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U.S. DEPARTMENT OF ENERGY
Office of Science

Avoiding Electric Panel and Service Costs While Saving the Grid

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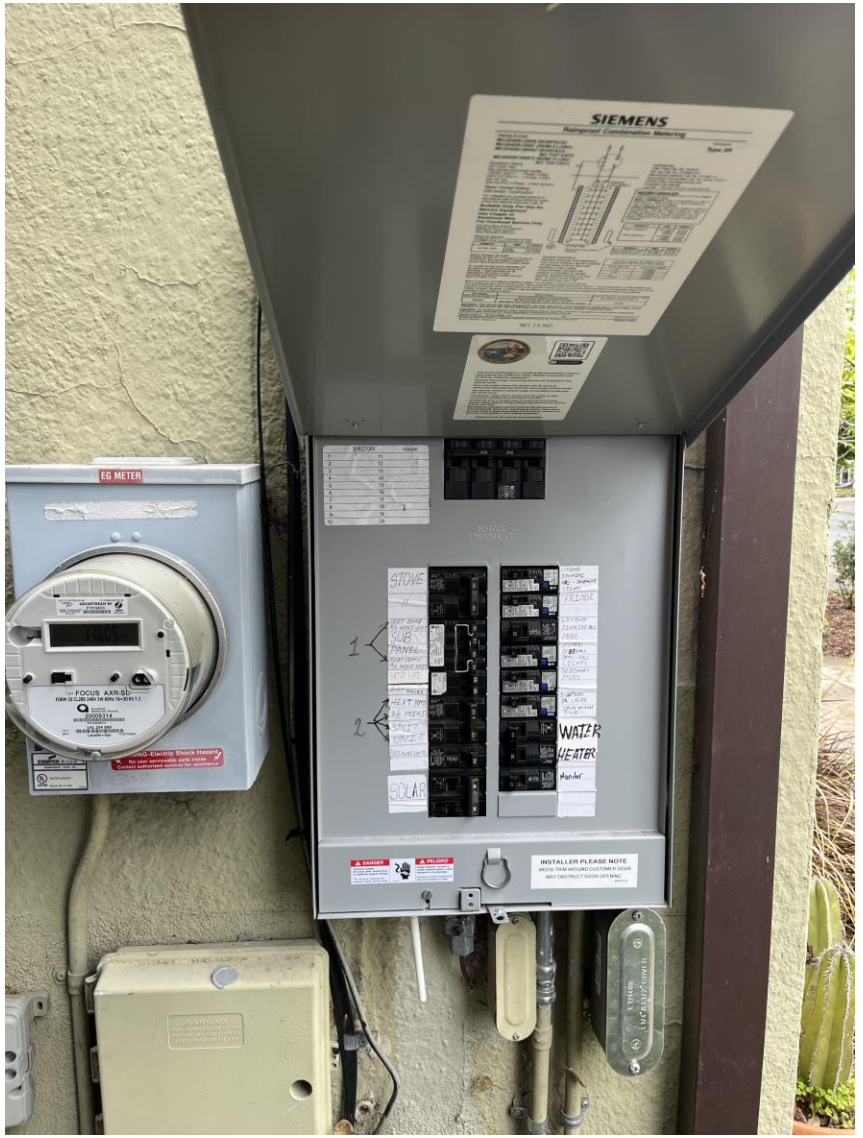
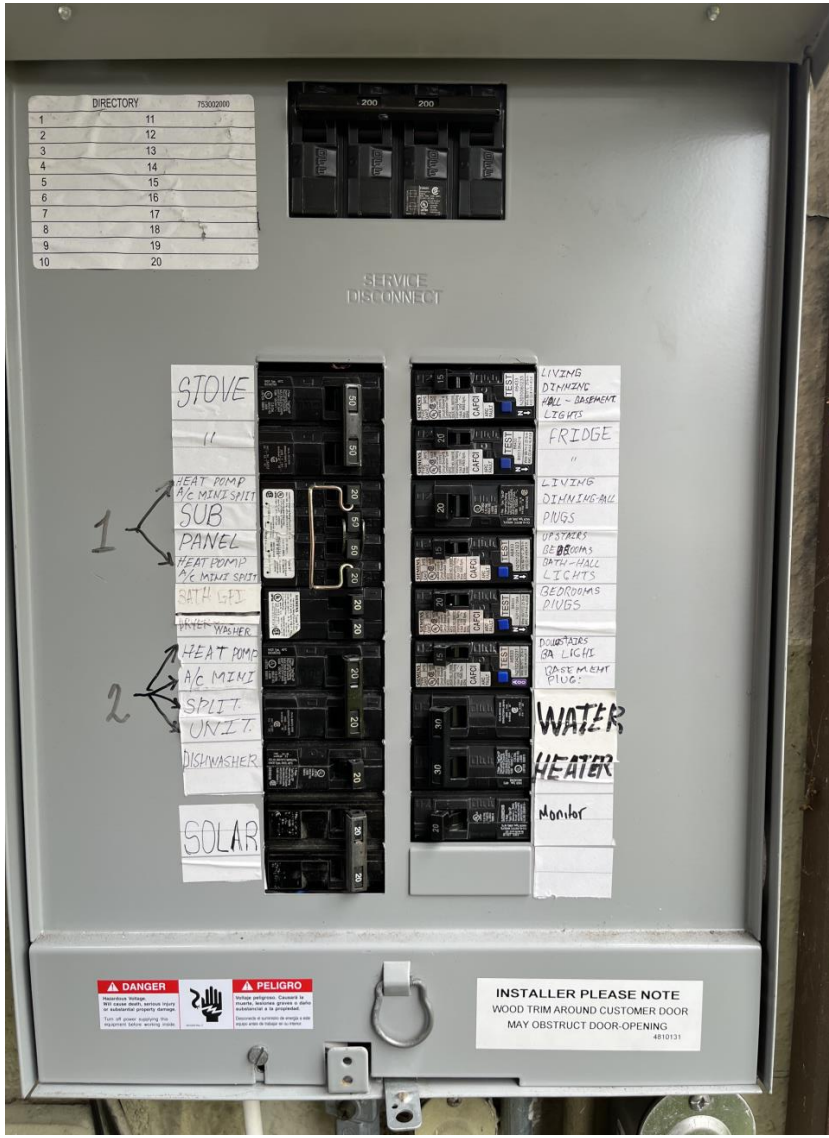
Retrofit USA – April 23rd 2025

What are we talking about?





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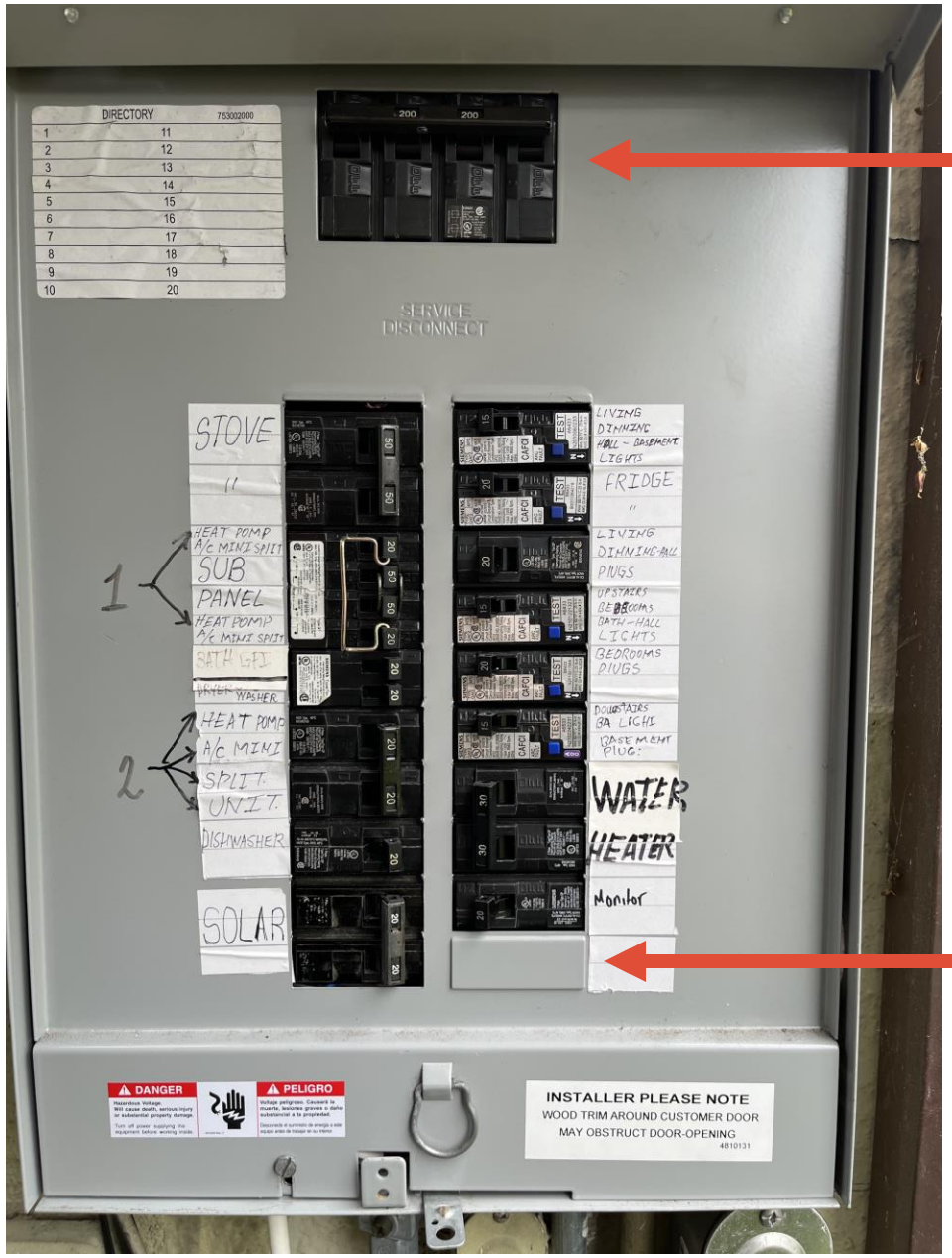


Service disconnect (200A)

Breakers serving individual circuits

Empty breaker slot

Homes are adding electric loads

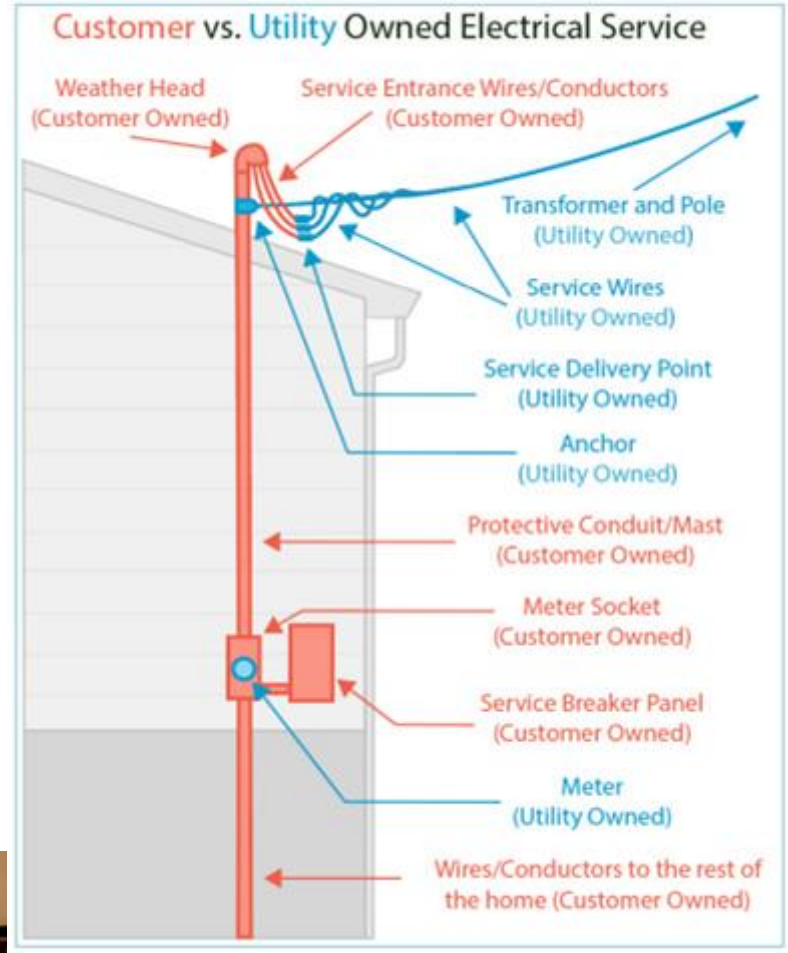
Issues for Homes

What does it cost?

Circuits: **$500-$1,500 each**
Panel: **$1,000-$5,000**
Service: **$1,000-$25,000** to homeowner + similar amount for utility
Rewiring trigger: **$10,000 - $20,000**
New Transformer: **$10,000 - $100,000**

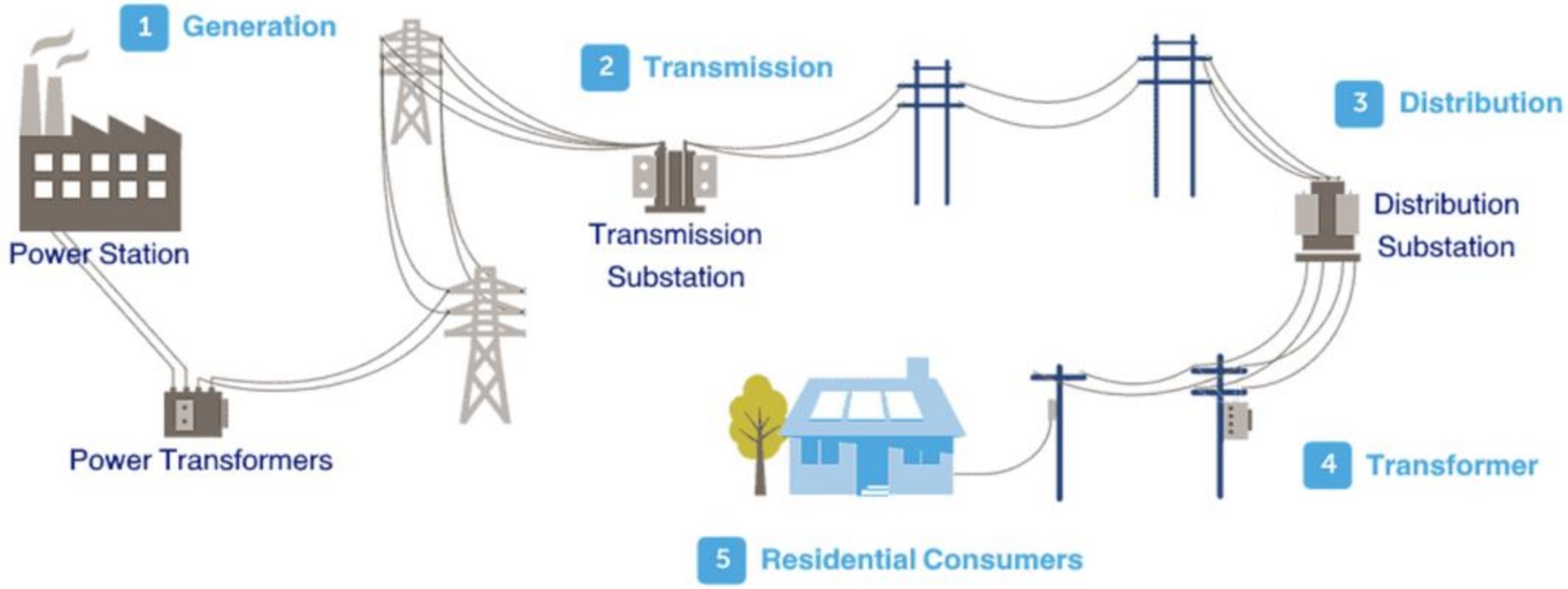
Time delays

Weeks to months project delays
>1-year lead time on transformers
Utility might reject your interconnection



Issues for the grid

Infrastructure driven by peak power, not energy
High costs – passed on to ratepayers
High peak power = more potential blackouts/restrictions – a problem for grid resilience



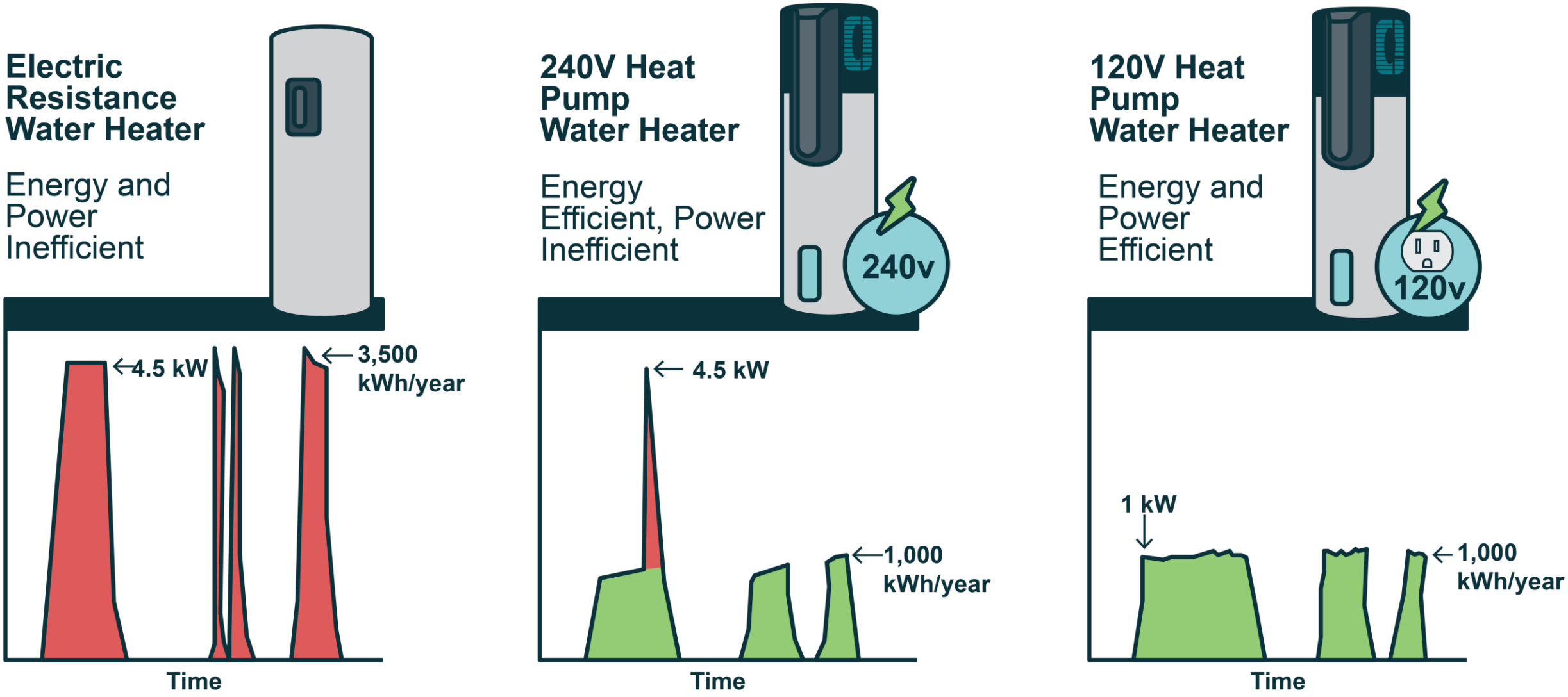
New concepts:

Power Efficiency
Low Peak Power

	Power	
Energy	**High**	**Low**
High	EV, PV	HP/HPWH*
Low	Cooking, Dryer	Lights, plugs, etc.

* Depends on Auxiliary Resistance (“strip”) Heat

Power Efficient/Low Peak Power



Are we ready?

What's Installed in Homes? - Breakers

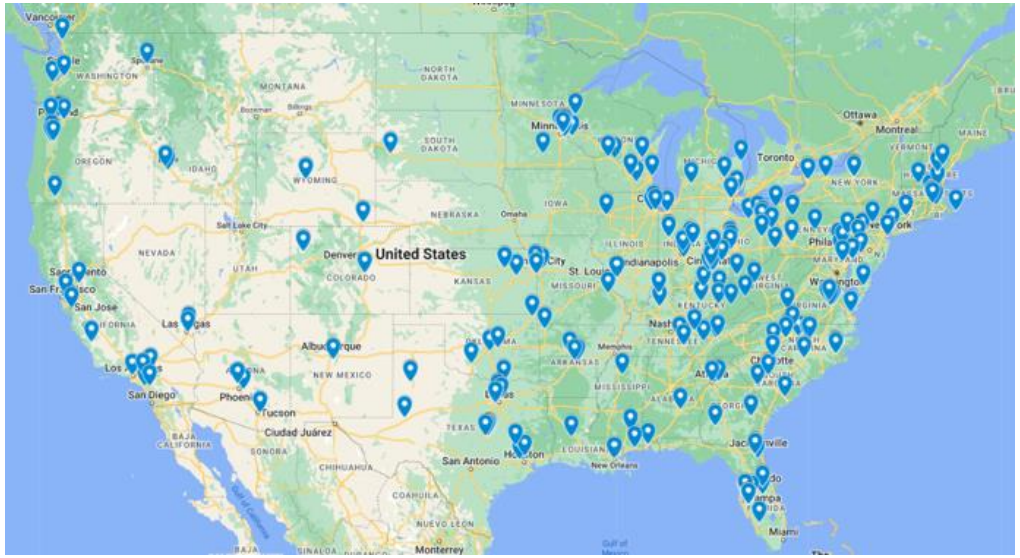
BayRen Home Electrification Checklist (over 6,000 homes)

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

National Citizen Science approach – 300 homes

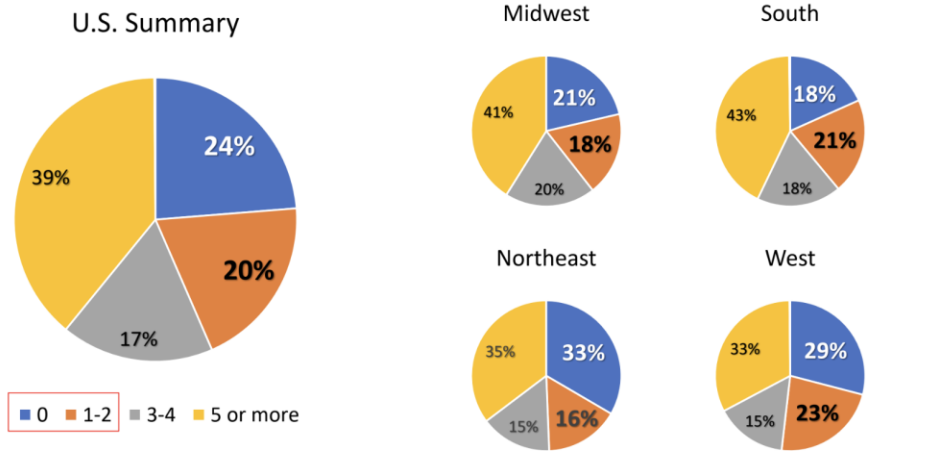
- 100A: 75% have free space
- 200A: 80% have free space

EPRI study (2950 homes) – regional variations



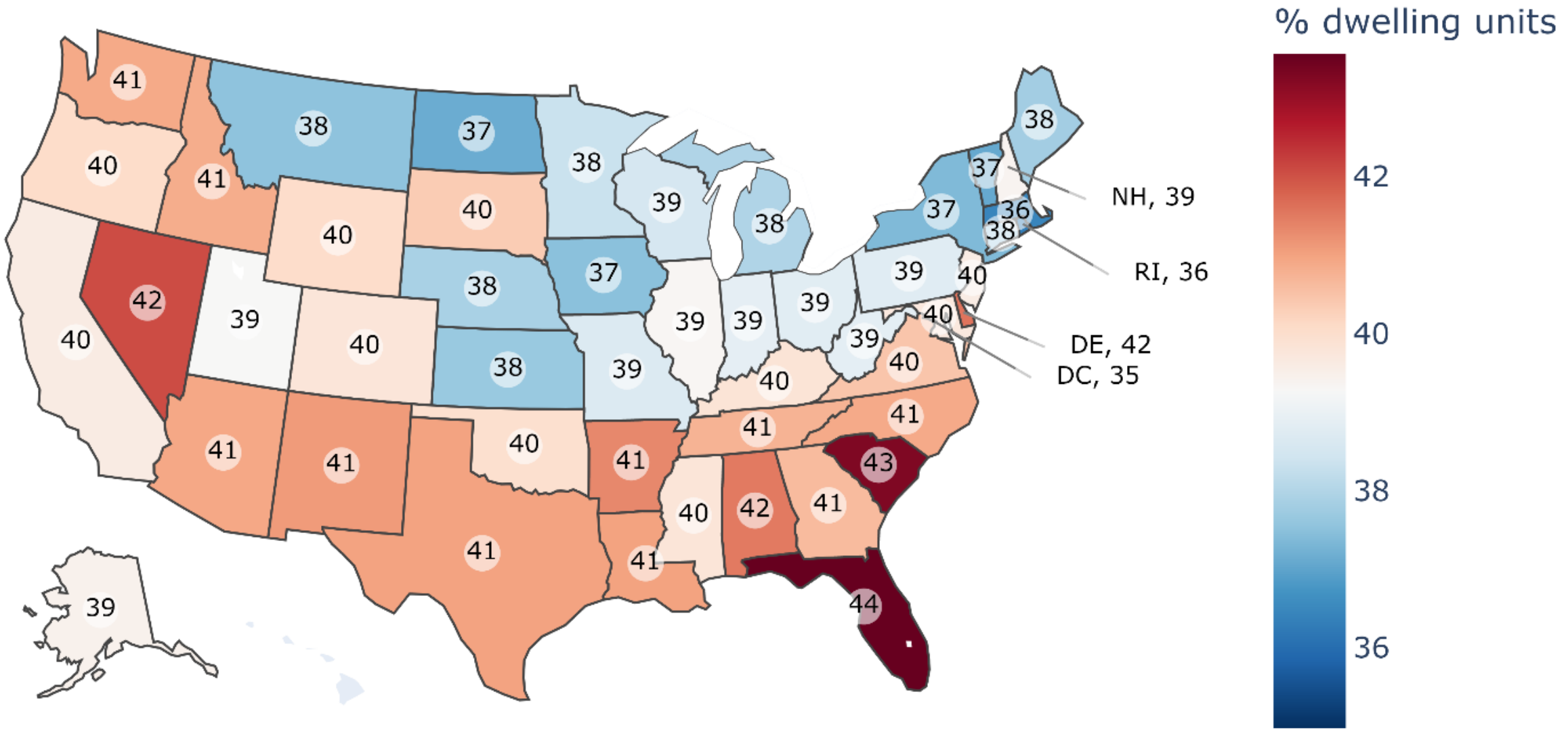
How many open breaker slots does your panel have?

n=2,950



44 % of households have two or less open breaker slots

Homes with 5 or more breaker spaces

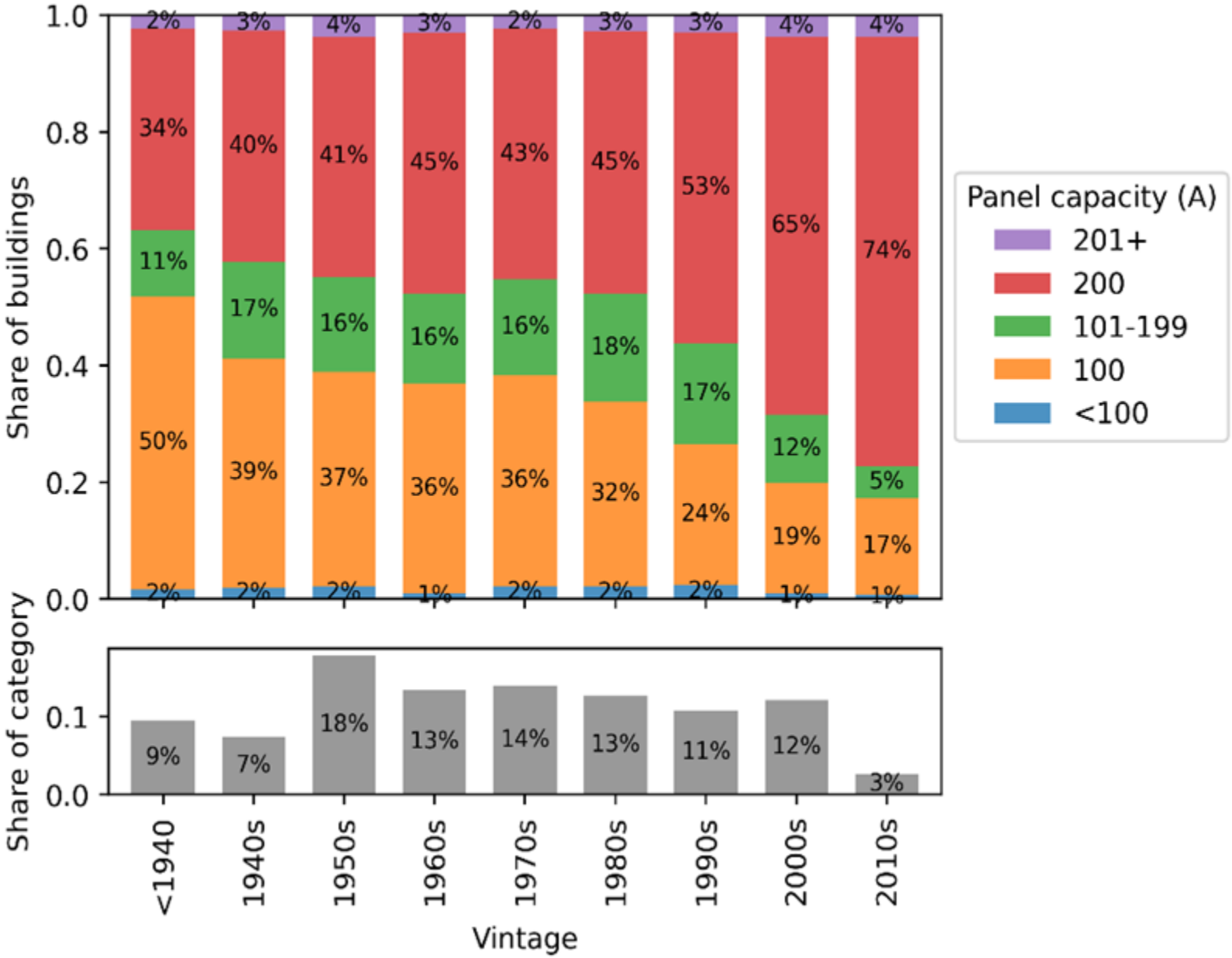


Preliminary - do not cite

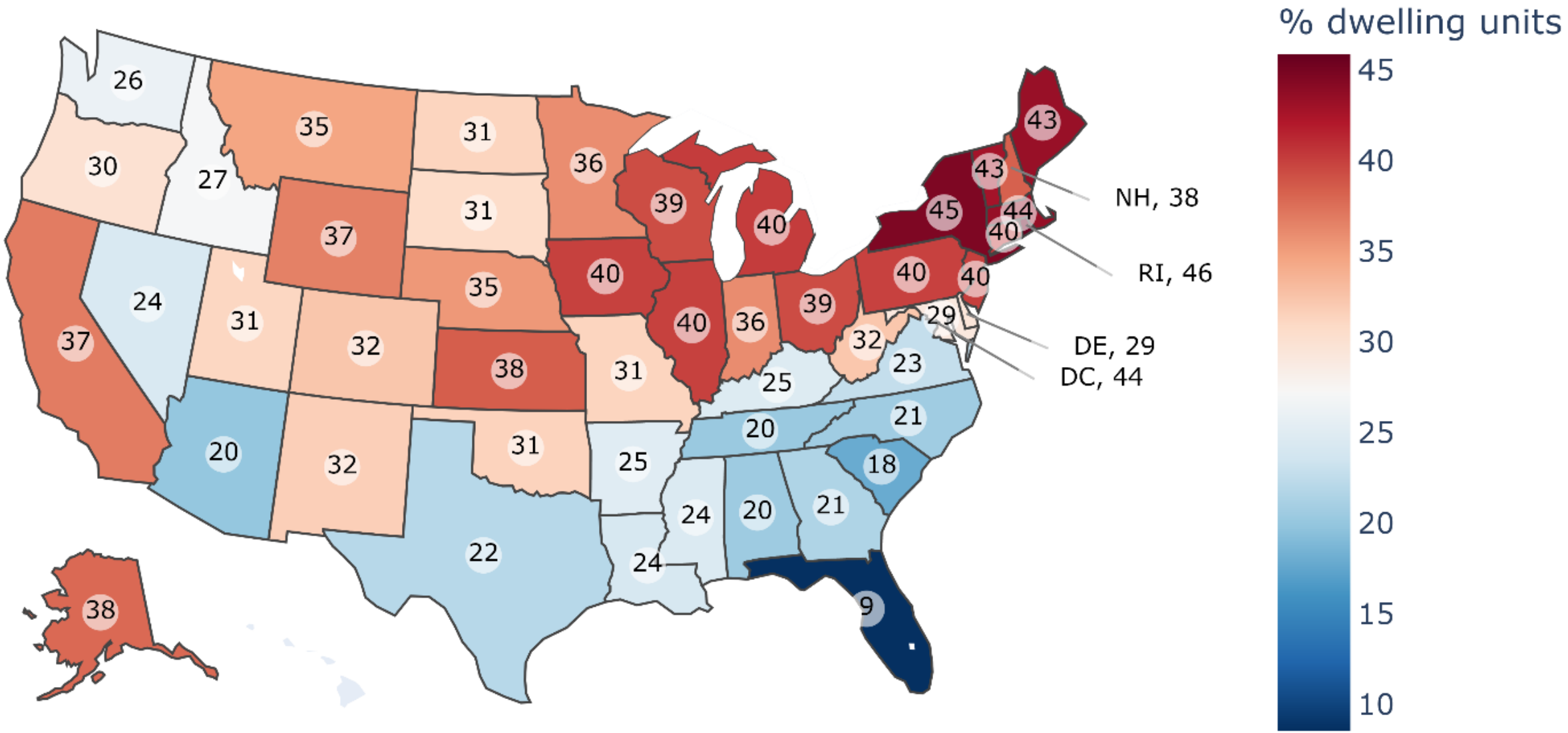
What's Installed in Homes? - Amps

37,000 single-family homes +
30,000 ResStock runs

Can we add loads and stay under 100A?



Homes with 100A or less

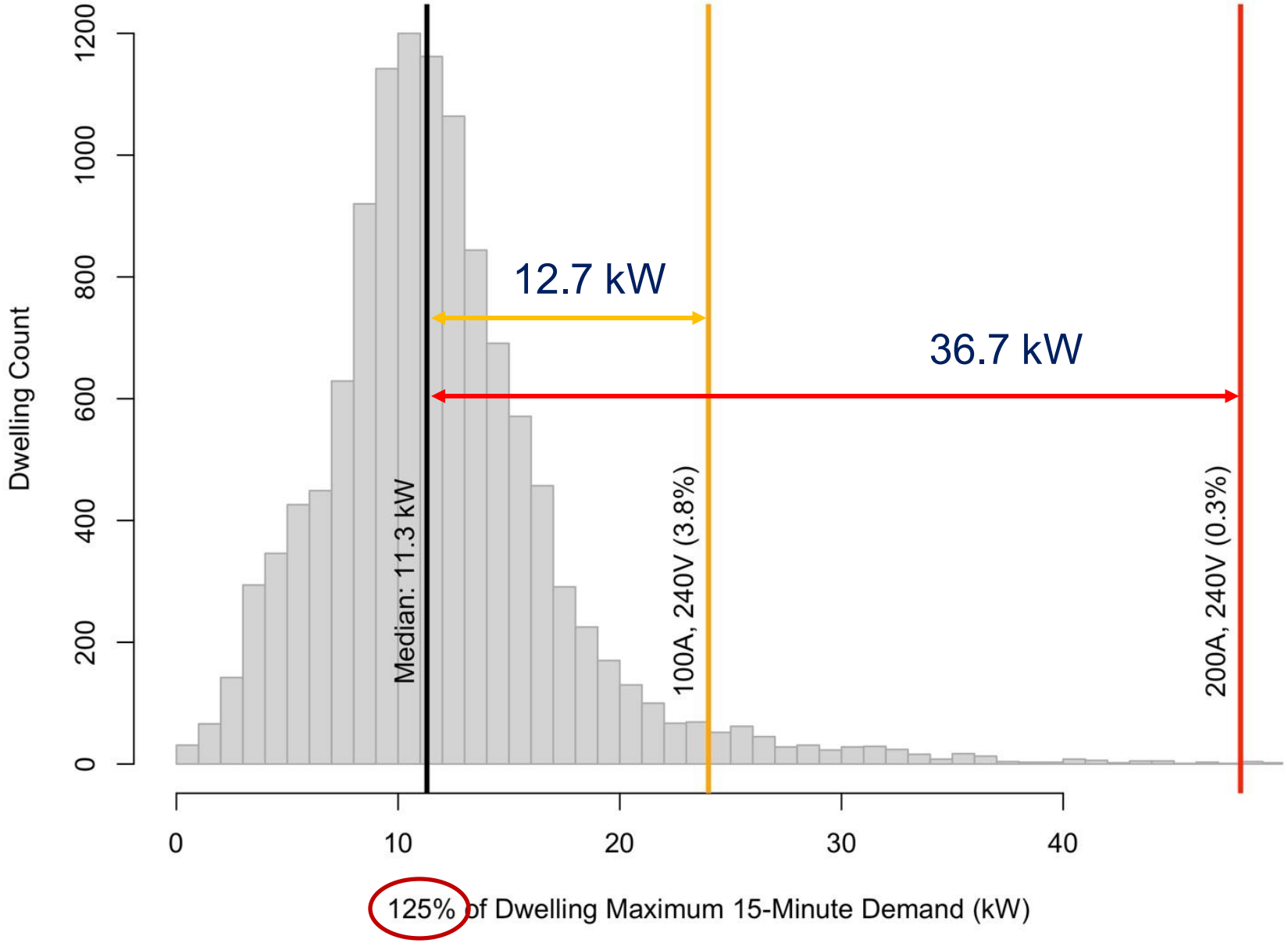


Preliminary - do not cite

Capacity to Add Loads?

12,000 Homes, multiple years, 15 minute peak

- Vast majority never exceed 100A
- Typically using 50% of capacity
- Loads rarely operate at the same time



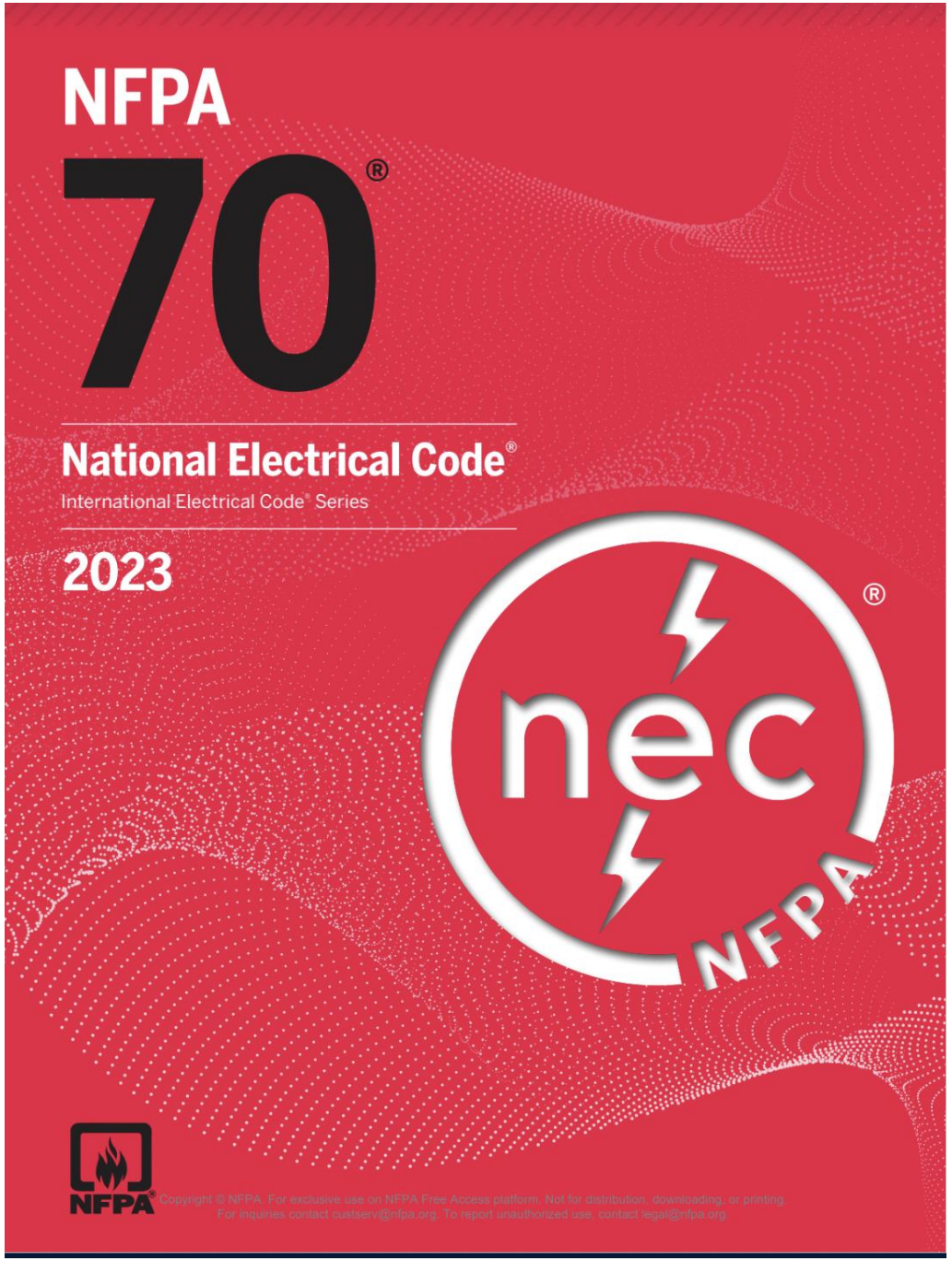
Preliminary - do not cite

Great! So why can’t we just add whatever we want?

NEC load calculations are used to size household electrical service for maximum power demand

These calculations have conservative load coincidence assumptions

This leads to over-sized electrical service in most homes



NEC Compliance Paths

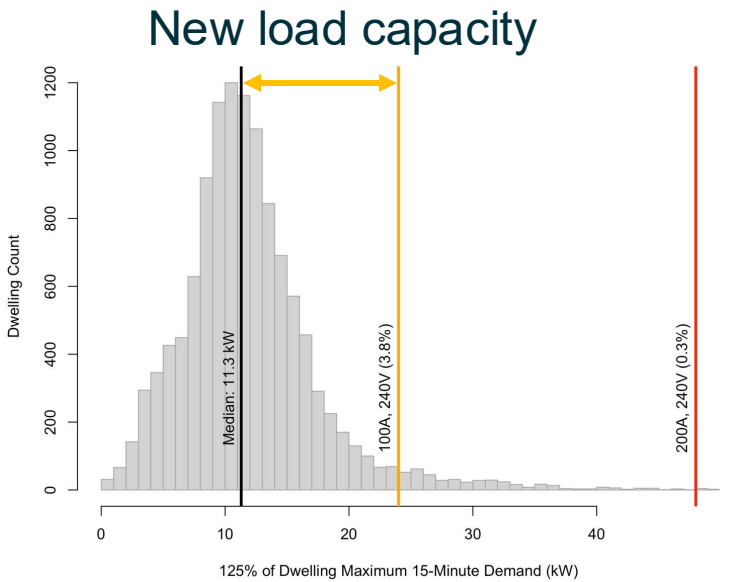
NEC 220.87 – Metered Data (very rarely used)

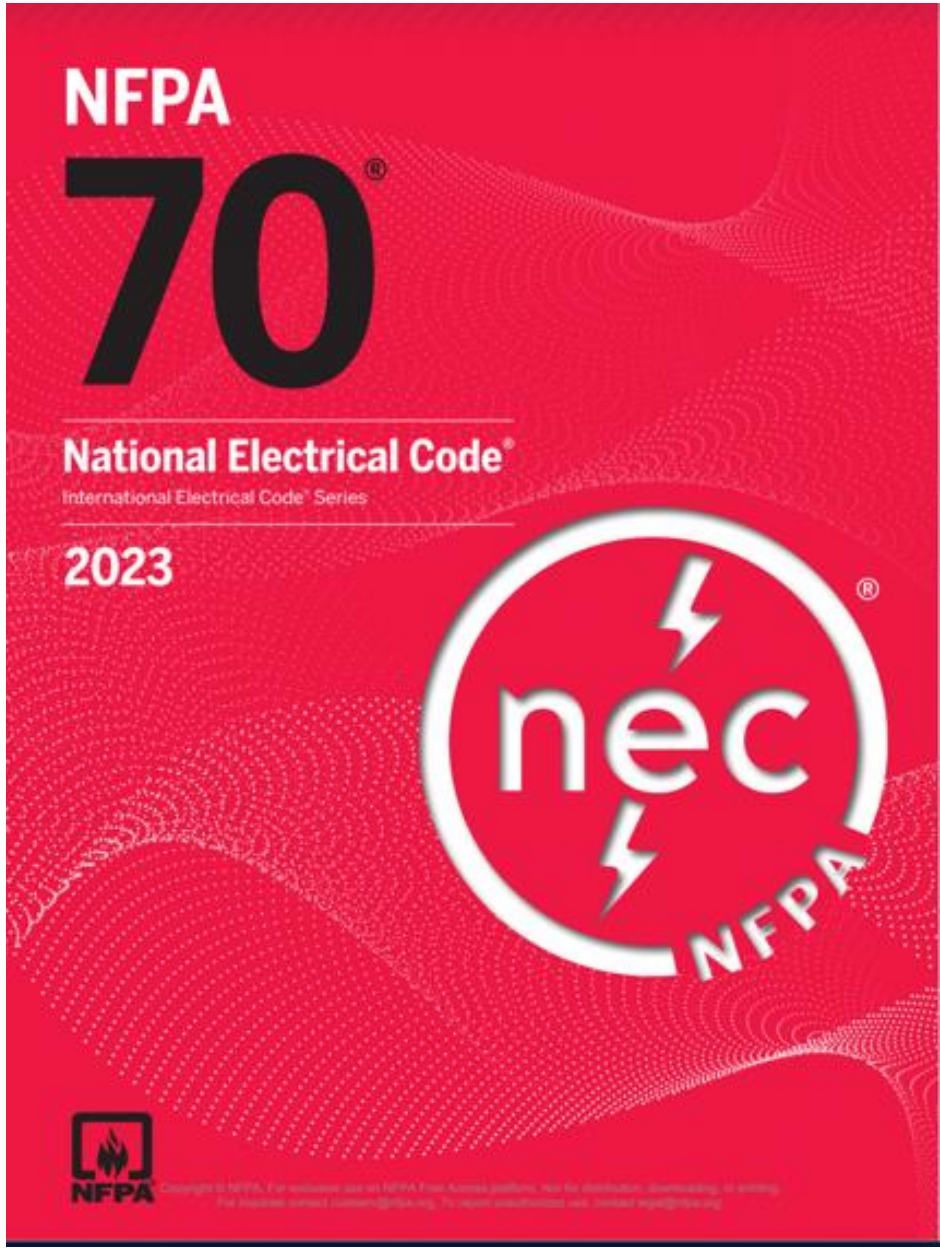
- 15 minute metered data*
- Total load = (Metered Load) x 1.25 + New Load

NEC 220.83 – Sum Connected Loads (commonly used)

- Adding nameplates

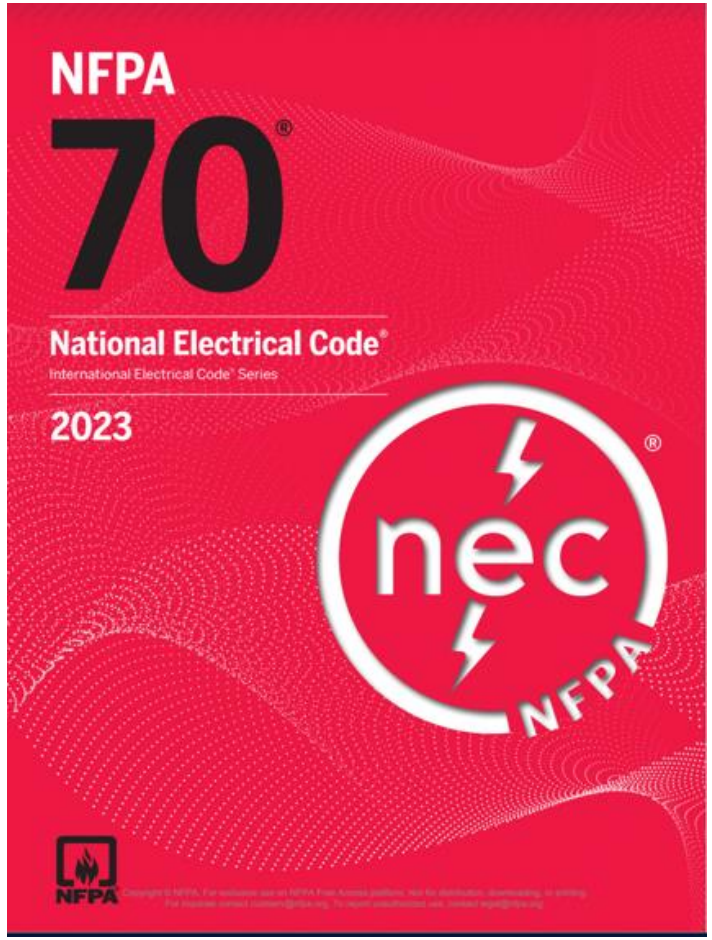
220.87 almost always allows more loads to be added





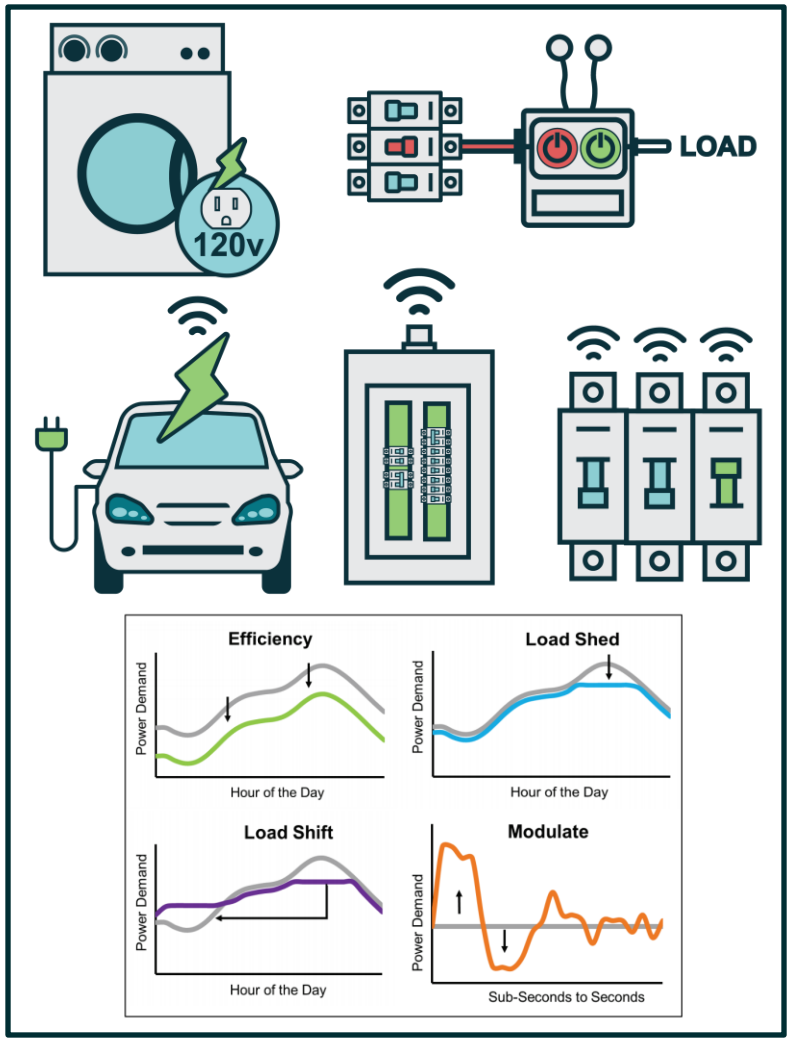
What is driving panel replacement and service changes?

1. Solar PV and EV Charging
2. Simplified approaches by electricians
    - Not using existing metered data options
    - Profitable upsell?
    - Habit/comfort/risk aversion?
3. NEC unclear about options/exemptions
4. NEC may not be using reasonable peak power and load diversity assumptions
5. Local code authorities unprepared
    - Some will not allow circuit sharing or smart panel controls

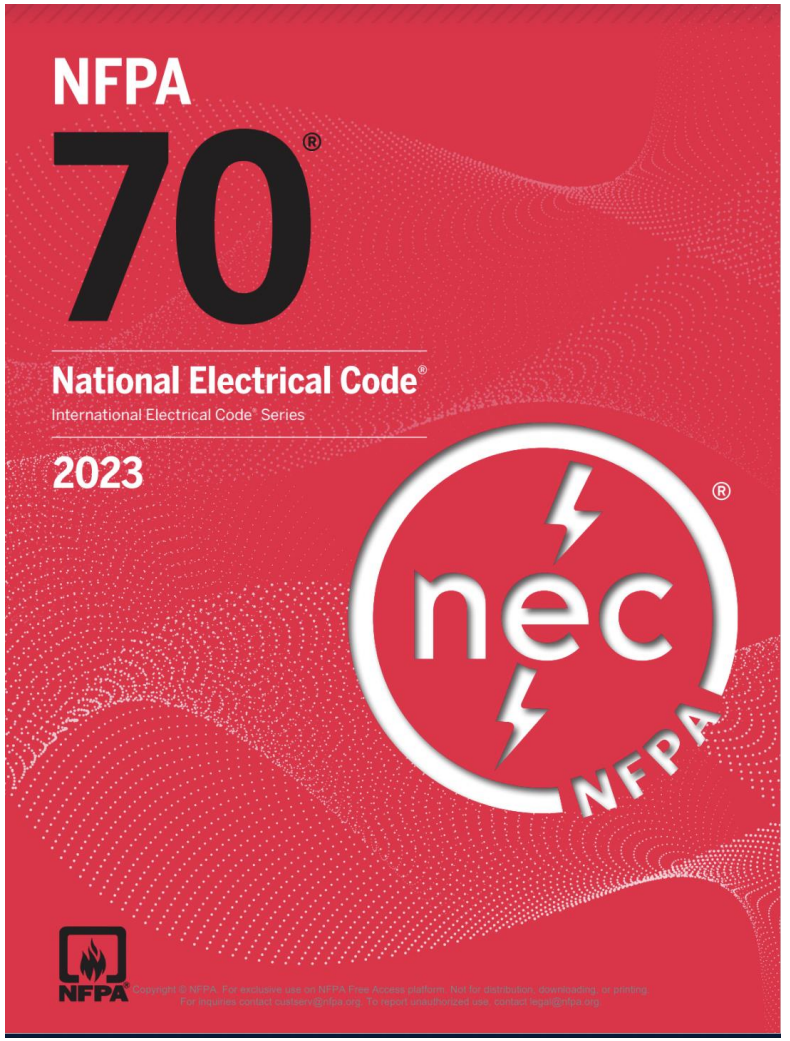


How do we address this?

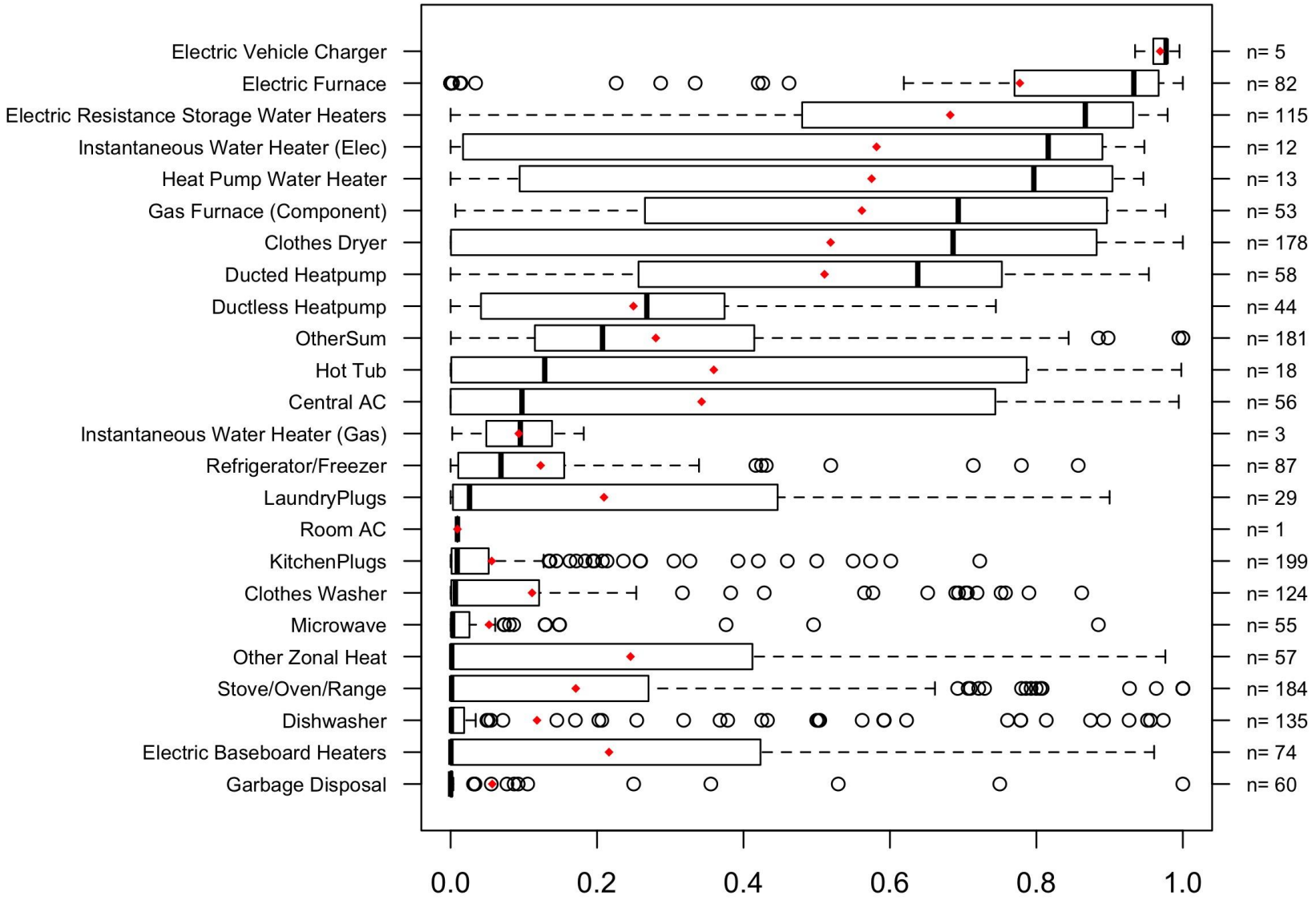
Advances in Technology



Code Innovations



How Much Do End-Uses Operate During the ***Dwelling*** Peak?



When the Home Peaks, the EV charger or Electric Furnace is on near their maximum

Heat pumps… not so much

When the Home Peaks, most appliances and plugs are off

Code Innovations for 2026 NEC– Existing Dwelling Unit (NEC 120.83)

- 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
- Easier to use load controls

Being smarter about the NEC

Watt Diet Strategies

Basic strategies for avoiding an electrical panel upsize can include:

01 - Select appliances that combine two functions into one machine

For example, the kitchen range (combining an oven and cooktop in one slide-in appliance), which lets us avoid a separate high power circuit for wall ovens. Another example is a combined washer/condensing dryer machine that lets us avoid needing a circuit for the clothes dryer.

02 - Select power efficient versions of the appliances

Choose the 15-amp version of a heat pump water heater instead of the 30-amp nearly identical version. Selecting high performance, power sipping versions of heat pumps instead of lower performance versions. Select power efficient and energy efficient heat pump dryers if you want a separate clothes dryer.

03 - Reduce heat loss and cooling loss by insulating and air sealing

04 - Use prioritized circuit sharing devices

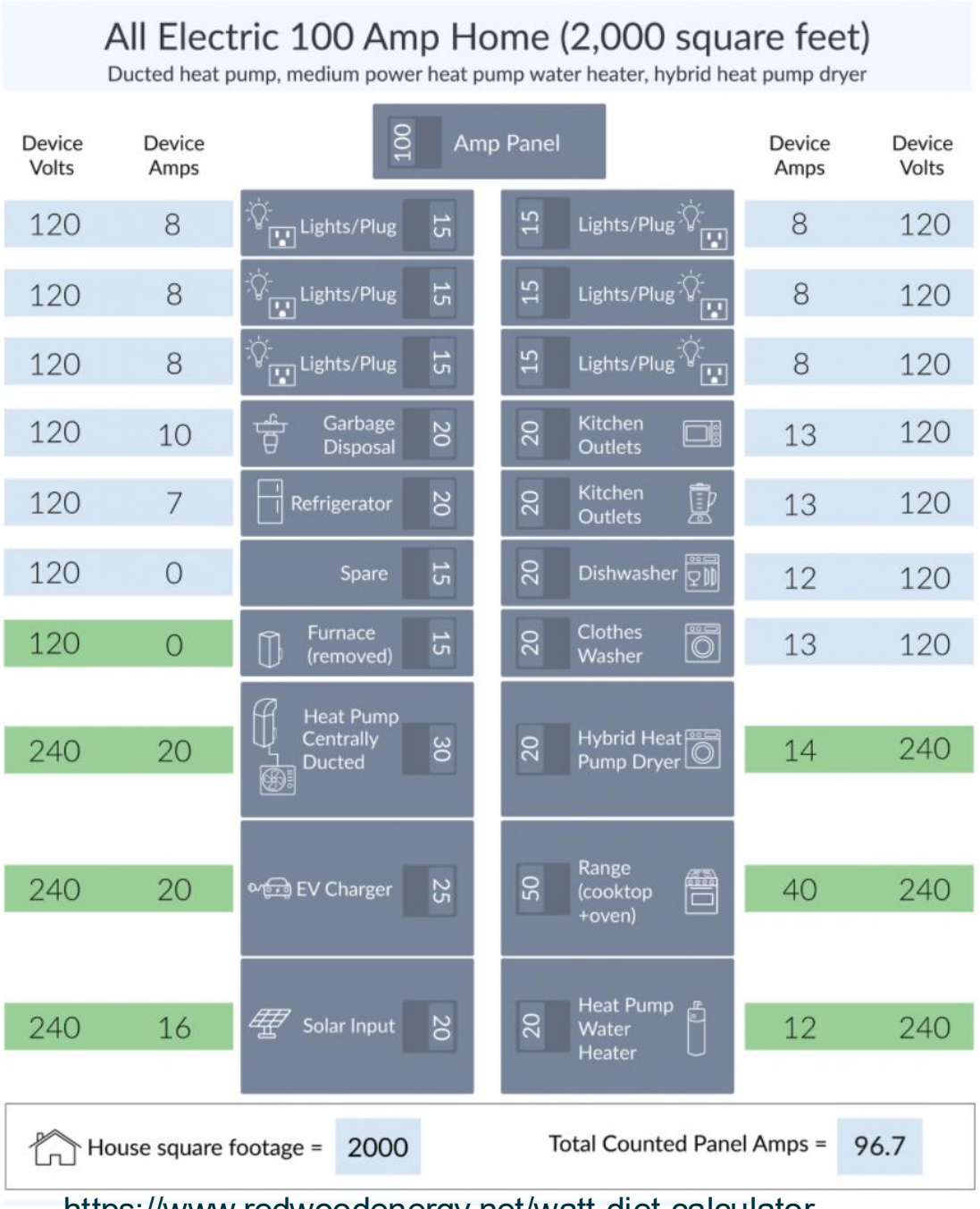
These handy devices can automatically pause car charging while other appliances, like the dryer, finish.

05 - Use EV charger pausing circuits

These briefly pause EV charging if many devices are on at once and the main breaker is at risk of popping.

06 - Avoid overkill in your EV charger settings.

For example, pick a 20-amp or 30-amp outlet for your EV charging and avoid 50-amp chargers at home. A 20-amp outlet can deliver 100 miles of charge overnight and more than 50,000 miles of charge in a year. Bigger car batteries don't require bigger circuits; they give you flexibility about when you charge.

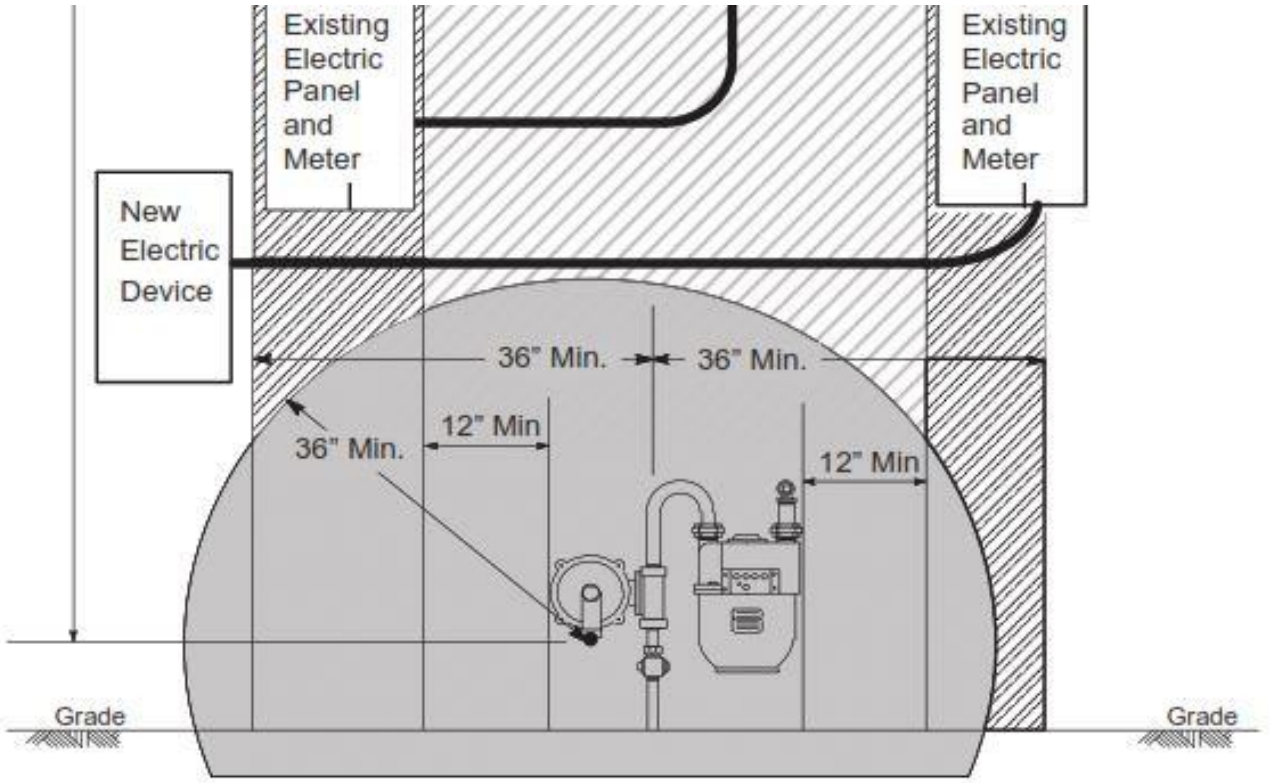


https://www.redwoodenergy.net/watt-diet-calculator

Other Regulation Challenges

Utility service requirements PG&E “Green book”

Results in (unnecessary?) panel moves and re-installs



LEGEND

- Regulator Vent Opening
- New Conduit Without Fittings, Couplings, or Joints Except Connection to Panel
- No Existing Electric Meter/Panel and No New Electric Devices (See Notes 1 and 2)
- No Electrical, No Conduit, No Source of Ignition, No Meter/Panel, and No New Grounding Wires or Clamps
- No New Electric Devices. Only Electric Panel Upgrades and Like-for-Like Panel Replacements are Allowed.

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

Advances in Technology – 120V “Plug-In” Appliances

120v HPWH

- Can plug into regular 120V outlet
- Typical operation only 400W
- Peak power 1000W not 4500W

120V Plug in heat pump

Advances in Technology – Battery-Integrated Appliances

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

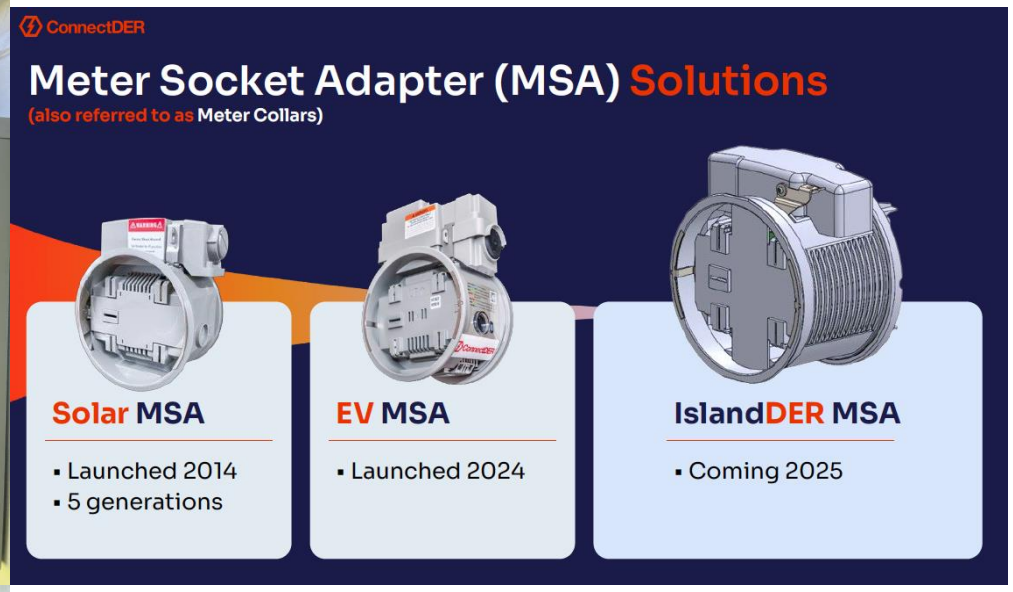
Electric cooking is largest nameplate load in most homes (~12,000 W)

- Reduce to ~1,500 W using battery to serve short-term loads
- 3-5 kWh battery

Advances in Technology – Meter Socket Adapter

Interconnection outside of the panel for Solar PV and EVs

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



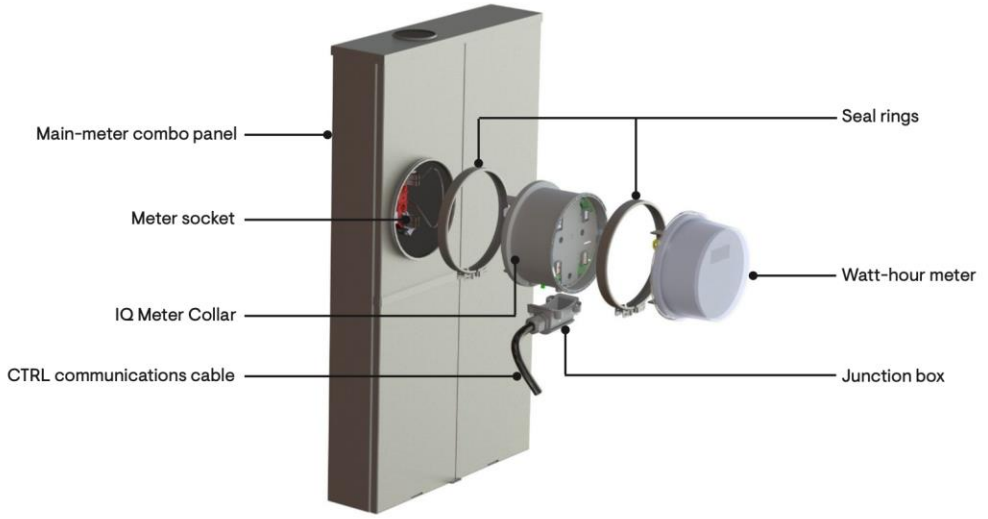


Figure 3: IQ Meter Collar installed on a utility meter socket

Images credit: Connect DER and Enphase

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]

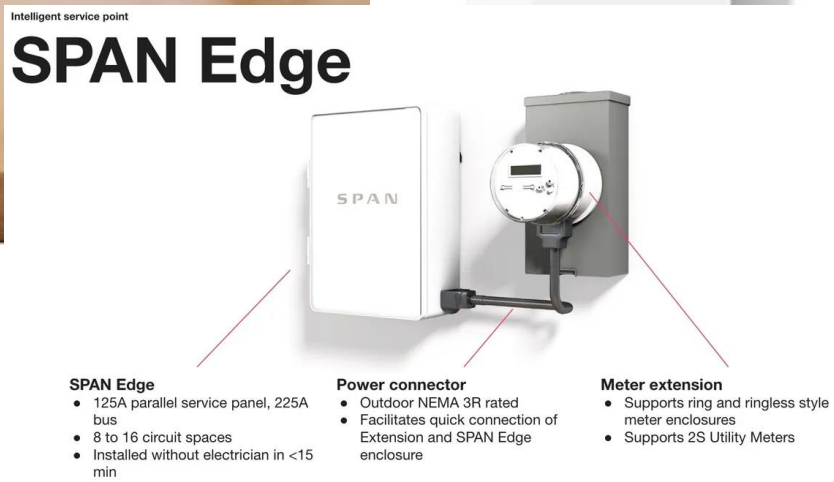
Smart Splitter

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 & Sub-Panels



Advances in Technology – “Balcony” Solar

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

Backfeed solar power into household wiring instead of into panel

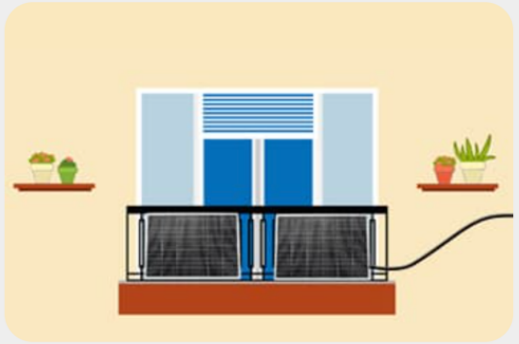
Power limited for safety (<800W) – no utility isolation

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

How to avoid Electric Panel and Service Costs While Saving the Grid

- Go beyond Energy Efficiency: Power Efficiency and Low Peak Power
- High POWER end uses are driving this problem not high ENERGY uses
- Most homes have plenty of capacity for new loads
- Utilize new low power technologies (more coming)
- Be smarter about home electric systems
- Use latest NEC (2026)…. and future updates

Questions?