The Rate Design Imperative

WHY THE STATUS QUO HAS CEASED TO BE AN OPTION

PRESENTED BY

Ahmad Faruqui, Ph.D.

Principal

PRESENTED TO

21st Century Energy Policy Development Task Force, Indiana

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The tariffs of yesterday will not work tomorrow; they hardly work today

Flat volumetric rates with low fixed charges

Inclining or declining block rates with low fixed charges

Seasonal rates with low fixed charges

The tariffs of tomorrow are beginning to take shape before our eyes

TOU rates with significant price differential and shorter peak periods (SMUD)

Three-part rates with demand charges (Ameren, Arizona Public Service, Georgia Power and Salt River Project)

Dynamic pricing rates with higher fixed charges (OGE)

Real-time pricing (RTP) rates with day-ahead and hour-ahead frequency (Georgia Power)

RTP which flows directly to devices

Best in class tariffs that exist today

OGE’s residential variable-peak pricing rate which is offered on an opt-in basis; it has attracted 20% of residential customers

SMUD’s residential TOU pricing rate, default offering, has more than 90% of customers on the rate

California implemented TOU plus critical-peak pricing rates as the default tariff for commercial and industrial customers

Georgia Power’s has thousands of commercial and industrial customers on RTP

What’s likely to happen in the next few years

Ameren Missouri and Georgia Power will be rolling out several TOU rates and also a three-part rate to residential customers

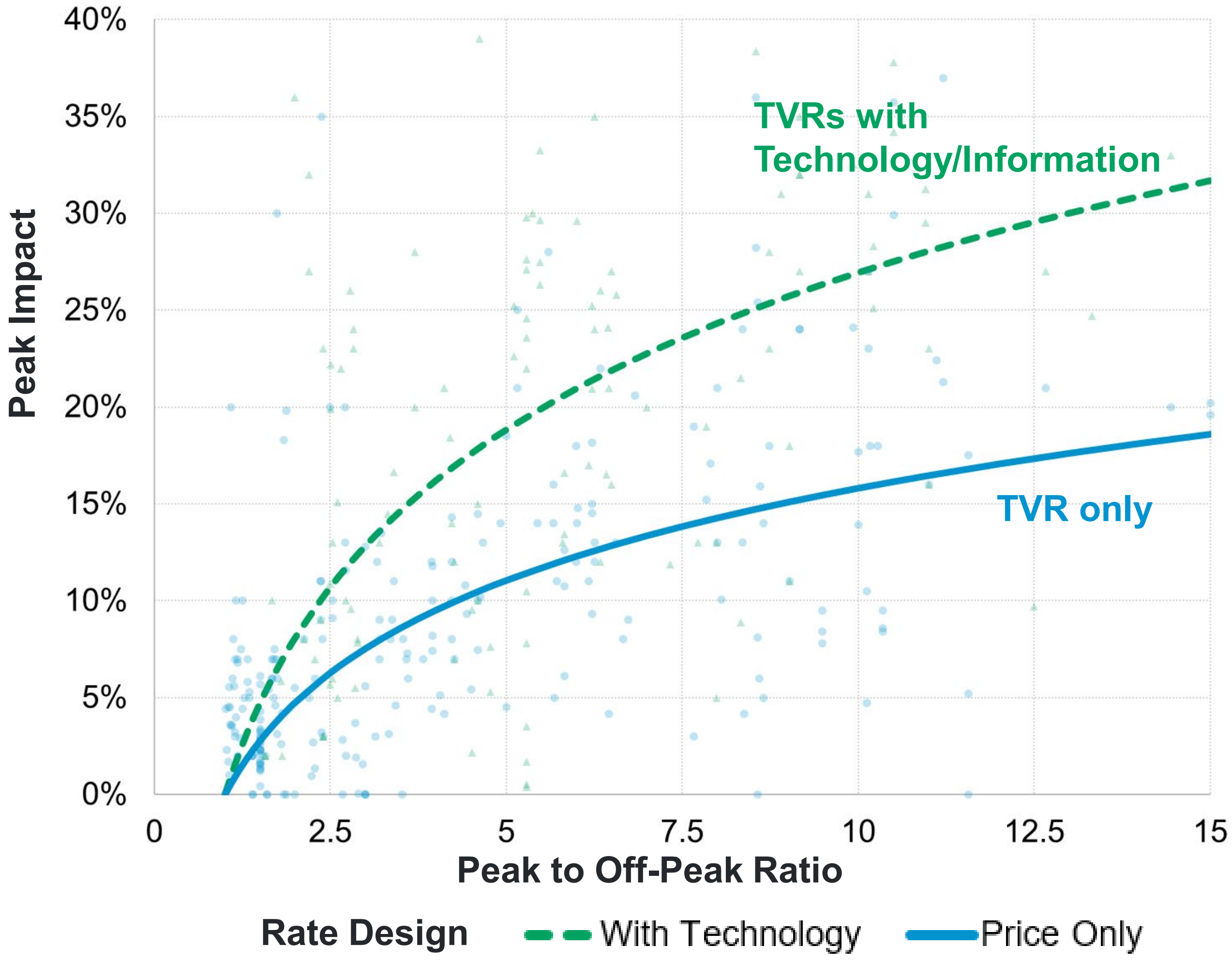
California’s investor-owned utilities have begun rolling out TOU rates to all residential customers on a default basis

Consumers Energy (Michigan) began the process in June 2021

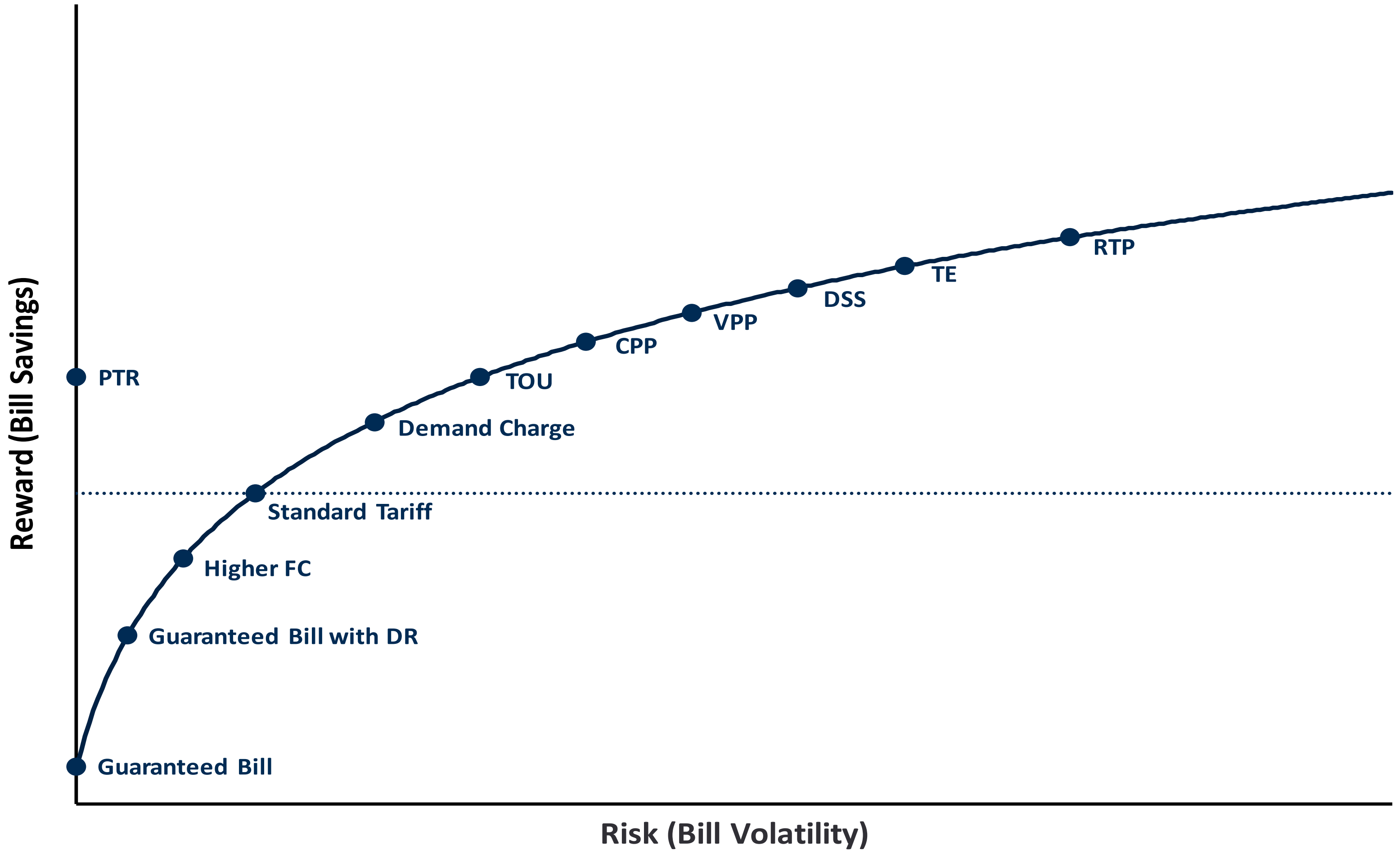
Xcel Energy (Public Service Company) in Colorado will do the same once smart meters are rolled out

As prices-to-devices become feasible, dynamic pricing rates will begin to be offered to residential customers

Results from nearly 400 pilots show that customers respond to time-varying rates (TVR)



Utilities can enhance customer satisfaction by providing choice of tariffs to customers



Time-varying prices (TVPs) come in many shapes and forms

Rate	Definition
1- Time-of-Use *(TOU)*	The day is divided into peak and off-peak time periods. Prices are higher during the peak period hours to reflect the higher cost of supplying energy during that period
2- Critical Peak Pricing *(CPP)*	Customers pay higher prices during critical events when system costs are highest or when the power grid is severely stressed
3- Peak Time Rebates *(PTR)*	Customers are paid for load reductions on critical days, estimated relative to a forecast of what the customer would have otherwise consumed (their "baseline")
4- Variable Peak Pricing *(VPP)*	During alternative peak days, customers pay a rate that varies by day to reflect dynamic variations in the cost of electricity
5- Real-Time Pricing *(RTP)*	Customers pay prices that vary by the hour to reflect the actual cost of electricity
6- Two-part Real-Time Pricing *(2-part RTP)*	Customer's current rate applies to a baseline level of consumption. A second, marginal cost based, price applies to deviations from the baseline consumption
7- Three-part Rates *(3-part Rates)*	In addition to volumetric energy charge and fixed charge, customers are also charged based on peak demand, typically measured over a span of 15, 30, or 60 minutes
8- Fixed Bill with Incentives	Customers pay a fixed monthly bill accompanied with tools for lowering the bill (such as incentives for lowering peak usage)

Residential TVPs have been deployed around the world

	Type of Rate	Applicability	Participating Customers
Oklahoma *(OGE)*	Variable Peak Pricing (VPP)	Opt-in	20% (130,000)
Maryland *(BGE, Pepco, Delmarva)*	Peak Time Rebate (PTR)	Default	80%
Ontario, Canada	Time-of-Use (TOU)	Default	90% (3.6 million)
Great Britain	Time-of-Use (TOU)	Opt-in	13% (3.5 million)
Hong Kong *(CLP Power Limited)*	Peak Time Rebate (PTR)	Opt-in	27,000
Arizona *(APS, SRP)*	Time-of-Use (TOU)	Opt-in	APS: 57%, SRP: 36%
California *(PG&E, SCE, SDG&E)*	Time-of-Use (TOU)	Default (2020)	TBD – 75-90%*
California *(SMUD)*	Time-of-Use (TOU)	Default	75-90%*
Colorado *(Fort Collins)*	Time-of-Use (TOU)	Mandatory	100%
Illinois *(ComEd, Ameren IL)*	Real Time Pricing (RTP)	Opt-in	50,000
Michigan *(Consumers Energy)*	Time-of-Use (TOU)	Default (2020)	TBD – 75-90%*
France	Time-of-Use (TOU)	Opt-in	50%
Spain	Real Time Pricing (RTP)	Default	40%
Italy	Time-of-Use (TOU)	Default	75-90%*

*Estimated participation based on historical trends

Winter-peaking utility experience with TVPs

	Study Years	Form(s) of TVP	Peak Price Ratio	Peak Impact	Notes
Puget Sound Energy	2001-2002	TOU	1.4	~5% reduction in peak period usage per month over a 15-month period	Involved four pricing periods. Customer response was encouraging in the first year, but declined in the second after a reduction in the peak price ratio and negative media coverage (in one quarter, customers experienced an average 80 c/month *loss*)
Pacific Power	2004	TOU	1.7-2.1	9% in winter morning, 8% in winter evening	Did not meet cost-effectiveness from a total resource cost perspective, in part due to low participation coupled with a high dropout rate
BC Hydro	2006-2008	TOU, TOU/CPP	*TOU:* 3-6 *CPP:* 7.9	2%-4% reduction in on-peak TOU period, 5% in critical peak period	Analysis of the second winter found that enabling tech (in-home display) doubled estimated TOU and CPP reductions
Hydro-Québec	2008-2010	TOU, TOU/CPP	*TOU:* 1.4-1.7 *CPP:* 3	Only significant in critical peak period under TOU/CPP rate (~6% reduction)	Hydro-Québec is offering opt-in PTR and CPP rates to thousands of customers and observing a 12.5% reduction from CPP rates and 10% reduction from PTR
Portland General Electric	2016-2018	TOU, PTR, TOU/PTR	*TOU:* 1.8-2.6	*TOU:* Only statistically significant in summer *PTR:* 7%-12% winter demand savings for opt-in, 5% for opt-out PTR *TOU/PTR:* 1%-5%	Usage reductions were less significant in winter than summer, in part because approximately 60% of TOU participants have gas heating

TVP offerings in the United States

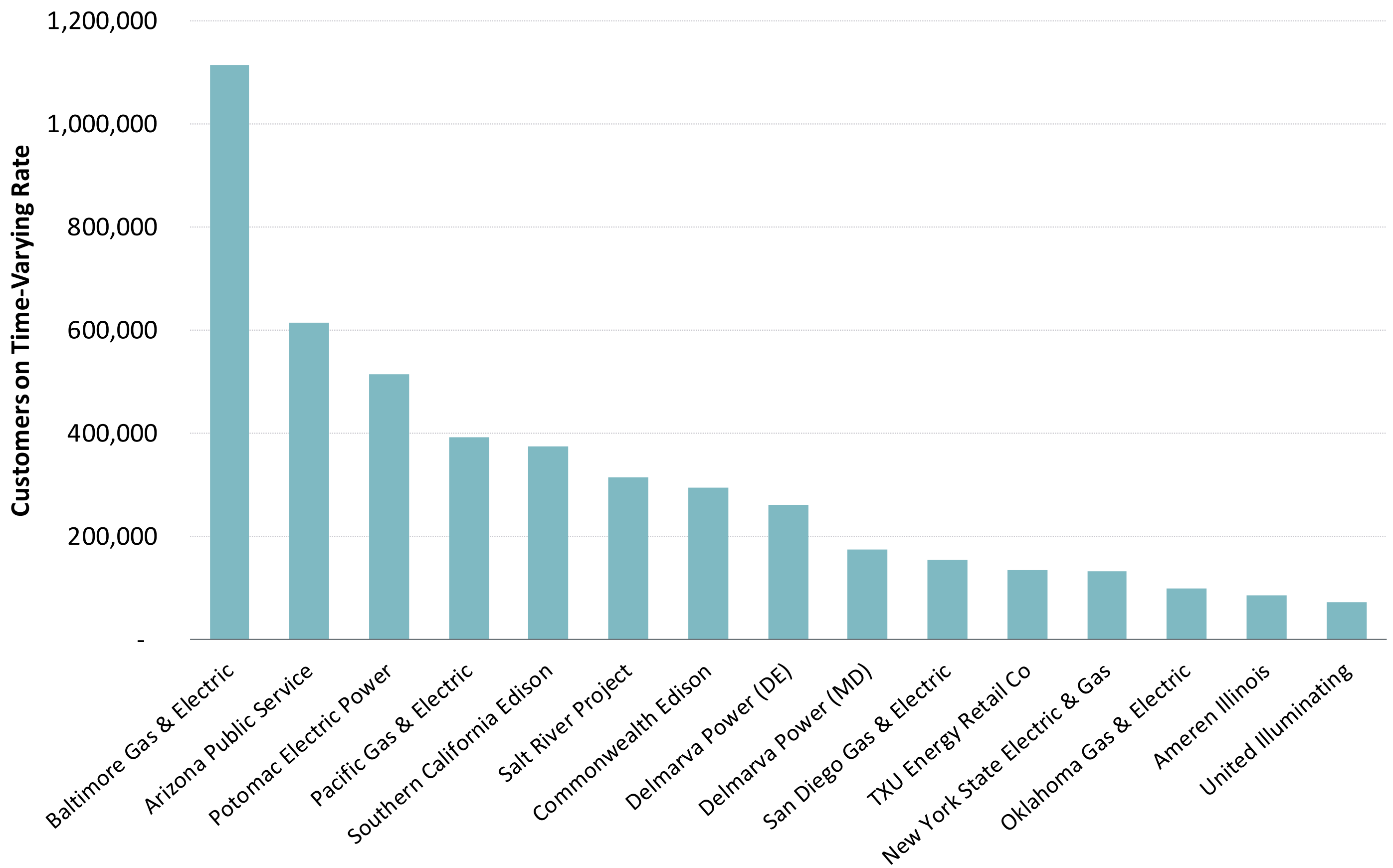
According to 2018 EIA Form-861, **322 U.S. utilities offer at least one form of time-varying rate** to residential customers

- 303 offer Time-of-Use (TOU)
- 29 offer Critical Peak Pricing (CPP)
- 14 offer Peak Time Rebate (PTR)
- 9 offer Variable Peak Pricing (VPP)
- 6 offer Real-Time Pricing (RTP)

Altogether, **5.5 million customers** (or 4% of all residential customers) are enrolled on one of these time-varying rates

Largest TVP deployments

The following **15 utilities accounted for 86% of all customers** enrolled on a time-varying rate



In the past, five “Immortal” objections have impeded tariff modernization

Objection 1: While time-varying rates might reduce peak load, they will not lower customer bills

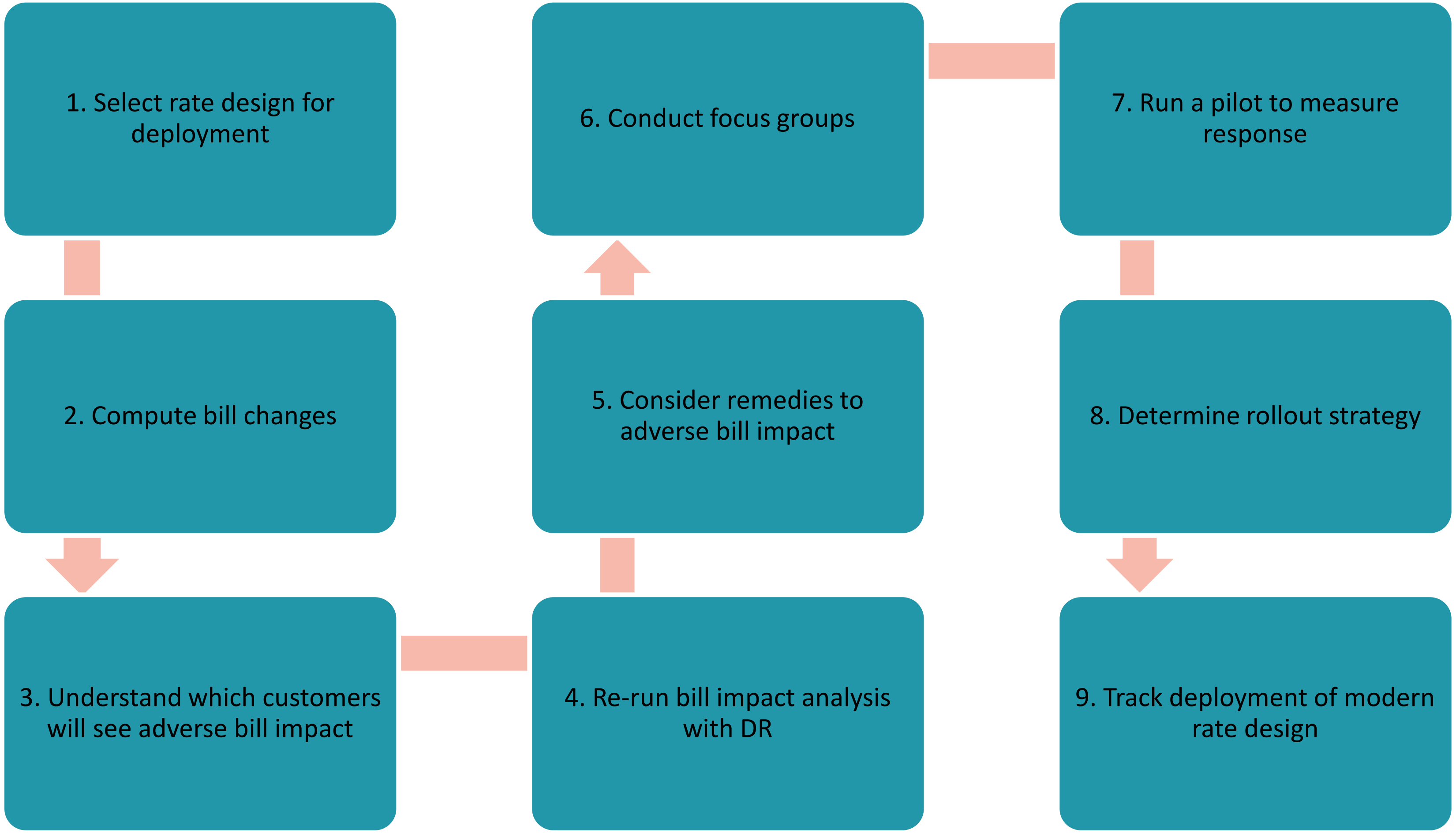
Objection 2: Lower peak demand will not lower transmission and distribution costs since they do not depend on load

Objection 3: On-going pilots with time-varying rates show minimal customer reaction to price signals in changing their load profiles

Objection 4: Customers have little time or interest in becoming a home energy manager. They just want the lights to come on when they flip the switch and get an affordable bill at the end of the month.

Objection 5 : Time-varying tariffs will harm low income customers, senior citizens, and people with medical disabilities

In the future, we can overcome the objections by following this process



Let me close by quoting Arthur C. Clarke

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

WHAT IS THE DRIVING THE NEED FOR CHANGING RATE DESIGNS

Electricity customers have become more demanding throughout the nation

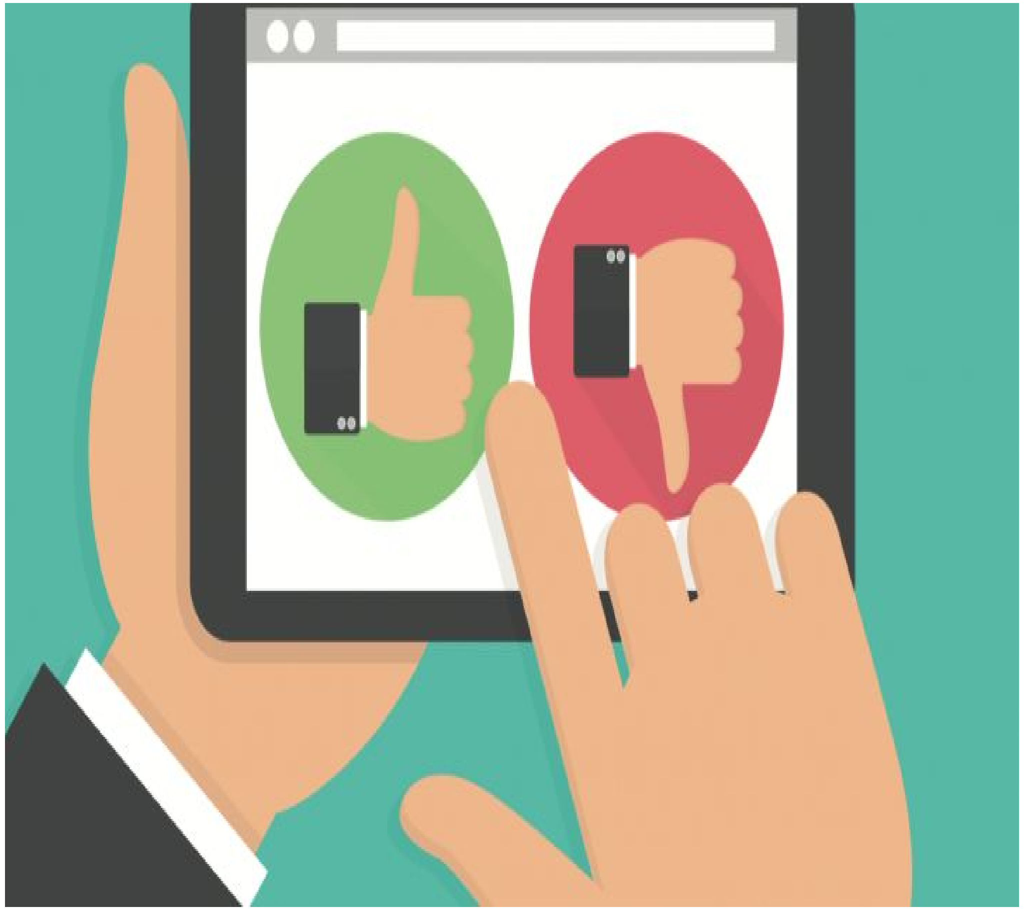
Everyone wants to lower their energy bills

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

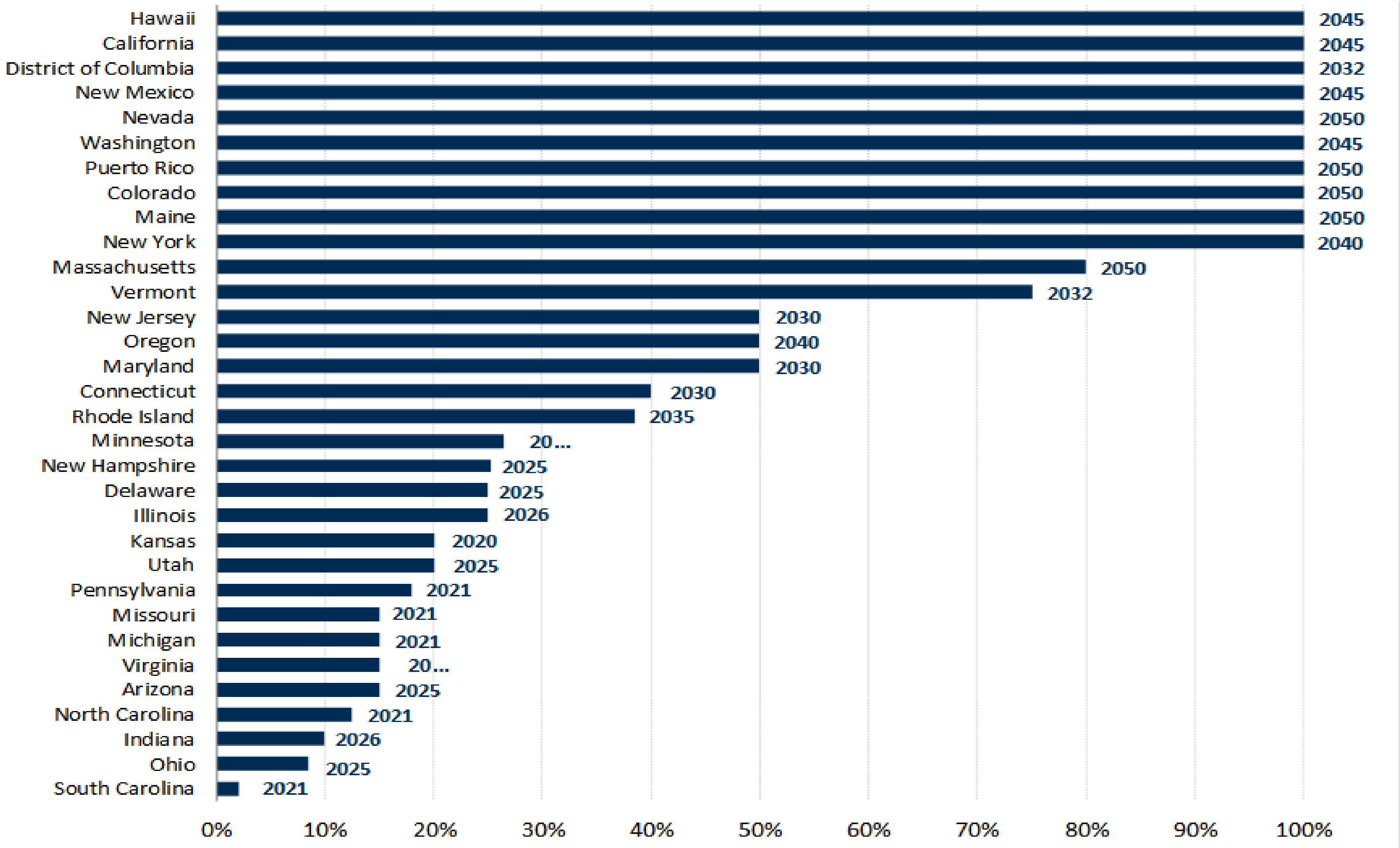
They often come with timers and are addressable via WiFi

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

They are often paired with smart thermostats

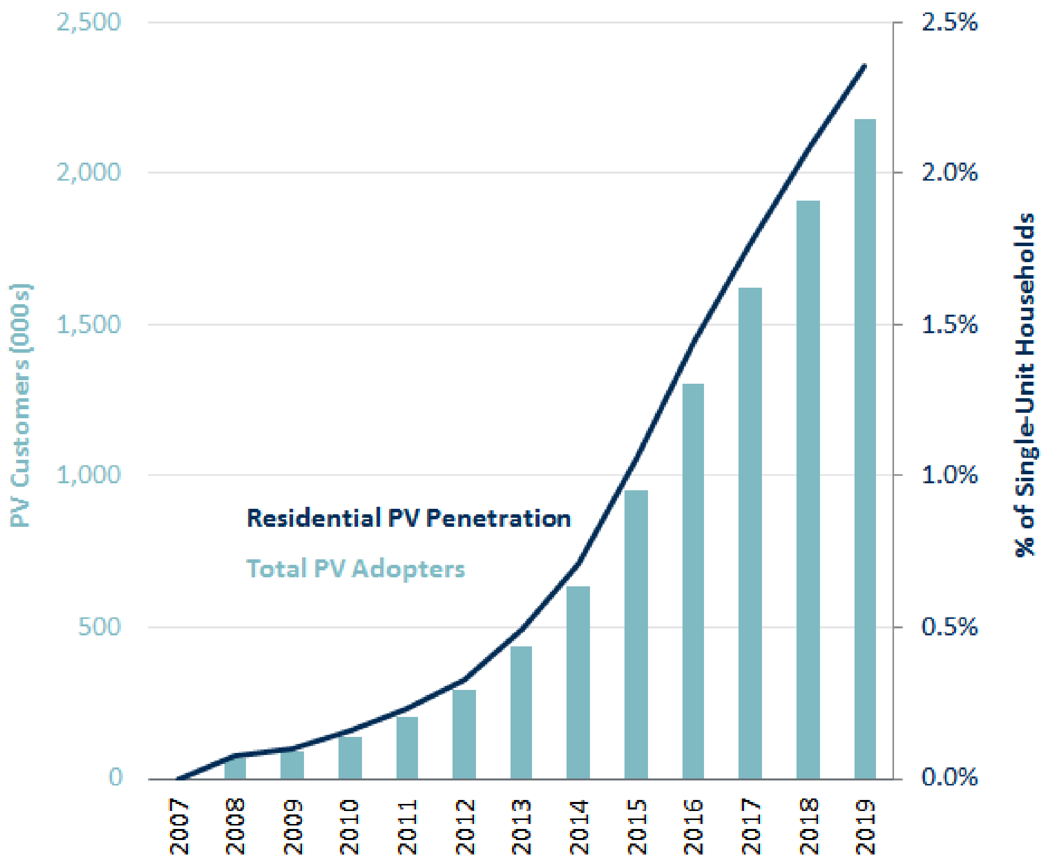
WiFi is nearly ubiquitous as are smart phones and apps, allowing remote control of equipment

States are going green with envy



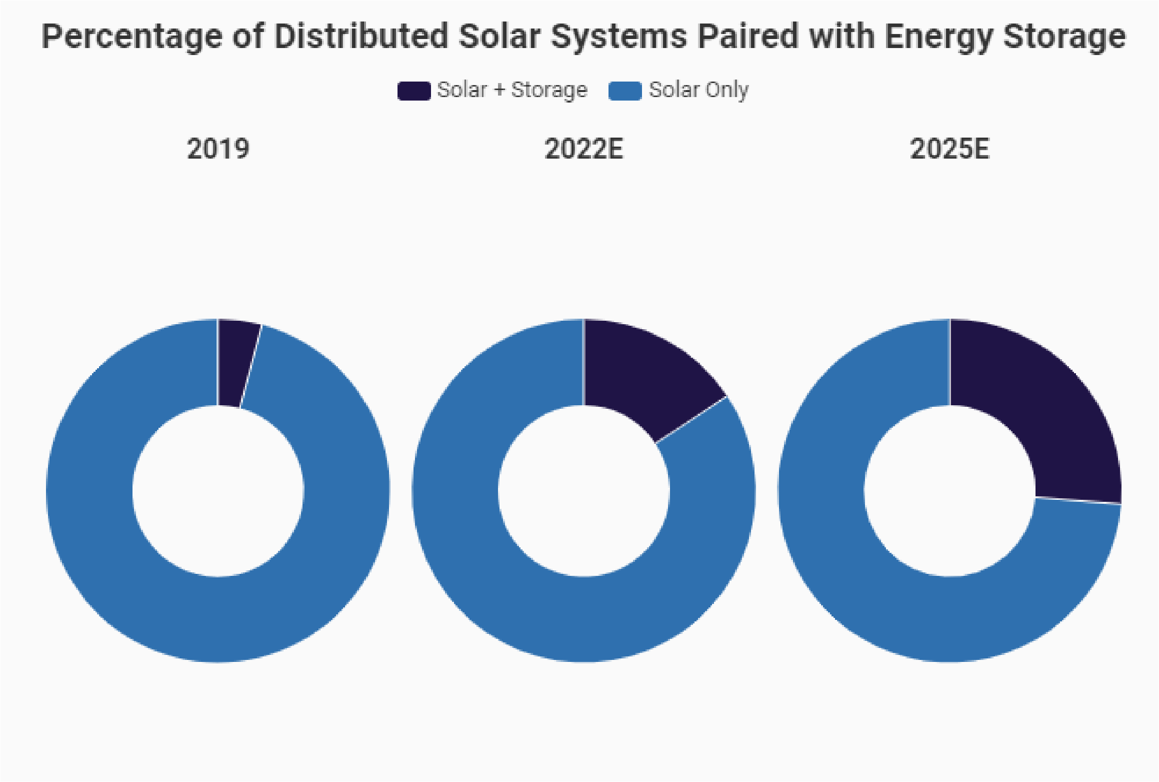
Notes: Targets for Hawaii, DC, and Maine specify 100% renewables, while other 100% targets allow for different forms of clean energy. New Jersey has also issued an Energy Master Plan targeting 100% clean energy by 2050. Targets for Colorado, Minnesota, Missouri, New Mexico, and North Carolina are specific 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



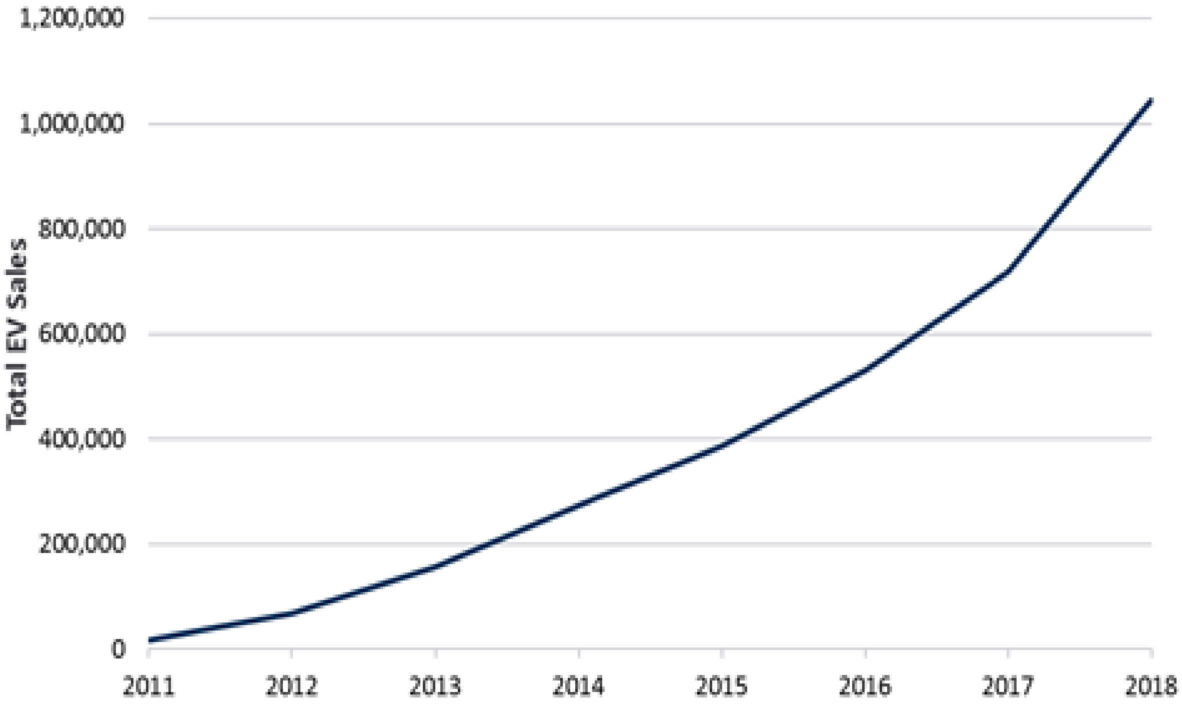
Source: Residential PV adopter counts from Form EIA-861, "Net Metering" data. Residential PV penetration calculated as Residential PV Adopters over total number of single-unit households, using U.S. Census data.

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



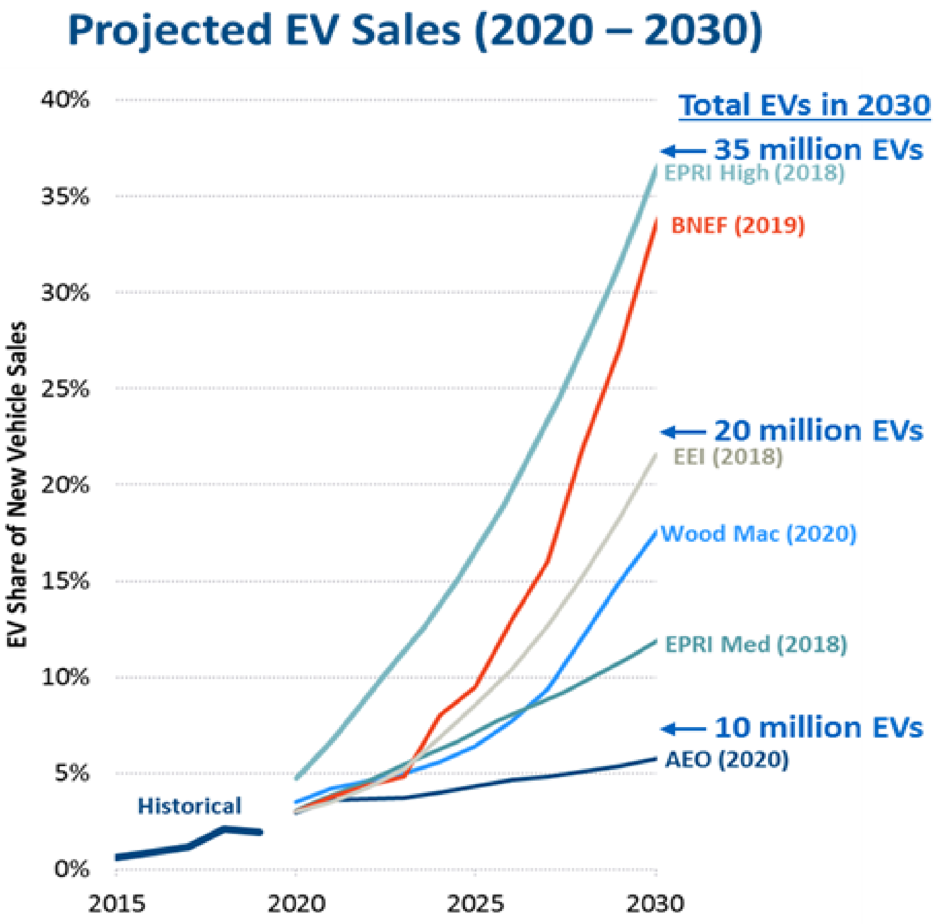
Source: SEIA/Wood Mackenzie, "U.S. Solar Market Insight 2019 Year-in-Review," https://www.seia.org/us-solar-market-insight

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



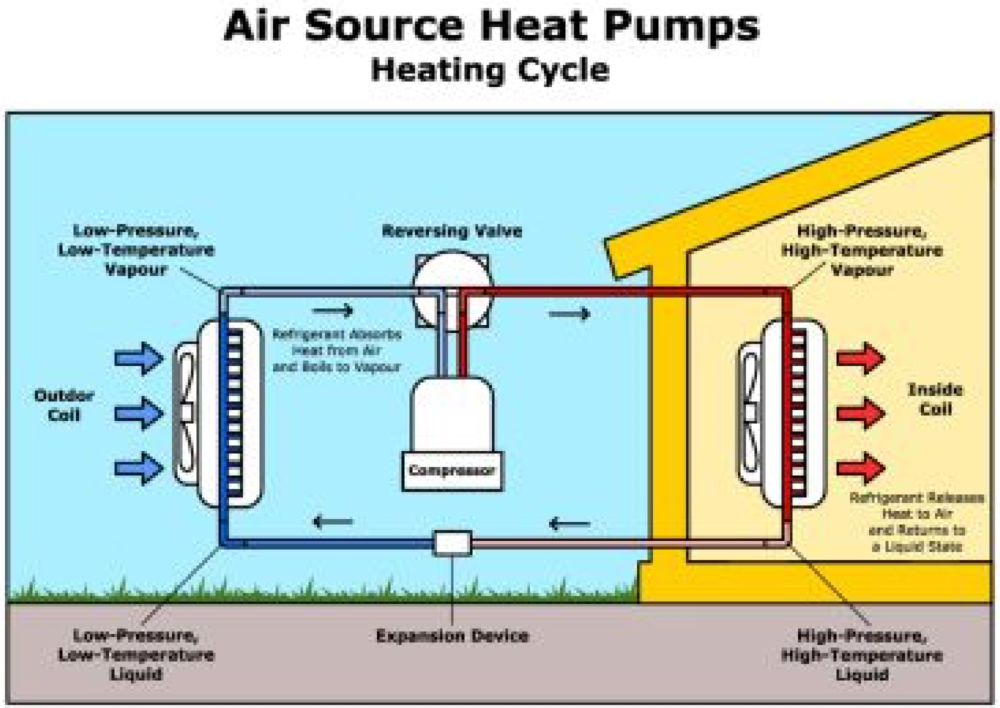
Source: The Brattle Group review of various reports and forecasts

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

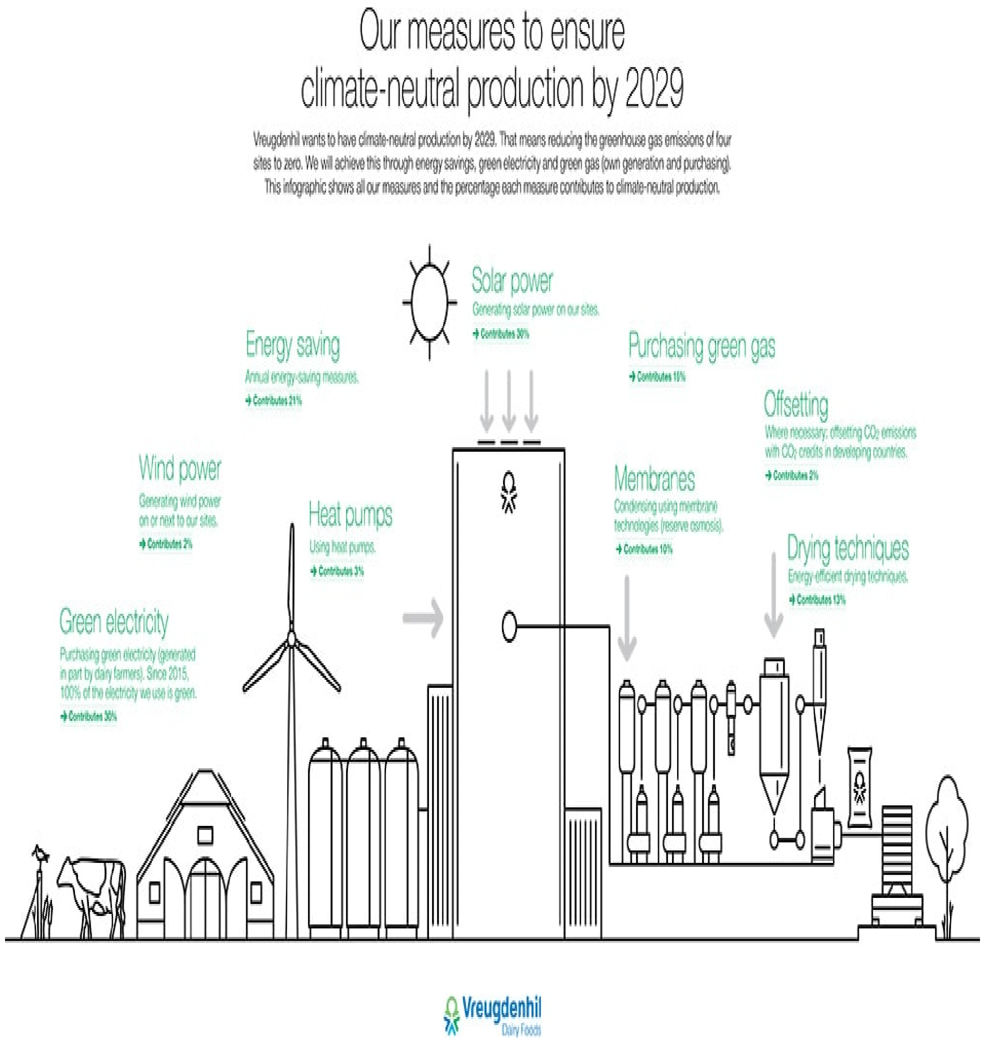
Source: https://www.epa.gov/greenpower/green-power-partnership-national-top-100

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 B

ADDITIONAL READINGS

Selected papers on pricing and customer-centricity

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

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

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

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

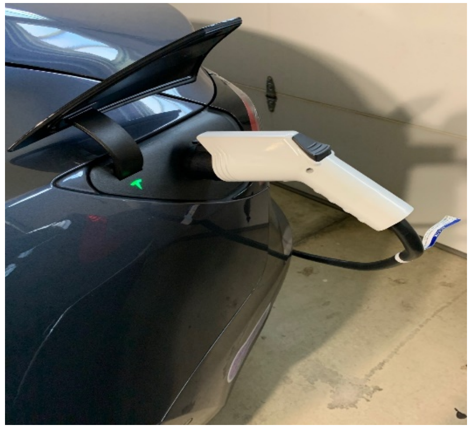
"Rate Design 3.0 – Future of Rate Design," *Public Utilities Fortnightly*, May 2018.

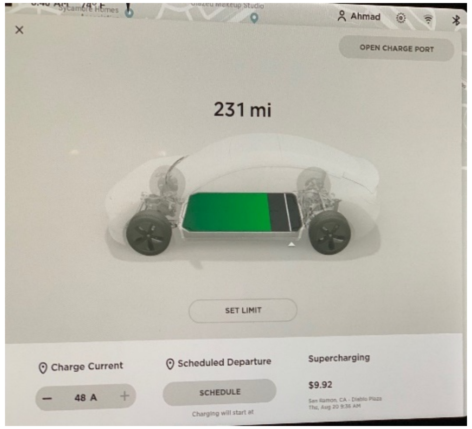
"Innovations in Pricing: Giving Customers What They Want," *Electric Perspectives*, September/October 2017.

APPENDIX C

THE CONSUMER OF THE FUTURE

Yesterday's customer is today's prosumer and tomorrow's prosumager





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

AHMAD FARUQUI, PH.D.
Principal | San Francisco, CA
Ahmad.Faruqui@brattle.com
+1.925.408.0149

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 100 papers in peer-reviewed and trade journals and co-edited 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 obtained 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.