DOCKETED	
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Project Title:	Equitable Building Decarbonization Program
TN #:	271855
Document Title:	Staff Workshop on Residential Decarbonization Energy Bill Impact Analyses - Slides
Description:	All slides used by participants of the Staff Workshop on Residential Decarbonization Energy Bill Impact Analyses, June 16, 2026
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Docketed Date:	8/7/2026

Public Workshop: Residential Decarbonization Energy Bill Impact Analyses

June 16, 2026

Today's Schedule

9:00 Welcome & Logistics
Tiffany Mateo, CEC

9:05 Opening Remarks
Commissioner Andrew McAllister, Ph.D., CEC

9:15 Overview of Building Decarbonization Analysis Types and Uses
Diana Maneta, CEC

9:35 Model-Based Energy Bill Impact Analysis
Tiffany Mateo, CEC
William Graswich & Karen Maoz, CPUC & Guidehouse
Q&A

10:30 Meter-Based Energy Bill Impact Analysis
Jason Harville, CEC
Ram Narayanamurthy, CEC
Adam Scheer, Recurve
Lisa Schmidt, Home Energy Analytics
Robert Buchanan, SnuggPro
Q&A

11:55 Validation Analysis and Beyond Heat Pumps
Mudit Saxena, XeroHome
Tom Hoff & Brittany Farrell, Clean Power Research

12:35 Q&A and Public Comment

12:55 Closing Remarks & Adjourn

Data and Analysis to Inform the Equitable Building Decarbonization Program

Residential Decarbonization Bill Impact Analysis Workshop
June 16, 2026

EBD Statewide Direct Install Program Overview

- The program serves...

Low-Income Households

- Single-family
- Multifamily
- Manufactured and mobile homes

Owner-occupied and rented (with tenant protections)

Underresourced Communities

- Disadvantaged communities
- Low-income communities

Eligible Measures

Statewide Direct Install Program

Heating and Cooling

- Heat pump
- Duct testing/sealing
- Smart thermostat
- Ceiling fan, whole-house fan

Building Envelope

- Insulation
- Air sealing
- Solar window film

Water Heating

- Heat pump water heater
- Low-flow showerheads and faucets

Cooking, Laundry

- Induction range or cooktop
- Electric clothes dryer

Air Quality, Lighting

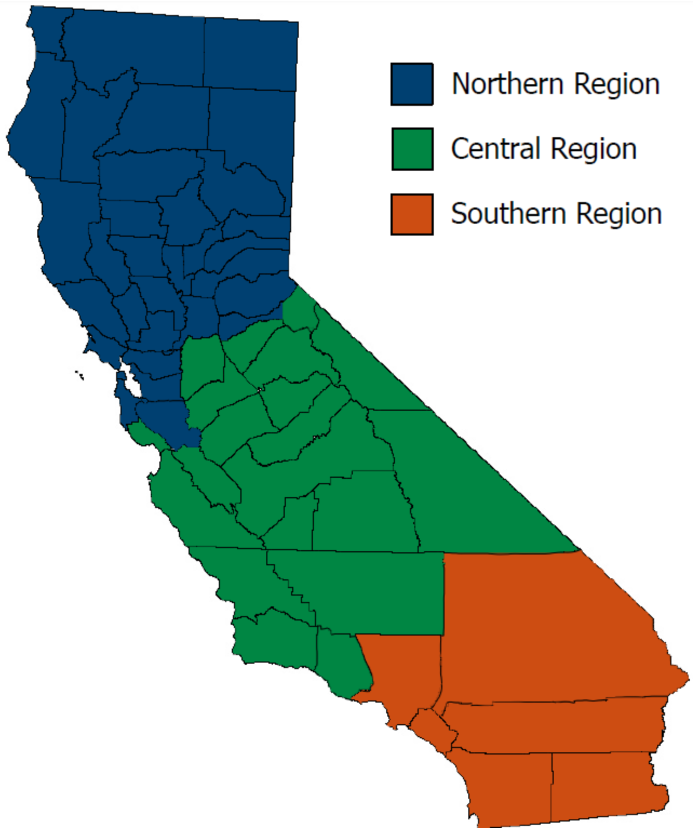
- Air filtration
- LED lights

Electrical and Remediation

- Electrical wiring and panel upgrades
- Remediation and safety

Program Budget by Region

Statewide Direct Install Program



Region	Regional Administrator	% of Funding*	Funding: State	Funding: Federal	Funding: Total
North	Association for Energy Affordability	23%	$78,027,500	$35,478,190	$113,505,690
Central	Center for Sustainable Energy	19%	$64,457,500	$29,308,070	$93,765,570
South	County of Los Angeles	58%	$196,765,000	$89,466,740	$286,231,740
Total	**All Regions**	**100%**	**$339,250,000**	**$154,253,000**	**$493,503,000**

** Funding allocation based on population of underresourced communities in each region*

Program Stages

Continuous Improvement

Program design and community selection

Outreach and enrollment

Home assessments and identification of recommended measures

Retrofits

Tracking outcomes

Data-Driven Program Design and Implementation

Continuous Improvement

Program design and community selection

Outreach and enrollment

Home assessments and identification of recommended measures

Retrofits

Tracking outcomes

Types of Analysis

CEC staff's **modeled bill impact analysis** for different packages of measures, climate zones, and utility rates

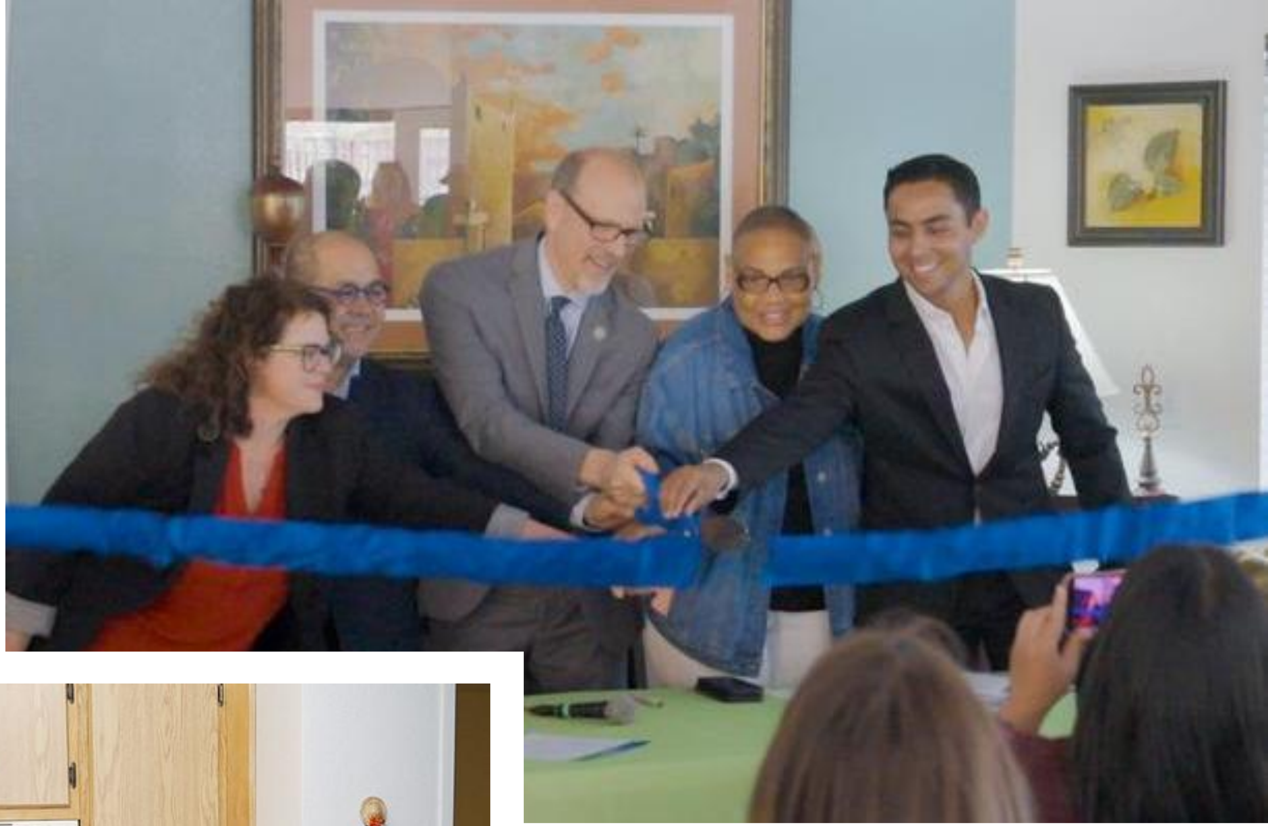
Analysis of household meter data to identify homes most likely to benefit from retrofits (support from Recurve)

Regional administrators conduct **energy modeling** to inform selection of measures and estimate bill impacts

Program results **measured using meter data** to determine energy savings and bill impacts for each project

Recent Progress

Statewide Direct Install Program



Contact

Diana Maneta

Policy and Technical Lead for Equitable Building Decarbonization Programs

diana.maneta@energy.ca.gov

Website: https://www.energy.ca.gov/programs-and-topics/programs/equitable-building-decarbonization-program

Docket: 22-DECARB-03

Residential Low-Income Energy Bill Impacts Analysis

June 16, 2026

Tiffany Mateo

Reliability, Renewable Energy, and Decarbonization Incentives Division

California Energy Commission

Staff Report

Published and Available Online

Low-Income Residential Energy Bill Impact Analysis

Modeling the Impacts of Decarbonization Activities on Energy Bills in California

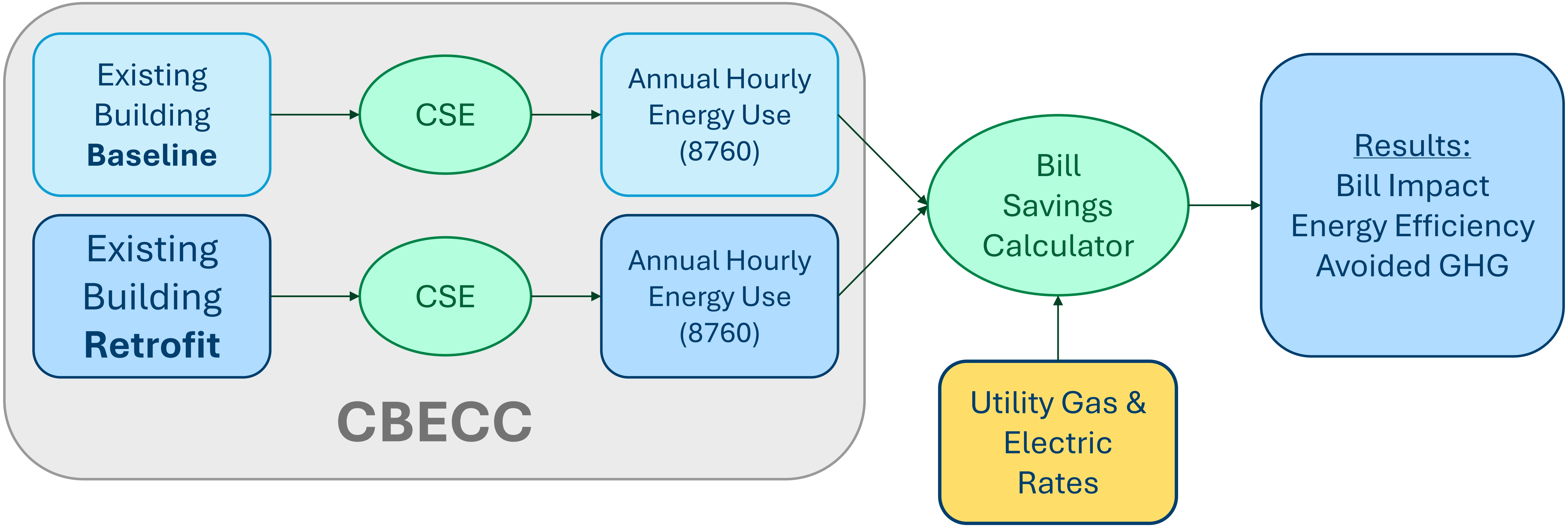
Website Link: https://www.energy.ca.gov/publications/2026/low-income-residential-energy-bill-impact-analysis-modeling-impact

Presentation:

- Modeling analysis methodology
- Analysis results summary
- High level takeaways
- Next Steps

Bill Impact Analysis Methodology

Model-Based Analysis



CBECC Modeling Scope

Building Types	Electrification Measures	Envelope Measures
• 1-story SF (2) • 2-story SF • Low-rise MF • Mid-rise MF • Single wide MH • Double wide MH	• HPWH • HP HVAC (+duct sealing, excluding MF) • High efficiency HP HVAC • Electric cooking • Electric clothes drying	• Attic insulation (excluding MF, single wide MH) • Floor insulation (MH only) • Air sealing • Solar window film

Models were run for all 16 climate zones.

Building Types Modeled

Residential Type	Floor Area (ft^2)	Number of Stories	Number of Bedrooms
1) Single family	1,250	1	2
2) Single family	1,750	1	3
3) Single family	2,250	2	4
4) Low rise Multifamily	7,320	2	8 units (four 2 bedroom; four 1 bedroom)
5) Midrise Multifamily	95,028	6	88 units (128 bedrooms)
7) Single Wide	910	1	2
8) Double Wide	1,512	1	3

CBECC Model Assumptions

Single Family and Multifamily Prototypes

Vintage Category Mixed Fuel Prototype (Baseline with AC*)	Ceiling Insulation	Env. Seal ACH50	Duct Leakage	Furnace AFUE HP HSPF (Heating)	HP SEER* (Cooling)	Water Heater UEF
a) Pre-1975	R-17 **R-38**	16 **11.2**	15% **10%**	0.78 **8.8** **10.0**	13.0 **15.0** **16.0**	0.58 **NEEA Tier 3**
b) 1975-1983	R-19 **R-38**	13 **9.1**	15% **10%**	0.78 **8.8** **10.0**	13.0 **15.0** **16.0**	0.58 **NEEA Tier 3**
c) 1984-2005	R-27 **R-38**	8 **5.6**	15% **10%**	0.78 **8.8** **10.0**	13.0 **15.0** **16.0**	0.58 **NEEA Tier 3**

*No AC load in CZ 1 and CZ 5. No AC load in CZ 3, Pre-1975 baseline.
AC load is included in the retrofit

CBECC Model Assumptions (Continued)

Manufactured Home Prototypes

Vintage Category Mixed Fuel Prototype	Ceiling* Insulation	Floor Insulation	Env. Seal ACH50	Duct Leakage	Furnace AFUE **HP HSPF** (Heating)	HP SEER (Cooling)	Water Heater UEF
a) Pre-1976	R-7 **R-30**	R-0 **R-19**	16 **11.2**	15% **10%**	0.78 **8.8**	13.0 **15.0**	0.58 **NEEA Tier 3**
b) 1976-1994	R-11 **R-30**	R-7 **R-19**	13 **9.1**	15% **10%**	0.78 **8.8**	13.0 **15.0**	0.58 **NEEA Tier 3**
c) Post-1994	R-19 SW R-22 DW **R-30**	R-19 **R-19**	11.5 **8**	15% **10%**	0.78 **8.8**	13.0 **15.0**	0.58 **NEEA Tier 3**

*Ceiling insulation only applies to double wide manufactured home prototypes.

Energy Rates - CARE

Utility	Tiered Rate	TOU Rate	Electrification Rate
PG&E	E1	TOU C	E-ELEC
SCE	D	TOU 4-9	Prime
SDG&E	DR	DR1	TOU-ELEC
LADWP	Tier	NA	NA
SMUD	R	TOU	NA

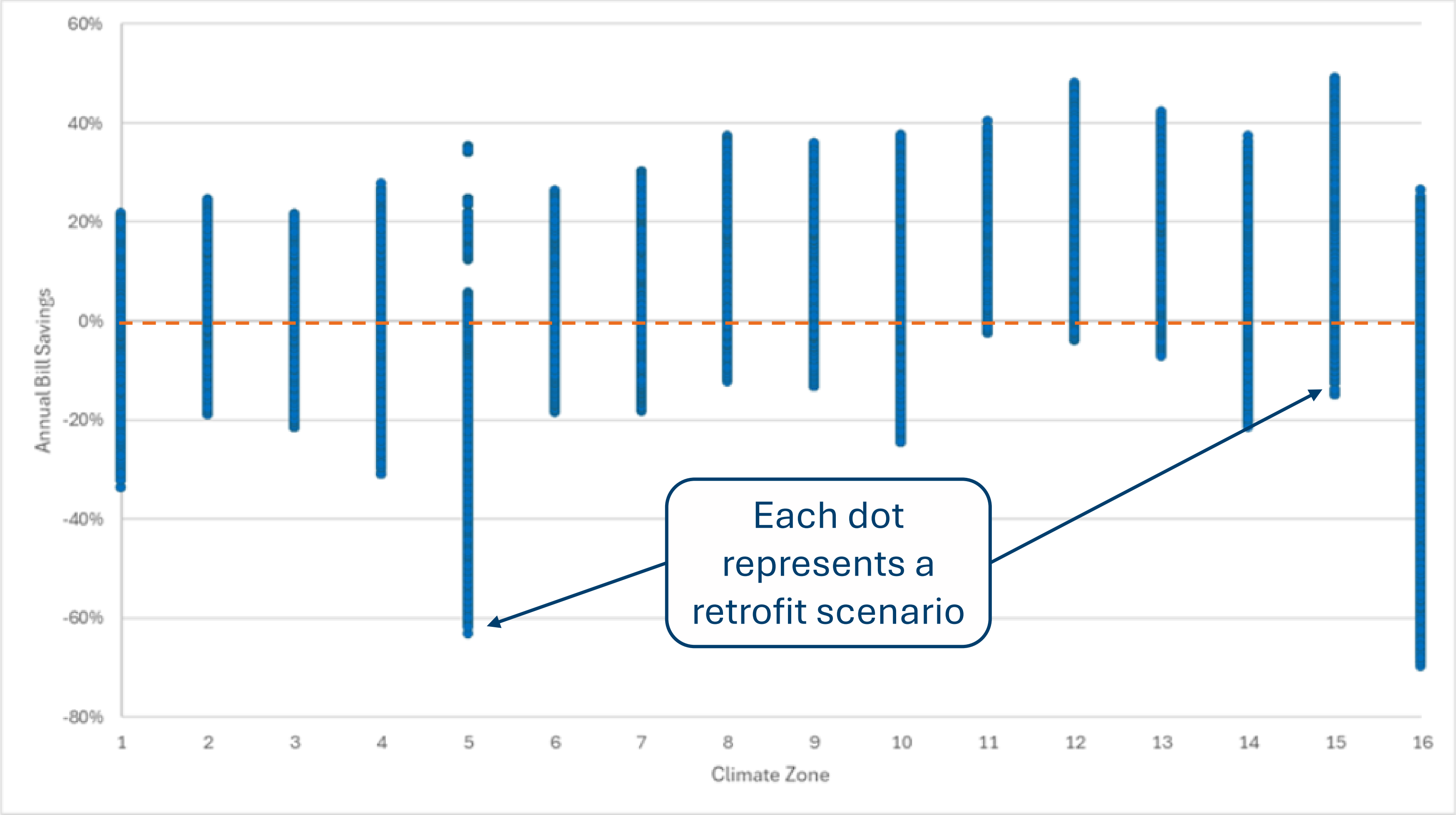
<u>Gas</u>

- PG&E: G-1
- SoCalGas: GR
- SDG&E: GR

- E-ELEC and Prime rates are only applied to retrofit models.
  - These rates require a heat pump water heater or heat pump for HVAC (or solar PV, battery storage, or EV).
- **All rates had the low income or CARE discount applied.**
  - CARE: 20% discount on gas; 30-35% discount on electricity.
- Rates used: Jan – Dec 2024.

Bill Impact Analysis Results

Annual Bill Savings of Heat Pump Retrofit Prototype Scenarios

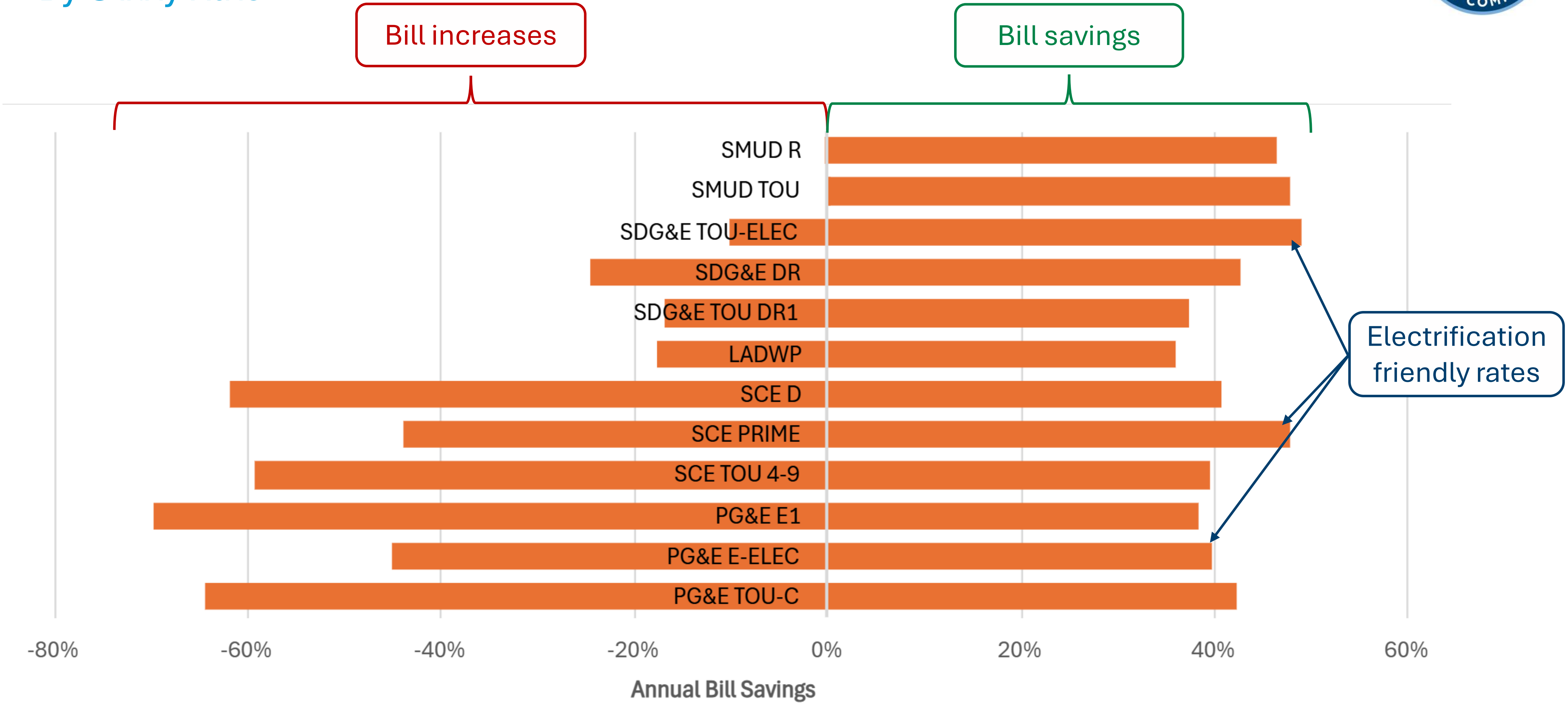


Positive values = bill savings

Negative values = bill increases

Annual Bill Savings of Heat Pump Retrofits Prototypes

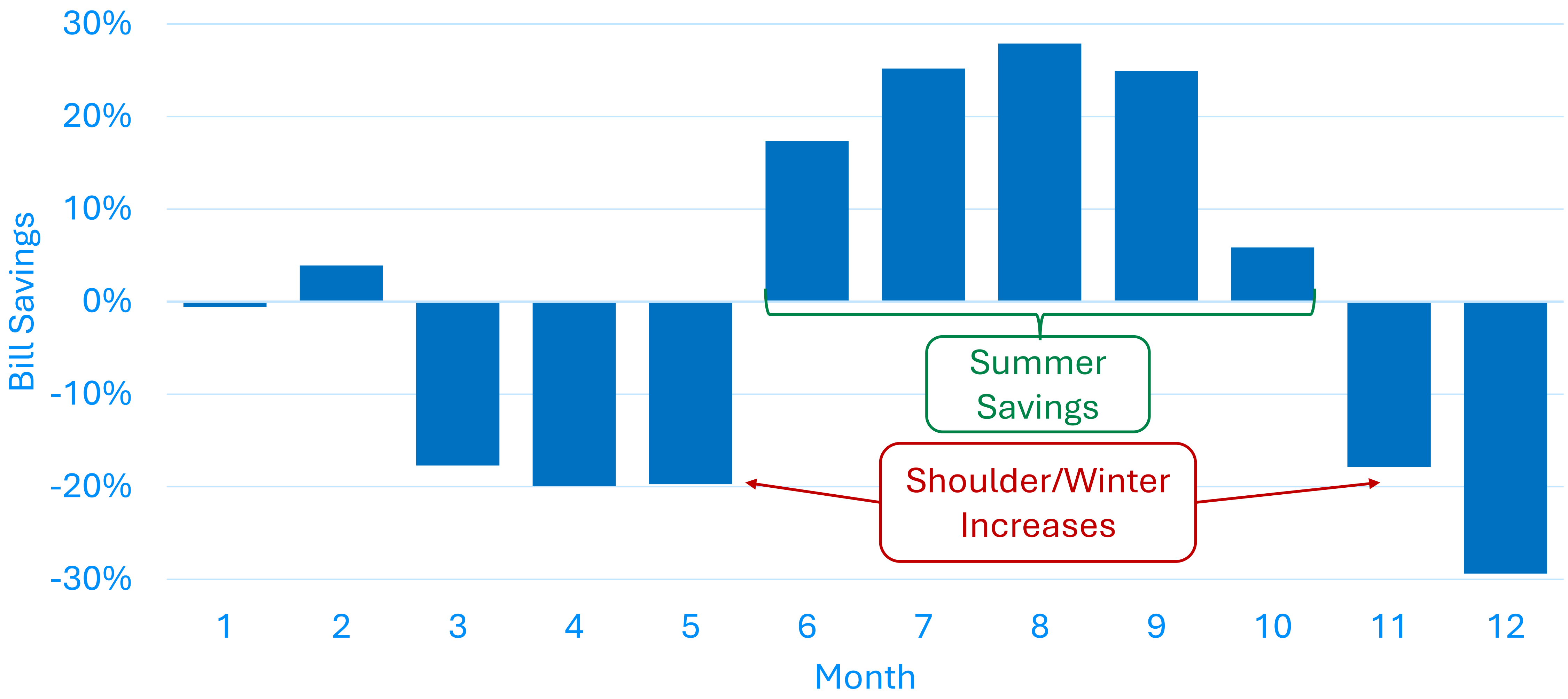
By Utility Rate



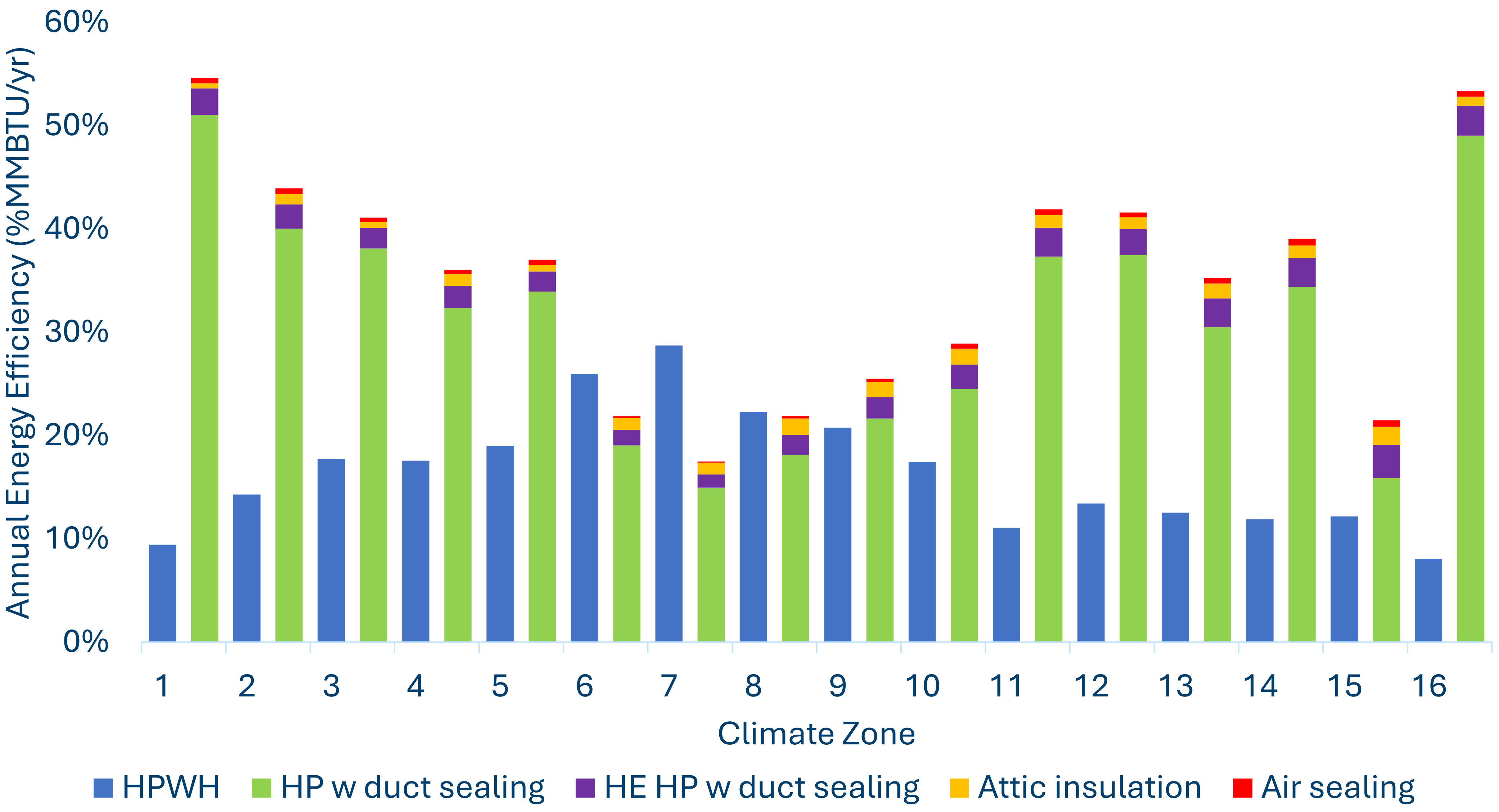
Using 2024 rates with low-income discounts applied

Bill Impact by Month

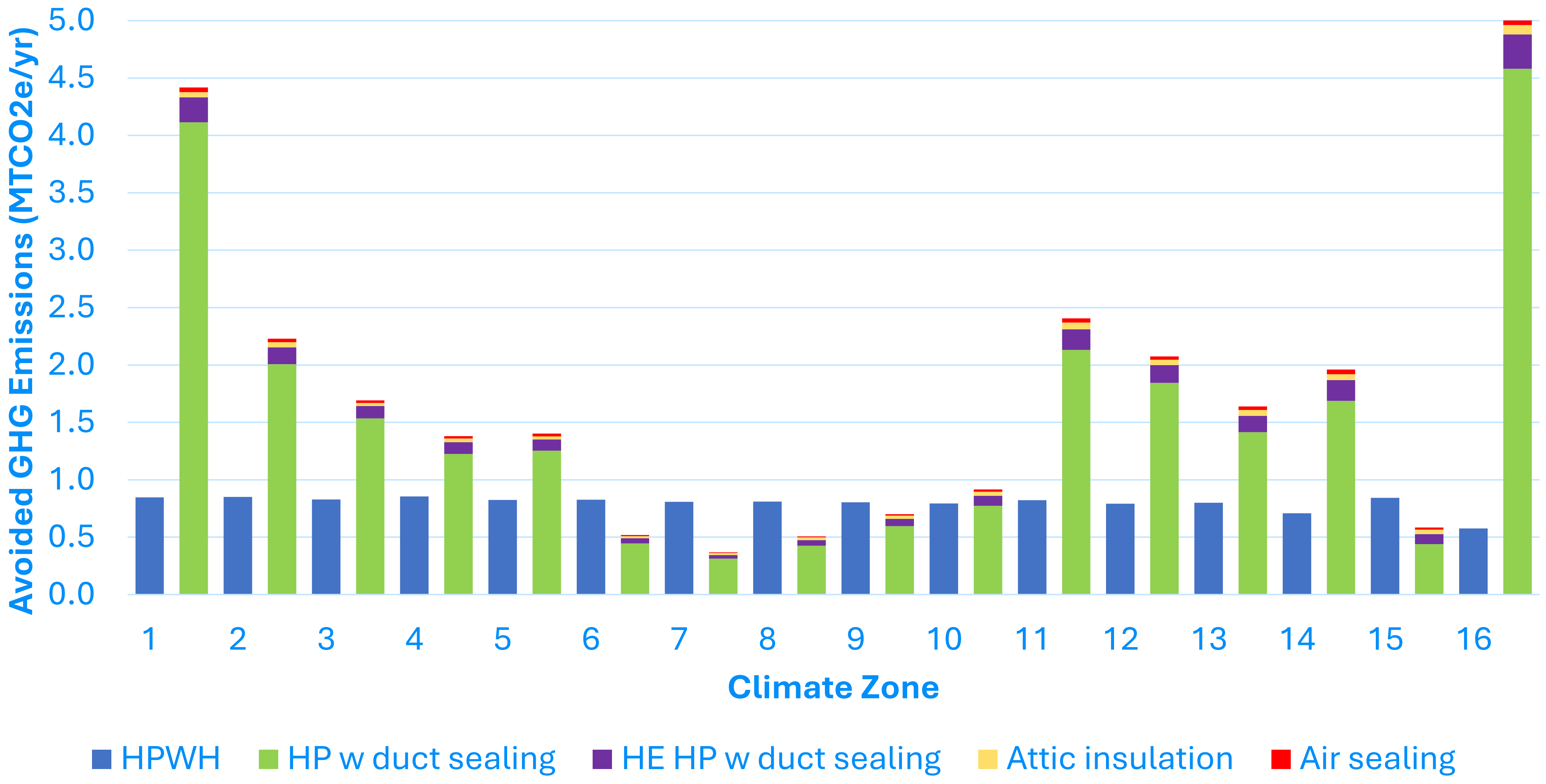
Heat Pump HVAC Retrofit, Climate Zone 6, SCE Prime



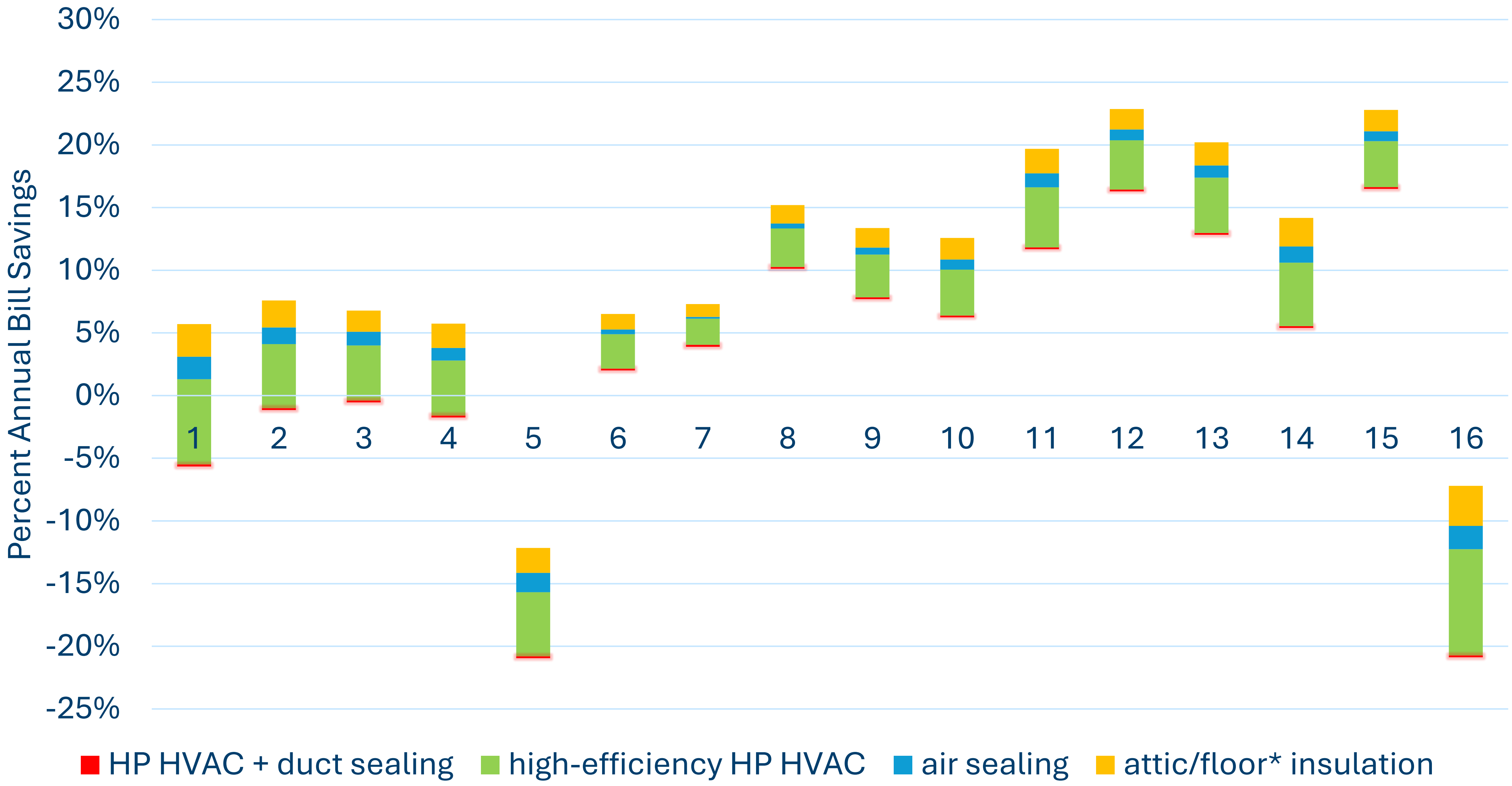
Energy Efficiency by CZ



Avoided GHG Emissions



Incremental Envelope Measures Bill Impact by CZ

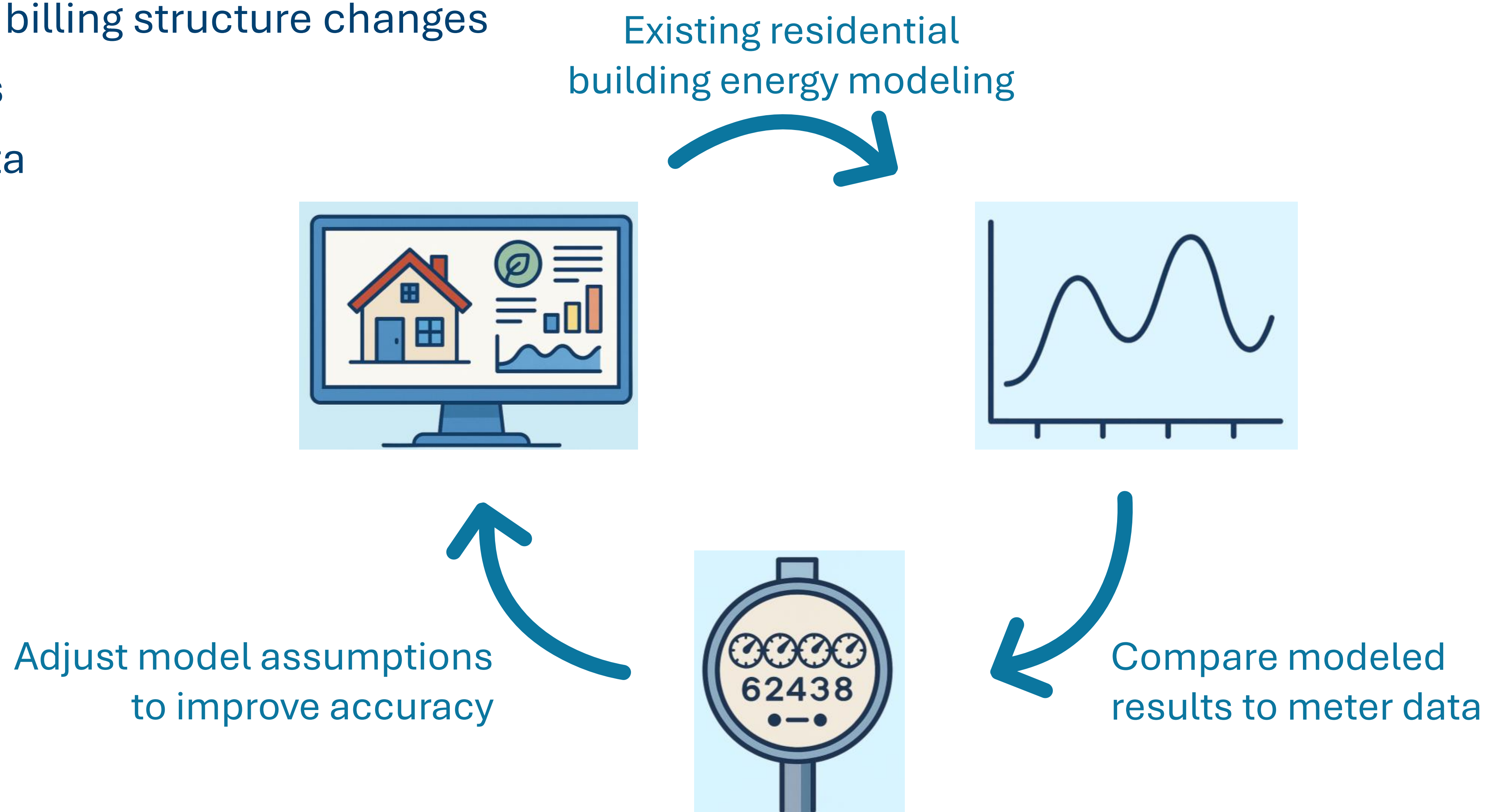


High Level Takeaways

- Climate and utility rate are the two primary factors determining energy bill impact.
- HPWH retrofit scenarios showed **bill savings in most areas.**
- HP HVAC retrofit scenarios showed
  - **bill savings in high cooling load climates** (CZ 8-13 and 15).
  - **bill increases in low cooling load and high heating load climates**: Santa Maria (CZ 5) and mountain areas (CZ 16).
  - High efficiency equipment and envelope measures incrementally contribute to bill savings.
- Electrification-friendly rates resulted **in 5-10% higher bill savings** than default TOU rates.
- Bill impact varies by season

Next Steps and Analysis Updates

- Solar PV and Battery
- Utility rates and billing structure changes
- Non-CARE rates
- Utility meter data



Thank you!

https://www.energy.ca.gov/publications/2026/low-income-residential-energy-bill-impact-analysis-modeling-impact

EquitableBuildingDecarb@energy.ca.gov

The customer electrification estimator is currently in draft form and not available publicly.

Guidehouse

Customer Electrification Estimator

June 2026

outwit complexity™

Agenda

CPUC Customer Electrification Estimator

Purpose

Background & Context:

Develop a California tool that helps Investor-Owned Utility (IOU)* residential customers estimate how electrification or fuel substitution measures may affect utility bills.

Objective:

- Enable customers to compare what may happen with their utility bills if they electrify different technologies
- Produce a CPUC-owned tool configurable for regular rate updates

*The tool can accommodate Community Choice Aggregator (CCA) rates, but the IOU rates may be used a proxy or relative impact calculation for CCA customers.

Project Overview

1. Analysis generates millions of permutations of estimates of home energy bills based on a variety of home parameters (location, utility, home size, appliances installed, rate, etc.)

2. The **draft** web tool estimator would function as a large-scale lookup database based on user input of home characteristics and planned upgrades to compare electric and gas bill amounts before and after fuel substitution. **The web tool is not yet ready for public release.**

Calculator Framework Description

Rate Engine

Calculates customer monthly bill using hourly consumption data

- Configurable to accommodate any set of 8760 data
- Flexible rate input workbook to include both residential and non-residential rate structures
- Each billing component individually entered for granular differentiation of each rate

Bill Calculator

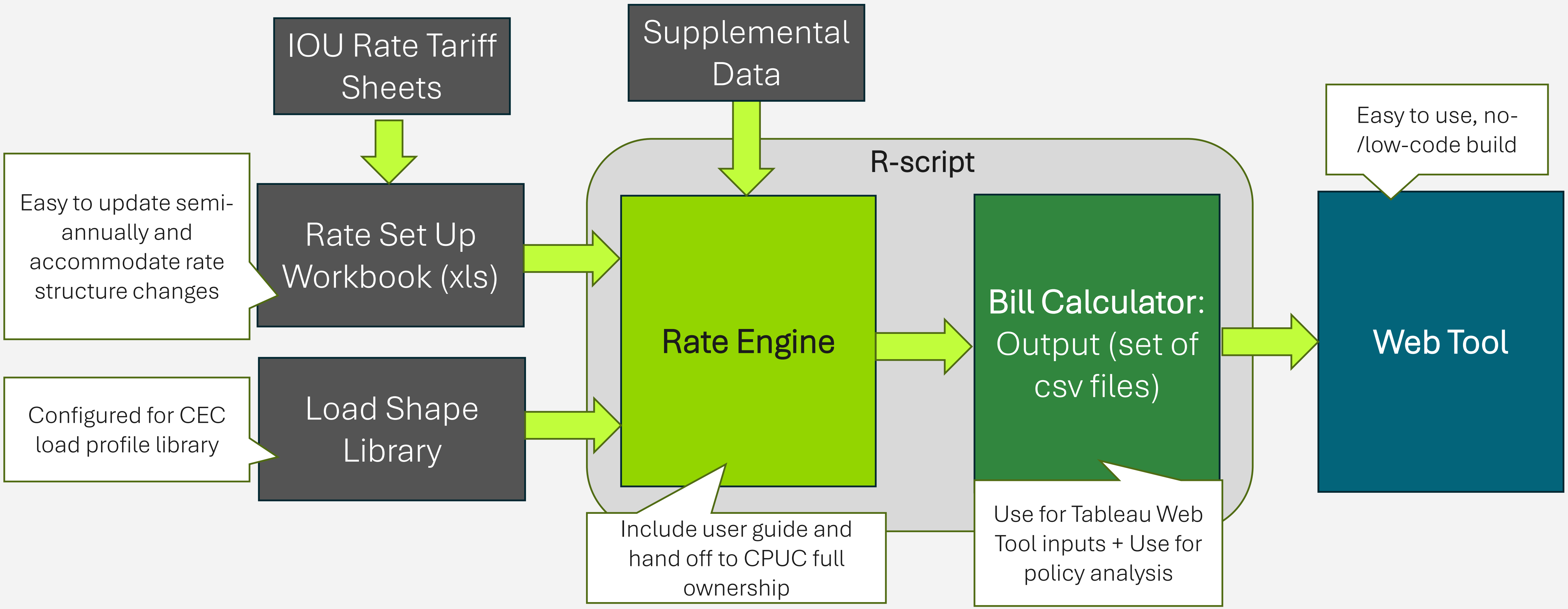
Estimates bill amount for multiple energy use profile permutations

- Can calculate whole building bill amounts from pre-loaded 8760 load profiles
- Incorporate new rate structures and values
- Outputs bill amounts for each unique load profile for every analyzed gas & electric rate

Web Tool (TBD)

To Be Announced

Tool Workflow: Rate Engine and Web Tool



Methodology: Rate Engine + Web Tool

Step 1: Ingest Rates

Build out rate library within Excel template
- Check for any changes in rate structure
- Add new tariffs
- Update existing tariff

Run rate set up script for gas and electric rate information

Step 2: Ingest Load Profiles

- Define load profile characteristics
- Pre process load profile library tagging with unique characteristics

Step 3: Ingest + Map Other Data

- Zip code mapping
- Solar and battery load profiles
- Net Billing Tariff charges by IOU

Step 4: Calculate Bill Amounts

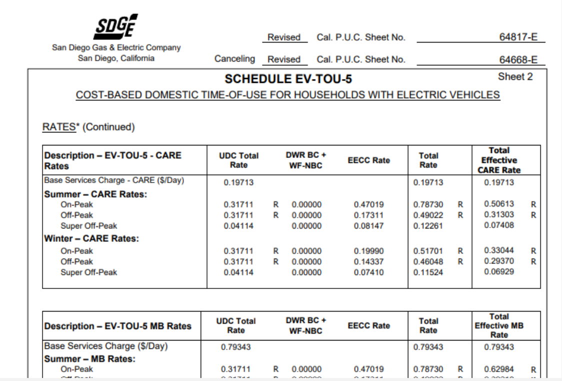
- Multiply through the rate structure and its associated billing components to the time-based 8760 load profile
- Use zip code map and PV & battery loadshapes, as applicable

Step 5: Process Data for Web Tool

- Tool output files structured for dashboard design
- Link the electric and gas calculations

Step 1: Ingest Rates

- Source most common rates from the four IOUs
- Rate analysis includes Basic Service Charge
- Simplifying assumptions:
  - **Annual or semi-annual charges.** Excludes charges that are not applied monthly, such as the California Climate credit, from the bill calculations.
  - **NEM.** Includes analysis for net energy metering (NEM) 1.0, 2.0, and 3.0 (also referred to as net billing tariff or NBT) for all on-site generation with or without battery storage. The code currently applies import charges and export credits to bill calculations but does not account for credit carry-overs into future months.
  - **Billing Cycles.** Customer bills will be calculated using the calendar months.
  - **CARE and FERA discounts.** CARE and FERA discount percentages (%) will be applied to the total bill amount.
  - **Medical baselines.** The rate engine will not provide bill estimates for customers on medical baselines.
  - **Holidays.** The rate engine will ignore holidays, instead treating them as standard weekdays or weekends when calculating bills.



SDGE
San Diego Gas & Electric Company
San Diego, California

Revised Cal. P.U.C. Sheet No. 64817-E
Canceling Revised Cal. P.U.C. Sheet No. 64668-E

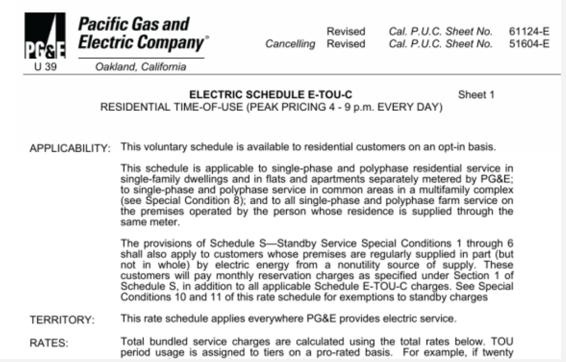
SCHEDULE EV-TOU-5 Sheet 2

COST-BASED DOMESTIC TIME-OF-USE FOR HOUSEHOLDS WITH ELECTRIC VEHICLES

RATES* (Continued)

Description – EV-TOU-5 - CARE Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective CARE Rate
Base Services Charge - CARE ($/Day)	0.19713			0.19713	0.19713
Summer – CARE Rates:					
On-Peak	0.31711 R	0.00000	0.47019	0.78730 R	0.50613 R
Off-Peak	0.31711 R	0.00000	0.17311	0.49022 R	0.31303 R
Super Off-Peak	0.04114	0.00000	0.08147	0.12261	0.07408
Winter – CARE Rates:					
On-Peak	0.31711 R	0.00000	0.19990	0.51701 R	0.33044 R
Off-Peak	0.31711 R	0.00000	0.14337	0.46048 R	0.29370 R
Super Off-Peak	0.04114	0.00000	0.07410	0.11524	0.06929

Description – EV-TOU-5 MB Rates	UDC Total Rate	DWR BC + WF-NBC	EECC Rate	Total Rate	Total Effective MB Rate
Base Services Charge ($/Day)	0.79343			0.79343	0.79343
Summer – MB Rates:					
On-Peak	0.31711 R	0.00000	0.47019	0.78730 R	0.62984 R



Pacific Gas and Electric Company®
U 39 Oakland, California

Revised Cal. P.U.C. Sheet No. 61124-E
Cancelling Revised Cal. P.U.C. Sheet No. 51604-E

ELECTRIC SCHEDULE E-TOU-C Sheet 1
RESIDENTIAL TIME-OF-USE (PEAK PRICING 4 - 9 p.m. EVERY DAY)

APPLICABILITY: This voluntary schedule is available to residential customers on an opt-in basis.

This schedule is applicable to single-phase and polyphase residential service in single-family dwellings and in flats and apartments separately metered by PG&E; to single-phase and polyphase service in common areas in a multifamily complex (see Special Condition 8); and to all single-phase and polyphase farm service on the premises operated by the person whose residence is supplied through the same meter.

The provisions of Schedule S—Standby Service Special Conditions 1 through 6 shall also apply to customers whose premises are regularly supplied in part (but not in whole) by electric energy from a nonutility source of supply. These customers will pay monthly reservation charges as specified under Section 1 of Schedule S, in addition to all applicable Schedule E-TOU-C charges. See Special Conditions 10 and 11 of this rate schedule for exemptions to standby charges

TERRITORY: This rate schedule applies everywhere PG&E provides electric service.

RATES: Total bundled service charges are calculated using the total rates below. TOU period usage is assigned to tiers on a pro-rated basis. For example, if twenty

Step 2: Ingest Load Profiles

- **Source from CEC designed and developed load profile library** (Bill Impact Analysis of Decarbonization Activities on Existing Homes, Presented February 8, 2024, RREDI Division)

Building Types

- Single Family, small
- Single Family, medium
- Single Family, large
- Low rise Multifamily
- Midrise Multifamily
- Three vintages: Pre-1975, 1975-1983, 1984-present

Electrification Measures

- HVAC: heat pump standard and high efficiency
- Water heating: heat pump water heater
- Clothes dryer: heat pump clothes dryer
- Stovetop cooking: induction

Envelope Measures

- Duct sealing for SF only
- Attic insulation
- Floor insulation
- Air sealing

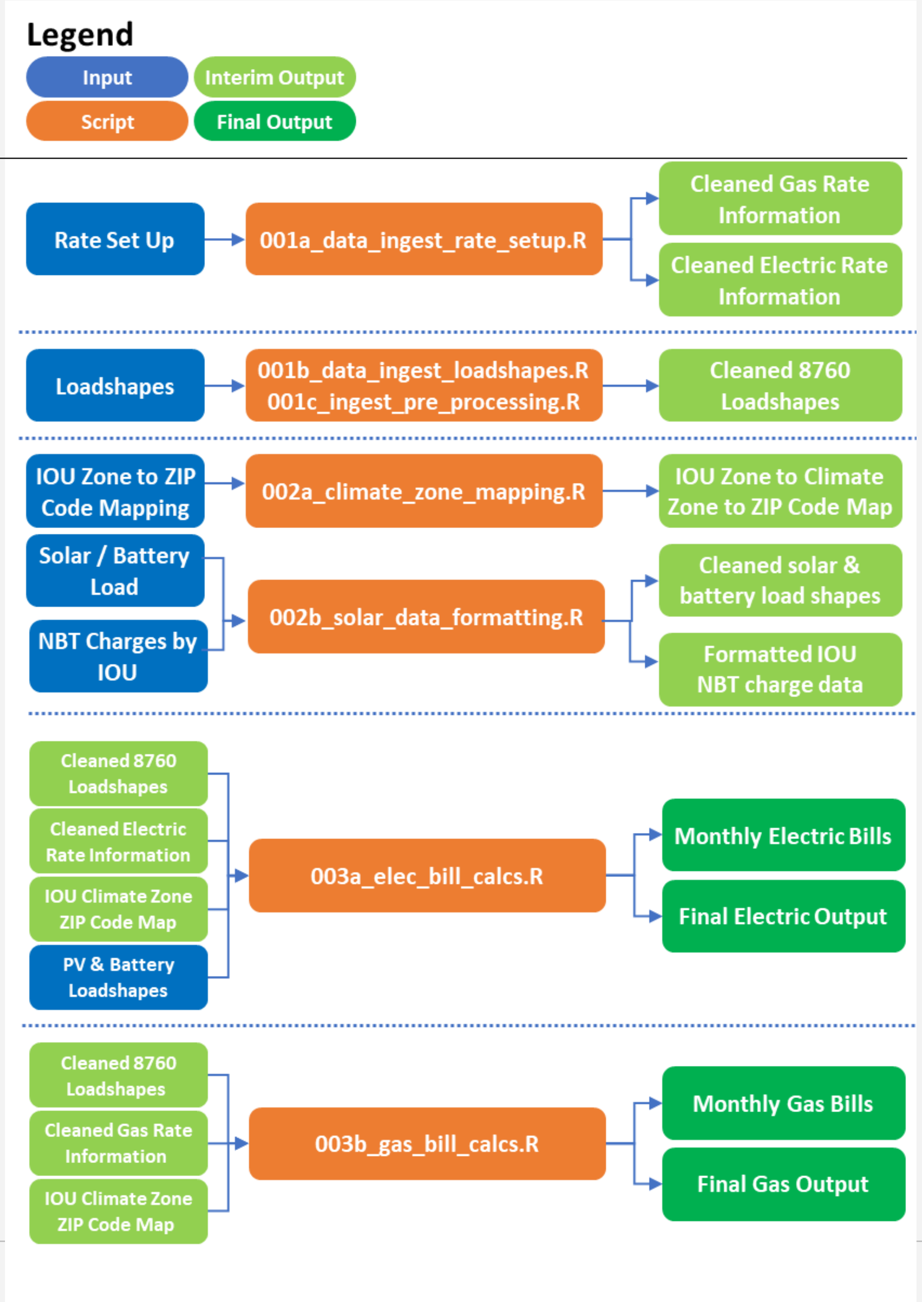
Step 3: Ingest + Map Other Data

- **Zip code map** required for
  - Assigning load profiles by CEC Climate Zone
  - Mapping to IOU-specific territory
  - Linking IOU tariff-based territory regions for baseline tier thresholds

- To account for **solar and storage** impacts
  - Adjust CEC load profiles with solar and/or storage standard load profiles from CEC IEPR
  - Account for tariff type (NEM 1.0, 2.0 or 3.0) dependent on date of installation
  - Include net billing tariff (for NEM 3.0), NBT, total export credits for hourly exports to the grid

Step 4: Calculate Bill Amounts

- R-script Workflow illustrated
- Includes steps for:
  - Loading rate set up for both electric and gas
  - Ingesting load profiles
  - Ingesting other data sets (zip code mapping, solar/battery load profiles, and NBT charges by IOU)
  - Cleaning load profile library and aligning to dimensions analysis
  - Outputting a set of CSV files



Step 5: Process Data for Web Tool

Bill Calculator Output - User Input Field for Web Tool

Field	Description
Electric Utility	Applicable electric IOU (gas IOU defaulted)
Building Type	Applicable building type
Tech 1 (HVAC)	HVAC retrofit level
Tech 2 (DWH)	Water heater retrofit level
Tech 3 (Cooking)	Cooking equipment retrofit level
Tech 4 (Dryer)	Clothes dryer retrofit level
Existing central AC	Specifies whether the home has central AC
Building Vintage	Home construction year
Building envelope	Building envelope retrofit level
Solar and Battery	Specifies the inclusion of PV load or PV & Battery load
nem_type	Based on year of PV/battery system
Existing electric rate	Applicable electric rate code

Guidehouse

Thank You

Karen Maoz
Karen.maoz@guidehouse.com

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Q&A

Interval Data and Analysis

Jason Harville, Director of Enterprise Data and Analytics

Agenda

- Interval Meter Data: What is it?
- Interval Meter Data: Upcoming changes.
- Energy Data Analysis Program

“IMD”: CCR Title 20 Section 1353

What is it?

“IMD” refers to all data collected under CCR Title 20, Section 1353

- 6 utilities (PG&E, SCE, SDG&E, SoCalGas, LADWP, SMUD) submit
  - Billing-level energy consumption and charges for all retail meters (gas and electric)
  - Interval-level consumption for smart meters (excluding SoCalGas, LADWP)
  - Associated account, location, and meter information
- 8+ years of data (beginning 2018), new submissions quarterly
- ~40 terabytes *compressed*

1.5 Trillion records

Upcoming Changes

Regulatory Changes

1. Reporting Tempo
   - Reporting period now monthly with 45 days to report.
   - Data freshness will now be 45-75 days, from 90-180 days.
2. Natural Gas Interval Data
   - NG intervals reported at whatever interval they are collected. Likely daily.
3. New Data Fields
   - Lat/Long for meters, fully parsed postal addresses.
   - Customer IDs to tie together service accounts.
   - Other fields for customer group, billing baseline, and joining rate data.

Imperial Irrigation District will begin reporting this year.

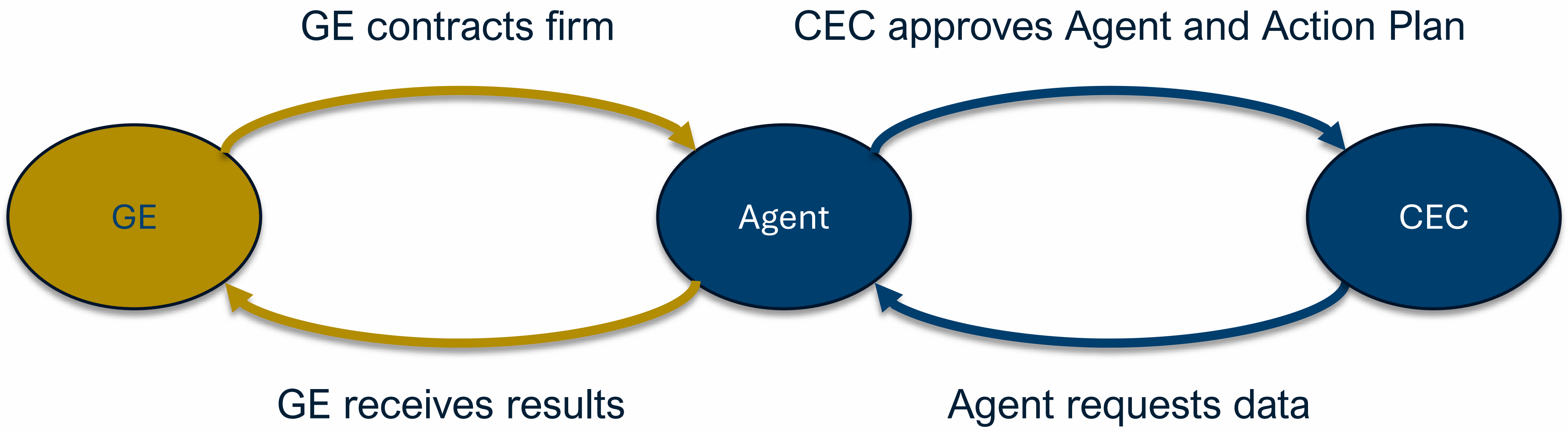
New data will start being submitted around the new year, depending on utility.

Energy Data Analysis Program (EDAP)

EDAP Overview

Energy Data Analysis Program (EDAP) allows a CEC-designated Agent to work with confidential CEC data on behalf of a Govt Entity (GE) while protecting privacy.

- GE selects and pays for analytics firm under their own contract
- CEC designates firm as an Agent and oversees confidential data handling
- GE receives non-confidential results without receiving confidential data



Resources

Title 20, Section 1353

- Express terms describing updated regs: https://efiling.energy.ca.gov/GetDocument.aspx?tn=269462&DocumentContentId=106551
- Docket for 24-OIR-03: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=24-OIR-03

Energy Data Analysis Program

- Home Page: https://www.energy.ca.gov/programs-and-topics/programs/energy-data-analysis-program-edap
- edap@energy.ca.gov for general info or to start the process for becoming an Agent or starting a project under EDAP.

Thank You

Data Analytics to Support Building Efficiency and Electrification

CEC Data Workshop
6/16/26

Ram Narayanamurthy

Program Manager – California Energy Commission, Efficiency Division

Heat pump bill impacts: State of knowledge

- More than 20 studies on heat pump bill impacts for California
- Most studies based on energy modeling, not bill analysis
- Studies vary with models used for both heating and cooling load calculations and assumptions for energy rates
  - Most used models: Restock, EnergyPlus, CBECC
  - Rate assumptions: Highly varied from statewide average to local time varying rates
  - Energy use calculation: Annual or heating only
  - Whole home or only HVAC or Water heating analysis
  - Papers include publications by National labs such as NLR, RMI, Rewiring America, Harvard University, CA IOU Codes and Standards, etc.

Analysis of studies and publications

Papers vary with input data such as rate information and model used.

Table 6: Rate Information Used in Study Before Heat Pump Retrofit

Article or Study	Time-of-Use	Tiered	Flat Rate	Average (state or national)	Discounted	Bundled (volumetric and fixed charge)	No rate information provided
Bill Impacts of Home Electrification Across the Bay Area	X						
Bill Impacts of Decarbonizing Existing Single-Family Homes	X					X	
Bill Impacts of Home Electrification	X						
Heat Pumps Can Lower Energy Bills for Californians Today	X		X				
The Customer Bill Impacts of Efficient Building Electrification		X					
Impacts of Household Electrification on Energy Affordability in Los Angeles	X	X					
				X		X	
	X						

Table 1: Categorization of Studies

Analytical Approach	Studies Included
Model	Dunlap (2025), Mahone (2019), Miller (2024), Moe (2023), Mustacich (2023), Shea (2025), Shen (2025), Sumawan (2024), Wilson (2024)
Field Study	Fountain (2019), Harrington (2025)
Hybrid	Mateo (2026), Mustacich (2025)
Engineering Calculation	Shafiee (2026)

Source: CEC staff analysis

Some papers do not use representative data (e.g., a one for heating value across the state), and should be de-emphasized

What is Interval Meter Data "IMD"?

- IMD or Interval Meter Data refers to meter data collected by utilities, including 15 minute electricity use and hourly gas use data
- CCR Title 20 Section 1353 (aka IMD or AMI)
  - Disaggregated, meter-level, billing and electric interval data
  - Reported quarterly by 6 largest CA utilities, 90 - 180 day lag, mid-2018 to present.
  - Billing-level data for all retail gas and electric meters
    - Bill charges, energy consumption, location, customer properties like rate schedule and NAICS
  - Interval readings for all smart electric meters in PG&E, SCE, SDG&E, and SMUD territories
    - Both electricity delivered and returned
    - Intervals reported at whatever granularity a meter collects (15-min, hourly)
  - Billions of billing records and over a trillion interval records

The Vision for IMD analysis

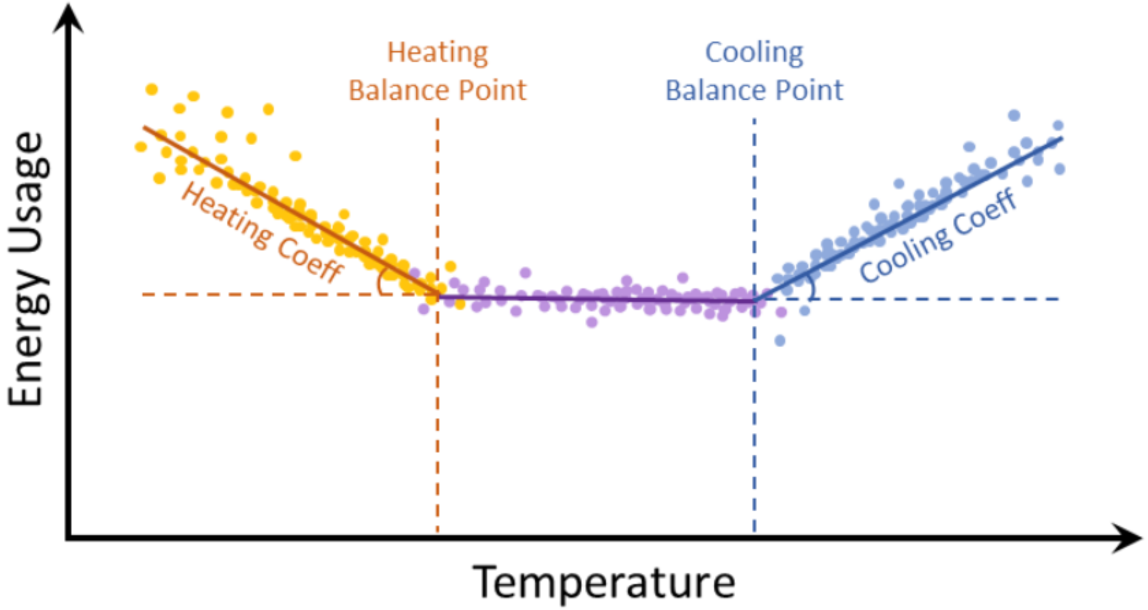
- **The Data Repository**
  - Reported quarterly by 6 largest CA utilities, mid-2018 to present at highest possible granularity - over a trillion interval records
- **What do we have today?**
  - CEC multi-divisional teams working group
  - Identified starter use cases including heat pump analysis and asset ratings
- **The larger vision**
  - Improve decision making and impact analysis using data
  - Create a statewide building database combining energy data, asset ratings and geospatial location data
  - Other uses such as EE program verification, code verification, distribution planning

The Future - Use Cases for AMI Data

1. Residential heat pump count
2. Enable verification of program information using geotagging
3. Energy bill savings from Energy Efficiency and Electrification
4. Energy code performance verification using measured performance to calibrate energy models
5. Benchmarking automation, verification and energy analysis
6. Home Energy Ratings and labelling
7. Distribution grid impact
8. Evaluation of demand flexibility potential

Use Case #1
Heat Pump Detection: Residential

- Problem Statement: **How can IMD be used to estimate the count of installed space heating heat pumps in California?**
- Potential Methodology:
  - Identify signature patterns in IMD that indicate electric heating.
  - Use weather normalized correlation of electric energy use in heating season to detect heat pumps vs. electric heating.



Use Case #2: Program Verification using geotagging

- Problem Statement: **Use geospatial tagging to improves matching program and IMD data sets**
- Methodology:
  - Establish a unique building identifier (UBID)
  - Overcome address matching issues that stymie analysis
  - Examples:
    - Validating HP bill impacts by matching permit data with geotagged IMD data

Use Case #3: Automate Benchmarking

- Problem Statement:

Can IMD be used as the primary source of energy data for the Benchmarking Program?

- Potential Methodology:
  - Assign geospatial features to IMD addresses; add to IMD.
  - Align Benchmarking with IMD through geospatial features.
  - For identified buildings within IMD > 50k sf GFA, capture monthly energy use.
  - Monthly, county batch download of energy datasets to be used within CEC.

Use Case #4: Verify Accuracy of Benchmarking Energy Reports

- Problem Statement:

Are the energy reports submitted by building owners accurate?

- Potential Methodology:
  - Assign geospatial features to IMD addresses; add to IMD.
  - Align Benchmarking with IMD through geospatial features.
  - Adjusting for error, identify buildings where self-reported energy use is significantly different from measured.

Use Case #5: Energy Code compliance

- Problem Statement: **How do new buildings perform compared to their Title24 predicted energy use?**
- Potential Methodology:
  - Detect buildings with IMD data that only started reporting in the last 2 years.
  - Can leverage Benchmarking data to conduct compliance verification.
  - Query permit database to get CF1R results.
  - Compare actual vs. predicted energy performance and analyze by building type to look at compliance with energy code.

Use Case #6: Home Energy Rating and Labeling

- Problem Statement: **How can IMD be used to improve accuracy of building energy modeling? Goal is to create a reliable asset rating system that is scalable.**
- Potential Methodology:
  - Collect available building assessors' data and permit data with information on homes' characteristics.
  - Apply standards for occupant behavior.
  - Run BEMs, then apply IMD learning methodology to improve confidence of the models.
  - Generate energy asset rating and label.

Thank You!

RECURVE

Bill Impact and Forecasting Methods

Using Measured Results to Improve Outcomes

Adam Scheer

June 16, 2026

OpenDSM Purpose

1. **Establish open source"weights and measures" for demand side programs**

2. **Enable demand side programs to compete at scale, *including against supply side options***

3. **Remove evaluation barriers to integrated programs**

LF ENERGY

OpenDSM Timeline

2015
CA adopts "existing conditions baseline" policies[1]

2016
CalTRACK 1.0 and OpenEEmeter:
- Monthly Methods
- Daily Methods

2017
CalTRACK 2.0:
- Hourly Methods

2019
OpenEEmeter donated to LFE as open source project

2020
CalTRACK incorporated into DOE GRIDmeter comparison group methods

2020
CalTRACK only method cited in CPUC NMEC Rulebook

2022
CalTRACK incorporated into CAISO Demand Response methods

2024
Enhanced OpenEEmeter Daily Methods

2024
OpenEEmeter approved by DOE for IRA programs

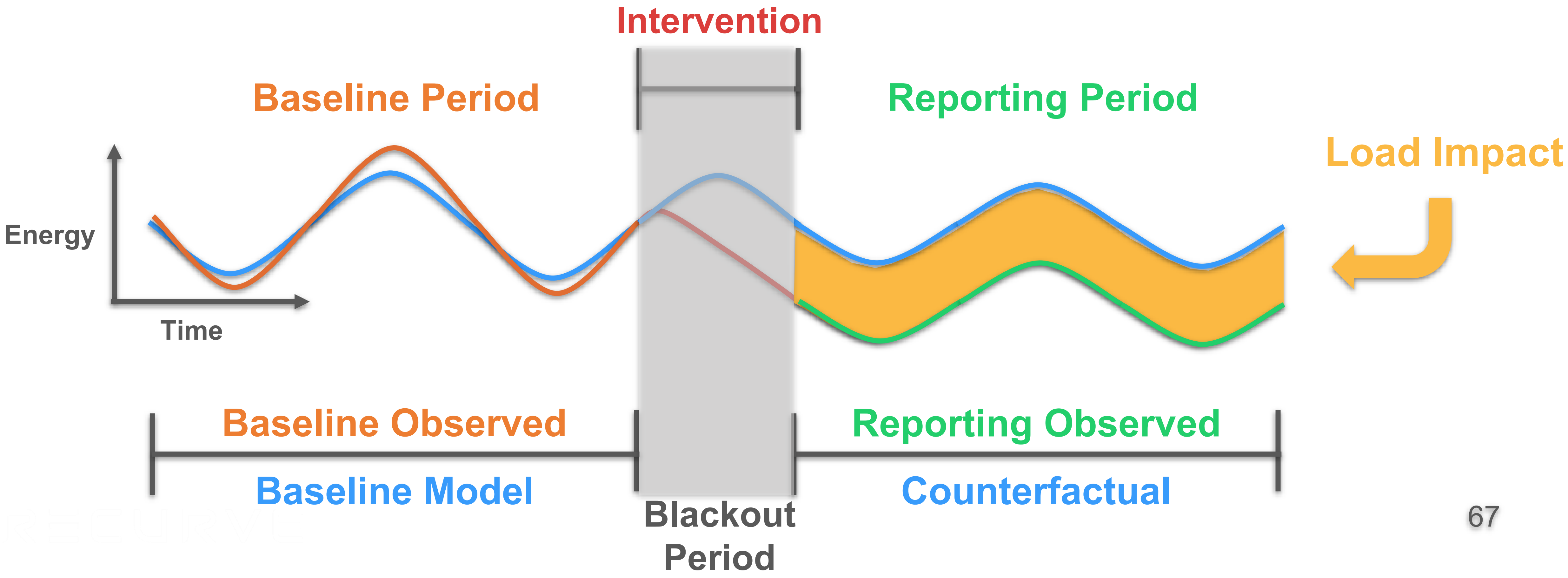
2025
Release of OpenDSM, including revamped hourly model

[1]Including:
- AB 802
- SB 350
- CPUC HOPPS Ruling

Elements of OpenDSM Load Impacts Calculation

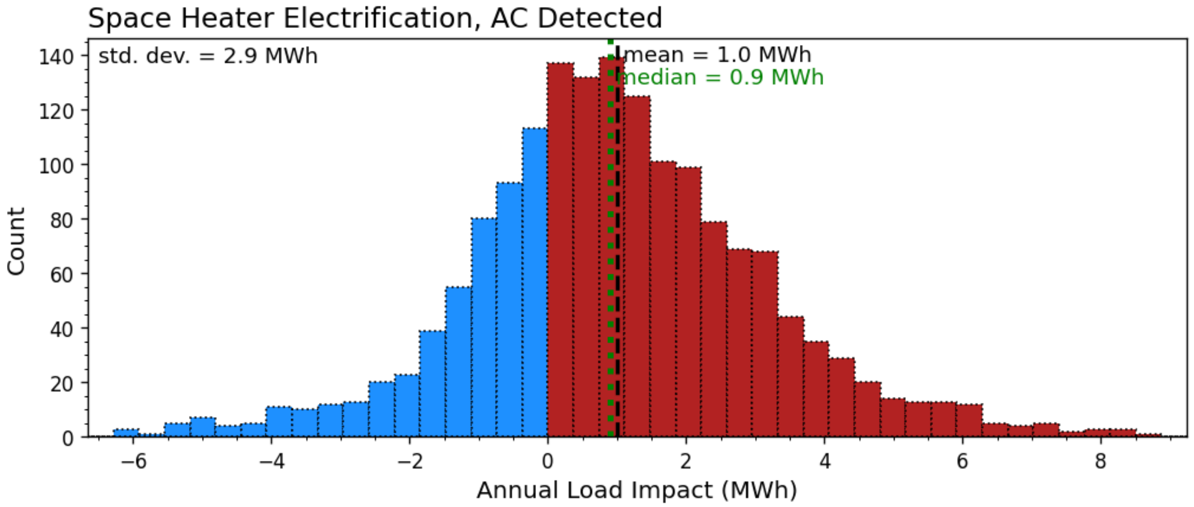
LF ENERGY OPENDSM

Meter-Level Results

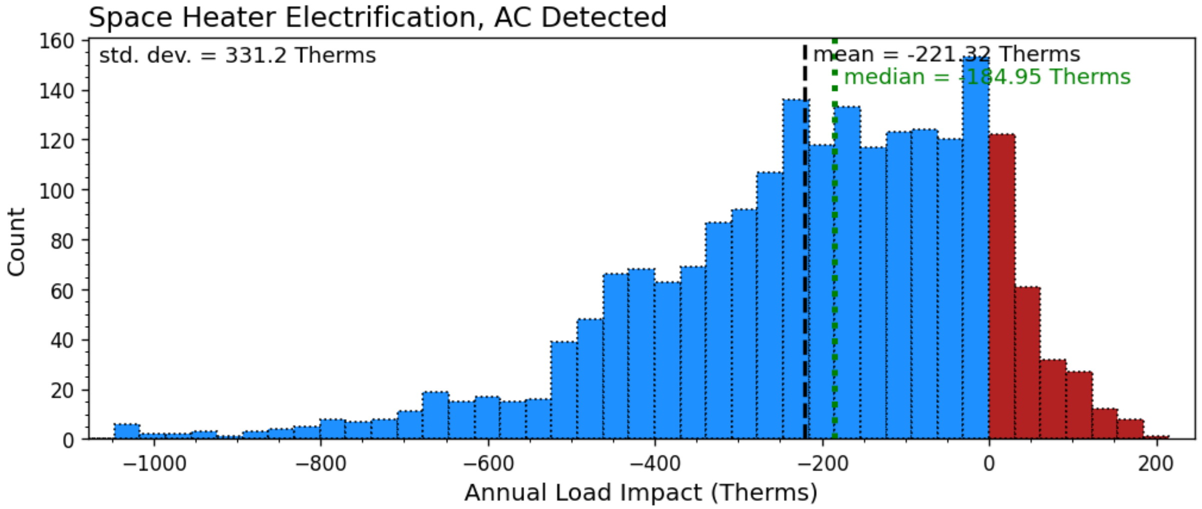


Example: Measured Heat Pump Load Impacts

Electric



Gas



Wide distributions of project-level results

Bill Impacts and Rate Analysis

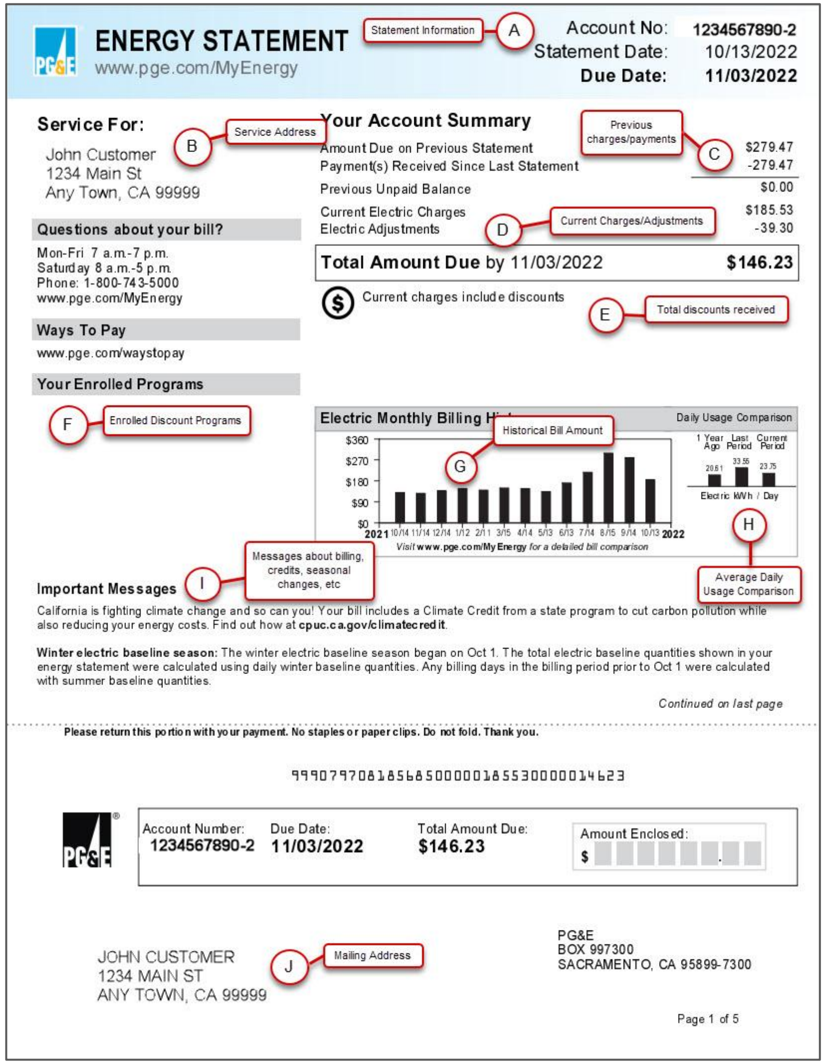
Recurve Bill Impacts Methodology

Using load impact measurements:

1. **Calculate *counterfactual* bill**
2. **Calculate observed bill**
3. **Observed - Counterfactual = Impact**

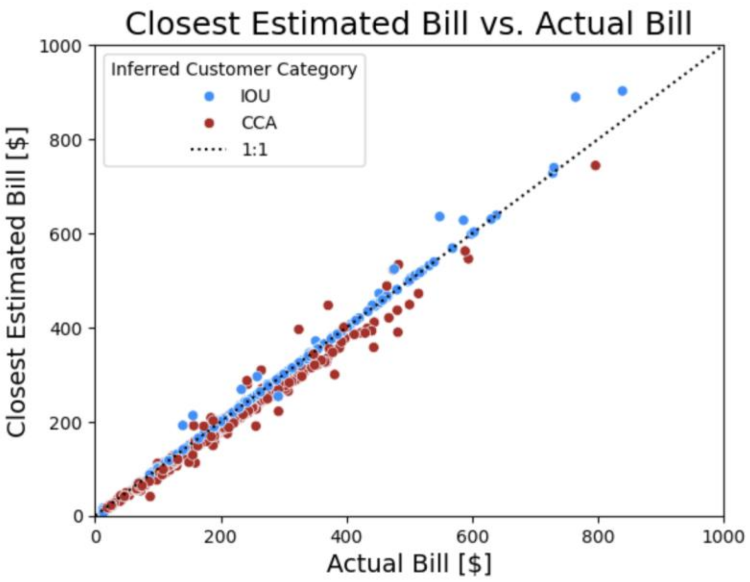
Our approach accounts for:

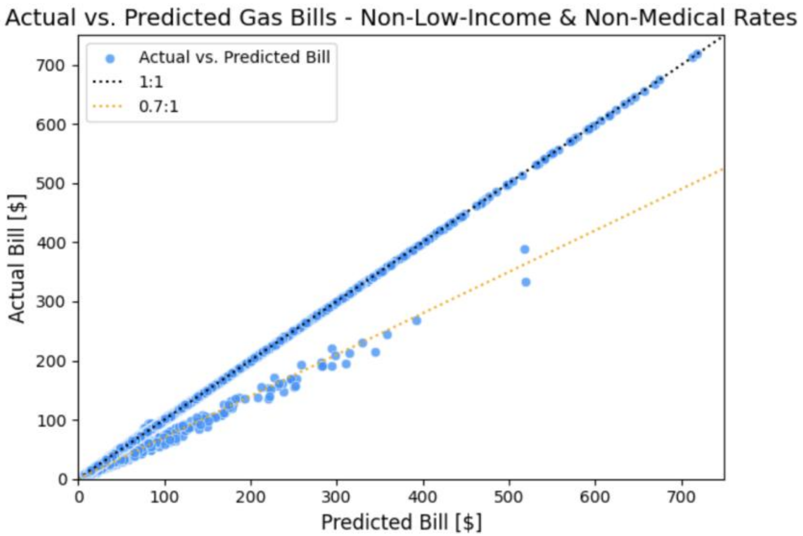
- **Specific customer rate schedule**
  - **Fixed vs volumetric rates etc.**
- **Baseline allowances**
- **CCA status**
- **NEM specificis**
- **Additional details**



Genability API to compute electric bills. In-house tool developed for gas bills

Validation Via Bill Replication





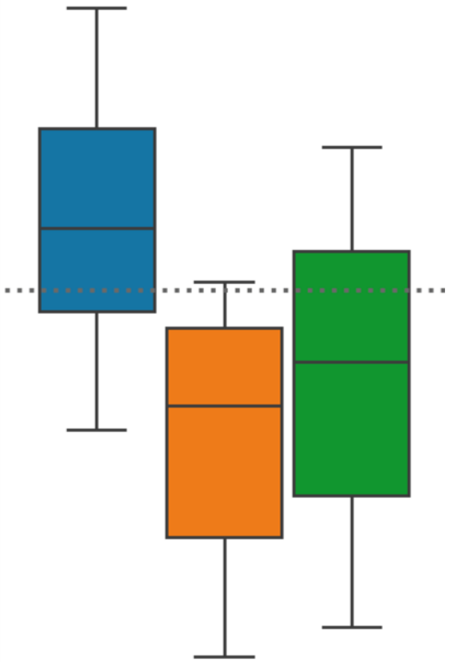
				Accuracy Metric	
Fuel	**Utility**	**Type**	**Bills Tested**	**Within 5%**	**Within $3**
Gas	PG&E	Market Rate	1,280	96.6%	100.0%
		Low Income	128	98.2%	98.4%
	SoCalGas	Market Rate	325	94.2%	93.9%
		Low Income	75	89.3%	94.7%
Electricity	PG&E	Market Rate	209	96.7%	72.3%
		Low Income	46	87.0%	84.8%
	SCE	Market Rate	351	89.7%	64.4%
		Low Income	96	86.5%	76.0%
	SMUD	Market Rate	173	82.7%	62.4%

> 80% successful replication of bills within 5% achieved across all electric and gas utilities and income segments.

Electrification Bill Impacts: A Primer

A customer gets a heat pump. What do we expect?

- The electric bill will go up. ⬆
- The gas bill will go down. ⬇



The critical question: What is the net impact?

How do we gauge this?

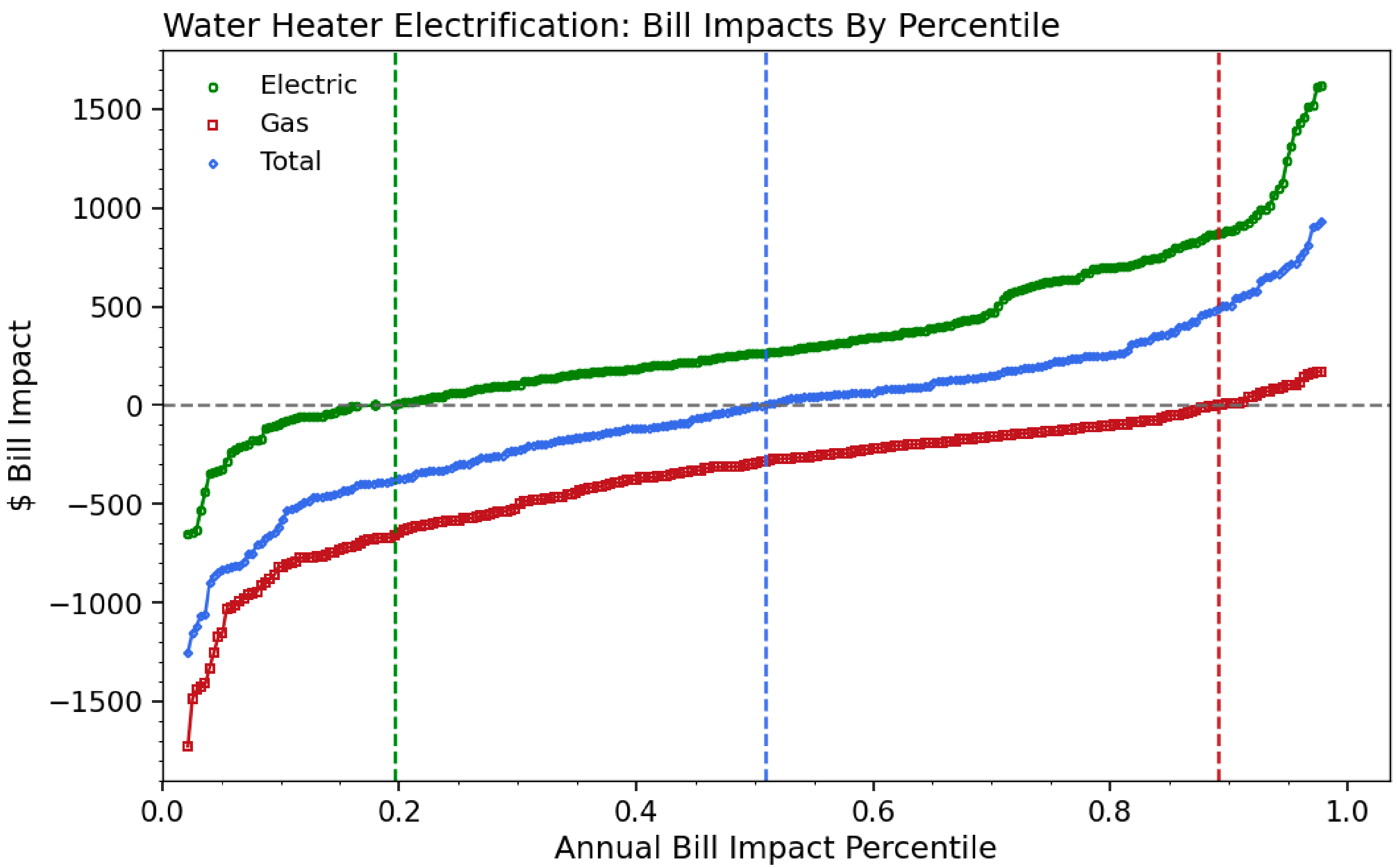
What are the drivers?

What can we recommend to the Program and for policymakers?

Bill Impacts: TECH Water Heaters

Water Heater Projects

- 80% have annual electric bill *increase*
- 89% have annual gas bill *reduction*
- 51% have annual total bill *reduction*

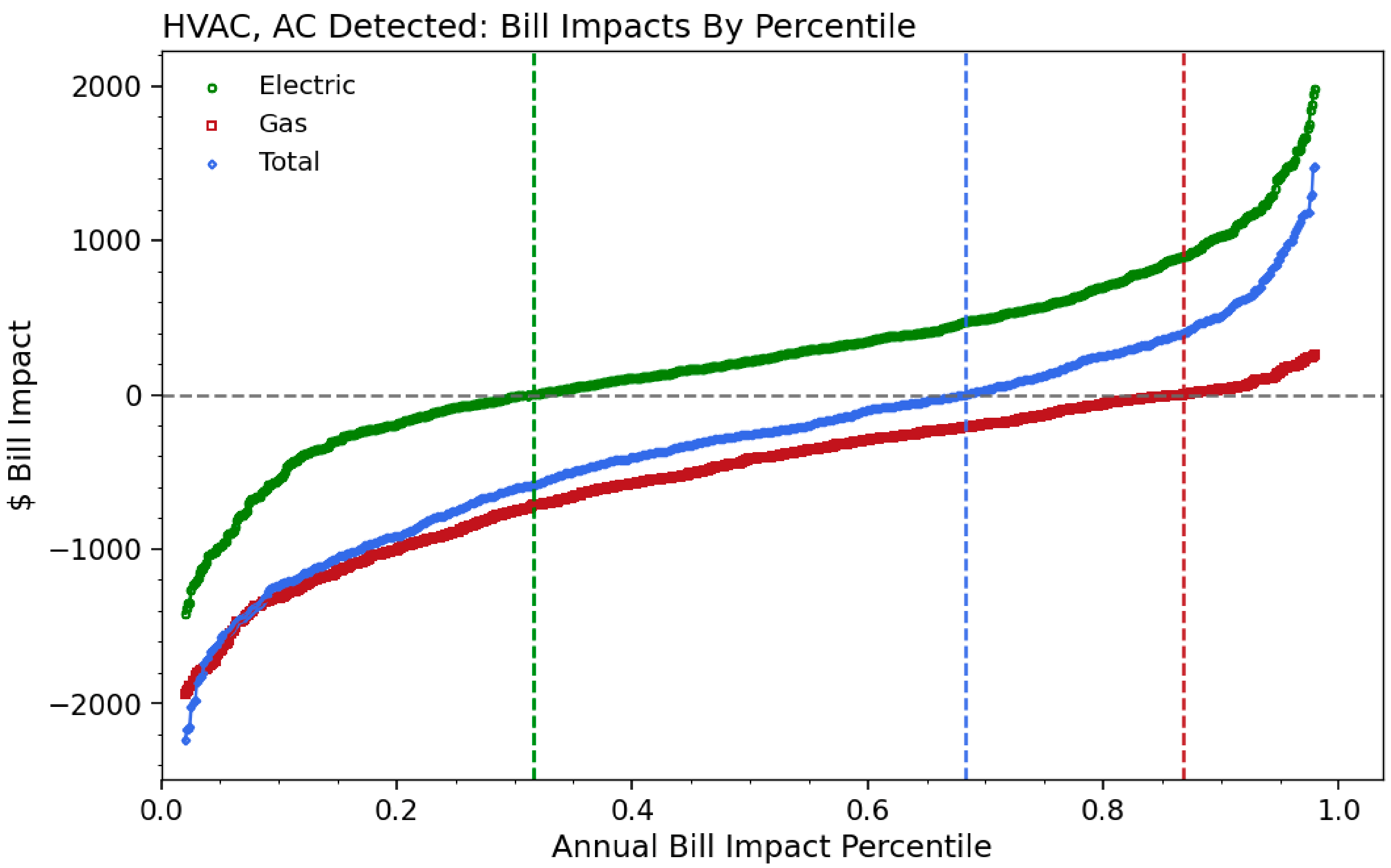


- **<u>Median</u> annual total bill reduction = $6**

Bill Impacts: HVAC, AC Detected

Water Heater Projects

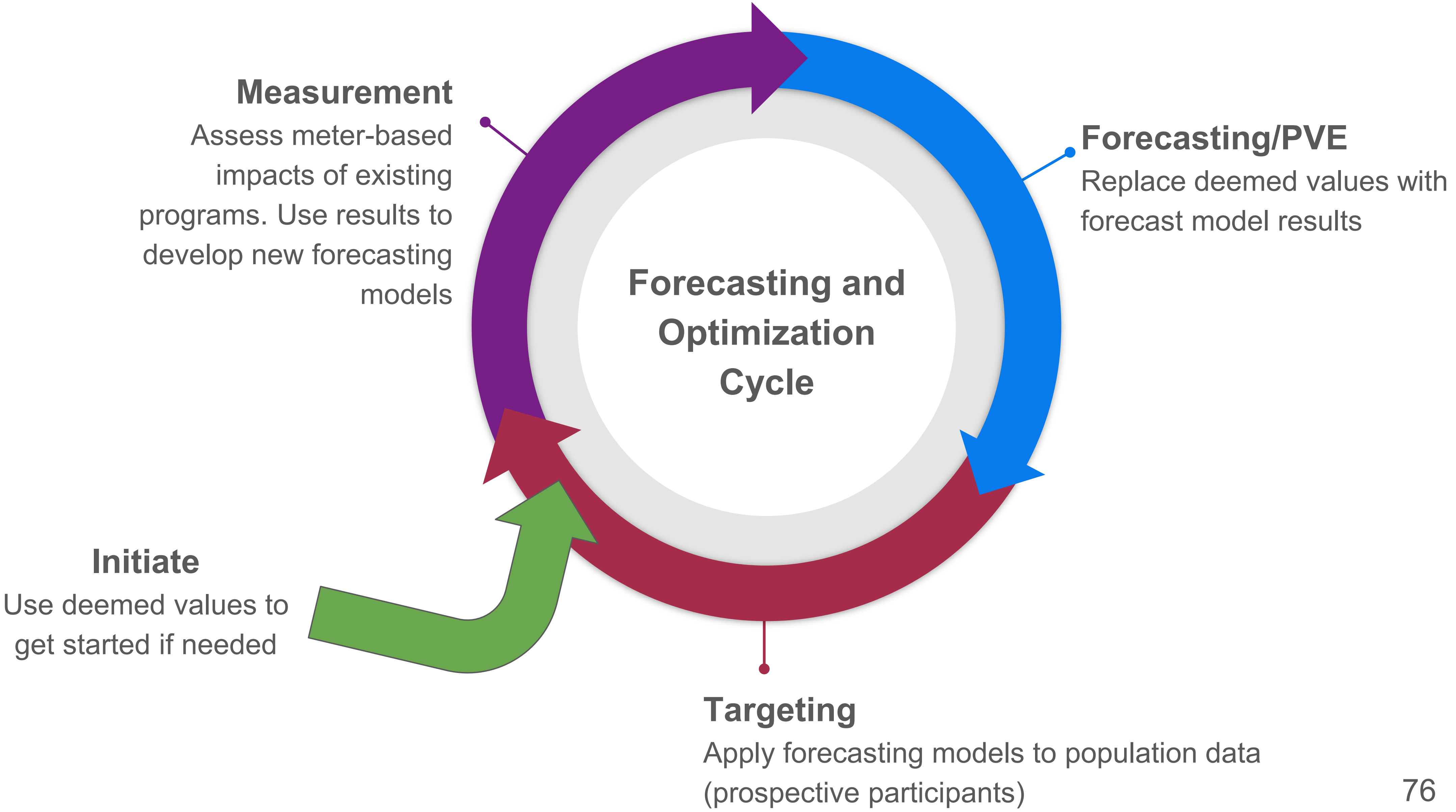
- 67% have annual electric bill *increase*
- 83% have annual gas bill *reduction*
- 67% have annual total bill *reduction*



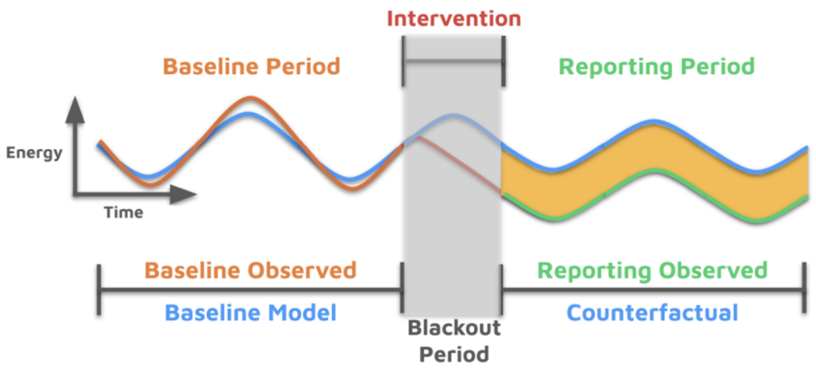
- **<u>Median</u> annual total bill reduction = $260**

Measurement-Based Forecasting

Recurve's Measurement-Based Forecasting Cycle



Forecasting Process



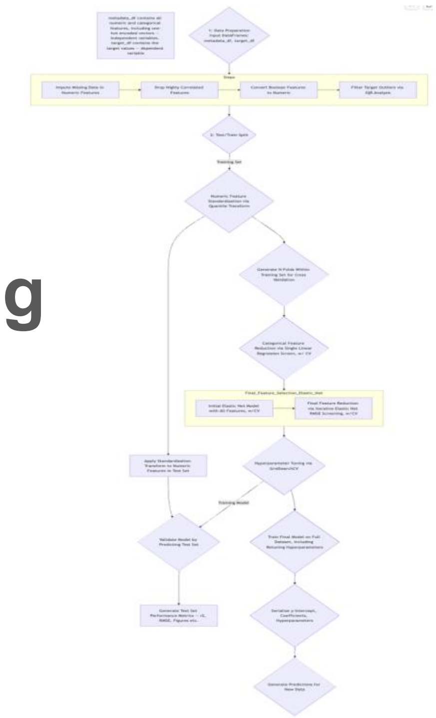
We *want* to predict:

Project-Level Impacts
- Electric
- Gas
- TSB
- GHG

We *use* to predict:

Targeting Features
- Load Disagg
- Usage Patterns

Customer Metadata
- Location
- Demographics

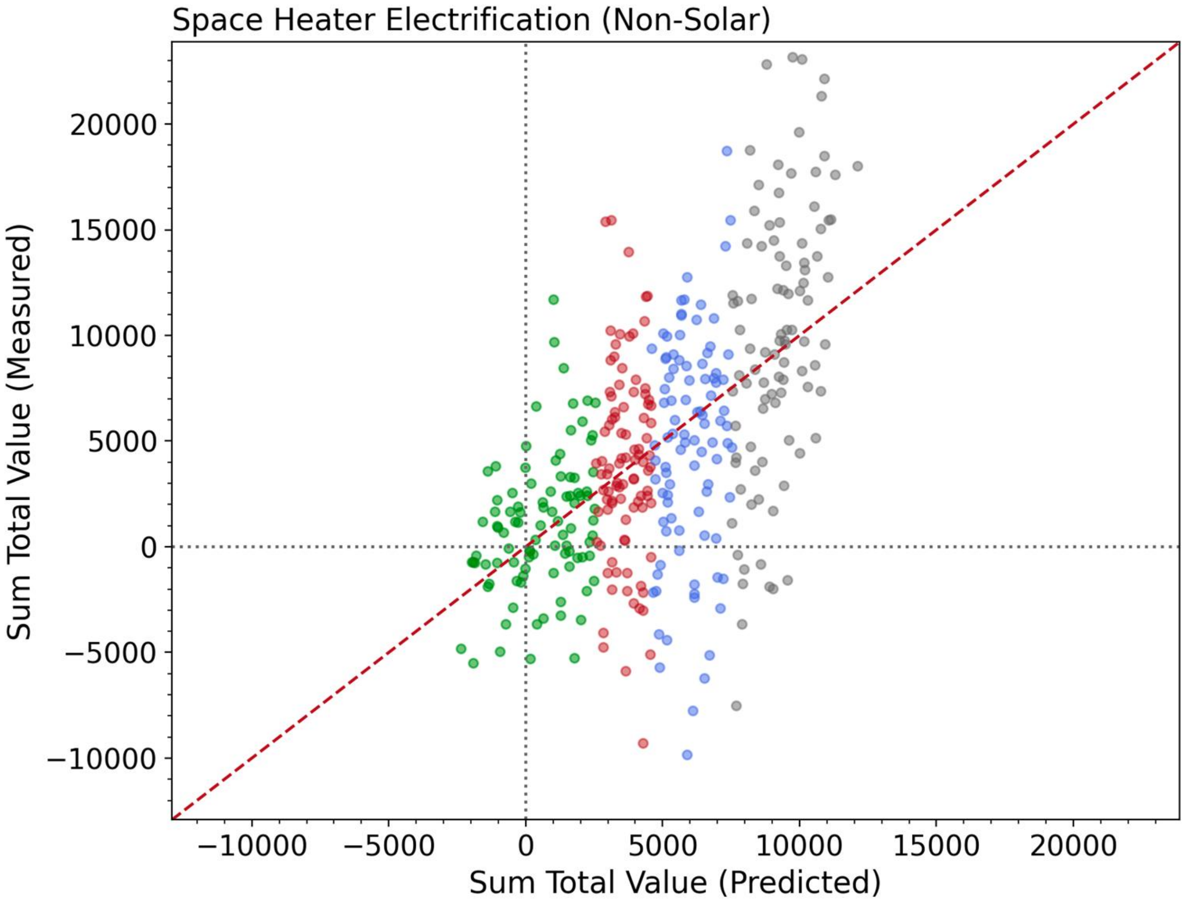


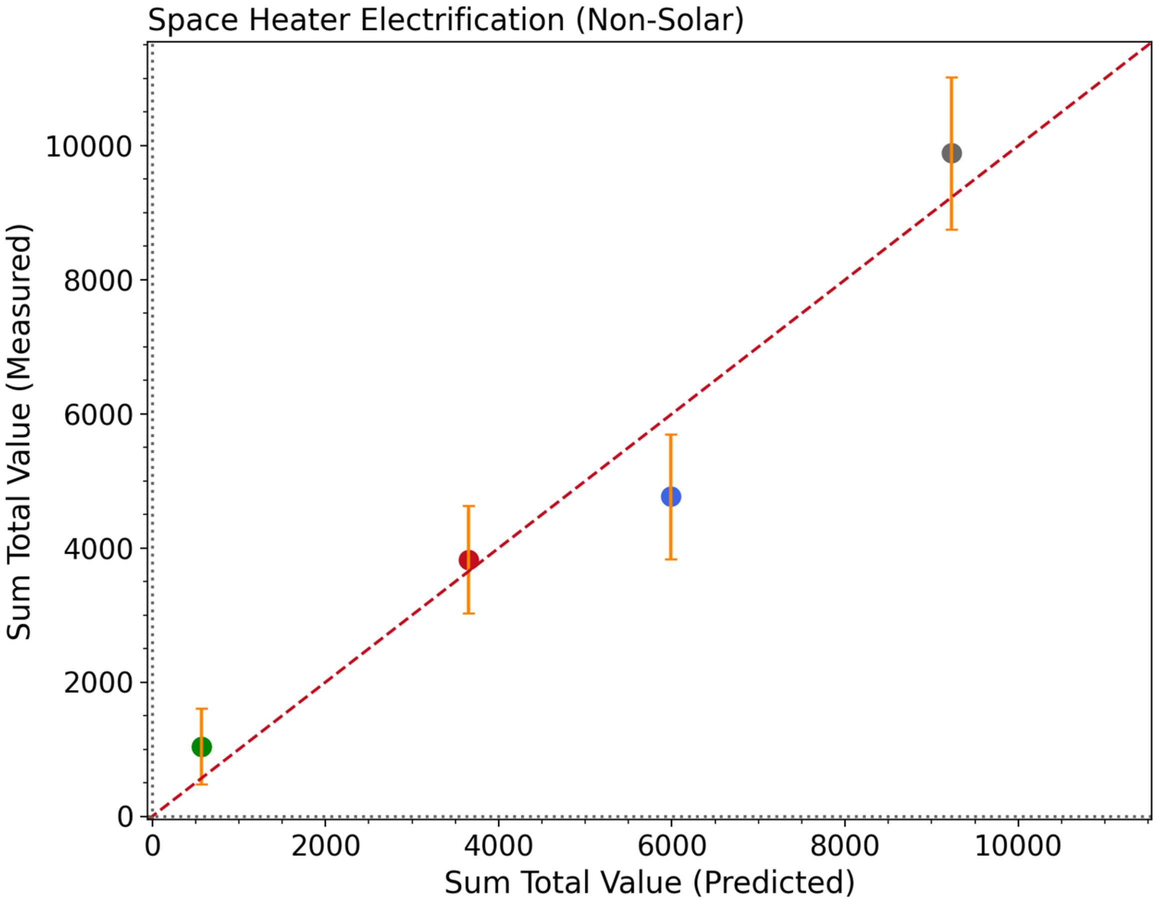
Machine Learning Pipeline

Predict Metrics for *New* Projects

Example: Can we Forecast and Optimize Heat Pump TSB?

HVAC Electrification Test Set





Top 1/4 of customers by forecasted prediction deliver > 3.2x TSB vs bottom 3/4.

Forecasting for Holistic Optimization

Not All Electrification Objectives are Well Aligned

Correlations between objectives based on measured results and customer data:

Correlation Matrix	Low Income	HTR County	Disadvant. Comm.	GHG Savings	TSB	Annual Bill Savings
Peak MWh Savings	-0.02	0.16	0.02	0.10	0.51	0.54
Annual Bill Savings	-0.02	0.14	0.06	0.39	0.68	
TSB	-0.09	0.11	-0.06	0.88		
GHG Savings	-0.12	0.04	-0.11			
Disadvant. Comm.	0.24	0.28				
HTR County	0.13					

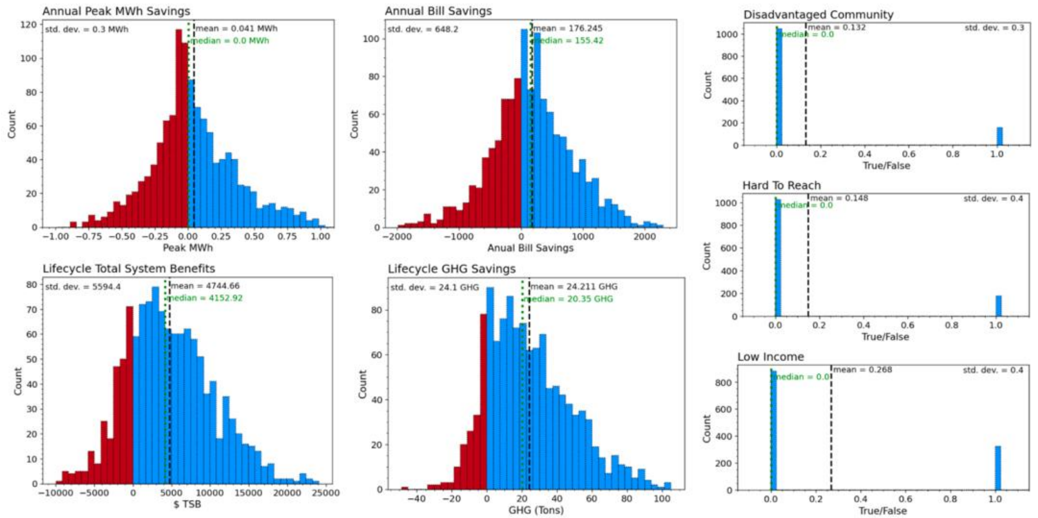
What if…forecasting could balance diverse program objectives?

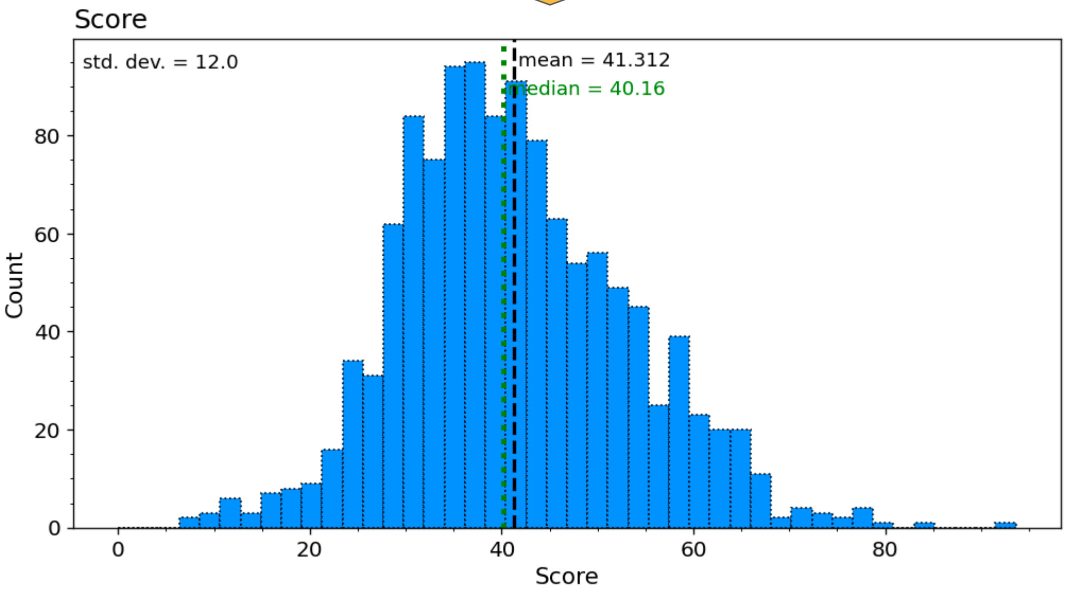
If you had 100 pennies to spread across your program’s goals, where would you put them?

Objective
Maximize GHG emissions reductions
Serve low income customers
Maximize system benefits
Serve hard-to-reach (HTR) areas
Maximize customer bill savings
Maximize peak period savings
Serve disadvantaged communities

The Electrification Potential Score

Objective	Weight
Maximize GHG emissions reductions	10
Serve low income customers	7.5
Maximize system benefits	20
Serve hard-to-reach (HTR) areas	7.5
Maximize customer bill savings	23.75
Maximize peak period savings	23.75
Serve disadvantaged communities	7.5





Every customer is assigned a *score* that reflects their ability to achieve the holistic combination of program goals.

A Clear Path to Program Optimization

Every metric is significantly improved among high scoring customers

Predicted Score Bin	Predicted Score	Measured Score	Peak MWh Savings	Annual Bill Savings ($)	TSB ($)	GHG Savings (Tons CO_2)	Disadvant. Comm.	HTR County	Low Income
1	31.07	32.53	-0.115	-$88	$2,618	18.58	0.0%	0.0%	5.5%
2	36.85	37.76	0.007	$226	$4,508	22.91	1.1%	0.0%	12.2%
3	42.73	43.43	0.102	$266	$5,733	27.64	15.6%	4.4%	34.4%
4	51.48	54.57	0.244	$556	$7,865	32.98	37.4%	50.5%	47.3%

Low Score

High Score

Top quartile vs bottom quartile projects

- Yield $556 annual bill savings vs $88 bill increase
- 3X higher TSB
- 78% higher GHG savings
- Much higher participation among all equity populations

The Next Million Heat Pumps

If we can shift 10% of projects from the bottom quartile of electrification potential to the top, we will achieve *$525 Million* higher TSB and save low income customers an additional *$20 Million* annually on their energy bills.

The EBD Electrification Potential Score

The EBD Electrification Potential Score

50 pennies for bill savings

50 pennies for GHG savings

Top Quartile Customers

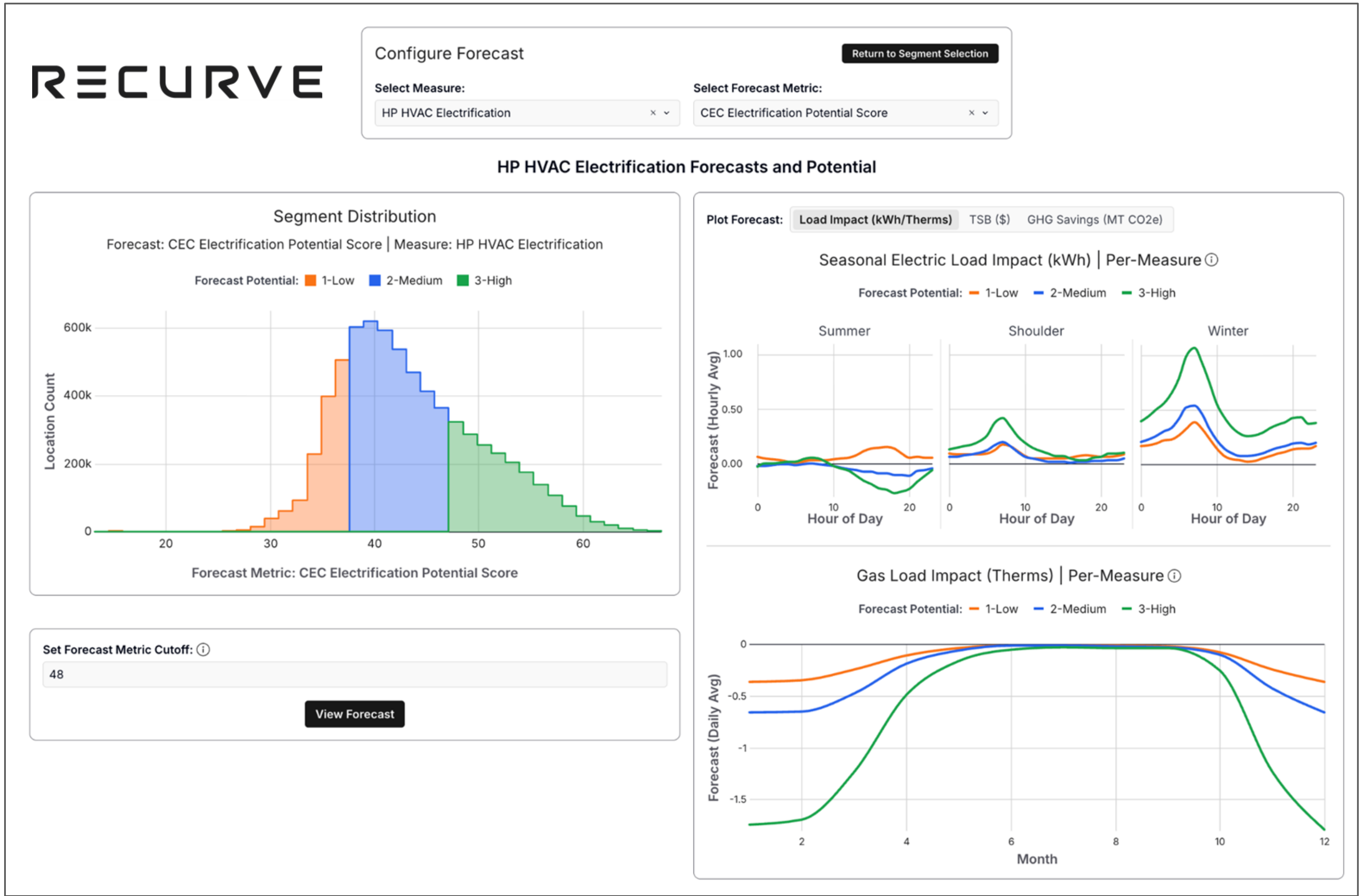
Annual Bill Savings:

$340 vs -$60

GHG Savings:

32 Tons vs 9 Tons

Measurement-Based Forecasting Dashboard



Break

Complexities of Residential Electrification: The Customer's Perspective

Real World Examples from PG&E customers

Lisa Schmidt, Lisa@hea.com

Introduction

- Home Energy Analytics

Founded in 2011 to help people reduce the energy used in their homes. The widespread introduction of smart meters enabled a whole new way to analyze residential energy use.

- Smart Audit

AMI data analysis web app developed by HEA. First deployed in 2012 in several Bay Area cities including Mountain View

- HomeIntel

P4P residential energy efficient program for PG&E customers. Started in 2017. Smart Audit plus access to a personal energy coach.

Electrification is Complex

Most people aren't armed with the tools to make it happen.

- What appliances in what order?
- Incentives?
- Contractors?
- Panel capacity?
- Optimum rate plan?
- Load shifting?
- Settings/commissioning?

More Data Enables a Better Outcome

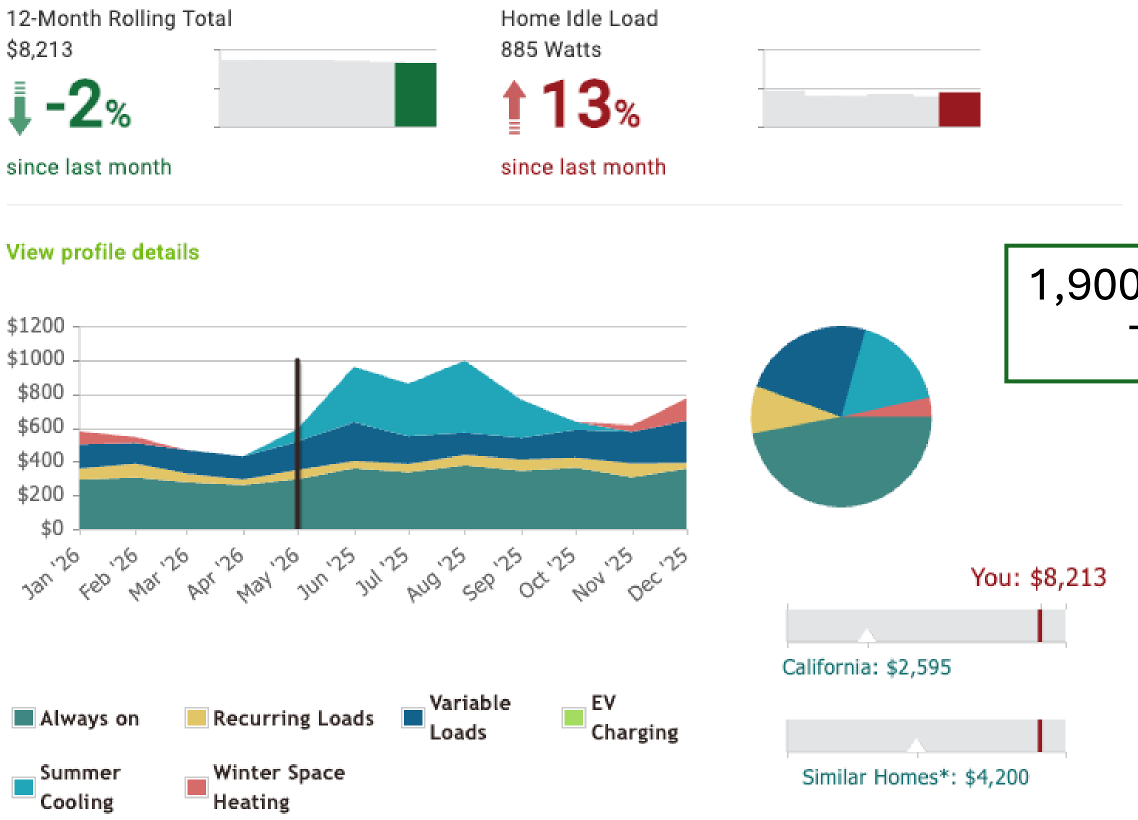
Customer Steps

1. Understand how energy is currently used in your home
2. Understand the impact of electrifying
   - HVAC
   - Water heating
   - Cooking & Clothes Drying
   - Other?
3. Understand the cost of electrifying
   - Panel upgrade required? (using NEC 220.87)
   - How to find incentives & a qualified contractor
4. Optimize rate plan and TOU for maximum dollar savings

Smart Audit analyzes. Energy Coach assists.

Step 1: Understand Existing Energy Use

- Smart Audit utilizes AMI data to analyze a home's energy use
  - Initially analyze at least 1 year of data
  - Continuously updates progress
- First released 2011
  - Added EV support
  - Added PV and battery support
  - Added electrification analysis
  - Added Spanish
- Key component of PG&E's HomeIntel program (join.hea.com)
- 100,000 homes analyzed



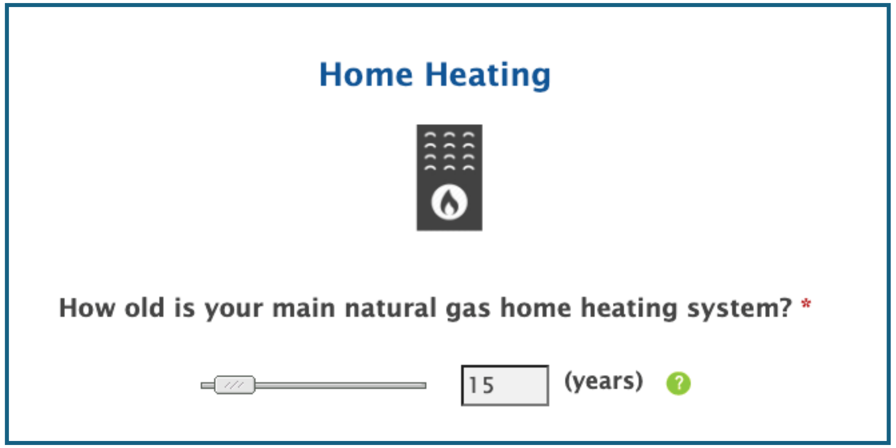
1,900 sqft. SFR
Tracy

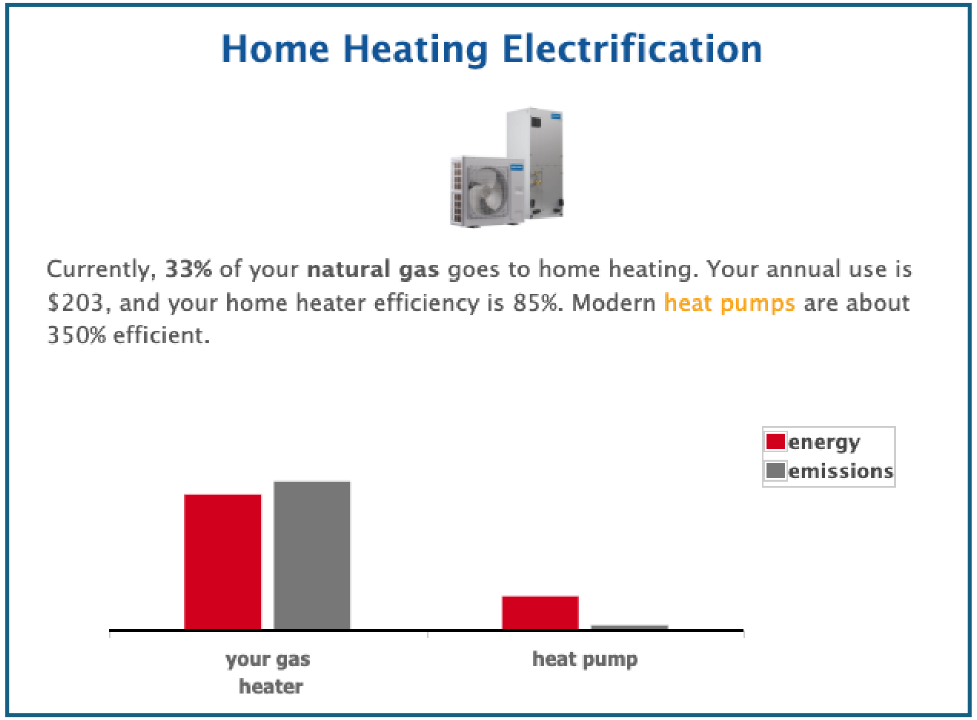
Every Home is Unique.

PP96915

HOME ENERGY ANALYTICS

Step 2: Understand the Impact of Electrifying





With a heat pump, your energy bill would cost $24 more per year.
If you switch to rate plan EV2, it would have cost you $15 less than current. If you also utilize pre-heating strategies during peak periods, it becomes $58 less than current.

PP96915

Step 2: Understand the Impact of Electrifying

HOME ENERGY ANALYTICS

Water Heating

Do you use a natural gas Water Heater?

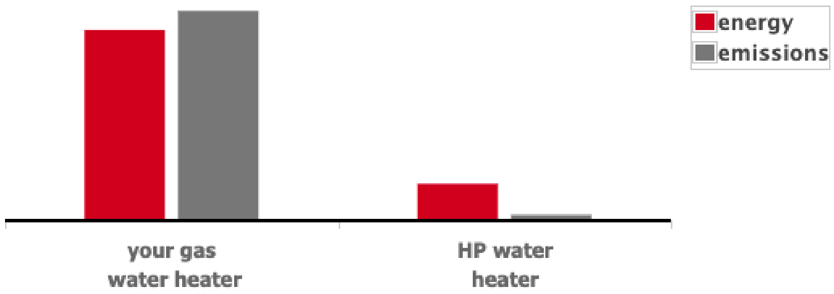
Yes

Input your water heater efficiency (if you know it) *

65 **(percent)**

Water Heating Electrification

Currently, **44.7%** of your **natural gas** goes to water heating. Your annual use is $274 and your water heater efficiency is 65%. Heat pump water heaters are about 350% efficient.



Electrification would reduce your energy use by 81% and carbon emissions by 98% (by 3,315 pounds to 66 pounds of CO_2e) every year.

With a new water heater, your energy bill would cost $40 less per year.
If you switch to rate plan EV2, it would have cost you $73 less than current. If you also avoid peak periods, it becomes $124 less than current.

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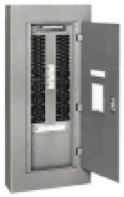
Step 2: Understand the Impact of Electrifying

Electric Panel Size



Looking up your panel size now avoids unnecessary hassle and costs later. In addition, if you enter your Panel Size below you'll get a chance to try a new Panel Wizard tool after you click Next.

It is very important to know your panel size before installing big new electric appliances.

My main electric panel size in Amps

100

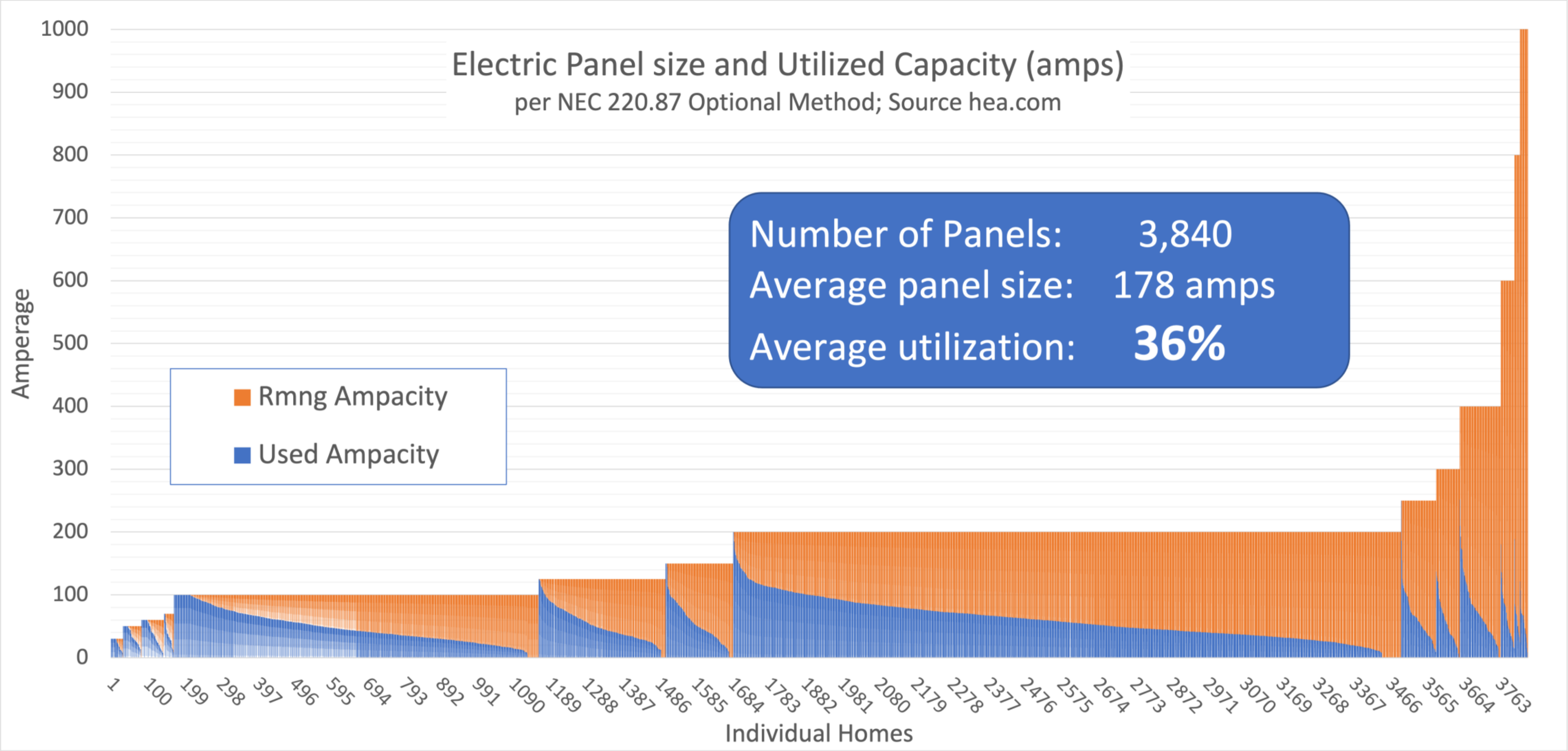
?

*Based on this panel size, we estimate you have **remaining electric panel capacity of 10.76 kW** (44.9 amps at 240 volts).*

PP96915

HOME ENERGY ANALYTICS

Panel Capacity normally NOT an Issue



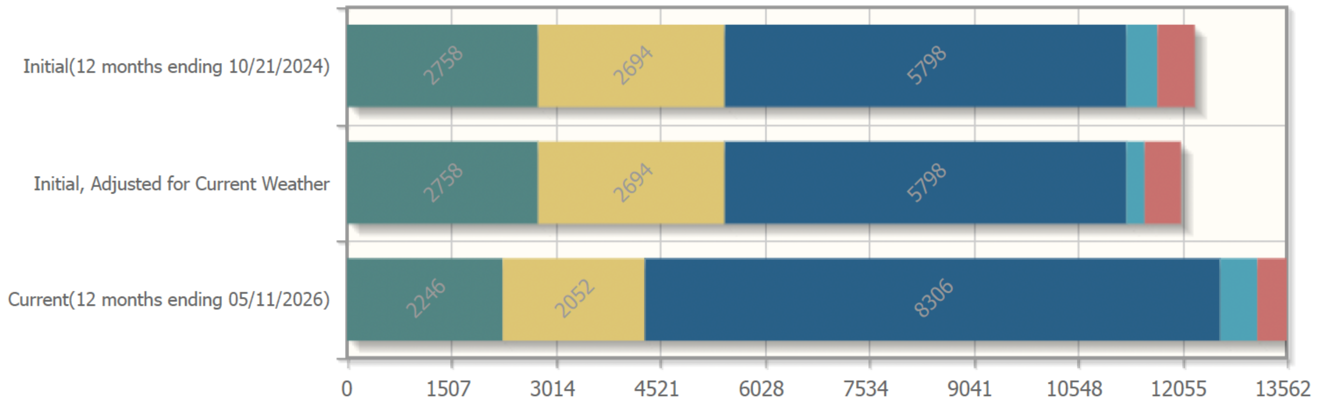
HOME ENERGY ANALYTICS

Electrification Example: Energy

- Progress tracked via AMI data
- Weather normalized
- Total energy use decreased in a vast majority of homes after electrification.

How has my Electricity Use changed? (in kWhs)

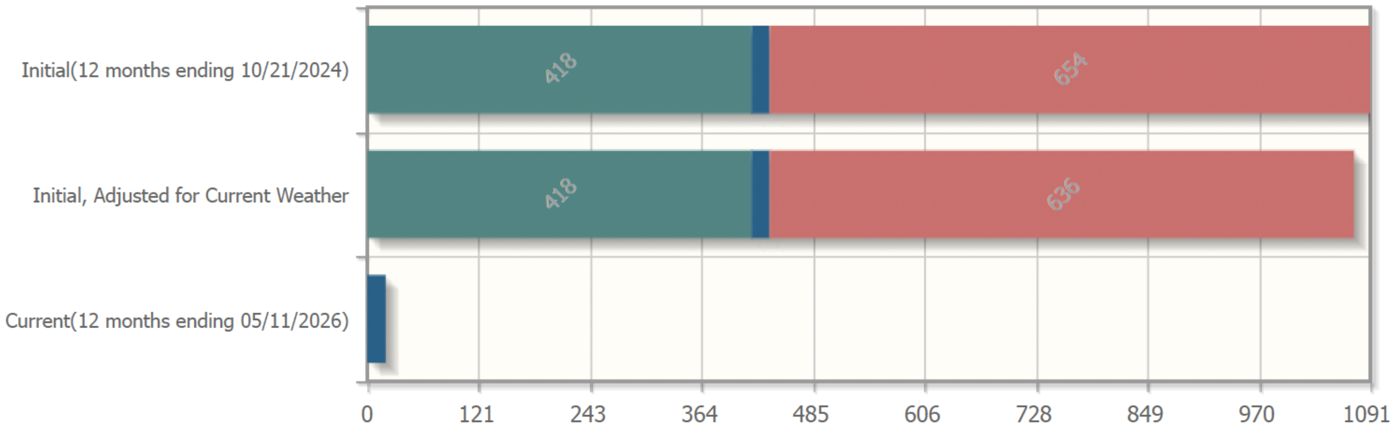
12 months electricity use in kWhs



Since 10/21/2024, on an absolute basis, your annual electricity use has gone up 1,325 kWhs (10%). Taking weather differences into account, your annual electricity use has gone up 1,525 kWhs (12%).

How has my Natural Gas Use changed? (in therms)

12 months gas use in therms



Since 10/21/2024, on an absolute basis, your annual natural gas use has gone down 958 therms (0%). Taking weather differences into account, your annual natural gas use has gone down 940 therms (0%).

HOME ENERGY ANALYTICS

Electrification Example: Cost

- Yearly bill is lower in this case
- Lowering bill may require changing rate plans and/or load shifting and/or efficiency actions
- Lots of variation in cost changes

Progress Report

[redacted]

May 2026

Report generated for PP54685 on June 08, 2026
A service provided by Home Energy Analytics Inc.

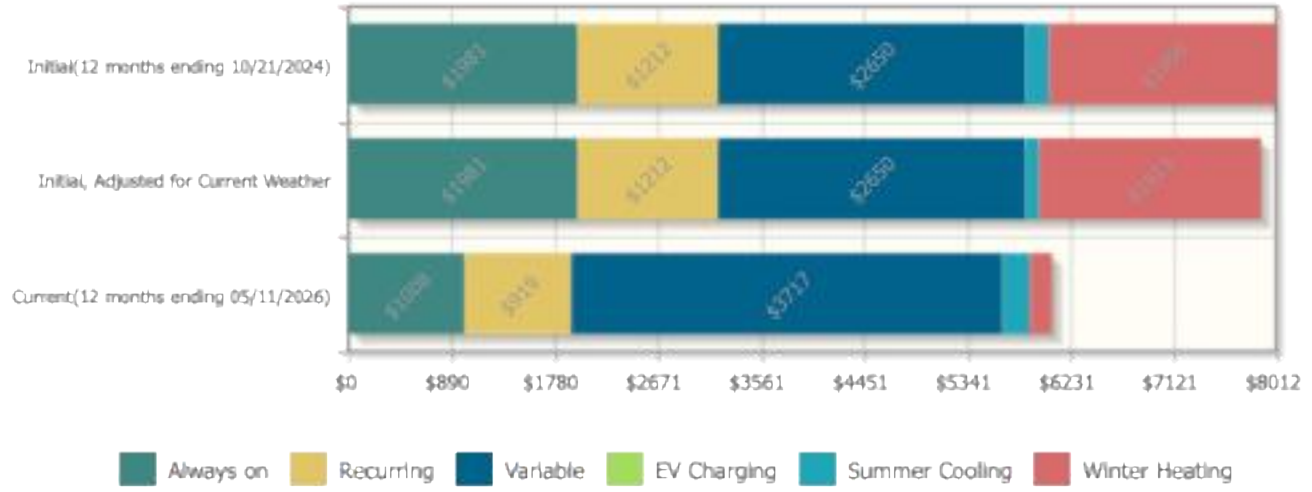
Household Summary

Number of Occupants:	5.0	Rent/Own:	Owner	Activation Date:	October 21, 2024
Type of Home:	Single Family	Size of Home:	4,102 sqft.	Year Home Was Built:	1983
Pool:	Yes	Fountain, pond, etc.:	No	Hot Tub/Spa:	No

How has my energy cost changed?

12 months energy cost

Each of the charts below compare information about your home across two different periods: (1) the Initial 12 month period just before you signed up for this service, and (2) the most recent 12 months.
Because both periods cover all seasons, we effectively "normalize" the two periods for variations caused by seasonal energy use. However, we also need to adjust for the different weather conditions (for example a particularly cold winter or one summer that was hotter than the next) so we also normalize the energy use for the initial period to match the weather of the most recent period.



Since 10/21/2024, on an absolute basis, your annual energy cost has gone down $1,941 (24%).
Taking weather differences into account, your annual energy cost has gone down $1,805 (22%).

Cost changes: Post electrification examples

Progress Report

[redacted]

May 2026

Report generated for PP81921 on June 08, 2026
A service provided by Home Energy Analytics Inc.

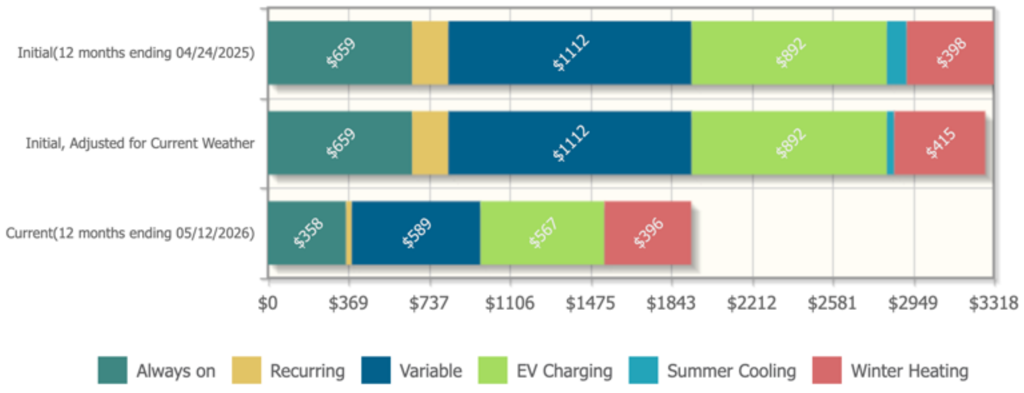
Household Summary

Number of Occupants:	3.0	Rent/Own:	Owner	Activation Date:	April 24, 2025
Type of Home:	Condo or Townhouse	Size of Home:	1,305 sqft.	Year Home Was Built:	1982
Pool:	No	Fountain, pond, etc.:	No	Hot Tub/Spa:	No

How has my energy cost changed?

12 months energy cost

Each of the charts below compare information about your home across two different periods: (1) the Initial 12 month period just before you signed up for this service, and (2) the most recent 12 months.
Because both periods cover all seasons, we effectively "normalize" the two periods for variations caused by seasonal energy use.
However, we also need to adjust for the different weather conditions (for example a particularly cold winter or one summer that was hotter than the next) so we also normalize the energy use for the initial period to match the weather of the most recent period.



Since 04/24/2025, on an absolute basis, your annual energy cost has gone down $1,276 (39%).
Taking weather differences into account, your annual energy cost has gone down $1,239 (38%).

Progress Report

[redacted]

June 2026

Report generated for PP66193 on June 09, 2026
A service provided by Home Energy Analytics Inc.

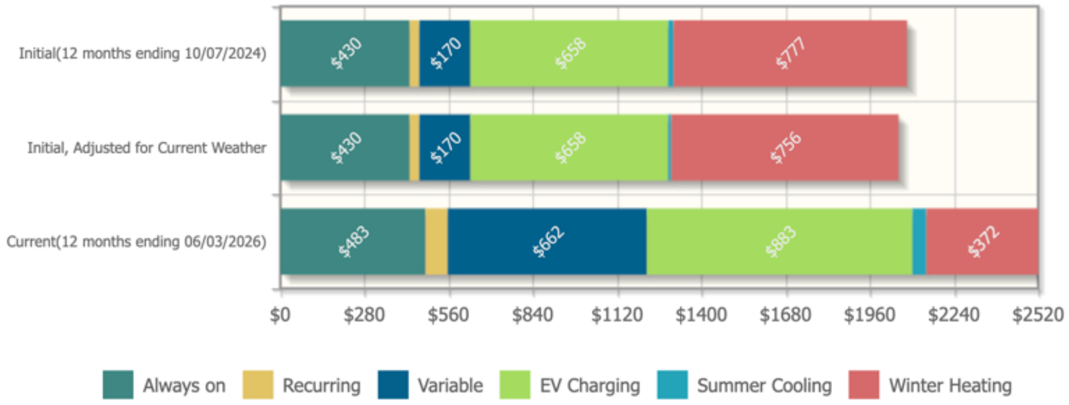
Household Summary

Number of Occupants:	3.0	Rent/Own:	Owner	Activation Date:	October 07, 2024
Type of Home:	Single Family	Size of Home:	1,806 sqft.	Year Home Was Built:	1956
Pool:	No	Fountain, pond, etc.:	No	Hot Tub/Spa:	No

How has my energy cost changed?

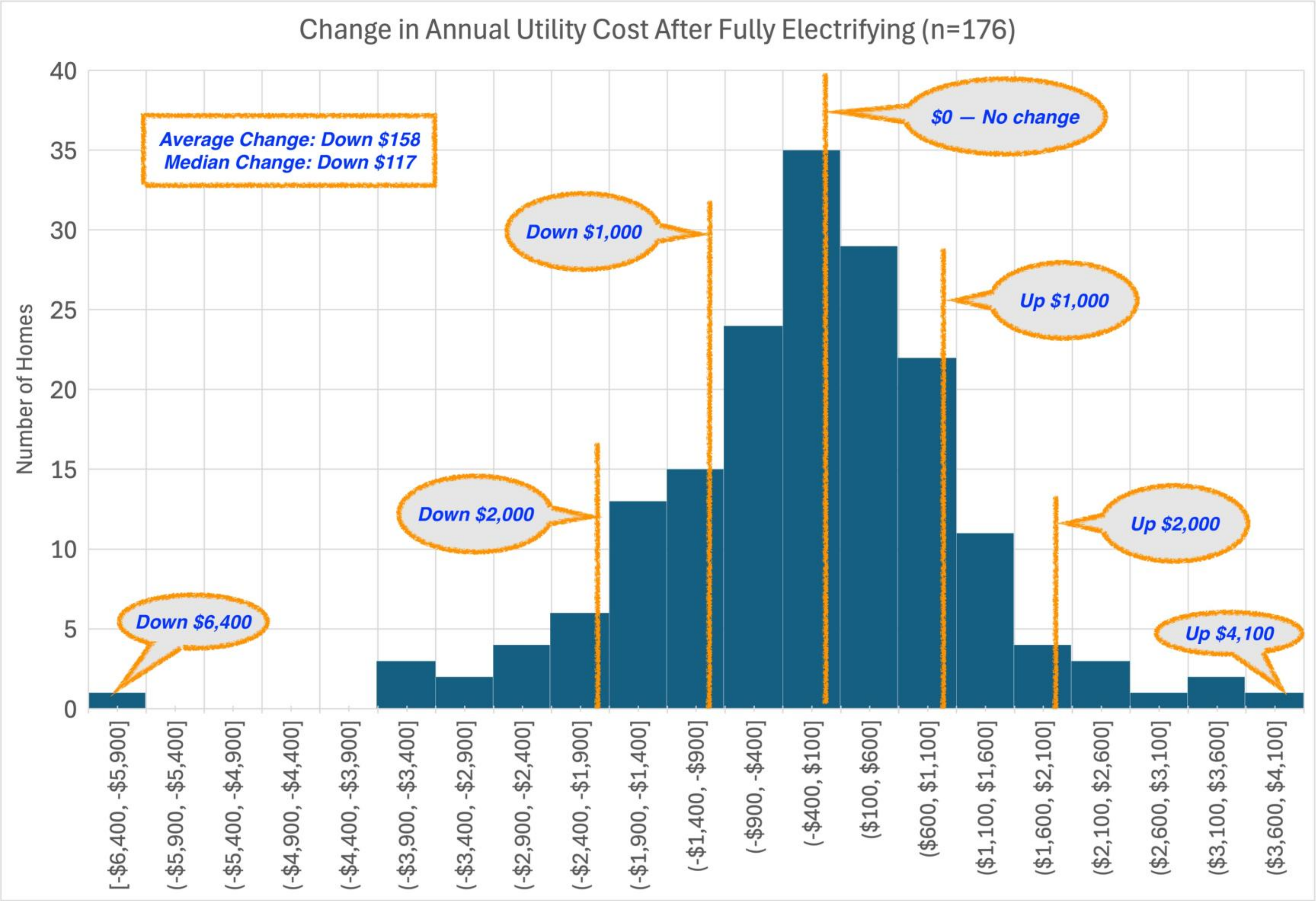
12 months energy cost

Each of the charts below compare information about your home across two different periods: (1) the Initial 12 month period just before you signed up for this service, and (2) the most recent 12 months.
Because both periods cover all seasons, we effectively "normalize" the two periods for variations caused by seasonal energy use.
However, we also need to adjust for the different weather conditions (for example a particularly cold winter or one summer that was hotter than the next) so we also normalize the energy use for the initial period to match the weather of the most recent period.



Since 10/07/2024, on an absolute basis, your annual energy cost has gone up $525 (26%).
Taking weather differences into account, your annual energy cost has gone up $554 (28%).

Post Electrification Cost Changes



SNUGGPRO™

FRANKLIN ENERGY™

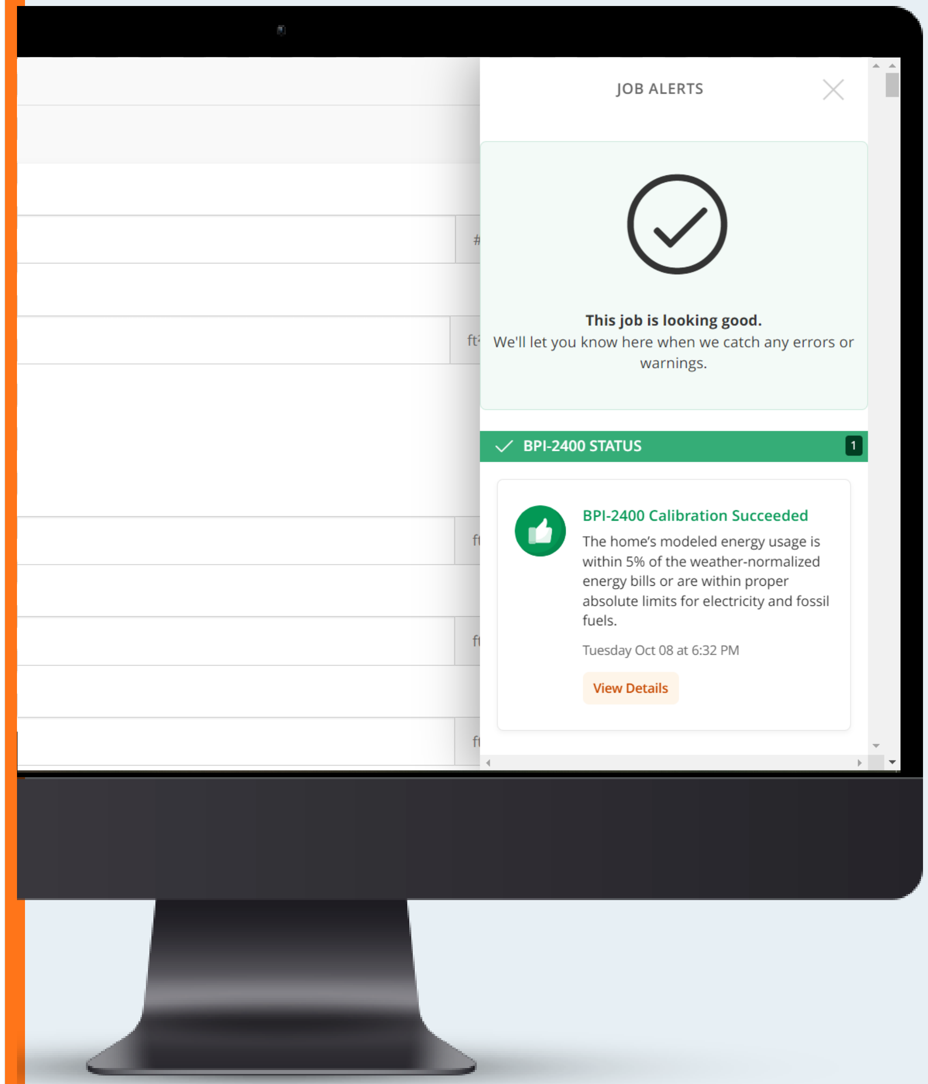
SNUGG PRO ENERGY MODELING

Rob Buchanan
Senior Building Performance Engineer
16 June 2026

SNUGGPRO™

Simplified Program Integration

AGENDA



1. Inputs & calibration
2. Modeling
3. Savings projections
    1. Results from a sample job

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Whole-Home Workflow Solution

Model Calibration

Collect 12 months historical energy data and weather normalize it

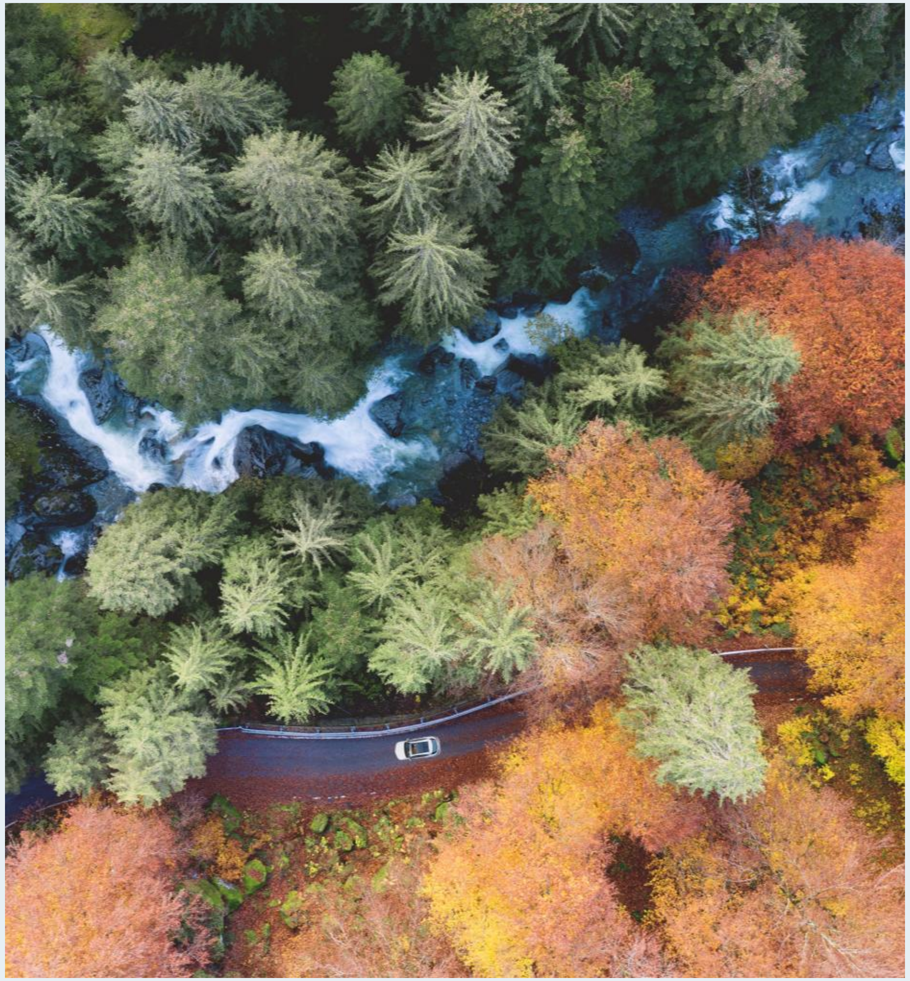
Collect data on the home

SNUGGPRO™

Adaptable Energy Support

Twelve months' usage

- 355 days usage history for all fuels, including secondary fuels



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Adaptable Energy Support

Collect data on the home

- Actual measurements
- Observation-based estimates

SNUGGPRO™

Adaptable Energy Support

Bring together usage and household data

Users utilize ranges for imprecise observations

Snugg Pro runs calibrates using a whole-building physics model against weather-normalized utility bills.

Use BPI-2400 calibration to ensure existing home’s features are reasonably precise

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Simplified Program Integration

Sample job

- 1939 Build
- 1000 sqft
- Fresno zip code
- Gas HVAC, water heat, and range

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Adaptable Energy Support

Calibration results

Calibration Results

Bias | Absolute

Fuel Type		Heating	Cooling	Baseload
Electricity	Detailed	0%	-20.66%	0.00%
Natural Gas	Simple	-0.66%	0%	-0.66%

Calibration Results

Bias | Absolute

Fuel Type		Heating	Cooling	Baseload
Electricity	Detailed	0 kWh	277.20 kWh	0.00 kWh
Natural Gas	Simple	1.58 therms	0 therms	1.96 therms

Modeling results

Calibrated input	Sample job
ACH50	4,120
Duct location	Unconditioned space
Duct insulation	None
Estimated duct LTO	6%
Wall insulation	R-0
Attic insulation	R-11

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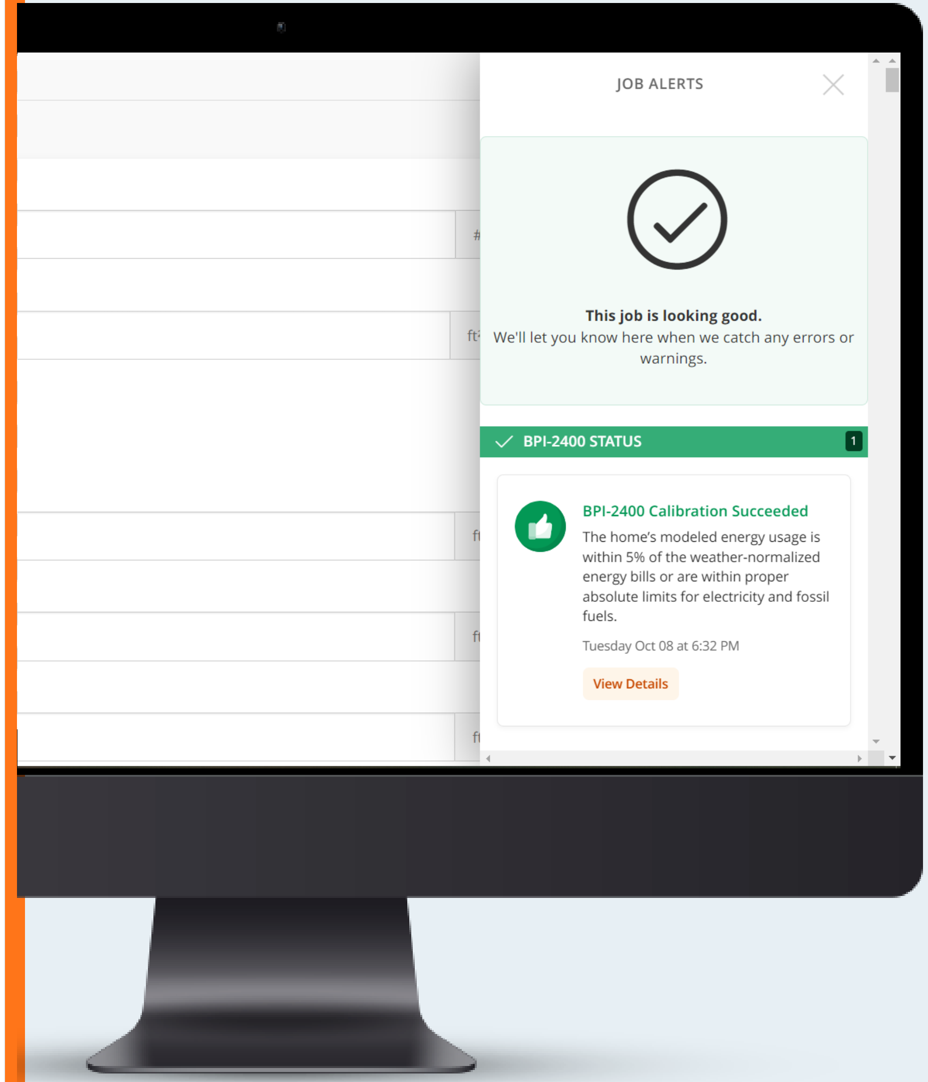
Simplified Program Integration

Propose improvements



Full electrification

- Attic & Wall insulation
- HVAC
- Water heat
- Induction range

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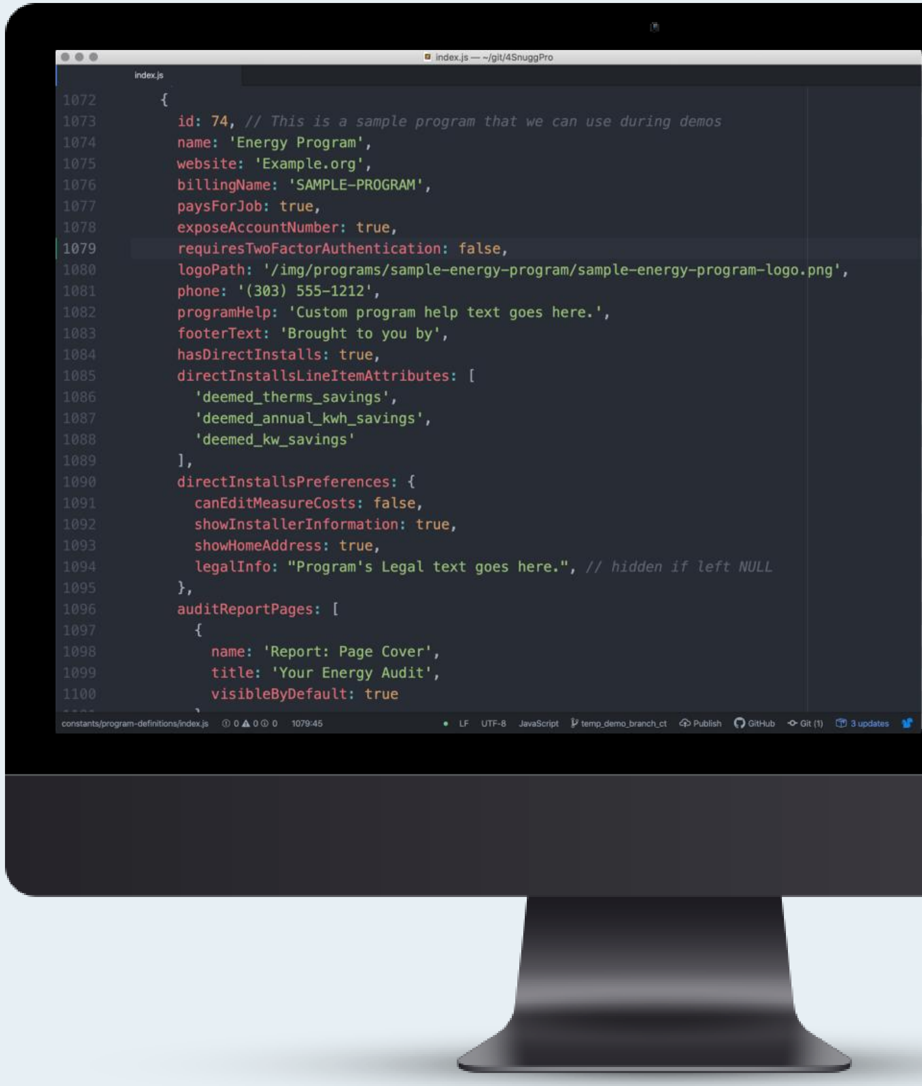
Simplified Program Integration

Base and improved modeled in parallel

- Same fundamental inputs
- Different efficiency and performance specifications



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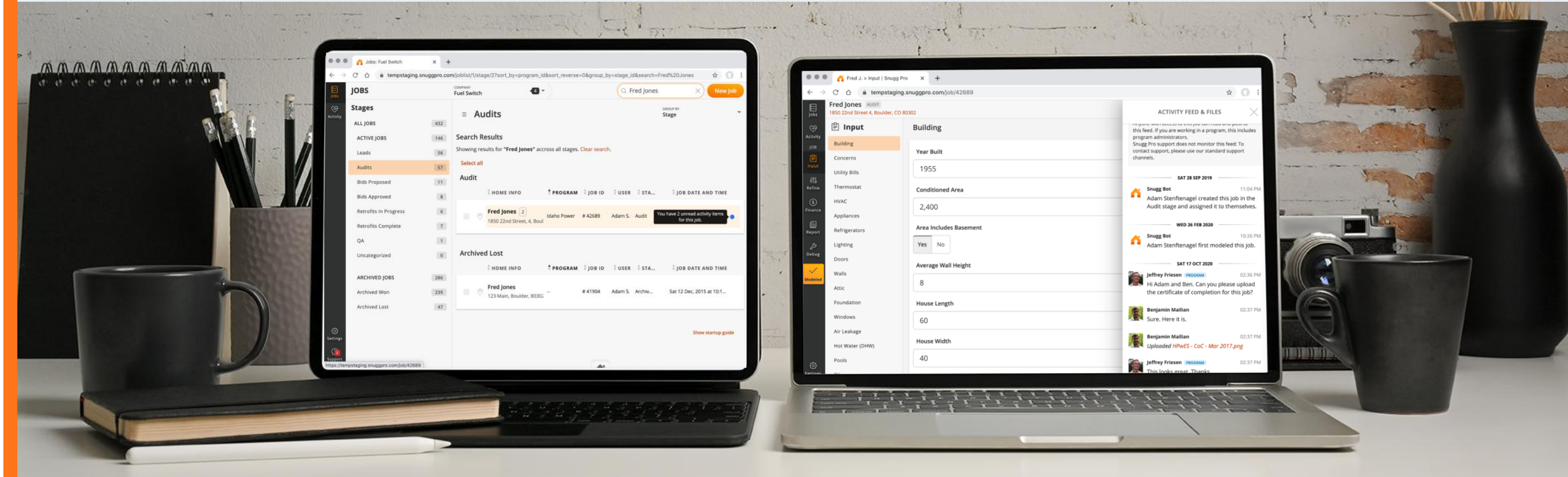
Contractor-Preferred Platform

Compare results

- Model estimated usage for base & improved homes using TMY15 data
- Compare annual usage



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Adaptable Energy Support

Compare results

FUELS	BASE	IMPROVED	SAVED
Total Fuel Energy Usage therms/year	539	0	539
Natural Gas Energy Usage therms/year	539	0	539

View detailed usage →

METRIC	BASE	IMPROVED	SAVED
Electric Energy Usage kWh/year	6,152	7,767	-1,615
Total Energy Usage MMBtu/year	74.89	26.51	48.38
Fuel Energy Cost $/year	$ 744	$ 0	$ 744
Electric Energy Cost $/year	$ 2,011	$ 2,538	$ -527
Total Energy Cost $/year	$ 2,754	$ 2,538	$ 216
CO2 Production Tons/year	4.2	1.7	2.5
Payback years			0
Total Energy Savings			64.60%
Total Carbon Savings			60%

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Adaptable Energy Support

Data underpinning calculations

- Interactive & interdependent modeling
- Gas & electric use normalized to BTU
  - Ratio of before & after BTU is energy savings
- Increase in electric consumption resulting from electrification represented as "negative" energy savings
- Usage history solely used to calibrate home as-is

Q&A

Using Utility Data to Improve Residential Energy Models

Lessons from the field

Mudit Saxena, CEO & Founder, XeroHome™

CEC Residential Decarbonization Energy Bill Impact Analyses

July 16th, 2026

CONFIDENTIAL

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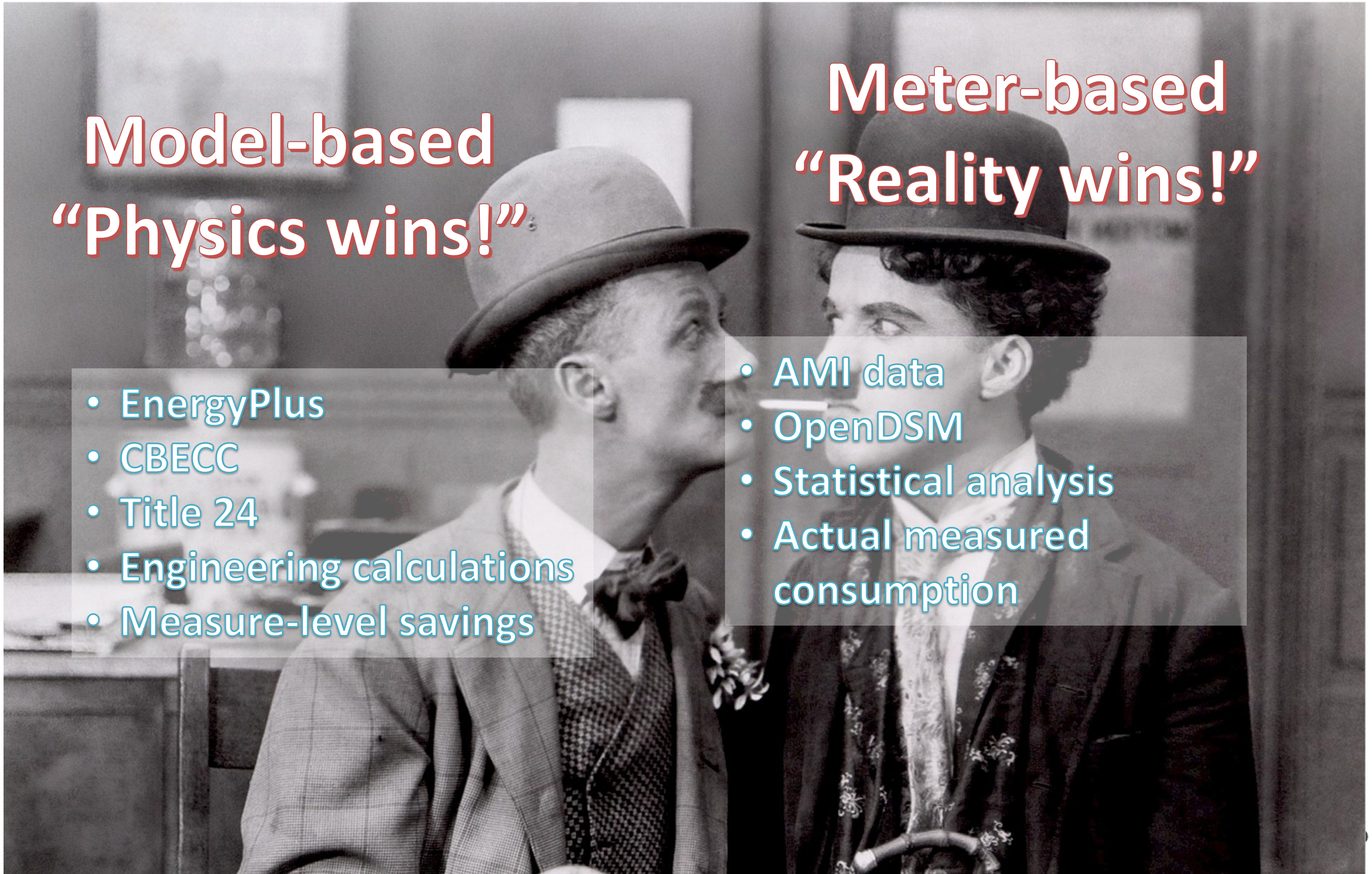
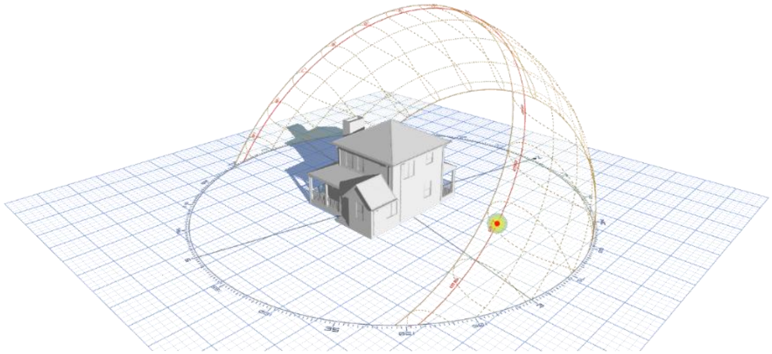
Twenty years ago, the industry split into two camps



The problem ...



Modeling alone:

- ❌ Wrong assumptions
- ❌ Unknown equipment
- ❌ Unknown occupancy

Meter analysis alone:

- ❌ Doesn't know bldg. characteristics
- ❌ Doesn't know upgrade packages
- ❌ Hard to predict future scenarios

Both sides are right.
Both sides are wrong.

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Why this matters

California needs answers to questions like:

- Should this home get a heat pump?
- What will happen to utility bills?
- What savings should we expect?
- Which homes should direct install programs target?

None of these can be answered perfectly by either approach alone.

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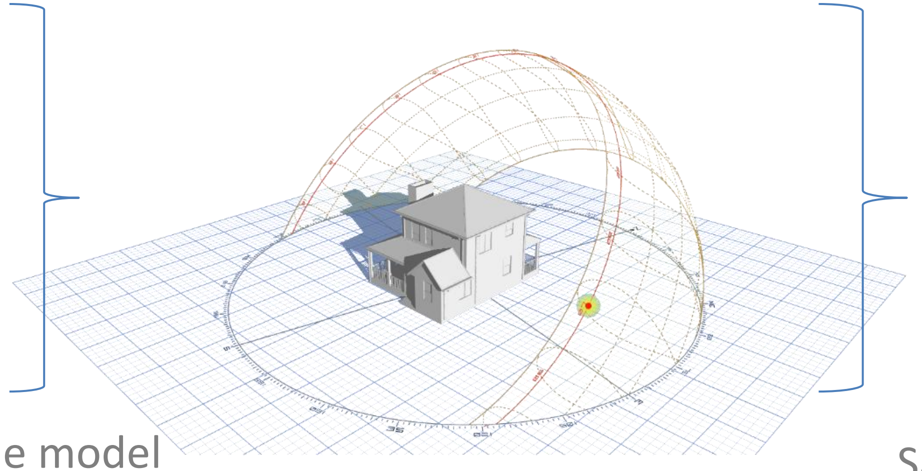
The emerging hybrid approach

FEEDBACK LOOP

Inputs



Outputs

Baseline model
Calibration

PHYSICS-BASED
ENERGY MODEL

Savings
Validation

Utility data informs the model …
… Models explain the utility data

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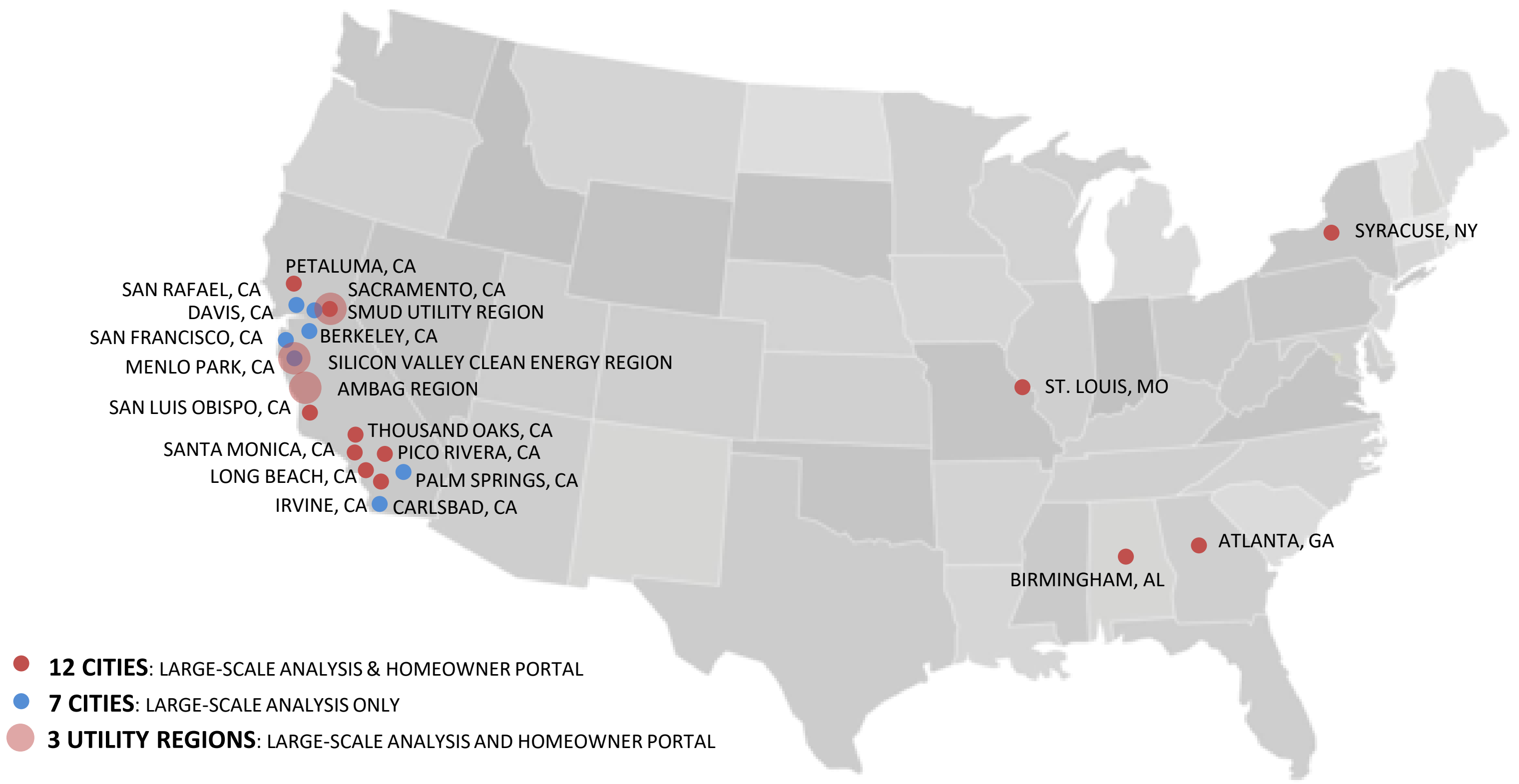
What we have learned from modeling 1 Million+ homes



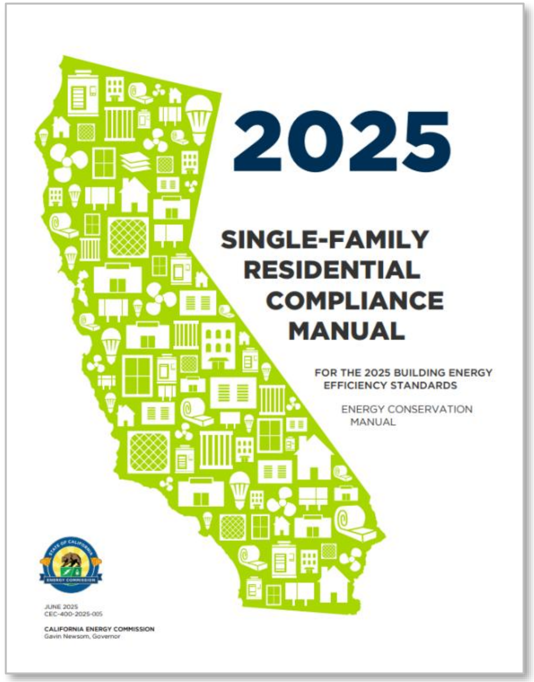
Deployments funded by: Southern California Edison (SCE), Sacramento Municipal Utility District (SMUD), Pacific Gas & Electric (PG&E), Silicon Valley Clean Energy (SVCE), Association of Monterey Bay Govts. (AMBAG), City of Sacramento, New York State Energy & Research Development Auth. (NYSERDA), Ameren Missouri, National Grid New York, Alabama Power, Georgia Power, Electric Power Research Institute (EPRI)

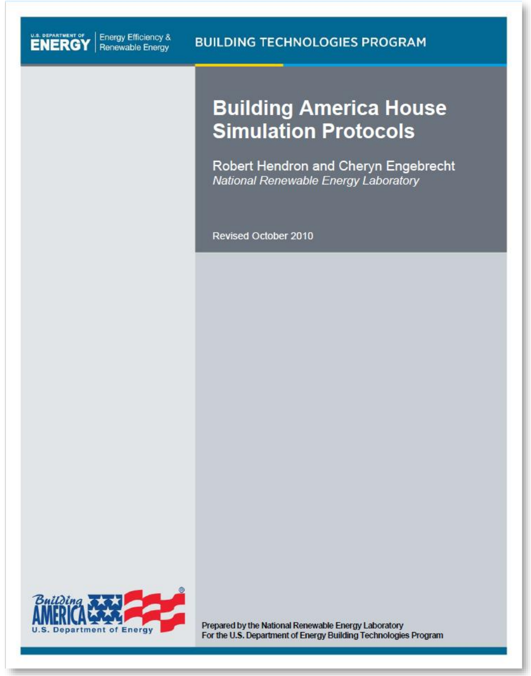
What we have learned from modeling 1 Million+ homes

- Lesson #1: Utility data enables calibration at several scales
- Lesson #2: Every new input data layer reduces uncertainty
- Lesson #3: Energy data can inform building characteristics
- Lesson #4: Utility data comes with built-in variance
- Lesson #5: Better decisions require both models and measurements

Lesson #1:
Utility data enables calibration at several scales

- Calibration at portfolio scale – By comparing simulated and measured energy use across entire housing stocks, modeling frameworks such as **Title 24 vintage tables** and **DOE residential simulation protocols**, can be refined to better reflect how homes actually perform in the field.





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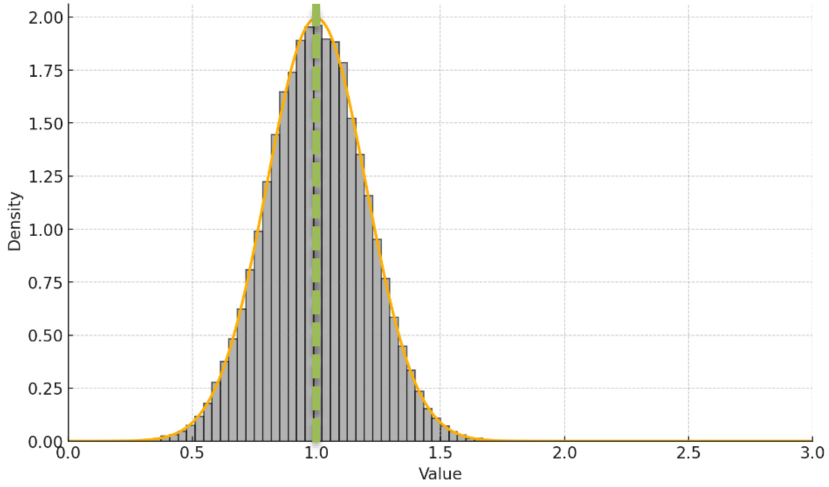
Calibration at portfolio scale

1. Group homes by vintage
2. Compare modeled energy use to actual utility data
3. Adjust assumptions
4. Improve vintage tables

$$Calibration\ Coefficient = \frac{Energy\ Use_{Actual}}{Energy\ Use_{Modeled}}$$



<1 Calib. Coef. = actual energy use was **less** than modeled

1 Calib. Coef. = an **exact match**

>1 Calib. Coef. = actual energy use was **more** than modeled

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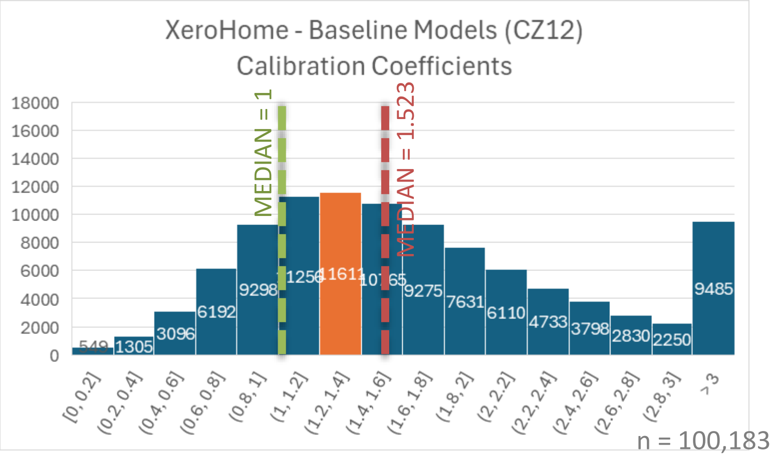
Calibration at portfolio scale

Incorporating actual energy use data to refine inputs led to

- **78% reduction in systematic bias**
  Median moved closer to 1: from 1.523 → 1.117
- **24% reduction in uncertainty**
  Std Dev moved closer to 0: from 1.049 → 0.793

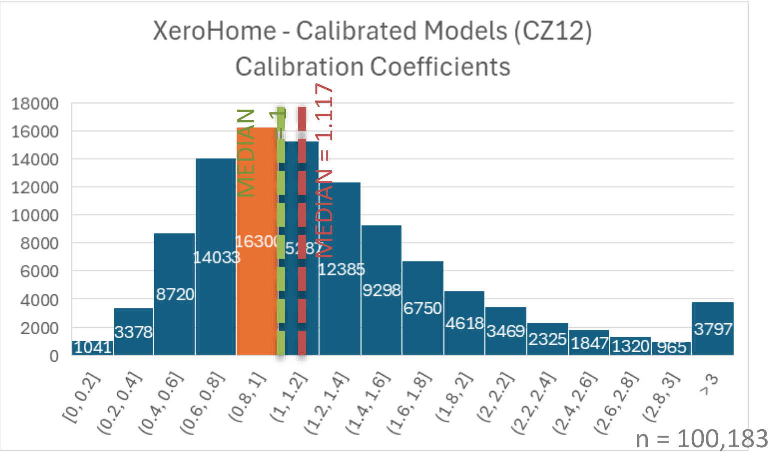
- The models shifted from being systematically biased with high uncertainty to better aligned with reality and more consistent.

Without Energy Data



1st Quartile	Median	3rd Quartile	IQR	Std Dev.
1.086	1.523	2.129	1.043	1.049

With Energy Data



1st Quartile	Median	3rd Quartile	IQR	Std Dev.
0.789	1.117	1.567	0.778	0.793

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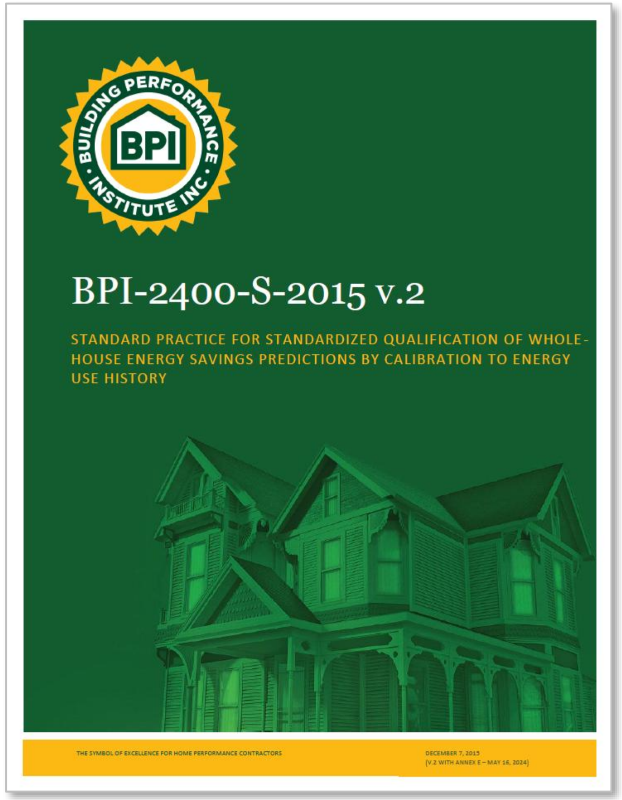
Calibration at individual model level

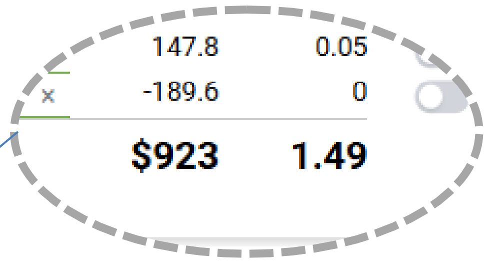
1. Start with better assumptions (see calibration at scale)
2. Collect site-level data
3. Adjust the unknown variables
4. Follow BPI-2400-S-2015 procedure to match model's output to energy data



Calibration at individual model level
Example

Before Calibration

Calculated savings from HP HVAC

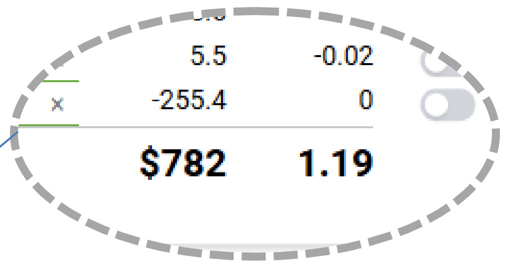


Calibration at individual model level

Example

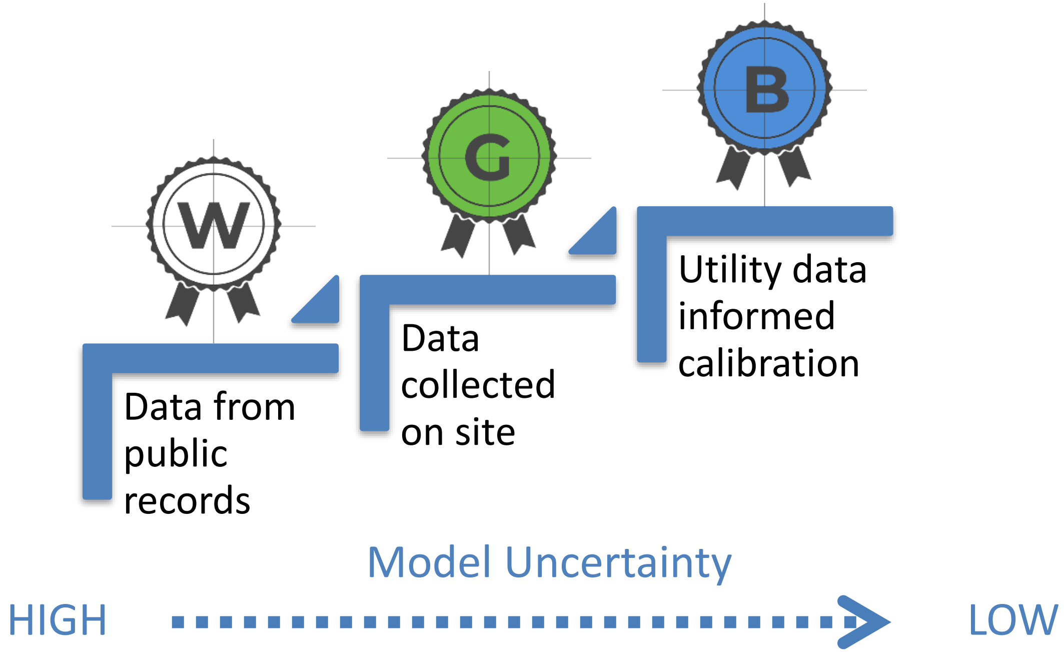
After Calibration

Calculated savings from HP HVAC



Lesson #2:
Every new input data layer reduces uncertainty

- Model accuracy depends on both the simulation engine and the quality of building inputs
- XeroHome captures building information successive data layers – White, Green, and Blue badges
- Each layer improves model fidelity by replacing assumptions with measured information.



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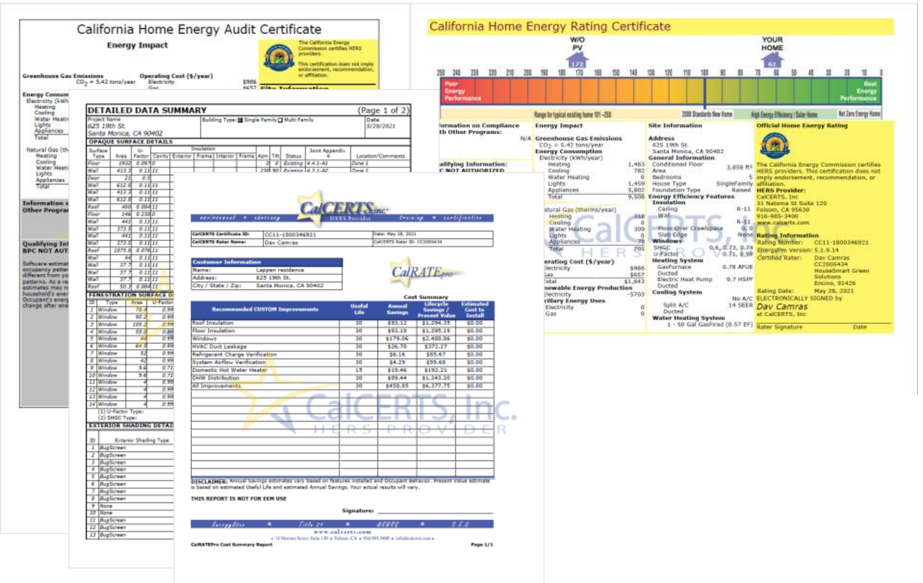
Professional Home Energy Audits
Conducted for 7 homes in Southern California



Home A

Home B

Home C

Home D

Home E

Home F

Home G

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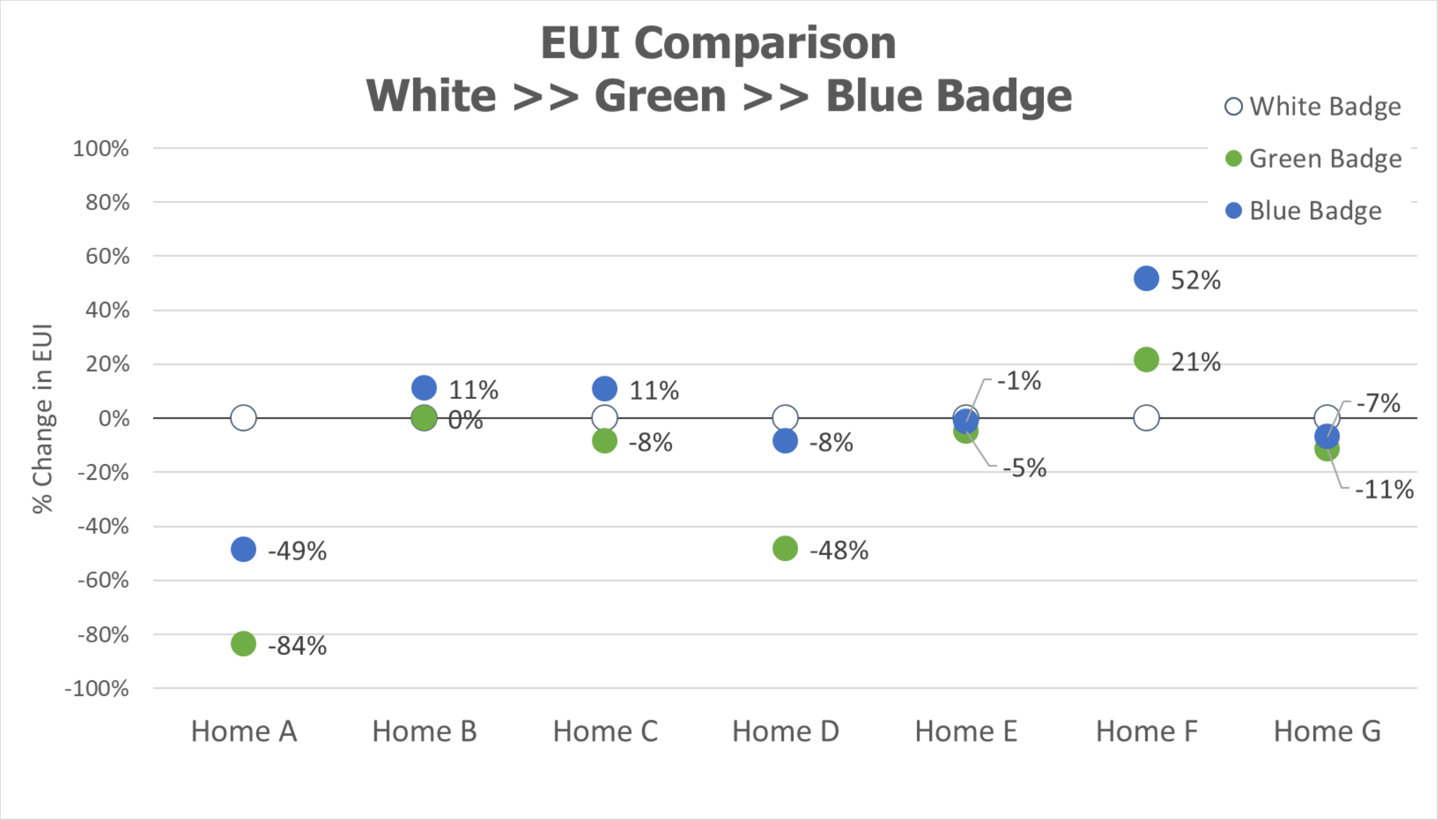
How did building model EUI change across 3 badges?



- In 5 out of 7 homes EUI change was ***within 10%*** between XeroHome's white badge and energy calibrated, assessor-developed blue badge energy model

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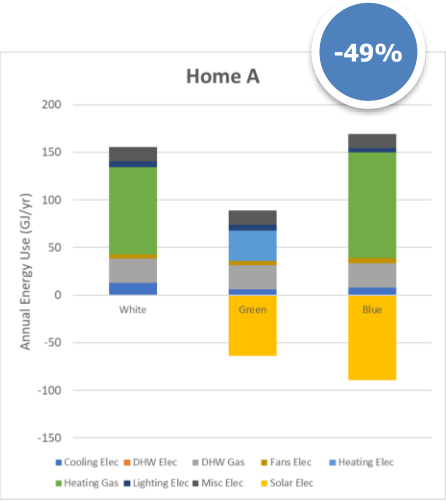
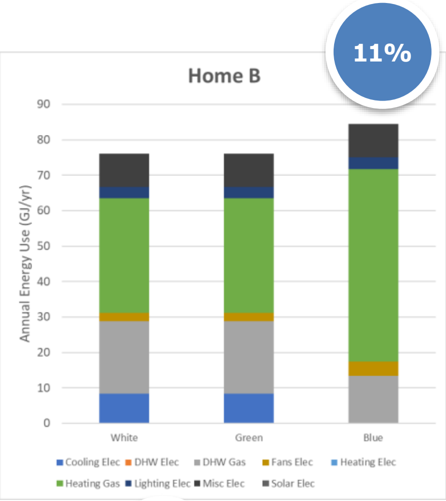
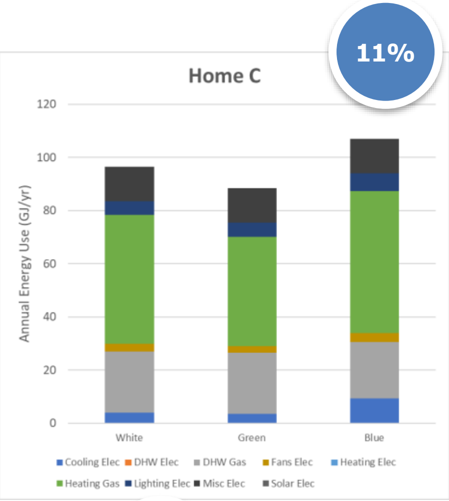
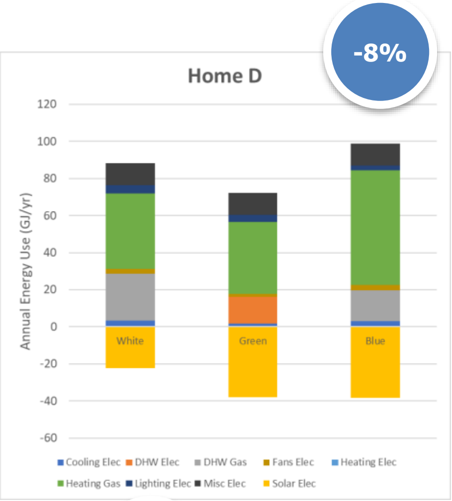
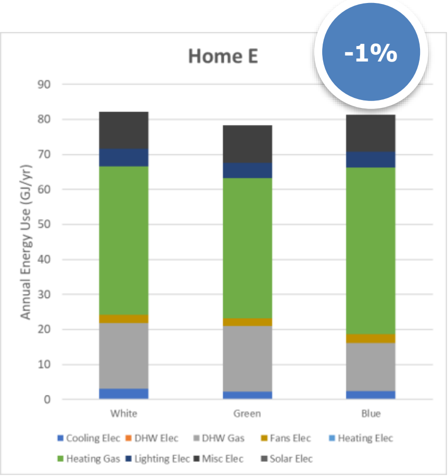
All 7 Homes
Energy Use Breakdown Comparisons

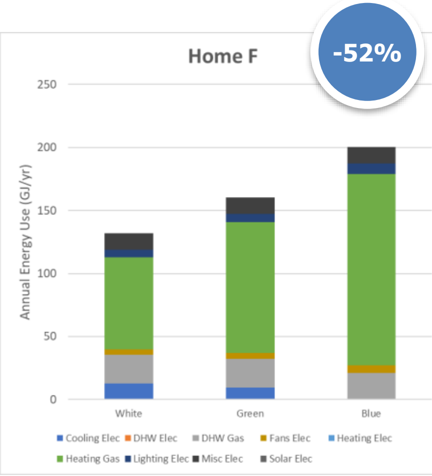


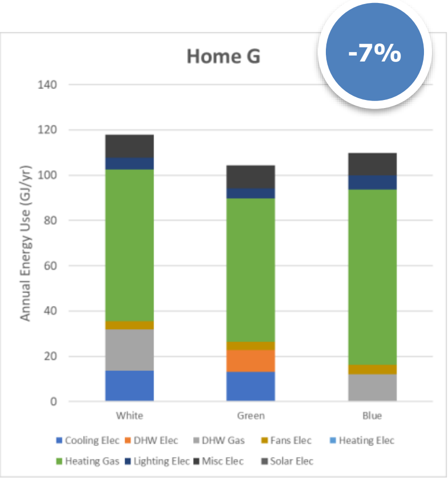












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Lesson #3:
Energy data can inform building characteristics

- XeroHome applied a weather-response analytics approach to **probabilistically identify homes with**
    - No Cooling vs Central ACs vs Room ACs
    - Elec vs Gas Heating
- The magnitude, seasonality, and consistency of weather-sensitive loads create distinct equipment signatures.

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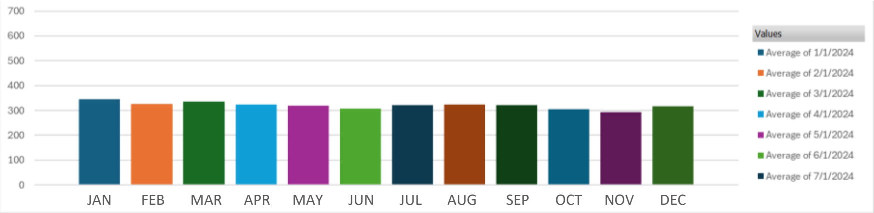
Monthly energy data analysis to identify HVAC systems

- No Cooling Gas Heating

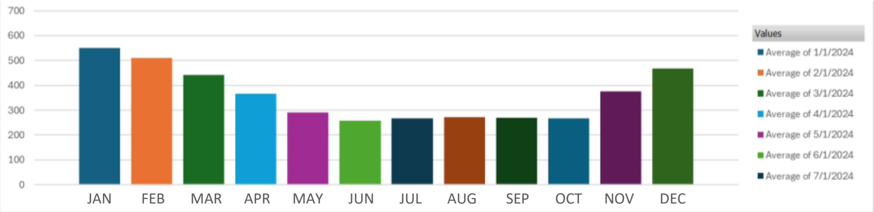
Should be flat across 12 months

ELECTRIC ENERGY USE (kWh)



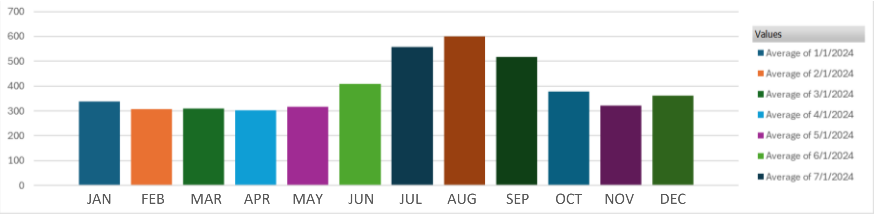
- No Cooling Elec Heating

Should have higher elec use in winters



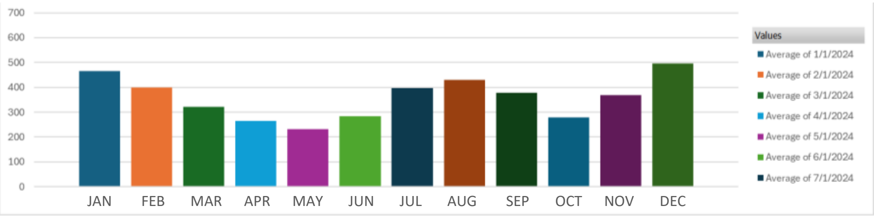
- Elec Cooling Gas Heating

Should have higher elec use in summers



- Elec Cooling Elec Heating

Should have high elec use in summers and winters



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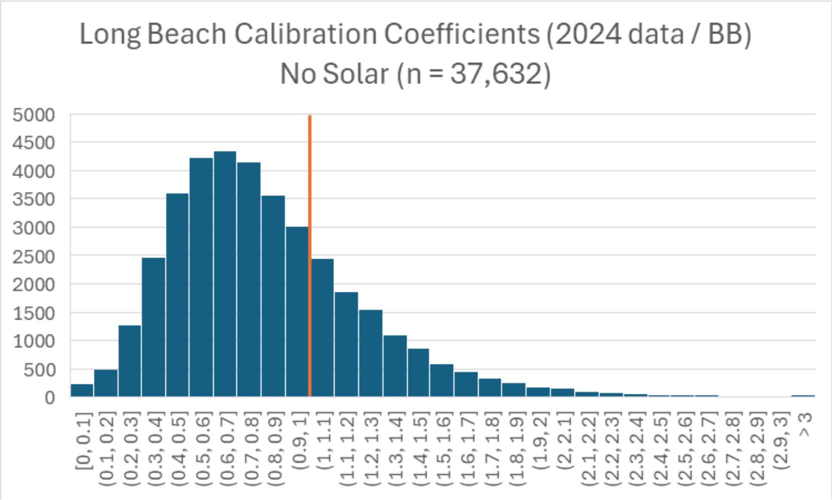
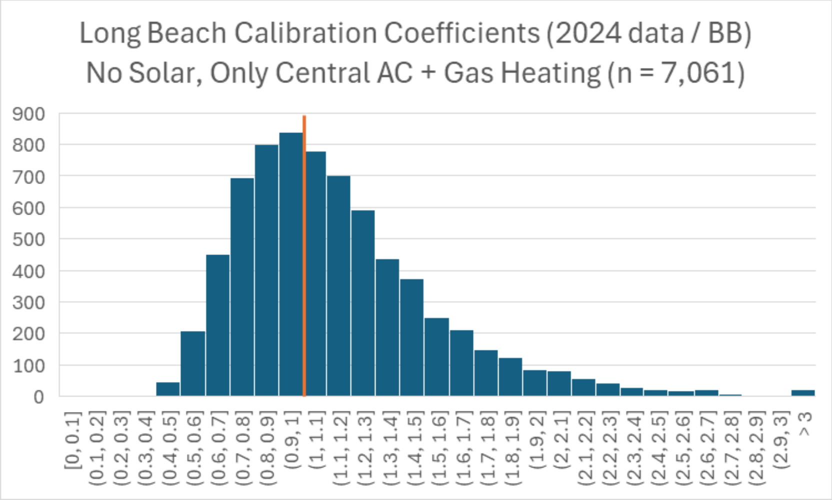
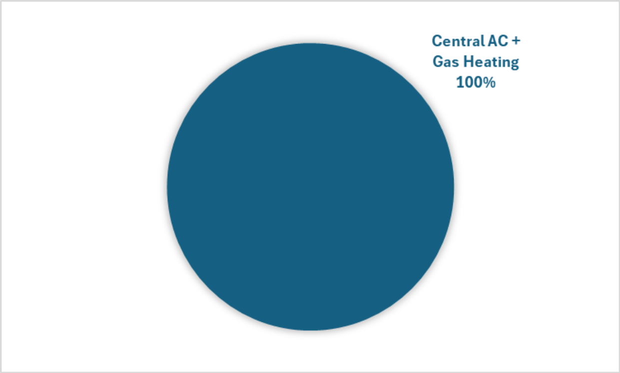
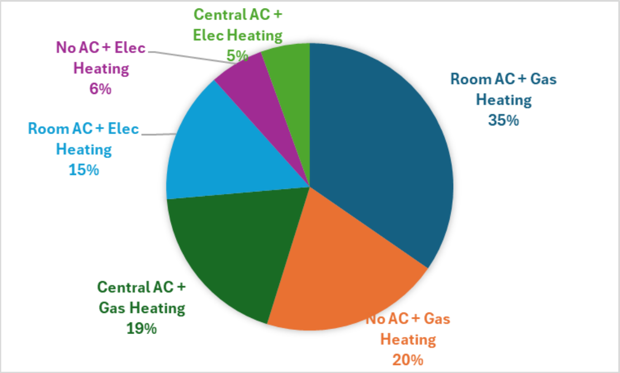
Modeling improvement quantified

- Histogram of calibration coefficients









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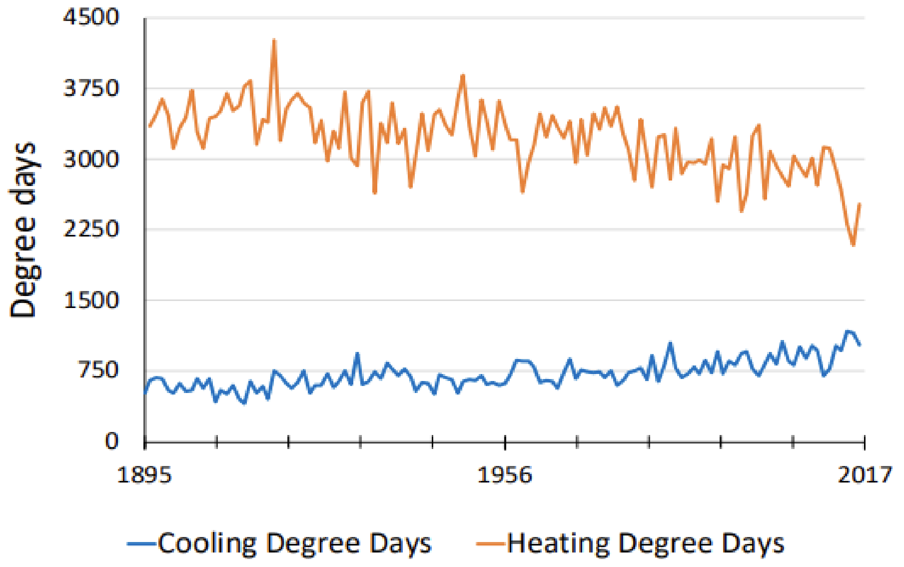
Lesson #4: Utility data comes with built-in variance

- **Weather Impacts**: Energy use can vary year over year due to weather changes – Hotter years drive more cooling, less heating and vice versa.

Figure 1. Cooling and Heating Degree Days



Note: Degree days measure the difference between the average daily temperature and a reference temperature of 65 degrees Fahrenheit (°F). Cooling degree days measure how much the average daily temperature is higher than 65°F; heating degree days, how much it is lower than 65°F. For example, an average daily temperature of 75°F corresponds to a cooling degree day value of 10. Each value shown in the graph is the sum of degree days for that year.

Source: NOAA, 2017a

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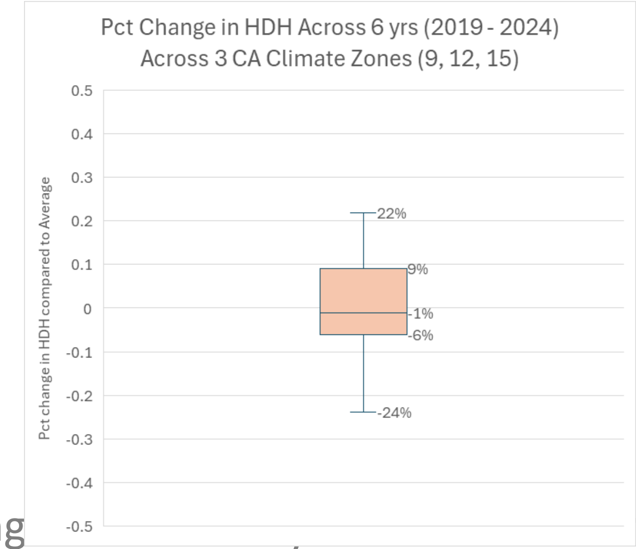
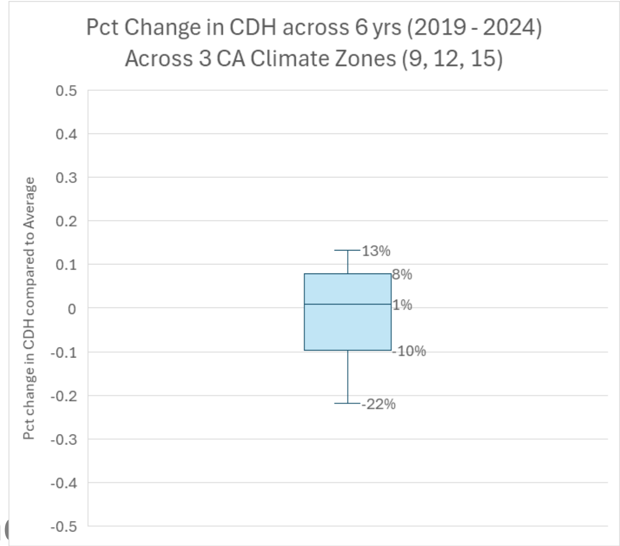
Variance Due to Weather

- Due year-over-year change in weather, heating and cooling energy needs in homes can vary widely which can be measured using heating degree hours (HDH) and cooling degree hours (CDH)

$$\textit{For hours where } T_{hour} < 65, \qquad HDH_{Base\ 65} = \sum (65 - T_{hour})$$

$$\textit{For hours where } T_{hour} > 65, \qquad CDH_{Base\ 65} = \sum (T_{hour} - 65)$$





- Year-over-year heating
- Year-over-year cooling need can vary between **+8% and -10%** for most homes

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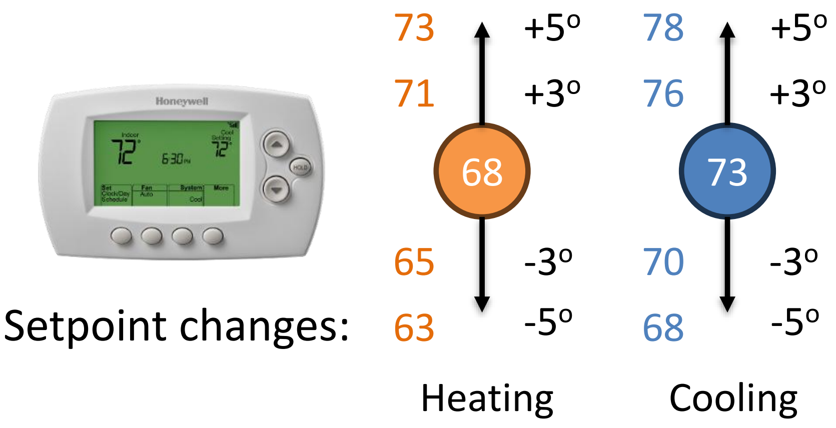
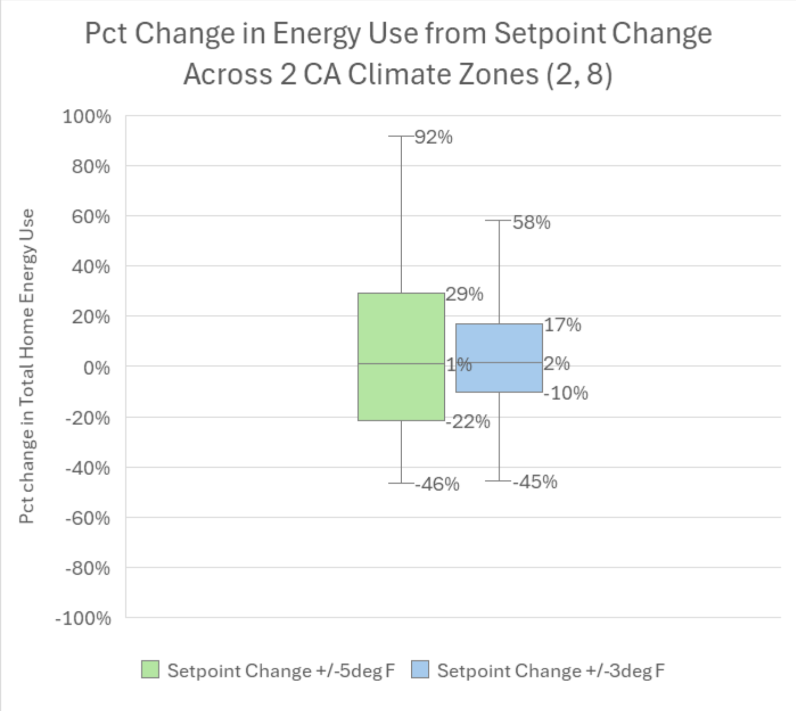
Variance Due to Behavior

- **Behavioral Impacts**: Energy use can vary with operational changes – Thermostat settings, time spent at home (e.g., working from home), window operation, and number of occupants, etc.

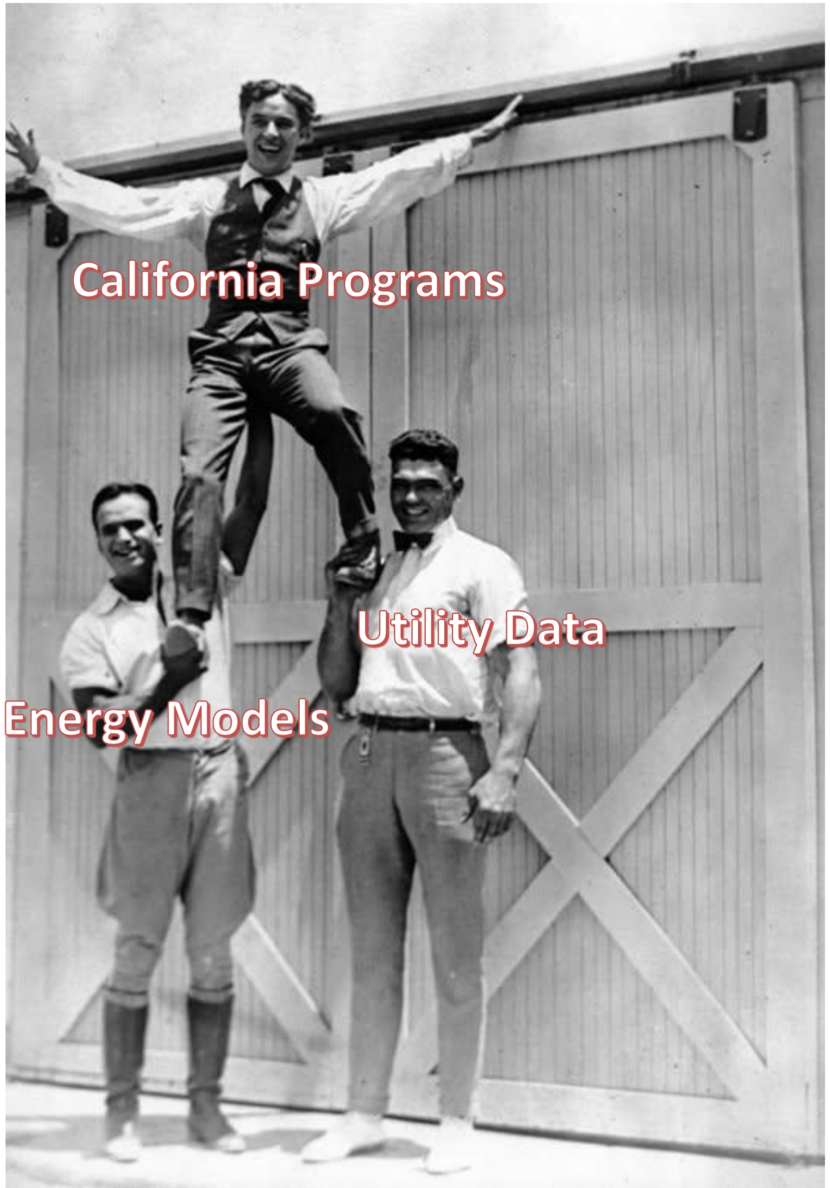




Lesson #5:
Better decisions require both models and measurements

- Building energy models explain why a home uses energy.
- Utility data reveals how a home actually uses energy.
- Neither approach alone provides a complete picture.

- Combining both creates more accurate, actionable, and scalable decarbonization analysis.



Thank you!

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https://about.xerohome.com

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FleetView®

Cost-Effectively Reduce GHGs Using Clean Energy

Tom Hoff and Brittany Farrell

CEC Public Workshop - Residential Decarb Bill Impact Analysis

June 16, 2026

Clean Power Research®

Agenda

Cost-effectively eliminate GHG emissions in homes

One home's journey

Energy affordability depends on rates, information & decisions

Demand flexibility is one way to maximize bill savings

Million similar homes could provide electric grid support

Load analysis including CAISO peak day

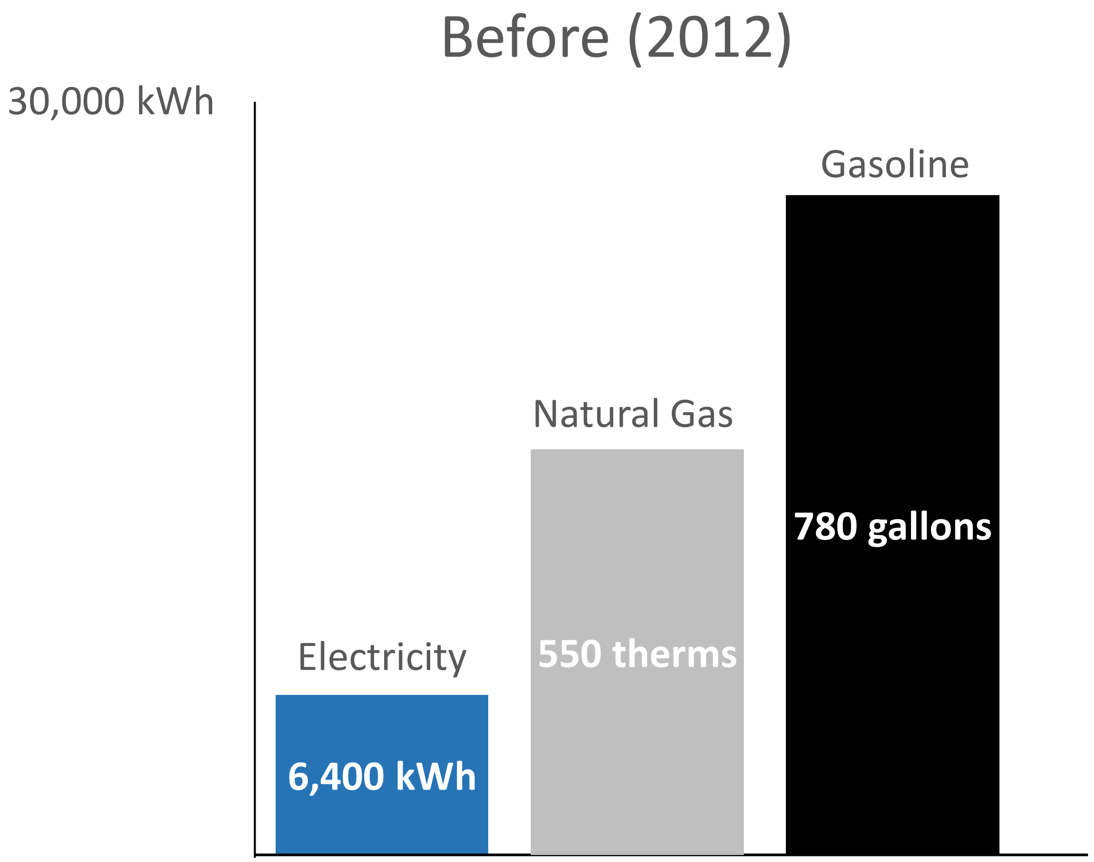
NY case study how to target building electrification investments

Balance heat pump equipment and shell efficiency investments

Cost-Effectively Eliminate GHG Emissions in Homes

One Home's Journey

Consumed ~50,000 kWh-e Before Electrification

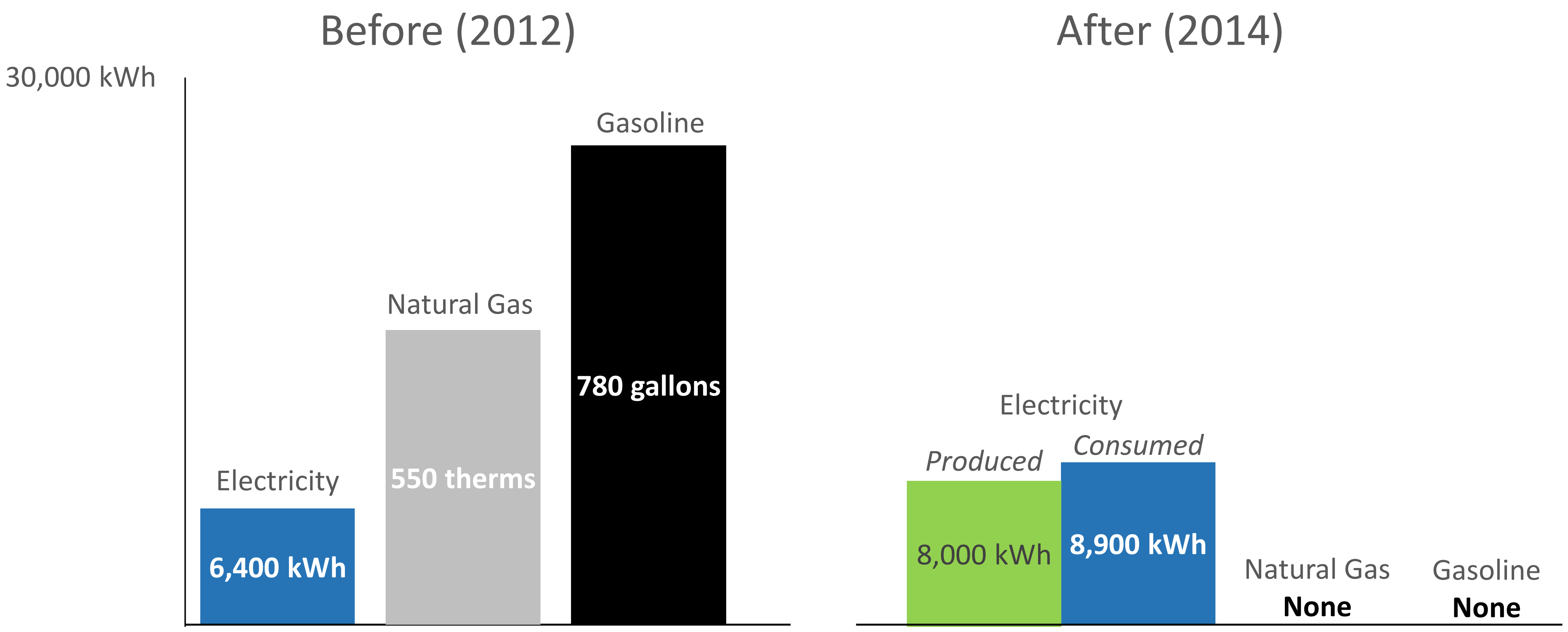


45-year-old

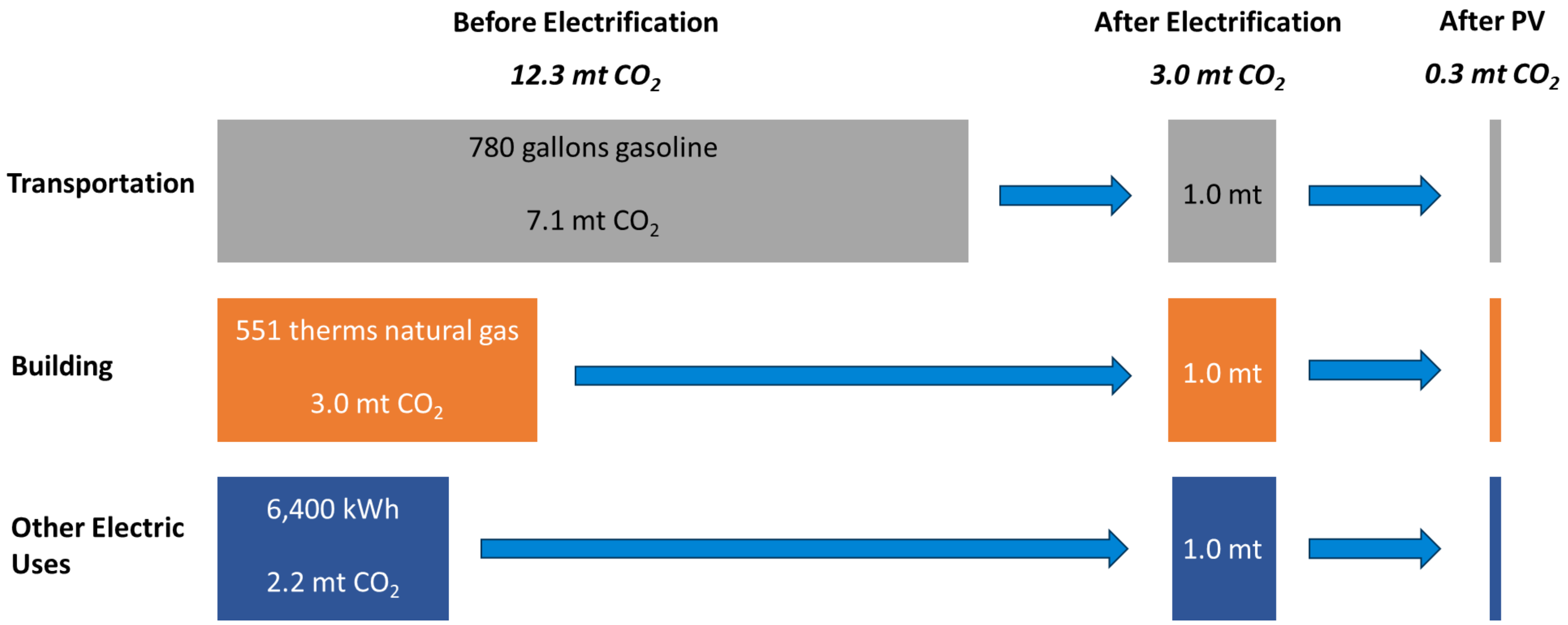
2,900 ft^2 house

Napa, California

Reduced Net Consumption by 98% After Efficiency, Electrification & PV

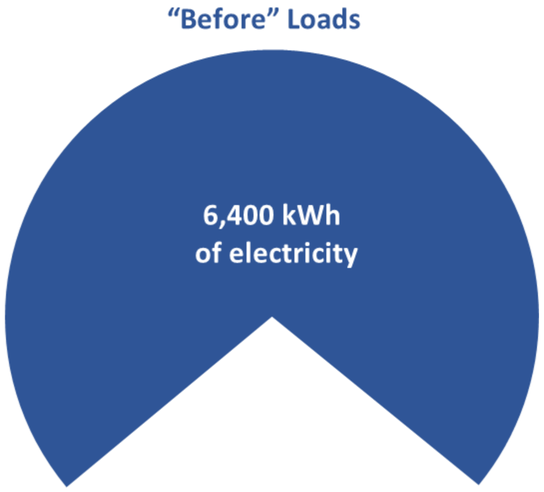


Reduced GHGs by 98%

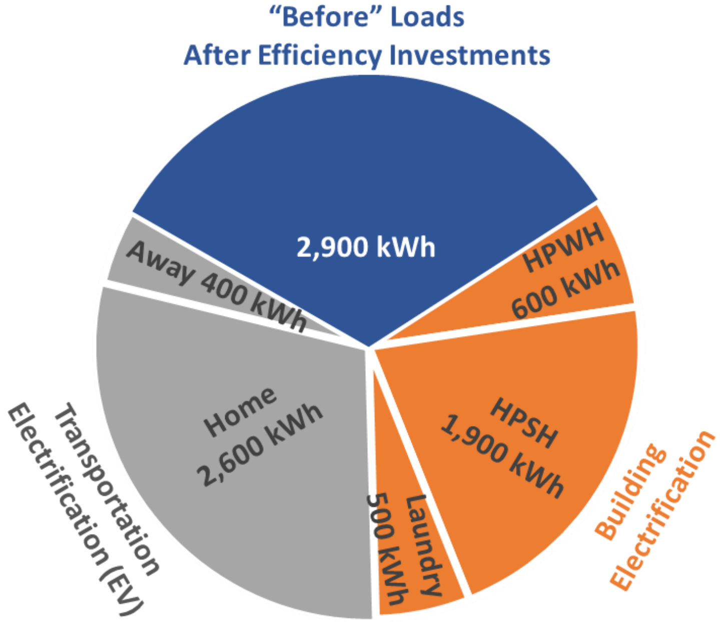


Electricity Consumption Details

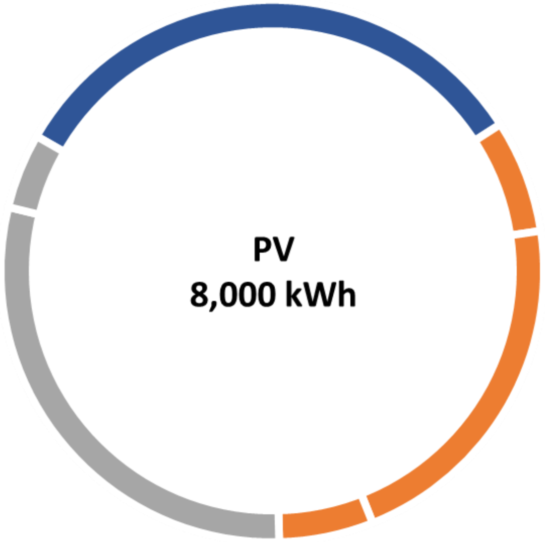
Before Electrification



After Electrification



After PV



Energy Affordability Depends on Rates, Information & Decisions

Demand Flexibility is One Way to Maximize Bill Savings

Rate Structure Change

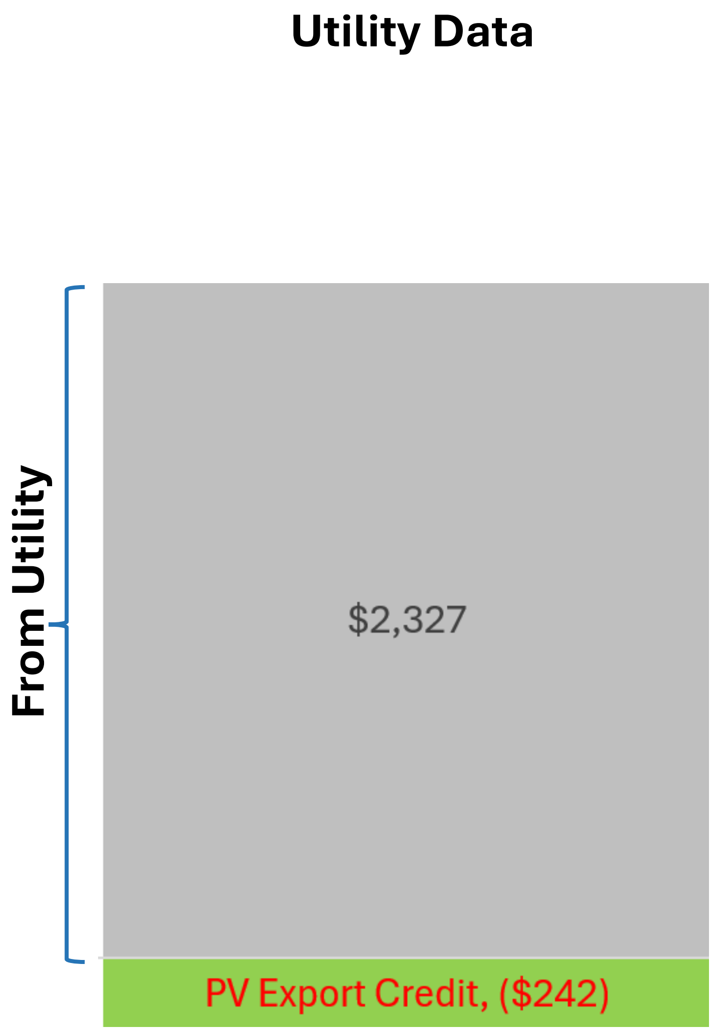
Customer was on Net Energy Metering (NEM) rate until February 2025

Customer transition to Solar Billing Tariff (SBT) after 20 years on NEM

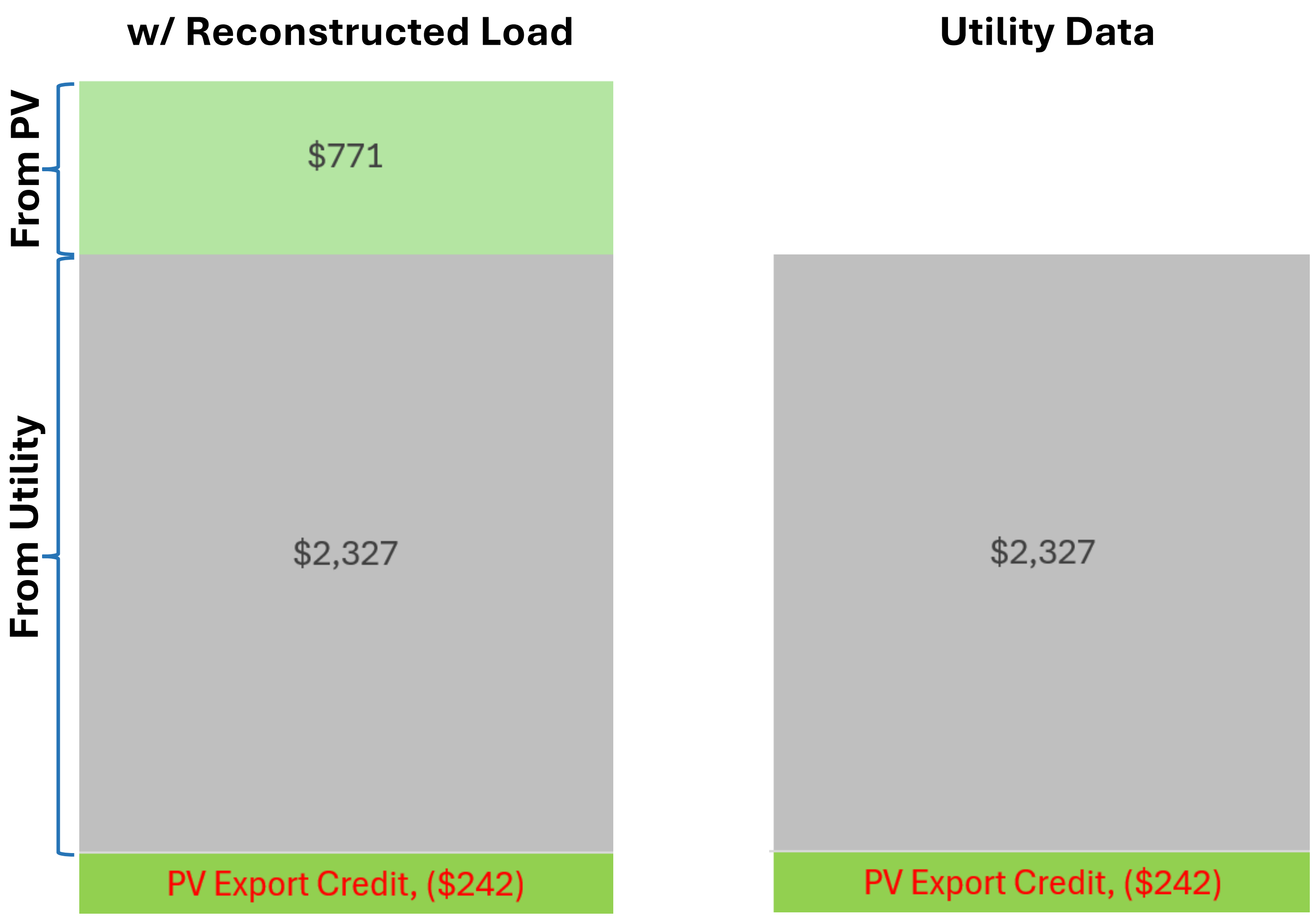
Using 2016 load data, bill would have quadrupled

- $550 under NEM
- $2,085 under SBT

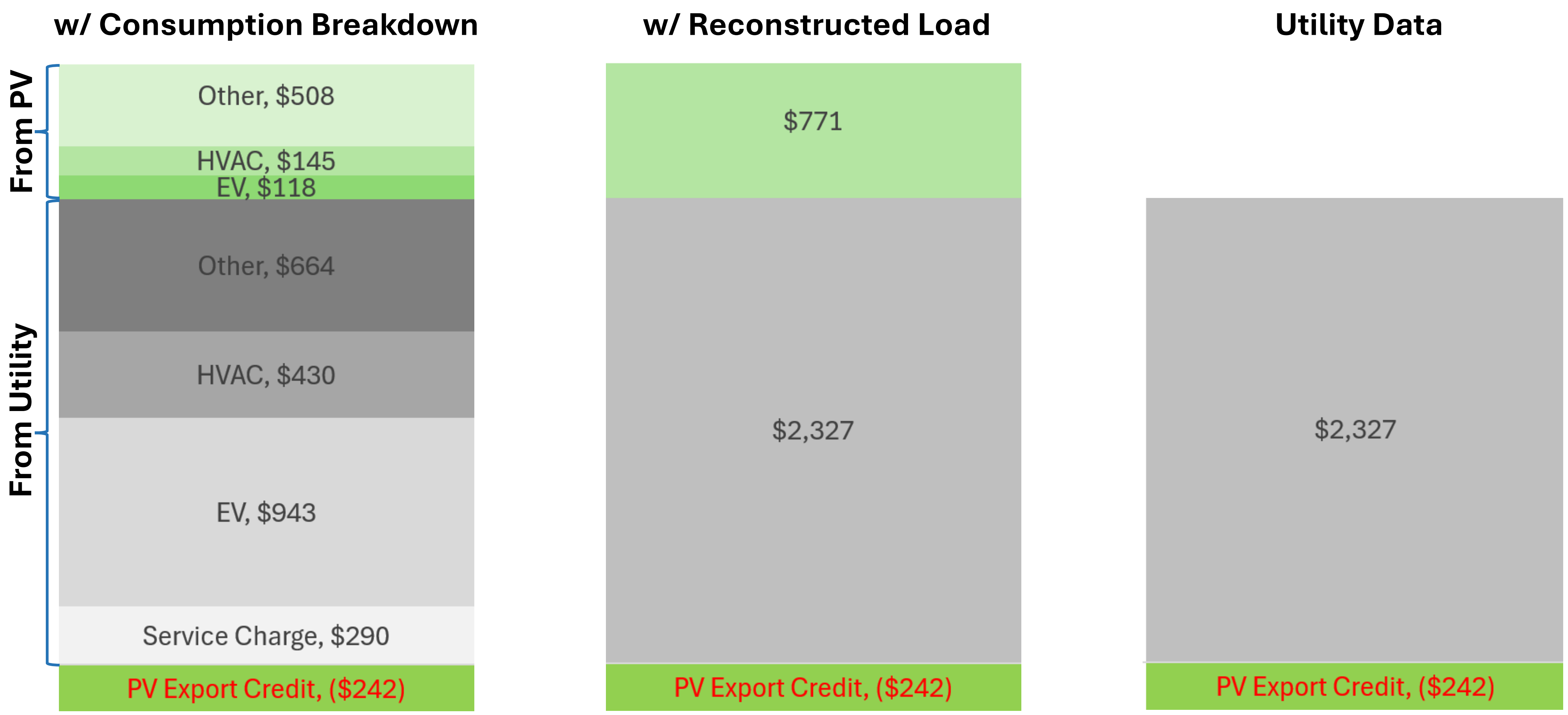
Need Data to Provide Customers with Guidance



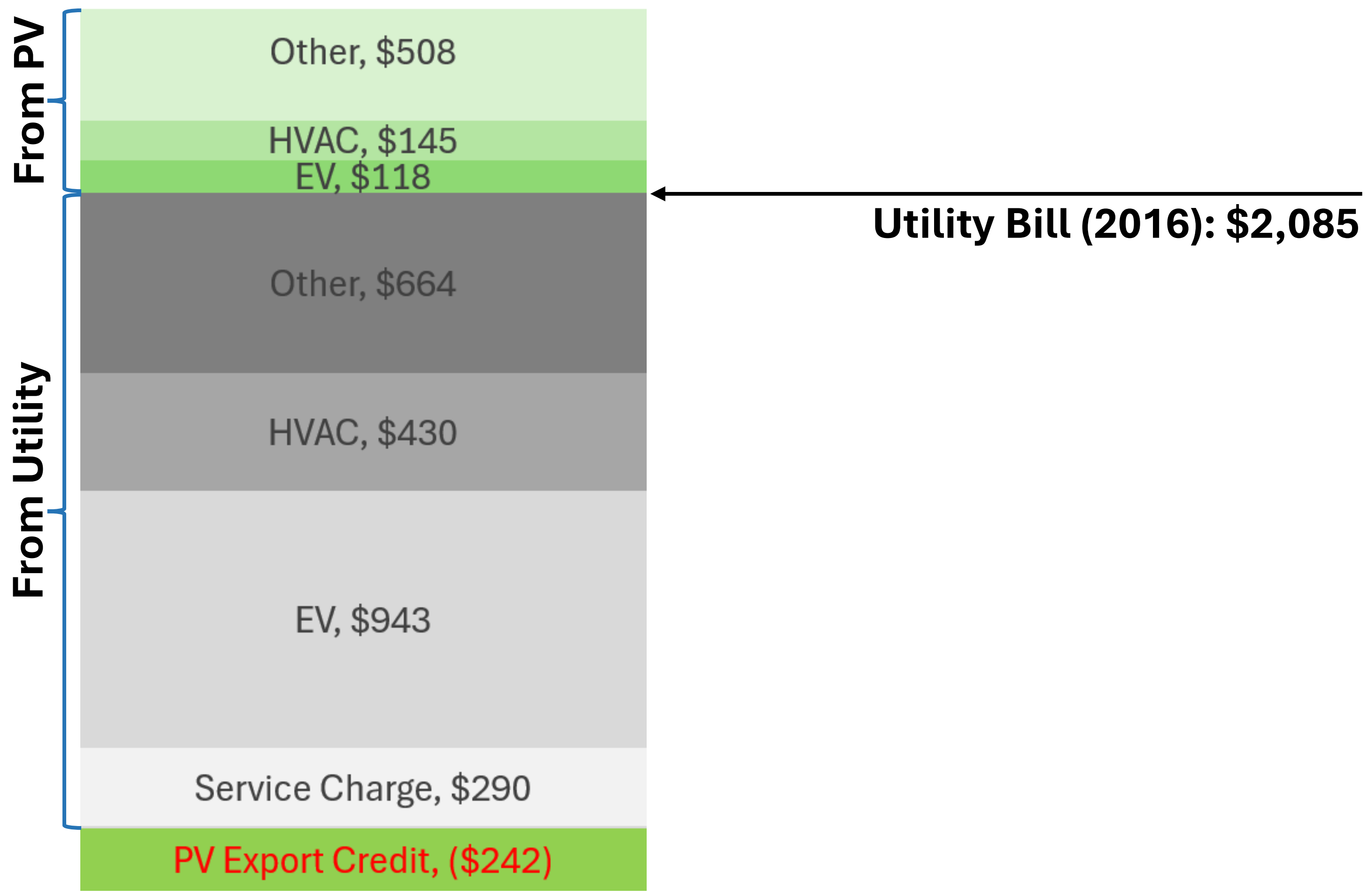
Reconstructed Load Data Provides Additional Information



Breakdown of Consumption Provides Actionable Information

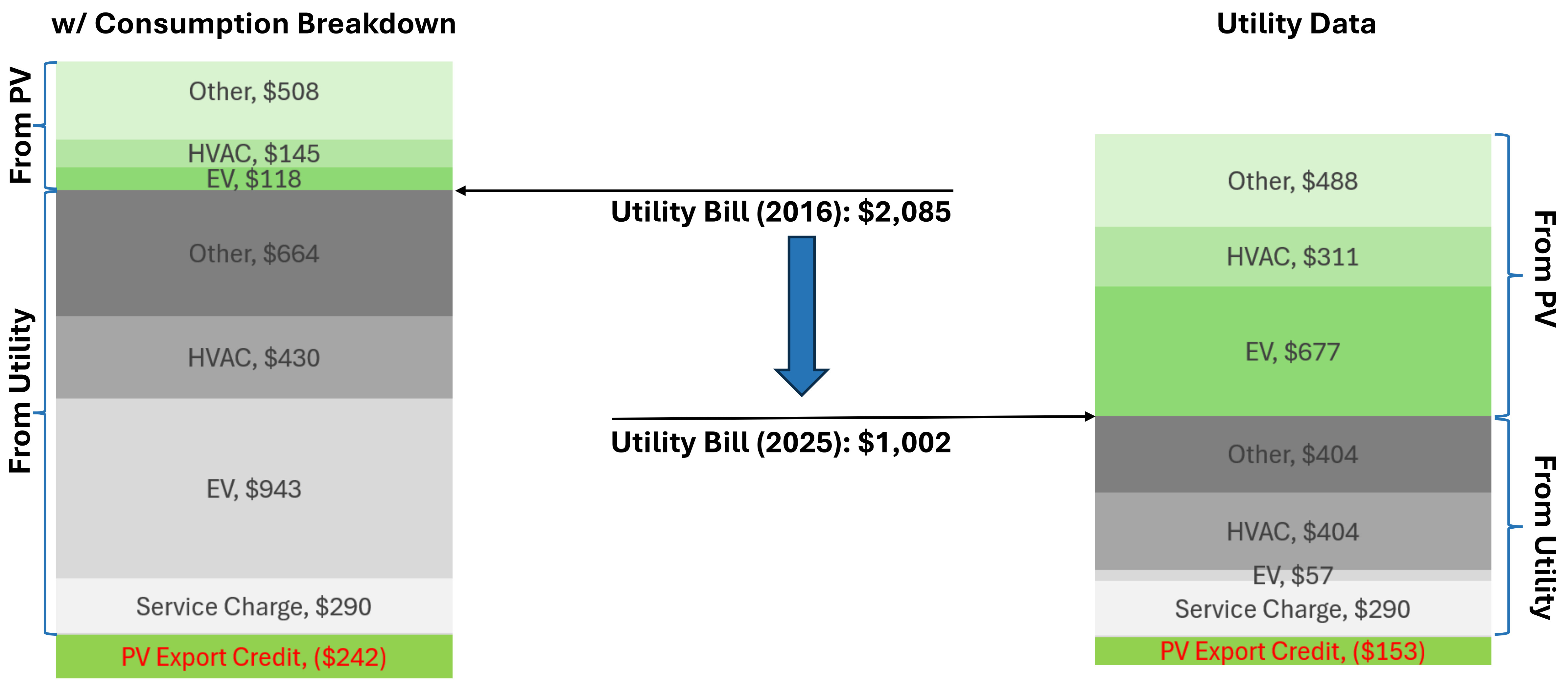


Little Demand Flexibility (2016)



Clean Power Research

Demand Flexibility (2025) Cuts Bill in Half and Saves Over $1,000

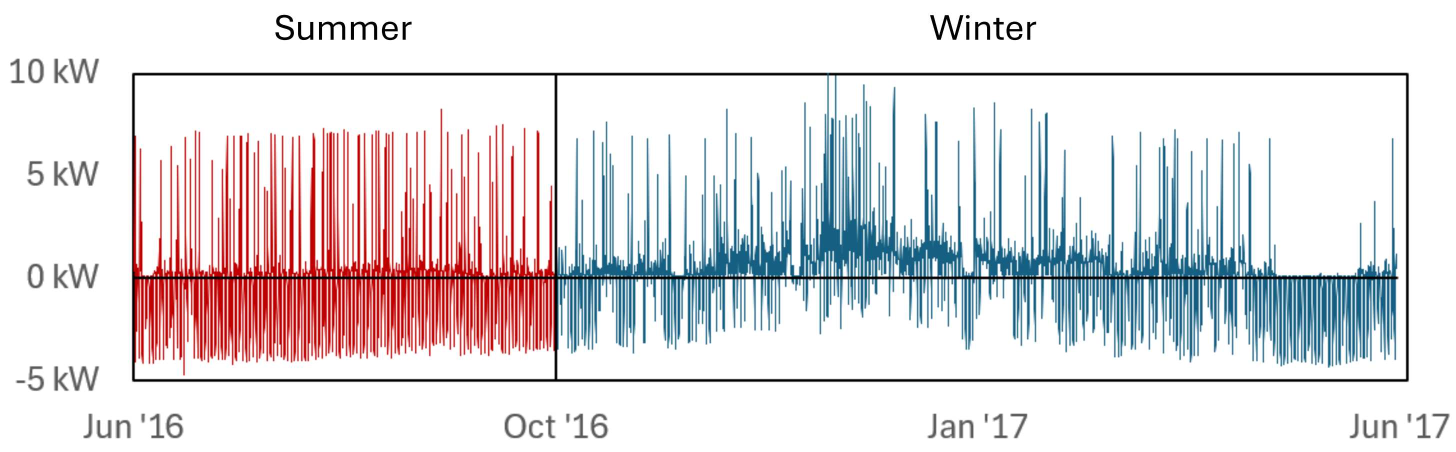


Million Similar Homes Could Provide Electric Grid Support

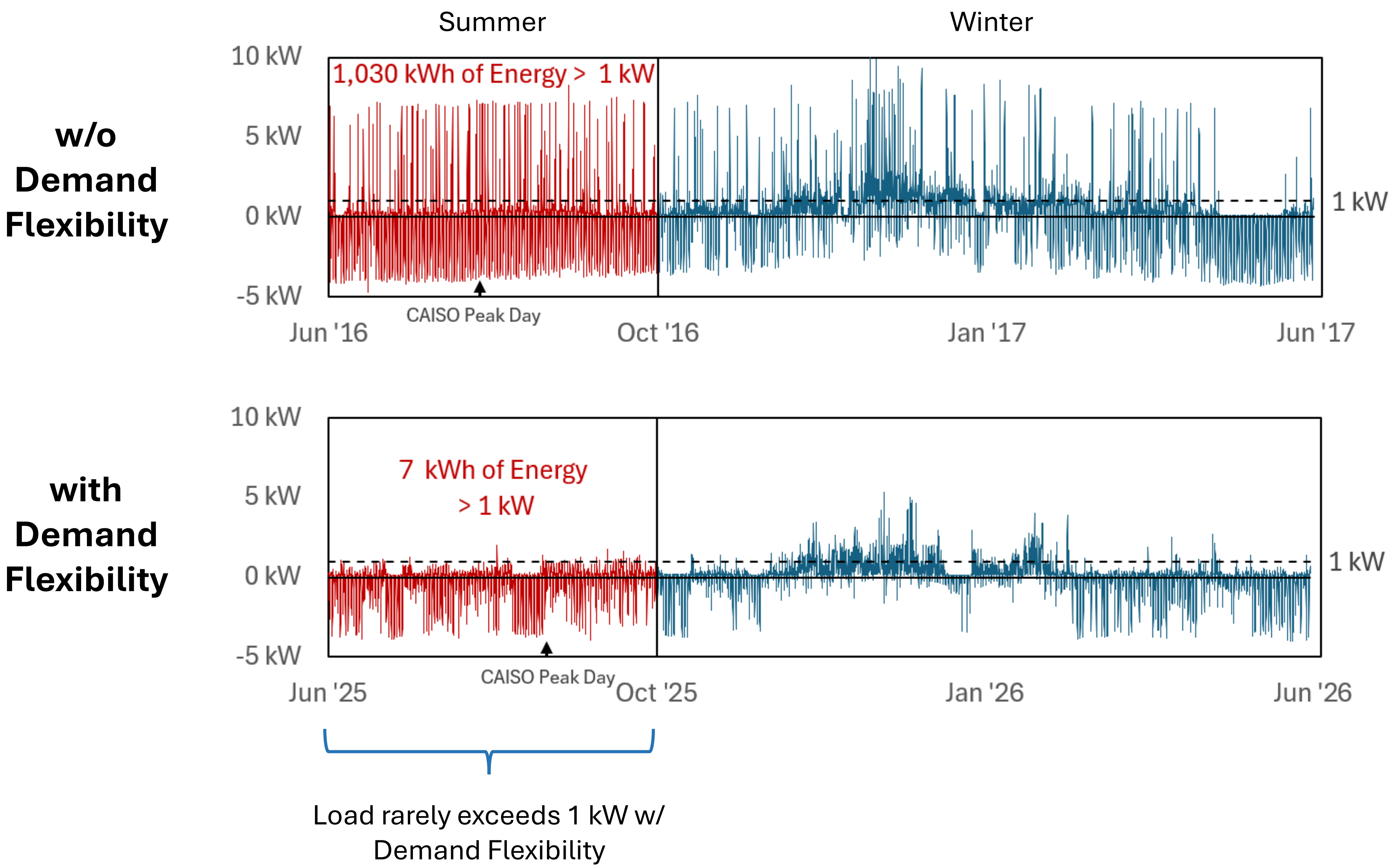
Load Analysis Including CAISO Peak Day

Hourly Loads Vary Widely w/o Demand Flexibility (2016)

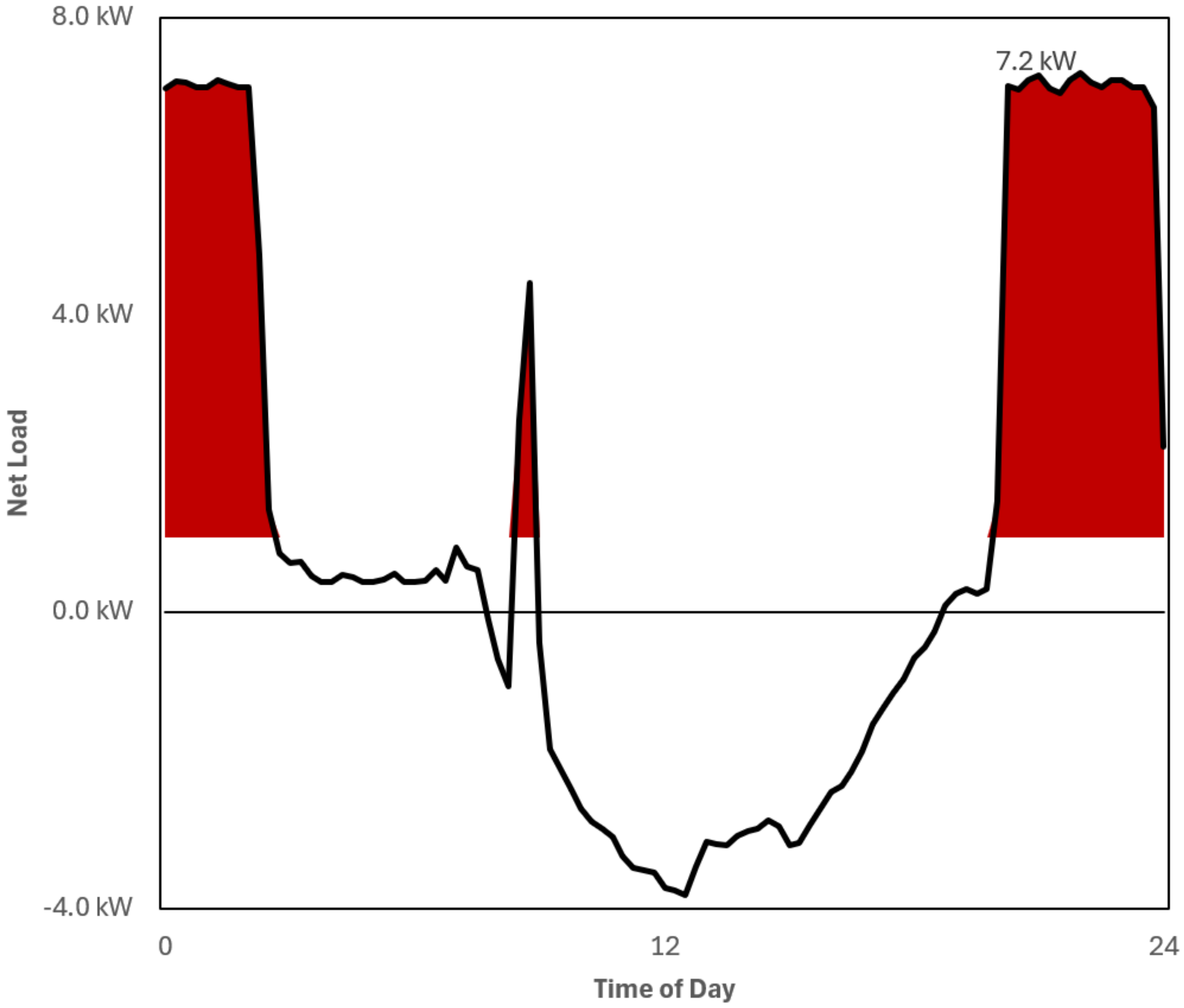
w/o Demand Flexibility



Demand Flexibility (2025) Reduces Stress on Grid

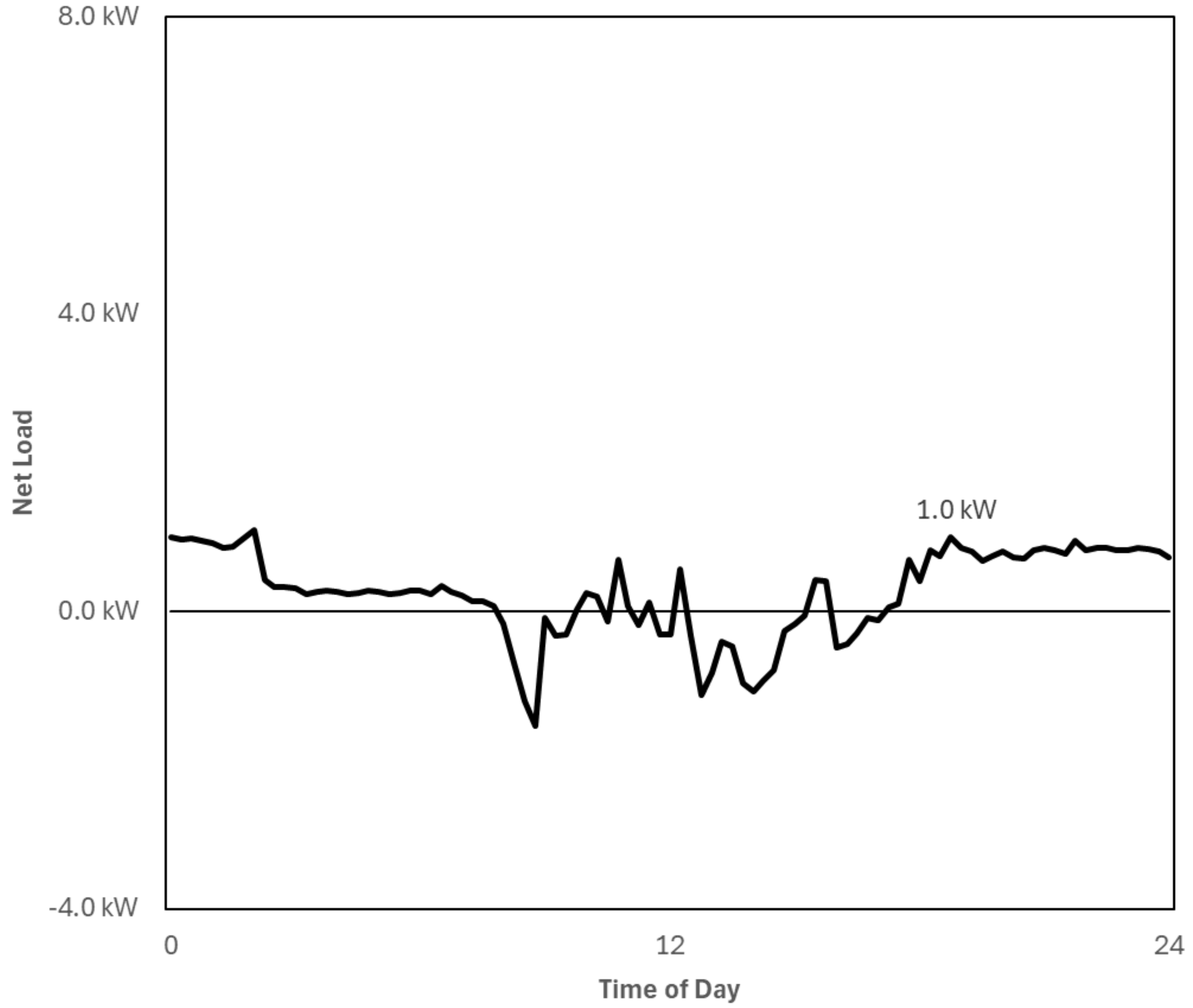


2016 CAISO Peak Day (July 27): Home Consumed 39 kW above 1 kW



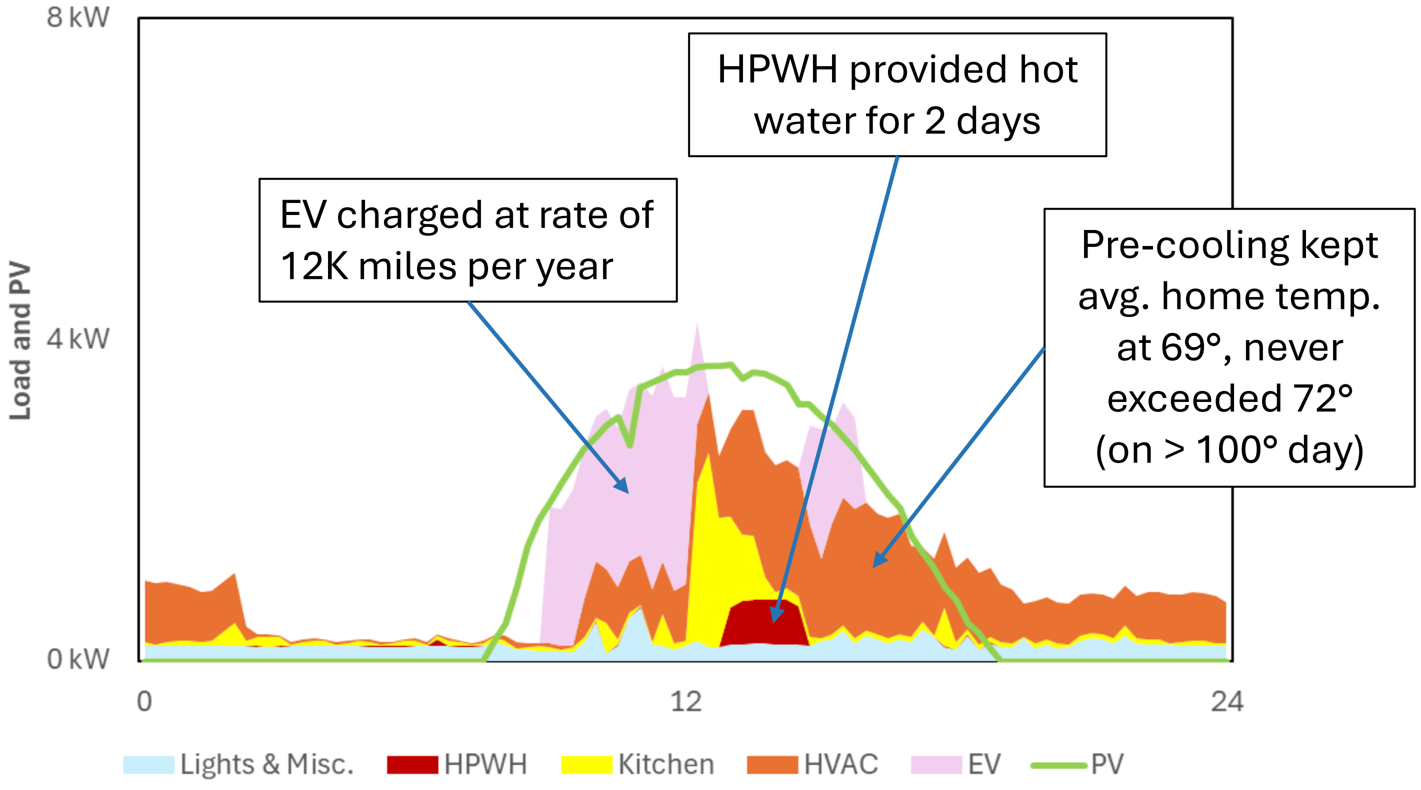
39 kWh of energy consumed above 1 kW

2025 CAISO Peak Day (August 21): Home's Peak Load is Low



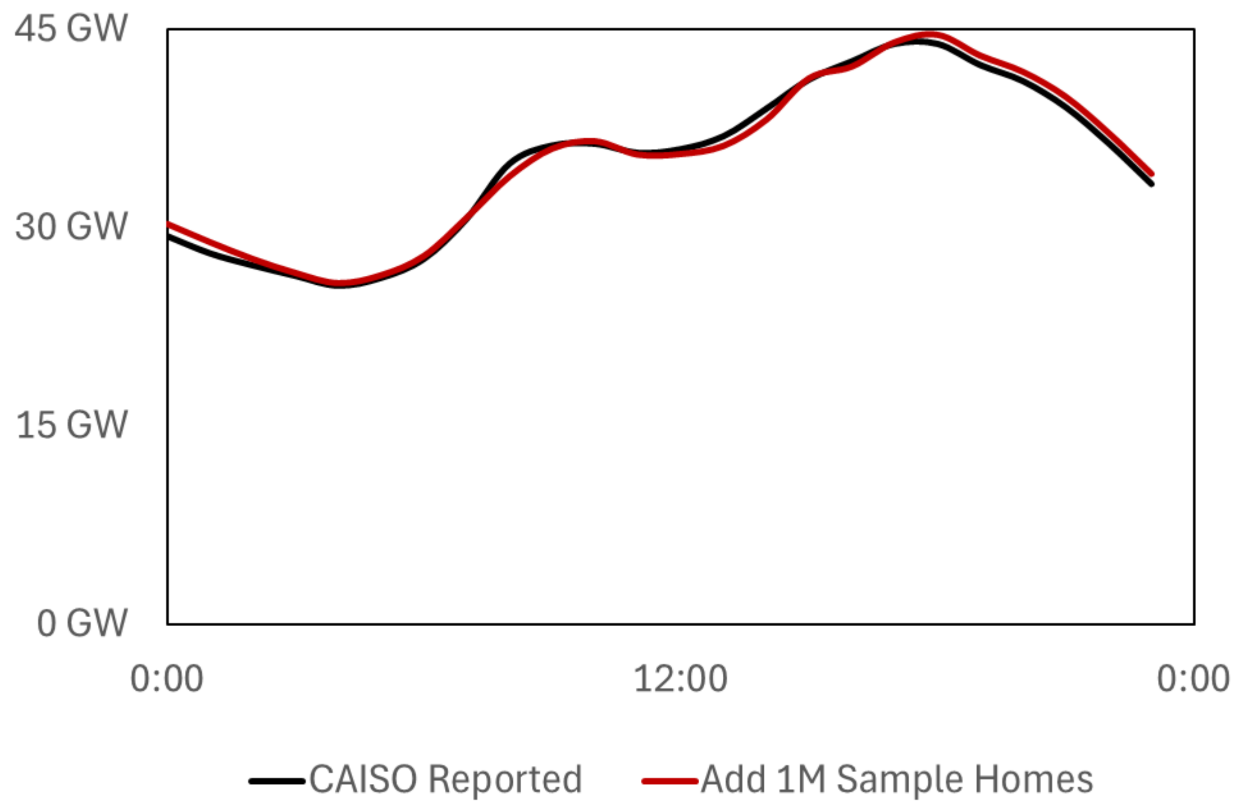
No energy consumed above 1 kW

Comfortable, Active Home on 2025 CAISO Peak Load Day (August 21)



ADDING 1 Million Sample Homes to Grid Would Have Minimal Impact

CAISO Peak Load Day, August 21, 2025



Note: Impact would probably be load reduction because it would be the **CHANGE** in load from 1 million homes, not the **ADDITION**

NY Case Study How to Target Building Electrification Investments

Balance Heat Pump Equipment and Shell Efficiency Investments

How Can We Meet customers Where They Are?

Home 1

1505 sq ft | 2 floors | Built in 1920

Annual energy use:

- **Natural Gas: 84 MMBTU**
- **Electric: 17 MMBTU**

Home 2

1424 sq ft | 2 floors | Built in 1930

Annual energy use:

- **Natural Gas: 144 MMBTU**
- **Electric: 15 MMBTU**

~$10,000

Thermal efficiency investment for each home

Including:
- Air sealing
- Wall insulation
- Attic insulation

in similar quantities

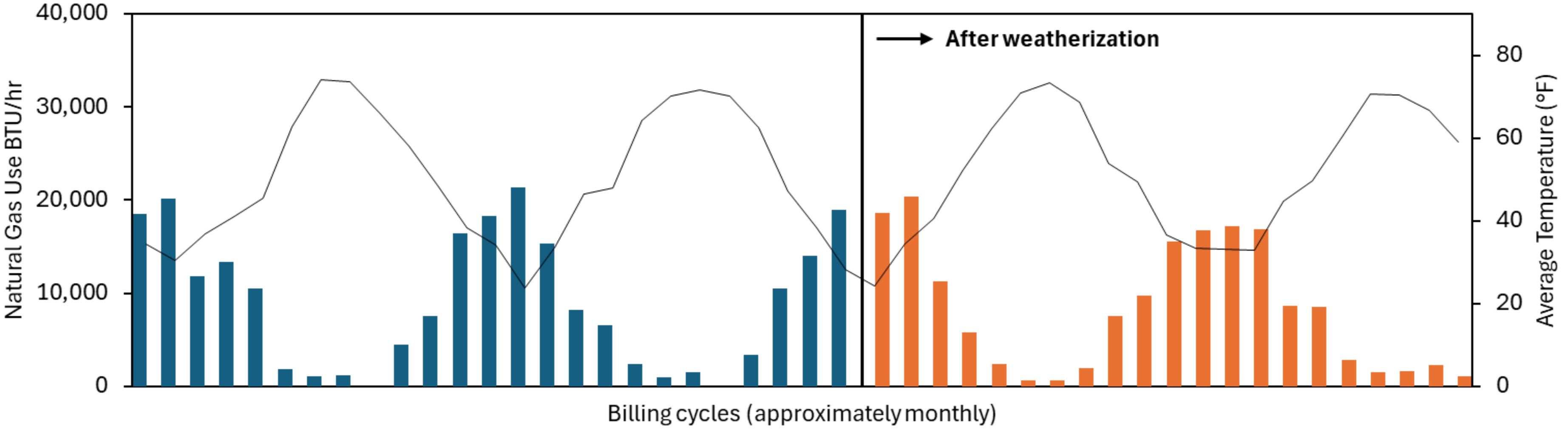
78 MMBTU

contractor estimated natural gas savings

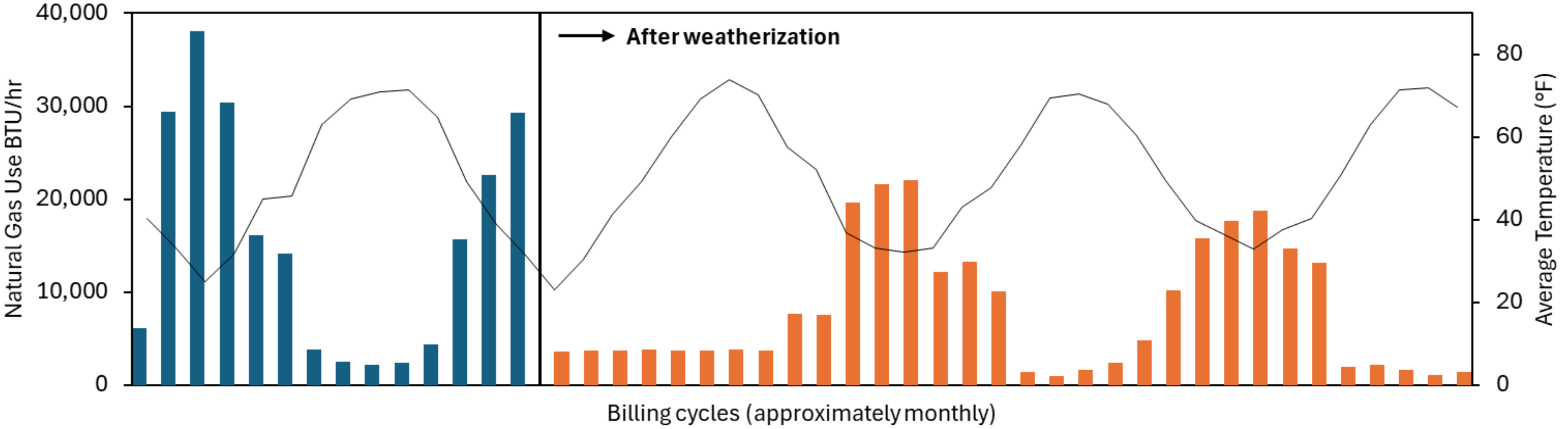
Using NY Technical Resource Manual models

How Does Energy Use Change?

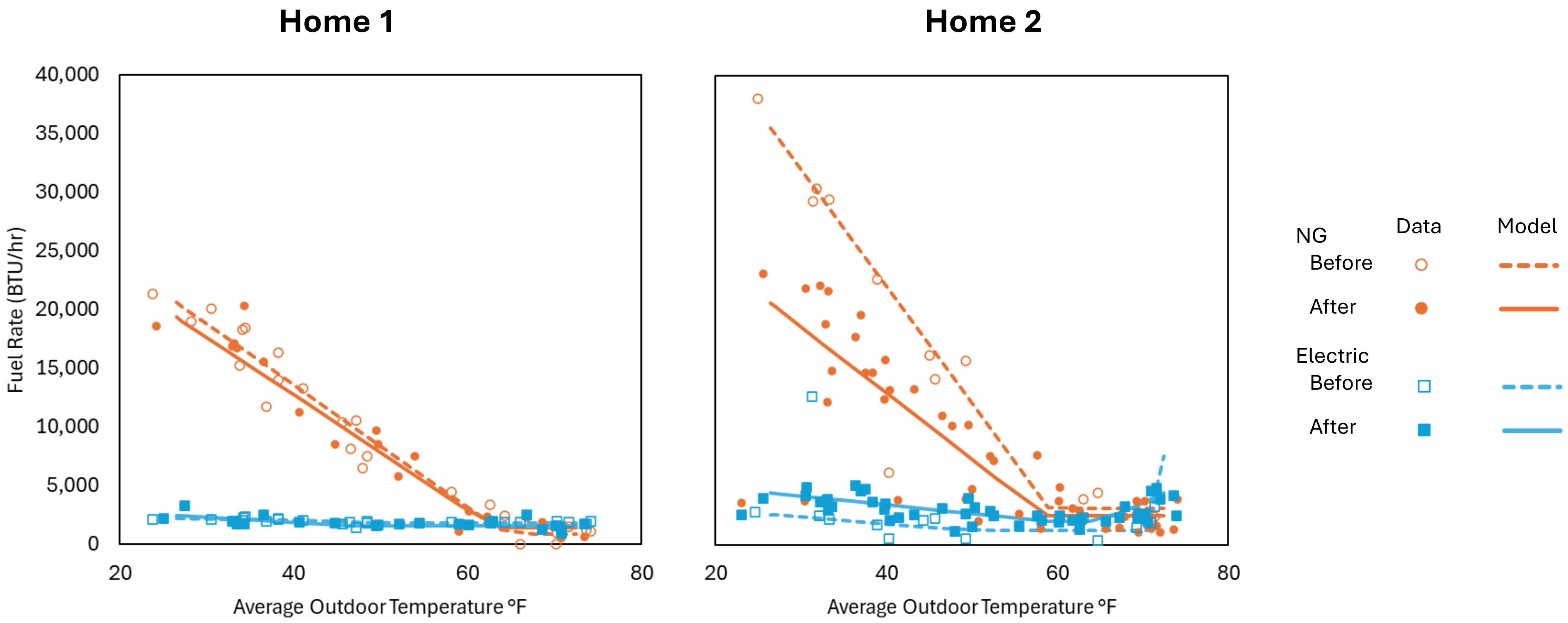
Home 1



Home 2



Virtual Energy Audit Models



Modeled total energy savings: 6.5%

Modeled total energy savings: 32.0%

How Can We Tell Which Home Will Save With Shell Investments?

Effective R-Values

	Before	After
Home 1	7.1	7.1
Home 2	3.5	5.7

Thermal efficiency scores:
The Effective R-Value

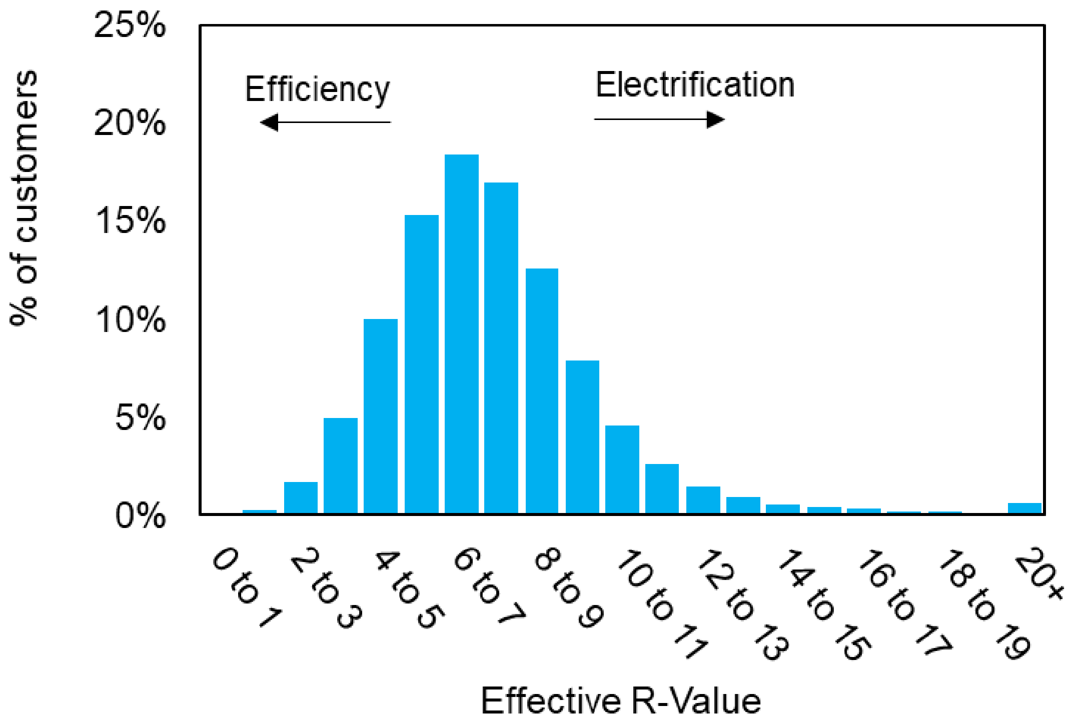
Calculate Effective R-Value based:

- Heating fuel rate
- Approximate exterior surface area

Use Effective R-Values to:

- Compare homes
- Communicate efficiency
- Qualify customers for programs

Virtual Energy Audits Facilitate Bulk Assessments in Upstate New York



- Use only utility provided data
- No touch for customers
- Run quickly
- Inexpensive per home
- Require only monthly billing data

Impressions from New York

New York is using virtual energy audits to meet aggressive decarbonization goals:

- Spend dollars where they will be most impactful
- Engage with the right customers for each type of program
- Use data to help customers make smart energy decisions
- Follow up on participating customers and quantify natural gas savings

"There is great value in the Clean Power Research data, which is helping us deliver highly targeted outreach and marketing campaigns to effectively reach customers in the market for and/or need of home insulation.

Using this data and focusing our outreach on those most in need has the potential to increase close rates on the installs due to more favorable return on investment (ROI) for our customers, as well as improve savings per home."

Michael DelNegro
Manager
Conservation and Load Management
NYSEG/RG&E

Conclusions

Intelligent investments can cost-effectively reduce GHG emissions

The right information can improve energy affordability

Properly operated fully electrified homes can support electric grid

Tools can help target building electrification investments

Products Trusted by 14 of the Top 15 U.S. Utilities

Clean Power Research®

Advancing the energy transformation for more than 25 years

Expertise

- Enterprise-grade cloud software
- Pioneering research with 85+ patents

Industries served

- 85+ utilities and energy agencies
- 340+ solar industry accounts

Utility solutions

PowerClerk®

No-code workflow automation

FleetView®

Behind-the-meter insights

WattPlan®

Trusted energy advice

Solar industry solutions

SolarAnywhere®

Solar data and intelligence

Clean Power Research®

Powering Intelligent Energy Decisions©

Thank You

Tom Hoff, tomhoff@cleanpower.com

Brittany Farrell, brittanyf@cleanpower.com

Q&A

Public Comment

Adjourn

Thank you for your attendance!