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RECURVE



Enhancing the CEC dataset to unlock DER analytics

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July 15, 2026



Challenge: a mountain (range) of raw data

CEC's dataset is an incredible resource with some key challenges to unlocking its value.

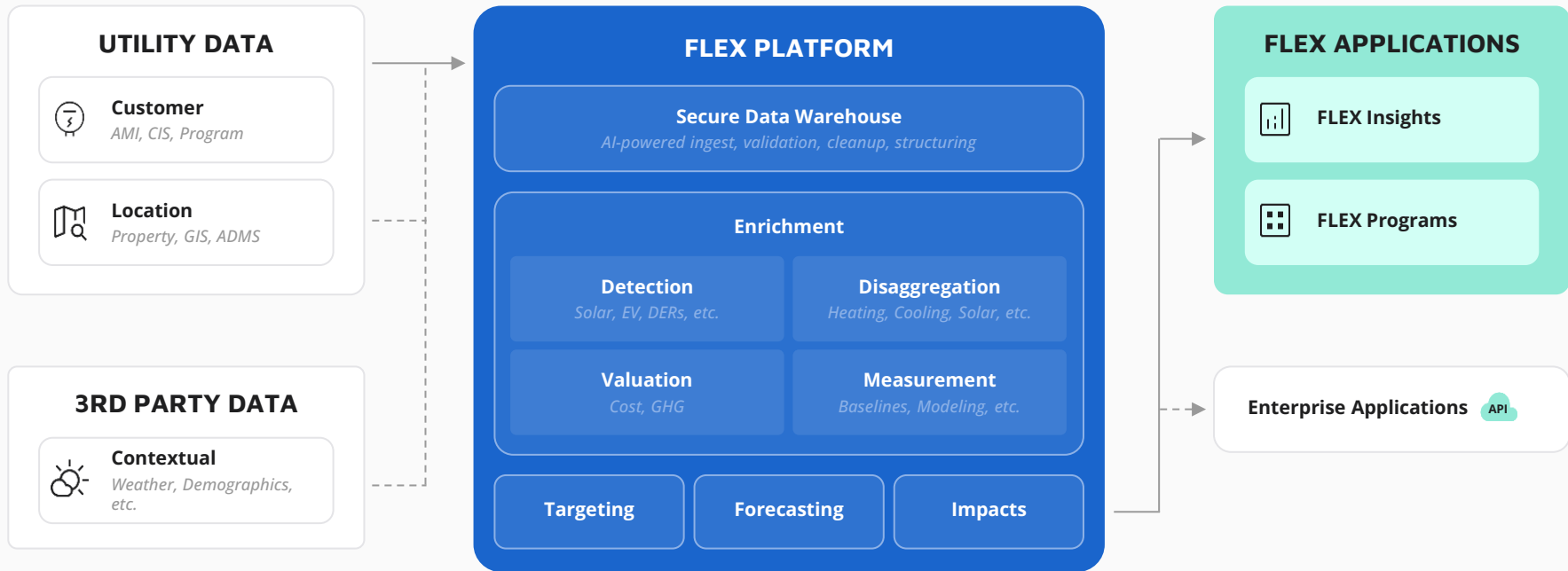
Very big: Raw residential data alone is 250 TB. Ad-hoc querying is costly; pre-computation of metrics is essential.

Multiple sources: Six different utilities in a patchwork of overlapping service territories.

Limited site characteristics: Utilities provide address, solar status, and rate code, but NOT residence type, climate zone, census information, etc.

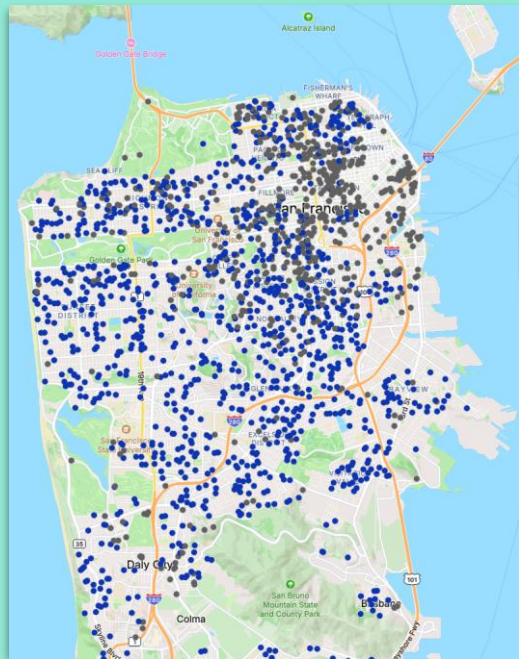
Solution: Data enrichment with FLEX Platform

Recurve's FLEX platform organizes and enriches disparate customer data to deliver trusted insights.



Site-level data enrichment

- **Address normalization.** Standardize address formatting
- **Location matching across utilities.** Matched gas and electricity meters enable a complete picture of customer energy consumption
- **Housing type classification.** Distinguish single-family and multifamily residences with address-level analysis
- **External datasets.** Additional address-level data from third-party sources, such as:
 - County and census tract
 - Census data (e.g., median income in census tract)
 - CEC Building Climate Zone and Forecast Zone
 - Disadvantaged and Low-Income Community status
 - Manufactured housing status



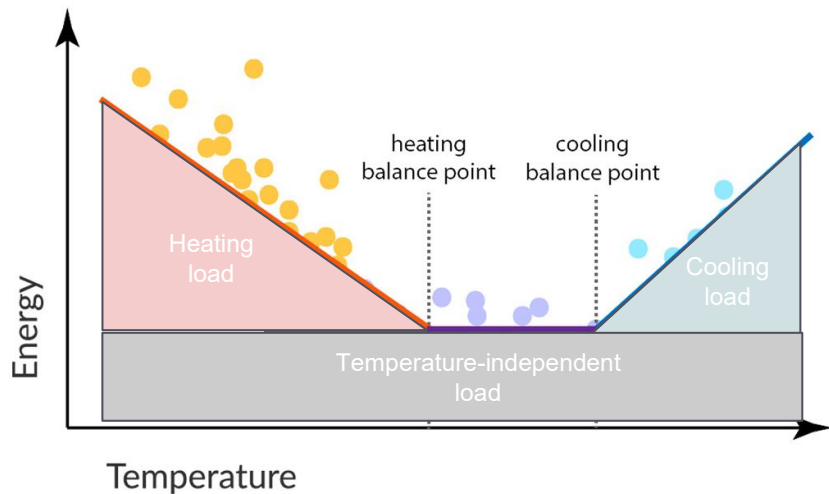
Single Family - Blue
Multifamily - Gray

Disaggregating Heating and Cooling with OpenDSM

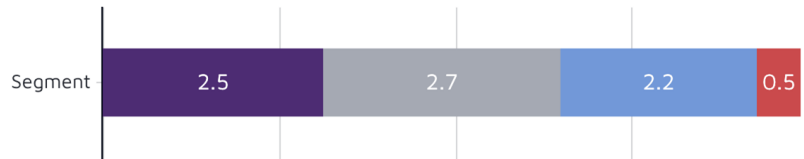
OpenDSM is software developed by Recurve to characterize metered energy consumption and measure load impacts.

It can disaggregate heating, cooling, and temperature-independent load for each meter on a seasonal and annual basis.

Recurve's **FLEX platform** computes these and numerous other consumption metrics for each meter in CEC's dataset.



■ Heating MWh ■ Cooling MWh ■ Discretionary MWh ■ Baseload MWh



<https://opensdm.energy/>

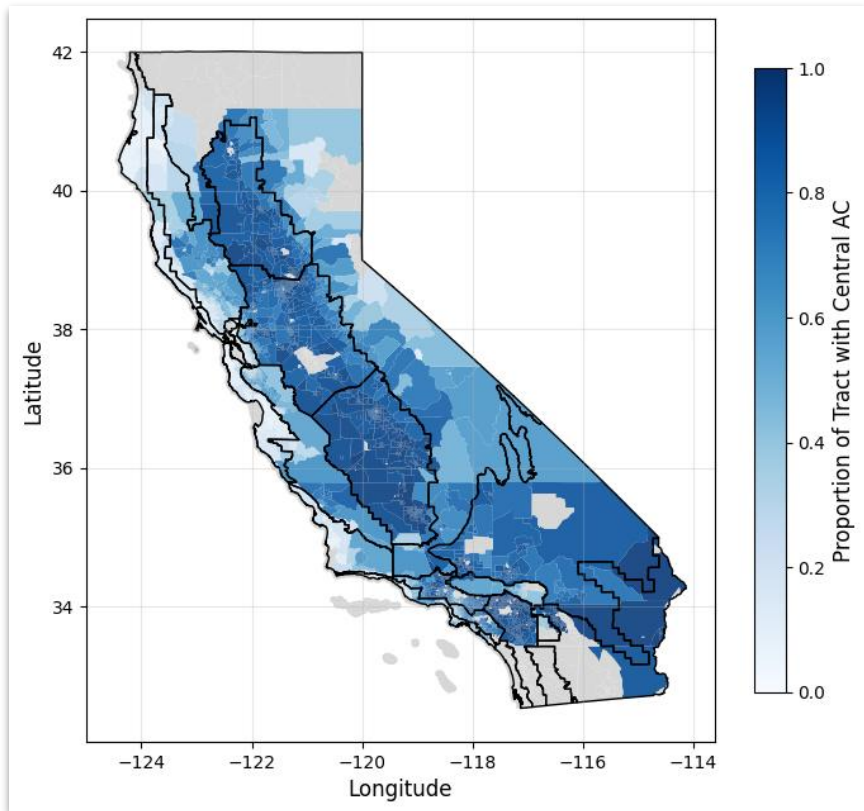
HVAC load detection and statewide saturation

Recurve's platform detects the presence of important end uses:

- Central air conditioning
- Primary electric space heating
- Primary gas space heating
- Gas water heating

With these detections, we compute the saturation of each end use by climate zone, county, ZIP code, and census tract.

Resulting saturations are broadly consistent with RASS results but are more granular and up to date.



Note: the dataset used here did not contain data from SDG&E, PacifiCorp or small municipal and irrigation-district utilities © RECURVE 2026 | 6

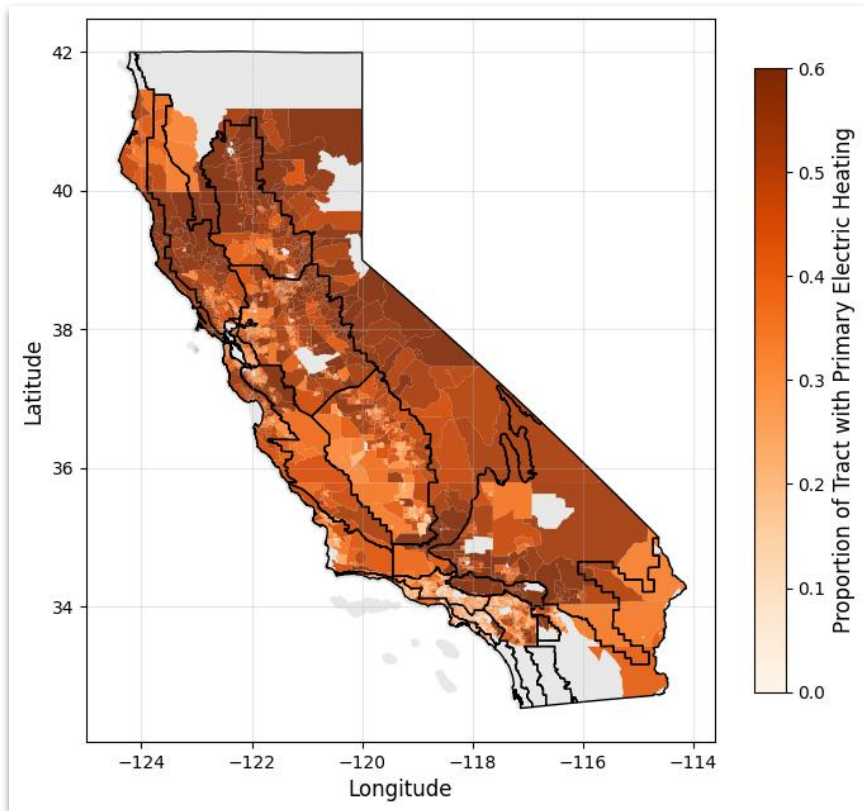
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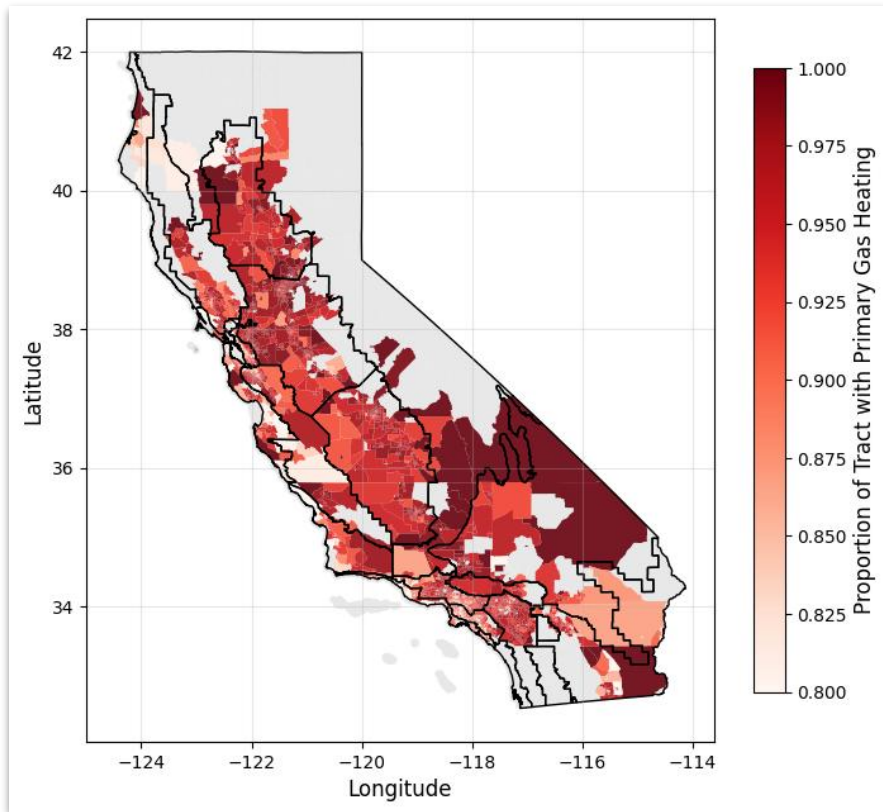
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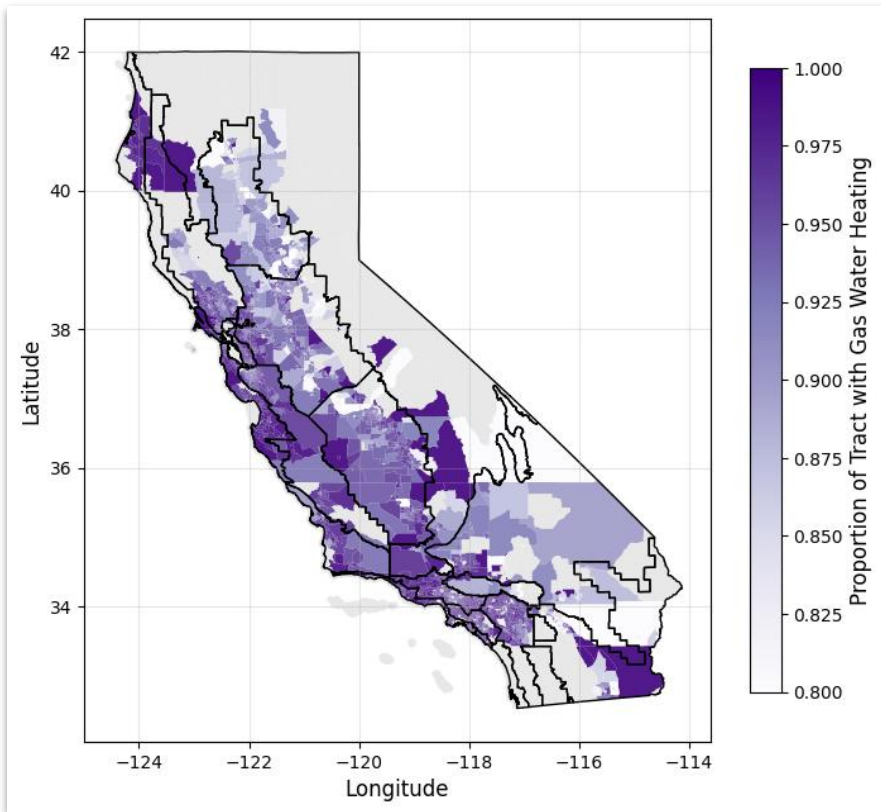
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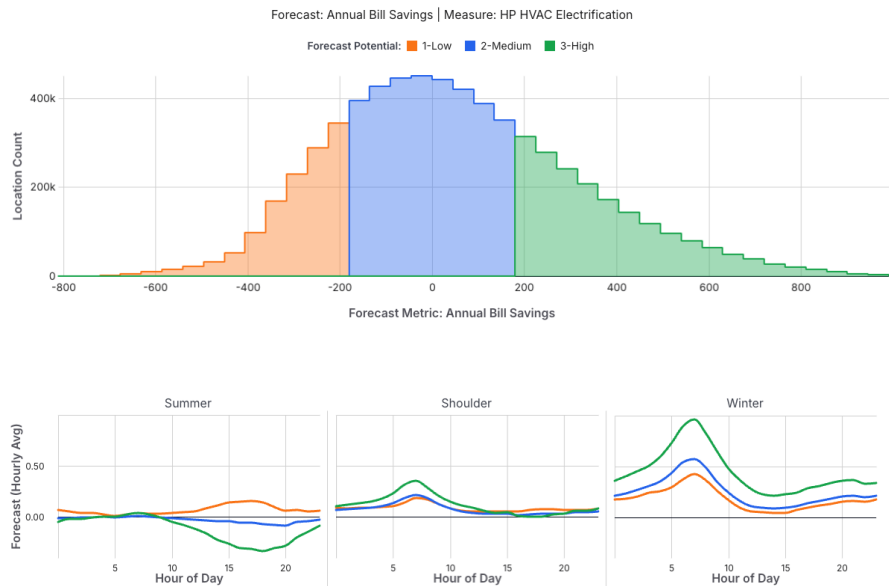
Measurement-based forecasting models for electrification

Recurve performs impact measurement for the CPUC's TECH Clean California electrification program using the CEC's meter data.

Thousands of HVAC and water heating measurements enable forecasted impacts for millions of CA households:

- Energy impacts (gas and electricity)
- Customer bill impacts
- Greenhouse gas impacts
- Grid impacts (total system benefit)

These forecasts are supporting customer outreach for CEC's Equitable Building Decarbonization program.



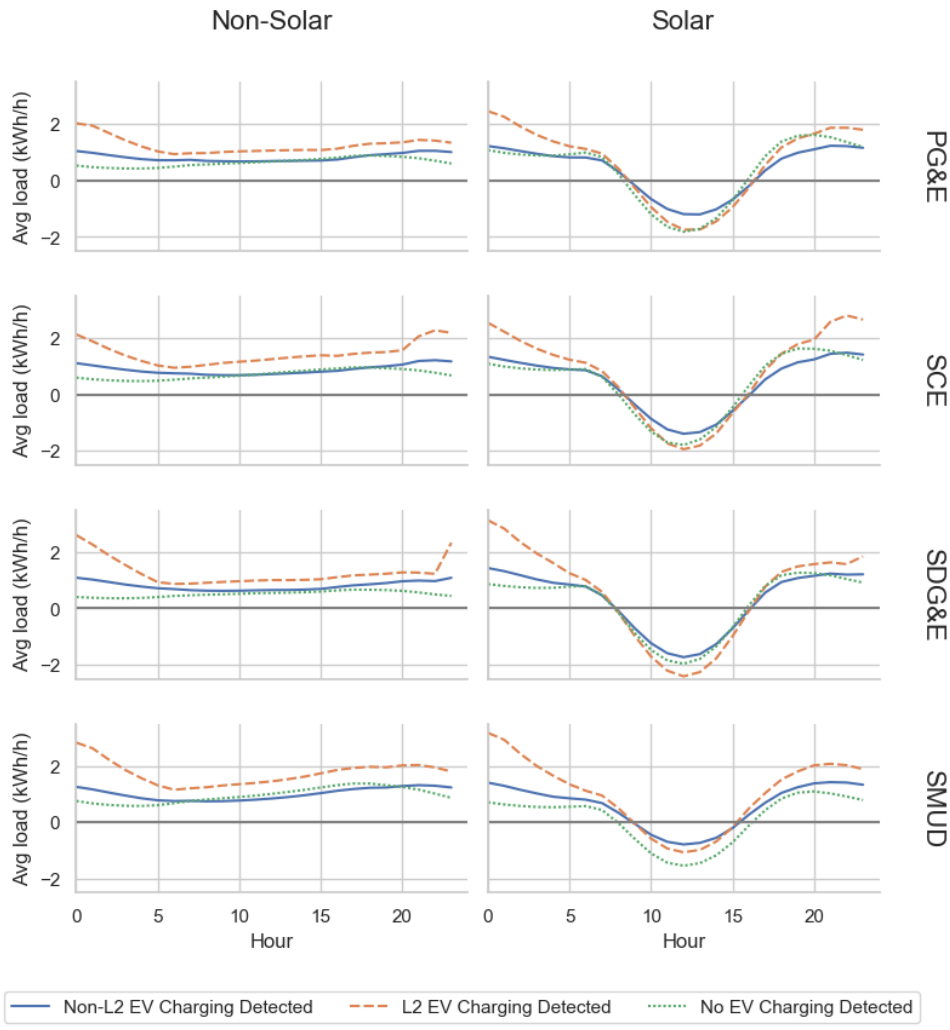
Forecasted statewide distribution of bill impacts (top) and corresponding load shape impacts (bottom) for HVAC heat pump installations from the EBD forecasting dashboard.

Detecting EV charging

Recurve's FLEX platform identifies meters with EV charging usage patterns using a neural-net model

- We used EV registration data from the CA DMV to refine and validate the detection
- This allows us to distinguish EV *registration* from EV *charging*

We identified the subset with Level 2 EV charging by assessing the frequency of high-load events



Assessing EV detection success

Validating with DMV data is tricky

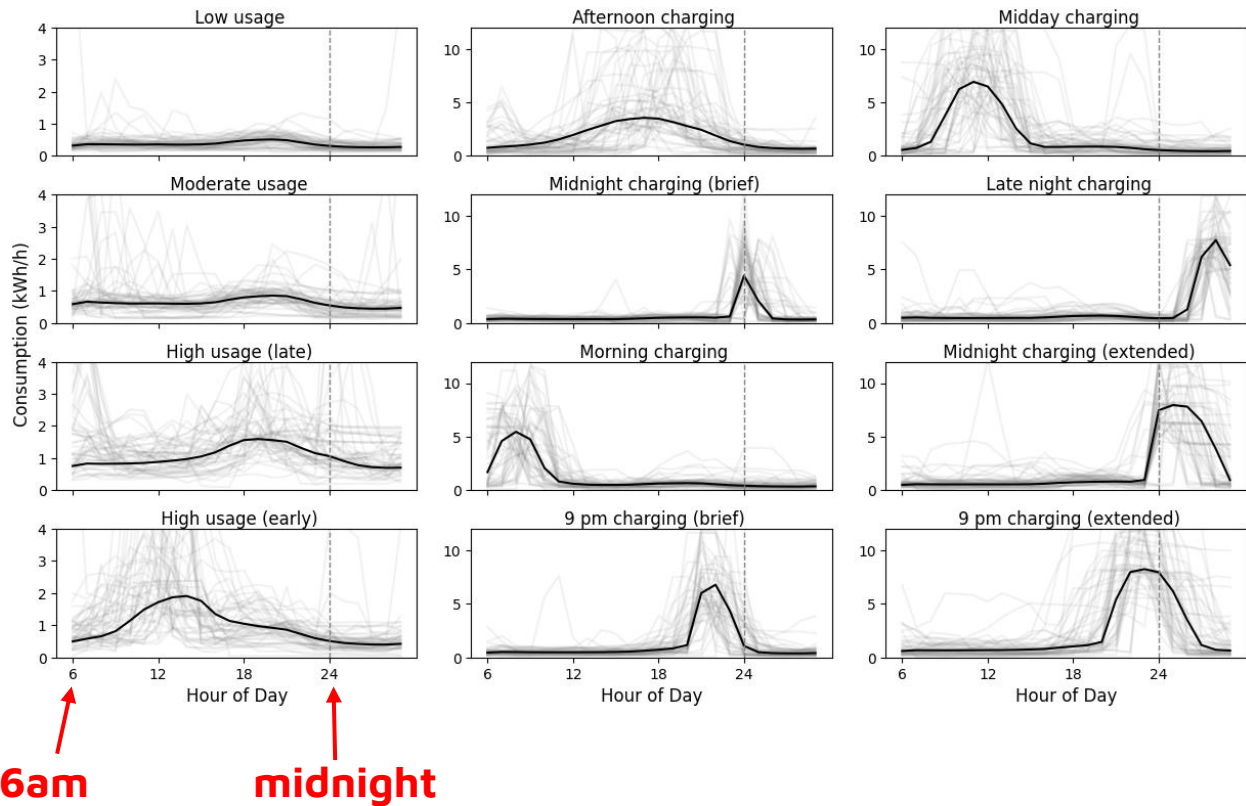
- We know some EVs are not charged at their registered address
- Level 1 and PHEV charging will be harder to detect than Level 2 BEVs
- Recent EV purchases will be harder to detect

The California Vehicle Survey helps define expectations

- **66%** of BEV owners and **34%** of PHEV owners have Level 2 charging at home
- **5%** of EV owners do not have access to home charging at all

- We detect EV charging for **58%** of BEV registrations and **23%** of PHEV registrations with 1+ years of ownership
- **84%** of detections appear to have Level 2 charging
- **28%** of detections are at addresses *without* a registered EV
- These results imply **80-100%** detection of BEVs with Level 2 charging.
 - Detection rates are lower for PHEVs (24-34%) and Level 1 charging (23-39%)

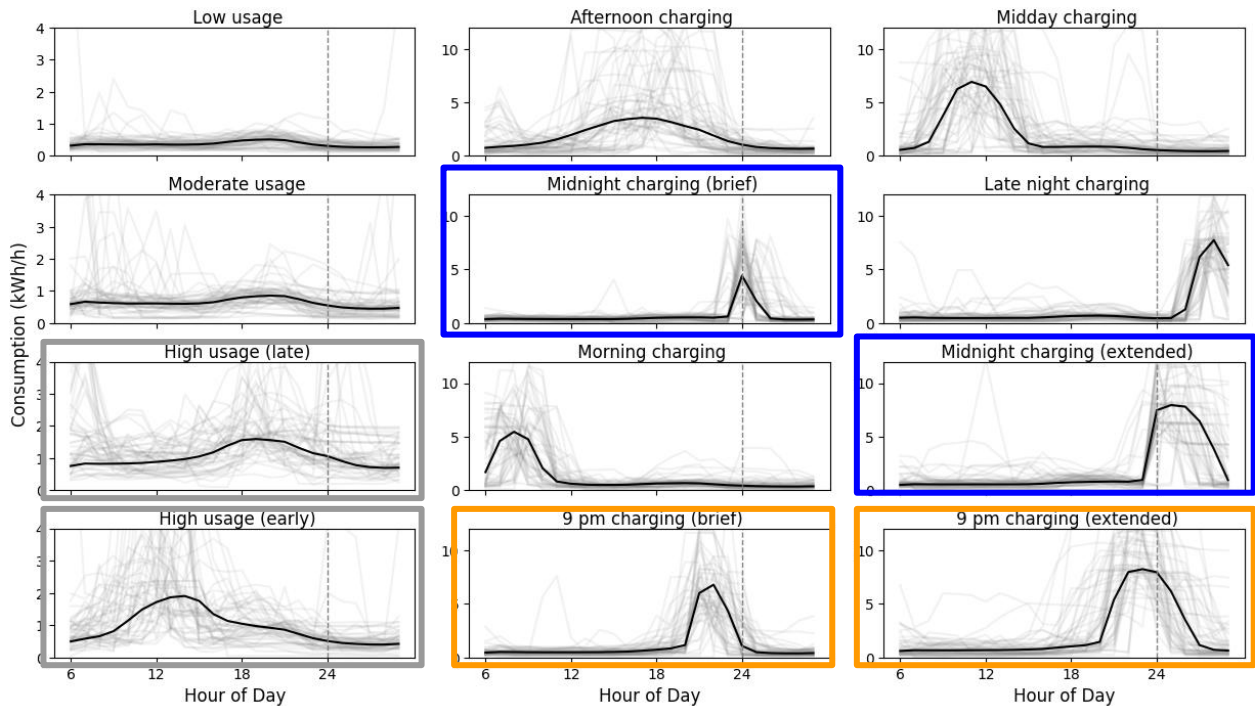
Characterizing charging behaviors with load shape clustering



A three-step process

1. Cluster individual customer load shapes to find representative patterns
2. Cluster these patterns across the full dataset to find typical patterns in the population

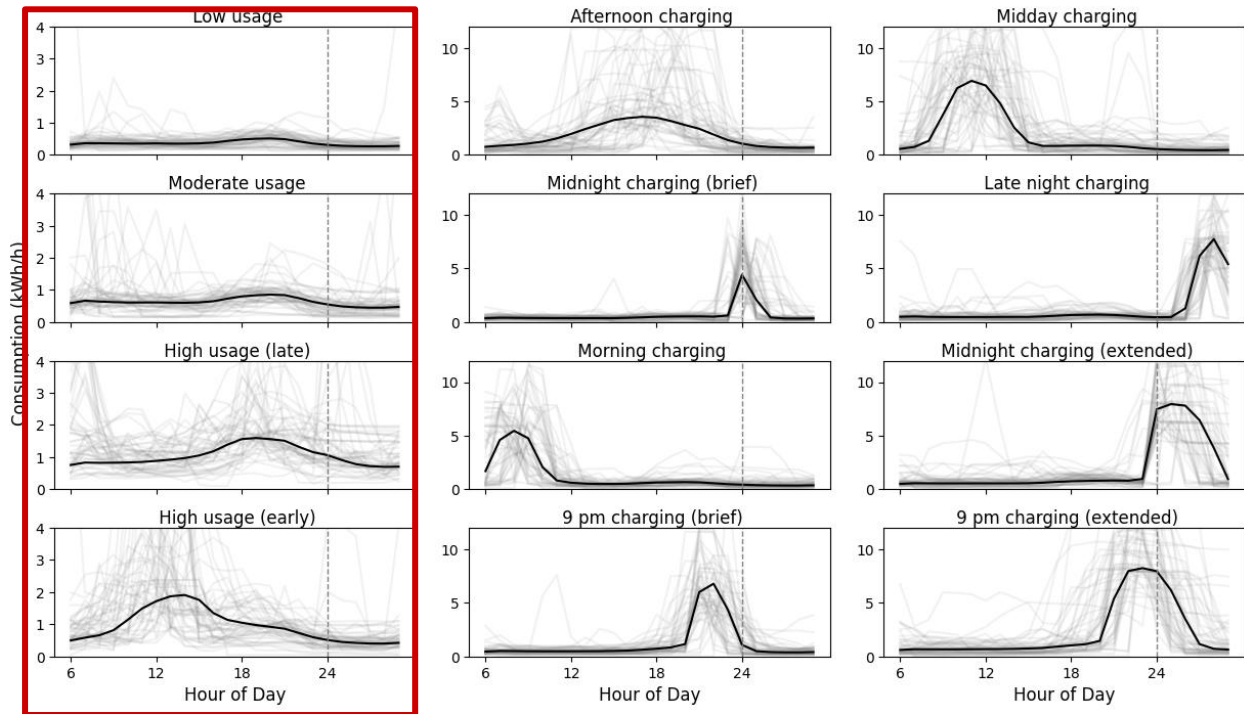
Characterizing charging behaviors with load shape clustering



A three-step process

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3. Combine patterns that reflect similar charging decisions

Characterizing charging behaviors with load shape clustering

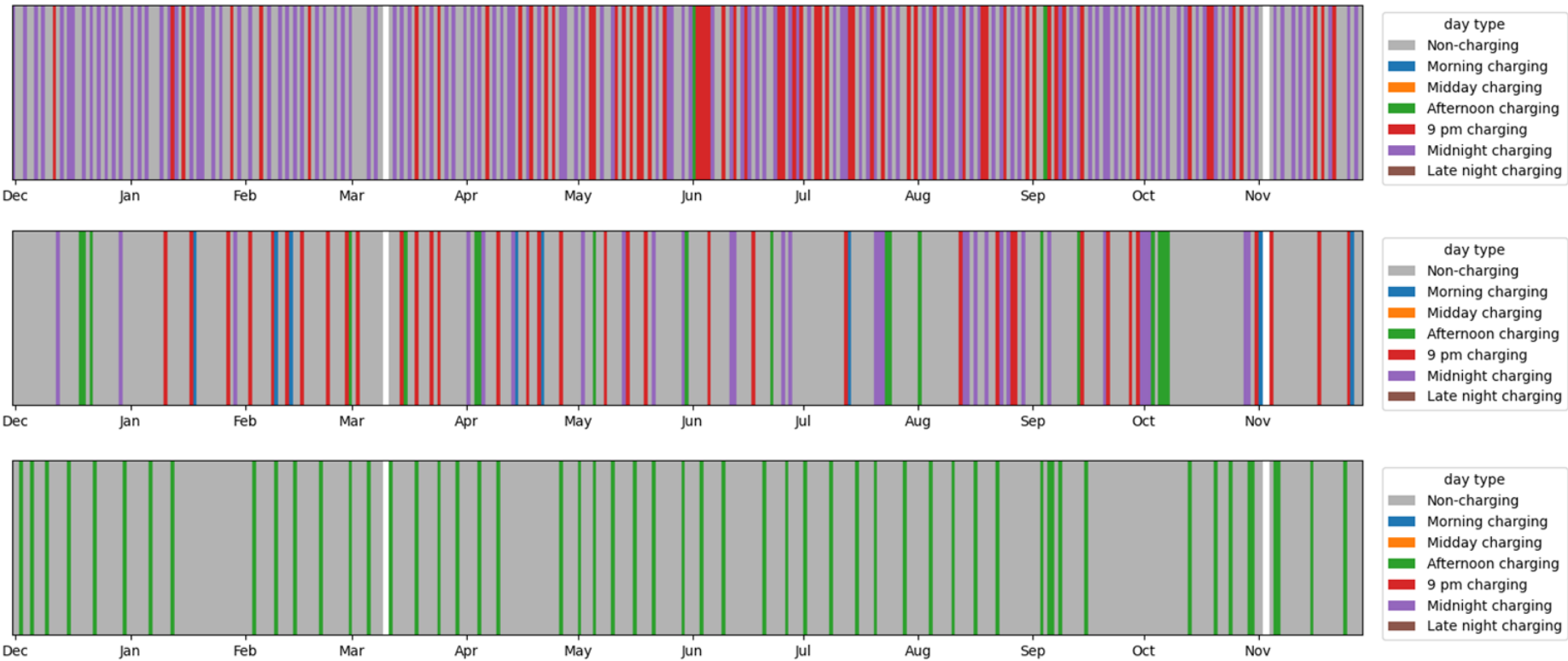


Non-charging clusters

A three-step process

1. Cluster individual customer load shapes to find representative patterns
2. Cluster these patterns across the full dataset to find typical patterns in the population
3. Combine patterns that reflect similar charging decisions

...and on the individual level



Daily charging patterns over a year for three individual meters with Level 2 EV charging

Summary-Data Enrichment

Recurve's FLEX Platform is enhancing CEC's data in several areas to support more effective analysis



Site-level data enrichment

Address matching, housing types, external datasets



Load disaggregation and end-use detection

Heating and cooling loads, load shape metrics, AC and heating detection



EV charging detection and characterization

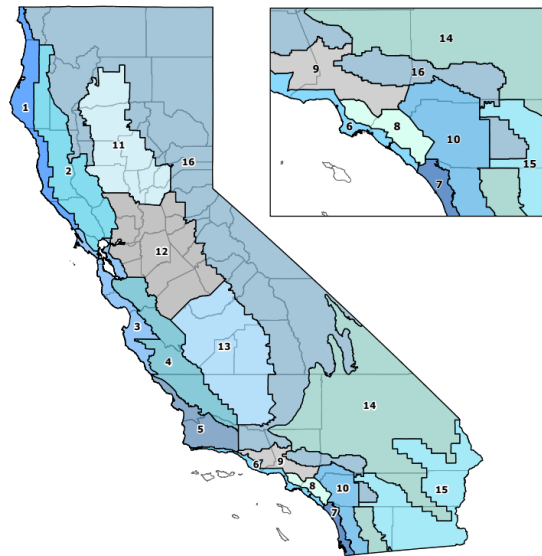
EV charging detection, Level 2 charging detection, load shape clustering

Example Analysis: Assessing Equity in Cooling Access

Analysis Overview

Assess equity in cooling access and forecasted electrification bill impacts across California households and priority populations

- Cooling needs and AC access by climate zone and community type
- Forecasted bill impacts of heat pump water heaters and heat pump HVAC
- Differences for three different priority communities compared to others:
 - **Low-income communities (LIC)**, defined by census tract
 - **Disadvantaged communities (DAC)**, defined by census tract
 - **Low/moderate income (LMI)** customers, identified by income-qualified rates (e.g., CARE)

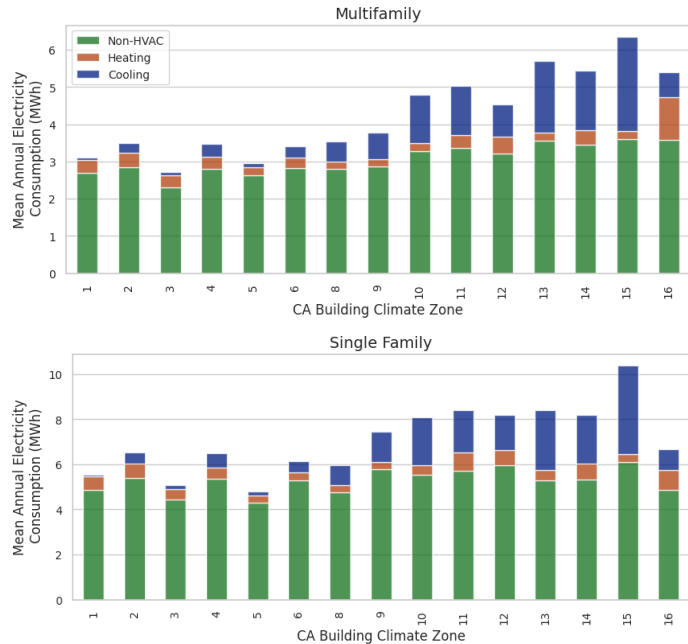


California Climate Zones

Cooling Loads And AC

Cooling is a large share of use in hot climates and central AC saturation is high

- Cooling energy is highest in hot inland and desert zones, especially CZs 10–15
- Non-HVAC loads vary much less across zones; single- and multifamily usage patterns look similar
- Hot zones show more than 75 percent central AC saturation, with over 90 percent in CZ15; very few homes have zero cooling



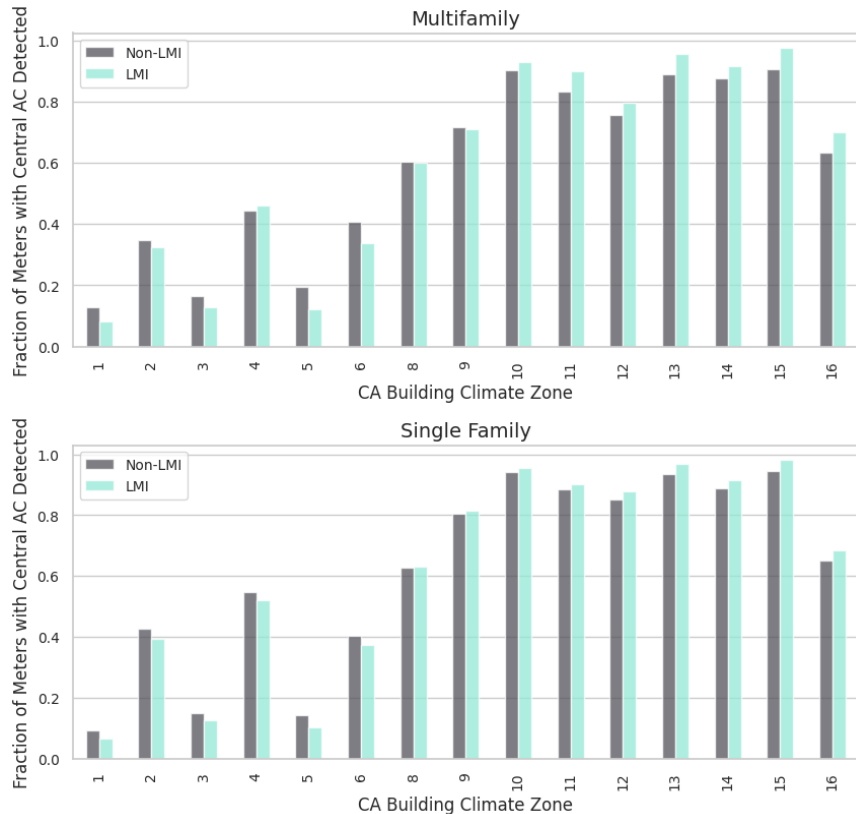
End-use electricity consumption by climate zone for multifamily and single-family homes.

Assessing equity of AC access

In cooler climate zones, LMI customers have lower AC saturations, but LMI AC saturations are similar or higher in hot climate zones.

→Cooling appears to be largely non-discretionary in hot climate zones; it may be more effective to focus on relative energy burden than on access.

LIC and DAC populations yield similar findings

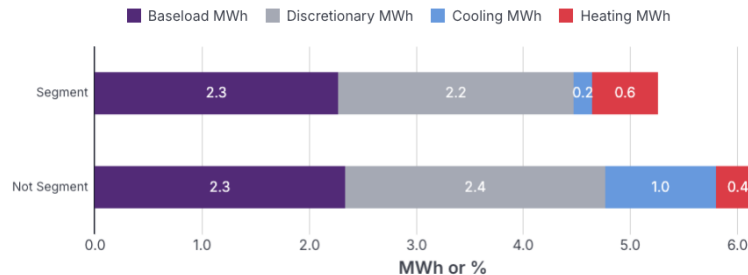


Identifying unmet cooling needs where they exist

Unmet cooling needs appear small, but they do exist. Exploration tools in FLEX Platform allow such subgroups to be identified for intervention.

At right: LMI single-family homes without AC in climate zone 15. (263 homes out of 10 million in the full dataset). Load disaggregation shows that these homes are occupied but lack cooling.

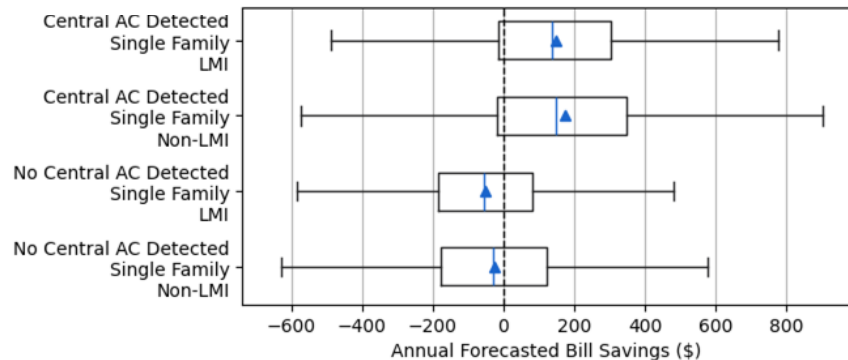
Precise targeting capabilities like these help the CEC's Equitable Building Decarbonization program identify customers most likely to benefit from electrification.



Forecasting bill impacts of HVAC electrification

Space-heating electrification has mixed bill outcomes; rates and existing AC status drive equity risk

- Forecasted heat pump HVAC bill impacts range from savings to increases
- Dwelling type and existing AC are the biggest drivers of differences
- Priority populations have similar bill-impact distributions to others at fixed climate, dwelling type, and AC status
- Electricity rates also strongly shape impacts; recent LSE rate increases may make future outcomes less favorable than those modeled



Forecasted heat-pump HVAC bill impacts in single-family homes, by AC status, and income group

Thank you

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