

The State of Electric Vehicle Home Charging Rates

A SUMMARY

PRESENTED TO
Colorado PUC

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THE **Brattle** GROUP

Introduction and Methodology

Introduction

- The purpose of this presentation is to summarize residential EV-specific rate offerings in the United States
- The presentation includes the following sections:
 - Drivers and goals of EV-specific rates
 - A survey of current EV-specific rate offerings
 - Review of two pilot studies of EV-TOU effectiveness

Methodology

- The survey draws upon the following sources:
 - OpenEI Utility Rates Database
 - Utility tariff sheets

Drivers and Goals of EV-Specific Rates

Background

EV rate offerings are an opportunity improve the economic efficiency of EV charging behavior

- Consumer electric vehicles use approximately 225-275 kWh per month
- Level 1 charging consumes 1.4 kW of power
- Level 2 charging uses 6.2-7.6 kW of power
- A majority of EV charging occurs at home

Possible Utility Goals

1. Encourage EV adoption by reducing charging costs
2. Provide price signals that encourage optimal EV charging patterns while accurately collecting costs

The impact of rate design on EV attractiveness depends on (desired/actual) charging patterns

Annual EV Charging Cost per Traveler

Rate Designs		Flat rate	TOU (3:1 ratio)	TOU (10:1 ratio)	Inclining block rate	Unconstrained demand charge	Peak period demand charge
Charging Profiles	Off Peak L1	\$744	\$510	\$289	\$971	\$562	\$550
	On Peak L1	\$744	\$1,059	\$1,356	\$971	\$639	\$676
	Post-Commute L2	\$744	\$886	\$1,021	\$971	\$976	\$1,155
	Off Peak L2	\$744	\$510	\$289	\$971	\$882	\$550
	On Peak L3	\$744	\$1,290	\$1,807	\$971	\$1,335	\$1,656
	Autonomous Fleet	\$744	\$824	\$899	\$971	\$808	\$904

Comparable annual fuel cost of an ICE vehicle at \$3/gal, 30 mpg is **\$1,460**

Notes:

Rates and charging profiles are purely illustrative

Typical annual residential electricity bill is \$1,140

Assumes constant vehicle miles traveled across all charging profiles

Each rate is applicable to whole home load, but figures shown are only incremental EV charging costs

Rates are revenue neutral for a class average residential customer

—TOU and demand charges incentivize off-peak charging but also introduce an element of financial risk for the EV owner

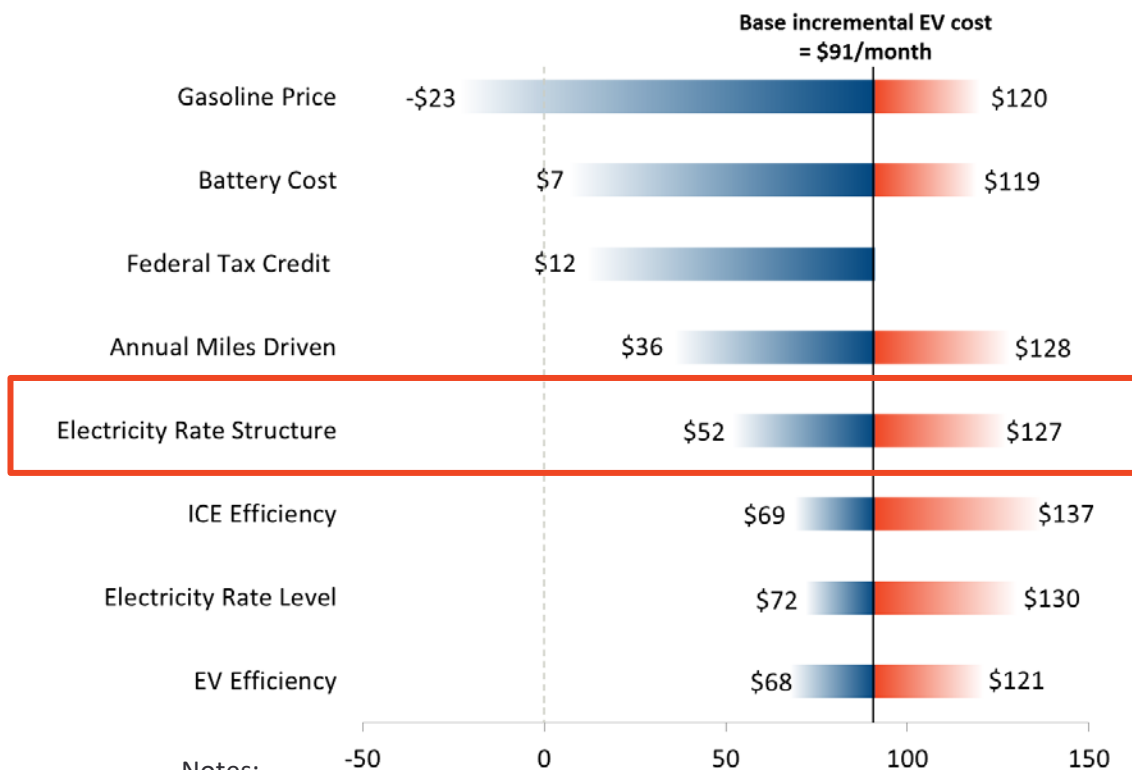
—It will be important to understand the extent to which customers are able and willing to respond to these price signals

—Technology that automates charging control will likely play a key role

—Fleets with higher utilization likely favor frequent, fast charging and potentially have less flexibility to respond to price signals

Rate design appears more likely to influence charging patterns than to impact EV adoption

Incremental Monthly Cost of EV Ownership Relative to ICE Vehicle (Illustrative)



Comments

- Rate design appears to impact total EV ownership costs modestly relative to other cost drivers, though this is heavily dependent on charging patterns
- Additionally, there are significant non-economic drivers of vehicle adoption
- Thus, rate design may be a better tool for influencing the behavior of EV owners rather than being a primary consideration in the vehicle purchase decision

Utilities and Types of Rates

21 US utilities are currently offering EV-specific rates

- 12 Investor Owned Utilities
- 6 Municipal Utilities
- 3 Cooperatives

31 unique EV rate designs

- 27 TOU rates (1 of which has inclining blocks)
- 2 Inclining Block rates
- 1 Flat rate
- 1 Flat rate with flat demand charge

Differences in rate applicability

- 18 rates apply to entire residence
- 8 rates apply strictly to EV charging, metered separately (the costs of separate metering are generally incurred by the customer)
- 5 rates can be applied to entire residence or strictly EV charging

Rates – General Trends

- Diverse array of rate offerings
- Most utilities' EV-specific rates are more advantageous than comparable non-EV offerings. Designed to encourage enrollment and off-peak charging by offering:
 - Cheaper off-peak rates
 - Reduced or eliminated tiers of inclining block rate
- A few rates are less advantageous than comparable non-EV rates (longer or more expensive peak periods). These rates are generally required in order to receive utility-sponsored EV rebates or utility-financed charging infrastructure.
- Several pilot programs are testing ultra-high price ratios (>10)
- Several rates are either identical to other non-EV residential rates or are the only TOU rates offered.

TOU Rates

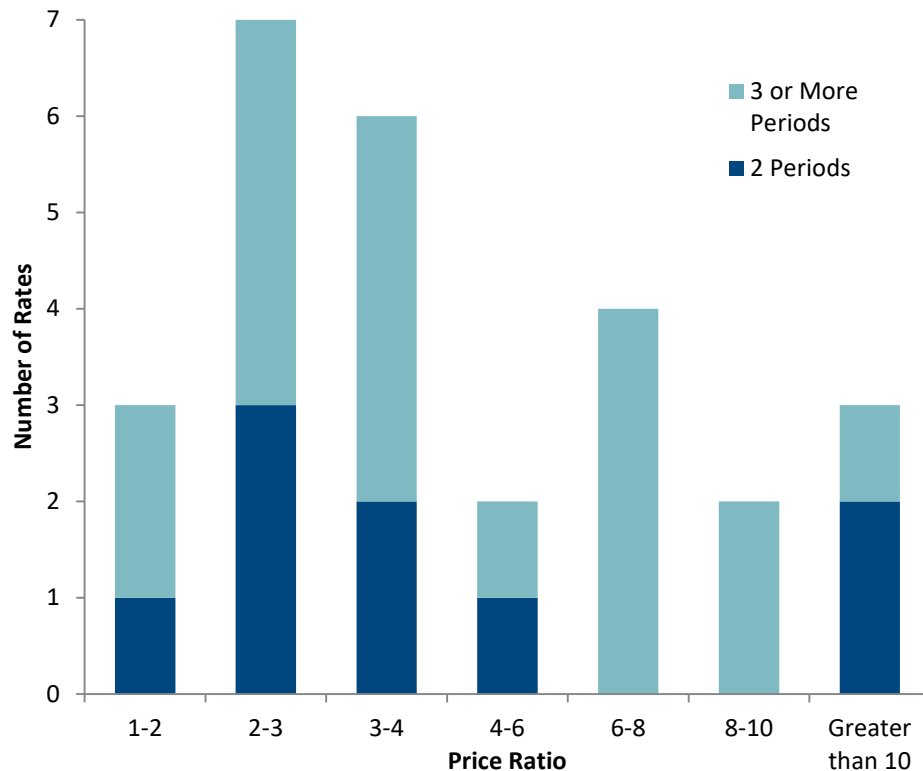
Of the 27 TOU rates:

- 9 have 2 pricing periods in both Summer and Winter
- 11 have 3 pricing periods in both Summer and Winter
- 5 have 3 pricing periods in Summer but 2 in Winter
- 2 have 4 pricing periods

Many different arrangements of pricing periods, seasons, price ratios, and fixed costs.

TOU Rates – Price Ratios

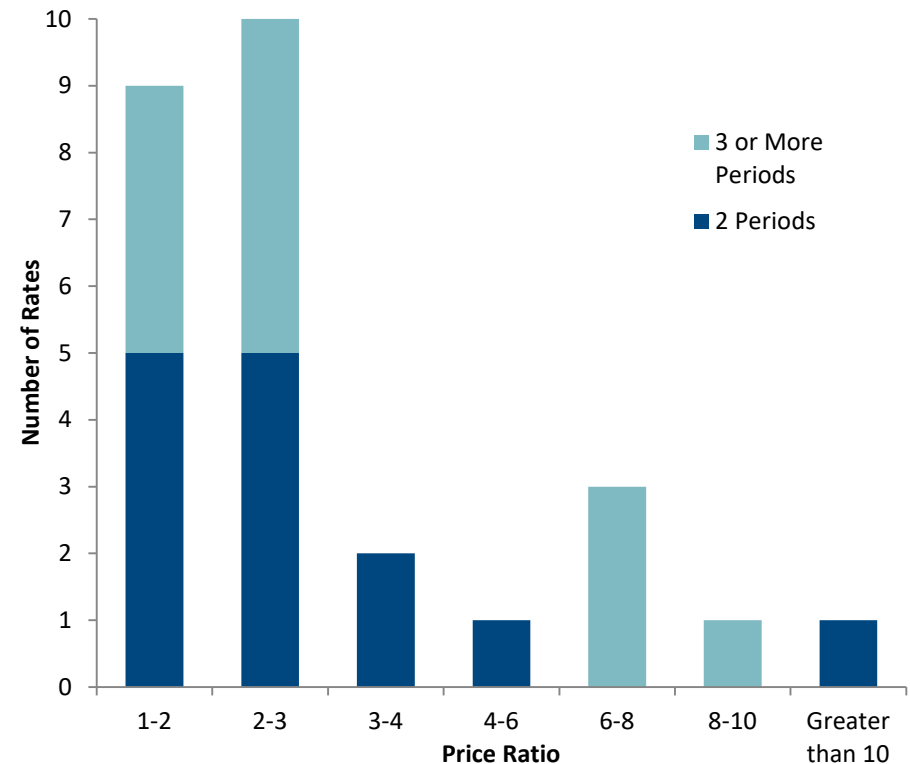
Summer Price Ratios (Peak Rate to Lowest Off-Peak Rate)



2 Period Median = 3.19

3 or More Period Median = 3.74

Winter Price Ratios (Peak Rate to Lowest Off-Peak Rate)

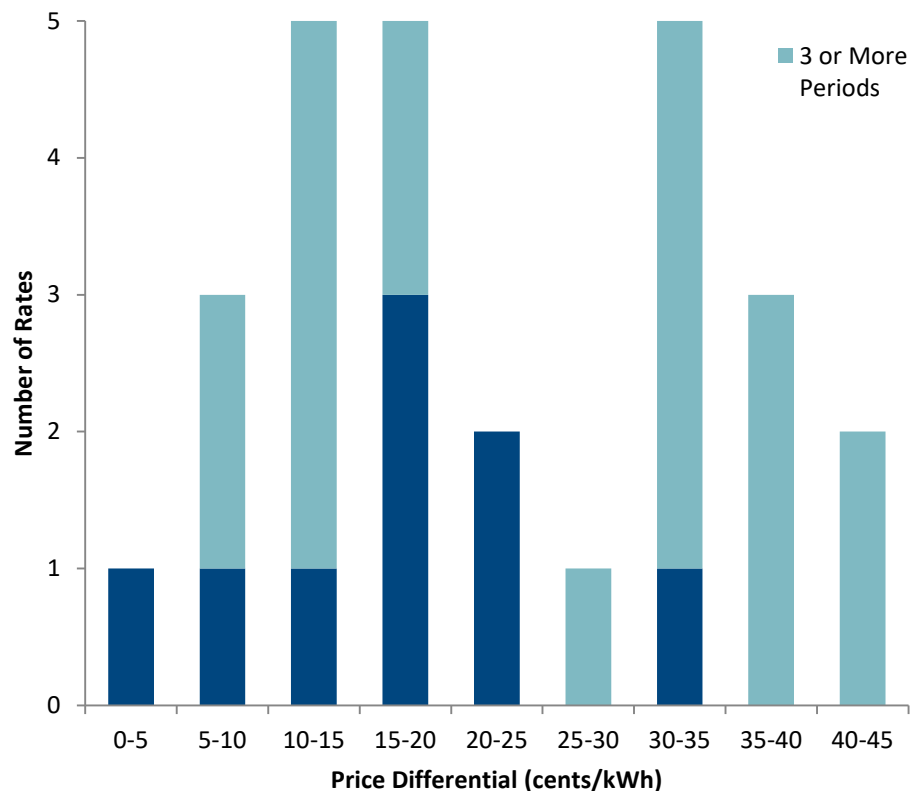


2 Period Median = 2.36

3 or More Period Median = 2.54

TOU Rates – Price Differentials

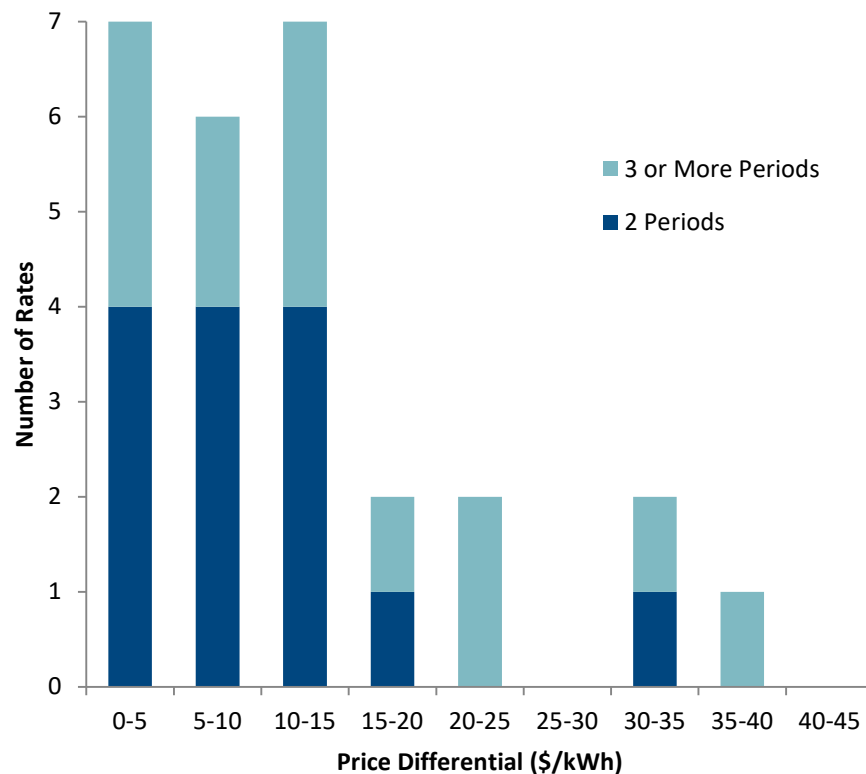
Summer Price Differentials (Peak Rate to Lowest Off-Peak Rate)



2 Period Median = 17 cents/kWh

3 or More Period Median = 28 cents/kWh

Winter Price Differentials (Peak Rate to Lowest Off-Peak Rate)

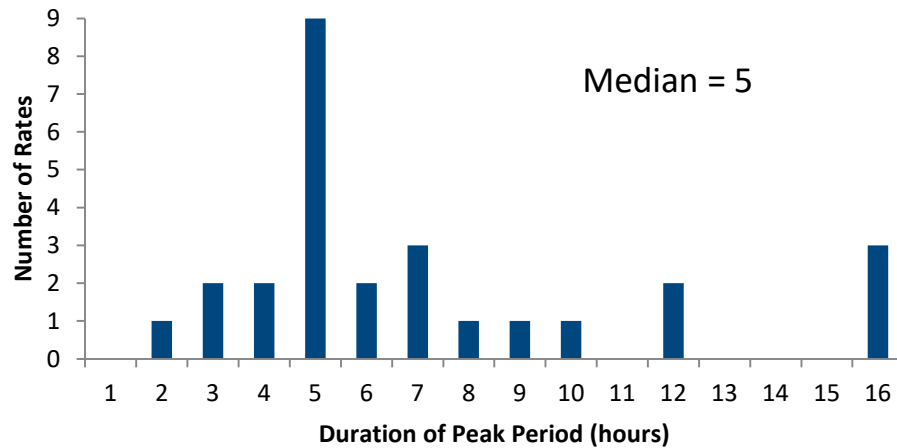


2 Period Median = 9 cents/kWh

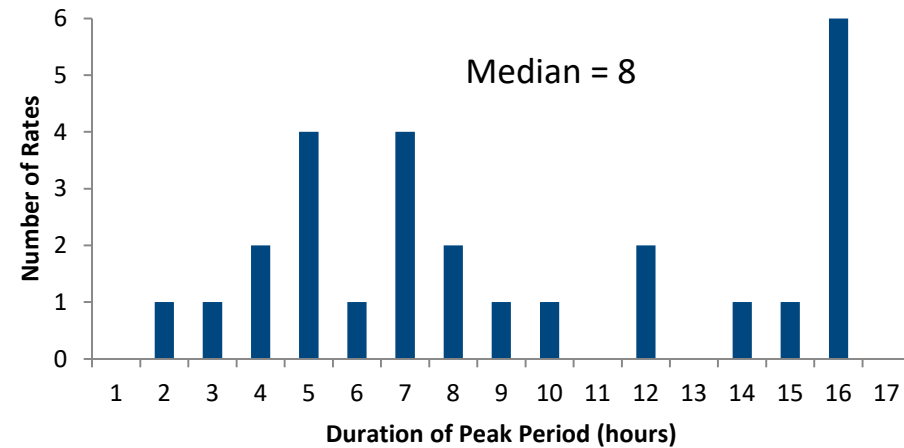
3 or More Period Median = 12 cents/kWh

TOU Rates – Duration of Peak Window

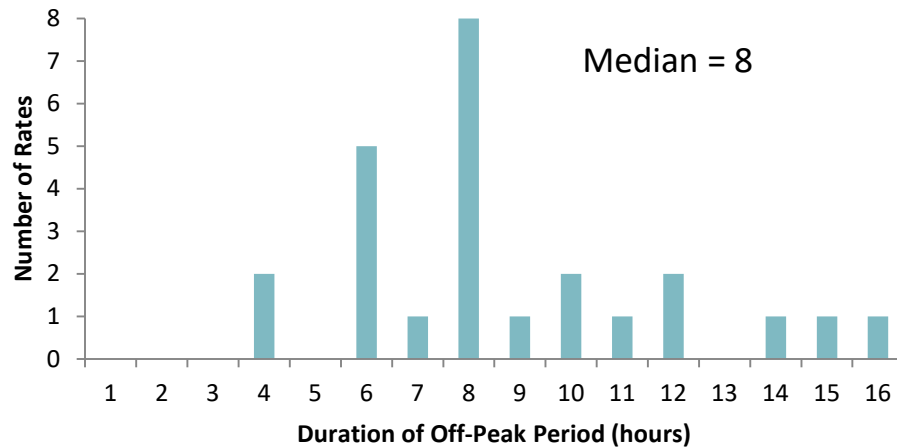
Summer Peak Period Duration



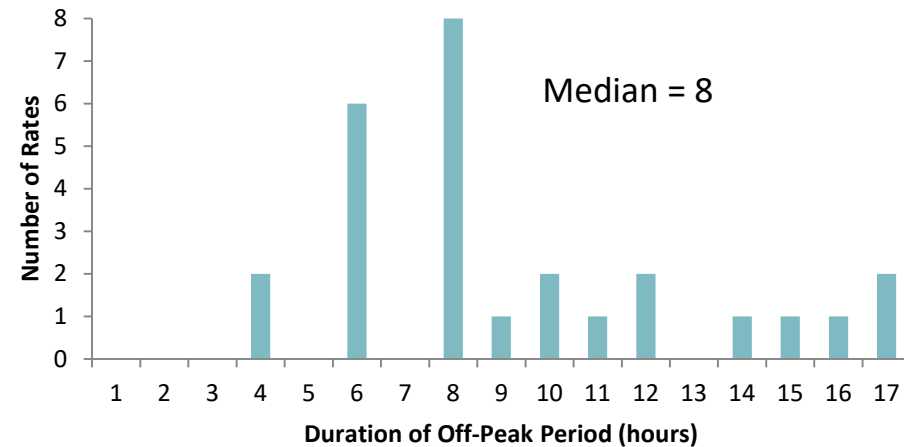
Winter Peak Period Duration



Summer Off-Peak Period Duration



Winter Off-Peak Period Duration



Pilot Studies

San Diego Gas & Electric – EV TOU Pilot Study

- 3 different 3-period rates with varying price ratios (roughly 2, 4, and 6 for peak/super off-peak)
- All rates applied strictly to EV charging, not the entire residence
- 430 participants owning a Nissan LEAF with a charging timer and Level 2 charging
- EV owners were found to be responsive to price signals and shifted a majority of charging to super off-peak hours
- Participants exhibited learning behavior, increasingly shifting consumption as the study progressed

EPRI – Salt River Project EV Driving, Charging and Load Shape Study

- Observational study of 70 EVs of various models subject to different rate plans
- TOU rates found to be highly effective in shifting peak loads
- Energy use and charging load varied widely across different models and charger types

Conclusions

- Electric vehicle owners have significantly different needs, load shapes, and flexibility than other residential customers, supporting the creation of new rate offerings
- EV TOU rates encourage optimal charging patterns, creating a win-win for utilities and EV owners
- Initial findings from two EV charging pilots indicates that charging load is highly responsive to rate design, though further empirical research is needed in this area

References

- Electric Power Research Institute. “Electric Vehicle Driving, Charging, and Load Shape Analysis: A Deep Dive Into Where, When, and How Much Salt River Project (SRP) Electric Vehicle Customers Charge.” 3002013754. July 2018.
- Cook, Jonathan, Candice Churchwell, and Stephen George. “Final Evaluation for San Diego Gas & Electric’s Plug-in Electric Vehicle TOU – Pricing and Technology Study.” Nexant, Inc. Submitted to San Diego Gas & Electric. February 20, 2014.

Appendix:

Monthly Cost of EV Ownership Assumptions

General Assumptions:

- 10 year vehicle life
- 24 kWh battery
- 10% registration fee
- 12% charging losses
- \$600 charger cost
- 7% annual discount rate

Sensitivity Assumptions:

Component	Units	Low	Base	High
Electricity Rate Level	<i>cents/kWh</i>	8	12	20
Electricity Rate Structure		Off-Peak w/ TOU (10:1)	Flat	Post-Commute w/ Demand Charge
EV Efficiency	<i>miles/kWh</i>	5.0	3.0	2.0
ICE Efficiency	<i>MPG</i>	25	30	50
Annual Miles Driven	<i>miles/year</i>	30,000	15,000	5,000
Federal Tax Credit	\$	7,500	0	---
Battery Cost	<i>\$/kWh</i>	200	500	600
Gasoline Price	<i>\$/gal</i>	\$5.00	\$3.00	\$2.00

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Ahmad Faruqui's consulting practice is focused on the efficient use of energy. His areas of expertise include rate design, demand response, energy efficiency, distributed energy resources, advanced metering infrastructure, plug-in electric vehicles, energy storage, inter-fuel substitution, combined heat and power, microgrids, and demand forecasting. He has worked for nearly 150 clients on 5 continents. These include electric and gas utilities, state and federal commissions, independent system operators, government agencies, trade associations, research institutes, and manufacturing companies. Ahmad has testified or appeared before commissions in Alberta (Canada), Arizona, Arkansas, California, Colorado, Connecticut, Delaware, the District of Columbia, FERC, Illinois, Indiana, Kansas, Maryland, Minnesota, Nevada, Ohio, Oklahoma, Ontario (Canada), Pennsylvania, ECRA (Saudi Arabia), and Texas. He has presented to governments in Australia, Egypt, Ireland, the Philippines, Thailand and the United Kingdom and given seminars on all 6 continents. His research has been cited in Business Week, The Economist, Forbes, National Geographic, The New York Times, San Francisco Chronicle, San Jose Mercury News, Wall Street Journal and USA Today. He has appeared on Fox Business News, National Public Radio and Voice of America. He is the author, co-author or editor of 4 books and more than 150 articles, papers and reports on energy matters. He has published in peer-reviewed journals such as Energy Economics, Energy Journal, Energy Efficiency, Energy Policy, Journal of Regulatory Economics and Utilities Policy and trade journals such as The Electricity Journal and the Public Utilities Fortnightly. He holds BA and MA degrees from the University of Karachi, an MA in agricultural economics and Ph. D. in economics from The University of California at Davis.

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Brattle Projects & Research on Electrification

Ongoing

- Forecasting the impacts of new utility initiatives on EV adoption (EPRI)
- System Dynamics based modeling of EV adoption and impacts on utilities (ComEd)
- Developing a framework for evaluating the cost-effectiveness of ratepayer-funded electrification programs (EPRI)
- Reviewing rate design alternatives for public EV fast charging stations (EEI)
- Developing forward-looking ratemaking strategies, including rate design for EVs (GRE)

Recent

- Assessment of the benefits and costs of residential grid-interactive electric water heating (NRECA/NRDC)
- Assessment of the economy-wide technical potential for electrification (Brattle White Paper)
- Exploration of the implications of ride sharing and vehicle automation for electric utilities (Brattle White Paper, Electricity Journal Article, PUF Article)

Additional Brattle Resources

[The Electrified Future is Shared](#), Jürgen Weiss, Public Utilities Fortnightly, PUF 2.0, Mid-February 2018

[The electrification accelerator: Understanding the implications of autonomous vehicles for electric utilities](#), Jürgen Weiss, Ryan Hledik, Roger Lueken, Tony Lee, Will Gorman, The Electricity Journal 30 (2017) 50–57, December 2017

[New Sources of Utility Growth: Electrification Opportunities and Challenges](#); Retail Energy Practice Briefing Series; The Brattle Group, November 2017

[Electrification: Emerging Opportunities for Utility Growth](#), Jürgen Weiss, Ryan Hledik, Michael Hagerty and Will Gorman, January 2017

Our Electrification Services

- Market Potential Assessments
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- Electrification Strategy Development
- Macroeconomic Impact Modeling
- Rate Design for Electric Vehicle (EV) Charging
- EV Adoption Modeling
- Regulatory Strategy and Support
- Pilot Development

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