Electrical Service Panel Capacity in California Households with Insights for Equitable Building Electrification

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ACEEE Summer Study, Panel 1

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BERKELEY LAB

UCLA

NREL Transforming ENERGY

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Outline

- Background on electrical panels
- Methods (LBNL and UCLA), raw data and equity indicators
- California housing stock predictions
- Conclusions

Why Do We Care?

- Decarbonization of homes will add lots of new electrical loads
- These new loads may lead to panel and service upsizing
- Panel and service upsizing is expensive and time-consuming
- These problems might adversely affect different housing types and populations in ways that exacerbate current inequalities

How Big Are These Problems?

- Unclear currently which homes are the most constrained and challenging
  - B*usiness-as-usual* practice suggests many panels under 200A may require upsizing

- Understanding scope of this challenge requires characterizing existing panels
  - What are current service capacities?
  - Do different capacity assessment procedures agree?
  - Do house characteristics matter: age, size, DAC Status?

What Might This Cost?

- Depends on location, need for panel relocation, underground service drop, and home modifications

  - **Panel: $3,500** ($1,000-$5,000)
  - **Circuits: $1,384 each** ($500-$1,500)
  - Service: $1,000-$25,000 (combination of direct cost to individual properties and indirect cost to all rate payers)

  - **National cost for panels only (very rough estimate): $150-250 billion**

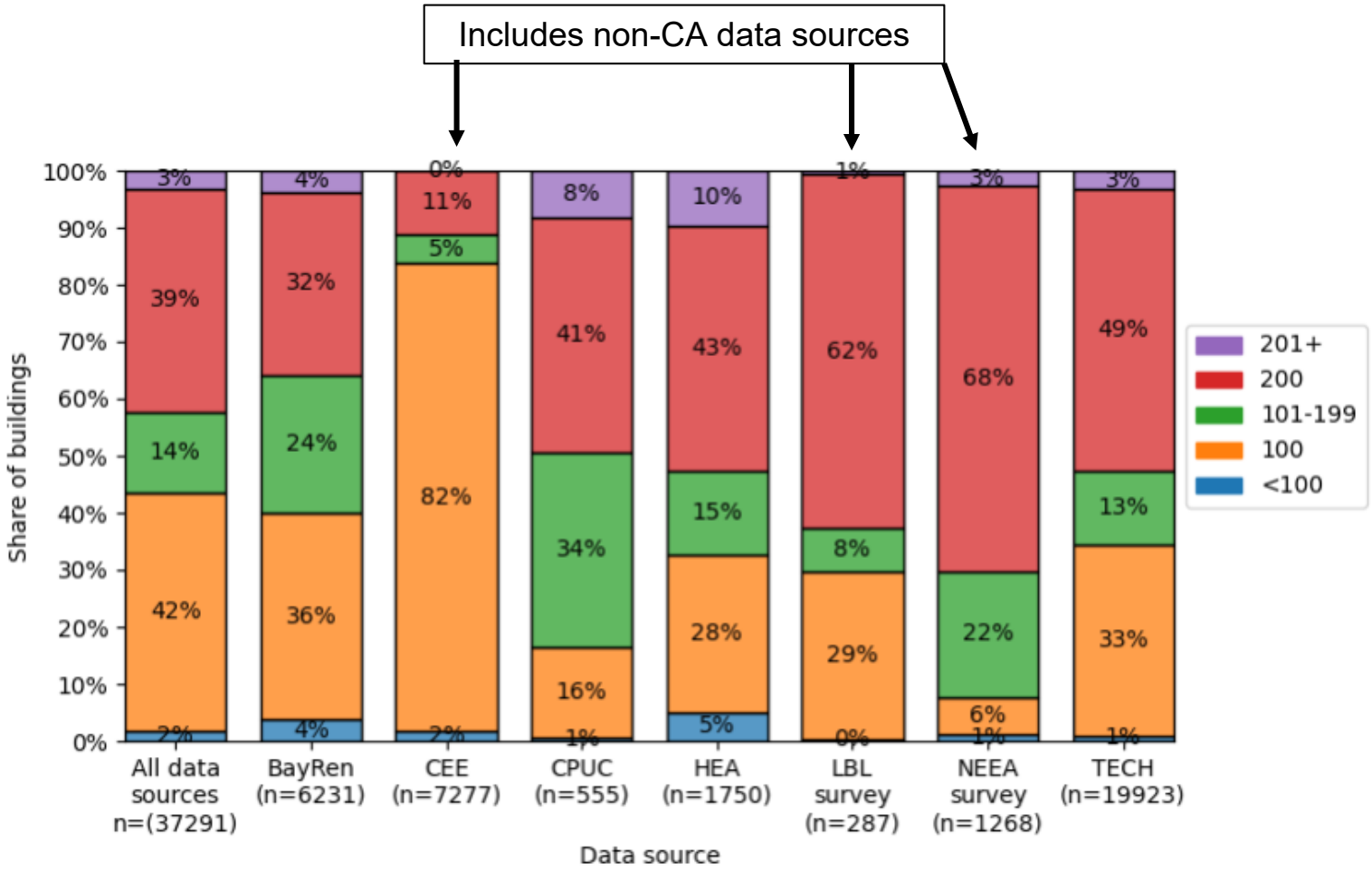
LBNL Energy Program Machine Learning

Raw panel and housing data from various programs

Machine learning classification model for panel ratings

ResStock metadata

Housing stock predictions



UCLA Permit Data Record

Direct:

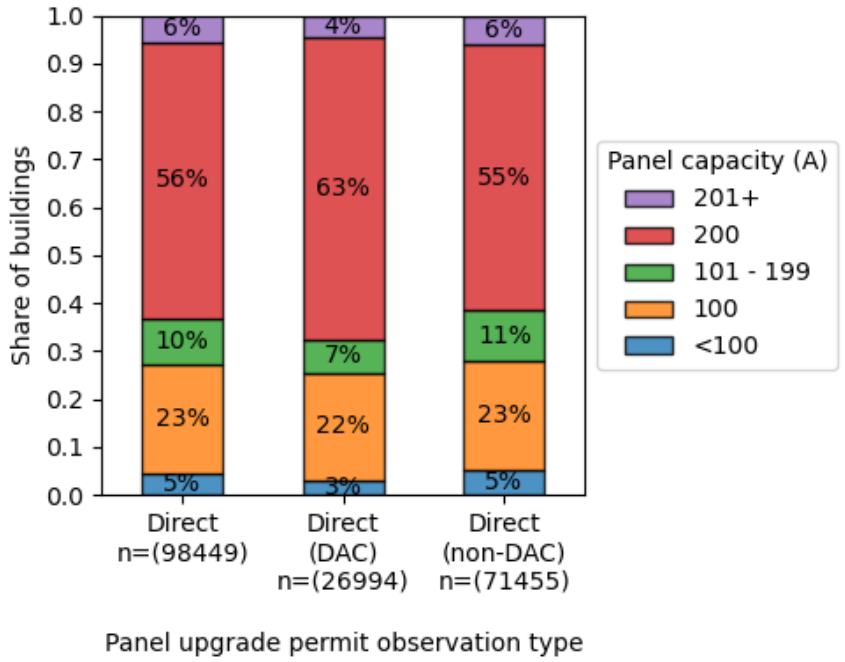
Observed panel upgrade and housing data from municipal building permit records

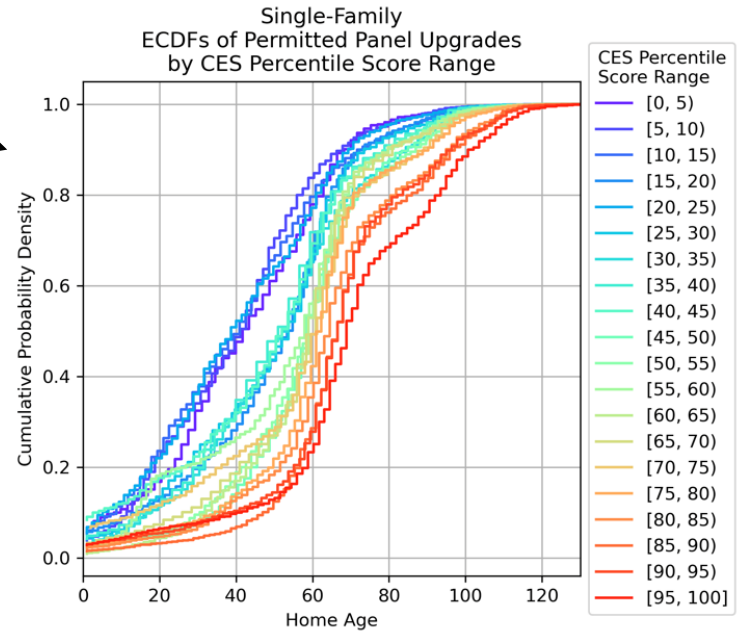
Indirect:

Inferred panel ratings based on assumptions about panel sizes as-built combined with probabilities of past upgrade based on vintage and permit data CDFs

State parcel data from CoreLogic

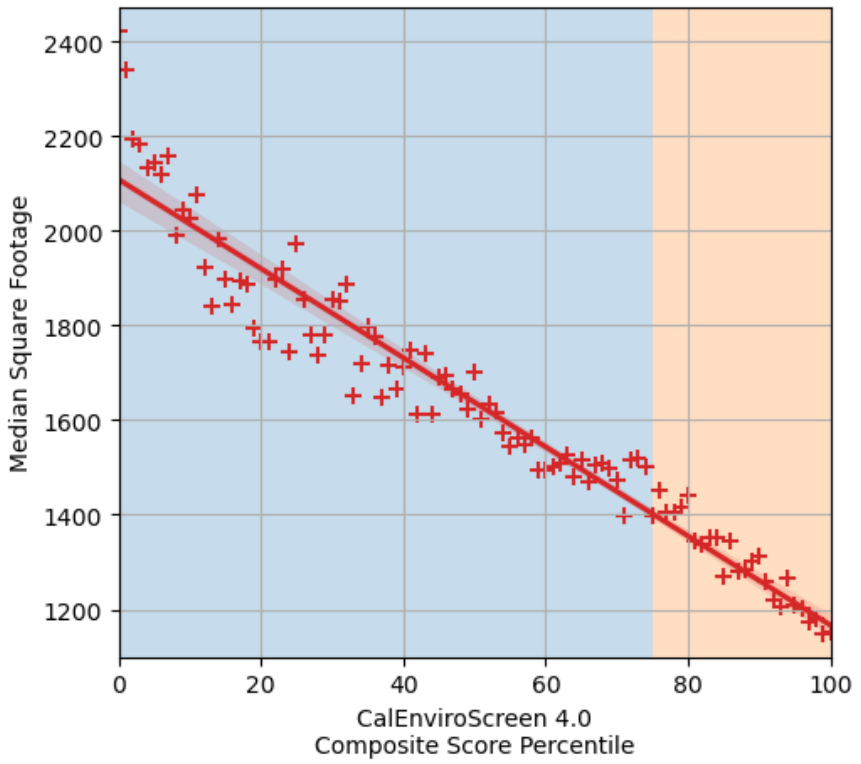
Housing stock predictions



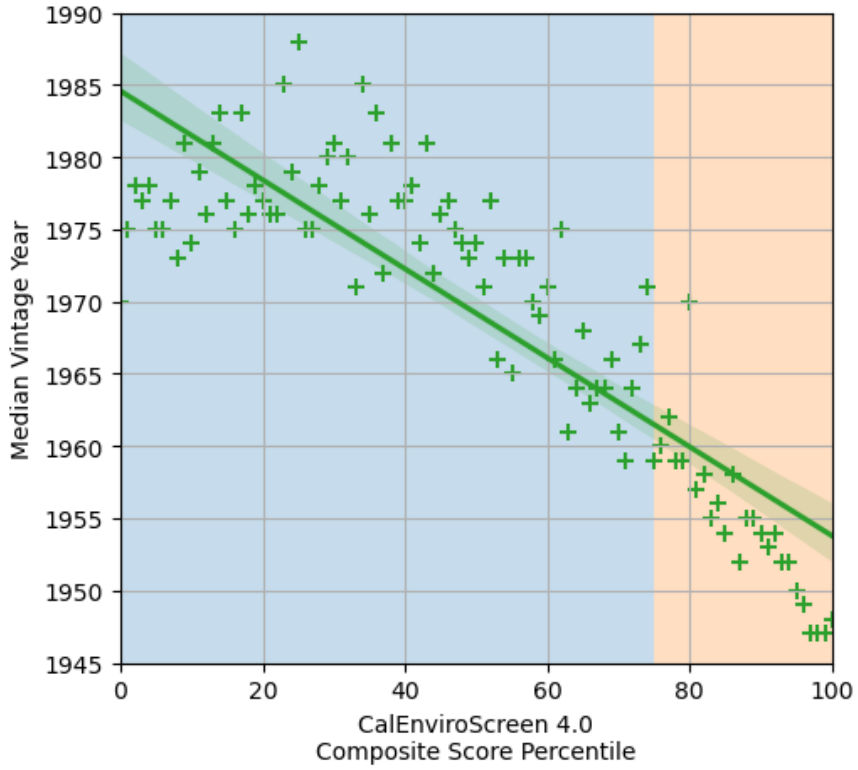


Equity Indicators

FLOOR AREA



VINTAGE



- Many variables available for assessing Equity Status, reflecting different features, from poverty to pollution
- Panel datasets do not use consistent equity variable mappings
- UCLA uses Disadvantaged Community (DAC) status per CalEnviroScreen 4.0 >75th percentile
- LBNL uses % of Area Median Income relative to the Federal Poverty Level
- Floor area and vintage are correlated with equity status, so we use these as shared comparative features

Panel Ratings in CA Single-Family Housing Stock

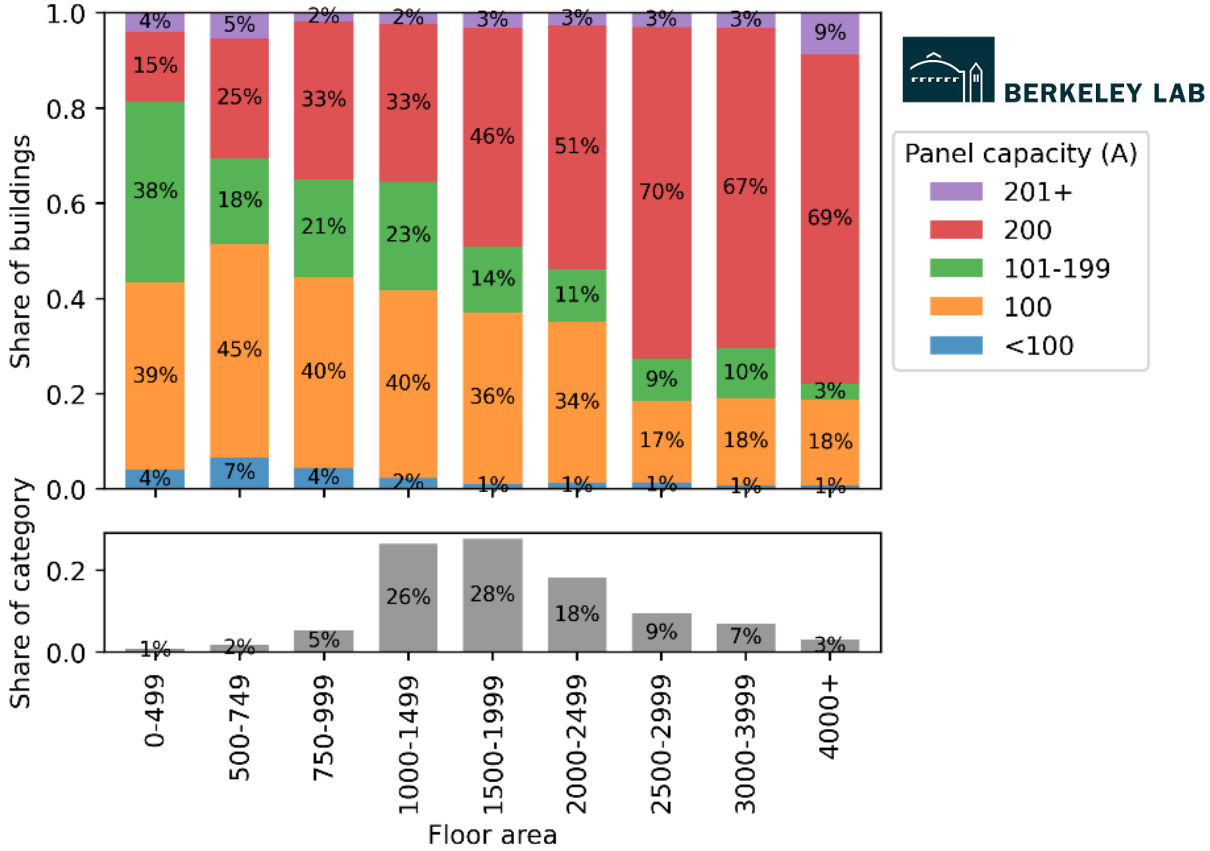
Panel Ratings	LBNL Housing Stock (%)	UCLA Housing Stock (%)
<100A	1.8%	3.0%
100A	33.3%	31.7%
101-199A	15.3%	15.0%
200A	46.6%	39.0%
201+A	3.0%	11.3%

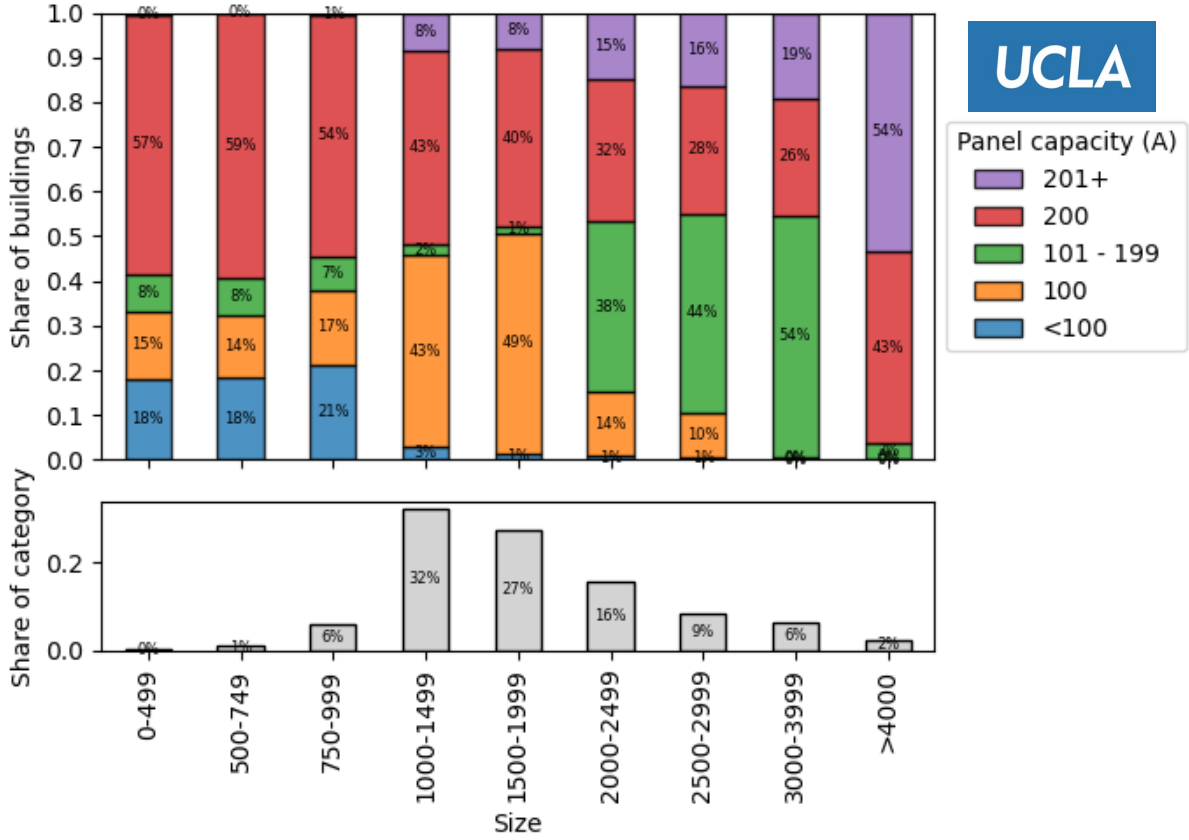
- Strong general agreement between methods
- 200A are most common, followed by 100A and 101-199A
- Small numbers of very small (<100) and very large panels (>200)

Panel Capacity Relationship to Building Characteristics

- Floor area
- Vintage
- Equity status

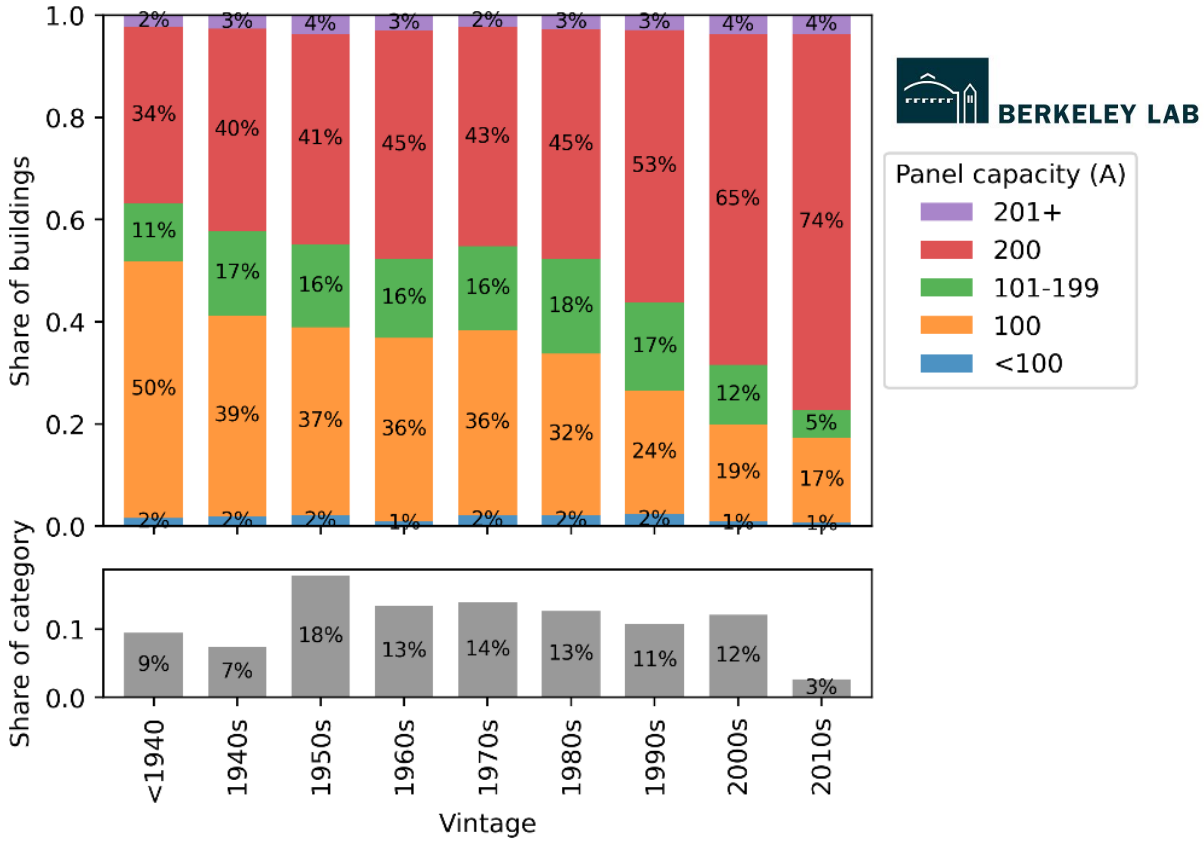
Panel Ratings by Floor Area

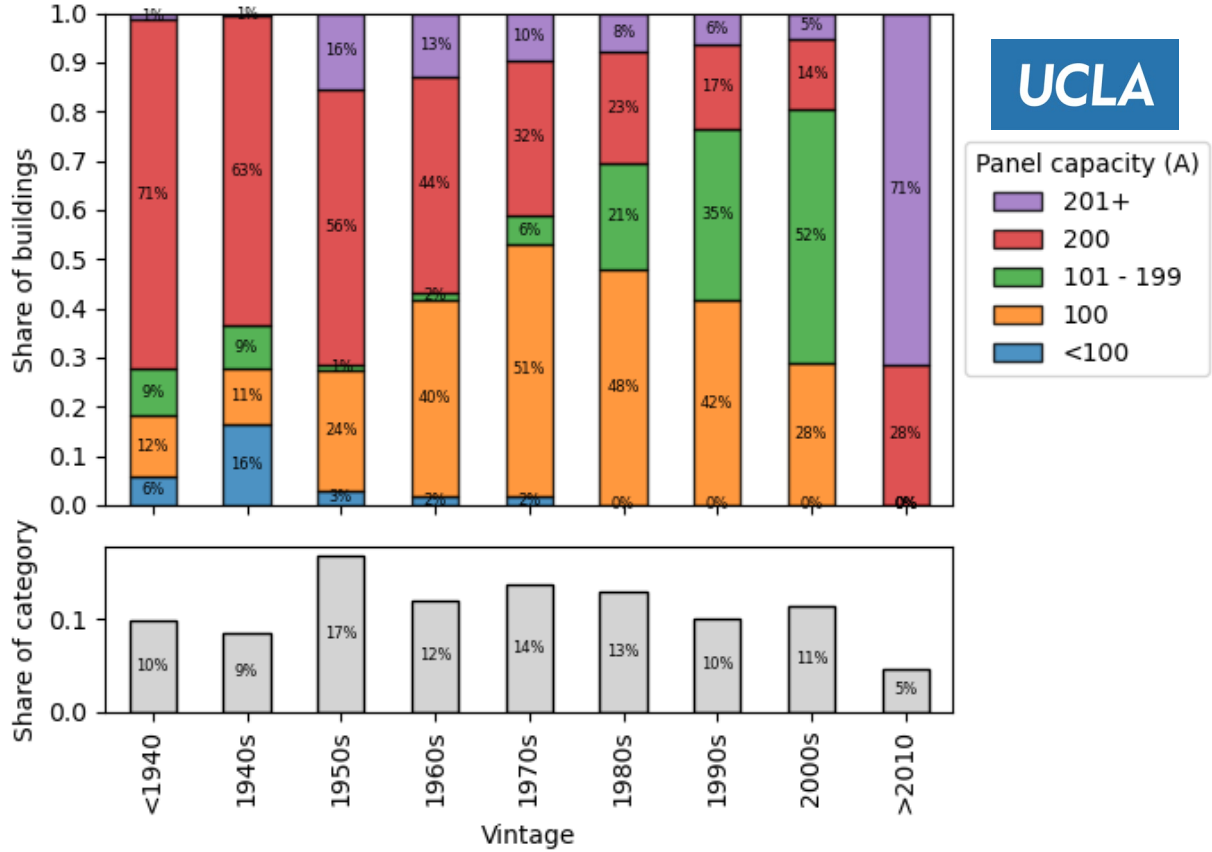




- Smaller homes have smaller panels
- Very different predictions in the few smallest and largest homes
- UCLA method suggests many more 101-199 panels (green) in larger homes, and more very small (blue) and very large (purple) panels in small and large homes, respectively
- LBNL method shows 200A dominating in larger homes

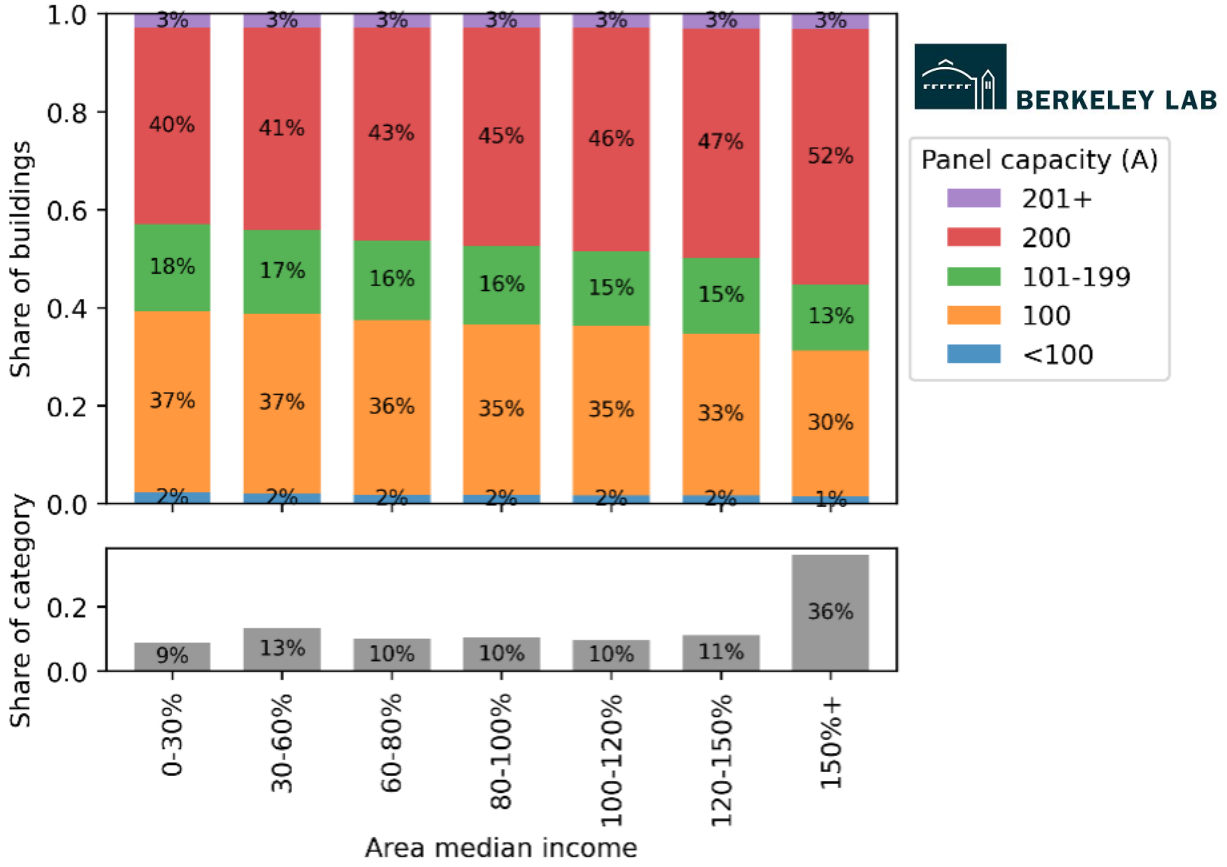
Panel Ratings by Vintage

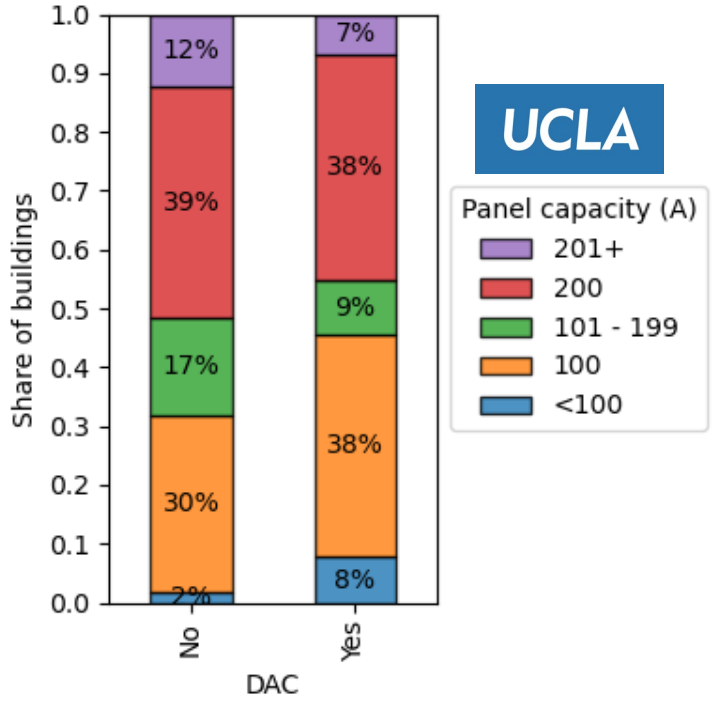




- Quite distinct vintage trends across methods
- Both agree that many older homes have already upgraded panel/service to 100-200A
- LBNL method shows smooth progression of panel rating increasing in newer homes
- UCLA method shows oldest homes have the most 200A panels, with more 100A panels in the 1950-2000 homes (not yet upgraded), and panels >200A dominating newest homes

Panel Ratings by Equity Status





- Smaller panels are more frequent in lower-income/DAC homes
- UCLA method shows bigger shifts in the smallest and largest panels
- LBNL method attributes most changes to the 100-200A panels

Summary

- Overall panel ratings in single-family homes:
  - ~50% of panels in CA are 200A or larger (fewer electrification challenges)
  - ~35% are 100A or lower (more electrification challenges)
- Comparisons by floor area, vintage and equity status reveal distinctions between prediction methods

Panel Rating	LBNL	UCLA
<100A	Very infrequent	Most frequent in smallest, oldest and DAC homes
100A	Most frequent in smaller, older, lower income homes	Most frequent in 1000-2000 ft2 and those built from 1950-2010
101-199A	Most frequent in smallest homes	Most frequent in 2000-4000 ft^2 homes and those built from 1980-2010
200A	Most frequent in largest, newest, higher income homes	Most frequent in smallest and oldest homes (due to upgrades from original as-built condition)
>200A	Very infrequent	Most frequent in homes >4,000 ft^2 and those built from 2010-present

Implications

- Roughly 1/3 of CA single-family homes have panels 100A or smaller. For full electrification, these homes will do one of the following:
    - **Retain their existing panel** without issue
    - **Retain their existing panel using low-power electrification (LPE) strategies** (e.g., low-power appliances, load controls and load planning)
    - **Replace and upsize their existing panel** and circuits to support new loads or address safety hazards
- LBNL/NREL are performing an national analysis to characterize each of these paths

- Panel ratings do not follow simple rules and are diverse across equity factors, sizes and vintages. Advanced predictive methods and more data collection are needed.

- Equity communities may face greater challenges and need additional support when electrifying
    - More likely to have lower panel ratings, partly due to smaller and older homes
    - Less likely to have already performed a permitted panel replacement
    - Least able to afford panel upsizing costs or design support for LPE

Informal Sessions on Panels and Power Efficiency

- **Electrical panels in US homes: a conversation about sharing data, resources and strategies for Panel Optimization**
  - Tuesday, 8/6 2:00 pm, Acacia
- **Electrification with existing electrical infrastructure: what are the market needs for affordable electrification**
  - Tuesday, 8/6 3:00 pm, Heather

THANK YOU

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