OPTIMIZING HEATING AND ELECTRIC LOADS IN RETROFITS

APRIL 2025 | New Orleans, LA

PRESENTER(S)

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NHPC
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SOLVING ELECTRICAL CAPACITY AND BREAKER SPACE CONSTRAINTS

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Home retrofits are adding electric loads

Added Loads:

- Heat pumps for heating/cooling/hot water
- Cooking
- Clothes drying
- Solar PV
- EV Chargers
- Batteries
- Backup power systems
- Auxiliary Dwelling Units
- Kitchen remodels

Retrofit Issues:

Do we have enough amps?
Do we have enough breaker slots?
Do we need to add 240V circuits?
Do you need to pay for a new transformer?
Utility might reject your interconnection due to local distribution limits

Issues in the home

What does it cost?

Circuits: **$250-$750 each**
Panel replacement: **$1,000-$5,000**
Service replacements: **$1,000-$25,000** to homeowner + similar amount for utility
Pole transformer: **$3,000-$5,000**
Pad or subsurface transformer**: $10,000-80,000**
Rewiring: Can trigger knob & tube replacement **~$10,000-20,000**

Time delays

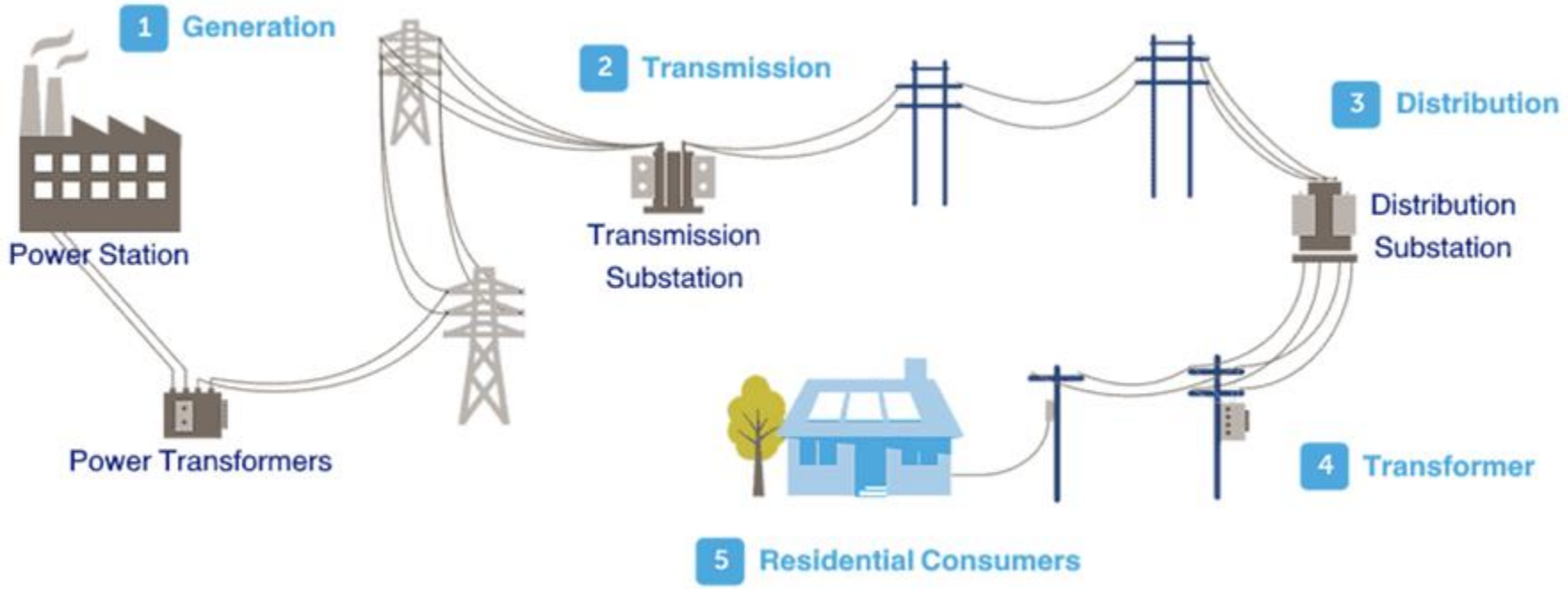
3-6 months project delays
>1-year lead time on transformers

Image from EPRI

Image courtesy of All-electric California

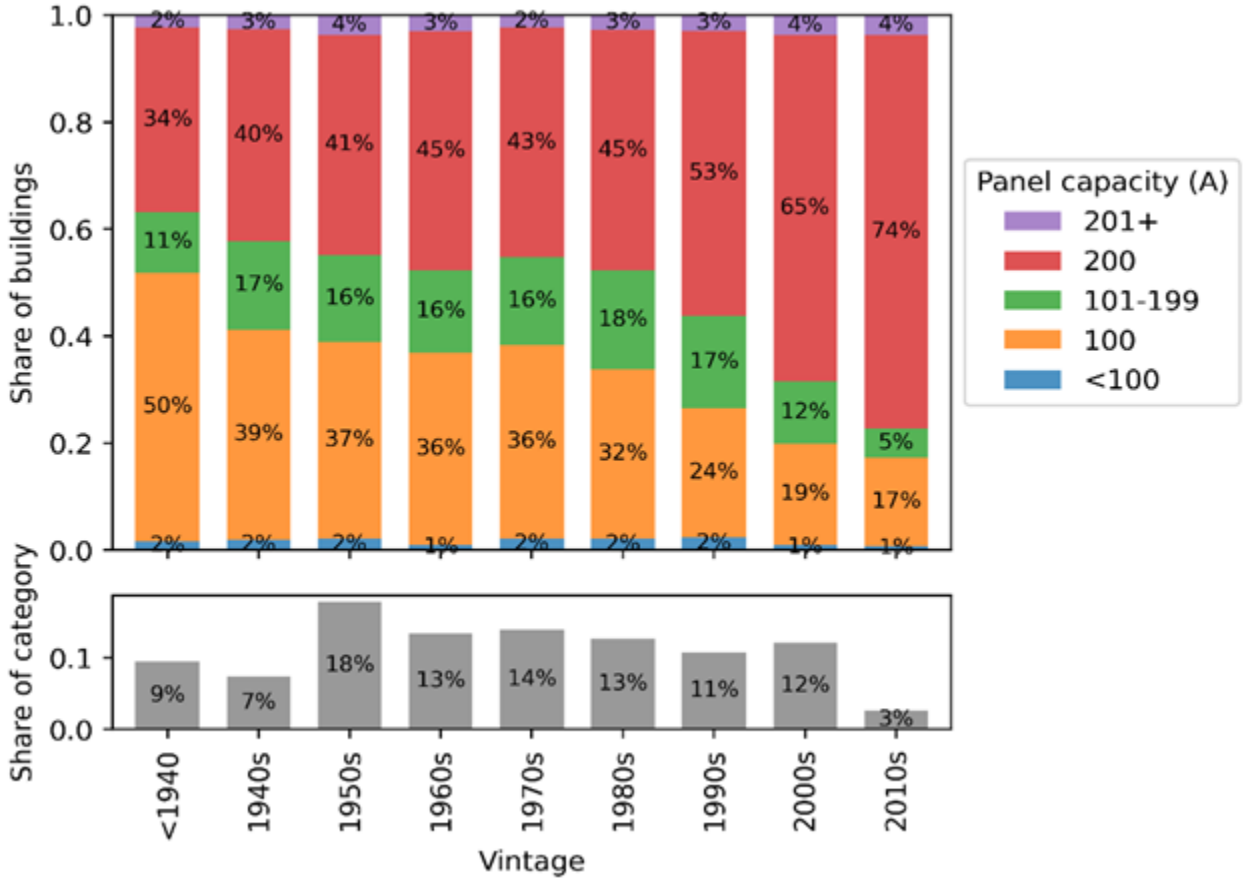
Issues for the grid

Infrastructure driven by peak power, not energy
High costs – passed on to ratepayers: in CA, **PG&E Base rate 41 cents/kWh**
High peak power = more potential blackouts/restrictions – a problem for grid resilience

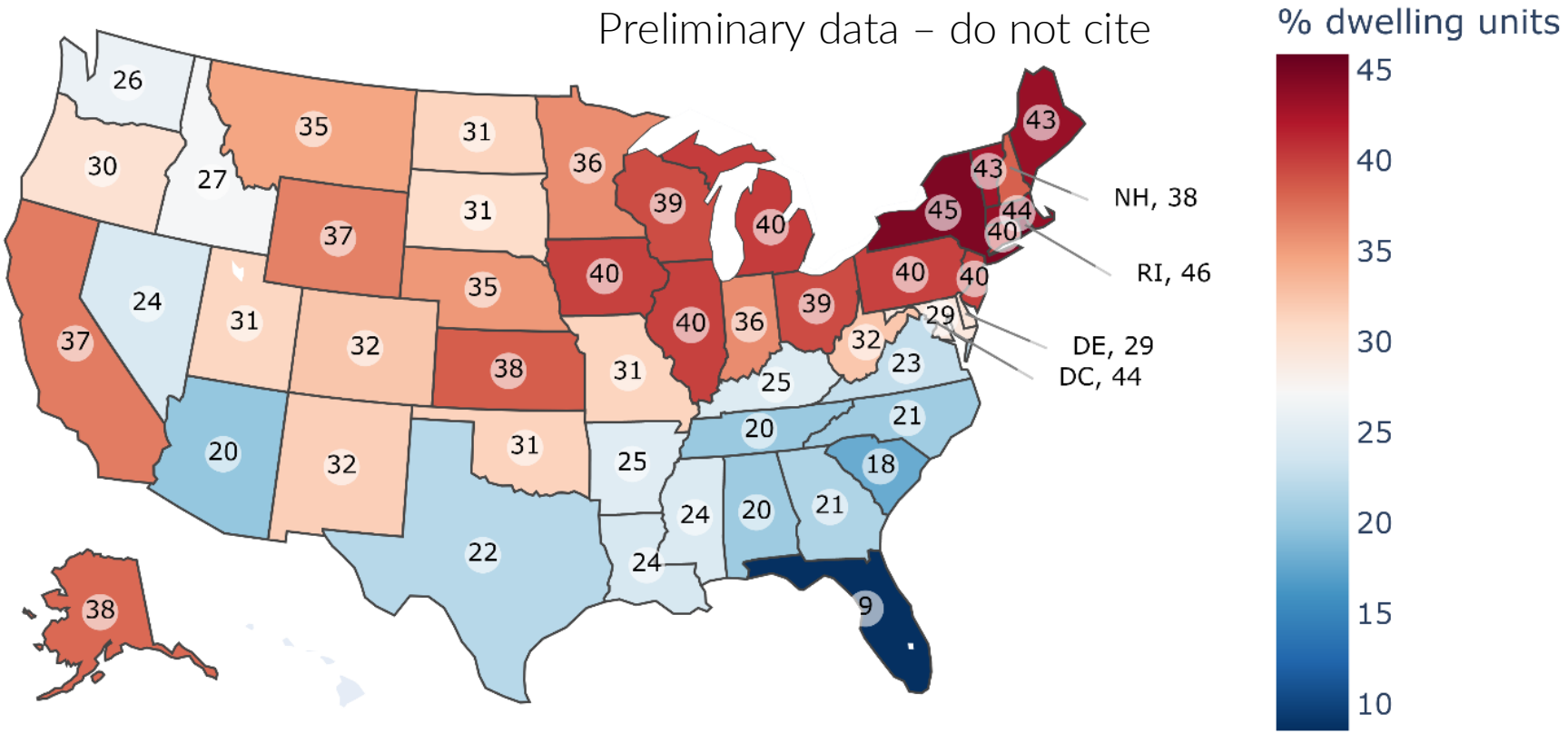


What Panels are Installed in Homes?

Panel capacity (A) from 37,000 single-family homes used to predict national distribution using ResStock



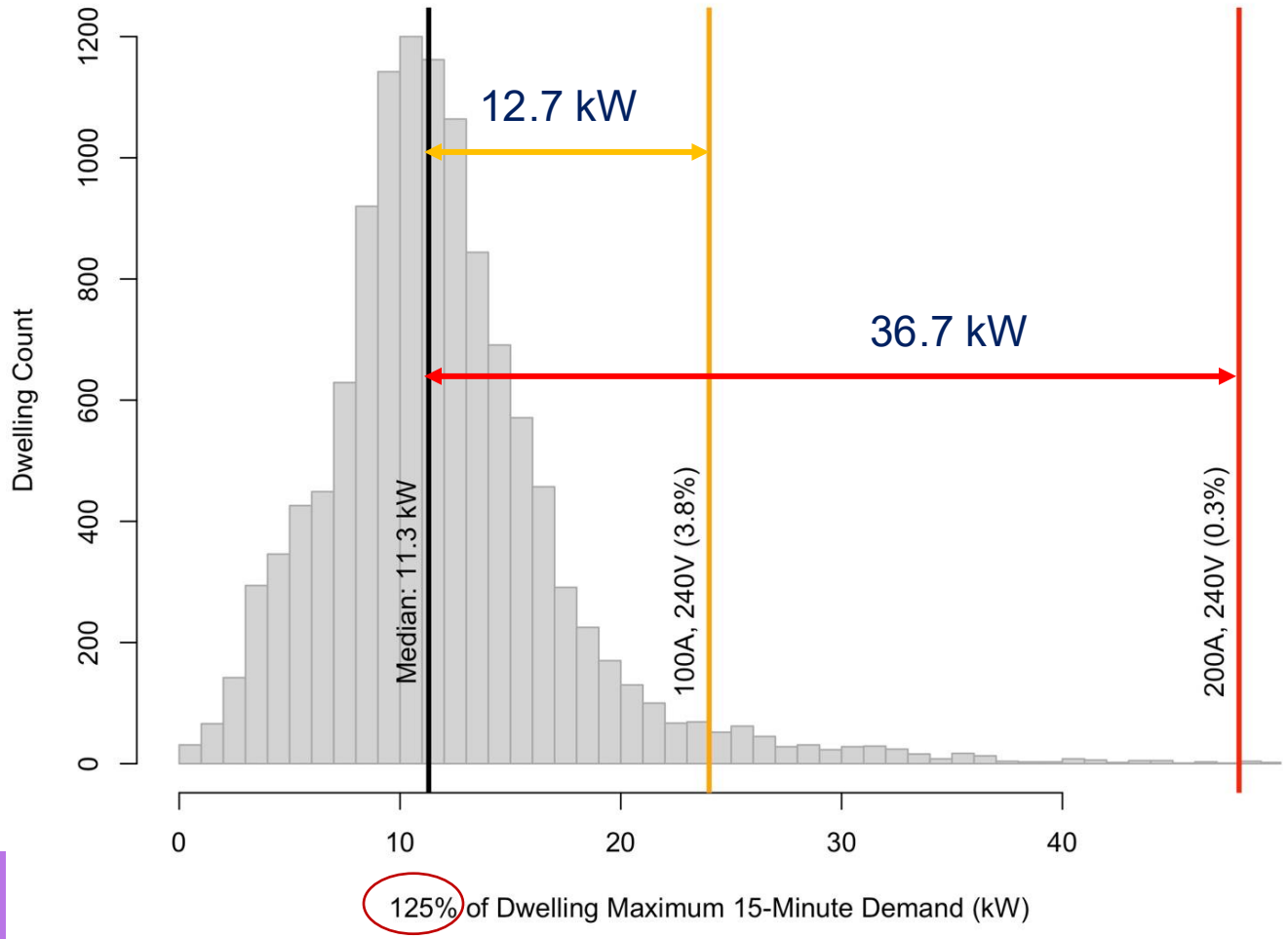
Share of homes with predicted panel capacity 100A or less



Can We Add new Loads?

15-minute measurements of peak load in about 12,000 homes

- The median home with a 100A panel uses <50% of its capacity
- Vast majority never exceed 100A

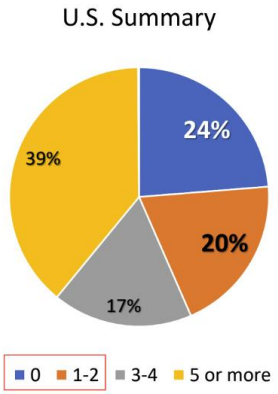


Beyond Amps – Space for breakers?

BayRen Home Electrification Checklist (over 6,000 homes)

- 100A: 31% have free space
- 200A: 48% have free space

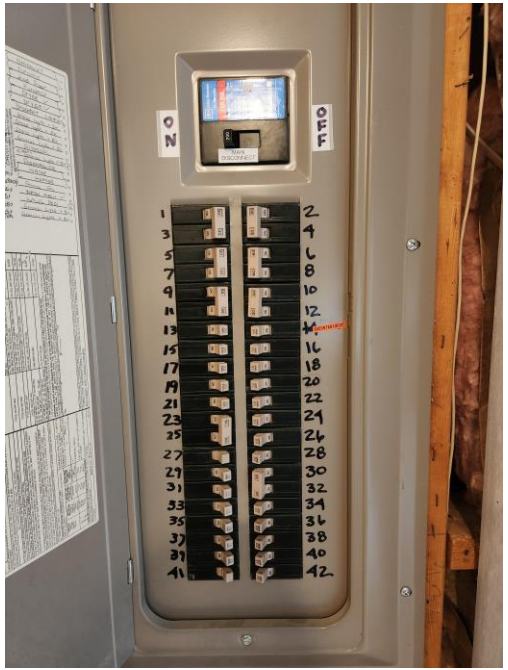
EPRI Study of Electrical Panels (2,950 Homes)



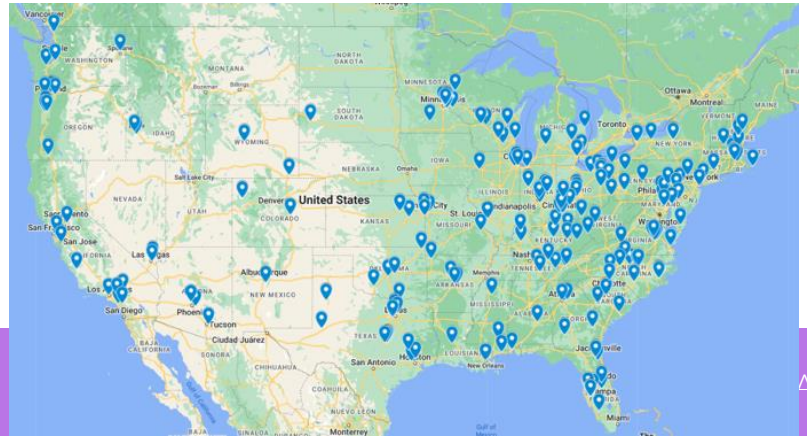
National Citizen Science approach (300 homes)

- 100A: 75% have free space
- 200A: 80% have free space

NO SPACE



LOTS OF SPACE



What is driving panel replacement and service changes?

- Reports from utilities: Current main drivers are adding Solar PV and EV Charging
- Simplified approaches by electricians
  - Not using existing paths in the National Electric Code, e.g., using metered data
  - Profitable upsell
  - Habit/comfort/risk aversion
- NEC unclear about options/exemptions
- NEC may not be using reasonable peak power and load diversity assumptions
- Local code authorities unprepared
  - Some will not allow circuit sharing or smart panel controls

Not heat pumps?

TECH Clean California

- 6% of 21,146 heat pump projects replaced panels

Vermont HP program

- 10,000 heat pumps – on average added only ~200 W (Nameplate was 3600 W)

Cadmus ccASHP study

- 8% service panel replacement
- 10% subpanel installs
- 1% utility transformer replacement

Existing homes in the NEC…

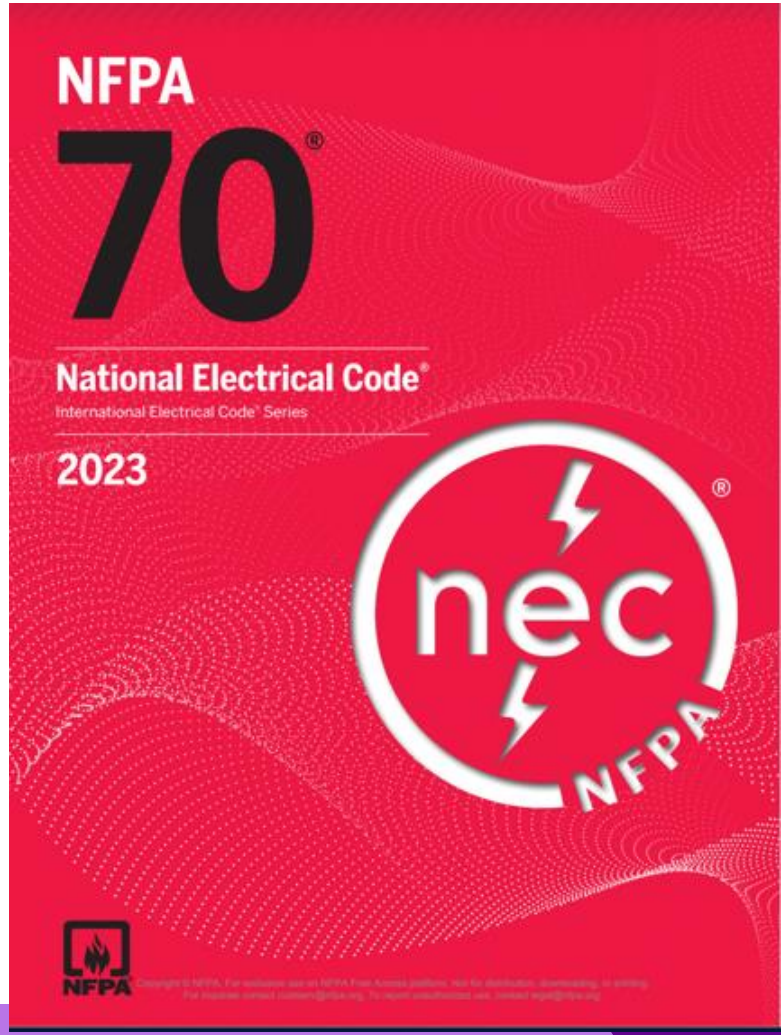
NEC 220.87 – Metered Data (very rarely used)

- Existing loads based on metering data (15 minute*)
- Total load = (Metered Load) x 1.25 + New Load

NEC 220.83 – Sum Connected Loads (used all the time)

- Existing loads = sum of connected loads with different treatment when adding HVAC

* Not the 60 minute data you get from your utility smart meter

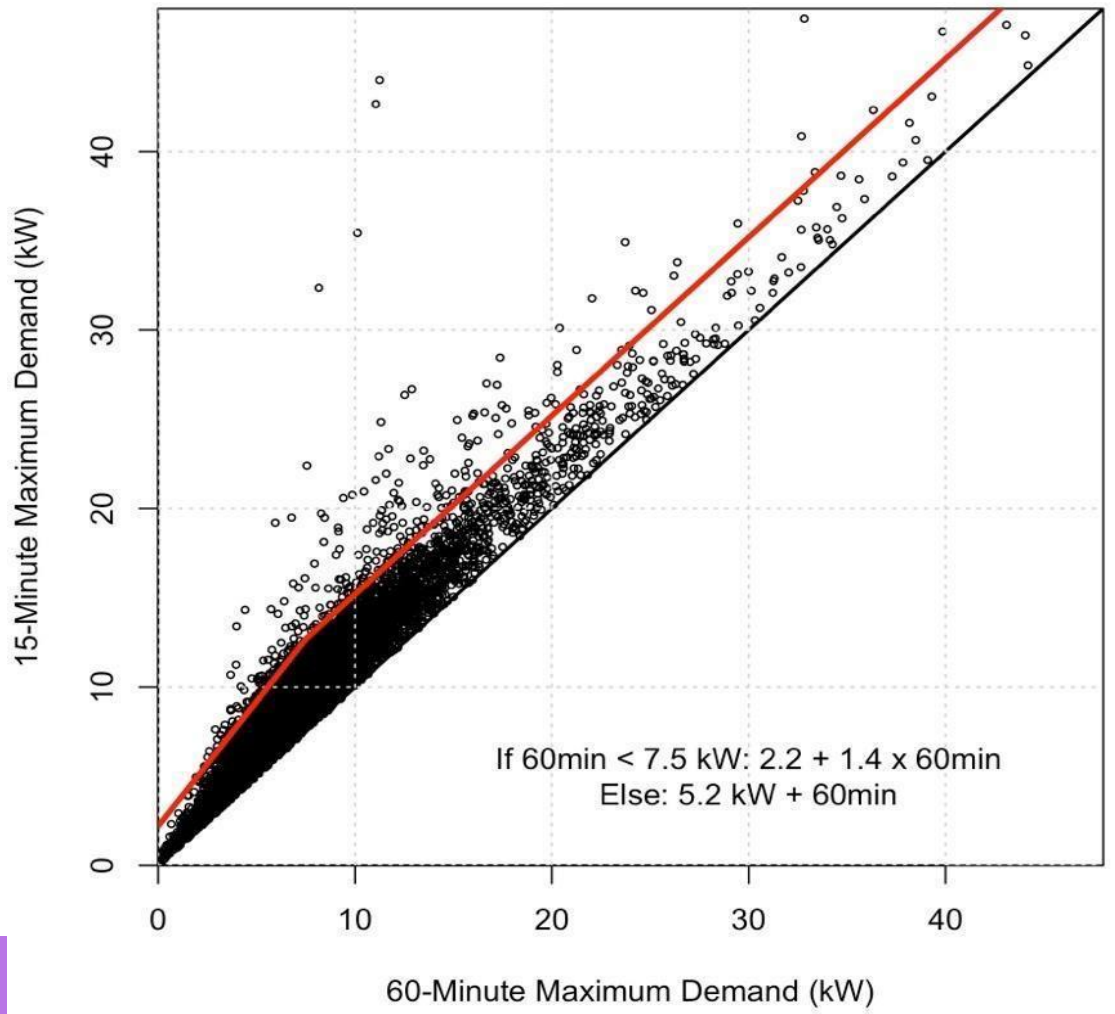


Converting 60-minute to 15-minute peak demand

Measurements from about 12,000 homes

Red line is potential conversion factor – captures 99% of peak events

Maybe used in the future



Other Regulation Challenges

Utility service “PG&E Green book” – leads to expensive work – moving panels, rewiring, new service drop, potential service denial

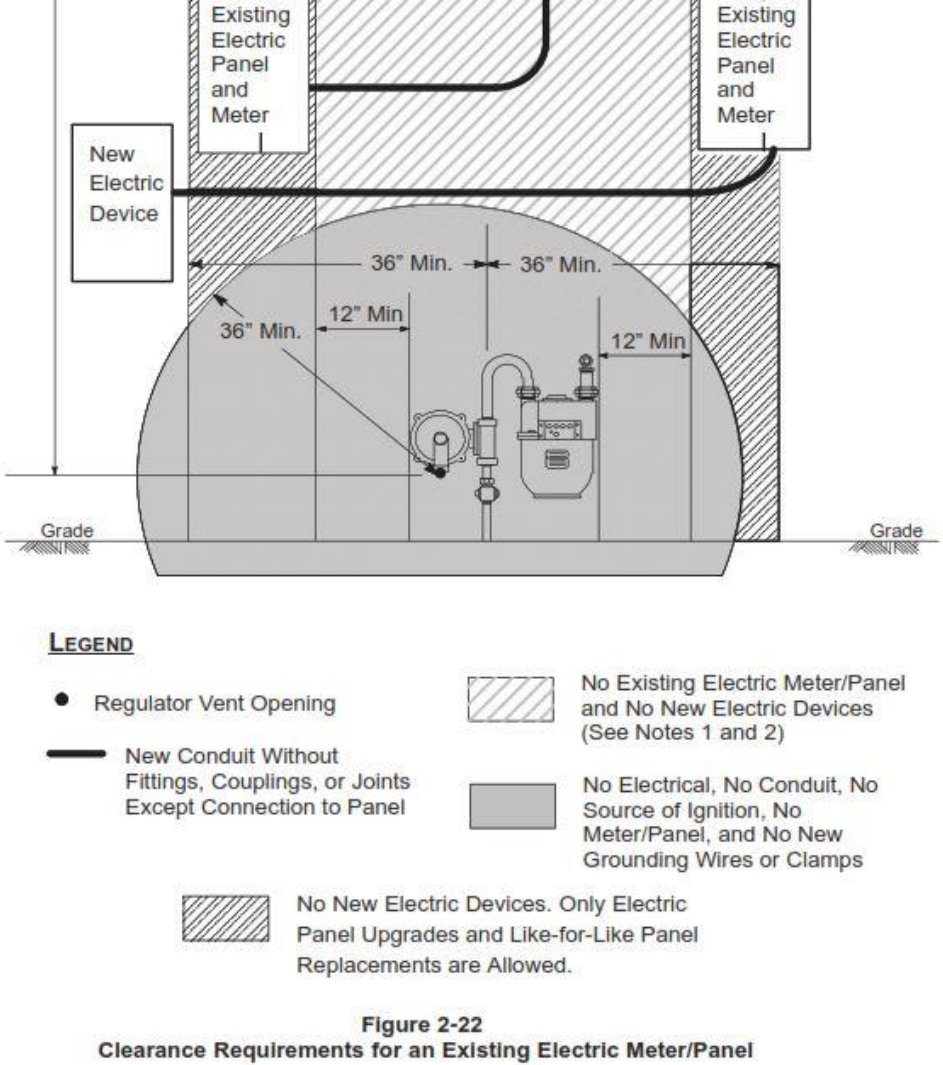
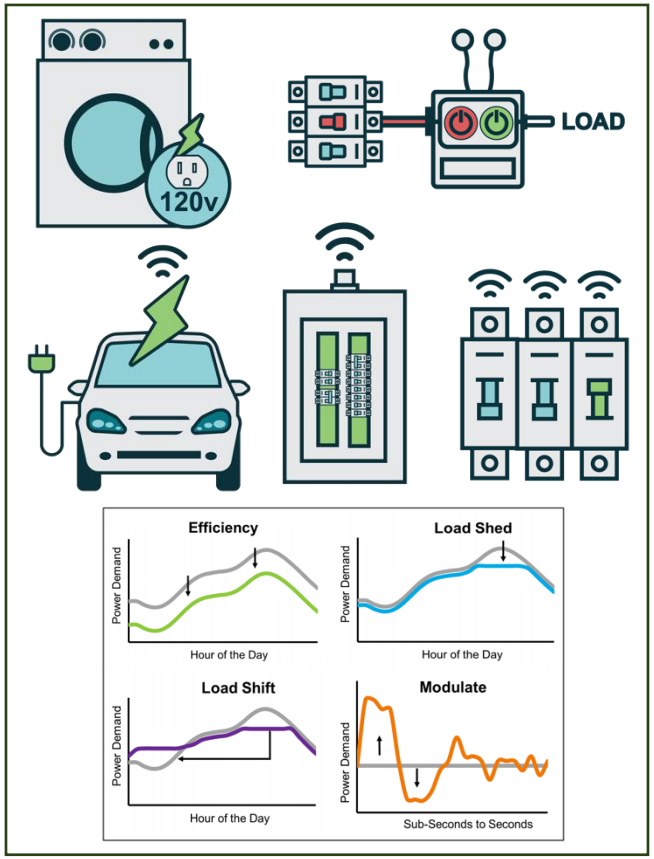


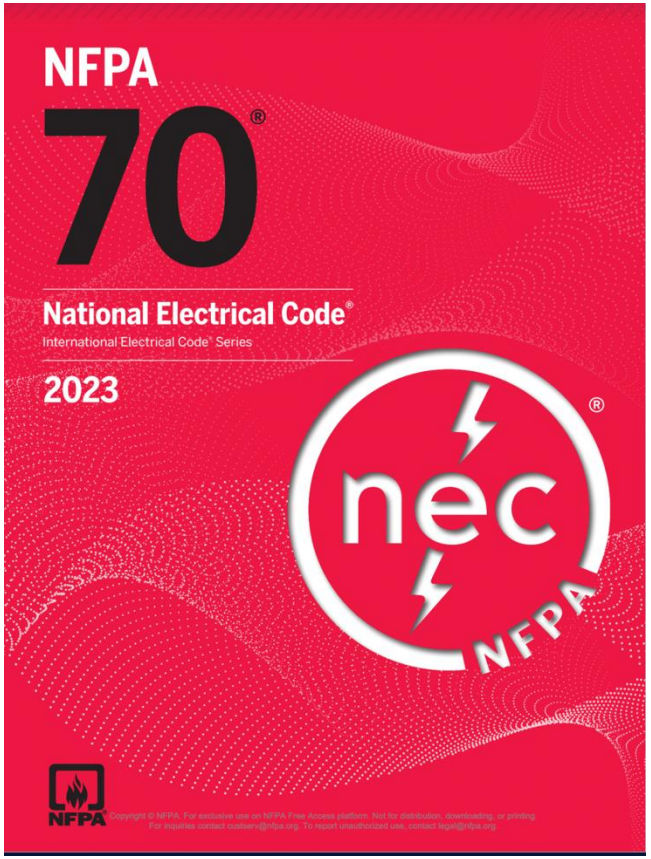
Figure 2-22
Clearance Requirements for an Existing Electric Meter/Panel

How To Avoid These Issues?

Advances in Technology



Code Innovations



Advances in Technology – 120V Appliances

120v HPWH

- Can plug into regular 120V outlet
- Typical operation only 400W
- Strip heat <<< 240V water heaters

120V Plug in heat pump

Advances in Technology – Circuit Sharing and Pausing

EV-PowerShare[xliii]

EV-PS Smart

SimpleSwitch[xliv]

240V / EV Circuit Switch

BSA Electronics[xli]

Dryer Buddy

Neo Charge[xlii]

Smart Splitter

Advances in Technology – Controls

Whole house power limits – great for avoiding new utility service drop or as a “service” to limit peak load on the grid

Smart Breakers

Smart Panels

Advances in Technology – Meter Socket Adapter

Interconnection outside of the panel/busbar

Address space constraints and sizing limitations imposed by solar 120% rule

Useful for Solar PV and EV Chargers

Islanding capability coming soon – disconnect from utility allows house to remain powered

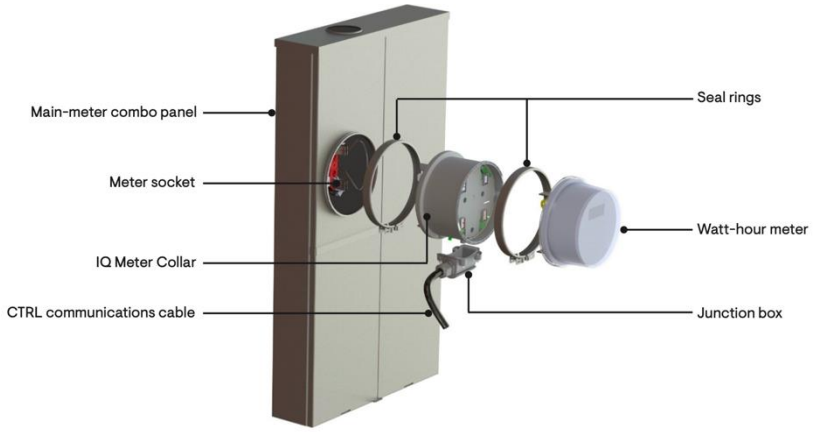


Figure 3: IQ Meter Collar installed on a utility meter socket

Images credit: Connect DER and Enphase

Advances in Technology – Battery-Integrated Appliances

Re-use existing range/cooktop 120V receptacle for cooker interconnection

Electric cooking is largest nameplate load in most homes (~12kW)

- Reduce to ~1.5 kW at 120V using battery to serve short-term loads
- Impulse cooktop 3 kWh battery
- Copper range 5 kWh battery

Future integrations likely include water heating & HVAC

Advances in Technology – “Balcony” Solar

Currently not allowed in the US, but ~500k in Germany

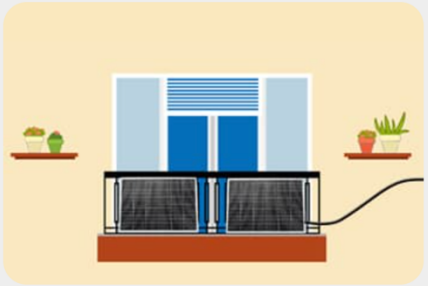
Power limited for safety (<800W) – no utility isolation

Relatively low cost: ~$500

Can have integrated battery

Portable – ideal for renters

Non-”balcony” applications



Start With A Balcony

Rigid Solar Panels Or Lightweight Solar Panels Receive The Power Of Sunlight

Plug It In

Use Micro Inverter To Convert DC Power To AC Power To Connect To The Power Grid

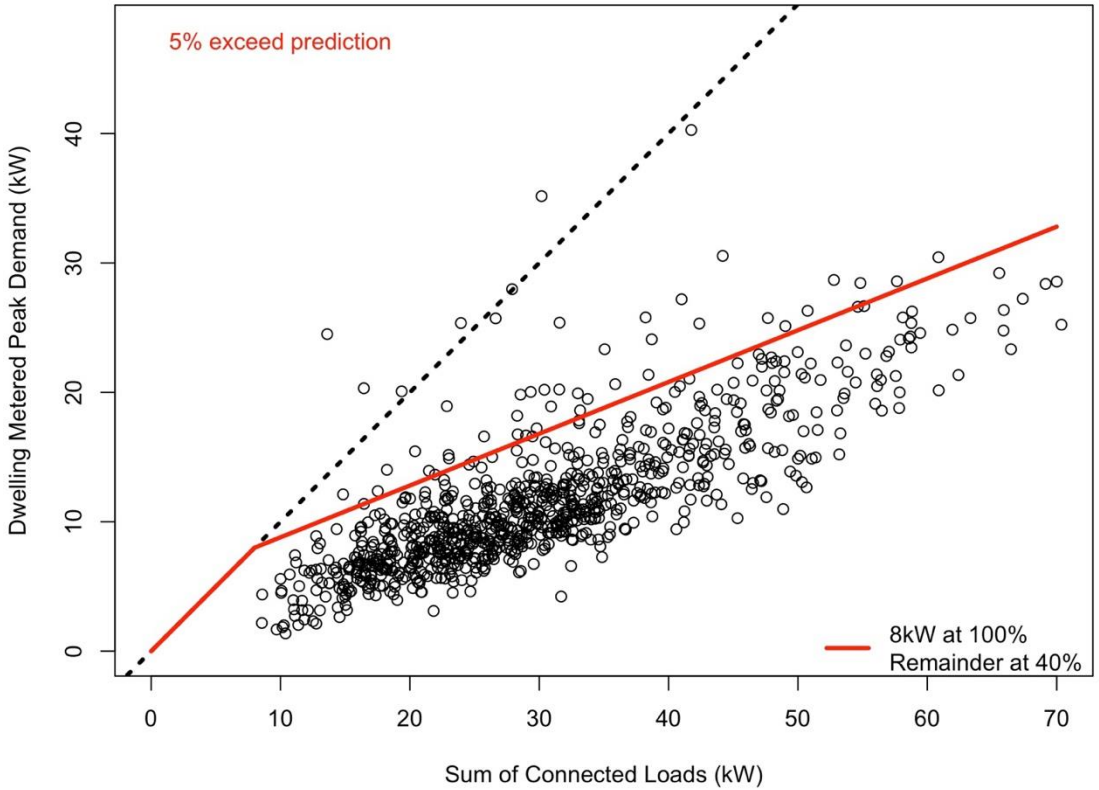
Power All Your Home Appliances

No Cost Is Required. Rigid Solar Panels Can Last Up To 25 Years

Code Innovations – Existing Dwelling Unit (NEC 120.83)

When using inventory of appliance/equipment nameplates:

- Simplified language – easier for contractors and AHJs
- New HVAC heat pumps at 50% (was 100%) of nameplate rating
- EV charging and resistance heating at 80% of nameplate
- Lighting and receptacle loads reduced from 3 to 2 watts per ft^2
- Eliminate double-counting of loads



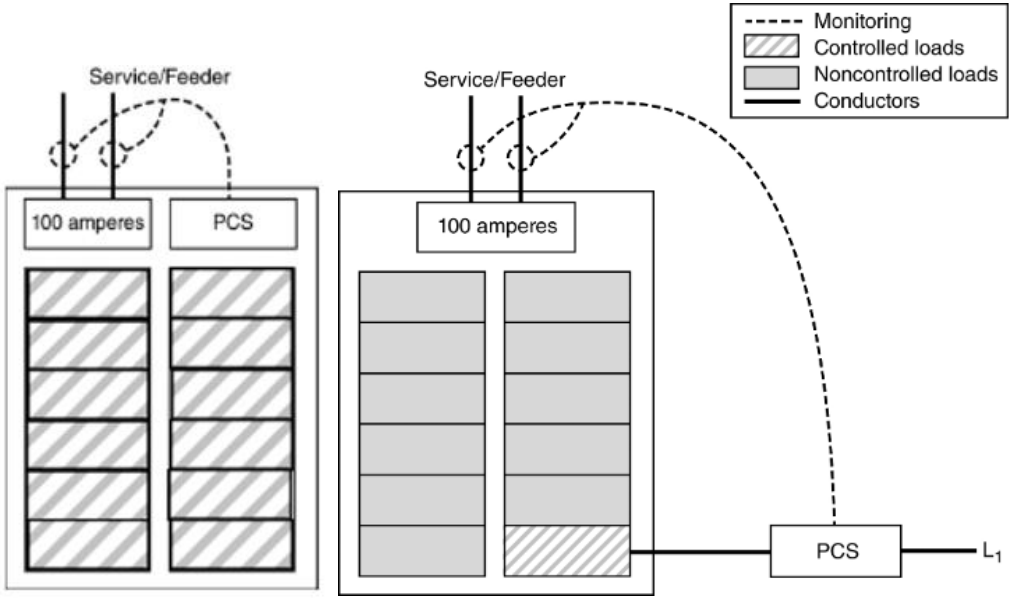
Code Innovations – Using Load Controls

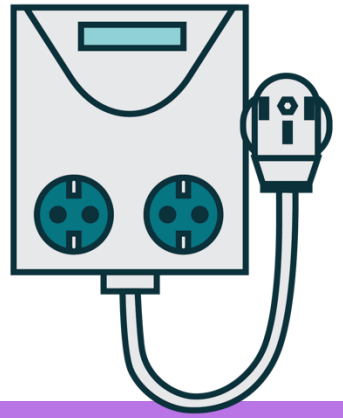
Power Control Systems (NEC 120.7):

- Load control provisions apply to ALL load calculations
- Appropriate treatment of PCS load controllers that address common use cases in dwellings
- New Appendix D Calculation examples using PCS

Noncoincident Loads (120.6):

- Explicit allowance for noncoincident loads provided by listed equipment





Reducing panel replacements

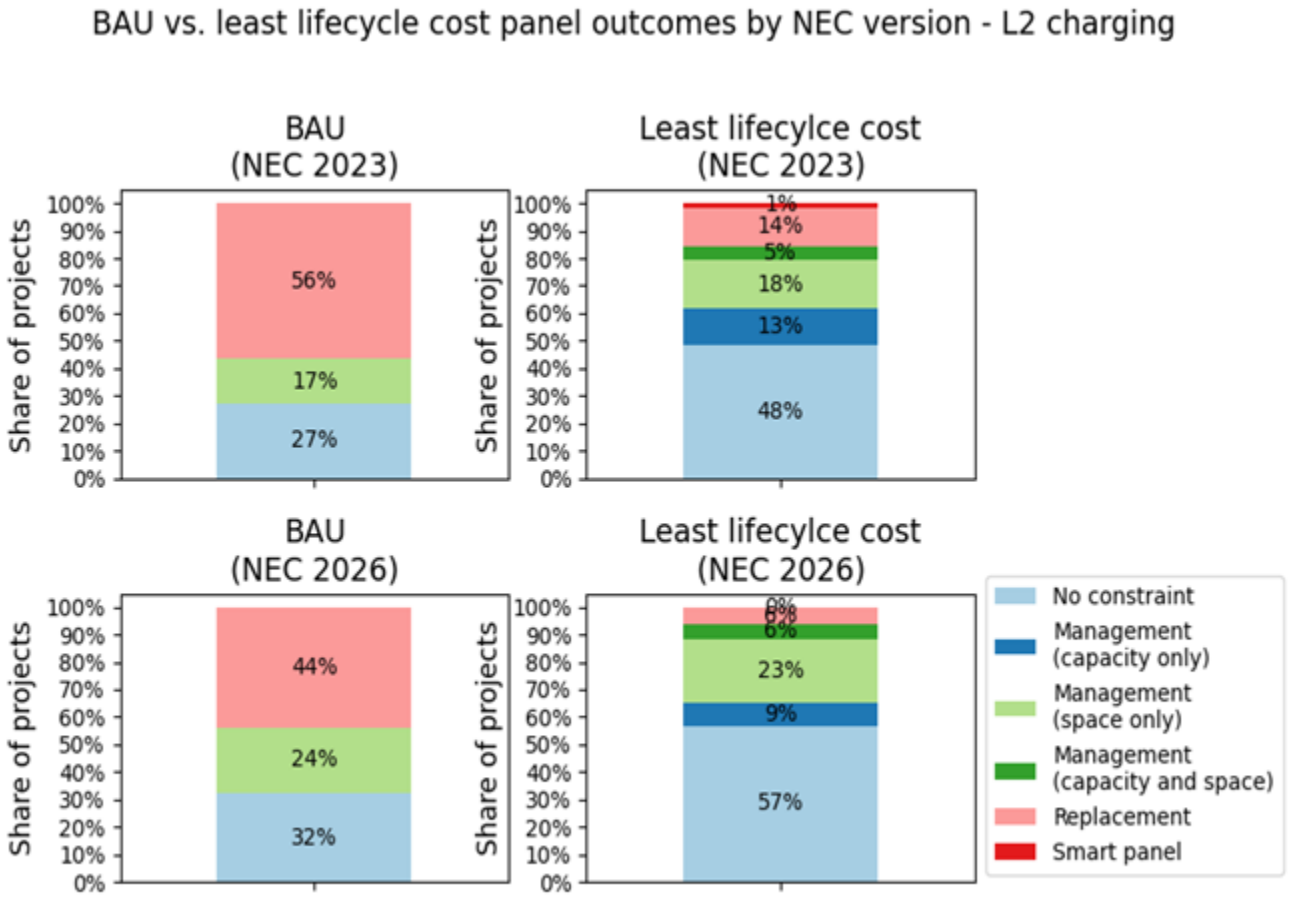
What fraction of panels need replacing:

With business-as-usual electrification:

- 56% (2023 NEC)
- 44% (2026 NEC)

With least-cost technical solutions:

- 15% (2023 NEC)
- 6% (2026 NEC)



Preliminary - do not cite

Summary

- High POWER end uses are driving costs and grid stresses not high ENERGY uses
- Use Low Power technologies to reduce costs and help the grid be affordable and resilient
- Improvements in 2026 NEC can reduce need for new panels and/or high power utility service – consider using metered data in your retrofit projects