DISPATCHING DEMAND VIA DYNAMIC PRICING

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THE Brattle GROUP

There are many ways to dispatch demand

- Flex alerts and other voluntary appeals
- Direct load control of certain appliances
- Curtailment and interruptible rates
- Just turn off the power

OR

- Send price signals that vary dynamically in response to the severity of the scarcity

We have evidence from 371 experimental tests of time-varying rates drawn from 9 countries that ….

Summary of Countries in Arc					
Country	N	CPP	TOU	PTR	VPP
Australia	14	12	2	0	0
Canada	50	8	39	3	0
Hong Kong	8	0	4	4	0
Ireland	16	0	16	0	0
Italy	1	0	1	0	0
Japan	12	8	0	0	4
New Zealand	3	0	3	0	0
United Kingdom	4	1	3	0	0
United States	263	79	111	62	11
Total	**371**	**108**	**179**	**69**	**15**

…that customers respond to time-varying rates by reducing peak demand

Has anyone deployed dynamic pricing?

It’s the default tariff for all residential customers in Spain

- Customers with contracted demand below 10 kW pay an hourly market price. Those without smart meters are assigned a deemed profile and pay an average price
- Some 13 million customers (50% of the market) are on real-time pricing

Nordic countries

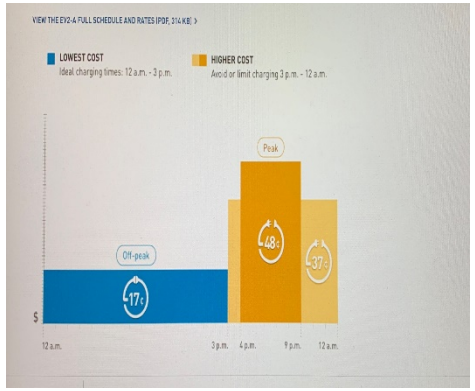
- 7% of Finnish residential customers pay an hourly price that is tied to the spot price in the regional market
- 78% of Norwegian household contracts are tied to spot price

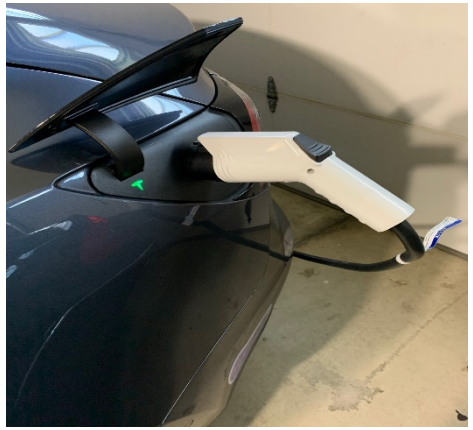
OG&E has some 20% of its residential customers on variable-peak pricing

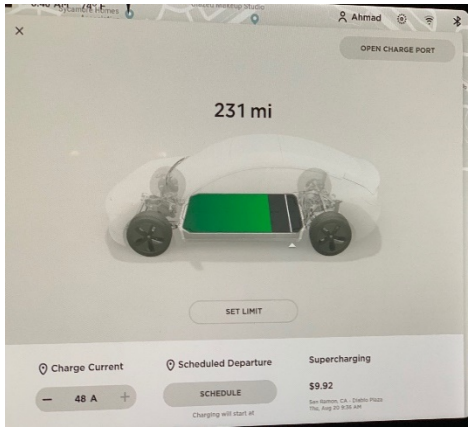
Georgia Power has some 2,200 commercial and industrial customers on RTP

Source: https://www.ssb.no/en/statbank/table/09364/tableViewLayout1/?rxid=3b9a3d6f-6e0c-4648-bc6c-1311bbbd1379

How about California, which and accounts for roughly half of the US population of PVs and EVs?







Surprisingly, it's a laggard when it comes to dynamic pricing despite doing pilots going back to the 1990s

Based on an initiative of the California Energy Commission, it deployed CPP as the default tariff about a decade ago for C&I customers; but many customers opted-out of it because of insufficient customer support

Today, California offers CPP as an opt-in tariff for residential customers

The state is now moving toward default TOU rates for all residential customers which lack a dynamic element

California needs to move to default CPP as the grid becomes renewable-intensive https://www.utilitydive.com/news/6-reasons-why-california-needs-to-deploy-dynamic-pricing-by-2030/578156/

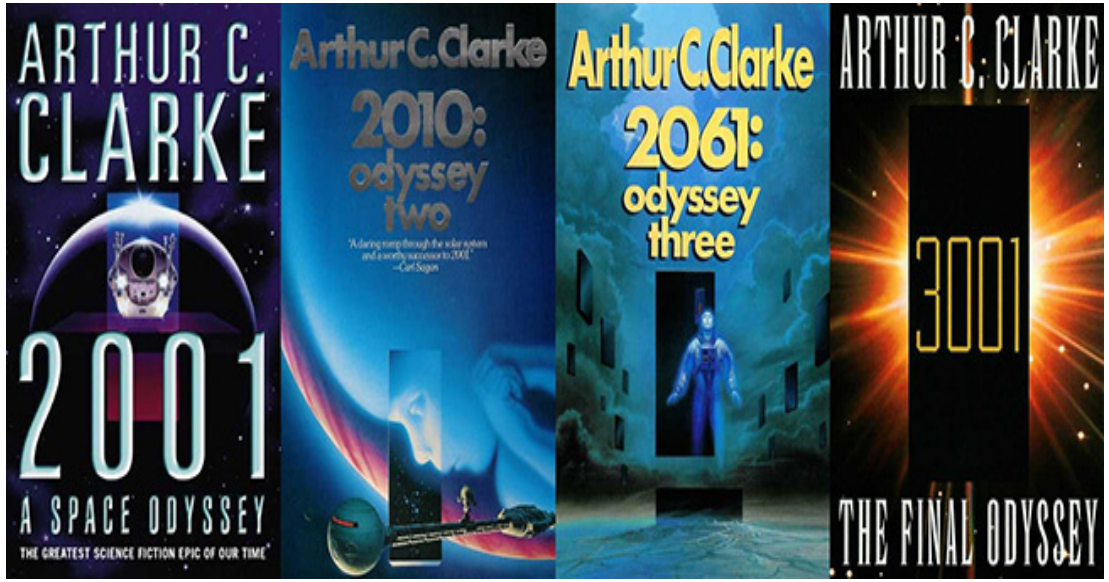
Are we going to see this in our lifetime?

You can always expect a radical new idea to generate three reactions:

“It is completely impossible”

“It’s possible but not worth doing”

“I said it was a good idea all along”



APPENDIX A

ADDITIONAL READINGS

Selected papers on pricing and customer-centricity

"The Tariffs of Tomorrow: Innovations in Rate Designs," *IEEE Power and Energy Magazine*, vol. 18, no. 3, pp. 18-25, May-June 2020.

"Refocusing on the consumer," *Regulation*, Spring 2020.

"Customer centricity: Lynchpin of strategy," *Public Utilities Fortnightly*, November 1, 2019.

"2040: A Pricing Odyssey," *Public Utilities Fortnightly*, June 1, 2019.

"Rate Design 3.0 – Future of Rate Design," *Public Utilities Fortnightly*, May 2018.

"Innovations in Pricing: Giving Customers What They Want," *Electric Perspectives*, September/October 2017.

APPENDIX B

QUOTABLE QUOTES

Why do we have so little price-responsive demand?

"The greatest barriers [to price responsive demand] are legislative and regulatory, deriving from state efforts to protect retail customers from the vagaries of competitive markets." Eric Hirst

"In electricity markets, as generating capacity constraints are reached, relatively little demand can be rationed by short-term price movements and, instead, must be rationed administratively with rolling blackouts. [This situation could be avoided if more demand-side instruments were available such as having] more customers who can see and respond to rapid changes in market prices and expanded use of price-contingent priority rationing contracts. The demand response instruments that are available are poorly integrated with spot markets ... moreover, the prices that are paid ... are too low compared to the long-run cost of generating capacity." Paul Joskow

APPENDIX C

THE CONSUMER OF THE FUTURE

Electricity customers have become more demanding throughout the nation

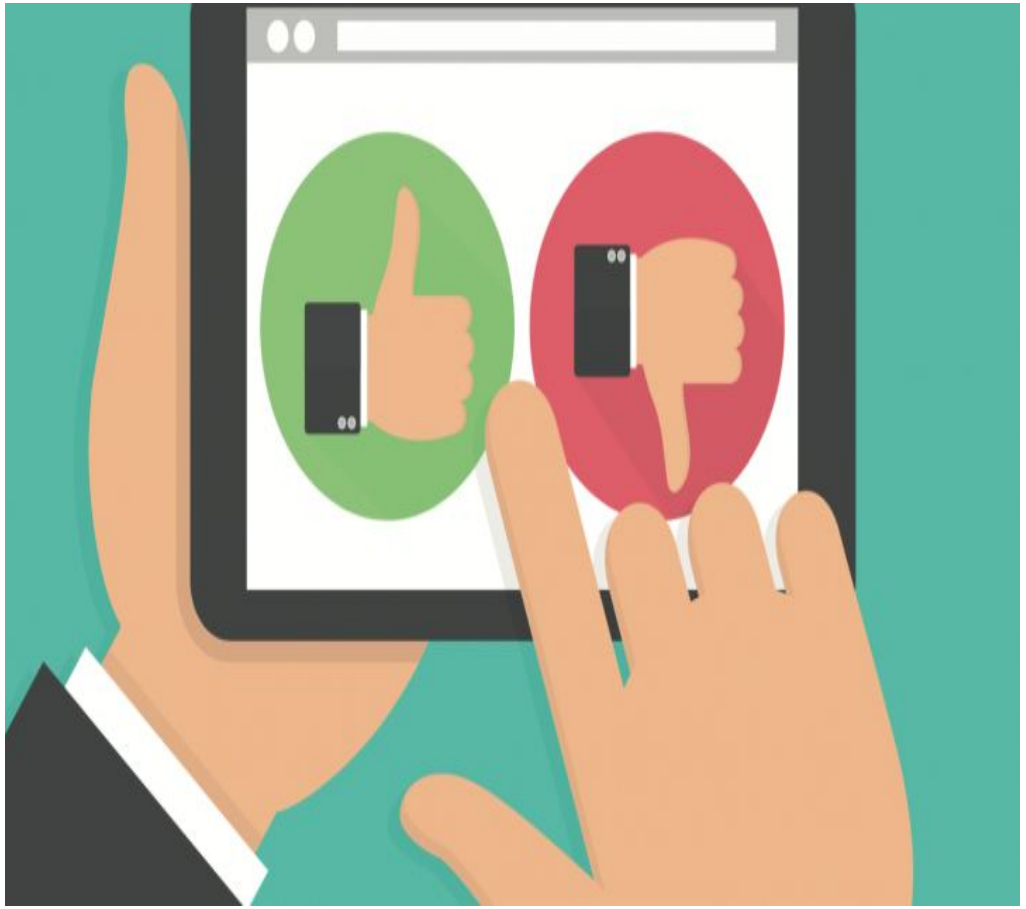
Everyone wants to lower their energy bills

The Millennials have gone organic

Some are looking into self-generation and microgrids

Builders are offering zero energy homes

Utilities need to modernize their tariffs or risk losing customers



Tech has entered the room

Appliances, light bulbs, and water heaters are much more energy efficient than they were just a decade ago

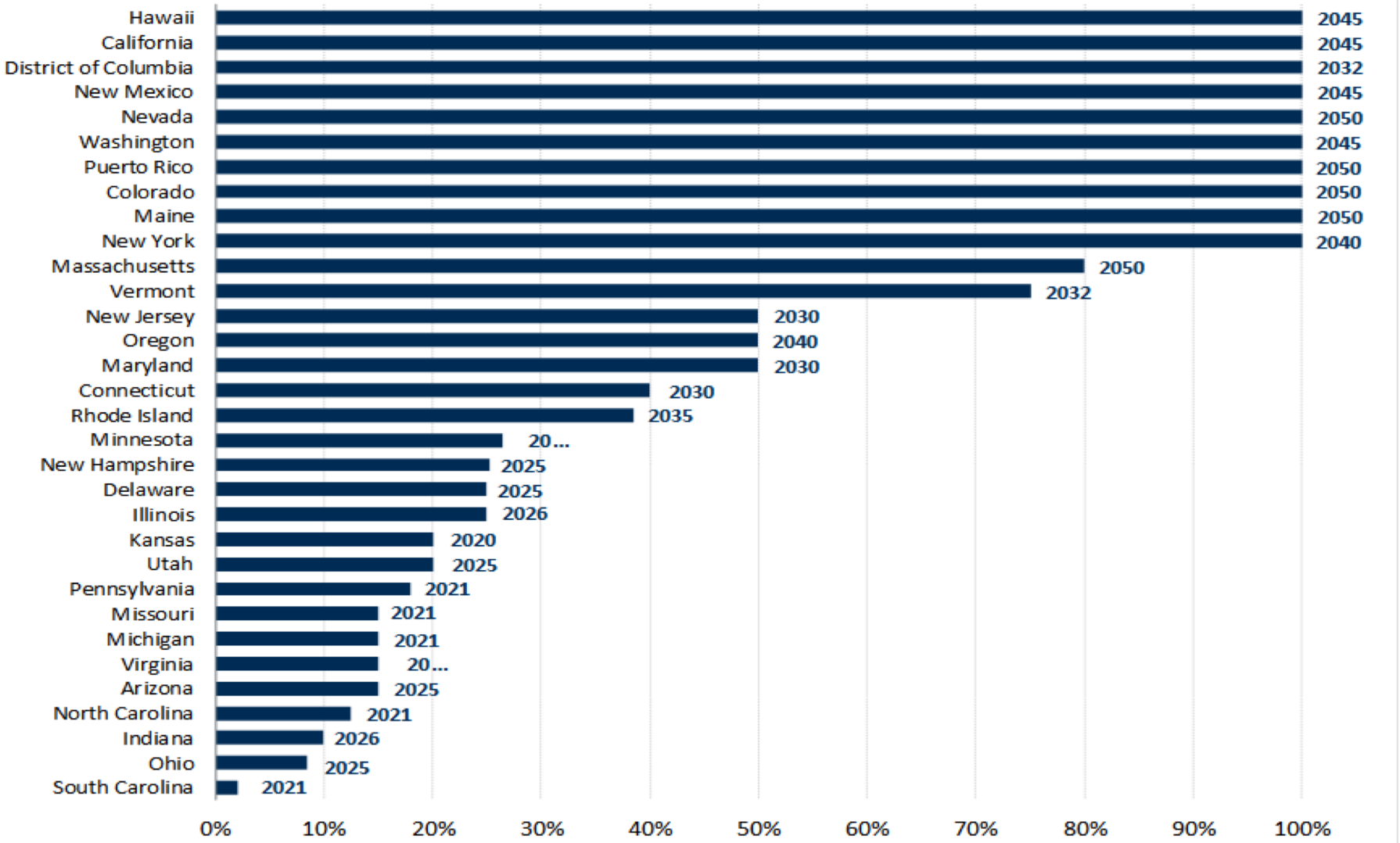
They often come with timers and are addressable via WiFi

Central air conditioners, heat pumps, and gas furnaces are also becoming more energy efficient

They are often paired with smart thermostats

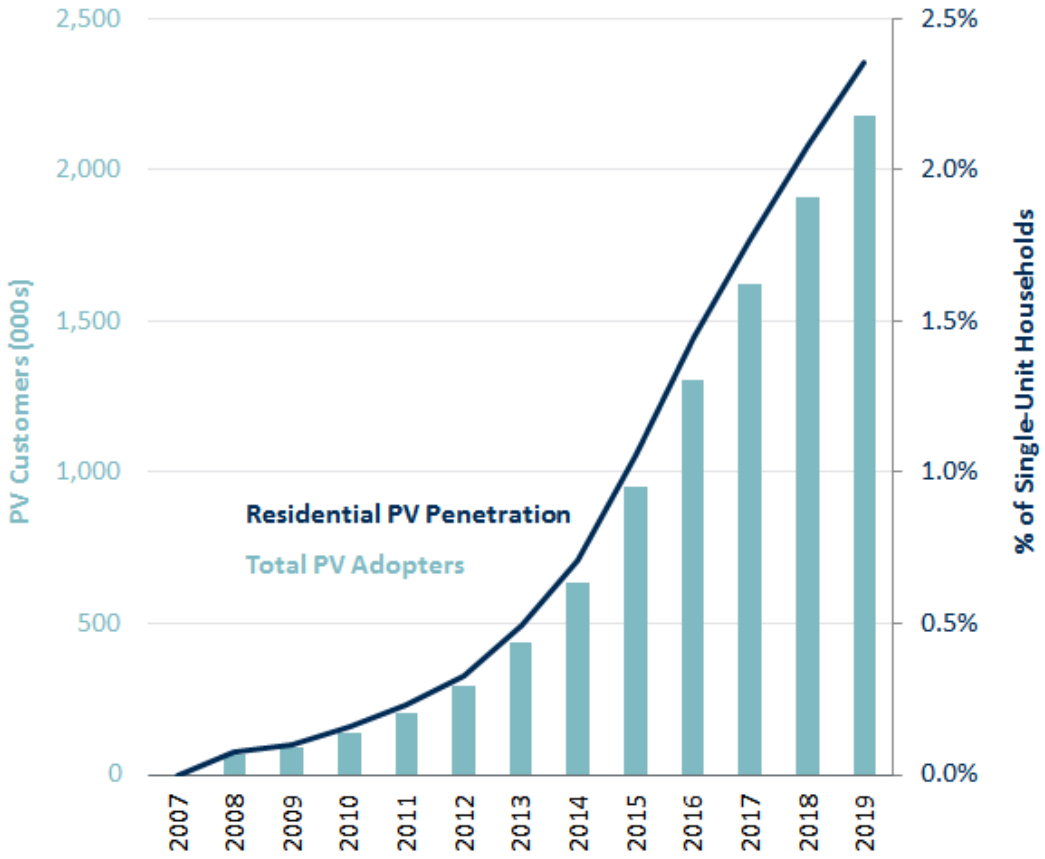
WiFi is nearly ubiquitous as are smart phones and apps, allowing remote control of equipment

States are going green with envy



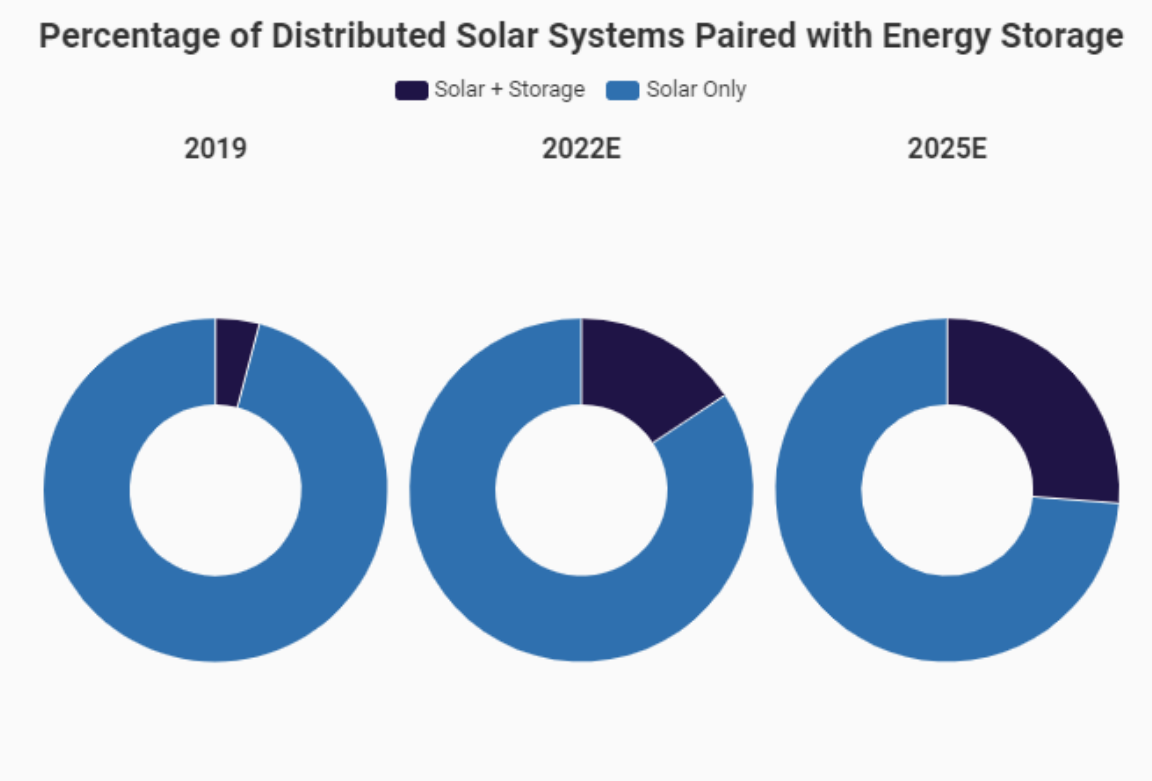
Notes: Targets for Hawaii, DC, and Maine specify 100% renewables, while other 100% targets allow for different forms of clean energy. New Jersey has also issued an Energy Master Plan targeting 100% clean energy by 2050. Targets for Colorado, Minnesota, Missouri, New Mexico, and North Carolina are specific to IOUs. Massachusetts' goal of 80% by 2050 is based on its Clean Energy Standard, while a separate Renewable Portfolio Standard has an implied target of 35% by 2030 (with Class I requirement growing by 1% per year thereafter).

Tired of paying high electric bills, residential customers are turning into prosumers



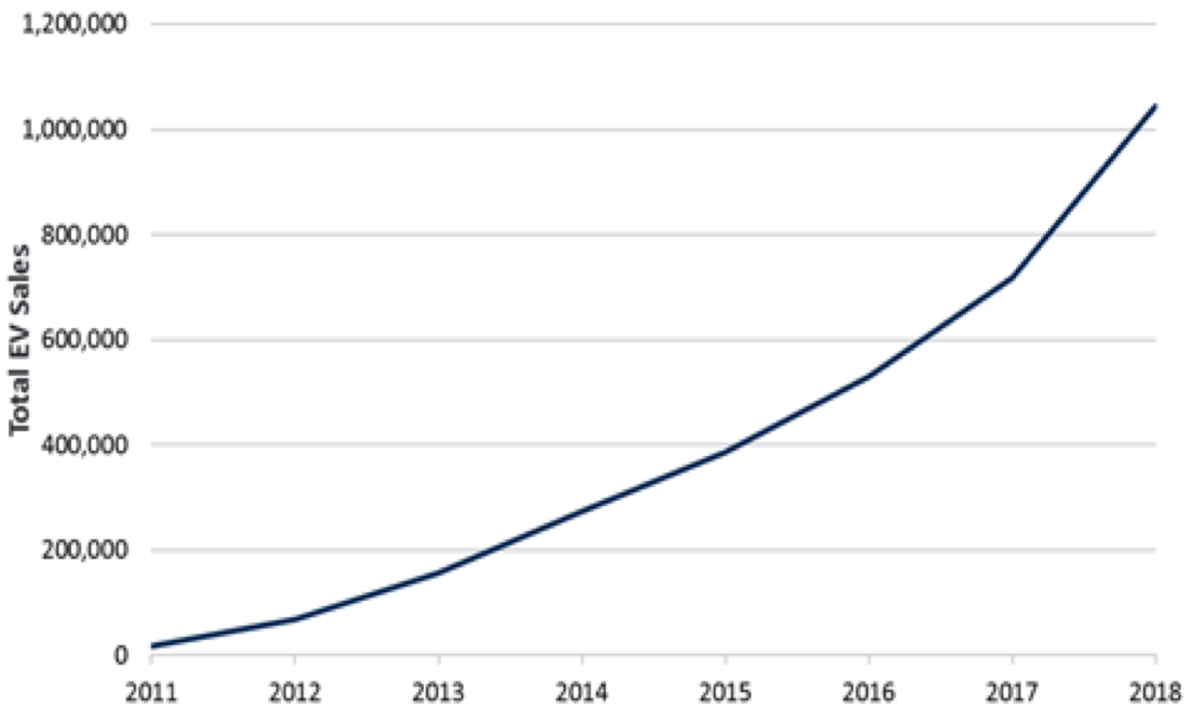
Source: Residential PV adopter counts from Form EIA-861, "Net Metering" data. Residential PV penetration calculated as Residential PV Adopters over total number of single-unit households, using U.S. Census data.

Prosumers are turning into prosumagers. By 2025, more than 25% of all behind-the-meter solar systems will be paired with storage, compared to under 5% in 2019



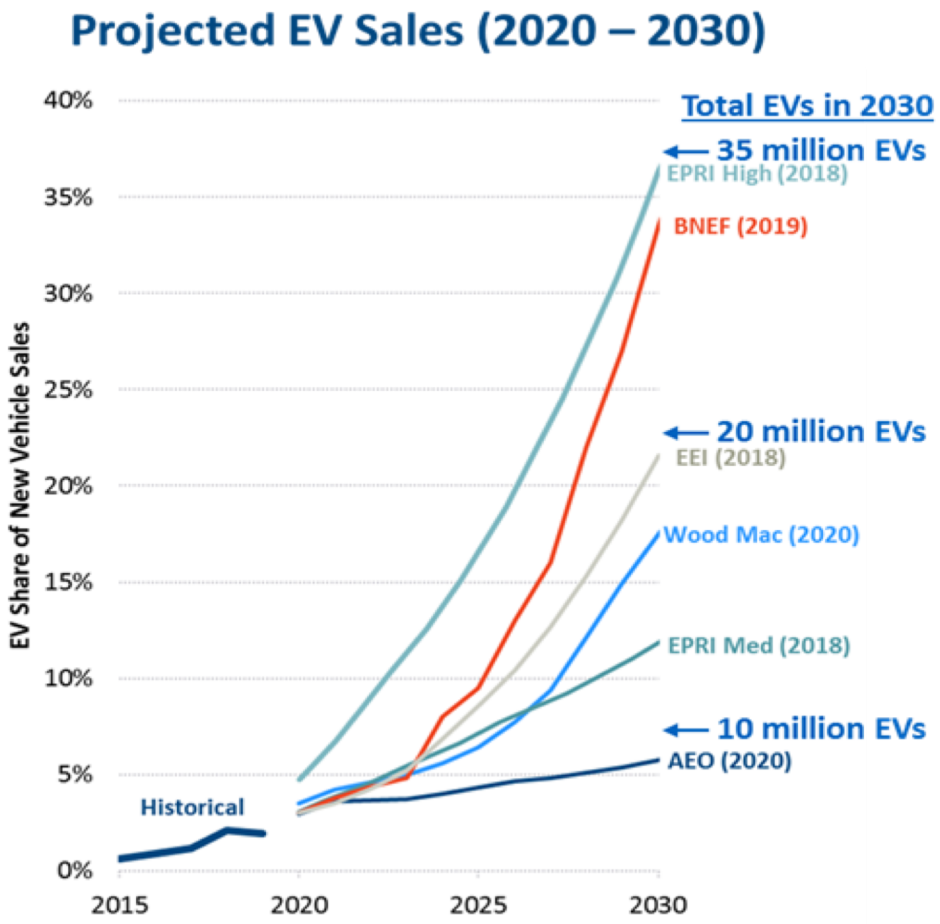
Source: SEIA/Wood Mackenzie, "U.S. Solar Market Insight 2019 Year-in-Review," https://www.seia.org/us-solar-market-insight

Consumers are also buying electric vehicles (EVs) in increasing numbers



Source: EV sales from Atlas EV Hub

Most forecasts show exponential EV growth over the next decade



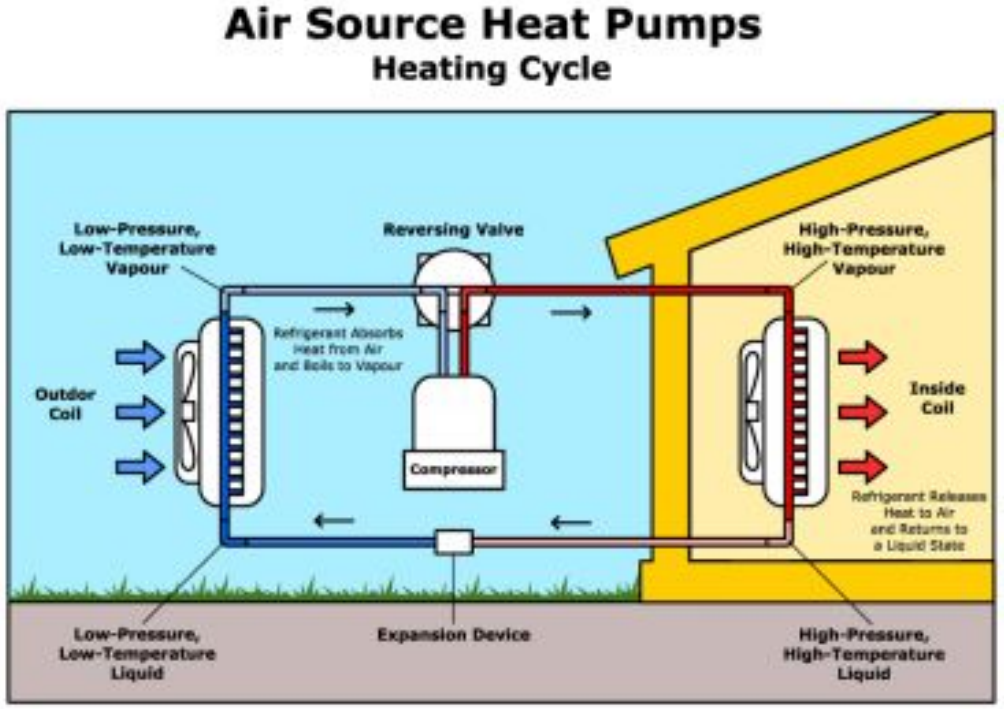
Source: The Brattle Group review of various reports and forecasts

Building decarbonization is being encouraged through incentives and/or mandated in new construction

Utilities are encouraging the adoption of heat pumps for space heating and water heating

In a few cases, utilities are ensuring that new homes are built as all-electric homes

A few cities have banned the use of gas for cooking in restaurants



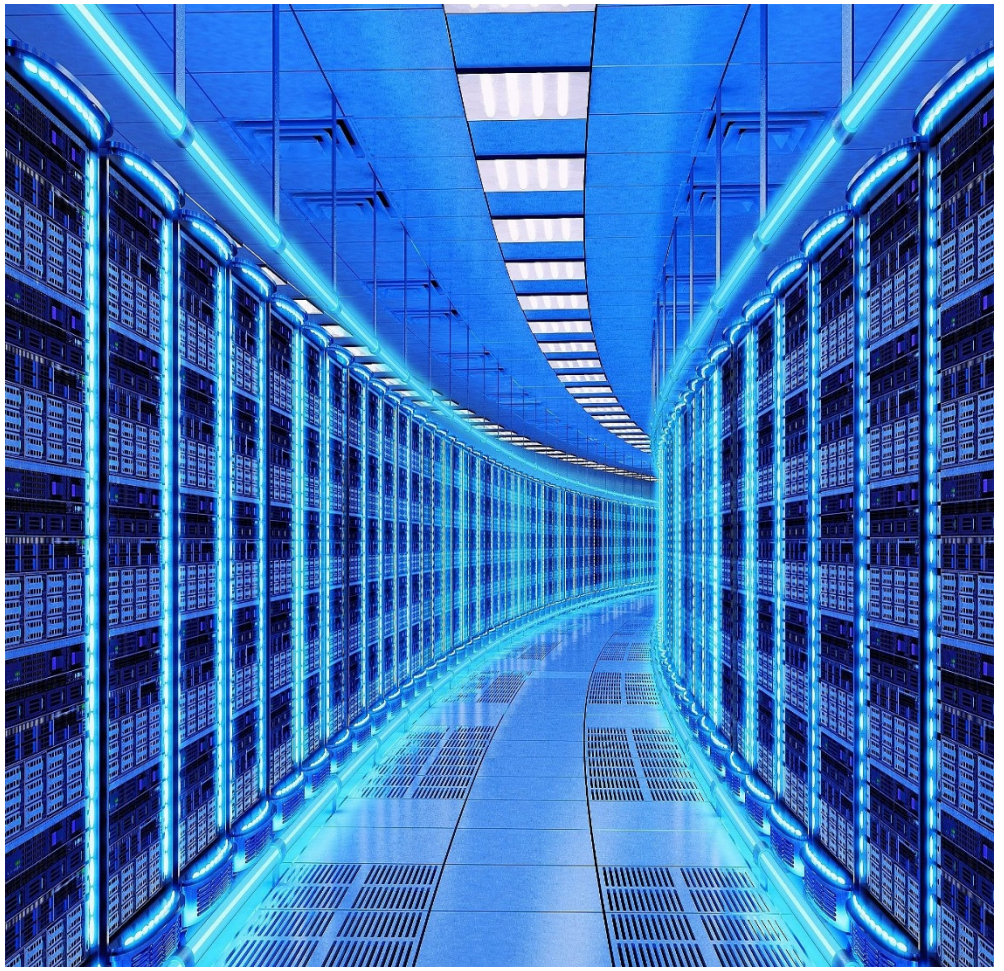
Among commercial customers, data centers are emerging as giant consumers of energy

Tech giants want to get all their power from renewable resources

They are setting the pace for all commercial customers

Big Box stores such as Best Buy, Kroger, and Walmart are going green

Cities, colleges, state governments, and universities are joining the green parade



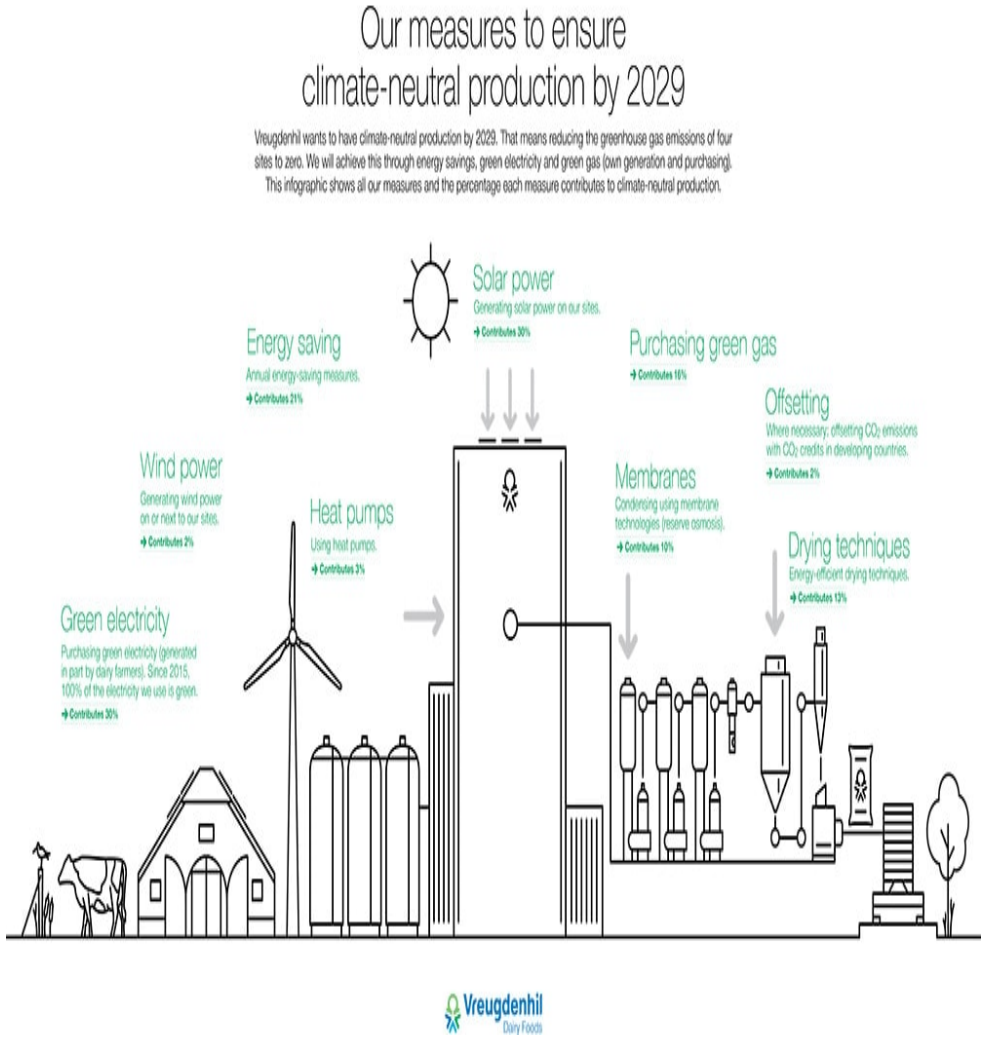
Source: https://www.epa.gov/greenpower/green-power-partnership-national-top-100

Industrial customers are shopping for the best deals

Manufacturing plants are installing flexible manufacturing systems and investing heavily in process modernization

Many are installing co-generation systems, some are installing microgrids, and still others are installing on-site solar generation

Customers are negotiating aggressively for the best prices, often threatening to move elsewhere



APPENDIX D

A POCKET HISTORY OF RATE DESIGN

A Pocket History of Rate Design

Year	Author	Contribution
1882	Thomas Edison	• Electric light was priced to match the competitive price from gas light and not based on the cost of generating electricity
1892	John Hopkinson	• Suggested a two-part tariff with the first part based on usage and the second part based on connected kW demand
1894	Arthur Wright	• Modified Hopkinson's proposal so that the second part would be based on actual maximum demand
1897	Williams S. Barstow	• Proposed time-of-day pricing at the 1898 meeting of the AEIC, where his ideas were rejected in favor of the Wright system
1946	Ronald Coase	• Proposed a two-part tariff, where the first part was designed to recover fixed costs and the second part was designed to recover fuel and other costs that vary with the amount of kWh sold
1951	Hendrik S. Houthakker	• Argued that implementing a two-period TOU rate is better than a maximum demand tariff because the latter ignores the demand that is coincident with system peak
1961	James C. Bonbright	• Published "Principles of Public Utility Rates" which would become a canon in the decades to come

A Pocket History of Rate Design (Concluded)

Year	Author	Contribution
1971	William Vickrey	• Proffered the concept of real-time-pricing (RTP) in *Responsive Pricing of Public Utility Services*
1976	California Legislature	• Added a baseline law to the Public Utilities Code in the *Warren-Miller Energy Lifeline Act*, creating a two-tiered inclining rate
1978	U.S. Congress	• Passed the *Public Utility Regulatory Act (PURPA)*, which called on all states to assess the cost-effectiveness of TOU rates
1981	Fred Schweppe	• Described a technology-enabled RTP future in *Homeostatic Control*
2001	California Legislature	• Introduced *AB 1X*, which created the five-tier inclining block rate where the heights of the tiers bore no relationship to costs. By freezing the first two tiers, it ensured that the upper tiers would spiral out of control
2001	California PUC	• Began rapid deployment of California Alternative Rates for Energy (CARE) to assist low-income customers during the energy crisis
2005	U.S. Congress	• Passed the *Energy Policy Act of 2005*, which requires all electric utilities to offer net metering upon request

Presenter Information

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Dr. Faruqui provides expert advice and testimony on rate design, load flexibility, energy efficiency, demand response, distributed energy resources, demand forecasting, decarbonization, and electrification. He has worked for over 150 clients on five continents and appeared before regulatory bodies, governments, and legislative councils.

He has authored or coauthored more than 150 papers in peer-reviewed and trade journals and co-edited four books on industrial structural change, customer choice, and electricity pricing. His work has been cited in *Bloomberg, Business Week, The Economist*, and *Forbes*, in addition to *The New York Times* and the *Washington Post*, and he has appeared on NPR and Fox Business News.

Dr. Faruqui has taught economics at San Jose State, UC Davis and the University of Karachi and delivered guest lectures at Carnegie Mellon, Harvard, Idaho, MIT, New York, Northwestern, Rutgers, Stanford, and UC Berkeley. He holds an MA in Agriculture Economics and a PhD in Economics from UC Davis, and a BA and an MA in Economics from the University of Karachi.