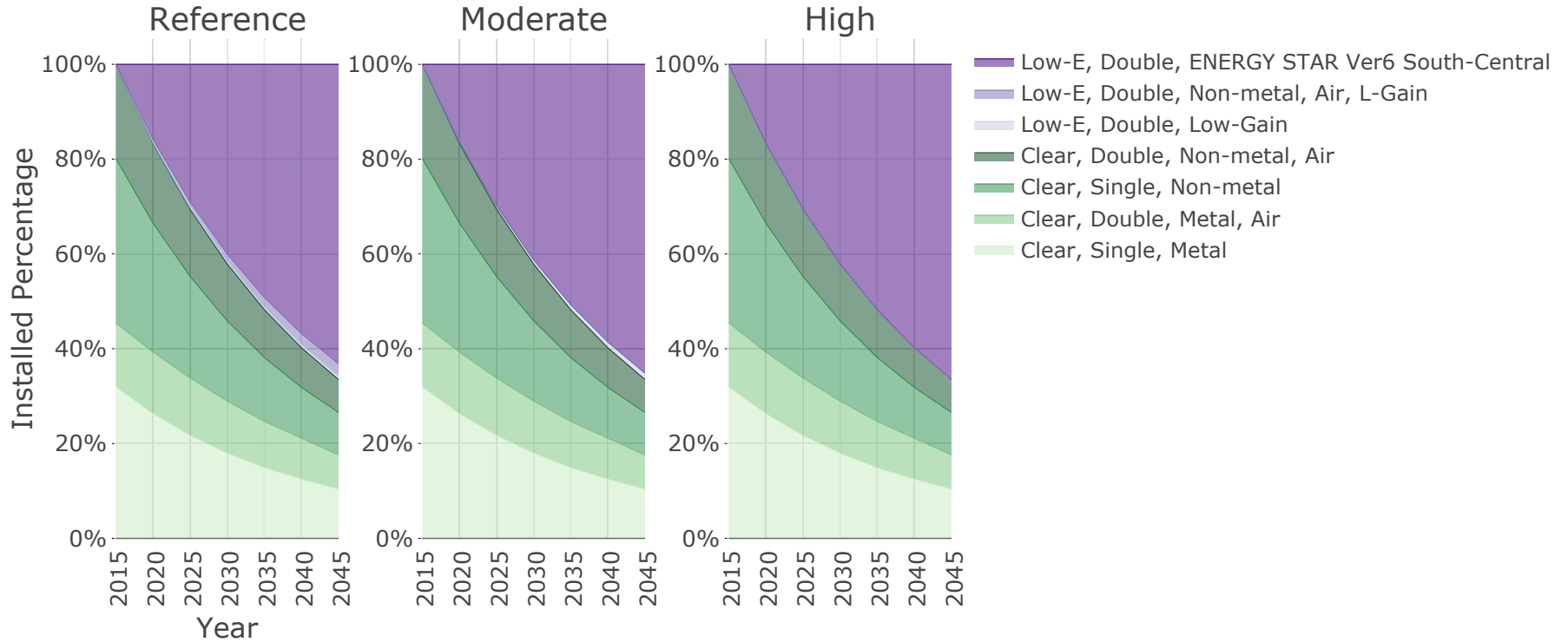
Residential Wall Insulation



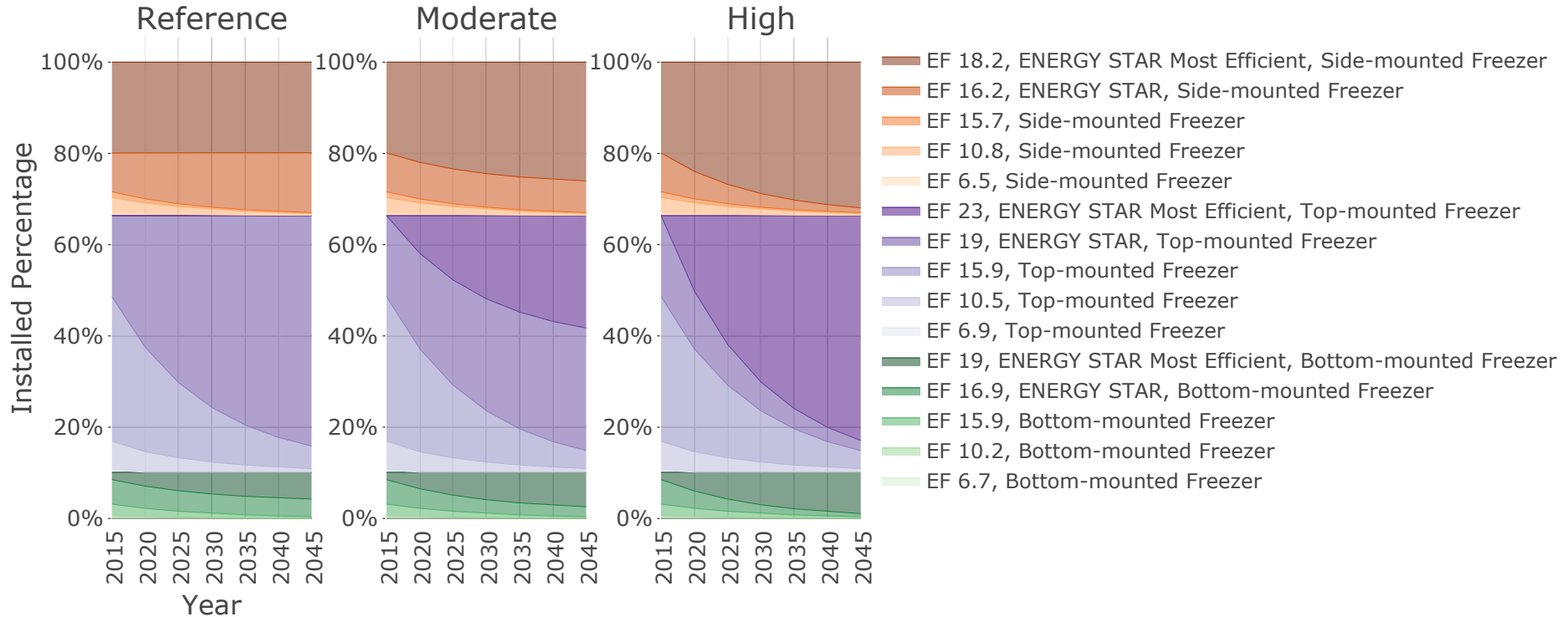
Residential Infiltration



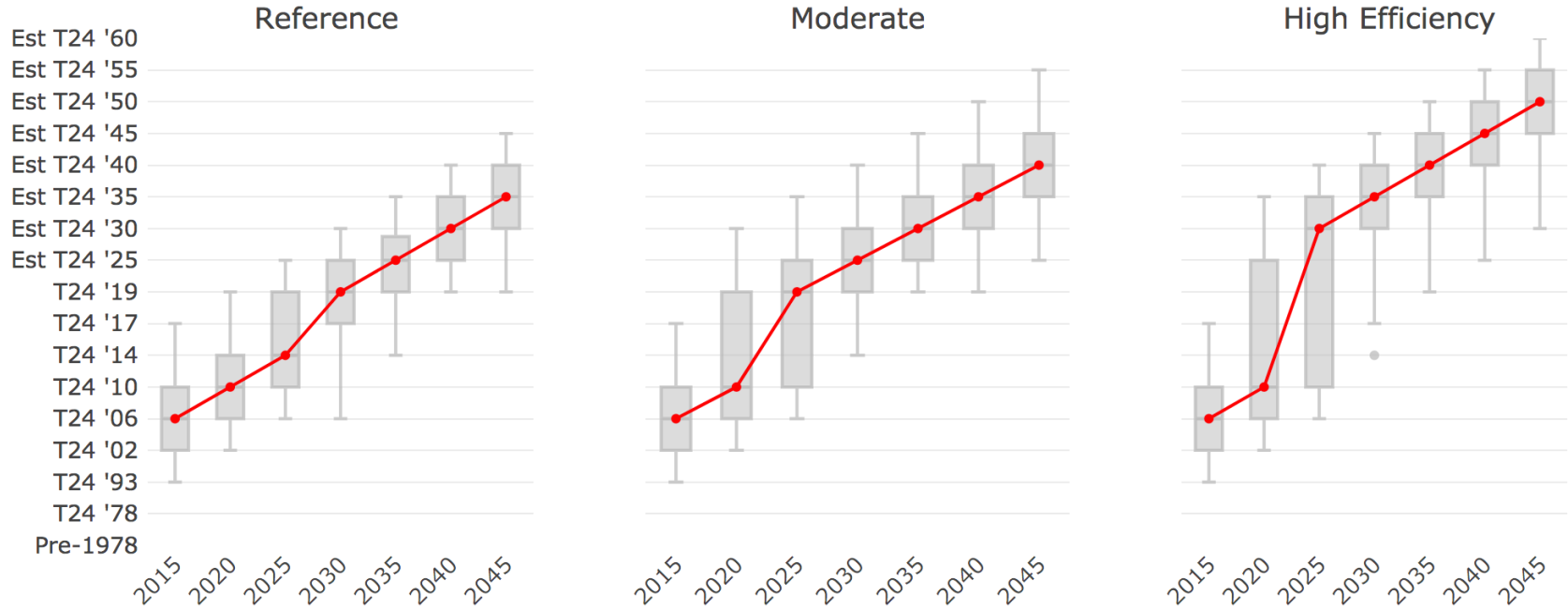
Residential Windows



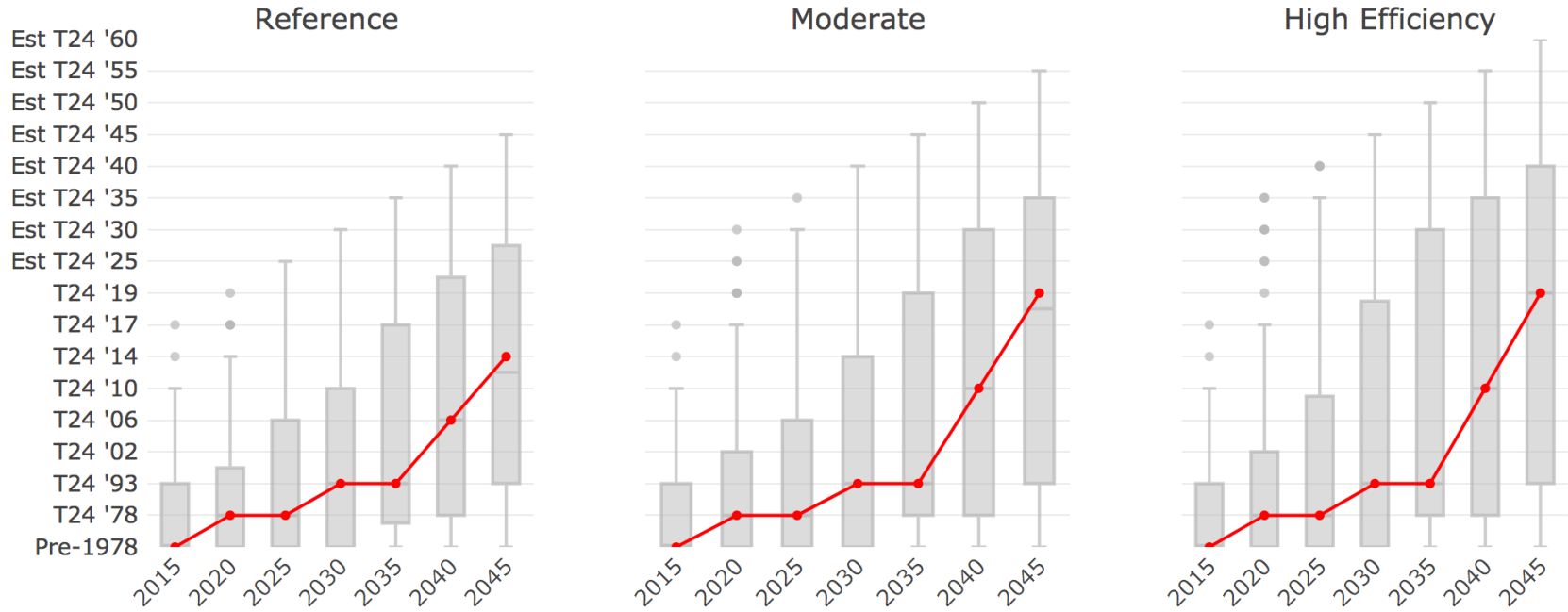
Residential Refrigerators



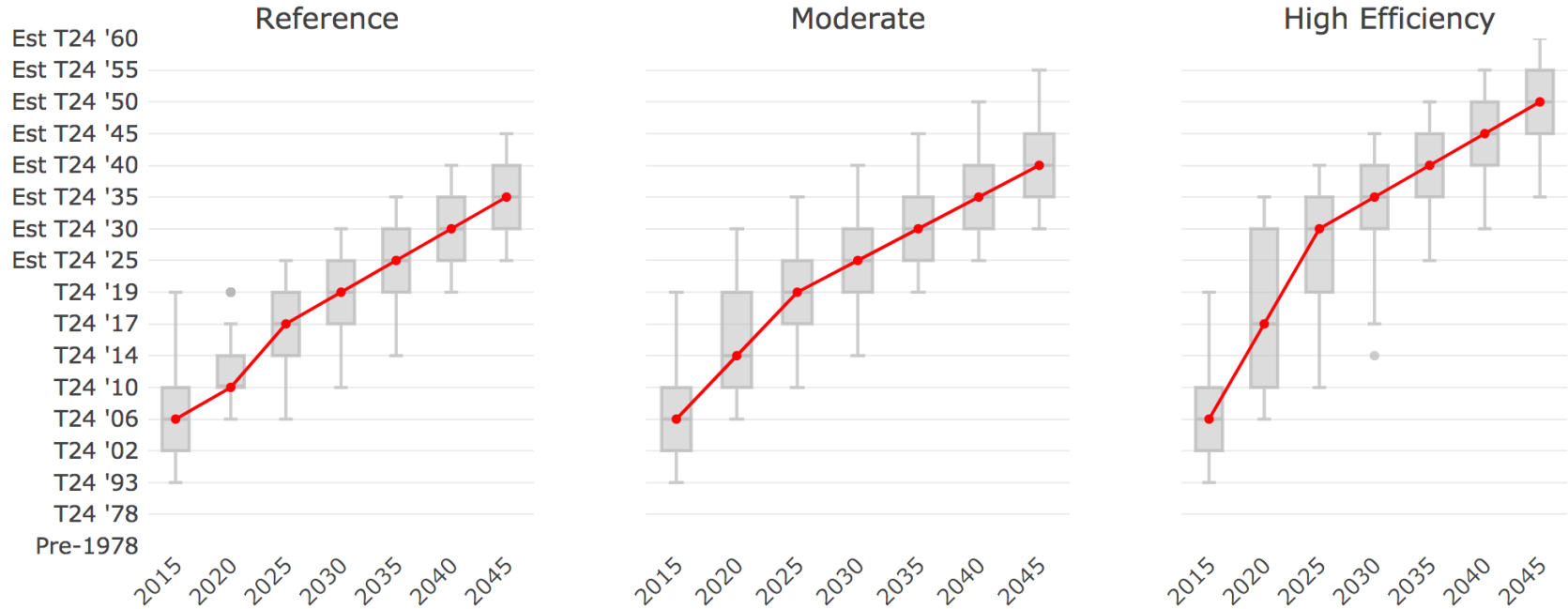
Commercial Service Water Heating Efficiency



Commercial Envelope Efficiency



Commercial Interior Lighting Efficiency



Commercial Exterior Lighting Efficiency

