IWCS Special session

October 30, 2025

GRID AT THE CROSSROADS: INNOVATION AND INFRASTRUCTURE

Travis Kavulla, Vice President of Regulatory Affairs

NRG Energy

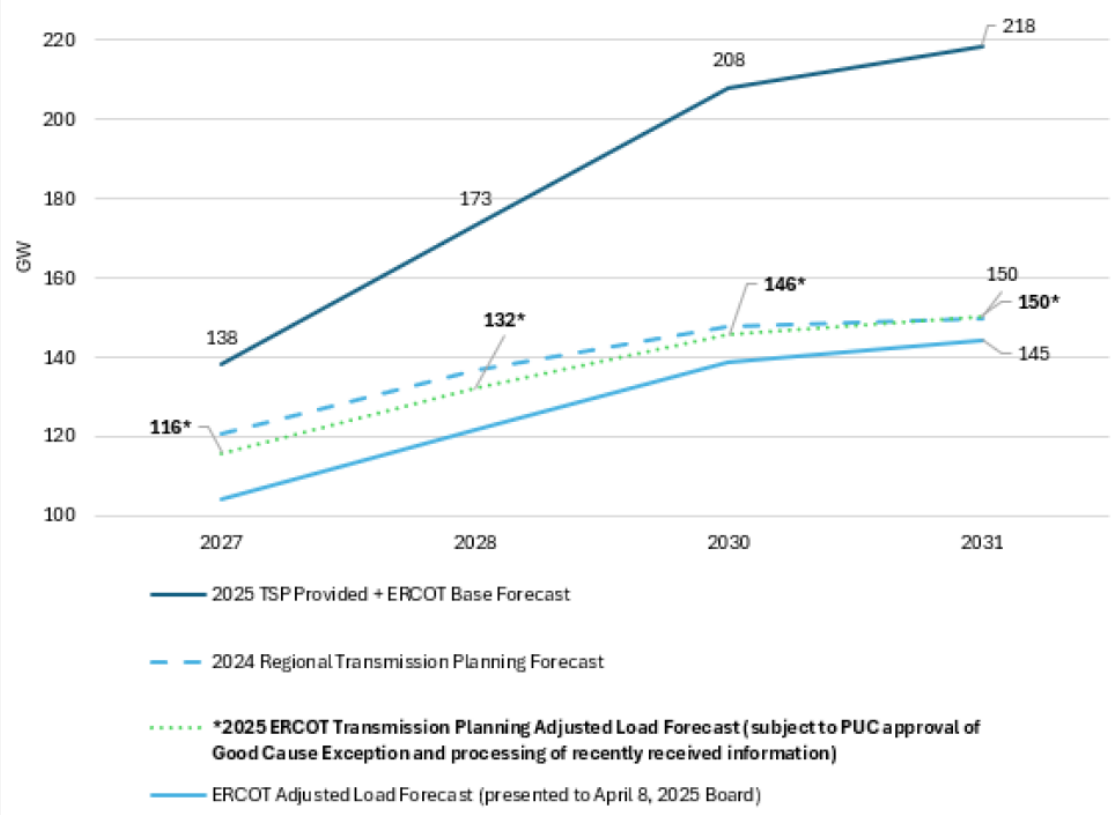
SUMMARY

- Demand forecasts for power are extremely robust but highly uncertain
- Ultimate rate impacts for everyday consumers could be good—or bad—depending on whether the *normal* economics of network industries obtain (lower unit costs with more throughput) in our current, somewhat *abnormal* environment
- One critical question in this regard is whether demand (both existing and new) can be sufficiently flexible to avoid imposing too many new costs on the grid. In other words, how “smart” is our smart grid?

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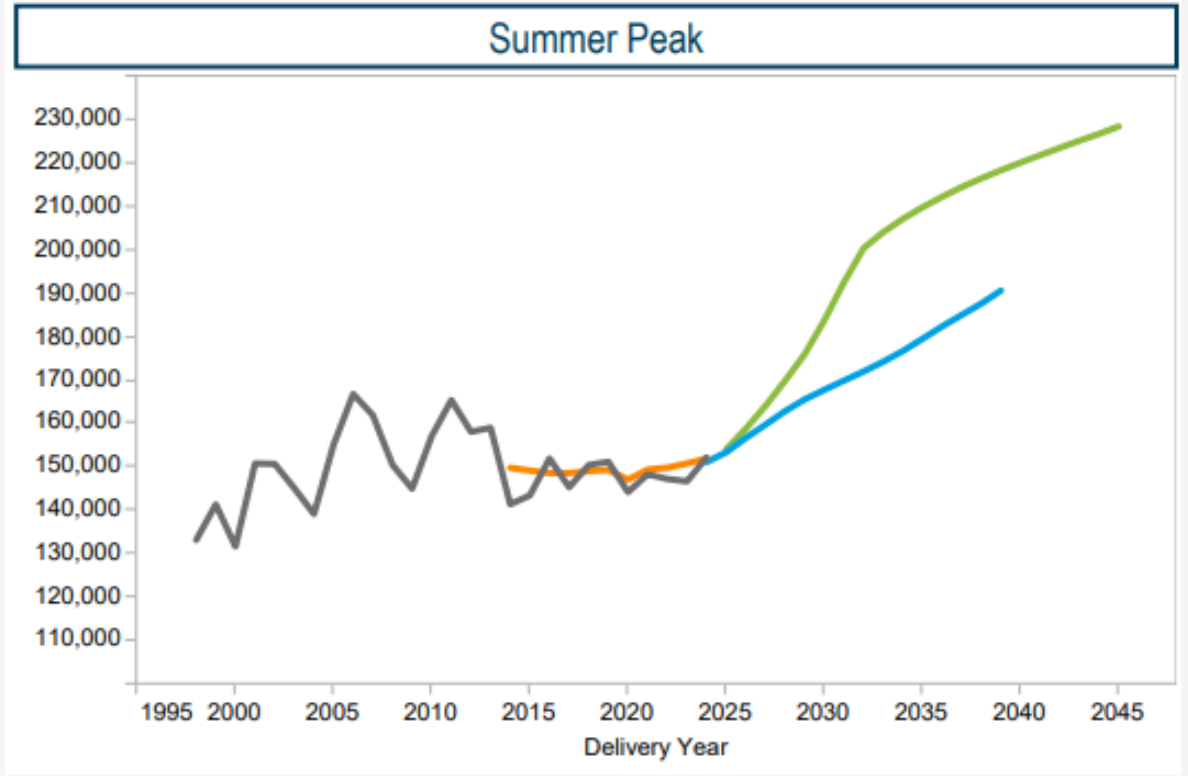
DATA CENTERS ARE DRIVING INCREDIBLE LOAD FORECASTS

ERCOT (Texas)



Source: ERCOT's Revisions to Adjusted Load Forecasts and Amended Draft Proposed Order.

PJM (Mid-Atlantic to Chicago)



Source: PJM Long-Term Load Forecast Report, 2025.

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UTILITY PRICES: ONE BIG DIVISION PROBLEM?

- The grid, which is mostly large capital costs of a fixed nature with a good measure of ‘fixed’ O&M to support it, is subject to cost-of-service regulation where price results from:

$$\frac{\text{Network Fixed Costs}}{\text{Volumes of Throughput}}$$

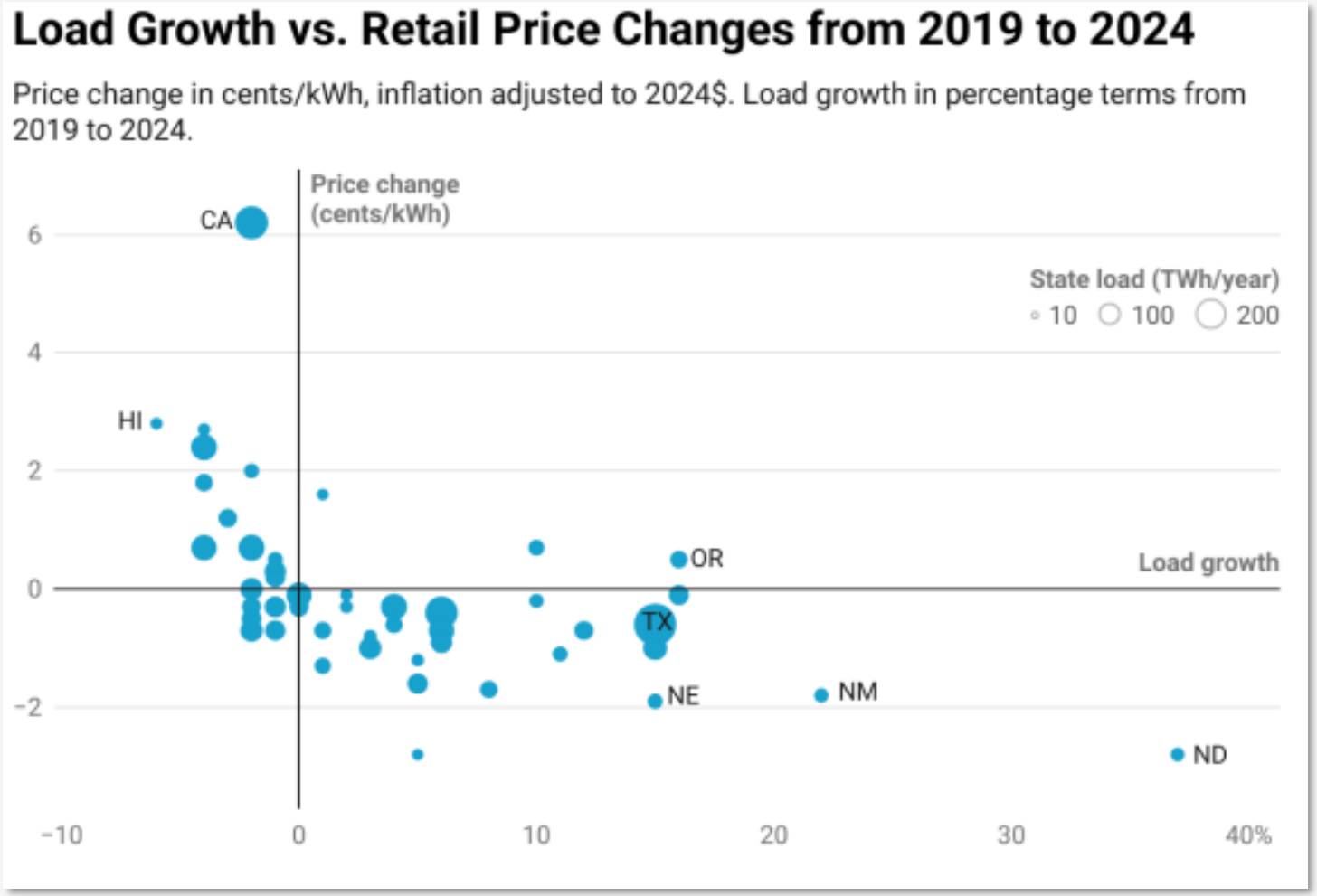
- The math is not hard!
  - If you add demand to the system without triggering new capital investments, rates are lower for everyone
  - If you add 1 unit of demand but that triggers 2 units of new fixed costs, rates go *up* for everyone (unless costs are directly allocated to the new demand)

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A NEW LBNL STUDY SHOWS THIS EFFECT WITH EMPIRICAL DATA

- North Dakota the big winner of the demand-growth Olympics: If the numerator includes a lot of fixed grid costs that can fit a bunch more load under the hood, and demand booms, prices go *down*

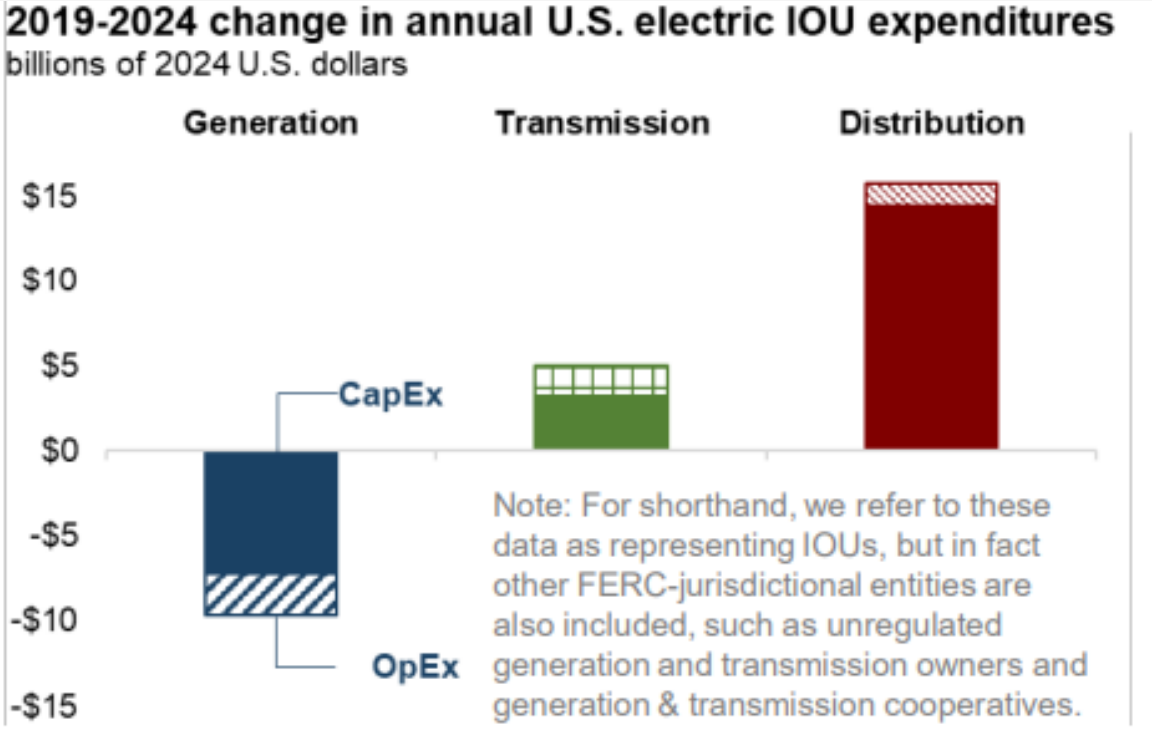
- Conversely, consider California: eroding the denominator by subsidizing rooftop solar, in a way that dumps a big net cost of that subsidy into the numerator. (And fires, lots of fires: also a numerator effect with no denominator upside.)

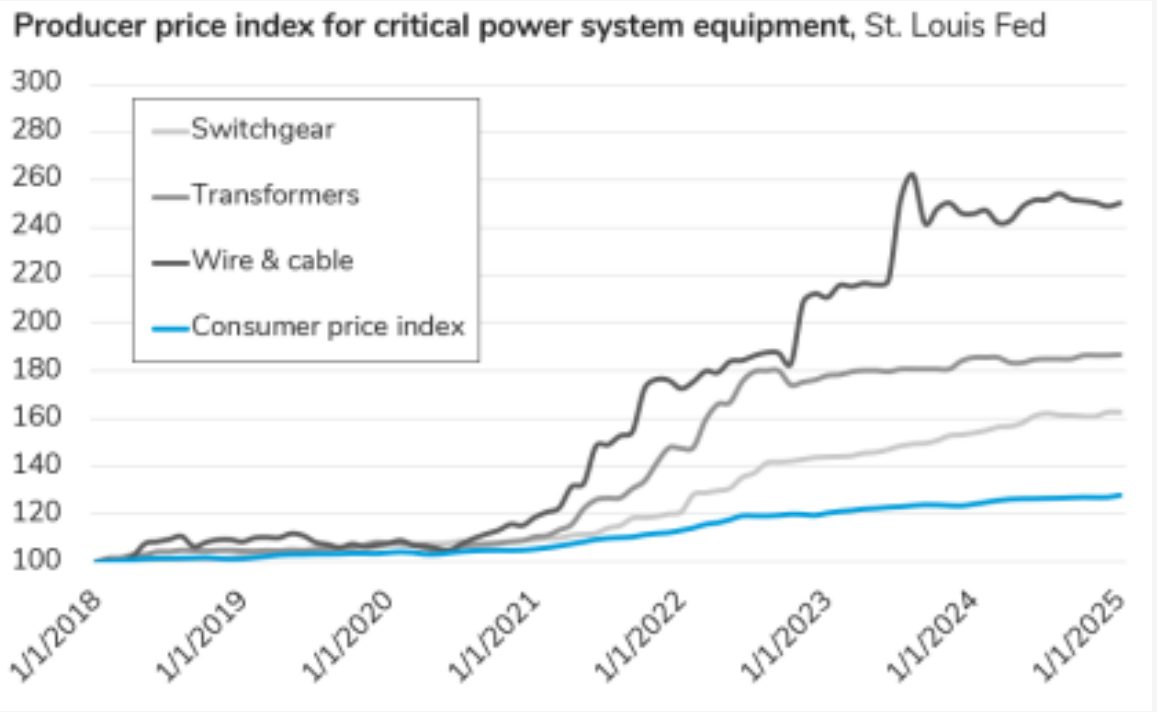


Source: Ryan Wiser *et al.*, "Factors Influencing Recent Trends in Retail Electricity Prices in the United States," Lawrence Berkeley National Laboratory and The Brattle Group, October 2025, Slide 35.

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BUT WILL THIS GOOD-NEWS STORY ABOUT DEMAND GROWTH & POWER PRICES HOLD TRUE?





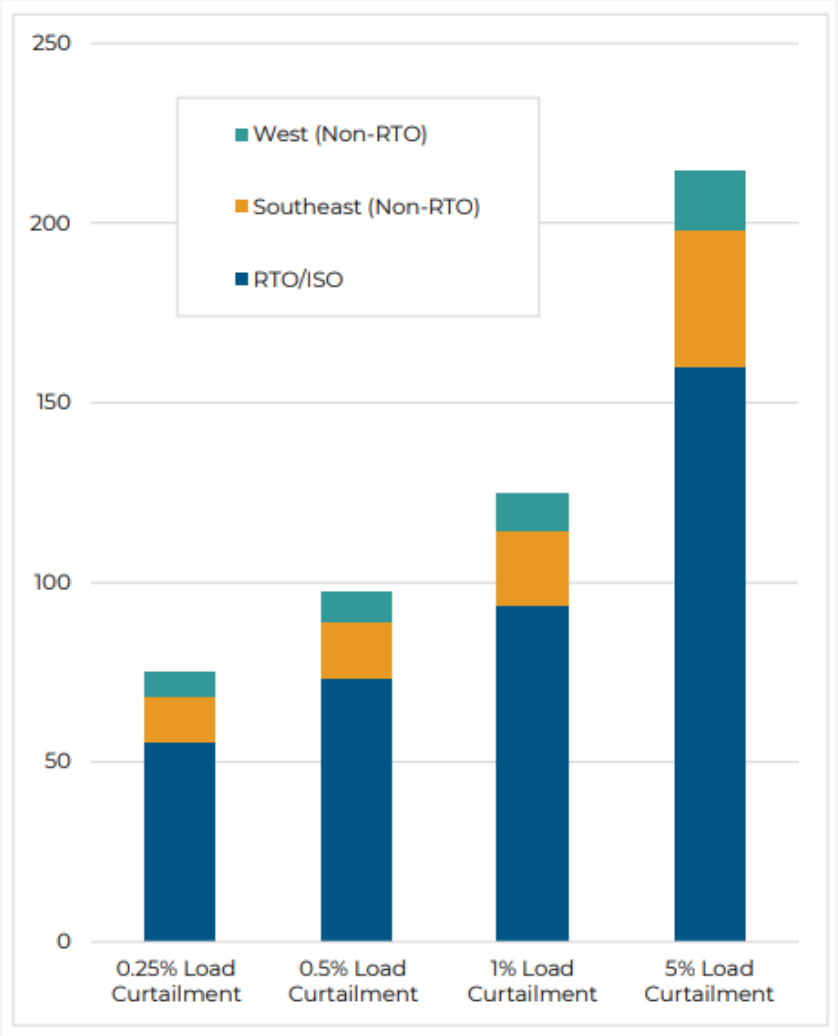
Source: Ryan Wiser *et al.*, "Factors Influencing Recent Trends in Retail Electricity Prices in the United States," Lawrence Berkeley National Laboratory and The Brattle Group, October 2025, Slides 27 and 29

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HOW MUCH ‘HEADROOM’ EXISTS ON THE POWER GRID DEPENDS ON ASSUMPTIONS ABOUT *DEMAND* FLEXIBILITY

- Consider the airline industry:
  - “Load factor” was also historically low—until regulatory policies introduced more competition around demand, at which point airlines optimized fleets, engaged in creative pricing, differentiated product offers.
  - Airlines like utilities used to be largely sheltered from competition and economically regulated—it now doesn’t take many empty seats to make an otherwise good airline unprofitable.

- Can those same incentives obtain in the power sector?
  - Even modest voluntary shifts in consumption open up huge capacity in the power grid.

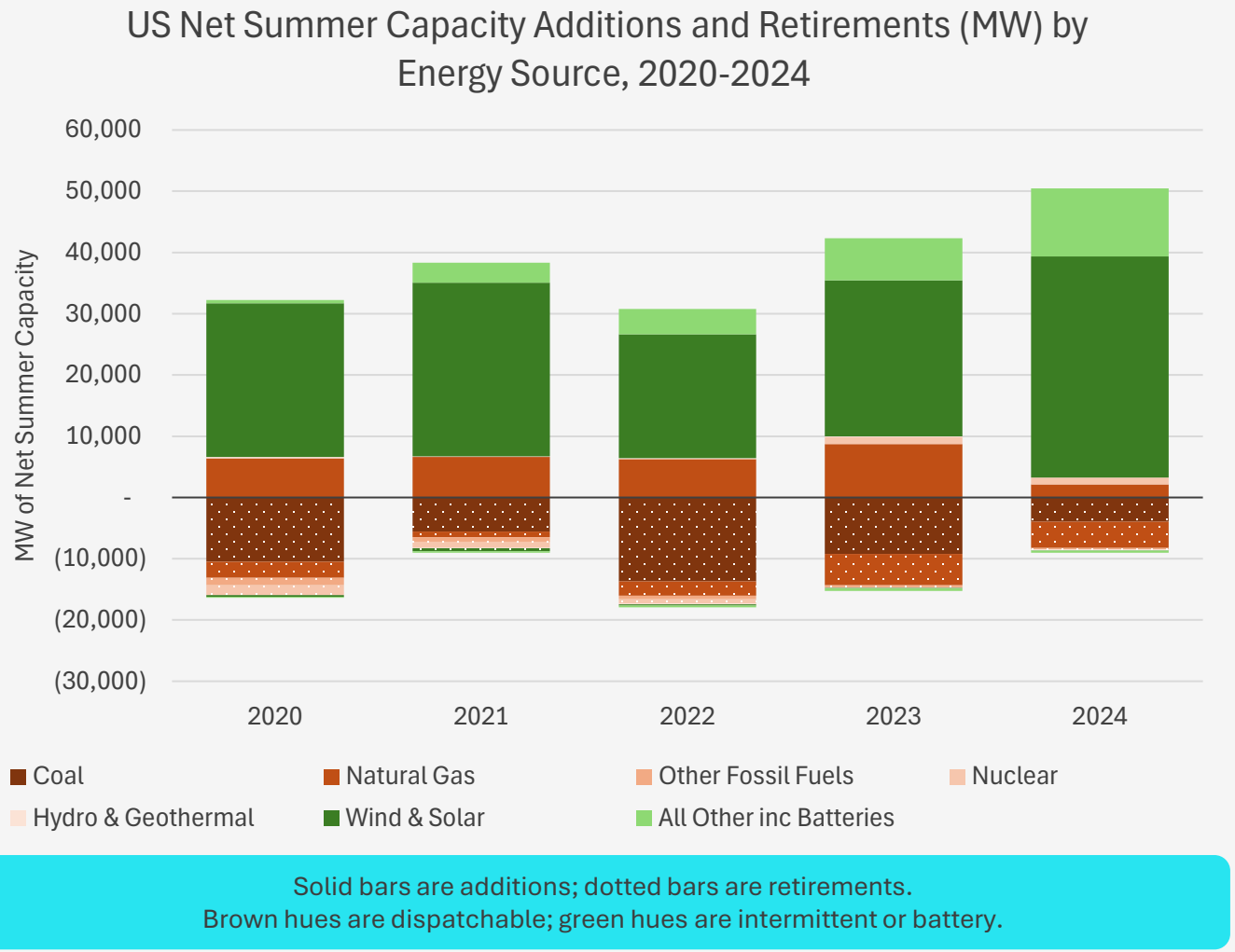


Source: Norris, T. H., T. Profeta, D. Patino-Echeverri, and A. Cowie-Haskell. 2025. *Rethinking Load Growth: Assessing the Potential for Integration of Large Flexible Loads in US Power Systems*. NI R 25-01. Durham, NC: Nicholas Institute for Energy, Environment & Sustainability, Duke University.

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CAN DEMAND BE AS DYNAMIC AS SUPPLY?

- In the power sector, the market for supply has a lot of churn: new technologies, fast-ramping capabilities (gas and batteries), renewables that produce a lot of intermittent but cheap energy
- *But* demand for electricity long seen as inelastic. Why?
  - **Regulatory philosophy:** a public service that needs to be available on demand, at reasonable prices during all hours
  - **A self-fulfilling prophecy?** If retail prices are 'flat', then there is no incentive to back off demand even during hours when the wholesale price of energy is sky high.
  - **Even if you wanted to…** No system architecture for most of electricity history of sending prices to most end-use customers
  - **And what's the point?** Low or flat marginal costs anyways during much of electricity's history



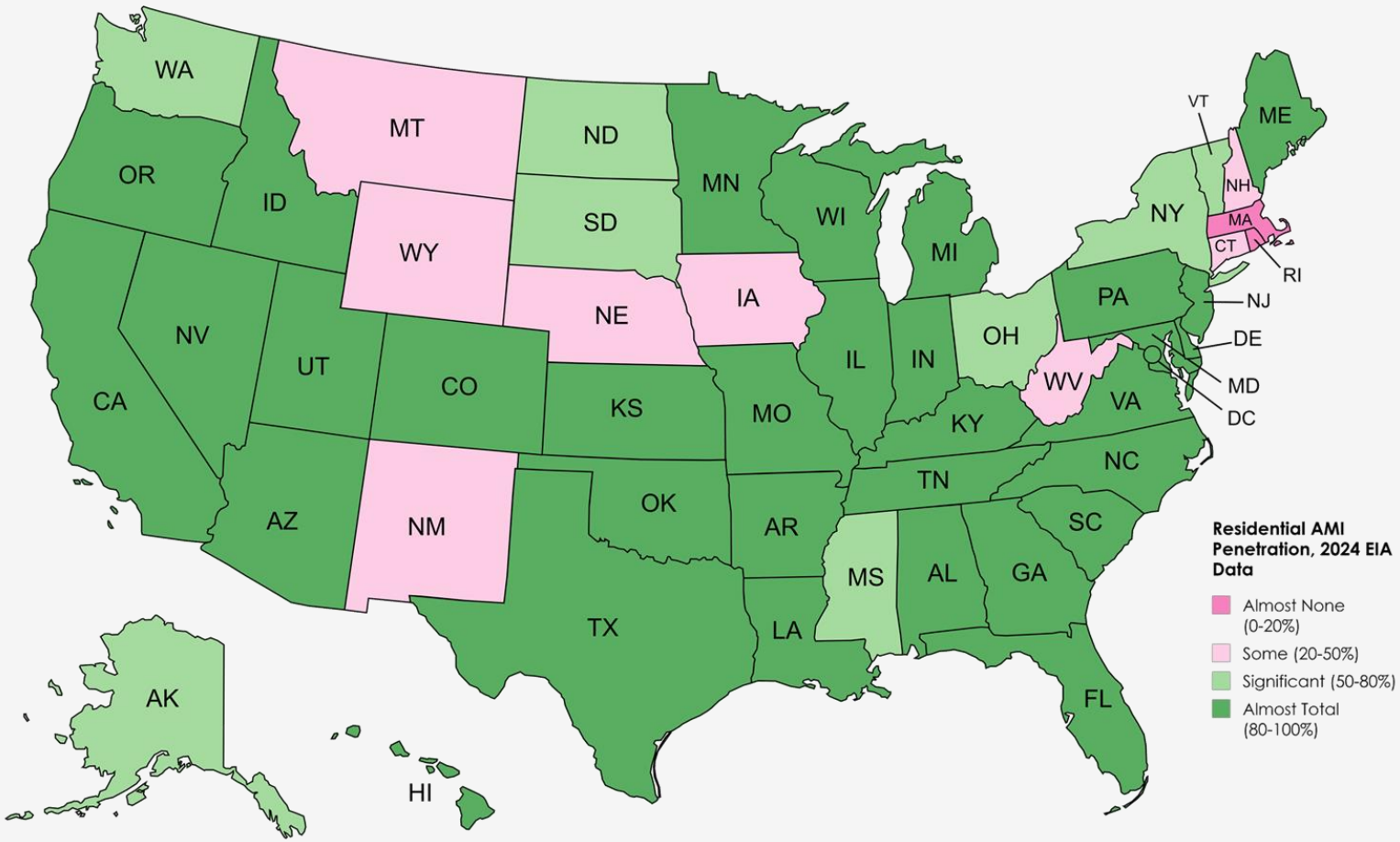
Source: EIA, *Electrical Power Annual* for years 2020 to 2024, Table 4.6, "Capacity additions, retirements, and changes by energy source."

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ALL OF THAT IS WRONG (PART I)

- Prices can now be sent to end-use customers, or to retailers/distributed-energy-resource providers who may intermediate those prices on their behalf through automation

- Advanced Metering Infrastructure becoming ubiquitous (~three-quarters of all U.S. customers)



Source: EIA 861 Data for 2024.

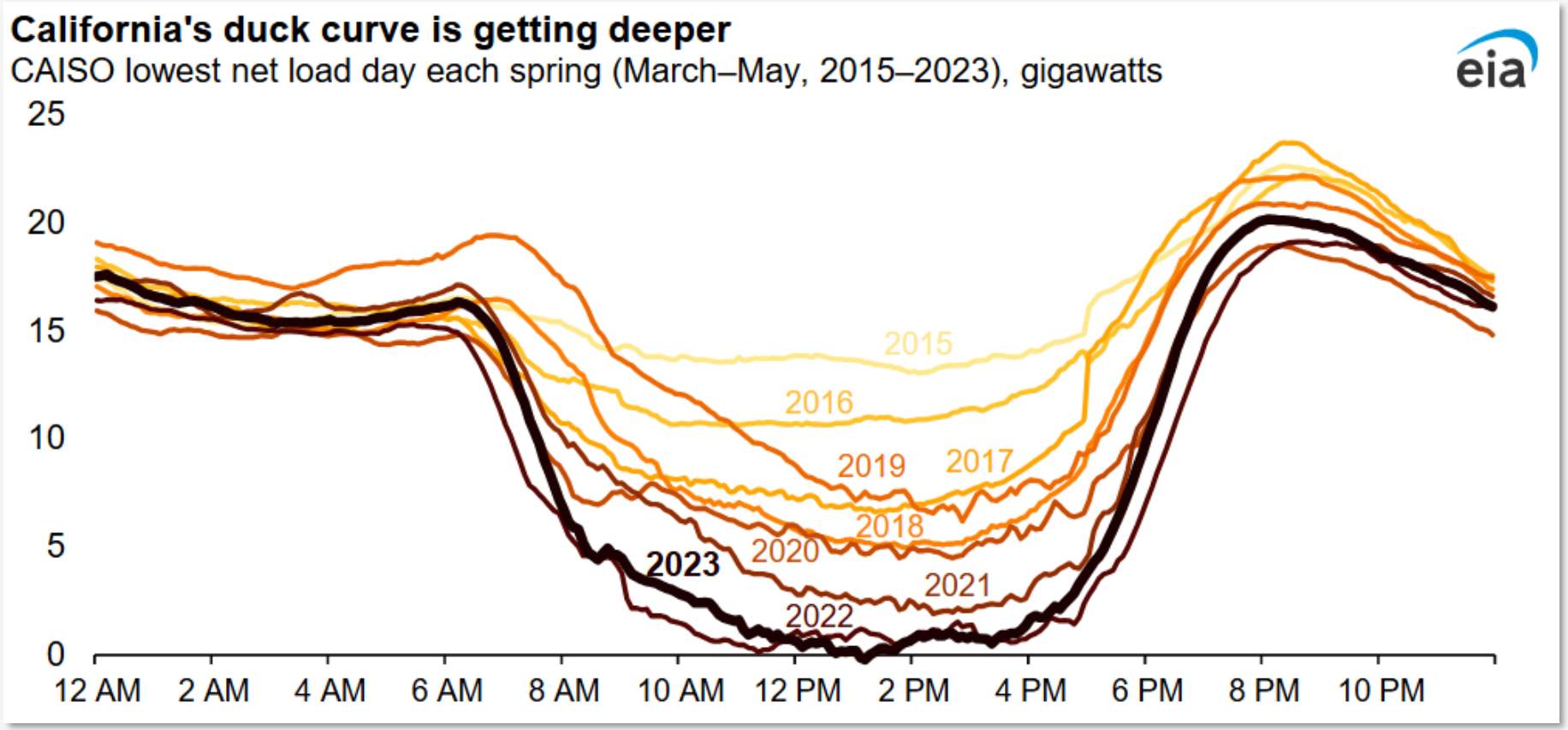
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ALL OF THAT IS WRONG (PART II)

Marginal costs are no longer low and/or flat, because:

- There are periods of great abundance of zero-marginal cost energy, and there are periods where scarcity reigns. See California's "duck curve" at right.

- Demand growth at peak requires *new* capital investments in the infrastructure required to transmit and delivery energy.

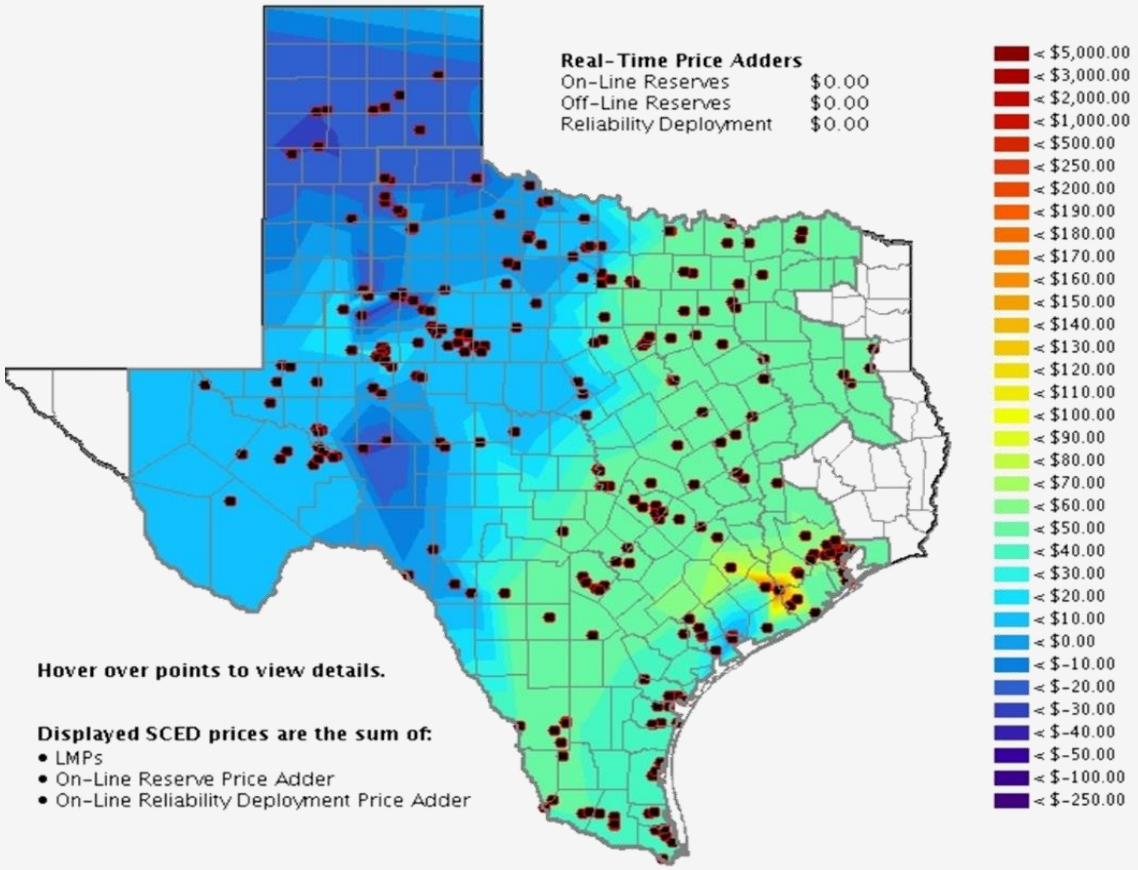


Source: EIA, "As solar capacity grows, duck curves are getting deeper in California", June 21, 2023.

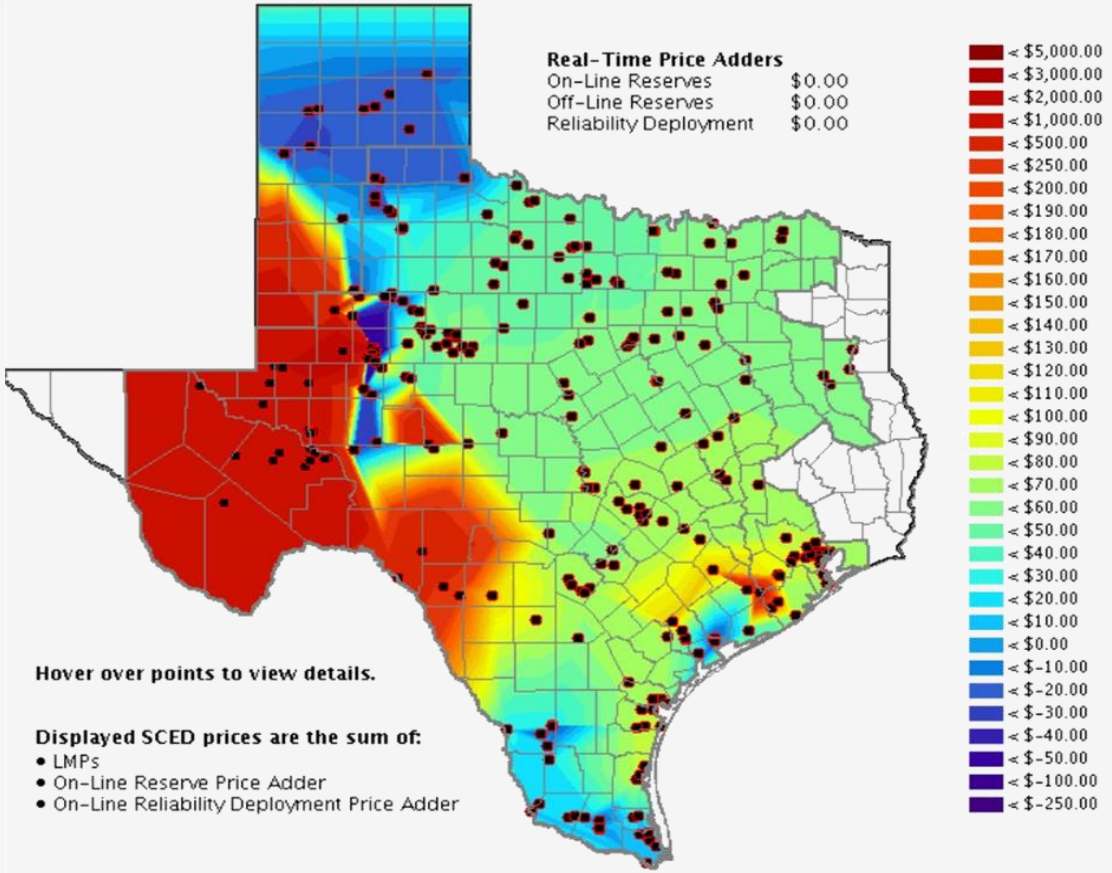
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THE MARKETS COME AT YOU FAST!

6:55 p.m., Apr 27, 2022



8:15 p.m., Apr. 27, 2022



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ALL OF THAT IS WRONG (PARTS III & IV)

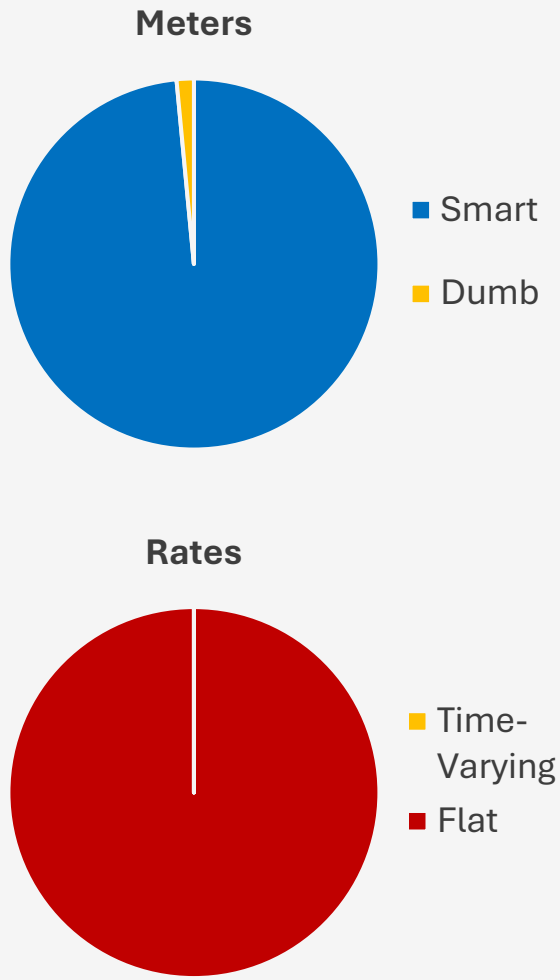
- Flat rate design is *contrary* to the core principle of regulated ratemaking, that prices should equal costs; a ‘flat rate’ seems incompatible with ‘cost of service’ regulation in any precise sense

- Customers behaviorally respond to pricing, and technology gives ‘demand flexibility’ greater potential through
  - Maryland PSC pilot shows double-digit demand reductions in response to Time of Use pricing
  - ‘smart devices’ including air conditioning & heating, water heaters, electric vehicles, wifi-controlled outlet plugs
  - consumer-side storage & production (at-home batteries, rooftop solar)

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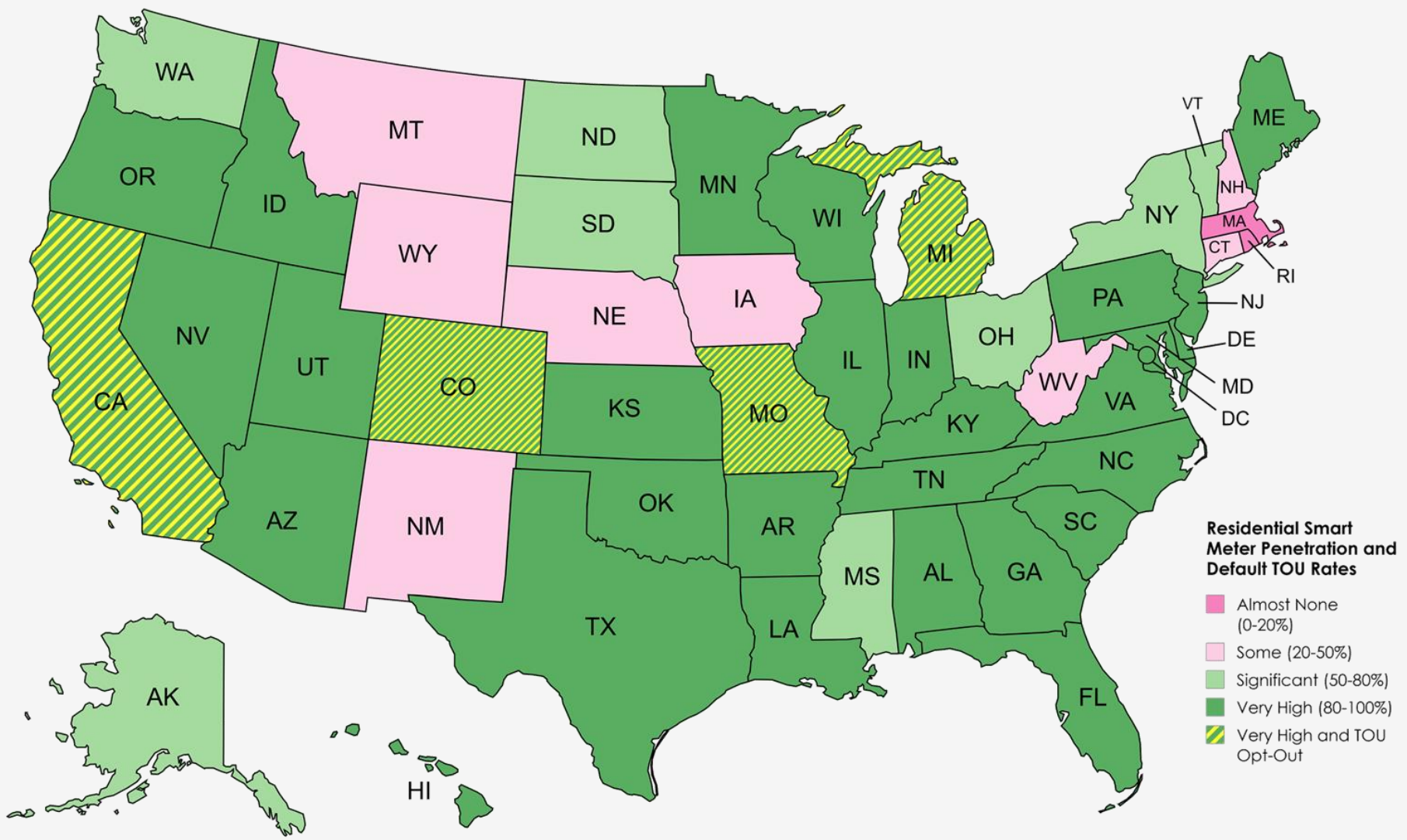
SMART METERS, DUMB RATES

- Commissioner Rob Powelson (PA PUC): “To be frank, it is pointless to have smart meters if you are still going to have ‘dumb’ rates.” (2009)
- Pennsylvania law (AB 129) makes smart meter deployment contingent on time-varying rate offerings.
- By 2019, FirstEnergy’s 4 operating companies deployed 2 million advanced meters in the Commonwealth.
- Less than *100* customers have opted into TOU rates, an enrollment rate equal to five-thousandths of 1%.



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SMART METERS, DUMB RATES (CONT'D)



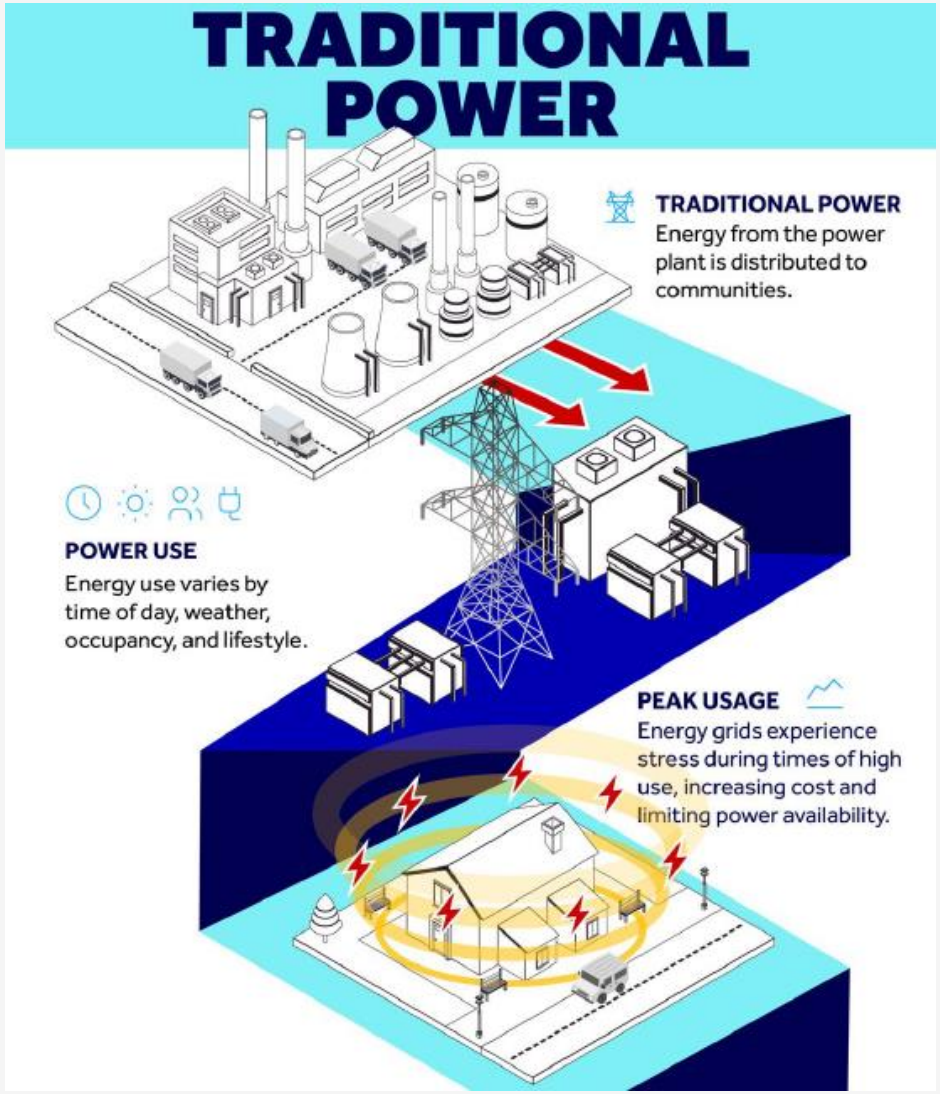
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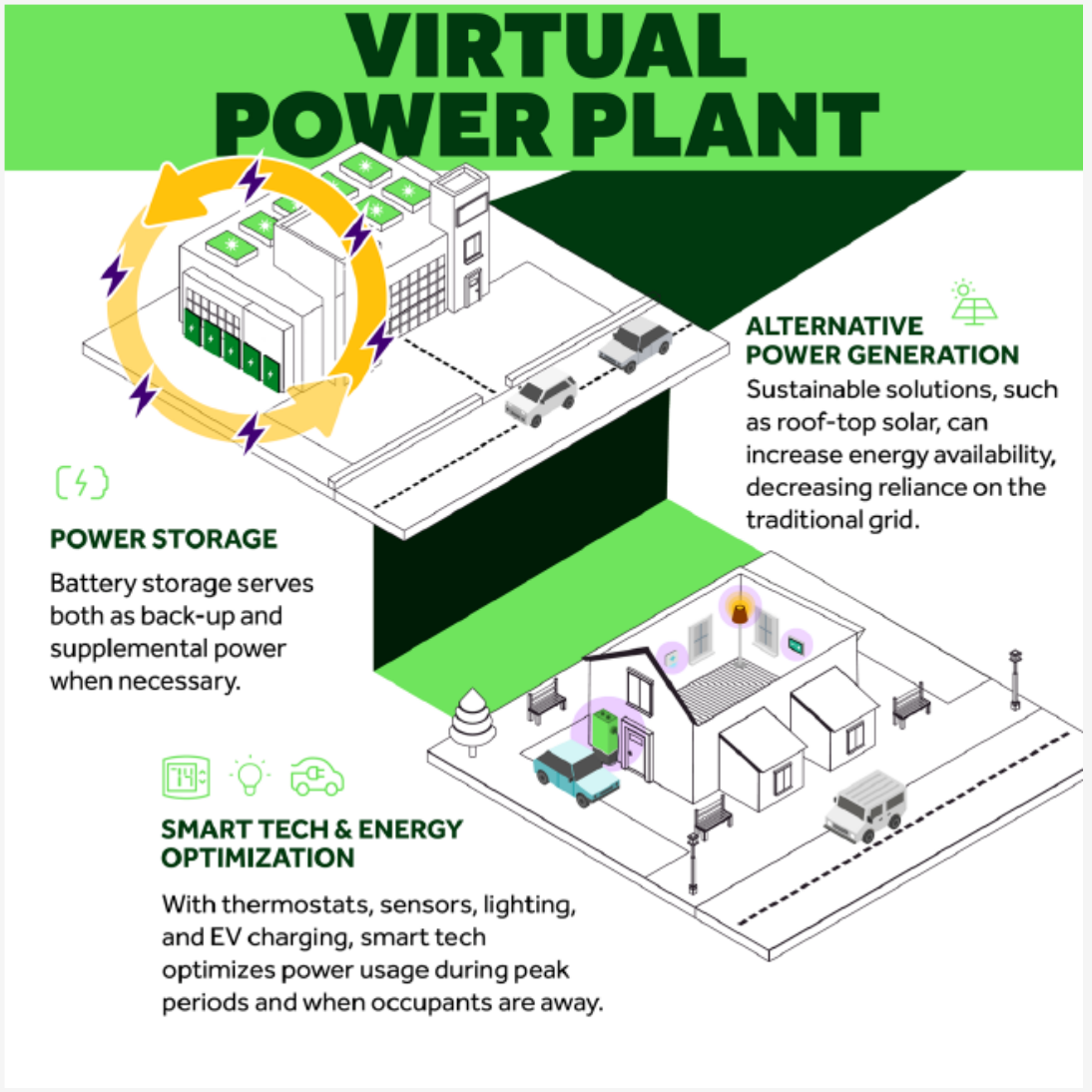


CAN ELECTRICITY ‘APPS’ BE AS EXCITING AS THE STUFF ON YOUR PHONE?

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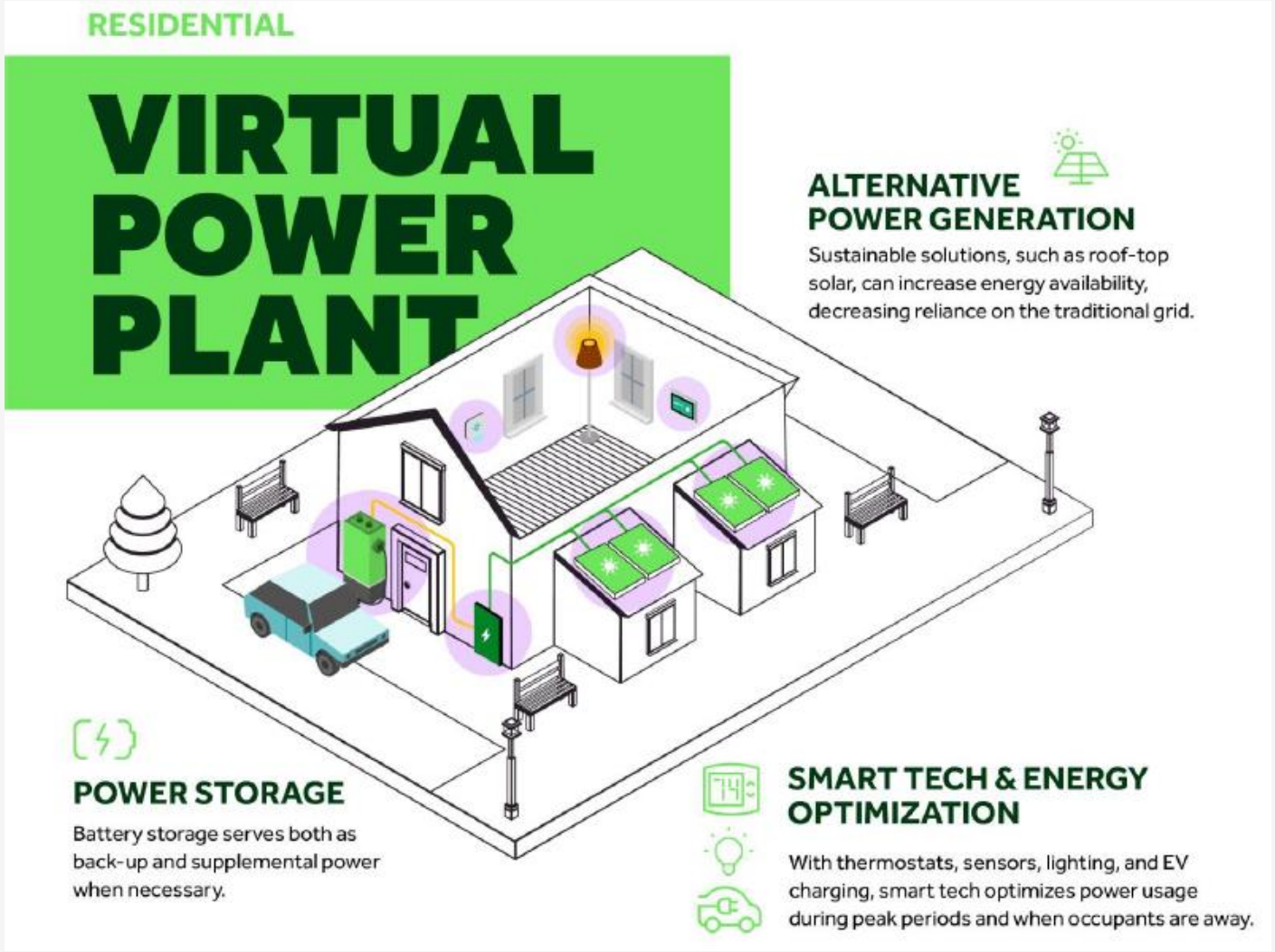
VPPS PROVIDE FLEXIBILITY TO THE GRID





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RESIDENTIAL APPLICATIONS OF VPP



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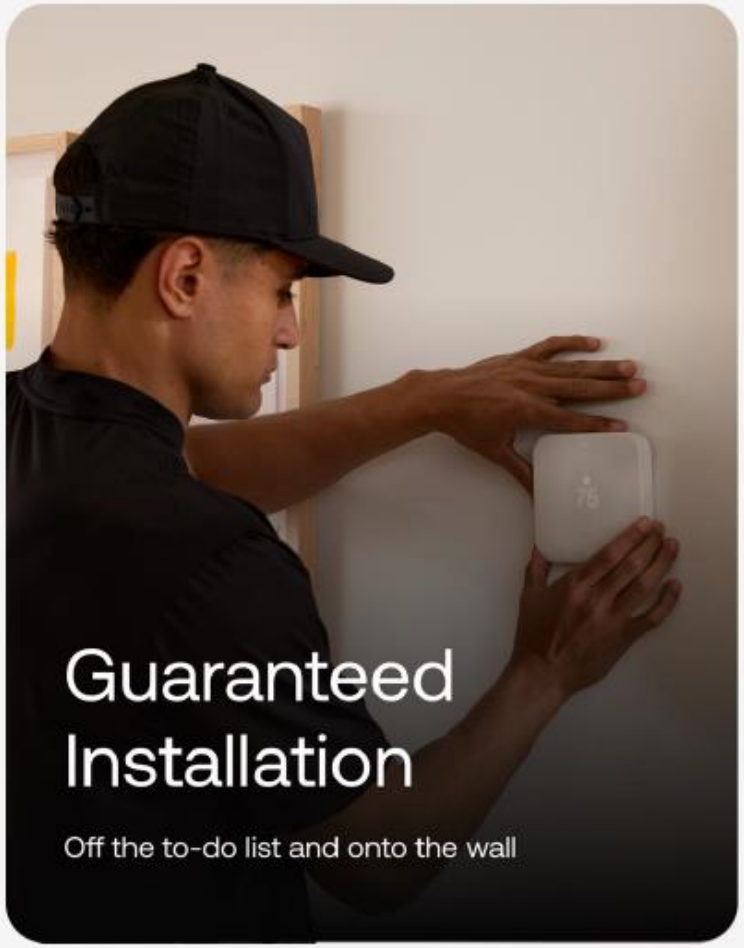
COMBINING SMART HOME CAPABILITIES WITH ENERGY SUPPLY

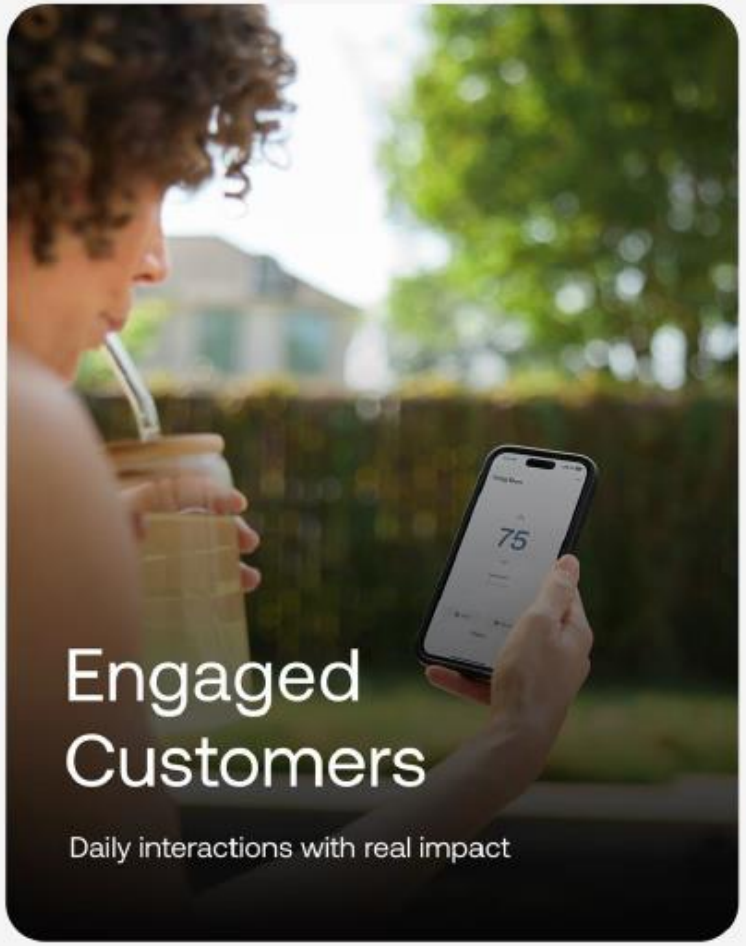


Vivint & Reliant - Smarter Home Bundle

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MAKING VPP ACCESSIBLE AT SCALE



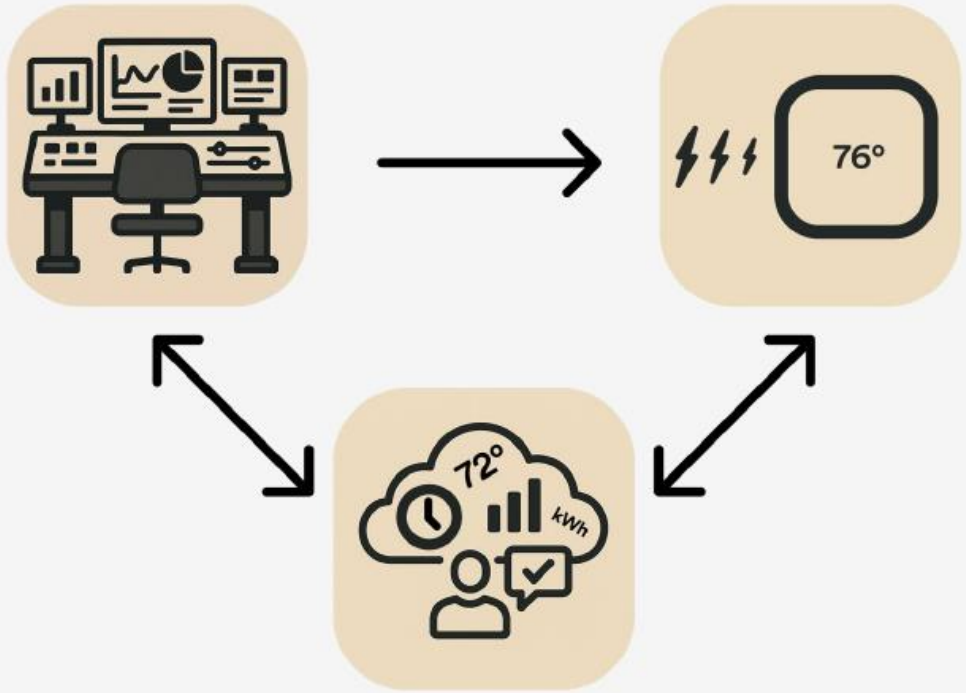




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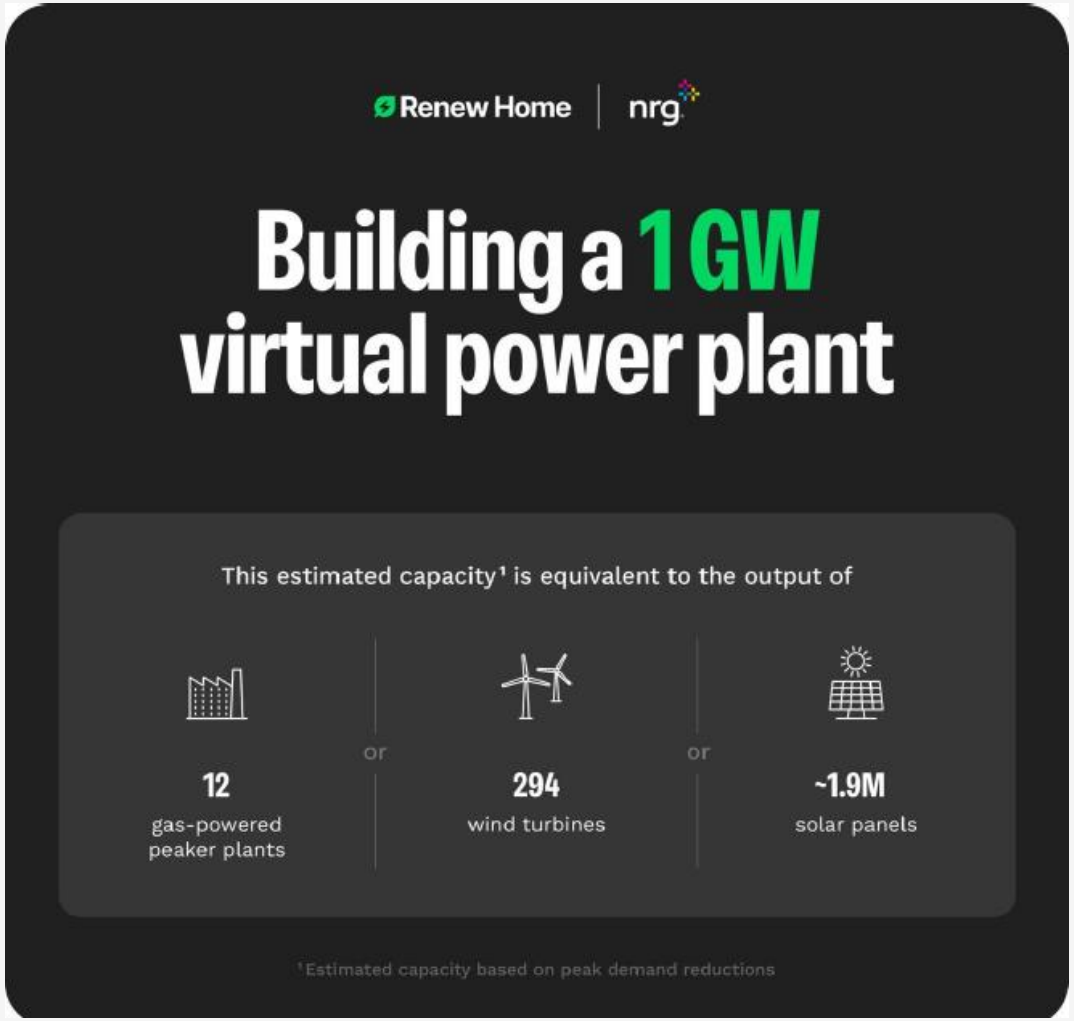
VPP OPTIMIZED LOAD REDUCTION

- Learn customers' schedules
- Listen to them when they say they want to make a change
- Personalized optimization - Occupancy & individual preferences
- Maximizing value for customer & VPP



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NRG & RENEW HOME ANNOUNCED A 1 GW VIRTUAL POWER PLANT



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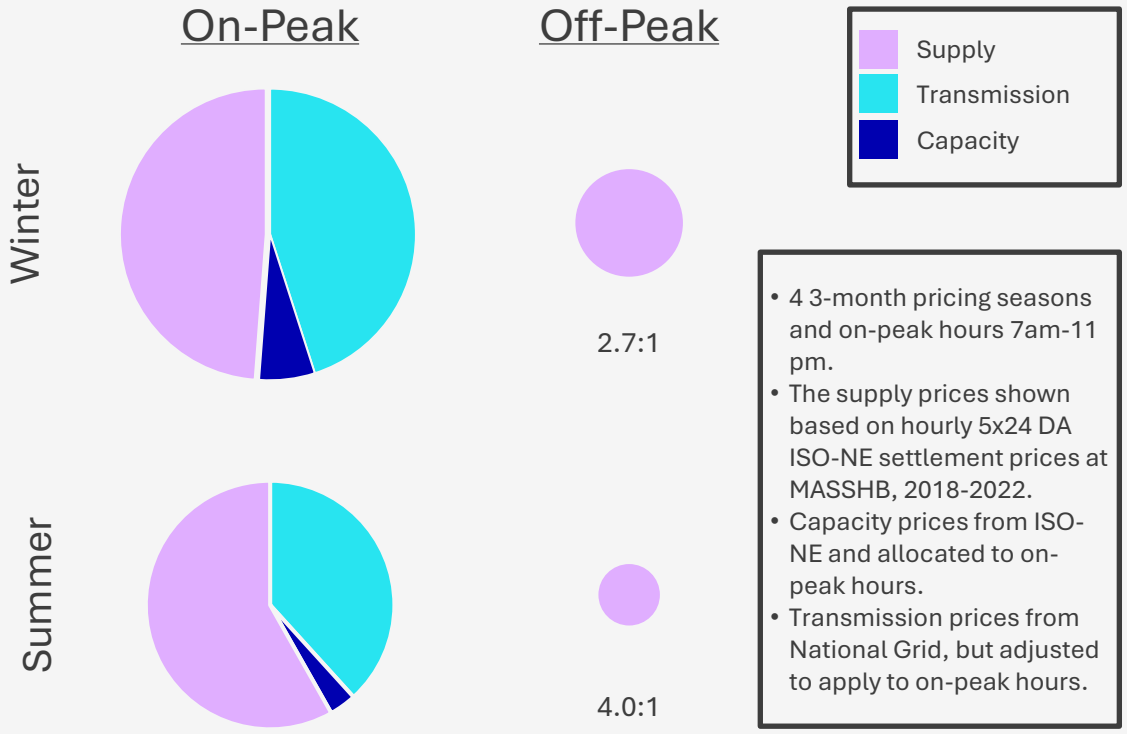
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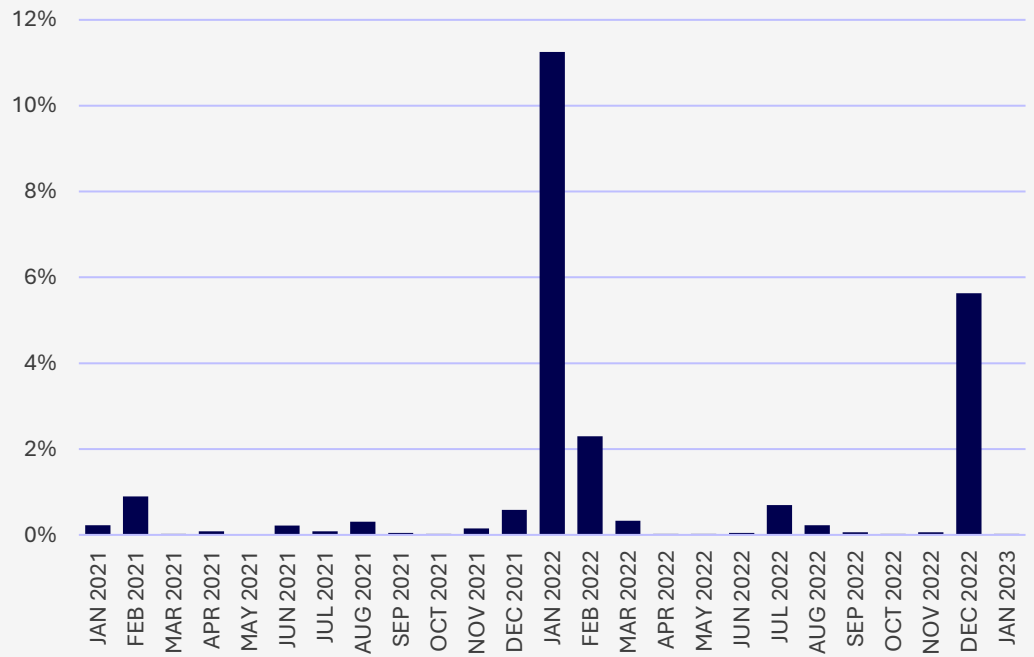
AN ILLUSTRATIVE EXAMPLE OF UTILITY TIME-VARYING RATE DESIGN

National Grid (MA) cost structure justifies a TOU supply price spread of 3x- 4x



- 4 3-month pricing seasons and on-peak hours 7am-11 pm.
- The supply prices shown based on hourly 5x24 DA ISO-NE settlement prices at MASSHB, 2018-2022.
- Capacity prices from ISO-NE and allocated to on-peak hours.
- Transmission prices from National Grid, but adjusted to apply to on-peak hours.

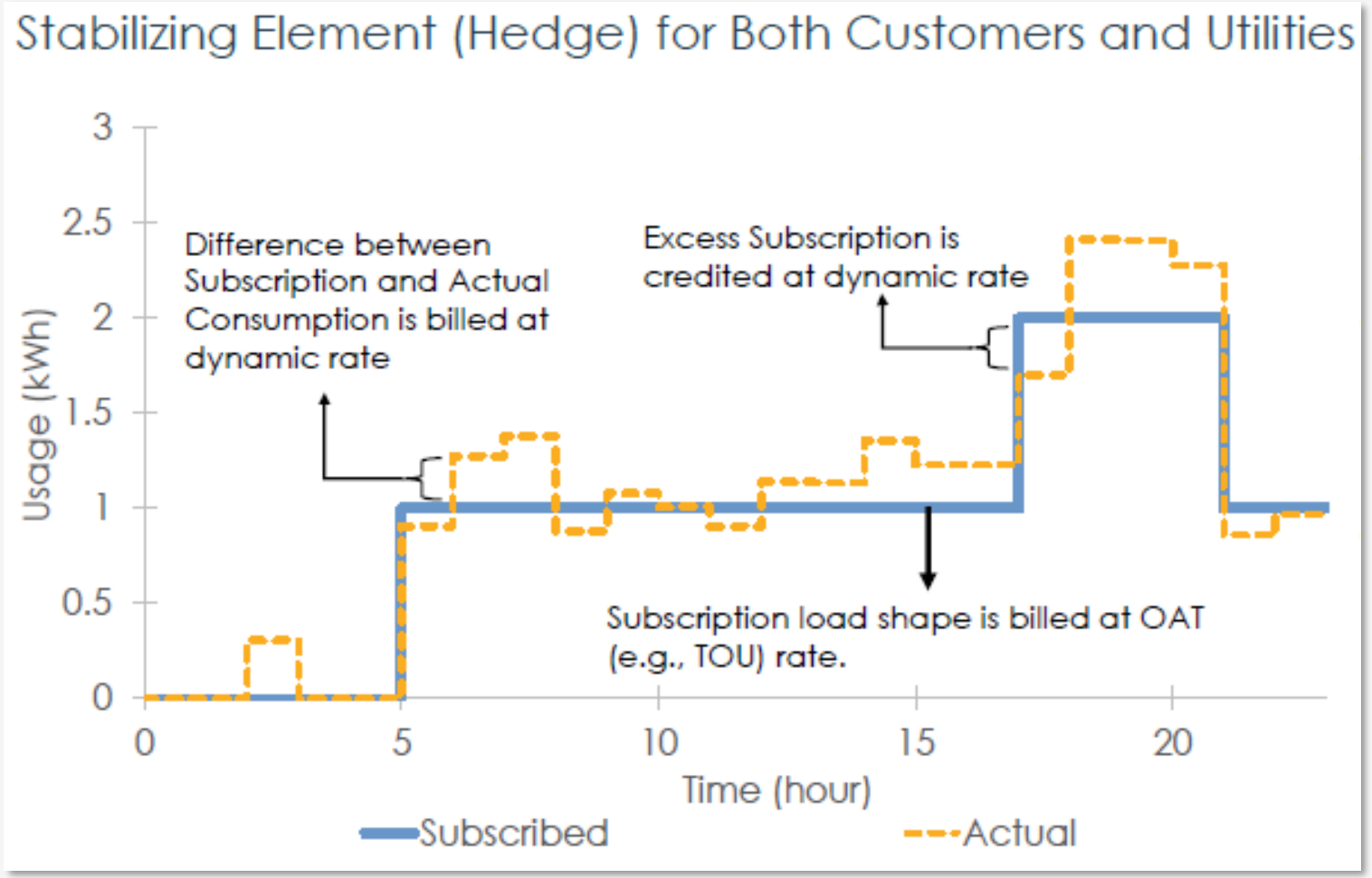
Oil-fired generation as a % of total supply in ISO-NE 01/21 to 01/23



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MONTHLY SUBSCRIPTIONS: AN IDEA NOT YET IMPLEMENTED

- Subscriptions offered by utility
- Third party aggregators/brokers could evaluate offers and manage risk
  - Hedges
  - Comprehensive device management



Source: California Public Utility Commission, Demand Response and Retail Rates Sections, Energy Division, "Workshop: CalFUSE Whitepaper & Staff Proposal," July 21, 2022, slide 48. Link.

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