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MISSOURI PUBLIC SERVICE COMMISSION

FILE NO. ER-2019-0335

DIRECT TESTIMONY

OF

AHMAD FARUQUI, Ph.D.

ON

BEHALF OF

UNION ELECTRIC COMPANY

D/B/A AMEREN MISSOURI

St. Louis, Missouri

July 2019

Q. What is your name and address?

A. My name is Ahmad Faruqui, Ph.D.. I am a Principal with The Brattle Group. My business address is 201 Mission Street, Suite 2800, San Francisco, California 94105.

Q. On whose behalf are you testifying?

A. I am filing testimony on behalf of Ameren Missouri.

Q. What is the purpose of your testimony?

The purpose of my testimony is to comment on the merits of Ameren Missouri's proposal to introduce some new rate designs for its residential customers. My testimony will address the structure, rationale, and demonstrated success of modern rate design and the specific rate offerings that Ameren Missouri has proposed to test and deploy.

Q. Have you previously testified before the Missouri Public Service Commission?

A. No, I have not.

Q. What are your qualifications?

A. I am an energy economist with over 40 years of consulting and research experience. I have also taught economics at the University level for seven years at three universities.

My consulting practice is focused on customer engagement. My 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.

A statement of my qualifications is contained in Schedule AF-D1 attached to my testimony.

Q. Are rate designs being reformed around the country?

A. Yes, modern rate designs are beginning to be deployed throughout the United States. Utilities are increasingly moving away from the traditional volumetric rate that has been the hallmark of residential tariffs for the past century toward modern rate designs.

Rate designs are being modernized to accommodate changes that have been taking place on both the supply side and the demand side of the electricity market.

Q. What changes on the supply side are driving the need for rate design modernization?

A. On the supply side, utilities are changing their generation mix in response to market forces and directives from governmental agencies, legislation and regulations. Wholesale prices are low but becoming increasingly volatile. Additionally, the one-way grid is being transformed into an integrated, two-way grid. Finally, homes are increasingly being equipped with smart meters.

Q. What changes on the demand side are driving the need for design modernization?

A. Digital technologies such as smart homes, electric vehicles, distributed generation, and smart metering are changing the way customers interact with electric utilities. In addition, Wi-Fi connections are becoming ubiquitous and many consumers are accessing the web through their smart phones. Modern utility customers have access to far more information regarding their electricity use today than they did just five years ago.

They are turning green in how they live their life – whether it is buying organic produce, shopping at farmer's markets, or buying energy – in large numbers, and the younger consumers of today demand far greater control over their consumption of electricity than did their parents' generation. Customers are increasingly turning into prosumers through adoption of solar panels, battery storage, and fuel cells.

Another impetus for rate modernization is that customers have diverse preferences and want to be able to choose a rate that best fits their individual lifestyle. Some customers simply want the lowest bill and are willing to shift their usage around the clock to achieve that if given the opportunity. Other customers prefer consistency and desire a predictable bill, even if it comes at a premium. Modern rate design leaves behind the one-size-fits-all model by embracing diverse offerings that maximize customer choice and ultimately customer satisfaction.

Q. What are the main benefits of modernizing rate designs?

A. Modern rates allow utilities to send cost-reflective and equitable price signals that incentivize efficient customer behavior while prioritizing system reliability and environmental sustainability. They also promote equity between customers, and by creating bill stability for customers, they also may create revenue stability for the utility in the long term.

Q. What are the principles that should be considered when designing modern rates?

A. Modern rates share one common trait. They reflect the cost structure of generating and delivering electricity. They conform to the principles outlined in James C.

Bonbright's Principles of Public Utility Rates.[1] In one word, they support cost causation. Bonbright laid out eight principles in the first edition of the text. These were expanded into ten principles in the second edition.[2]

The Bonbright principles are almost universally cited in rate proceedings throughout the U.S. and are often used as a foundation for designing rates. They can be condensed into five core principles:

1. *Economic Efficiency* – The price of electricity should convey to the customer the cost of producing it, ensuring that resources consumed in the production and delivery of electricity are not wasted. If the price is set equal to the cost of providing a kWh, customers who value the kWh more than the cost of producing it will use the kWh and customers who value the kWh less will not. This will encourage the development and adoption of energy technologies that are capable of providing the most valuable services to the power grid, and thus the greatest benefit to electric customers as a whole.
2. *Equity* – There should be no unintentional subsidies between customer types. A classic example of the violation of this principle occurs under flat rate pricing structures (i.e., cents/kWh). Since customers have different load profiles, "peaky" customers, who use more electricity when it is most expensive, are subsidized by less "peaky" customers who overpay for cheaper off-peak electricity. Note that equity is not the same as social justice, which is related to

[1] James C. Bonbright, Principles of Public Utility Rates, (Columbia University Press: 1961) 1st Edition.

[2] James C. Bonbright, Albert L. Danielsen, and David R. Kamerschen, Principles of Public Utility Rates,
2nd ed. (Arlington, VA: Public Utility Reports, 1988).

inequities in socioeconomic status rather than cost. The pursuit of one is not necessarily the pursuit of the other, and vice versa.

3. *Revenue Adequacy and Stability* – Rates should recover the authorized revenues of the utility and should promote revenue stability. Theoretically, all rate designs can be implemented to be revenue neutral within a class, but this would require perfect foresight of the future. Changing technologies and customer behaviors make load forecasting more difficult and increase the risk of the utility either under-recovering or over-recovering costs when rates are not cost-reflective.
4. *Bill Stability* – Customer bills should be stable and predictable while striking a balance with the other ratemaking principles. Rates that are not cost reflective will tend to be less stable over time, since both costs and loads are changing over time. For example, if fixed infrastructure costs are spread over a certain number of kWh's in Year 1, and the number of kWh's halves in Year 2, then the price per kWh in Year 2 will double even though there is no change in the underlying infrastructure cost of the utility.
5. *Customer Satisfaction* – Rates should enhance customer satisfaction. Because most residential customers devote relatively little time to reading their electric bills, rates need to be relatively simple so that customers can understand them and perhaps respond to the rates by modifying their energy use patterns. Giving customers meaningful cost reflective rate choices helps enhance customer satisfaction.

Q. What are some different types of modern rate designs?

A. Several rate designs can be regarded as modern. A few are shown in Table 1.

Table 1 – Examples of Modern Rate Designs

Rate Design	Definition
Critical Peak Pricing (CPP)	Customers pay higher prices during critical events when system costs are highest or when the power grid is severely stressed.
Demand Charges	Customers are charged based on peak electricity consumption, typically over a span of 15, 30, or 60 minutes.
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")
Real-Time Pricing (RTP)	Customers pay prices that vary by the hour to reflect the actual cost of electricity
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.
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.
Fixed bill	Customers pay a fixed monthly bill accompanied with tools for lowering the bill (such as incentives for lowering peak usage).

It should be noted that with the advent of smart meters, electricity rates can and often do combine two or even three of the elements listed in Table 1, thereby creating highly customizable multi-layered price signals. For example, demand rates are often implemented along with TOU energy charges, and fixed bills are often paired with peak time rebates.

Bonbright says that the most cost-reflective rate is a three-part rate that combines:

1. A fixed monthly charge to recover the full costs of billing, metering, and customer service.
2. A demand charge for recovering distribution capacity costs. This is often recovered on a non-coincident peak basis. Sometimes the demand charge will also include the cost of transmission capacity and sometimes also the cost of generation capacity, but the practice is likely to vary by utility. The latter demand charges are based on coincident peak capacity. Sometimes both a non-coincident and a coincident peak demand charge are offered to recover the three elements of capacity costs. Sometimes transmission and distribution capacity costs are recovered through the energy charge.
3. A time-varying energy charge for recovering energy costs. In some cases, this may also include the cost of transmission capacity and the cost of generation capacity. This could take one of many forms, such as a simple time-of-use rate, a critical-peak pricing rate, a variable-peak pricing rate, or a real-time pricing rate.

Q. Which utilities are offering modern rate designs today?

A. Nationwide, millions of customers being served by various utilities are on TOU rates today. The highest deployment is in Arizona where 57% of Arizona Public Service' residential customers and 36% of Salt River Project's residential customers are on an opt-in TOU rate. All residential customers in Fort Collins, Colorado were moved to a mandatory TOU rate in October 2018. Next year, all residential customers of the investor-owned utilities in California and one of the utilities in Michigan will be defaulted onto TOU rates. The Colorado Public Utility Commission is considering making a similar move.

The province of Ontario, Canada made this move about ten years ago. Today, some 90% of the customers in that province are on TOU rates. British Columbia, Canada is studying the question, and in Europe, residential customers in Italy are on default TOU rates.

Peak Time Rebates (PTR) are now being offered by utilities in Maryland, California, and Illinois.

Oklahoma Gas and Electric (OGE) in Oklahoma has about 20% of its customers on technology-enabled dynamic pricing rates.

Real Time Pricing (RTP) is being offered in Illinois and some 50,000 customers are on it. In Estonia and Spain, the default residential tariff is real-time pricing.

More than 60 demand charges are being offered to residential customers in 22 states. See Schedule AF-D2. Large numbers of customers are on demand charges in Arizona and Wyoming. Flat bill options exist in Georgia and Oklahoma.

Q. Have residential customers accepted modern tariffs?

A. Yes, residential customers have accepted modern tariffs where they have been offered. A majority of modern tariffs have been implemented on an optional basis, either opt-in or default, and the numbers of customers voluntarily enrolling (either opting in or declining to opt out) in the new tariffs indicate a broad acceptance of the innovative rate offerings. Selected examples of customer participation are shown in Table 2.

Table 2 – Examples of Customer Participation in Modern Rate Offerings

Utility or Location	Type of Rate	Applicability	Participating Customers
Oklahoma Gas & Electric	Variable Peak Pricing (VPP)	Opt-in	20% (130,000)

Maryland (BGE, Pepco, Delmarva)	Dynamic 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)	Dynamic Peak Time Rebate (PTR)	Opt-in	27,000
Arizona (APS, SRP)	Time-of-Use (TOU)	Opt-in	57% of APS' residential customers (20% of which are also on a demand charge), 36% of SRP's
California (PG&E, SCE, SDG&E)	Time-of-Use (TOU)	Default (2019)	TBD – 75-90%*
California (SMUD)	Time-of-Use (TOU)	Default	75-90%*
Colorado (Fort Collins)	Time-of-Use (TOU)	Mandatory (for residential)	100%
Illinois (ComEd, Ameren Illinois)	Real Time Pricing (RTP)	Opt-in	50,000
France	Time-of-Use (TOU)	Opt-in	50%
Spain	Real Time Pricing (RTP)	Default	50%
Italy	Time-of-Use (TOU)	Default	75-90%*

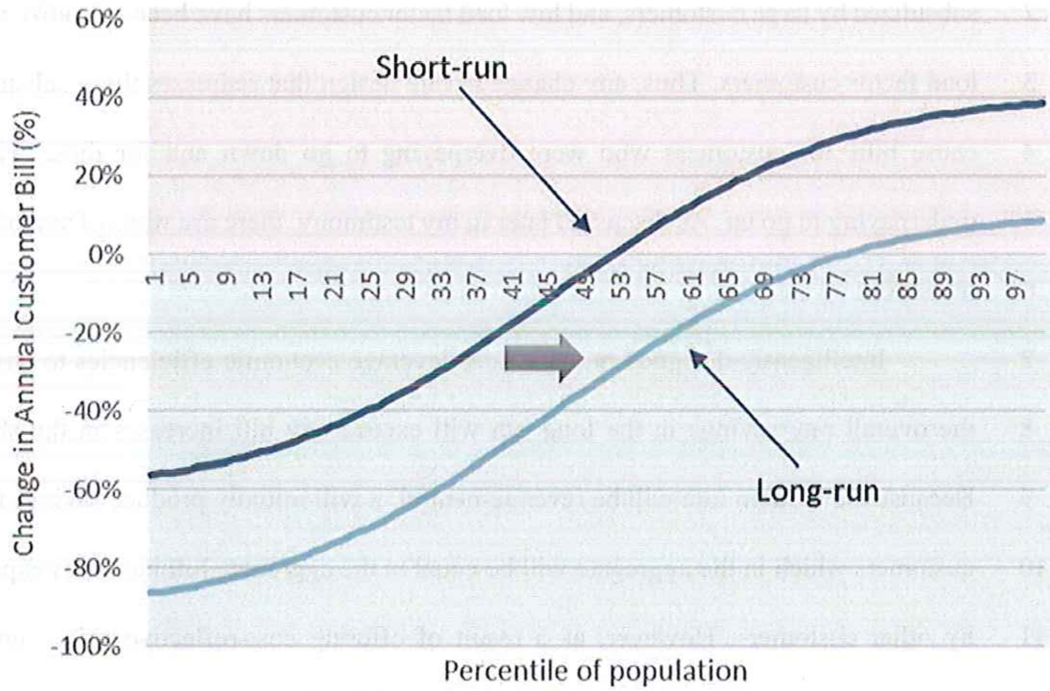
***Estimated participation based on historical trends**

Q. Have customers been able to lower their energy bills with modern rate designs?

A. On the whole, yes. Under flat volumetric rates, small customers have been subsidized by large customers, and low load factor customers have been subsidized by high load factor customers. Thus, any change in rate design that redresses these subsidies will cause bills for customers who were overpaying to go down and for those who were underpaying to go up. As discussed later in my testimony, there are ways of smoothing the transition.

Intelligently-designed modern rates leverage economic efficiencies to ensure that the overall rate savings in the long run will exceed any bill increases in the short run. Because the modern rate will be revenue-neutral, it will initially produce savings for some customers which in the aggregate will be equal to the aggregate bill increases experienced by other customers. However, as a result of offering cost-reflective price signals and creating opportunities for load shifting, customer behavior will change over time to reduce total system costs. Those net savings will accrue to ratepayers such that their total bill savings will exceed any remaining bill increases. Additionally, the number of customers whose bills decrease will usually (but not always) exceed the number of customers whose bills increase. This concept is explicated visually in Figure 1.

Figure 1 – Illustration of Bill Impacts due to Tariff Transition



Q. Do customer load shapes change in response to modern rate designs?

A. Yes, there is an extensive body of evidence that customers are responsive to rate changes and will shift their load shapes according to price signals. I have conducted a survey of 349 experimental deployments of time-varying modern rates (including TOU, CPP, PTR, and VPP) and the customer responses to those rates.3 Econometric analysis indicates a clear and statistically significant relationship between the strength of the price signal and the magnitude of customer response. When provided with enabling technology such as smart thermostats or in-home displays, the customer price response is even

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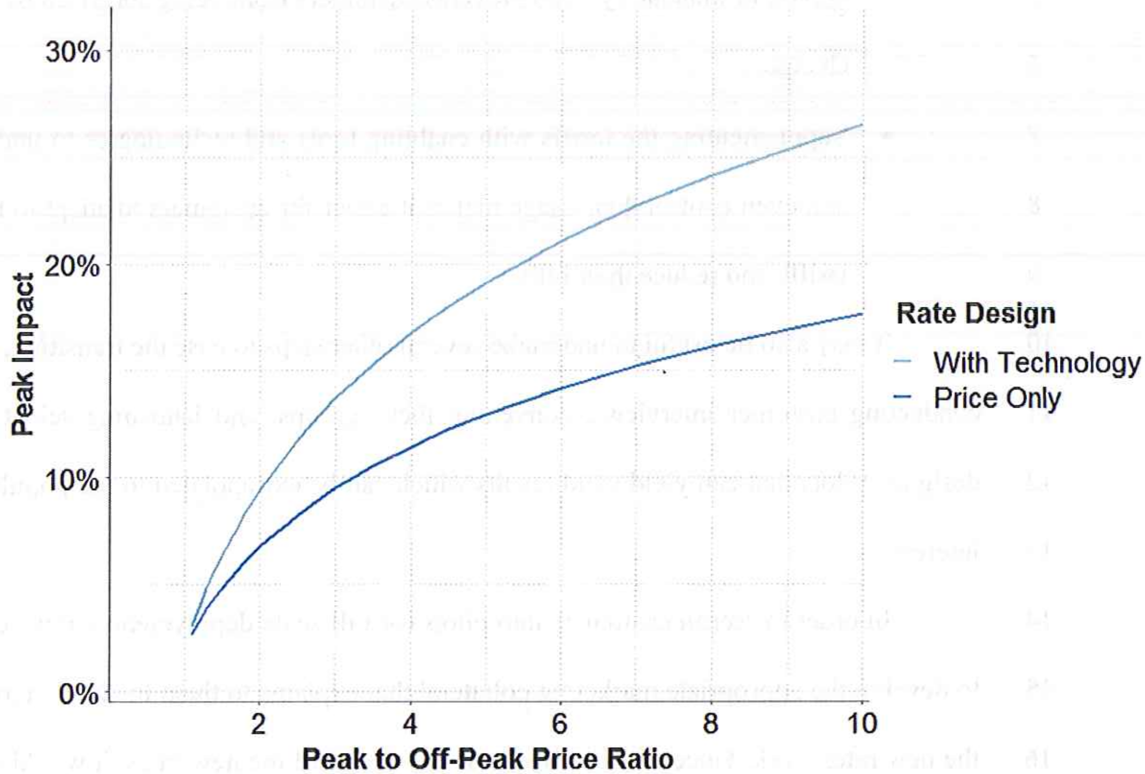
[3] Ahmad Faruqui and Cecile Bourbonnais, "The Transformative Power of Time-Varying Rates," Energy Central, March 8, 2019, https://www.energycentral.com/c/em/transformative-power-time-varying-rates; Ahmad Faruqui, Sanem Sergici, and Cody Warner, "Arcturus 2.0: A meta-analysis of time-varying rates for electricity," *The Electricity Journal* 30, Issue 10 (December 2017): 65, https://doi.org/10.1016/j.tej.2017.11.003.

stronger. This relationship, expressed in terms of peak impact (reduction in peak demand) and peak to off-peak price ratio (average peak rate divided by average off-peak rate) is shown in Figure 2.

Figure 2 – The impact of time-varying rates on customer peak demand



Q. What are some alternative ways to manage the transition to the modern rate designs?

A. In order to preclude negative customer reaction and realize the full benefits of the modern rates, it is imperative that customers understand and accept the rates. There are several ways to maximize customer understanding and acceptance of modern rates:

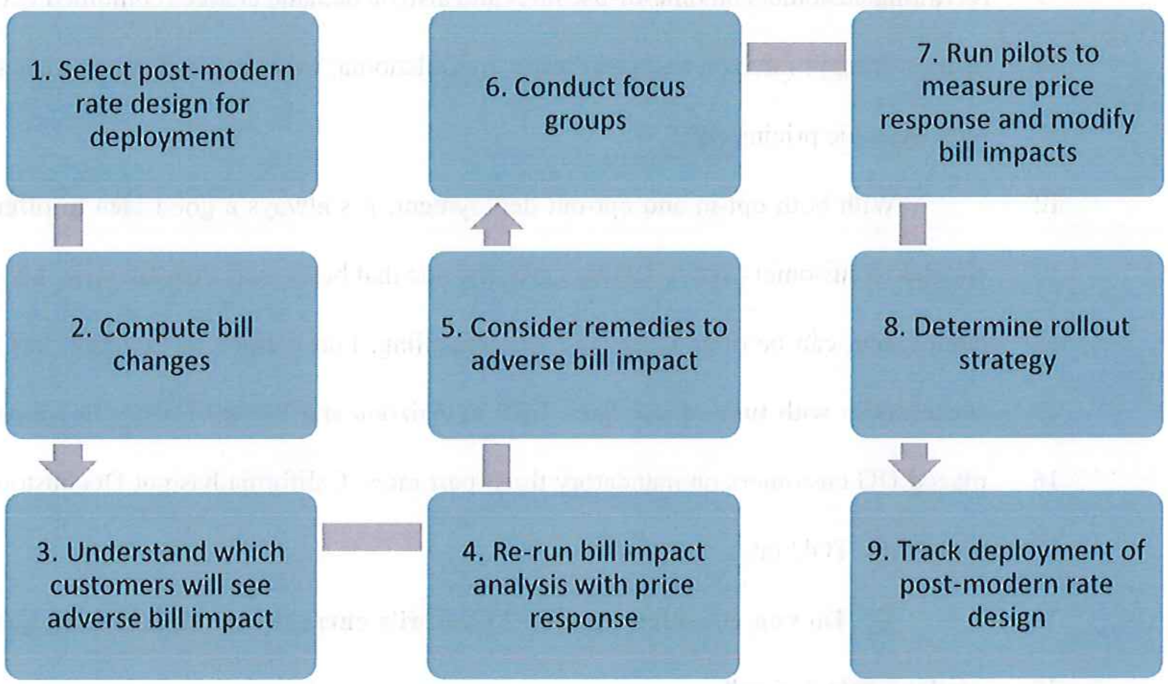
- Rolling out new tariffs on a gradual basis gives customers time to learn how the rates work and plan accordingly.

- Providing bill protection for the first year or two is an approach some utilities have taken in order to give customers a grace period to adjust to the new rates without being penalized financially.
- Offering the modern tariffs first on an opt-in basis and later transitioning to a default or mandatory basis prevents customers from being surprised by sudden change.
- Supplementing the tariffs with enabling tools and technologies to understand and even control their usage makes it easier for customers to adapt to the new tariffs and reduce their bills.

It may also be useful to undertake several other steps to ease the transition, such as conducting customer interviews, convening focus groups, and launching scientifically-designed pilots that can yield valid results which can be extrapolated to the population of interest.

In order to recruit customers into pilots (or full-scale deployments), it is necessary to develop the appropriate marketing collateral that explains to them in simple terms how the new rates work. Once Ameren Missouri has designed the new rates, it would be good to "road test" them by explaining them to a small sample of customers through one-on-one interviews and then testing them further in focus groups. The focus groups should span the demographic and socio-economic footprint of Ameren Missouri's service area to make sure all consumer perspectives are captured. In the focus groups, the moderator should explain how current rates work and the issues with continuing the current rates, thereby laying the foundation for rate design reform. Then he or she should explain the new rates and how they will address the issues with the current rates. At that point, the participants should provide their comments on the understandability of the terms used to explain the new rates and offer any suggestions they might have on what language, and mechanism should be used to recruit customers. This will help Ameren Missouri in revising the collateral. The key steps in transitioning to modern rate designs are summarized in Figure 3.

Figure 3 – Transitioning to modern rate designs: A suggested pathway



Q. Eventually, should modern rate designs be offered on an opt-in, opt-out or mandatory basis?

A. While opt-out deployment is the fastest way to get the largest number of customers on modern rate designs, there are pros and cons to opt-out deployment. Many states have decided to go the opt-out route, for example California and Michigan. Earlier, the Canadian province of Ontario proceeded with opt-out deployment of simple TOU rates and now some 90% of customers are on that rate. The biggest question that has to be answered is: are customers ready to be defaulted on the new rate? If not, then it's better to go all out with opt-in deployment, to get customers to understand the reasons why they are being offered the new rate. For example, utilities in Arizona have had a lot of success with recruiting customers on time-of-use rates and also on demand charges combined with time-of-use (energy) rates on an opt-in basis. In Oklahoma, OGE has had spectacular success with dynamic pricing rates.

With both opt-in and opt-out deployment, it's always a good idea to offer a few choices to customers and to let them pick the one that best meets their lifestyle. Mandatory deployment can be done if the case is compelling. Fort Collins in Colorado has done it successfully with time-of-use rates. SRP in Arizona and Westar Energy in Kansas have placed DG customers on mandatory three-part rates. California has put DG customers on mandatory TOU rates.

Q. Do you consider Ameren Missouri's current rate structure to qualify as modern rate design?

A. No. Ameren Missouri's current volumetric rate structure is not consistent with the principles of modern rate design.

Q. Would you recommend that Ameren Missouri immediately move to modern rate design?

A. I would initially recommend that Ameren Missouri spend time to understand its residential customers' preferences and interactions with likely modern rate designs. The most effective way of achieving this objective is to offer these rates on an opt-in basis, undertake focus groups to understand customer preferences, and pilot studies to test and learn in a small scale.

Q. What modern rate designs are being proposed by Ameren Missouri?

A. Ameren Missouri is approaching this gradually, by proposing to introduce two new opt-in rate structures, and pilot a third modern rate. The two new offerings are TOU energy rates, each designed with the goal of targeting different customer lifestyles and preferences. The proposed pilot rate includes TOU energy charges, a non-coincident peak demand charge, and a fixed monthly charge.

Q. How are customers going to benefit from these rate designs?

A. At a minimum, customers opting in to new rate structures or being included in pilot studies automatically benefit by virtue of having more choice than they previously had. However, regardless of the voluntary or mandatory basis, the three-part rates will benefit customers by way of decreased average bills when they modify their usage patterns, reduced cross subsidies, and potentially reduced system externalities.

Q. What will be the likely impact on customer load shapes?

A. Ameren Missouri's two opt-in TOU rates have peak to off-peak ratios of 2.5 and 6 respectively, in the summer months. Based on simulations that are described below, I expect that these rates will lead to 7% and 12.4% peak reductions. Ameren Missouri's pilot 3-part tariff has a peak to off-peak ratio of 5.9, and is expected to yield a peak reduction of 12.3% (before including the impact of the NCP demand charge). It is, of course, possible that the actual impacts will be different from these estimates, but that can be determined ex-post if Ameren Missouri decides to undertake an impact evaluation of these rates.

Q. How did you estimate these impacts?

A. At Brattle, we maintain a proprietary database of pricing pilots and programs that record the rates tested, price ratios and estimated impacts for roughly 350 individual pricing treatments. We estimated a regression model between price ratios and resulting impacts to parameterize this relationship. We used the parameters of this regression model to estimate the impacts for Ameren Missouri's modern rates, given their price ratios.

Q. What benefits will accrue to the Ameren Missouri system as a whole?

A. The Ameren Missouri system will benefit from the increased efficiency of the modern price signals. By discouraging consumption during peak hours, the rates will generate significant savings in system costs. These savings could take the form of lower net energy costs[4] (meeting demand with low or zero marginal cost resources instead of expensive peaking resources), reduced capacity (resource adequacy) costs, or deferred transmission and distribution system investments.

Q. Would it be useful to pilot a three-part rate design before offering it on a full-scale basis?

A. Yes, piloting this rate will allow Ameren Missouri to observe load-shifting and gather customer feedback from a representative population of their own customers.

[4] Changes in fuel costs, purchased power expense, and off-system sales revenues arising from the load changes.

The insights gained from the pilot program will prove invaluable in deciding how to implement the rate designs on a full-scale basis.

Q. How should the pilot be designed?

A. The pilot should be designed so the results have internal validity (cause and effect between rates and changes in load shapes are properly established) and external validity (the pilot results can be extrapolated to the population of interest). The key is to randomly select customers who will be placed on the new rates and to make sure that a control group of customers is available to make sure that the effect of other factors that might change during the treatment period (such as weather, the economy, and customer attitudes) can be properly netted out. There are several ways of designing pilots and these are elaborated upon in Schedule AF-D3.

Q. How should customers be recruited?

A. In general, customers will be recruited by sending a letter explaining to the customer why he or she has been selected to participate in the pilot. It would explain in plain English the rationale for transitioning to modern rate designs and the importance of testing the rates in a pilot setting before proceeding with a full-scale launch. The recipient would have the option of signing onto the pilot by returning a post-card or going to a website. They would also be able to call a number and talk to a company representative. In general, only 5% of the customers who are invited to join the pilot elect to do so. This should be built into the customer recruitment plan. These details and other best practices for customer recruitment is discussed in Schedule AF-D4.

Q. What should be the sample size of the pilot?

A. As explained in Schedule AF-D2, the sample size should be at least 670 treatment customers. The pilot should also include at least 670 control group customers.

Q. How should the results of the pilot be quantified?

A. A variety of methods are available for quantifying the results of the pilot. These include analysis of variance (ANOVA), analysis of covariance (ANCOVA), and demand models. ANOVA controls for pre-existing differences between the treatment and control groups, and provides an estimate of the difference in differences using a comparison of means. ANCOVA allows for the existence of covariates such as appliance holdings, household size and so on and provides a more accurate estimate than ANCOVA. However, neither ANOVA nor ANCOVA allow results to be extrapolated outside of the specific rates being tested. For example, if the ratio of peak to off-peak prices is 2:1 in the pilot, ANOVA and ANCOVA will quantify the reduction in peak demand that occurs when the 2:1 ratio is applied. However, they will not be able to answer the question of what happens when the ratio is 1.5:1 or 3:1. That requires the use of demand models. Each of these methods has been used in a variety of experiments with innovative pricing designs.

Q. Eventually, should the modern rate designs be offered on an opt-in, opt-out or mandatory basis?

A. Over the long haul, opt-out deployment of what Ameren Missouri regards as the best rate design is the way to go. This default offering should be supplemented with a few other rate designs, consistent with the desire to offer choices to customers. Preserving customer choice lets customers choose the rate that best suits their own preferences and lifestyle, but because many customers are predisposed to the status quo, offering the choice to opt-out rather than opt-in will almost certainly yield a higher participation rate in the modern tariff.

Q. How would you conclude your testimony?

A. Ameren Missouri is taking some important steps to modernize its residential rate designs. These rate designs will allow the company to leverage its investment in advanced metering infrastructure. They will also give customers greater control over their usage and bills.

Dr. Ahmad Faruqui is an energy economist 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 across five continents. His clients include electric and gas utilities, state and federal commissions, independent system operators, government agencies, trade associations, research institutes, and manufacturing companies. Dr. Faruqui has testified or appeared before commissions in Alberta (Canada), Arizona, Arkansas, California, Colorado, Connecticut, Delaware, the District of Columbia, FERC, Idaho, Illinois, Indiana, Kansas, Maryland, Montana, Minnesota, Nevada, Ohio, Oklahoma, Ontario (Canada), Pennsylvania, Saudi Arabia, and Texas. He has presented to governments in Australia, Egypt, Ireland, Jamaica, the Philippines, Saudi Arabia, 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, USA Today,* and *Utility Dive.* 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 is also a member of the editorial board of *The Electricity Journal.*

Dr. Faruqui holds B.A. and M.A. degrees from the University of Karachi, both with the highest honors, and an M.A. in agricultural economics and a Ph.D. in economics from The University of California at Davis, where he was a research fellow.

AREAS OF EXPERTISE

- *Expert witness.* He has testified or appeared before state commissions in Arkansas, California, Colorado, Connecticut, Delaware, the District of Columbia, Illinois, Indiana, Iowa, Kansas, Michigan, Maryland, Ontario (Canada) and Pennsylvania. He has assisted clients in submitting testimony in Georgia and Minnesota. He has made presentations to the California Energy Commission, the California Senate, the Congressional Office of Technology Assessment, the Kentucky Commission, the Minnesota Department of Commerce, the Minnesota Senate, the Missouri Public Service Commission, and the Electricity Pricing Collaborative in the state of Washington.

- *Innovative pricing.* He has identified, designed and analyzed the efficiency and equity benefits of introducing innovative pricing designs such as three-part rates, including fixed monthly charges, demand charges and time-varying energy charges; dynamic pricing rates, including critical peak pricing, variable peak pricing and real-time pricing; time-of-use pricing; and inclining block rates.
- *Regulatory strategy.* Dr. Faruqui has helped design forward-looking programs and services that exploit recent advances in rate design and digital technologies in order to lower customer bills and improve utility earnings, while lowering the carbon footprint and preserving system reliability.
- *Cost-benefit analysis of grid modernization.* He has assessed the feasibility of introducing smart meters and other devices, such as programmable communicating thermostats that promote demand response, into the energy marketplace, in addition to new appliances, buildings, and industrial processes that improve energy efficiency.
- *Demand forecasting and weather normalization.* He has pioneered the use of a variety of models for forecasting product demand in the near-, medium-, and long-term, using econometric, time series, and engineering methods. These models have been used to bid into energy procurement auctions, plan capacity additions, design customer-side programs, and weather normalize sales.
- *Customer choice.* He has developed methods for surveying customers in order to elicit their preferences for alternative energy products and alternative energy suppliers. These methods have been used to predict the market size of these products and to estimate the market share of specific suppliers.
- *Hedging, risk management, and market design.* He has helped design a range of financial products that help customers and utilities cope with the unique opportunities and challenges posed by a competitive market for electricity. He conducted a widely-cited market simulation to show that real-time pricing of electricity could have saved Californians millions of dollars during the Energy Crisis by lowering peak demands and prices in the wholesale market.

- *Competitive strategy.* He has helped clients develop and implement competitive marketing strategies by drawing on his knowledge of the energy needs of end-use customers, their values and decision-making practices, and their competitive options. He has helped companies reshape and transform their marketing organization and reposition themselves for a competitive marketplace. He has also helped government-owned entities in the developing world prepare for privatization by benchmarking their planning, retailing, and distribution processes against industry best practices, and suggesting improvements by specifying quantitative metrics and follow-up procedures.
- *Design and evaluation of marketing programs.* He has helped generate ideas for new products and services, identified successful design characteristics through customer surveys and focus groups, and test marketed new concepts through pilots and experiments.
- *Academic experience.* He has given lectures at the University of California, Berkeley, University of California, Davis, Harvard University, University of Idaho, Massachusetts Institute of Technology, Michigan State University, Northwestern University, University of San Francisco, , Stanford University, University of Virginia, and University of Wisconsin-Madison. Additionally, he has led a variety of professional seminars and workshops on public utility economics around the world. Finally, he has taught economics at San Jose State University, University of California, Davis, and the University of Karachi.

EXPERIENCE

Innovative Pricing

- **Cost of service and tariff design study.** for a large electric utility in South-East Asia, Brattle provided consulting services for their cost of service and tariff design studies for incentive based regulation, covering regulatory period 2 (2018-2020). Our work focused on understanding the cost drivers, reviewing the extent to which the current tariffs reflect the cost drivers, and developing new tariffs that better align with current and projected costs.
- **Impact analysis for TOU rates in Ontario.** Measured the impacts of a system-wide Time of Use (TOU) deployment in the province of Ontario, Canada, on behalf of the Ontario Power Authority. To account for the lack of a designated control group, Brattle created a quasi-experimental design that took advantage of differences in the timing of the TOU rollout.

- **Measurement and evaluation for in-home displays, home energy controllers, smart appliances, and alternative rates for Florida Power & Light (FPL).** Carried out a 2-year impact evaluation of a dynamic and enabling technology pilot program. Used econometric methods to estimate the changes in load shapes, changes in peak demand, and changes in energy consumption for three different treatments. The results of this study were shared with Department of Energy as to fulfil the data reporting requirements of FPL's Smart Grid Investment Grant.

- **Report examining the costs and benefits of dynamic pricing in the Australian energy market.** For the Australian Energy Market Commission (AEMC), developed a report that reviewed the various forms of dynamic pricing, such as time-of-use pricing, critical peak pricing, peak time rebates, and real time pricing, for a variety of performance metrics including economic efficiency, equity, bill risk, revenue risk, and risk to vulnerable customers. It also discussed ways in which dynamic pricing could be rolled out in Australia to raise load factors and lower average energy costs for all consumers without harming vulnerable consumers, such as those with low incomes or medical conditions requiring the use of electricity.

- **Whitepaper on emerging issues in innovative pricing.** For the Regulatory Assistance Project (RAP), developed a whitepaper on emerging issues and best practices in innovative rate design and deployment. The paper included an overview of AMI-enabled electricity pricing options, recommendations for designing the rates and conducting experimental pilots, an overview of recent pilots, full-deployment case studies, and a blueprint for rolling out innovative rate designs. The paper's audience was international regulators in regions that were exploring the potential benefits of smart metering and innovative pricing.

- **Assessing the full benefits of real-time pricing.** For two large Midwestern utilities, assessed and, where possible, quantified the potential benefits of the existing residential real-time pricing (RTP) rate offering. The analysis included not only "conventional" benefits such as avoided resource costs, but under the direction of the state regulator was expanded to include harder-to-quantify benefits such as improvements to national security and customer service.

- **Pricing and technology pilot design and impact evaluation for Connecticut Light & Power (CL&P).** Designed the Plan-It Wise Energy pilot for all classes of customers and subsequently evaluated the Plan-It Wise Energy program (PWEP). PWEP tested the impacts of CPP, PTR, and time of use (TOU) rates on the consumption behaviors of residential and small commercial and industrial customers.

- **Dynamic pricing pilot design and impact evaluation: Baltimore Gas & Electric.** Designed and evaluated the Smart Energy Pricing (SEP) pilot, which ran for four years. The pilot tested a variety of rate designs including critical peak pricing and peak time rebates on residential customer consumption patterns. In addition, the pilot tested the impacts of smart thermostats and the Energy Orb.
- **Impact evaluation of a residential dynamic pricing experiment: Consumers Energy (Michigan).** Designed the pilot and carried out an impact evaluation with the purpose of measuring the impact of critical peak pricing (CPP) and peak time rebates (PTR) on residential customer consumption patterns. The pilot also tested the influence of switches that remotely adjust the duty cycle of central air conditioners.
- **Impact simulation of Ameren Illinois utilities' power smart pricing program.** Simulated the potential demand response of residential customers enrolled to real-time prices. Results of this simulation were presented to the Midwest ISO's Supply Adequacy Working Group (SAWG) to explore alternative ways of introducing price responsive demand in the region.
- **The case for dynamic pricing: Demand Response Research Center.** Led a project involving the California Public Utilities Commission, the California Energy Commission, the state's three investor-owned utilities, and other stakeholders in the rate design process. Identified key issues and barriers associated with the development of time-based rates. Revisited the fundamental objectives of rate design, including efficiency and equity, with a special emphasis on meeting the state's strongly-articulated needs for demand response and energy efficiency. Developed a score-card for evaluating competing rate designs and applied it to a set of illustrative rates that were created for four customer classes using actual utility data. The work was reviewed by a national peer-review panel.
- **Analyzed the economics of self-generation of steam.** Specified, estimated, tested, and validated a large-scale model that analyzes the response of some 2,000 large commercial customers to rising steam prices. The model includes a module for analyzing conservation behavior, another module for the probability of self-generation switching behavior, and a module for forecasting sales and peak demand.
- **Design and impact evaluation of the statewide pricing pilot: Three California utilities.** Working with a consortium of California's three investor-owned utilities to design a statewide pricing pilot to test the efficacy of dynamic pricing options for mass-market

customers. The pilot was designed using scientific principles of experimental design and measured changes in usage induced by dynamic pricing for over 2,500 residential and small commercial and industrial customers. The impact evaluation was carried out using state-of-the-art econometric models. Information from the pilot was used by all three utilities in their business cases for advanced metering infrastructure (AMI). The project was conducted through a public process involving the state's two regulatory commissions, the power agency, and several other parties.

- **Economics of dynamic pricing: Two California utilities.** Reviewed a wide range of dynamic pricing options for mass-market customers. Conducted an initial cost-effectiveness analysis and updated the analysis with new estimates of avoided costs and results from a survey of customers that yielded estimates of likely participation rates.

- **Economics of time-of-use pricing: A Pacific Northwest utility.** This utility ran the nation's largest time-of-use pricing pilot program. Assessed the cost-effectiveness of alternative pricing options from a variety of different perspectives. Options included a standard three-part time-of-use rate and a quasi-real time variant where the prices vary by day. Worked with the client in developing a regulatory strategy. Worked later with a collaborative to analyze the program's economics under a variety of scenarios of the market environment.

- **Economics of dynamic pricing options for mass market customers - Client: A multi-state utility.** Identified a variety of pricing options suited to meet the needs of mass-market customers, and assessed their cost-effectiveness. Options included standard three-part time-of-use rates, critical peak pricing, and extreme-day pricing. Developed plans for implementing a pilot program to obtain primary data on customer acceptance and load shifting potential. Worked with the client in developing a regulatory strategy.

- **Real-time pricing in California - Client: California Energy Commission.** Surveyed the national experience with real-time pricing of electricity, directed at large power customers. Identified lessons learned and reviewed the reasons why California was unable to implement real-time pricing. Catalogued the barriers to implementing real-time pricing in California, and developed a program of research for mitigating the impacts of these barriers.

- **Market-based pricing of electricity - Client: A large Southern utility.** Reviewed pricing methodologies in a variety of competitive industries including airlines, beverages, and automobiles. Recommended a path that could be used to transition from a regulated utility environment to an open market environment featuring customer choice in both wholesale and retail markets. Held a series of seminars for senior management and their staffs on the new methodologies.

- **Tools for electricity pricing - Client: Consortium of several U.S. and foreign utilities.** Developed Product Mix, a software package that uses modern finance theory and econometrics to establish a profit-maximizing menu of pricing products. The products range from the traditional fixed-price product to time-of-use prices to hourly real-time prices, and also include products that can hedge customers' risks based on financial derivatives. Outputs include market share, gross revenues, and profits by product and provider. The calculations are performed using probabilistic simulation, and results are provided as means and standard deviations. Additional results include delta and gamma parameters that can be used for corporate risk management. The software relies on a database of customer load response to various pricing options called StatsBank. This database was created by metering the hourly loads of about one thousand commercial and industrial customers in the United States and the United Kingdom.
- **Risk-based pricing - Client: Midwestern utility.** Developed and tested new pricing products for this utility that allowed it to offer risk management services to its customers. One of the products dealt with weather risk; another one dealt with risk that real-time prices might peak on a day when the customer does not find it economically viable to cut back operations.

Demand Response

- **Combined heat and power generation study.** Investigated the economic potential for combined heat and power and regulatory policies to unlock that potential in a Middle Eastern country.
- **National action plan for demand response: Federal Energy Regulatory Commission.** Led a consulting team developing a national action plan for demand response (DR). The national action plan outlined the steps that need to be taken in order to maximize the amount of cost-effective DR that can be implemented. The final document was filed with U.S. Congress.
- **National assessment of demand response potential: Federal Energy Regulatory Commission.** Led a team of consultants to assess the economic and achievable potential

for demand response programs on a state-by-state basis. The assessment was filed with the U.S. Congress, as required by the Energy Independence and Security Act.

- **Demand response program review for Integrated Resource Plan development.** In response to legislation requiring the Connecticut utilities to jointly prepare a 10-year integrated resource plan, we conducted the analysis and helped prepare the plan. In coordination with the two leading utilities in the state, we conducted a detailed analysis of alternative resource solutions (both supply- and demand-side), drafted the report, and presented it to the Connecticut Energy Advisory Board. The analysis involved a detailed review and critique of the companies' proposed DR programs.
- **Integration of DR into wholesale energy markets.** Developed a whitepaper, "Fostering Economic Demand Response in the Midwest ISO," evaluating alternative approaches to efficiently integrating DR into its energy markets while encouraging increased participation. This work involved interviewing market participants and analyzing several approaches to economic DR regarding economic efficiency, participation rates, operational fit with other ISO rules, and susceptibility to state-level and ISO-level implementation barriers. This work involved an extensive survey of DR programs (qualification criteria, bidding rules, incorporation into market clearing software, measurement and verification, and settlement) in ISO/ Regional Transmission Organization (RTO) markets around the country. The project also required a detailed review of existing DR program tariffs for utilities in the RTO's service territory and development of a matrix for summarizing the various characteristics of these programs.
- **Integration of DR into resource adequacy constructs.** For the Midwest ISO, assisted in developing qualification criteria for DR as a capacity resource (we also developed estimates of likely future contributions of DR to resource adequacy, for use by their transmission planning group). For PJM, as part of our review of its capacity market, we developed recommendations on how to treat DR comparably to generation resources while accounting for the special attributes of DR. Our recommendations addressed product definition, auction rules, and penalty provisions. For the Connecticut utilities in their integrated resource planning, we evaluated future resource needs given various levels of demand response programs.

- **Evaluation of the demand response benefits of advanced metering infrastructure: Mid-Atlantic utility.** Conducted a comprehensive assessment of the benefits of advanced metering infrastructure (AMI) by developing dynamic pricing rates that are enabled by AMI. The analysis focused on customers in the residential class and commercial and industrial customers under 600 kW load.

- **Estimation of demand response impacts: Major California utility.** Worked with the staff of this electric utility in designing dynamic pricing options for residential and small commercial and industrial customers. These options were designed to promote demand response during critical peak days. The analysis supported the utility's advanced metering infrastructure (AMI) filing with the California Public Utilities Commission. Subsequently, the commission unanimously approved a $1.7 billion plan for rolling out nine million electric and gas meters based in part on this project work.

Smart Grid Strategy

- **Development of a smart grid investment roadmap for Vietnamese utilities.** For the five Vietnamese power corporations, developed a roadmap to guide future smart grid investment decisions. The report identified and described the various smart grid investment options, established objectives for smart grid deployment, presented a multi-phase approach to deploying the smart grid, and provided preliminary recommendations regarding the best investment opportunities. Also presented relevant case studies and an assessment of the current state of the Vietnamese power grid. The project involved in-country meetings as well as a stakeholder workshop that was conducted by Brattle staff.

- **Cost-benefit analysis of the smart grid: Rocky mountain utility.** Reviewed the leading studies on the economics of the smart grid and used the findings to assess the likely cost-effectiveness of deploying the smart grid in one geographical location.

- **Modeling benefits of smart grid deployment strategies.** Developed a model for assessing benefits of smart grid deployment strategies over a long-term (e.g., 20-year) forecast horizon. The model, called iGrid, is used to evaluate seven distinct smart grid programs and technologies (e.g., dynamic pricing, energy storage, PHEVs) against seven key metrics of value (e.g., avoided resource costs, improved reliability).

- **Smart grid strategy in Canada.** The Alberta Utilities Commission (AUC) was charged with responding to a Smart Grid Inquiry issued by the provincial government. Advised the AUC on the smart grid, and what impacts it might have in Alberta.

- **Smart grid deployment analysis for collaborative of utilities.** Adapted the iGrid modeling tool to meet the needs of a collaborative of utilities in the southern U.S. In addition to quantifying the benefits of smart grid programs and technologies (e.g., advanced metering infrastructure deployment and direct load control), the model was used to estimate the costs of installing and implementing each of the smart grid programs and technologies.

- **Development of a smart grid cost-benefit analysis framework.** For the Electric Power Research Institute (EPRI) and the U.S. DOE, contributed to the development of an approach for assessing the costs and benefits of the DOE's smart grid demonstration programs.

- **Analysis of the benefits of increased access to energy consumption information.** For a large technology firm, assessed market opportunities for providing customers with increased access to real time information regarding their energy consumption patterns. The analysis includes an assessment of deployments of information display technologies and analysis of the potential benefits that are created by deploying these technologies.

- **Developing a plan for integrated smart grid systems.** For a large California utility, helped to develop applications for funding for a project to demonstrate how an integrated smart grid system (including customer-facing technologies) would operate and provide benefits.

Demand Forecasting

- **Electricity sales and peak demand forecasting study:** For a large electric utility in South-East Asia, Brattle provided consulting services that involved assessing the performance of their load forecasting methodology and developing new models that provided more accurate forecasts.

- **Electricity consumption and maximum demand forecasting:** For a medium-sized utility in Asia-Pacific, Brattle provided consulting services on forecasting electricity consumption and maximum demand. Our work focused on analyzing drivers of growth in electricity sales, reviewed model performance, identified best practices and provided recommended approaches for analyzing trends in electricity sales and load forecasting.

- **Forecasting review.** Evaluated and critiqued the process conducted by an Australian utility company's electricity market forecasting, including the forecasting of electricity demand, supply, and price.

- **Comprehensive review of load forecasting methodology. PJM Interconnection.** Conducted a comprehensive review of models for forecasting peak demand and re-estimated new models to validate recommendations. Individual models were developed for 18 transmission zones as well as a model for the RTO system.

- **Analyzed downward trend: Western utility.** Conducted a strategic review of why sales had been lower than forecast in a year when economic activity had been brisk. Developed a forecasting model for identifying what had caused the drop in sales and its results were used in an executive presentation to the utility's board of directors. Also developed a time series model for more accurately forecasting sales in the near term and this model is now being used for revenue forecasting and budgetary planning.

- **Analyzed why models are under-forecasting: Southwestern utility.** Reviewed the entire suite of load forecasting models, including models for forecasting aggregate system peak demand, electricity consumption per customer by sector and the number of customers by sector. Ran a variety of forecasting experiments to assess both the ex-ante and ex-post accuracy of the models and made several recommendations to senior management.

- **U.S. demand forecast: Edison Electric Institute.** For the U.S. as a whole, developed a base case forecast and several alternative case forecasts of electric energy consumption by end use and sector. Subsequently developed forecasts that were based on EPRI's system of end-use forecasting models. The project was done in close coordination with several utilities and some of the results were published in book form.

- **Developed models for forecasting hourly loads: Merchant generation and trading company.** Using primary data on customer loads, weather conditions, and economic activity, developed models for forecasting hourly loads for residential, commercial, and industrial customers for three utilities in a Midwestern state. The information was used to develop bids into an auction for supplying basic generation services.

- **Gas demand forecasting system - Client: A leading gas marketing and trading company, Texas.** Developed a system for gas nominations for a leading gas marketing company that operated in 23 local distribution company service areas. The system made week-ahead and month-ahead forecasts using advanced forecasting methods. Its objective was to improve the marketing company's profitability by minimizing penalties associated with forecasting errors.

Demand-Side Management

- **The economics of biofuels.** For a western utility that is facing stringent renewable portfolio standards and that is heavily dependent on imported fossil fuels, carried out a systematic assessment of the technical and economic ability of biofuels to replace fossil fuels.

- **Assessment of demand-side management and rate design options: Large Middle Eastern electric utility.** Prepared an assessment of demand-side management and rate design options for the four operating areas and six market segments. Quantified the potential gains in economic efficiency that would result from such options and identified high priority programs for pilot testing and implementation. Held workshops and seminars for senior management, managers, and staff to explain the methodology, data, results, and policy implications.

- **Likely future impact of demand-side programs on carbon emissions - Client: The Keystone Center.** As part of the Keystone Dialogue on Climate Change, developed scenarios of future demand-side program impacts, and assessed the impact of these programs on carbon emissions. The analysis was carried out at the national level for the U.S. economy, and involved a bottom-up approach involving many different types of programs including dynamic pricing, energy efficiency, and traditional load management.

- **Sustaining energy efficiency services in a restructured market - Client: Southern California Edison.** Helped in the development of a regulatory strategy for implementing energy efficiency strategies in a restructured marketplace. Identified the various players that were likely to operate in a competitive market, such as third-party energy service companies (ESCO's) and utility affiliates. Assessed their objectives, strengths, and weaknesses and recommended a strategy for the client's adoption. This strategy allowed the client to participate in the new market place, contribute to public policy objectives, and not lose market share to new entrants. This strategy has been embraced by a coalition of several organizations involved in the California PUC's working group on public purpose programs.

- **Organizational assessments of capability for energy efficiency - Client: U.S. Agency for International Development, Cairo, Egypt.** Conducted in-depth interviews with senior executives of several energy organizations, including utilities, government agencies, and ministries to determine their goals and capabilities for implementing programs to improve energy end-use efficiency in Egypt. The interviews probed the likely future role of these organizations in a privatized energy market, and were designed to help develop U.S. AID's future funding agenda.
- **Enhancing profitability through energy efficiency services - Client: Jamaica Public Service Company.** Developed a plan for enhancing utility profitability by providing financial incentives to the client utility, and presented it for review and discussion to the utility's senior management and Jamaica's new Office of Utility Regulation. Developed regulatory procedures and legislative language to support the implementation of the plan. Conducted training sessions for the staff of the utility and the regulatory body.

Advanced Technology Assessment

- **Competitive energy and environmental technologies - Clients: Consortium of clients, led by Southern California Edison, included the Los Angeles Department of Water and Power and the California Energy Commission.** Developed a new approach to segmenting the market for electrotechnologies, relying on factors such as type of industry, type of process and end use application, and size of product. Developed a user-friendly system for assessing the competitiveness of a wide range of electric and gas-fired technologies in more than 100 four-digit SIC code manufacturing industries and 20 commercial businesses. The system includes a database on more than 200 end-use technologies, and a model of customer decision making.
- **Market infrastructure of energy efficient technologies - Client: EPRI.** Reviewed the market infrastructure of five key end-use technologies, and identified ways in which the infrastructure could be improved to increase the penetration of these technologies. Data was obtained through telephone interviews with equipment manufacturers, engineering firms, contractors, and end-use customers

TESTIMONY

Arizona

Rebuttal Testimony before the Arizona Corporation Commission on behalf of Arizona Public Service Company, in the matter of *Stacey Champion, et al., v Arizona Public Service Corporation*, Docket No. E-01345A-18-0002, August 17, 2018.

Direct Testimony before the Arizona Corporation Commission on behalf of Arizona Public Service Company, in the matter of *Stacey Champion, et al., v Arizona Public Service Corporation*, Docket No. E-01345A-18-0002, July 31, 2018.

Direct Testimony before the Arizona Corporation Commission on behalf of Arizona Public Service Company, in the matter of the Application of Arizona Public Service Company for a Hearing to Determine the Fair Value of the Utility Property of the Company for Ratemaking Purposes, to Fix a Just and Reasonable Rate of Return Thereon, to Approve Rate Schedules Designed To Develop Such Return, Docket No. E-01345A-16-0036, June 1, 2016.

Direct Testimony before the Arizona Corporation Commission on behalf of Arizona Public Service Company, in the matter of the Application for UNS Electric, Inc. for the Establishment of Just and Reasonable Rates and Charges Designed to Realize a Reasonable Rate of Return on the Fair Value of the Properties of UNS Electric, Inc. Devoted to the its Operations Throughout the State of Arizona, and for Related Approvals, Docket No. E-04204A-15-0142, December 9, 2015.

Arkansas

Direct Testimony before the Arkansas Public Service Commission on behalf of Entergy Arkansas, Inc., in the matter of Entergy Arkansas, Inc.'s Application for an Order Finding the Deployment of Advanced Metering Infrastructure to be in the Public Interest and Exemption from Certain Applicable Rules, Docket No. 16-060-U, September 19, 2016.

California

Rebuttal Testimony before the Public Utilities Commission of the State of California, Pacific Gas and Electric Company Joint Utility on Demand Elasticity and Conservation Impacts of Investor-Owned Utility Proposals, in the Matter of Rulemaking 12-06-013, October 17, 2014.

Prepared testimony before the Public Utilities Commission of the State of California on behalf of Pacific Gas and Electric Company on rate relief, Docket No. A.10-03-014, summer 2010.

Qualifications and prepared testimony before the Public Utilities Commission of the State of California, on behalf of Southern California Edison, Edison SmartConnect™ Deployment Funding and Cost Recovery, exhibit SCE-4, July 31, 2007.

Testimony on behalf of the Pacific Gas & Electric Company, in its application for Automated Metering Infrastructure with the California Public Utilities Commission. Docket No. 05-06-028, 2006.

Colorado

Rebuttal testimony before the Public Utilities Commission of the State of Colorado in the Matter of Advice Letter No. 1535 by Public Service Company of Colorado to Revise its Colorado PUC No.7 Electric Tariff to Reflect Revised Rates and Rate Schedules to be Effective on June 5, 2009. Docket No. 09al-299e, November 25, 2009.

Direct testimony before the Public Utilities Commission of the State of Colorado, on behalf of Public Service Company of Colorado, on the tariff sheets filed by Public Service Company of Colorado with advice letter No. 1535 – Electric. Docket No. 09S-__E, May 1, 2009.

Connecticut

Testimony before the Department of Public Utility Control, on behalf of the Connecticut Light and Power Company, in its application to implement Time-of-Use , Interruptible Load Response, and Seasonal Rates- Submittal of Metering and Rate Pilot Results- Compliance Order No. 4, Docket no. 05-10-03RE01, 2007.

District of Columbia

Direct testimony before the Public Service Commission of the District of Columbia on behalf of Potomac Electric Power Company in the matter of the Application of Potomac Electric Power Company for Authorization to Establish a Demand Side Management Surcharge and an Advance Metering Infrastructure Surcharge and to Establish a DSM Collaborative and an AMI Advisory Group, case no. 1056, May 2009.

Idaho

Rebuttal Testimony before the Idaho Public Utilities Commission on behalf of Idaho Power Company ("Idaho Power"), in the matter of the Application of Idaho Power Company for Authority to Establish New Schedules for Residential and Small General Service Customers with On-Site Generation, Case No. IPC-E-17-13, January 26, 2018.

Illinois

Direct testimony on rehearing before the Illinois Commerce Commission on behalf of Ameren Illinois Company, on the Smart Grid Advanced Metering Infrastructure Deployment Plan, Docket No. 12-0244, June 28, 2012.

Testimony before the Illinois Commerce Commission on behalf of Commonwealth Edison Company regarding the evaluation of experimental residential real-time pricing program, 11-0546, April 2012.

Rebuttal Testimony before the Illinois Commerce Commission on behalf of Commonwealth Edison Company in the matter of the Petition to Approve an Advanced Metering Infrastructure Pilot Program and Associated Tariffs, No. 09-0263, August 14, 2009.

Prepared rebuttal testimony before the Illinois Commerce Commission on behalf of Commonwealth Edison, on the Advanced Metering Infrastructure Pilot Program, ICC Docket No. 06-0617, October 30, 2006.

Indiana

Direct testimony before the State of Indiana, Indiana Utility Regulatory Commission, on behalf of Vectren South, on the smart grid. Cause no. 43810, 2009.

Kansas

Rebuttal testimony before the State Corporation Commission of the State of Kansas, on behalf of Westar Energy, in the matter of the Joint Application of Westar Energy, Inc. and Kansas Gas and Electric Company for Approval to Make Certain Changes in their Charges for Electric Services, Docket No. 18-WSEE-328-RTS, July 3, 2018.

Direct testimony before the State Corporation Commission of the State of Kansas, on behalf of Westar Energy, in the matter of the Joint Application of Westar Energy, Inc. and Kansas Gas and Electric Company for Approval to Make Certain Changes in their Charges for Electric Services, Docket No. 18-WSEE-328-RTS, February 1, 2018.

Reply affidavit before the State Corporation Commission of the State of Kansas, on behalf of Westar Energy, in the matter of the General Investigation to Examine Issues Surrounding Rate Design for Distributed Generation Customers, Docket No. 16-GIME-403-GIE, May 5, 2017.

Direct testimony before the State Corporation Commission of the State of Kansas, on behalf of Westar Energy, in the matter of the Application of Westar Energy, Inc. and Kansas Gas and Electric Company to Make Certain Changes in Their Charges for Electric Service, Docket No. 15-WSEE-115-RTS, March 2, 2015.

Louisiana

Direct testimony before the Council for the City of New Orleans on behalf of Entergy New Orleans, LLC, in the matter of Application of Entergy New Orleans, LLC for a Change in Electric and Gas Rates Pursuant to Council Resolutions R-15-194 and R-17-504 and for Related Relief, Docket No. UD-18-__, July 2018.

Direct testimony before the Louisiana Public Service Commission on behalf of Entergy Louisiana, LLC, in the matter of Approval to Implement a Permanent Advanced Metering System and Request for Cost Recovery and Related Relief in accordance with Louisiana Public Service Commission General Order dated September 22, 2009, R-29213, November 2016.

Direct testimony before the Council of the City of New Orleans, on behalf of Entergy New Orleans, Inc., in the matter of the Application of Energy New Orleans, Inc. for Approval to Deploy Advanced Metering Infrastructure, and Request for Cost Recovery and Related Relief, October 2016.

Maryland

Direct Testimony before the Maryland Public Service Commission, on behalf of Potomac Electric Power Company in the matter of the Application of Potomac Electric Power Company for Adjustments to its Retail Rates for the Distribution of Electric Energy, April 19, 2016.

Rebuttal Testimony before the Maryland Public Service Commission on behalf of Baltimore Gas and Electric Company in the matter of the Application of Baltimore Gas and Electric Company for Adjustments to its Electric and Gas Base Rates, Case No. 9406, March 4, 2016.

Direct testimony before the Public Service Commission of Maryland, on behalf of Potomac Electric Power Company and Delmarva Power and Light Company, on the deployment of Advanced Meter Infrastructure. Case no. 9207, September 2009.

Prepared direct testimony before the Maryland Public Service Commission, on behalf of Baltimore Gas and Electric Company, on the findings of BGE's Smart Energy Pricing ("SEP") Pilot program. Case No. 9208, July 10, 2009.

Minnesota

Rebuttal testimony before the Minnesota Public Utilities Commission State of Minnesota on behalf of Northern States Power Company, doing business as Xcel Energy, in the matter of the Application of Northern States Power Company for Authority to Increase Rates for Electric Service in Minnesota, Docket No. E002/GR-12-961, March 25, 2013.

Direct testimony before the Minnesota Public Utilities Commission State of Minnesota on behalf of Northern States Power Company, doing business as Xcel Energy, in the matter of the Application of Northern States Power Company for Authority to Increase Rates for Electric Service in Minnesota, Docket No. E002/GR-12-961, November 2, 2012.

Mississippi

Direct testimony before the Mississippi Public Service Commission, on behalf of Entergy Mississippi, Inc., in the matter of Application for Approval of Advanced Metering Infrastructure and Related Modernization Improvements, EC-123-0082-00, November 2016.

Montana

Prefiled direct testimony before the Public Service Commission of the State of Montana on behalf of NorthWestern Energy, in the matter of NorthWestern Energy's Application for Authority to Increase its Retail Electric Utility Service Rates and for Approval of its Electric Service Schedules and Rules, Docket No. D2018.2.12, September 28, 2018.

Nevada

Prepared rebuttal testimony before the Public Utilities Commission of Nevada on behalf of Nevada Power Company and Sierra Pacific Power Company d/b/a NV Energy, in the matter of net metering and distributed generation cost of service and tariff design, Docket Nos. 15-07041 and 15-07042, November 3, 2015.

Prepared direct testimony before the Public Utilities Commission of Nevada on behalf of Nevada Power Company d/b/a NV Energy, in the matter of the application for approval of a cost of service study and net metering tariffs, Docket No. 15-07, July 31, 2015.

New Mexico

Direct testimony before the New Mexico Regulation Commission on behalf of Public Service Company of New Mexico in the matter of the Application of Public Service Company of New Mexico for Revision of its Retail Electric Rates Pursuant to Advice Notice No. 507, Case No. 14-00332-UT, December 11, 2014.

Oklahoma

Rebuttal Testimony before the Corporation Commission of Oklahoma on behalf of Oklahoma Gas and Electric Company in the matter of the Application of Oklahoma Gas and Electric Company for an Order of the Commission Authorizing Applicant to modify its Rates, Charges and Tariffs for Retail Electric Service in Oklahoma, Cause No. PUD 201500273, April 11, 2016.

Direct Testimony before the Corporation Commission of Oklahoma on behalf of Oklahoma Gas and Electric Company in the matter of the Oklahoma Gas and Electric Company for an Order of the Commission Authorizing Applicant to modify its Rates, Charges and Tariffs for Retail Electric Service in Oklahoma, Cause No. PUD 201500273, December 18, 2015.

Responsive Testimony before the Corporation Commission of Oklahoma on behalf of Oklahoma Gas and Electric Company in the matter of the Application of Brandy L. Wreath, Director of the Public Utility Division, for Determination of the Calculation of Lost Net Revenues and Shared Savings Pursuant to the Demand Program Rider of Oklahoma Gas and Electric Company, Cause No. PUD 201500153, May 13, 2015.

Pennsylvania

Direct testimony before the Pennsylvania Public Utility Commission, on behalf of PECO on the Methodology Used to Derive Dynamic Pricing Rate Designs, Case no. M-2009-2123944, October 28, 2010.

Washington

Pre-filed Direct Testimony before the Washington Utilities and Transportation Commission on Behalf of Puget Sound Energy, Dockets UE-151871 and UG-151872, February 25, 2016.

REGULATORY APPEARANCES

Arkansas

Presented before the Arkansas Public Service Commission, "The Emergence of Dynamic Pricing" at the workshop on the Smart Grid, Demand Response, and Automated Metering Infrastructure, Little Rock, Arkansas, September 30, 2009.

Delaware

Presented before the Delaware Public Service Commission, "The Demand Response Impacts of PHI's Dynamic Pricing Program" Delaware, September 5, 2007.

Kansas

Presented before the State Corporation Commission of the State of Kansas, "The Impact of Dynamic Pricing on Westar Energy" at the Smart Grid and Energy Storage Roundtable, Topeka, Kansas, September 18, 2009.

Ohio

Presented before the Ohio Public Utilities Commission, "Dynamic Pricing for Residential and Small C&I Customers" at the Technical Workshop, Columbus, Ohio, March 28, 2012.

Texas

Presented before the Public Utility Commission of Texas, "Direct Load Control of Residential Air Conditioners in Texas," at the PUCT Open Meeting, Austin, Texas, October 25, 2012.

PUBLICATIONS

Books

Electricity Pricing in Transition. Co-editor with Kelly Eakin. Kluwer Academic Publishing, 2002.

Pricing in Competitive Electricity Markets. Co-editor with Kelly Eakin. Kluwer Academic Publishing, 2000.

Customer Choice: Finding Value in Retail Electricity Markets. Co-editor with J. Robert Malko. Public Utilities Inc. Vienna. Virginia: 1999.

The Changing Structure of American Industry and Energy Use Patterns. Co-editor with John Broehl. Battelle Press, 1987.

Customer Response to Time of Use Rates: Topic Paper I, with Dennis Aigner and Robert T. Howard, Electric Utility Rate Design Study, EPRI, 1981.

Chapters in Books

"Making the Most of the No Load Growth Business Environment," with Dian Grueneich. *Distributed Generation and Its Implications for the Utility Industry.* Ed. Fereidoon P. Sioshansi. Academic Press, 2014. 303-320.

"*Arcturus*: An International Repository of Evidence on Dynamic Pricing," with Sanem Sergici. *Smart Grid Applications and Developments, Green Energy and Technology.* Ed. Daphne Mah, Ed. Peter Hills, Ed. Victor O. K. Li, Ed. Richard Balme. Springer, 2014. 59-74.

"Will Energy Efficiency make a Difference," with Fereidoon P. Sioshansi and Gregory Wikler. *Energy Efficiency: Towards the end of demand growth.* Ed. Fereidoon P. Sioshansi. Academic Press, 2013. 3-50.

"The Ethics of Dynamic Pricing." *Smart Grid: Integrating Renewable, Distributed & Efficient Energy.* Ed. Fereidoon P. Sioshansi. Academic Press, 2012. 61-83.

"The Dynamics of New Construction Programs in the 90s: A Review of the North American Experience," with G.A. Wikler. *Proceedings of the 1992 Conference on New Construction Programs for Demand-Side Management*, May 1992.

"Forecasting Commercial End-Use Consumption" (Chapter 7), "Industrial End-Use Forecasting" (Chapter 8), and "Review of Forecasting Software" (Appendix 2) in *Demand Forecasting in the Electric Utility Industry.* C.W. Gellings and P.E. Lilbum (eds.): The Fairmont Press, 1992.

"Innovative Methods for Conducting End-Use Marketing and Load Research for Commercial Customers: Reconciling the Reconciled," with G.A. Wikler, T. Alereza, and S. Kidwell. *Proceedings of the Fifth National DSM Conference.* Boston, MA, September 1991.

"Time-of-Use Rates and the Modification of Electric Utility Load Shapes," with J. Robert Malko, *Challenges for Public Utility Regulation in the 1980s*, edited by H.M. Trebing, Michigan State University Public Utilities Papers, 1981.

"Implementing Time-Of-Day Pricing of Electricity: Some Current Challenges and Activities," with J. Robert Malko, *Issues in Public Utility Pricing and Regulation*, edited by M. A. Crew, Lexington Books, 1980.

Technical Reports

Analysis of Ontario's Full Scale Roll-out of TOU Rates – Final Study, with Neil Lessem, Sanem Sergici, Dean Mountain, Frank Denton, Byron Spencer, and Chris King, prepared for Independent Electric System Operator, February 2016.
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiwl7yLxLngAhWGEHwKHSD_DzQQFjAAegQIAhAC&url=http%3A%2F%2Fwww.ieso.ca%2F-%2Fmedia%2Ffiles%2Fieso%2Fdocument-library%2Fconservation-reports%2Ffinal-analysis-of-ontarios-full-scale-roll-out-of-tou-rates.pdf&usg=AOvVaw1pgHGs9arBZq2H8L2dJcJp

Quantifying the Amount and Economic Impacts of Missing Energy Efficiency in PJM's Load Forecast, with Sanem Sergici and Kathleen Spees, prepared for The Sustainable FERC Project, September 2014.

Structure of Electricity Distribution Network Tariffs: Recovery of Residual Costs, with Toby Brown, prepared for the Australian Energy Market Commission, August 2014.

Time-Varying and Dynamic Rate Design, with Ryan Hledik and Jennifer Palmer, prepared for RAP, July 2012.
https://www.raponline.org/wp-content/uploads/2016/05/rap-faruquihledikpalmer-timevaryingdynamicratedesign-2012-jul-23.pdf

The Costs and Benefits of Smart Meters for Residential Customers, with Adam Cooper, Doug Mitarotonda, Judith Schwartz, and Lisa Wood, prepared for Institute for Electric Efficiency, July 2011.
http://www.edisonfoundation.net/iee/Documents/IEE_BenefitsofSmartMeters_Final.pdf

Measurement and Verification Principles for Behavior-Based Efficiency Programs, with Sanem Sergici, prepared for Opower, May 2011.
http://files.brattle.com/files/8217_measurement_and_verification_principles_for_behavior-based_efficiency_programs_sergici_faruqui_may_2011.pdf

Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects. With R. Lee, S. Bossart, R. Hledik, C. Lamontagne, B. Renz, F. Small, D. Violette, and D. Walls. Pre-publication draft, prepared for the U. S. Department of Energy, Office of Electricity Delivery and Energy Reliability, the National Energy Technology Laboratory, and the Electric Power Research Institute. Oak Ridge, TN: Oak Ridge National Laboratory, November 28, 2009.

Moving Toward Utility-Scale Deployment of Dynamic Pricing in Mass Markets. With Sanem Sergici and Lisa Wood. Institute for Electric Efficiency, June 2009.

Demand-Side Bidding in Wholesale Electricity Markets. With Robert Earle. Australian Energy Market Commission, 2008. https://www.aemc.gov.au/sites/default/files/content/a2f43d16-f48f-4983-8776-9bc1dd71de65/Report-on-Demand-Side-Bidding-in-Wholesale-Electricity-Markets-by-The-Brattle-Group.pdf

Assessment of Achievable Potential for Energy Efficiency and Demand Response in the U.S. (2010-2030). With Ingrid Rohmund, Greg Wikler, Omar Siddiqui, and Rick Tempchin. American Council for an Energy-Efficient Economy, 2008.

Quantifying the Benefits of Dynamic Pricing in the Mass Market. With Lisa Wood. Edison Electric Institute, January 2008.

California Energy Commission. *2007 Integrated Energy Policy Report,* CEC-100-2007-008-CMF.

Applications of Dynamic Pricing in Developing and Emerging Economies. Prepared for The World Bank, Washington, DC. May 2005.

Preventing Electrical Shocks: What Ontario—And Other Provinces—Should Learn About Smart Metering. With Stephen S. George. C. D. Howe Institute Commentary, No. 210, April 2005.

Primer on Demand-Side Management. Prepared for The World Bank, Washington, DC. March 21, 2005.

Electricity Pricing: Lessons from the Front. With Dan Violette. White Paper based on the May 2003 AESP/EPRI Pricing Conference, Chicago, Illinois, EPRI Technical Update 1002223, December 2003.

Electric Technologies for Gas Compression. Electric Power Research Institute, 1997.

Electrotechnologies for Multifamily Housing. With Omar Siddiqui. EPRI TR-106442, Volumes 1 and 2. Electric Power Research Institute, September 1996.

Opportunities for Energy Efficiency in the Texas Industrial Sector. Texas Sustainable Energy Development Council. With J. W. Zarnikau et al. June 1995.

Principles and Practice of Demand-Side Management. With John H. Chamberlin. EPRI TR-102556. Palo Alto: Electric Power Research Institute, August 1993.

EPRI Urban Initiative: 1992 Workshop Proceedings (Part I). The EPRI Community Initiative. With G.A. Wikler and R.H. Manson. TR-102394. Palo Alto: Electric Power Research Institute, May 1993.

Practical Applications of Forecasting Under Uncertainty. With K.P. Seiden and C.A. Sabo.TR-102394. Palo Alto: Electric Power Research Institute, December 1992.

Improving the Marketing Infrastructure of Efficient Technologies: A Case Study Approach. With S.S. Shaffer. EPRI TR- I 0 1 454. Palo Alto: Electric Power Research Institute, December 1992.

Customer Response to Rate Options. With J. H. Chamberlin, S.S. Shaffer, K.P. Seiden, and S.A. Blanc. CU-7131. Palo Alto: Electric Power Research Institute (EPRI), January 1991.

Presentations

"Reinventing Demand Response for the Age of Renewable Energy," with Ryan Hledik, December 14, 2018.

"Enabling Grid Modernization through Alternative Rates and Alternative Regulation," with Sanem Sergici and William P. Zarakas, presented at the Energy Policy Roundtable in the PJM Footprint, November 29, 2018.

"Modernizing Distribution Tariffs for Households," presented to the Energy Consumers Association in Sydney, Australia, November 9, 2018.

"The State of Electric Vehicle Home Charging Rates," with Ryan Hledik and John Higham, presented to Colorado PUC, October 2018.

"Rate Design to Enable Flexible Loads," with Mariko Geronimo Aydin, presented at APPA Business & Financial Conference 2018, September 18, 2018.

"Customer-driven Rate Design is the Wave of the Future," presented at the Colorado Rural Electric Association Managers Association Meeting, September 10, 2018.

"Understanding the Costs and Benefits of Electrification: Electrification Cost-Benefit Case Studies," presented at the Electric Power Research Institute (EPRI) Electrification 2018 International Conference & Exposition, August 23, 2018.

"Do Load Shapes of PV Customers Differ From Other Customers?" with Walter Graf, Presented at the Center for Research in Regulated Industries (CRRI) 31st Annual Western Conference, June 28, 2018.

"Tariffs of the Future for Gas Utilities," with Léa Grausz, Henna Trewn, and Cecile Bourbonnais, presented at the Center for Research in Regulated Industries (CRRI) 31st Annual Western Conference, June 28, 2018.

"Collecting Allowed Revenues When Demand is Declining," with Henna Trewn and Léa Grausz, presented at the Center for Research in Regulated Industries (CRRI) 31st Annual Western Conference, June 28, 2018.

"Incentivizing the Adoption of Gas-Fueled Emerging Technologies with Pricing Tools," with Léa Grausz, presented at the 27th World Gas Conference, June 25, 2018.

"Estimating the Impact of Innovative Rate Designs," presented to Southern California Edison, June 7, 2018.

"Rate Design 3.0 and The Efficient Pricing Frontier," presented at the EUCI 2018 Residential Demand Charges Conference, Nashville, TN, May 15, 2018.

"Does Dynamic Pricing of Electricity Eliminate the Need for Demand Charges?" presented at the Harvard Electricity Policy Group's (HEPG) 89th Plenary Session, January 25, 2018.

"Dynamic Pricing: What Can We Learn From Other Jurisdictions?" presented at the California Public Utilities Commission's (CPUC) Electric Rate Forum, December 12, 2017.

"Demand Charges and Dynamic Pricing Are Complements, Not Substitutes," presented at the California Public Utilities Commission's (CPUC) Electric Rate Forum, December 11, 2017.

"Dynamic Pricing Works in a Hot and Humid Climate: Evidence from Florida," with Sanem Sergici and Neil Lessem, presented at the International Energy Policy & Programme Evaluation Conference, November 2, 2017.

"A Hybrid Model for Forecasting Electricity Sales and Peak Demand: A Case Study of TNB in Malaysia," with Sanem Sergici and Neil Lessem, presented at the International Energy Policy & Programme Evaluation Conference, November 2, 2017.

"Workshop on Pricing Reforms," with Neil Lessem, Presented to Energy Networks Association (ENA), October 17, 2017.

"A Walk on the Frontier of Rate Design," with Cody Warner, presented to the Western Farmers Electric Cooperative's Residential Demand Workshop, October 5, 2017.

"The Future of Tariff Reform: A Global Survey," with Léa Grausz and Hallie Cramer, presented to the Indiana Energy Association's (IEA) Annual Energy Conference, September 28, 2017.

"Forecasting the Impact of DSM on Energy Sales," with Zhen Wang, presented to the Edison Electric Institute (EEI), September 14, 2017.

"A Global Survey of Customer-centric Tariff Reforms," with Neil Lessem, presented to the Commerce Commission, Wellington, New Zealand, August 24, 2017.

"The Public Benefits of Leasing Energy Efficient Equipment: A Utility Case Study," with Henna Trewn and Neil Lessem, presented at the Center for Research in Regulated Industries' (CRRI) 30th Annual Western Conference, June 30, 2017.

"Estimating the Impact of DSM on Energy Sales Forecasts: A Survey of Utility Practices," with James Hall and Zhen Wang, presented at the Center for Research in Regulated Industries' (CRRI) 30th Annual Western Conference, June 29, 2017.

"Moving Forward with Tariff Reform," presented during the EEI Webinar on Rate Design, April 6, 2017.

"An Irreverent Take on Customer Research in Our Industry," presented at the EPRI Workshop: Understanding Customer Preferences for and Adoption of New Services and Technology, April 4, 2017.

"The Tariffs of Tomorrow," presented at the University of California, Davis Energy Efficiency Center Seminar, January 11, 2017.

"Residential Demand Charges, Distributional Effects and Energy Storage," with contributions from Ryan Hledik, presented during the Edison Electric Institute (EEI) Grid Talk Webinar, November 17, 2016.

"Curating the Future of Rate Design," presented at the EUCI's Residential Demand Charges Conference, October 20, 2016.

"Understanding Residential Customer Response to Demand Charges: Present and Future," with Sanem Sergici and Ryan Hledik, presented at EUCI's Residential Demand Charges Conference, October 20, 2016.

"Technology's Role, Rates and Customers, 1985-2016," presented at the Wisconsin Public Utility Institute, August 16, 2016.

"Dynamic Pricing & Demand Response," with Sanem Sergici, presented at IPU's 58th Annual Regulatory Studies Program: The Fundamentals Course, August 11, 2016.

"Retail Costing and Pricing for Electricity," with Philip Q Hanser and Sanem Sergici, presented at IPU's 58th Annual Regulatory Studies Program: The Fundamentals Course, August 11, 2016.

"Emerging Issues in Forecasting Energy Consumption," with Josephine Duh and Zhen Wang, Presented at the CRRI Western Conference 2016, June 24, 2016.

"A Three-Year Impact Evaluation of TOU Rates in Ontario, Canada," with Neil Lessem, presented at the Center for Research in Regulated Industries (CRRI) 29th Annual Western Conference, June 23, 2016.

"Capturing Smart Meter Enabled Benefits in System Wide Rollouts: June 23, 2016," presented at the Center for Research in Regulated Industries (CRRI) 29th Annual Western Conference, June 23, 2016.

"Residential Rates for the Utility of the Future," presented at Grid Edge World Forum 2016, June 22, 2016.

"Residential Rates for the Utility of the Future," presented to the Alternative Rate Design Stakeholder Process for Xcel Energy, May 13, 2016.

"Modeling Customer Response to Xcel Energy's RD-TOU Rate," with Ryan Hledik, presented to Xcel Energy, April 21, 2016.

"Residential Demand Charges: An Overview," presented at the EEI Rate Committee Meeting, March 15, 2016.

"A Conversation about Standby Rates," presented to Standby Rate Working Group Michigan Public Service Commission, January 20, 2016.

Articles and Papers

"Transitioning to Modern Residential Rate Designs," with Lea Grausz and Cecile Bourbonnais, Public Utility Fortnightly, January 2019.
https://www.fortnightly.com/fortnightly/2019/01/transitioning-modern-residential-rate-designs

"Status of Residential Time-of-Use Rates in the U.S.," with Ryan Hledik and Cody Warner, *Public Utilities Fortnightly*, November 1, 2018.
https://www.fortnightly.com/fortnightly/2018/11/status-residential-time-use-rates-us

"Net Metering FAQ – Rate design and subsidies," with Steve Mitnick, *Public Utilities Fortnightly,* October 2018.
https://www.fortnightly.com/fortnightly/2018/10/net-metering-faq

"Rate Design 3.0 – Future of Rate Design," *Public Utilities Fortnightly*, May 2018.
https://www.fortnightly.com/fortnightly/2018/05/rate-design-30

Book Review – 'Modernizing America's Electricity Infrastructure' by Mason Wilrich, *Public Utilities Fortnightly*, May 2018.
https://www.fortnightly.com/fortnightly/2018/05/mason-willrichs-modernizing-americas-electricity-infrastructure

"Do Load Shapes of PV Customers Differ?" with Walter Graf, *Public Utilities Fortnightly*, February 2018.
https://www.fortnightly.com/fortnightly/2018/02/do-load-shapes-pv-customers-differ

"Arcturus 2.0: A meta-analysis of time-varying rates for electricity," with Sanem Sergici and Cody Warner, *The Electricity Journal*, 30:10, December 2017, pp. 64-72.
https://www.sciencedirect.com/science/article/pii/S1040619017302750

"Moving Forward with Tariff Reform," with Mariko Geronimo Aydin, *Energy Regulation Quarterly*, Volume 5, Issue 4, December 2017.
http://www.energyregulationquarterly.ca/articles/moving-forward-with-tariff-reform#sthash.ZADdmZ2h.D2l1yz9z.dpbs

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

"Moving Forward with Electricity Tariff Reform," with Mariko Geronimo Aydin, *Regulation*, Fall 2017.
https://object.cato.org/sites/cato.org/files/serials/files/regulation/2017/9/regulation-v40n3-5.pdf

"Enhancing Customer-Centricity," with Henna Trewn, *Public Utilities Fortnightly*, August 2017.
https://www.fortnightly.com/fortnightly/2017/08/enhancing-customer-centricity

"The Public Benefits of Leasing Energy Efficient Equipment," with Neil Lessem and Henna Trewn, *The Electricity Journal*, 30:6, July 2017, pp. 8-16.
http://www.sciencedirect.com/science/article/pii/S1040619017301513

"Rethinking Customer Research in the Utility Industry," with Henna Trewn, *Public Utilities Fortnightly*, July 2017.
https://www.fortnightly.com/fortnightly/2017/07/rethinking-customer-research

"Do Manufacturing Firms Relocate in Response to Rising Electric Rates?" with Sanem Sergici, *Energy Regulation Quarterly*, 5:2, June 2017.
http://www.energyregulationquarterly.ca/articles/do-manufacturing-firms-relocate-in-response-to-rising-electric-rates#sthash.uLnrPMwh.dpbs

"Dynamic Pricing Works in a Hot, Humid Climate," with Neil Lessem and Sanem Sergici, *Public Utilities Fortnightly*, May 2017.
https://www.fortnightly.com/fortnightly/2017/05/dynamic-pricing-works-hot-humid-climate

"The impact of advanced metering infrastructure on energy conservation: A case study of two utilities," with Kevin Arritt and Sanem Sergici, *The Electricity Journal*, 30:3, April 2017, pp. 56-63.
http://www.sciencedirect.com/science/article/pii/S1040619017300726

"The impact of AMI-enabled conservation voltage reduction on energy consumption and peak demand," with Kevin Arritt and Sanem Sergici, *The Electricity Journal*, 30:2, March 2017, pp. 60-65.
http://www.sciencedirect.com/science/article/pii/S1040619016302536

"Overcoming the Over-Forecasting Bias of Pure Econometric Models: A utility case study," with Josephine Duh and Ingrid Rohmund, *Electricity Policy*, February 2017.

"The Impact of Time-of-Use Rates in Ontario," with Neil Lessem, Sanem Sergici, and Dean Mountain, *Public Utilities Fortnightly*, February 2017.
https://www.fortnightly.com/fortnightly/2017/02/impact-time-use-rates-ontario

"Competing Perspectives on Demand Charges," with Ryan Hledik, *Public Utilities Fortnightly*, September 2016.
https://www.fortnightly.com/fortnightly/2016/09/competing-perspectives-demand-charges

"An Economist's Dilemma: To PV or Not to PV, That Is the Question," *Electricity Policy*, March 2016.
http://files.brattle.com/files/5834_2016_to_pv_or_not_to_pv__faruqui14march2016.pdf
"Response to King-Datta Re: Time-Varying Rates," *Public Utilities Fortnightly*, March 2016.
https://www.fortnightly.com/fortnightly/2016/03/response-king-datta-re-time-varying-rates

"Impact Measurement of Tariff Changes when Experimentation is not an Option – A case study of Ontario, Canada," with Sanem Sergici, Neil Lessem, and Dean Mountain, *Energy Economics*, 52, December 2015, pp. 39-48.

"Efficient Tariff Structures for Distribution Network Services," with Toby Brown and Lea Grausz, *Economic Analysis and Policy*, 48, December 2015, pp. 139-149.

"The Emergence of Organic Conservation," with Ryan Hledik and Wade Davis, *The Electricity Journal*, Volume 28, Issue 5, June 2015, pp. 48-58.
http://www.sciencedirect.com/science/article/pii/S1040619015001074

"The Paradox of Inclining Block Rates," with Ryan Hledik and Wade Davis, *Public Utilities Fortnightly*, April 2015.
http://www.fortnightly.com/fortnightly/2015/04/paradox-inclining-block-rates

"Smart By Default," with Ryan Hledik and Neil Lessem, *Public Utilities Fortnightly*, August 2014.
http://www.fortnightly.com/fortnightly/2014/08/smart-default?page=0%2C0&authkey=e5b59c3e26805e2c6b9e469cb9c1855a9b0f18c67bbe7d8d4ca08a8abd39c54d

"Quantile Regression for Peak Demand Forecasting," with Charlie Gibbons, SSRN, July 31, 2014.
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2485657

"Study Ontario for TOU Lessons," *Intelligent Utility*, April 1, 2014.
http://www.intelligentutility.com/article/14/04/study-ontario-tou-lessons?quicktabs_11=1&quicktabs_6=2

"Impact Measurement of Tariff Changes When Experimentation is Not an Option – a Case Study of Ontario, Canada," with Sanem Sergici, Neil Lessem, and Dean Mountain, SSRN, March 2014.
http://ssrn.com/abstract=2411832

"Dynamic Pricing in a Moderate Climate: The Evidence from Connecticut," with Sanem Sergici and Lamine Akaba, *Energy Journal*, 35:1, pp. 137-160, January 2014.

"Charting the DSM Sales Slump," with Eric Schultz, *Spark*, September 2013.
http://spark.fortnightly.com/fortnightly/charting-dsm-sales-slump

"Arcturus: International Evidence on Dynamic Pricing," with Sanem Sergici, *The Electricity Journal*, 26:7, August/September 2013, pp. 55-65. http://www.sciencedirect.com/science/article/pii/S1040619013001656

"Dynamic Pricing of Electricity for Residential Customers: The Evidence from Michigan," with Sanem Sergici and Lamine Akaba, *Energy Efficiency*, 6:3, August 2013, pp. 571–584.

"Benchmarking your Rate Case," with Ryan Hledik, *Public Utility Fortnightly*, July 2013. http://www.fortnightly.com/fortnightly/2013/07/benchmarking-your-rate-case

"Surviving Sub-One-Percent Growth," *Electricity Policy*, June 2013. http://files.brattle.com/files/6849_surviving_sub-one percent_growth_faruqui_electricity_policy_june_2013.pdf

"Demand Growth and the New Normal," with Eric Shultz, *Public Utility Fortnightly*, December 2012. http://www.fortnightly.com/fortnightly/2012/12/demand-growth-and-new-normal?page=0%2C1&authkey=4a6cf0a67411ee5e7c2aee5da4616b72fde10e3fbe215164cd4e5dbd8e9d0c98

"Energy Efficiency and Demand Response in 2020 – A Survey of Expert Opinion," with Doug Mitarotonda, March 2012.
Available at SSRN: http://ssrn.com/abstract=2029150

"Dynamic Pricing for Residential and Small C&I Customers," presented at the Ohio Public Utilities Commission Technical Workshop, March 28, 2012.
https://emp.lbl.gov/sites/default/files/oh-techsupport-faruqui.pdf

"The Discovery of Price Responsiveness – A Survey of Experiments Involving Dynamic Pricing of Electricity," with Jennifer Palmer, *Energy Delta Institute*, Vol.4, No. 1, April 2012.
https://issuu.com/edi_quarterly/docs/edi2030_quarterly_1_april

"Green Ovations: Innovations in Green Technologies," with Pritesh Gandhi, *Electric Energy T&D Magazine*, January-February 2012.
https://electricenergyonline.com/energy/magazine/618/article/Green-Ovations-Innovations-in-Green-Technologies.htm

"Dynamic Pricing of Electricity and its Discontents" with Jennifer Palmer, *Regulation*, Volume 34, Number 3, Fall 2011, pp. 16-22.
http://files.brattle.com/files/6373_dynamic_pricing_of_electricity_and_its_discontents_faruqui_aug_3_2011.pdf

"Smart Pricing, Smart Charging," with Ryan Hledik, Armando Levy, and Alan Madian, *Public Utility Fortnightly*, Volume 149, Number 10, October 2011.

"The Energy Efficiency Imperative" with Ryan Hledik, *Middle East Economic Survey*, Vol LIV: No. 38, September 19, 2011.

"Are LDCs and customers ready for dynamic prices?" with Jürgen Weiss, *Fortnightly's Spark*, August 25, 2011.

"Dynamic pricing of electricity in the mid-Atlantic region: econometric results from the Baltimore gas and electric company experiment," with Sanem Sergici, *Journal of Regulatory Economics,* 40:1, August 2011, pp. 82-109.

"Better Data, New Conclusions," with Lisa Wood, *Public Utilities Fortnightly*, March 2011, pp. 47-48.

"Residential Dynamic Pricing and 'Energy Stamps,'" *Regulation,* Volume 33, No. 4, Winter 2010-2011, pp. 4-5.
http://www.cato.org/pubs/regulation/regv33n4/v33n4.html

"Dynamic Pricing and Low-Income Customers: Correcting misconceptions about load-management programs," with Lisa Wood, *Public Utilities Fortnightly*, November 2010, pp. 60-64.
https://www.fortnightly.com/fortnightly/2010/11/dynamic-pricing-and-low-income-customers

"The Untold Story: A Survey of C&I Dynamic Pricing Pilot Studies" with Jennifer Palmer and Sanem Sergici, *Metering International,* ISSN: 1025-8248, Issue: 3, 2010, p.104.

"Household response to dynamic pricing of electricity–a survey of 15 experiments," with Sanem Sergici, *Journal of Regulatory Economics* (2010), 38:193-225.

"Unlocking the €53 billion savings from smart meters in the EU: How increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment," with Dan Harris and Ryan Hledik, *Energy Policy*, Volume 38, Issue 10, October 2010, pp. 6222-6231.
http://www.sciencedirect.com/science/article/pii/S0301421510004738

"Fostering economic demand response in the Midwest ISO," with Attila Hajos, Ryan Hledik, and Sam Newell, *Energy*, Volume 35, Issue 4, Special Demand Response Issue, April 2010, pp. 1544-1552.
http://www.sciencedirect.com/science/article/pii/S0360544209004009

"The impact of informational feedback on energy consumption – A survey of the experimental evidence," with Sanem Sergici and Ahmed Sharif, *Energy*, Volume 35, Issue 4, Special Demand Response Issue, April 2010, pp. 1598-1608. http://www.sciencedirect.com/science/article/pii/S0360544209003387

"Dynamic tariffs are vital for smart meter success," with Dan Harris, *Utility Week*, March 10, 2010.

"Rethinking Prices," with Ryan Hledik and Sanem Sergici, *Public Utilities Fortnightly*, January 2010, pp. 31-39. https://www.fortnightly.com/fortnightly/2010/01/rethinking-prices

"Piloting the Smart Grid," with Ryan Hledik and Sanem Sergici, *The Electricity Journal,* Volume 22, Issue 7, August/September 2009, pp. 55-69.
http://www.sciencedirect.com/science/article/pii/S1040619009001663

"Smart Grid Strategy: Quantifying Benefits," with Peter Fox-Penner and Ryan Hledik, *Public Utilities Fortnightly*, July 2009, pp. 32-37.
https://www.fortnightly.com/fortnightly/2009/07/smart-grid-strategy-quantifying-benefits

"The Power of Dynamic Pricing," with Ryan Hledik and John Tsoukalis, *The Electricity Journal*, April 2009, pp. 42-56.
http://www.sciencedirect.com/science/article/pii/S1040619009000414

"Transition to Dynamic Pricing," with Ryan Hledik, *Public Utilities Fortnightly*, March 2009, pp. 26-33.
http://www.fortnightly.com/display_pdf.cfm?id=03012009_DynamicPricing.pdf

"Ethanol 2.0," with Robert Earle, *Regulation*, Winter 2009.
https://object.cato.org/sites/cato.org/files/serials/files/regulation/2008/11/v31n4-noted.pdf#page=1

"Inclining Toward Efficiency," *Public Utilities Fortnightly*, August 2008, pp. 22-27.
https://www.fortnightly.com/fortnightly/2008/08/inclining-toward-efficiency

"California: Mandating Demand Response," with Jackalyne Pfannenstiel, *Public Utilities Fortnightly*, January 2008, pp. 48-53.

"Avoiding Load Shedding by Smart Metering and Pricing," with Robert Earle, *Metering International*, Issue 1 2008, pp. 76-77.

"The Power of 5 Percent," with Ryan Hledik, Sam Newell, and Hannes Pfeifenberger, *The Electricity Journal*, October 2007, pp. 68-77.
http://www.sciencedirect.com/science/article/pii/S1040619007000991

"Pricing Programs: Time-of-Use and Real Time," *Encyclopedia of Energy Engineering and Technology*, September 2007, pp. 1175-1183.

"Breaking Out of the Bubble: Using demand response to mitigate rate shocks," *Public Utilities Fortnightly*, March 2007, pp. 46-48 and pp. 50-51.
https://www.fortnightly.com/fortnightly/2007/03/demand-response-breaking-out-bubble

"From Smart Metering to Smart Pricing," *Metering International*, Issue 1, 2007.

"Demand Response and the Role of Regional Transmission Operators," with Robert Earle, *2006 Demand Response Application Service*, Electric Power Research Institute, 2006.

"2050: A Pricing Odyssey," *The Electricity Journal*, October, 2006.
https://www.researchgate.net/publication/222677841_2050_A_Pricing_Odyssey

"Demand Response and Advanced Metering," Regulation, Spring 2006. 29:1 24-27.

"Reforming electricity pricing in the Middle East," with Robert Earle and Anees Azzouni, *Middle East Economic Survey (MEES)*, December 5, 2005.

"Controlling the thirst for demand," with Robert Earle and Anees Azzouni, *Middle East Economic Digest (MEED)*, December 2, 2005.

"California pricing experiment yields new insights on customer behavior," with Stephen S. George, *Electric Light & Power*, May/June 2005.
http://www.elp.com/index/display/article-display/229131/articles/electric-light-power/volume-83/issue-3/departments/news/california-pricing-experiment-yields-new-insights-on-customer-behavior.html

"Quantifying Customer Response to Dynamic Pricing," with Stephen S. George, *Electricity Journal*, May 2005.

"Dynamic pricing for the mass market: California experiment," with Stephen S. George, *Public Utilities Fortnightly*, July 1, 2003, pp. 33-35.

"Toward post-modern pricing," Guest Editorial, *The Electricity Journal*, July 2003.

"Demise of PSE's TOU program imparts lessons," with Stephen S. George. *Electric Light & Power*, January 2003, pp.1 and15.

"2003 Manifesto on the California Electricity Crisis," with William D. Bandt, Tom Campbell, Carl Danner, Harold Demsetz, Paul R. Kleindorfer, Robert Z. Lawrence, David Levine, Phil McLeod, Robert Michaels, Shmuel S. Oren, Jim Ratliff, John G. Riley, Richard Rumelt, Vernon L. Smith, Pablo Spiller, James Sweeney, David Teece, Philip Verleger, Mitch Wilk, and Oliver Williamson. May 2003. Posted on the AEI-Brookings Joint Center web site, at
http://www.aei-brookings.org/publications/abstract.php?pid=341

"Reforming pricing in retail markets," with Stephen S. George. *Electric Perspectives*, September/October 2002, pp. 20-21.

"Pricing reform in developing countries,*" Power Economics*, September 2002, pp. 13-15.

"The barriers to real-time pricing: separating fact from fiction," with Melanie Mauldin, *Public Utilities Fortnightly*, July 15, 2002, pp. 30-40.

"The value of dynamic pricing," with Stephen S. George, *The Electricity Journal*, July 2002, pp. 45-55.

"The long view of demand-side management programs," with Gregory A. Wikler and Ingrid Bran, in *Markets, Pricing and Deregulation of Utilities*, Michael A. Crew and Joseph C. Schuh, editors, Kluwer Academic Publishers, 2002, pp. 53-68.

"Time to get serious about time-of-use rates," with Stephen S. George, *Electric Light & Power*, February 2002, Volume 80, Number 2, pp. 1-8.

"Getting out of the dark: Market based pricing can prevent future crises," with Hung-po Chao, Vic Niemeyer, Jeremy Platt and Karl Stahlkopf, *Regulation*, Fall 2001, pp. 58-62.

"Analyzing California's power crisis," with Hung-po Chao, Vic Niemeyer, Jeremy Platt and Karl Stahlkopf, *The Energy Journal*, Vol. 22, No. 4, pp. 29-52.

"Hedging Exposure to Volatile Retail Electricity Prices," with Bruce Chapman, Dan Hansen and Chris Holmes, *The Electricity Journal*, June 2001, pp. 33-38.

"California Syndrome," with Hung-po Chao, Vic Niemeyer, Jeremy Platt and Karl Stahlkopf, *Power Economics*, May 2001, Volume 5, Issue 5, pp. 24-27.

"The choice not to buy: energy savings and policy alternatives for demand response," with Steve Braithwait, *Public Utilities Fortnightly*, March 15, 2001.

"Tomorrow's Electric Distribution Companies," with K. P. Seiden, *Business Economics*, Vol. XXXVI, No. 1, January 2001, pp. 54-62.

"Bundling Value-Added and Commodity Services in Retail Electricity Markets," with Kelly Eakin, *Electricity Journal*, December 2000.

"Summer in San Diego," with Kelly Eakin, *Public Utilities Fortnightly*, September 15, 2000.

"Fighting Price Wars," *Harvard Business Review*, May-June 2000.

"When Will I See Profits?" *Public Utilities Fortnightly*, June 1, 2000.

"Mitigating Price Volatility by Connecting Retail and Wholesale Markets," with Doug Caves and Kelly Eakin, *Electricity Journal*, April 2000.

"The Brave New World of Customer Choice," with J. Robert Malko, appears in *Customer Choice: Finding Value in Retail Electricity Markets*, Public Utilities Report, 1999.

"What's in Our Future?" with J. Robert Malko, appears in *Customer Choice: Finding Value in Retail Electricity Markets*, Public Utilities Report, 1999.

"Creating Competitive Advantage by Strategic Listening," *Electricity Journal*, May 1997.

"Competitor Analysis," *Competitive Utility*, November 1996.

"Forecasting in a Competitive Environment: The Need for a New Paradigm," *Demand Forecasting for Electric Utilities*, Clark W. Gellings (ed.), 2nd edition, Fairmont Press, 1996.

"Defining Customer Solutions through Electrotechnologies: A Case Study of Texas Utilities Electric," with Dallas Frandsen et al. *ACEEE 1995 Summer Study on Energy Efficiency in Industry*. ACEEE: Washington, D.C., 1995.

"Opportunities for Energy Efficiency in the Texas Industrial Sector," *ACEEE 1995 Summer Proceedings.*

"Study on Energy Efficiency in Industry," with Jay W. Zarnikau et al. *ACEEE*: Washington, D.C., 1995.

"Promotion of Energy Efficiency through Environmental Compliance: Lessons Learned from a Southern California Case Study," with Peter F. Kyricopoulos and Ishtiaq Chisti. *ACEEE 1995 Summer Study on Energy Efficiency in Industry.* ACEEE: Washington, D.C., 1995.

"ATLAS: A New Strategic Forecasting Tool," with John C. Parker et al. Proceedings: *Delivering Customer Value, 7th National Demand-Side Management Conference.* EPRI: Palo Alto, CA, June 1995.

"Emerging Technologies for the Industrial Sector," with Peter F. Kyricopoulos et al. *Proceedings: Delivering Customer Value, 7th National Demand-Side Management Conference.* EPRI: Palo Alto, CA, June 1995.

"Estimating the Revenue Enhancement Potential of Electrotechnologies: A Case Study of Texas Utilities Electric," with Clyde S. King et al. *Proceedings: Delivering Customer Value, 7th National Demand-Side Management Conference. EPRI*: Palo Alto, CA, June 1995.

"Modeling Customer Technology Competition in the Industrial Sector," *Proceedings of the 1995 Energy Efficiency and the Global Environment Conference*, Newport Beach, CA, February 1995.

"DSM opportunities for India: A case study," with Ellen Rubinstein, Greg Wikler, and Susan Shaffer, *Utilities Policy*, Vol. 4, No. 4, October 1994, pp. 285-301.

"Clouds in the Future of DSM," with G.A. Wikler and J.H. Chamberlin. *Electricity Journal*, July 1994.

"The Changing Role of Forecasting in Electric Utilities," with C. Melendy and J. Bloom. *The Journal of Business Forecasting*, pp. 3-7, Winter 1993–94. Also appears as "IRP and Your Future Role as Forecaster." *Proceedings of the 9th Annual Electric Utility Forecasting Symposium. Electric Power Research Institute (EPRI).* San Diego, CA, September 1993.

"Stalking the Industrial Sector: A Comparison of Cutting Edge Industrial Programs," with P.F. Kyricopoulos. *Proceedings of the 4CEEE 1994 Summer Study on Energy Efficiency in Buildings.* ACEEE: Washington, D.C., August 1994.

"Econometric and End-Use Models: Is it Either/Or Both?" with K. Seiden and C. Melendy. *Proceedings of the 9th Annual Electric Utility Forecasting Symposium. Electric Power Research Institute (EPRI)*. San Diego, CA, September 1993.

"Savings from Efficient Electricity Use: A United States Case Study," with C.W. Gellings and S.S. Shaffer. *OPEC Review*, June 1993.

"The Trade-Off Between All-Ratepayer Benefits and Rate Impacts: An Exploratory Study," *Proceedings of the 6th National DSM Conference.* With J.H. Chamberlin. Miami Beach, FL. March 1993.

"The Potential for Energy Efficiency in Electric End-Use Technologies," with G.A. Wikler, K.P. Seiden, and C.W. Gellings. *IEEE Transactions on Power Systems.* Seattle, WA, July 1992.

"Potential Energy Savings from Efficient Electric Technologies," with C.W. Gellings and K.P. Seiden. *Energy Policy*, pp. 217–230, April 1991.

"Demand Forecasting Methodologies: An overview for electric utilities," with Thomas Kuczmowski and Peter Lilienthal, *Energy: The International Journal*, Volume 15, Issues 3-4, March-April 1990, pp. 285-296.

"The role of demand-side management in Pakistan's electric planning," *Energy Policy*, August 1989, pp. 382-395.

"Pakistan's Economic Development in a Global Perspective: A profile of the first four decades, 1947-87," with J. Robert Malko, *Asian Profile*, Volume 16, No. 6, December 1988.

"The Residential Demand for Electricity by Time-of-Use: A survey of twelve experiments with peak load pricing," with J. Robert Malko, *Energy: The International Journal*, Volume 8, Issue 10, October 1983, pp. 781-795.

"Incorporating the Social Imperatives in Economic Structure: Pakistan in the years ahead," *The Journal of Economic Studies*, Volume 1, No. 1, Autumn 1974.

Summary of Residential Three-Part Tariffs

#	Utility	Utility Ownership	State	Residential Customers Served	Fixed charge ($/month)	Demand Charge ($/kW-month) Summer	Demand Charge ($/kW-month) Winter	Timing of demand measurement	Demand interval	Combined with Energy TOU?	Applicable Residential Customer Segment	Mandatory or Voluntary
[1]	Alabama Power	Investor Owned	AL	1,262,752	14.50	1.50	1.50	Any time	15 min	Yes	All	Voluntary
[2]	Alaska Electric Light and Power	Investor Owned	AK	14,466	11.13	6.51	10.76	Any time	Unknown	No	All	Voluntary
[3]	Albemarle Electric Membership Corp	Cooperative	NC	11,545	27.00	13.50	13.50	Peak Coincident	15 min	Yes	All	Voluntary
[4]	Alliant Energy (IPL)	Investor Owned	IA	402,199	11.50	17.40	11.62	Peak Coincident	60 min	Yes	All	Voluntary
[5]	Alliant Energy (WPL)	Investor Owned	WI	405,804	15.04	3.00	3.00	Peak Coincident	60 min	Yes	All	Voluntary
[6]	Arizona Public Service	Investor Owned	AZ	1,061,814	13.02	8.40	8.40	Peak Coincident	60 min	Yes	All	Voluntary
[7]	Arizona Public Service	Investor Owned	AZ	1,061,814	13.02	17.44	12.24	Peak Coincident	60 min	Yes	All	Voluntary
[8]	Black Hills Power	Investor Owned	SD	55,637	13.00	8.10	8.10	Any time	15 min	No	All	Voluntary
[9]	Black Hills Power	Investor Owned	WY	2,063	15.50	8.25	8.25	Any time	15 min	No	All	Voluntary
[10]	Butler Rural Electric Cooperative	Cooperative	KS	6,585	31.00	5.10	5.10	Peak Coincident	60 min	No	All	Mandatory
[11]	Butte Electric Cooperative	Cooperative	SD	4,910	45.00	9.50	9.50	Unknown	Unknown	No	All	Voluntary
[12]	Carteret-Craven Electric Cooperative	Cooperative	NC	35,805	30.00	11.95	9.95	Peak Coincident	15 min	No	All	Voluntary
[13]	Central Electric Membership Corp	Cooperative	NC	20,026	34.00	8.55	7.50	Peak Coincident	15 min	Yes	All	Voluntary
[14]	City of Fort Collins Utilities	Municipal	CO	62,770	6.16	2.60	2.60	Any time	Unknown	No	All	Voluntary
[15]	City of Glasgow	Municipal	KY	5,456	24.16	11.86	10.87	Peak Coincident	30 min	Yes	All	Voluntary
[16]	City of Kinston	Municipal	NC	9,702	14.95	9.35	9.35	Peak Coincident	15 min	No	All	Voluntary
[17]	City of Longmont	Municipal	CO	35,721	16.60	5.75	5.75	Any time	15 min	No	All	Voluntary
[18]	City of Templeton	Municipal	MA	3,500	3.00	8.00	8.00	Any time	15 min	No	All*	Mandatory
[19]	Cobb Electric Membership Corporation	Cooperative	GA	182,132	28.00	5.55	5.55	Peak Coincident	60 min	No	All	Voluntary
[20]	Dakota Electric Association	Cooperative	MN	96,982	12.00	14.70	11.10	Any time	15 min	No	All	Voluntary
[21]	Dominion Energy	Investor Owned	NC	102,079	16.39	9.76	5.66	Peak Coincident	30 min	Yes	All	Voluntary
[22]	Dominion Energy	Investor Owned	VA	2,173,471	11.53	5.46	3.79	Peak Coincident	30 min	Yes	All	Voluntary
[23]	Duke Energy Carolinas, LLC	Investor Owned	NC	1,669,923	14.00	7.83	3.92	Peak Coincident	30 min	Yes	All	Voluntary
[24]	Duke Energy Carolinas, LLC	Investor Owned	SC	478,509	9.93	8.15	4.00	Peak Coincident	30 min	Yes	All	Voluntary
[25]	Edgecombe-Martin County EMC	Cooperative	NC	10,369	31.00	8.75	8.00	Peak Coincident	Unknown	No	All	Voluntary
[26]	Flathead Electric Cooperative	Cooperative	MT	53,896	23.71	0.26	0.26	Peak Coincident	60 min	No	All	Mandatory
[27]	Fort Morgan	Municipal	CO	4,989	8.17	10.22	10.22	Unknown	Unknown	No	All	Voluntary
[28]	Georgia Power	Investor Owned	GA	2,144,447	10.00	6.64	6.64	Any time	30 min	Yes	All	Voluntary
[29]	Kentucky Utilities Company	Investor Owned	KY	426,225	12.25	7.87	7.87	Peak Coincident	15 min	No	All	Voluntary
[30]	Lakeland Electric	Municipal	FL	105,937	9.50	5.60	5.60	Peak Coincident	30 min	No	All	Voluntary
[31]	Lincoln Electric Cooperative	Cooperative	MT	5,056	39.39	0.75	0.75	Any time	15 min	No	All	Voluntary
[32]	Louisville Gas and Electric	Investor Owned	KY	356,424	12.25	7.68	7.68	Peak Coincident	15 min	No	All	Voluntary
[33]	Loveland Electric	Municipal	CO	31,458	23.50	9.80	7.35	Any time	15 min	No	All	Voluntary
[34]	Mid-Carolina Electric Cooperative	Cooperative	SC	48,265	24.00	12.00	12.00	Peak Coincident	60 min	No	All	Mandatory
[35]	Midwest Energy Inc	Cooperative	KS	29,976	22.00	6.40	6.40	Any time	15 min	No	All	Voluntary
[36]	NV Energy (SPP)	Investor Owned	NV	291,401	10.25	0.35 (daily)	0.35 (daily)	Peak Coincident	15 min	No	All	Voluntary
[37]	NV Energy (SPP)	Investor Owned	NV	291,401	15.25	0.26 (daily)	0.93 (daily)	Peak Coincident	15 min	Yes	All	Voluntary
[38]	Oklahoma Gas and Electric Company	Investor Owned	AR	55,190	9.75	1.00	1.00	Any time	15 min	No	All	Voluntary
[39]	Otter Tail Power Company	Investor Owned	MN	48,186	11.00	8.00	8.00	Any time	60 min	No	All	Voluntary
[40]	Otter Tail Power Company	Investor Owned	ND	45,790	18.38	6.52	2.63	Any time	60 min	No	All	Voluntary
[41]	Otter Tail Power Company	Investor Owned	SD	8,710	13.00	7.05	5.93	Any time	60 min	No	All	Voluntary
[42]	PacifiCorp	Investor Owned	OR	498,227	13.30	2.20	2.20	Unknown	Unknown	No	All	Voluntary
[43]	Pee Dee Electric Membership Cooperative	Cooperative	SC	28,754	34.40	8.50	7.00	Peak Coincident	Unknown	Yes	All	Voluntary
[44]	Platte-Clay Electric Cooperative	Cooperative	MO	21,070	25.38	2.50	2.50	Peak Coincident	60 min	No	All	Mandatory

[45]	Progress Energy Carolinas	Investor Owned	NC	1,162,473	16.85	4.88	3.90	Peak Coincident	15 min	Yes	All	Voluntary
[46]	Progress Energy Carolinas	Investor Owned	SC	136,294	11.91	5.38	4.14	Peak Coincident	15 min	Yes	All	Voluntary
[47]	Salt River Project	Political Subdivision	AZ	928,721	32.44	11.13	4.54	Peak Coincident	30 min	Yes	NEM Only	Voluntary
[48]	Salt River Project	Political Subdivision	AZ	928,721	32.44	21.94	8.13	Peak Coincident	30 min*	Yes	NEM Only	Voluntary
[49]	Santee Cooper Electric Cooperative	Cooperative	SC	32,829	50.00	6.00	6.00	Peak Coincident	30 min	Yes	NEM only	Mandatory
[50]	Smithfield	Municipal	NC	3,400	17.00	5.93	5.93	Peak Coincident	15 min	Yes	All	Voluntary
[51]	South Carolina Electric & Gas Company	Investor Owned	SC	605,717	14.00	12.04	8.60	Peak Coincident	15 min	Yes	All	Voluntary
[52]	Sun River Electric Cooperative	Cooperative	MT	4,460	32.00	4.00	4.00	Unknown	Unknown	No	All	Mandatory
[53]	Swanton Village Electric Department	Municipal	VT	3,236	11.33	9.17	9.17	Any time	15 min	No	All*	Mandatory
[54]	Tideland Electric Membe' Corp	Cooperative	NC	18,540	31.00	10.35	9.40	Peak Coincident	15 min	No	All	Voluntary
[55]	Tri-County Electric Cooperative	Cooperative	FL	16,131	23.00	7.00	7.00	Any time	15 min	No	All	Voluntary
[56]	Traverse Electric Cooperative, Inc.	Cooperative	MN	1,819	76.00	18.65	18.65	Peak Coincident	Unknown	No	All	Voluntary
[57]	Tucson Electric Power	Investor Owned	AZ	378,992	10.00	8.85	8.85	Peak Coincident	60 min	Yes	All	Voluntary
[58]	Tucson Electric Power	Investor Owned	AZ	378,992	10.00	8.85	8.85	Peak Coincident	60 min	No	All	Voluntary
[59]	Vigilante Electric Cooperative	Cooperative	MT	8,273	26.00	0.50 per KVA	0.50 per KVA	Any time	Unknown	No	All*	Mandatory
[60]	Westar Energy	Investor Owned	KS	327,214	16.50	6.91	2.13	Any time	30 min	No	All	Voluntary
[61]	Xcel Energy (PSCo)	Investor Owned	CO	1,228,305	19.31	10.08	7.76	Any time	15 min	No	All	Voluntary
[62]	Xcel Energy (PSCo)	Investor Owned	CO	1,228,305	6.54	13.38	10.46	Peak Coincident	60 min	No	All	Voluntary

Sources: Utility tariffs as of September 2018, and EIA Form 861 from 2016 (for Utility ownership and Residential Customers Served columns).

Notes:

For some utilities, the monthly fixed charge has been calculated by multiplying a daily charge by 30.5.
When the utility offered different basic service charges for single-phase and three-phase services, the single-phase service charge was selected.

[2]: Mandatory if customer consumes more than 5,000 kWh per month for three consecutive months or has a recorded peak demand of 20 KW for three consecutive months.

[4]: Only offered on a pilot basis. The billing demand is the sum of the highest hourly demand during on-peak hours of the current month plus 50% of the amount by which the highest hourly demand during the off-peak hours exceeds the highest on-peak demand.

[6]-[7]: The monthly fixed charge is a daily basic service charge multiplied by 30.5 days.

[8]-[9]: Black Hills also offers an optional time-of-use rate that includes both energy and demand charges for customers owning demand controllers.

[18]: *The demand charge only applies to demand measured in excess of 10 kW.

[22]: Demand charge is the sum of the distribution demand charge and the generation demand charge. The distribution demand charge is $1.549/kW and the generation demand charge is $3.910/kW for the summer and $2.242/kW for the winter.

[33]: The demand rate is closed to new customers after December 31, 2014.

[35]: The demand charge is based on the greater of the highest average 15 minute kW demand measured during the period for which the bill is rendered, and 80% of the average 15 minute maximum demand for the last three summer months.

[36]-[37]: Rates will be in place starting October 1, 2018. The billing demand is calculated as the sum of the customer's daily 15-min maximum demand during the billing period.

[39]-[41]: Demand is measured as the maximum winter demand for the most recent 12 months. New customers have an assumed demand of 3 kW for their first year. Fixed charge for MN is customer charge per month plus facilities charge per month. Fixed charge for ND and SD is just customer charge per month.

[42]: The demand charge is only applicable to three-phase customers.

[44]: Billing demand is the greater of the current month actual demand or 50% of peak demand established in the preceding eleven months.

[47]: Customers below 200 amps pay a fixed charge of $32.44 per month and customers above 200 amps pay $45.44 per month. Demand charges vary across three seasons: Winter, Summer (May, June, September, and October), and On-Peak Summer (July and August). The summer demand charges shown here apply for the On-Peak Summer period. The (on-peak) summer demand charge is $7.89 for up to 3kW of demand, $14.37 for the next 7kW, and $27.28 for over 10kW. The winter demand charge is $3.49 for up to 3kW, $5.58 for the next 7kW, and $9.57 over 10kW.

[48]: Customers below 200 amps pay a fixed charge of $32.44 per month and customers above 200 amps pay $45.44 per month. Demand charges vary across three seasons: Winter, Summer (May, June, September, and October), and On-Peak Summer (July and August). The summer demand charges shown here apply for the On-Peak Summer period. The Summer period demand charge is $19.29/kW. *The billing demand in each billing cycle is the average of the daily maximum 30-min integrated kW demands occurring during the on-peak periods of that billing cycle.

[53]: The demand charge is based on the greater of the measured demand for the current month and 85% of the highest recorded demand established during the preceding eleven months. *The rate is mandatory for all residential customers with monthly consumption equal to or greater than 1,800 kWh, measured on a rolling 12 month average basis.

[54]: The basic service charge is calculated as the average of the overhead service charge ($30/month) and the underground service charge ($32/month).

[57]-[58]: The demand charge is $8.85/kW for the first 7kW and $12.85/kW for any additional kWs.

[59]: *The demand charge applies only to KVA greater than 15 KVA.

MEMORANDUM

TO:	Steve Wills
FROM:	Sanem Sergici and Ahmad Faruqui
SUBJ:	Sample Size Calculations for Ameren Missouri's Three-part Rate Pilot
DATE:	June 25, 2019

I. Introduction

Ameren Missouri is proposing to implement a three-part rate pilot ("the pilot") for its residential customers. The purpose of the pilot is to test how the residential customers respond to three-part rate by modifying their usage pattern and develop an understanding of their perceptions of the rate through pre- and post-pilot surveys. Ultimately, the pilot will help to determine whether a three-part tariff is beneficial for residential customers as well as Ameren Missouri, thus informing the decision of whether the three-part tariff should be expanded to all customers through a future full-scale offering.

The pilot must be designed with a sufficient degree of methodological rigor in order to produce meaningful and useful results. Ameren Missouri commissioned The Brattle Group to provide advice on the design of the pilot. This memorandum provides an overview of Brattle's recommended experimental design for the pilot, and develops the required sample size for the pilot to yield statistically significant results.

II. Experimental Design Approach

To be credible and useful to policy makers, a pilot needs to be based on a scientific experimental design. That is the only way to ensure that it will have both internal and external validity. "Internal validity" means that a cause and effect relationship can be established between the treatment being tested in the pilot and the outcome of interest. The task requires excluding the effects of all other variables from the equation. "External validity" means that the results from the pilot program can be extrapolated to the population of interest.

Internal Validity

A control group needs to be set aside that will represent the "but-for" usage of the treatment group. Without a control group in the design, it is impossible to account for non-treatment variables that differ between the pre-treatment and treatment periods (such as the weather, the economy, or general changes in attitudes toward energy use brought about by other exogenous factors). Internal validity also requires a sufficient amount of pre-treatment data (baseline period data) to be collected to verify that the treatment and control groups were indistinguishable from each other before the treatment was introduced. If systematic pretreatment differences exist, they may cause the pilot to yield biased results, since the impacts attributed to the treatment in the pilot may in fact be attributable to other differences between the treatment and control groups.

Having pre-treatment data on both the control and treatment groups as well as the treatment- period data enables a *difference-in-differences* approach. In Figure 1 below, the values of the outcomes of interest, such as peak period usage, are represented by C1 and T1 for the control and treatment customer groups respectively. The treatment period outcomes are represented by C2 and T2. The difference between the change in treated customer behavior and the change in control customer behavior, represented by {(T2-T1)-(C2-C1)}, is the estimated effect of the program.

Figure 1: Treatment and Control Group Observations

	Control Group	**Treatment Group**
Pre-Treatment	C1	T1
Post-Treatment	C2	T2

Without a control group in the program design (i.e., relying on only (T2-T1)), it is not possible to control for all external factors that may change between the pre-treatment and treatment periods, such as macroeconomic changes or general changes in attitudes toward energy use brought about by other exogenous factors. Without pre-treatment data (i.e., relying on only (C2-T2)), it is difficult to verify that the treatment and control groups were truly comparable before the treatment was introduced. When systematic pre-treatment differences exist, that will bias the estimated effect size. Panel studies, with treatment and control customers and pre-treatment and treatment period data, are thus most powerful and most likely to produce internally valid estimates.

External Validity

The recruitment of the treatment group should mimic the likely larger scale deployment of the program. For example, if the pilot participants opt-in to the pilot, while the large scale program is likely to be offered on an opt-out basis, then the pilot conclusions should be interpreted carefully before transferring to the full-scale rollout of these rates. It is also important to note that efforts to boost customer experience and satisfaction with the pilot (such as shadow bills or bill protection or both) should only be pursued to the extent that these efforts are also going to be offered under the full-scale roll out. It is our understanding that Ameren Missouri is not planning to offer shadow bills and bill protection to the pilot customers at this time.

There are three widely used and accepted pilot design methods: randomized controlled trial ("RCT"), randomized encouragement design ("RED"), and random sampling with matched control group. We provide an overview of these three methods in Table 1 below.

Table 1 : Summary of Pilot Design Approaches

Possible Pilot Design Approaches	Description and Pros/Cons
Randomized Controlled Trial ("RCT")	Involves a random assignment of the recruited customers into the treatment and control groups. While this is the most rigorous approach from a measurement perspective, it is rarely used by electric utilities due to a potentially adverse impact on customer satisfaction (as it would involve either "recruit-and-deny" or "recruit-and-delay" approaches for some portion of the recruited customers).
Randomized Encouragement Design ("RED")	Allows the researcher to construct a valid control group, maintaining the benefits of an RCT design by not negatively affecting the customer experience. However, it requires much larger sample sizes, relative to the RCT approach, in order to be able to detect a statistically significant impact. Large sample sizes increase pilot implementation costs.
Random Sampling with Matched Control Group	Involves recruiting treated customers from a randomly selected sample, and using regression analysis to identify and match customers from the rest of the population that are most similar to the treatment customers. This matched control group approach strikes a good balance between achieving statistically valid results and requiring a manageable level of pilot participants.

Assessing the pros and cons of each approach as well as the practical and budget implications of customer recruitment with Ameren Missouri, the three-part rate pilot was designed using "random sampling with matched control group approach".

Under this pilot design approach, there is again randomization in selecting pilot participants, in that the utility randomly selects customers for the pilot offer. Customer recruitment may necessitate multiple waves or stages; randomization is used to determine the set of customers approached in each wave. The control group is chosen from the set of customers who were never approached for the pilot. Regression analysis is performed on these customers based on observable data, such as overall usage, peak usage, zip-code information, and other factors and a "propensity score" is estimated for each customer. This propensity score can be thought of as the probability of a customer to opt-in to the pilot based on their observable characteristics, had they been approached to. For each participating customer, the unapproached customer whose propensity score is most similar to the treatment customer is placed in the control group.1

This approach is known as a "quasi-experimental" approach, and is slightly less robust than the two experimental approaches discussed in Table 1 above. However, the ability to identify a control group that is similar to the treatment group on a variety of observable dimensions significantly mitigates concerns that there would be systematic differences between the two groups. Furthermore, this approach avoids the negative customer experience risks associated with the RCT approach and should have significantly lower customer recruitment costs than the RED approach.

III. Sample Size Calculations

"Sample size" refers to the number of participants (treatment customers) in a pilot. It is a critical element of pilot design. If the sample size is too small, it may not be possible to precisely detect impacts on the key variables that are of interest. A larger sample will increase the ability to detect impacts with precision, but will require a larger associated budget for customer recruitment.

A method known as "statistical power" estimation can be used to determine the minimum sample size that will likely be needed to produce statistically significant results.[2] In other words, the statistical power calculation can be used to establish a pilot recruitment target which is likely to accomplish the objectives of the pilot without exceeding pre-defined budget limitations.

1 It is possible that individual unapproached customers will be the closest match for more than one pilot participant and thus receive more weight in the ultimate difference-in-differences analysis.

2 More precisely, a statistical power calculation provides the degree of statistical significance with which a given impact can be detected for a given sample of customers.

There are several important parameters that are inputs to the statistical power analyses to determine the treatment and control group sample sizes. Some of these parameters are assumed, such as statistical significance levels and power of the test, some of them are calculated using hourly load data from a representative sample of 800 Ameren Missouri residential customers. These are summarized in Table 2 below.

It is important to note that Ameren Missouri's proposed three-part tariff has a seasonal variation with a peak/offpeak ratio of roughly 6/1 in the summer and 3.6/1 in the winter.[3] Based on the data from previous pilots, the expected peak reduction impacts are 12.3% and 9.3%, respectively for the summer and winter P/OP ratios. To be conservative, we calculated the Ameren pilot sample size to be able to detect a smaller impact of 6%. Resulting sample size would be large enough to detect any impact greater than 6%, including the impact of demand charges.

Table 2 : Statistical Power Calculation Parameters

Parameter	Description	Ameren Missouri Pilot Value
Minimum Detectable Difference (MDD)	• Refers to the minimum difference between the mean usages of treatment and control groups that can be reliably quantified, given a statistical precision criteria and size of the analysis sample.	• Assumed an MDD of 6%
Significance Level of Test (Type I error)	• Sample sizes should be determined such that one does not commit a Type I error in the measurements, that is, one does not incorrectly conclude that there is an impact due to the program treatment when in reality there is not	• 95% confidence level (or statistical significant at the 5% level)
Power of the Test (1- Type II error)	• Sample sizes should also be determined such that one does not commit a Type II error in the measurements, that is, one does not incorrectly conclude that there is no program impact while in reality there is an impact	• Assumed 80% power

3 These ratios are higher when demand charges are taken into account and applied to non-overnight hours. This implies that any sample size determined assuming a smaller P/OP ratio (and therefore smaller minimum detectable impact) should be sufficient to detect the impact of the demand charge.

Number of Repeat Observations	• Number of observations per household before and after the program	• Assumed 3 months of pre-treatment and 3 months of treatment data per household for each season
Correlation Coefficients	• Degree to which electric consumption is similar over time for a given household in the treatment and/or control groups	• Correlation between pre-treatment usages (r0): 0.79 • Correlation between post-treatment usages (r1): 0.76 • Correlation between pre- and post-treatment usages (r01): 0.69
Mean peak usage and Standard deviation	• Amount that electricity consumption varies across households within each group	• Mean peak usage: 1.57 kWh/h • St. dev: 1.38

Our statistical power calculations, based on the discussion and parameters above, have yielded a treatment sample size of 537 customers. It is likely that some of the pilot participants will drop out of the pilot over time (e.g., due to moving out of the service territory). This potential attrition in participation should be accounted for in the final sample size determination. Assuming 20% annual customer churn rate, the proposed sample size for the Ameren Missouri three-part rate pilot is 670 customers. In addition to the 670 customers that will be recruited for the pilot, the pilot will also include a matched control group of 670 customers.

THE Brattle GROUP

Privileged and Confidential
Prepared at the Request of Counsel

MEMORANDUM

TO: Steve Wills

FROM: Sanem Sergici and Ahmad Faruqui

SUBJ: Pilot Implementation Best Practices

DATE: June 25, 2019

I. Background

Ameren Missouri is proposing to implement a three-part rate pilot ("the pilot") for its residential customers. The purpose of the pilot is to test how the residential customers respond to three-part rate by modifying their usage patterns and develop an understanding of their perceptions of the rate through pre and post pilot surveys. The pilot must be designed with a sufficient degree of methodological rigor in order to produce meaningful and useful results.

The Brattle Group assisted Ameren Missouri with the experimental design of the pilot and developed the required sample size for the pilot to yield statistically significant results. However, there are other important elements of the pilots that should be carefully planned in advance for a smooth deployment of the pilot program. In this memorandum, we discuss these elements.

II. Recruitment Process

A well-planned pilot design requires balancing budgetary and practical considerations against research design features required to maintain the internal and external validity of the resulting research. A scientifically valid experimental design (as Brattle developed for Ameren Missouri's pilot and discussed in Schedule AF-D3) is a necessary but not a sufficient condition to ensure internal and external validity of the pilot. Practices followed in the recruitment process play an equally key role in maintaining the validity of the pilot design. Below, we discuss the main elements of the recruitment process.

A. Sampling Frame

Once the pilot design approach is determined (*i.e.*, opt-in, default, etc.), a sampling frame for the pilot must be determined. A sampling frame refers to a population from which a sample will be recruited to participate in a program and expected to yield inferences about the population from which it originates. The Ameren Missouri's three-part rate pilot is an opt-in program for residential customers; therefore the "*eligible residential population*" constitutes the sampling frame. For the purposes of this pilot, we may define eligible customers: i) to include customers with at least one year of AMI data at the start of the pilot; ii) to include those customers who have been residing at the same address for at least a year at the start of the pilot program, iii) to exclude customers on the budget billing plans, iv) to exclude customers with medical need flags and v) to exclude those customers who have been included in the control group for other utility programs, if any.

B. Sample Size

Once the sampling frame is determined, the next step is to run "statistical power analysis" to determine the treatment and control group sample sizes required to achieve a pre-determined statistical precision level. Details of the statistical power analysis is discussed in Schedule AF-D3.

It is likely that some of the pilot participants will drop out of the pilot over time (*e.g.*, due to moving out of the service territory). This potential attrition in participation should be accounted for in the final sample size determination.

C. Recruitment Materials

After determining the target sample sizes, the next step is to develop recruitment materials to sign up customers to the pilot. It is typical to undertake "focus group" research during this planning stage to test the effectiveness of different messaging and communication methods with the customers. In a focus group, customers who are eligible for participation in a program participate in a moderated discussion to share their perceptions of or reactions to a product, and in this case educational and recruitment materials that would be used for enrolling customers in the pilot. For instance, customers could be presented with bill inserts introducing the three-part rate pilot, in different formats and lengths. Several different versions of the pilot value proposition may be shared with the customers to identify the message that resonates the best with them. Focus groups can also test the effectiveness of different educational materials and assess whether customers find detailed bill analyses useful for their decision to enroll in the pilot.

Once the focus groups are concluded, the information gathered is summarized in a systematic way and utilized to finalize the recruitment materials.

D. Recruitment Strategy

Ideally, recruitment method (*e.g.*, direct mail, telemarketing, e-marketing, door-to-door) would mimic the approach that would be used in a future large-scale deployment of the rates tested. To the extent that this is known, it would be beneficial to use this approach in the pilot because it reduces the concern that different recruitment methods attract different types of customers and the pilot participants might be different from the participants of a larger scale program if it uses a different method. On the other hand, it would be valuable to test the effectiveness of different recruitment methods during the pilot and identify their cost-effectiveness as well as characteristics of customers responding to different methods. This information would be beneficial for a future large-scale deployment of these rates.[1]

Sometimes, availability of time emerges as an important determinant of the recruitment method. Certain recruitment processes take longer than others and the preferred method may not fit within the time frame available to complete the recruitment. For example, direct mail recruitment into a program or experiment can take several months of calendar time in order to achieve maximum enrollment, as multiple waves of marketing materials must be sent to targeted households. On the other hand, the same level of enrollment might be achievable through telemarketing or e-marketing in a few days' time. However, it is important to take into account whether telemarketing or e-marketing do not systematically exclude a certain fractions of the eligible population, such as elderly or non-tech savvy customers.

Once the recruitment method is determined, the next step is to determine the number of customers that will be targeted for recruitment. This number is a function of pilot sample size and estimated take-rates (other utility marketing efforts can be used as a guidance to inform these take rates) For instance, if the desired sample size is 600, and the expected take-rate is 2%, 30,000 customers should be targeted for recruitment. Typically, these customers are sent recruitment materials in multiple waves to minimize marketing costs. Using the same example, if the first wave involves 10,000 customers and yields 500 enrolled customers, the take-rate turns out to be 5%. This implies that the next wave can involve only 2000 customers to yield another 100 customers, and require sending marketing materials to only 2000 customers instead of 10,000 customers.

It is important to ensure that the team responsible for recruitment is following the pre-established protocols for recruitment. The team should be trained on the importance of internal and external validity of the pilot and consider the impact of potential deviations from the plan on the internal

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[1] See for details: https://www.smartgrid.gov/files/EPRI.pdf

and external validity. It is also essential to have a dedicated pilot project manager who oversees all pilot related activities and decisions.

E. Enrollment Process

When customers decide to enroll in a pilot, they are typically asked to call a utility call center number to officially sign up for the pilot. Call-center representatives ask several "eligibility screening questions" to potential enrollees to confirm their eligibility for the pilot. They may also implement a short pre-pilot survey to collect some additional information that might be useful for impact evaluation purposes (*e.g.*, income, housing type, etc.). Eligibility screening and pre-pilot survey questions should be prepared in advance and call-center representatives should follow a script in executing these questionnaires.

Sometimes, utilities offer "thank you incentives" to pilot participants for answering various questionnaires/surveys throughout the pilot. Typically, each pilot participant is paid two incentives: one at the beginning for answering the pre-pilot survey questions and one at the end for answering the post-pilot survey questions. These are typically in the range of $25 to $100. It is important not to present these thank you payments as sign-up incentives because the pilot should not attract certain types customers who are drawn to these incentives instead of being interested in the pilot objectives.

F. Pilot Metrics, Data Requirements and Data Collection Methods

While the recruitment is underway, metrics to be measured and tracked in the pilot should be identified. These metrics (*e.g.*, change in the customer peak demand, change in the overall usage level, program acceptance/attrition rates; reported behavior changes etc.) will determine the types of data to be collected and the data collection methods that will be utilized. Some of these metrics will require the collection of the interval data, while the others will require collection and classification of survey data. The length of the treatment period, the availability and amount of pre-treatment data are also important to identify during this stage.

To the extent that the data will be transferred between the utility and an impact evaluation vendor, a "data management plan" should be developed early on, along with the data collection templates. This plan should be complied with at all stages of data development, management, and transfer. This plan should also identify the timing associated with each data collection step.

Another key step at the data requirements stage is identifying the systems and materials that will be needed to execute data collection and processing. Required systems and materials can be expensive and if not properly anticipated, can put an entire experiment at risk of delay or even failure. Making modifications to existing utility systems to support an experiment may be more costly and risky than working around such systems through outsourcing.[2] It is also important to develop operational protocols to ensure that exposure to the treatment is systematically controlled throughout the experiment.

III. Impact Evaluation Approach

It is essential to develop an impact evaluation approach or a measurement and verification plan prior to a pilot's execution. This plan will largely help with the identification of pilot metrics and data requirements, but also provide a roadmap for the evaluators in analyzing the data from the pilot.

Impact evaluation approach is closely tied to the treatments tested, therefore it varies from one pilot to the other. However, if it is feasible to obtain multiple measurements of the treatment and control group customers both in the pre-treatment and treatment periods, the precision of the impacts could be greatly improved. These estimations employ a "panel data or cross-sectional time-series" technique which is based on comparing the same individuals over time as well as comparing different individuals at a given point in time, through regression models. Panel regressions also allow for the testing of a broad range of hypotheses in addition to the estimation of the load impacts, provided that the program is run and measurements are taken over a sufficiently long time period. For example, do the treatment impacts persist over time? Do the treatment impacts vary seasonally?

It is ideal to follow a two-prong approach to impact evaluation. The first prong involves models to estimate ex-post load impacts resulting from the implementation of pilot treatments. The second prong involves models to estimate own and substitution price elasticities representing customers' sensitivity to prices. These estimated elasticities will allow modeling the impact of prices that are different from those tested in the pilots. This is important because the prices in a future full-scale roll-out might be different from those tested in the pilot.

2 See for details: https://www.smartgrid.gov/files/EPRI.pdf

IV. Process Evaluation

In addition to the impact evaluation described above, process evaluation is a typical component of any measurement and verification effort. A process evaluation typically consists of an assessment of the implementation of the program, with the goal of producing better and more cost-effective pilot programs in the future. This assessment can typically be conducted by surveying or soliciting feedback from the various groups involved in the pilot program, including both participants (customers in the treatment group), implementers and administrators of the program. These data collection efforts should be used to evaluate the program along several dimensions, including:

- Customer recruitment and outreach
- Customer acceptance and interest in rates tested (post-pilot surveys)
- Profile of customers interested in rates tested
- Understanding the reasons for non-participation
- Understanding the reasons for participant attrition;
- Quality control practices
- Time, schedule and budget management
- Lessons learned
- Project resource constraints and staff training
- In-field and back-office challenges with implementation

The variety of perspectives allows the process evaluator to develop a well-rounded evaluation of aspects of program implementation, which can in turn be used to identify and describe program strengths and weaknesses. Ultimately, this type of evaluation can highlight the successes of the program as well as identifying possible improvements to program processes and designs. It may also provide guidance as to the scalability of the impacts. For example, if the feedback from the recruitment phase indicates widespread customer resistance to the pricing approach, it may have implications for the general applicability and external validity of the results.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Union Electric Company d/b/a Ameren Missouri's Tariffs to Decrease Its Revenues for Electric Service.	)))	File No. ER-2019-0335

AFFIDAVIT OF AHMAD FARUQUI

STATE OF California)
) ss
CITY OF San Ramon)

Ahmad Faruqui, being first duly sworn on his oath, states:

1. My name is Ahmad Faruqui. I work in the City of San Francisco, and I am employed by The Brattle Group as Principal.

2. Attached hereto and made a part hereof for all purposes is my Direct Testimony on behalf of Union Electric Company d/b/a Ameren Missouri consisting of 20 pages and Schedule(s) AF-D1 to AF-D4, all of which have been prepared in written form for introduction into evidence in the above-referenced docket.

3. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded are true and correct.

Ahmad Faruqui

Subscribed and sworn to before me this 28th day of June, 2019.

Notary Public

My commission expires: 09/17/2021

BADAL DHOLARIA
COMM. # 2214676
NOTARY PUBLIC-CALIFORNIA
CONTRA COSTA
My Commission Expires
SEPTEMBER 17, 2021