BEFORE THE STATE CORPORATION COMMISSION

OF THE STATE OF KANSAS

In the Matter of the Joint Application of Westar Energy, Inc. and Kansas Gas and Electric Company to Make Certain Changes in Their Charges for Electric Services	))))	Docket No. 18-WSEE-328-RTS

DIRECT TESTIMONY ON REMAND

OF

AHMAD FARUQUI

ON BEHALF OF

EVERGY KANSAS CENTRAL, INC. AND EVERGY KANSAS SOUTH, INC.

DOCKET NO. 18-WSEE-328-RTS

Q. What is your name and address?

A. My name is Ahmad Faruqui. I am a Principal with the Brattle Group, an economics consulting firm. My address is 201 Mission Street, Suite 2800, San Francisco, California 94105.

Q. On whose behalf are you submitting testimony?

A. I am testifying on behalf of Evergy.

Q. What is the purpose of your testimony?

A. I will review alternative solutions to the "free-rider problem" identified by the Kansas Supreme Court in matters pertaining to the installation of distributed generation ("DG"), including rooftop solar panels, by certain residential customers on their premises. Based on that review, I will recommend a primary solution for the Commission's consideration. I will also recommend a secondary solution.

Q. How is your testimony organized?

A. I begin by presenting my qualifications. Second, I review the policy issues associated with the installation of DG like rooftop solar panels by some residential customers. Third, I discuss alternative solutions identified by the Court. Fourth, I compute cross-subsidies associated with each solution and rank them based on various considerations. Fifth, I provide my recommendations.

Q. What are your qualifications as they pertain to this testimony?

A. I am an energy economist specializing in issues related to the consumption of energy. These include rate design, load flexibility, energy efficiency, demand response, distributed energy resources, demand forecasting, decarbonization, and electrification. In my career, I have advised 150 clients on five continents and appeared before regulatory bodies, governments, and legislative councils in Alberta (Canada), Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Egypt, FERC, Georgia, Illinois, Indiana, Iowa, Jamaica, Kansas, Kentucky, Michigan, Maryland, Minnesota, Missouri, Nevada, New Brunswick (Canada), Nova Scotia (Canada), Ohio, Oklahoma, Ontario (Canada), Pennsylvania, Philippines, Saudi Arabia (ECRA), Texas and Washington.

I have authored or coauthored more than 100 papers in peer-reviewed and trade journals and co-edited 4 books on industrial structural change, customer choice, and electricity pricing. My work has been cited in Bloomberg, Business Week, Economist, Forbes, and National Geographic in addition to Los Angeles Times, The New York Times, San Francisco Chronicle, San Jose Mercury News and Washington Post. I have appeared on Fox Business News and NPR.
I have taught economics at San Jose State, UC Davis and the University of Karachi and delivered guest lectures at Carnegie Mellon, Harvard, Idaho, MIT, New York, Northwestern, Rutgers, Stanford, UC Berkeley and UC Davis. I hold an MA in

Agricultural Economics and a PhD in Economics from UC Davis, and a BA and an MA in Economics from the University of Karachi.

Q. Have you been previously involved in discussions related to setting distributed generation rates before the Kansas Corporation Commission?

A. Yes, I have been involved in the 2015 General Rate Case, the generic DG docket and the 2018 General Rate Case. My involvement in electricity pricing matters in Kansas goes back to 2009. I have presented at a workshop on dynamic pricing and carried out other analyses related to smart grid strategies and energy efficiency.

Q. What are the policy issues associated with the installation of DG such as solar panels on the roofs of certain customers?

A. The primary policy issue associated with the installation of rooftop solar panels by residential DG customers is that it dramatically reduces the amount of power that DG customers buy from Evergy. If these customers are on standard two-part rates, the bulk of their bill consists of a volumetric charge. As the volume comes down, their bill goes down. But the cost to serve them does not go down as dramatically. In the case of Evergy, RS-DG customers purchase significantly less energy from the utility without reducing their demand by a corresponding amount – about a 49% reduction in energy with a less than 5% change in demand.[1] Furthermore, as shown below, the RS-DG customer's "net load profile" which results from combining the customer's load profile with the anticipated generation from a solar source is significantly different from the load profile of a non-DG residential customer.[2] A large portion of the cost to serve customers is fixed. It does not go down with volume. So, RS-DG customers do not pay the full cost of serving them, thereby creating the free rider problem identified by the Kansas Supreme Court. That deficiency in payment is ultimately recovered from RS (i.e., non-DG) customers.

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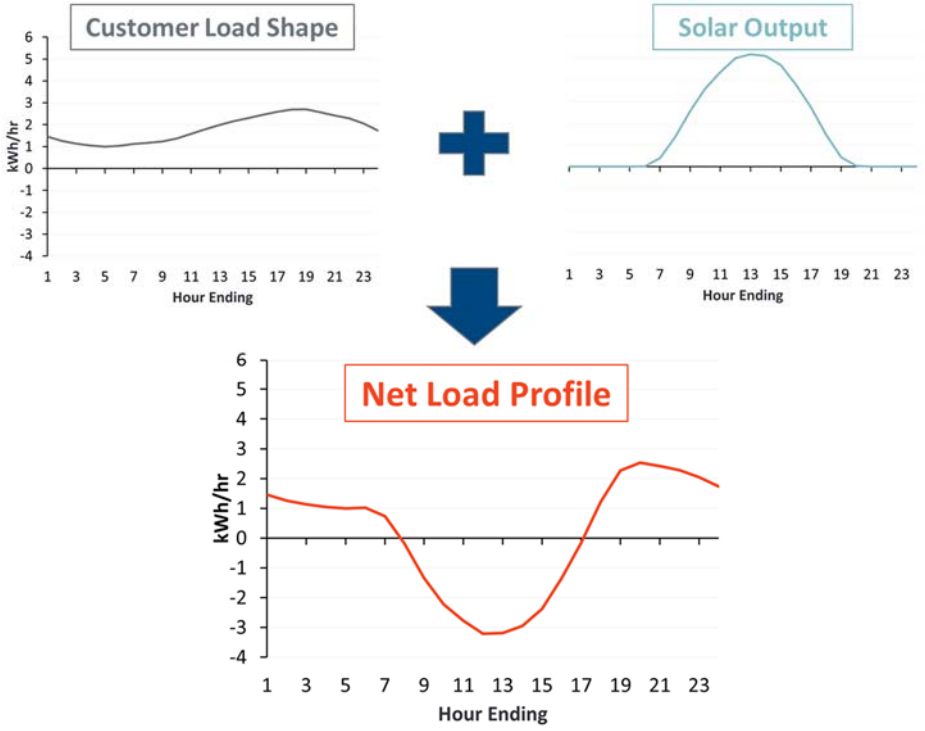
[1] Faruqui, Tr. at 194-95, Docket No. 16-GIME-403-GIE, incorporated into the record in above-captioned docket through administrative notice, *see* Tr., Vol. I, p. 182; Exhibit 4, Docket No. 16-GIME-403-GIE, incorporated into the record in above-captioned docket through administrative notice, *see* Tr., Vol. I, p. 182.

[2] Initial Faruqui Affidavit, Figure 2 at page 4.

Figure 1: Residential Customer Load Profile, Average Summer Day



Notes: Solar data based on Wichita, KS. Load data based on Westar's 2013 residential load research sample.

Q. Are there any policy issues associated with the use of two-part rates for residential DG customers?

A. Yes. Residential DG customers interact with the grid in a more sophisticated manner than residential non-DG customers. Non-DG customers simply import power from the grid but DG customers import power at certain times and export it at other times. In other words, they have a two-way interaction with the grid. The surplus power which they export to the grid is essentially stored on the grid, for later use, when they are in need of importing power. In other words, they use the grid as a free battery.

Q. Do RS-DG customers receive a special service from Evergy in comparison to standard RS customers?

A. Yes. From a grid capacity and reliability standpoint, it is clear that RS-DG customers are receiving an additional service from the utility because they are at various times transmitting power to the grid and imposing additional stress on it. The existence of partial requirements customers and non-dispatchable DG resources on the system can actually increase the utility's costs to serve customers by complicating system planning, managing load flow, and system dispatch and by imposing additional administrative, transactional, accounting, and billing burdens on customer service operations. These increased utility costs ultimately show up on RS customer's bills.

Furthermore, RS-DG customers are creating a new challenge to operators of the power grid – the export of electricity during daytime hours. If PV adoption is geographically clustered, this could lead to new capacity constraints on the distribution system, where distribution transformers are not equipped to handle large amounts of excess generation.[3] Having the capacity to manage both deliveries from (i.e., imports) and deliveries into the grid (i.e., exports) is critical to the utility/system operator. As I previously testified, the introduction of distributed generation into a distribution

[3] Initial Faruqui Affidavit, at 3.

system can impose significant costs on the operating utility.[4] Such increased costs are due to the introduction of new flows into the distribution system and trying to change a system that was created to accommodate a one-way flow from the larger-scale utility generator to consumers of electricity into a two-way flow.[5]

The analysis done of RS-DG customers on Evergy Kansas Central's system, demonstrates that the service they take from the Company – both the power they receive from the utility and the power they produce and send onto the grid – varies significantly from the service they took prior to becoming as RS-DG customer.

Q. What are the alternative solutions recommended by the Supreme Court?

A. The Court stated there is a free-ridership problem associated with DG customers. However, any solutions have to be non-discriminatory in nature and need to be applied to all customers. It identified a grid access charge, minimum monthly bills, time-of-use rates and declining block rates as options.

Q. In your opinion, is there a preferred option among these solutions which you would recommend for the Commission's consideration?

A. Yes, it is the grid access charge.

Q. Why is that your preferred option?

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[4] Faruqui, Tr. at 195-96, Docket No. 16-GIME-403-GIE, incorporated into the record in above-captioned docket through administrative notice, *see* Tr., Vol. I, p. 182.

[5] *Id.* at 218-219.

A. The logic for charging a grid access charge on RS-DG customers is the simple fact that they receive a special service from the grid since they don't just import power from Evergy but also export power to Evergy. Under current rate designs and net energy metering, they essentially use the grid as a free battery. Other customers have to pay for this additional service being provided by the grid to DG customers. They end up subsidizing the DG customers. Customers who don't have DG or solar panels would not pay the grid access charge since the size of their solar panels is zero because they are only importing power from the grid and not exporting power to the grid.

Q. Is a grid access charge discriminatory?

A. No. Because RS-DG and RS customers exhibit different consumption characteristics and because RS-DG customers use the utility's system differently from RS customers by both exporting and importing power to and from the grid, using a different rate design for RS-DG customers is not discriminatory. It is well-established under Kansas law that customers who use utility facilities differently may be charged different rates. As the court stated in *Midwest Gas Users Ass'n v. KCC*: "a rate structure imposing differing rates on different classes will be upheld if there is a reasonable basis to support it."[6] This is consistent with the language in the Kansas Supreme Court opinion discussed above that states that a rate design is only discriminatory and in violation of

[6] *Midwest Gas User Ass'n v. KCC,* 5 Kan. App. 2d 653, 663, 623 P.2d 924 (1981).

the statute if it charges RS-DG customers a higher price than non-DG customers for the same service."[7]

Here, RS-DG customers are partial requirements customers who have the ability to send power out onto the grid, unlike full requirements RS customers, and are therefore receiving a different service from the utility. Thus, K.S.A. 66-117d and the Kansas Supreme Court order do not prohibit Evergy from charging RS-DG customers a different rate, even if it results in an overall higher price for some RS-DG customers.

The grid access charge, which would be computed based on the size of a customer's installed DG capacity and expressed in $/kW of DG capacity, would appropriately charge RS-DG customers for the service they are taking when they utilize the grid when they are short on supply from their solar panels and when they have an excess of supply – in other words, when they are using the grid in a two-way fashion unlike all other residential customers. Even if there is disagreement on whether or not DG customers are getting a special service from the utility, the grid access charge can be applied equally to all residential customers (RS and RS-DG) without being regarded as discriminatory. By definition, the charge would be zero for RS customers since they don't have DG capacity and, therefore, do not export power to Evergy's grid.

[7] *Id.* (emphasis added).

The grid access charge would vary across RS-DG customers. Customers with higher DG capacity would pay more per month than customers with smaller DG capacity, thereby promoting equity within the RS-DG group of customers.

Q. Is there a major benefit of the grid access charge over other alternative solutions?

A. Yes, a grid access charge will not require any changes to rate design. All customers would continue to receive service on existing two-part rates. They would not have to be moved to a time-of-use rate or a declining block rate. They would not have to pay a minimum monthly bill. Customers with no solar panels would not have to pay a grid access charge.

Q. How would the grid access charge be computed?

A. It would be computed based on the size of the DG customer's solar panels. If the panels add up to a residential system of 4 kW-DC demand, and the charge is $3/kW-DC, then the DG customer will pay a monthly grid access charge of $12. Non-DG customers will not pay a grid access charge unless they decide to add DG, such as install solar panels on their roof.

Q. Has any other state imposed a grid access charge?

A. Yes, Arizona has such a charge in place and New York has approved the imposition of such a charge. Arizona Public Service applies the grid access charge to its DG customers who are on a time-of-use rate but not on a demand charge. The charge is $0.93/kW of DG capacity. It does not apply to DG customers who are on the other two DG rates

which feature three-part rates with demand charges. However, all three rate plans for DG customers have a monthly fixed charge that is 30% higher than that for non-DG customers.[8] In New York, a grid access charge, termed a Customer Benefit Contribution, has been approved by the Public Service Commission. It will be applied to DG customers in the year 2022.[9] New DG customers will be charged $0.69 to $1.09 per kW based on the utility, customer class and compensation option. ConEd will charge the highest amount, at $1.09/kW and New York State Electric & Gas will have the lowest amount. Existing DG customers will be unaffected by the change.

Q. Would you recommend a secondary option for the Commission's consideration?

A. Yes, a monthly minimum bill. It's easy to explain to customers and easy to implement. Suppose the minimum bill is $35 a month. All residential customers with bills in excess of $35 a month will not have to pay an additional charge. All residential customers with bills below $35 will have to pay an additional charge. As an example, consider two residential customers with monthly bills of $10 and $20 respectively. The customer

[8] [8] Arizona Public Service, "Residential Service Plans," accessed August 4, 2020, https://www.aps.com/-/media/APS/APSCOM-PDFs/Residential/Service-Plans/1804088-Plan_Comparison_-Update_FL.ashx?la=en.

[9] Utility Dive, "New York adopts net metering alternative, delays implementation due to COVID-19," July 17, 2020, https://www.utilitydive.com/news/new-york-adopts-net-metering-alternative-delays-implementation-due-to-covi/581812/.

with the $10 bill would pay an extra $25 a month and the customer with a $20 bill would pay an extra $15 a month.

Q. Has any other state approved a minimum bill?

A. Yes, minimum bills have been approved in Texas and California. A minimum bill is deployed by El Paso Electric in Texas where the charge is $30 per month.[10] It has also been deployed in California by the investor-owned utilities, e.g., Pacific Gas & Electric, where the charge is $10 per month under the commission's NEM 2.0 policy. Additionally, DG customers in California are on mandatory time-of-use rates.[11] A minimum bill is also being considered in the Carolinas where a multi-part settlement has been reached between Duke Energy and various other parties. The settlement includes a minimum bill of $30 a month.

Q. Why do you prefer a grid access charge over a minimum bill?

A. A grid access charge would apply to all customers but would only be paid by DG customers. The size of the charge would vary with the size of the panels, which can be viewed as a proxy for the magnitude of the cross subsidies.

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[10] PV Magazine, "Texas slaps El Paso solar customers with $30 minimum bill," December 15, 2017, https://pv-magazine-usa.com/2017/12/15/texas-slaps-el-paso-solar-customers-with-30-minimum-bill/.

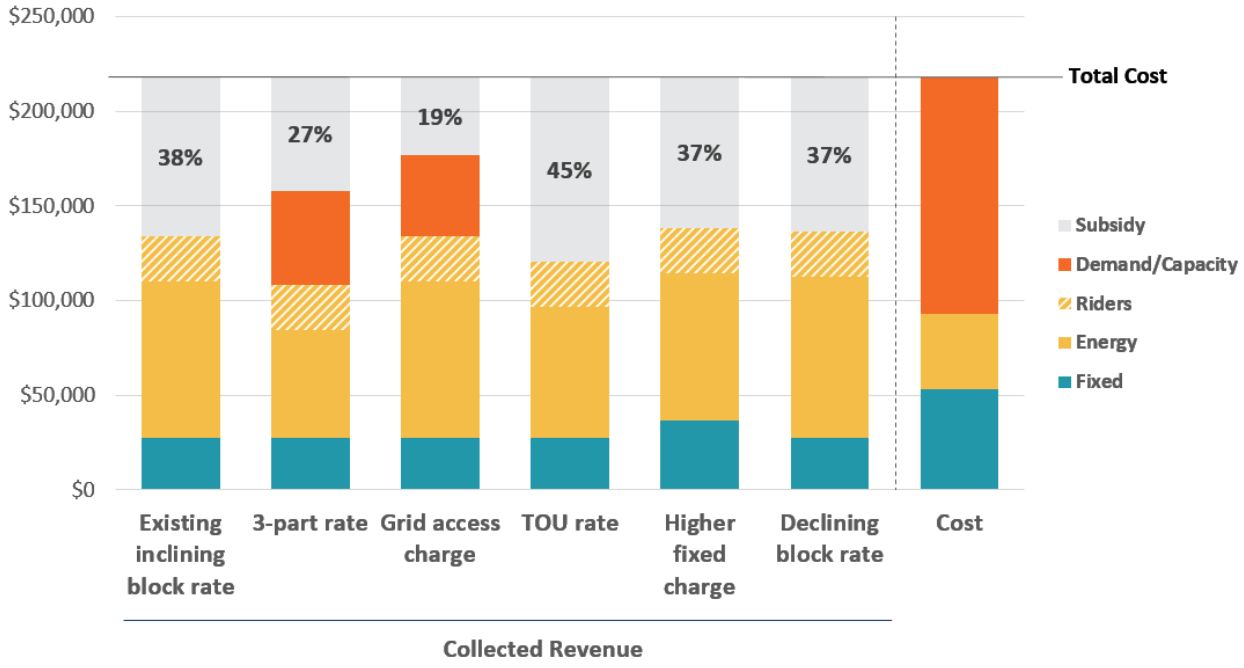
[11] EnergySage, "California net metering: everything you need to know about NEM 2.0," January 2, 2019, https://news.energysage.com/net-metering-2-0-in-california-everything-you-need-to-know/

In contrast, the minimum bill would not vary with the size of the panels. It would apply equally to all customers. Customers paying less than the minimum bill would have to pay extra to Evergy regardless of whether or not they have DG. In particular, it will raise the monthly bills for low use customers.

Q. Have you computed the amount by which the existing cross-subsidy being given by non-DG customers to DG customers would be reduced through a grid-access charge?

A. Yes. I have computed it. In Figure 1 below, I show the existing cross-subsidy and compare it with what it would be under a grid access charge of $3.00/kW and under a three-part tariff, which was originally approved by the Commission and the Court of Appeals. For reference purposes, I have also computed the cross-subsidy under a time-of-use rate (TOU), which was an alternative solution identified by the Supreme Court, under a higher fixed charge, and under a declining block rate. The rates used to compute the cross subsidy for the different rate options are revenue neutral to the residential class. In other words, the rate options collect the same amount of total revenue from non-DG residential customers.

Figure 1: DG CROSS-SUBSIDY UNDER ALTERNATIVE SOLUTIONS



Q. Notes: See Attachment B for more details on the cross-subsidy calculation. What do you conclude from reviewing the results show in Figure 1?

A. Three-part rates and grid access charges are the most cost-reflective options. They are also the most effective rate designs to reduce the cross subsidy. Currently, Evergy is under-collecting almost 40 percent of costs from DG customers. Under a three-part rate, this subsidy would decrease to less than 30 percent, and with a grid access charge of $3.00/kW, the gap would decrease to less than 20 percent. Under the other rate options evaluated, the cost under-collection would be close 40 percent, similarly to the subsidy under the existing inclining block rate.

Q. How would you summarize your testimony?

A. The best solution for addressing the free-ridership issue identified by the Court is to levy a grid access charge. The second best solution is a minimum bill.

Q. Does that conclude your testimony?

A. Yes, it does.

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Dr. Faruqui is an energy economist whose consulting practice encompasses rate design, demand response, distributed energy resources, demand forecasting, decarbonization, electrification and energy efficiency and load flexibility.

In his career, Dr. Faruqui has advised some 150 clients in 12 countries on 5 continents and appeared before regulatory bodies, governments, and legislative councils in Alberta (Canada), Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Egypt, FERC, Georgia, Illinois, Indiana, Iowa, Jamaica, Kansas, Kentucky, Michigan, Maryland, Minnesota, Missouri, Nevada, New Brunswick (Canada), Nova Scotia (Canada), Ohio, Oklahoma, Ontario (Canada), Pennsylvania, the Philippines, Saudi Arabia (ECRA), Texas, and Washington.

He has authored or coauthored more than 150 papers in peer-reviewed and trade journals and co-edited 5 books on industrial structural change, customer choice, and electricity pricing. His innovations have been cited in *Bloomberg*, *Businessweek*, *The Economist*, *Forbes*, and *National Geographic*, in addition to news outlets including the *Los Angeles Times*, *The New York Times*, *San Francisco Chronicle*, *San Jose Mercury News*, and the *Washington Post*. He has also appeared on Fox Business News and NPR.

He has taught economics at San Jose State University, the University of California, Davis, and the University of Karachi and delivered guest lectures at Carnegie Mellon, Harvard, Idaho, MIT, New York University, Northwestern, Rutgers, Stanford, UC Berkeley, and UC Davis. He has also given seminars on energy issues on 20 countries on 6 continents.

EDUCATION

- BA (highest honors) and MA (highest honors) in economics, mathematics, and statistics, University of Karachi
- MA in agricultural economics and PhD in economics, The University of California at Davis
- Regents' Fellowship, The University of California at Davis
- Dissertation Grant, Kellogg Foundation

AREAS OF EXPERTISE

Expert witness

Dr. Faruqui has testified or appeared before state commissions in Arizona, Arkansas, California, Colorado, Connecticut, Delaware, the District of Columbia, FERC, Illinois, Indiana, Iowa,

Kansas, Michigan, Maryland, Minnesota, Nevada, Ohio, Oklahoma, Ontario (Canada), Pennsylvania, Nova Scotia (Canada), and Texas. He has been engaged by regulatory bodies in Alberta (Canada), FERC, Hawaii, New Brunswick (Canada), Ontario (Canada) and Saudi Arabia (ECRA).

He has made presentations to the California Energy Commission, the California Senate, the Congressional Office of Technology Assessment, the Indiana General Assembly, the Kentucky Commission, the Michigan Commission, the Minnesota Department of Commerce, the Minnesota Senate, the Missouri Public Service Commission, and the Electricity Pricing Collaborative in Washington State.

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 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 in real-time prices. The 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. Cataloged 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 staff 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 the 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 the 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 product size. 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 of 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.
- Testimony before the Board of Directors on behalf of Salt River Project, in the matter of "An Evaluation of SRP's Electric Rate Proposal for Residential Customers with Distributed Generation," December 31, 2014.

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

- Testimony before the Board of Directors on behalf of SMUD, in the matter of "Encouraging Rooftop Solar without Creating Cross-subsidies," April 30, 2019.
- 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.

Georgia

- Direct testimony before the State of Georgia Public Service Commission on behalf of Georgia Power Company, in the matter of Georgia Power Company's 2019 Base Rate Case, Docket No. 42516, June 28, 2019.

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

- Rebuttal testimony before the Council of 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-18-07, March 2019.
- 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-18-07, 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.

Missouri

- Direct testimony before the Missouri Public Service Commission, on behalf of Union Electric Company d/b/a Ameren Missouri, in the matter of Union Electric Company d/b/a Ameren Missouri's Tariffs to Increase Its Revenues for Electric Service, ER-2019-0335, July 3, 2019.

Montana

- Rebuttal 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 Retail Electric Utility Service Rates and for Approval of Electric Service Schedules and Rules and Allocated Cost of Service and Rate Design, Docket No. D2018.2.12, April 2019.
- 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

Articles and Papers

- "Conceptual Discussion on a Potential Hidden Cross-Seasonal Storage: Cross-Seasonal Load Shift in Industrial Sectors," with Yingxia Yang and Jared DeFrain, *The Electricity Journal,* Volume 33, Issue 8, October 2020. https://www.sciencedirect.com/science/article/pii/S104061902030138X?dgcid=author
- "Alberta Commission Chair Retires and Reflects on Regulatory Career: A conversation with Mark Kolesar," *Public Utilities Fortnightly,* Volume 158, September 2020. https://www.fortnightly.com/fortnightly/2020/09/alberta-commission-chair-retires-and-reflects-regulatory-career
- "Avoiding Blackouts in California Through Load Flexibility," with Ryan Hledik, *Utility Dive*, September 2020. https://www.utilitydive.com/news/avoiding-blackouts-in-california-through-load-flexibility/585139/
- "Avoiding Blackouts," *Energy Central*, September 2020. https://energycentral.com/c/em/avoiding-blackouts
- "The Coming Transformation of the Electricity Sector: A conversation with Amory Lovins," *The Electricity Journal,* Volume 33, Issue 7, August–September 2020. https://www.sciencedirect.com/science/article/pii/S1040619020301196

- "The Tariffs of Tomorrow: Innovations in Rate Designs," with Cecile Bourbonnais, *IEEE Power and Energy Magazine*, Volume 18, Issue 3, May–June 2020.
- "Enhancing Rate Design Choices for Ontarians," *Energy Central*, June 2020. https://energycentral.com/c/em/enhancing-rate-design-choices-ontarians
- "6 Reasons Why California Needs to Deploy Dynamic Pricing by 2030," *Utility Dive*, May 2020. https://www.utilitydive.com/news/6-reasons-why-california-needs-to-deploy-dynamic-pricing-by-2030/578156/
- "Refocusing on the Consumer: Utilities regulation needs to prepare for the "prosumer" revolution," *Regulation,* March 2020. https://www.cato.org/sites/cato.org/files/2020-03/regv43n1-6.pdf
- "Why Dynamic Pricing Gets Back Seat in California: A dialogue with Commissioner Mike Peevey," *Public Utilities Fortnightly*, March 2020. https://www.fortnightly.com/fortnightly/2020/03/why-dynamic-pricing-gets-back-seat-california
- "Double Down on Efficiency," with Ralph Cavanagh, *Public Utilities Fornightly*, December 2019.
- "A New Paradigm for Utilities: Electrification of the Transportation and Heating Sectors," with Ryan Hledik, Jürgen Weiss, Michael Hagerty and Long Lam, *American Association Bar*, November 13, 2019.
- "Quantifying Net Energy Metering Subsidies," with Sanem Sergici, Yingxia Yang, and Maria Castañer, *The Electricity Journal*, Volume 32, Issue 8, October 2019.
- "Reducing electricity prices and establishing electricity markets in China: Dos and don'ts," with Yingxia Yang, *The Electricity Journal,* Volume 32, Issue 8, October 2019.
- "2040: A Pricing Odyssey: How to price electricity when the grid goes 100 percent green," *Public Utilities Fortnightly*, June 1, 2019.
- "Expanding Customer Choices in a Renewable Energy Future," with Mariko Geronimo Aydin, *Leadership in Rate Design*, May–June 2019.
- "Emerging Landscape of Residential Rates for EVs – Creative design ahead," with Ryan Hledik and John Higham, *Public Utility Fortnightly*, May 2019. https://www.fortnightly.com/fortnightly/2019/05/emerging-landscape-residential-rates-evs
- "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
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- " Stakeholder recommendations on rate design reform: Matter 357," with Cecile Bourbonnais, presented at the New Brunswick Energy and Utilities Board, May 12, 2020.
- "Moving Ahead with Time-Varying Rates (TVR): US and Global Perspectives," presented at the MI Power Grid: Energy Programs and Technology Pilots Stakeholder Meeting, April 16, 2020.
- "Moving Ahead with Time-Varying Rates (TVR): US and Global Perspective," presented to the NARUC Staff Subcommittee on Rate Design, April 6, 2020.
- "Demand on Demand," presented at the AESP Annual Conference, February 20, 2020.
- "Empirical Assessment of the Demand for Residential Solar Distributed Generation and the Impact of Electricity Rate Design Reform," with Agustin J. Ros and Cecile Bourbonnais, presented at the Rutgers University Center for Research in Regulated Industries, January 17, 2020.
- "Assessment of APS's Bill Comparison Web Tool: Methodology and Findings," with Ryan Hledik and Cecile Bourbonnais, December 10, 2019.

- "A Survey of Residential Time-of-Use (TOU) Rates," with Ryan Hledik and Sanem Sergici, November 12, 2019.
- "Advancing the Practice of Rate Design," presented at the 40th PLMA Conference, November 6, 2019.
- "The Total Value Test (TVT) for Assessing Electrification Programs," with Ryan Hledik and Omar Siddiqui, presented at the California Efficiency + Demand Management Council (CEDMC), October 24, 2019.
- "A Conversation about Customer Centricity," presented at Virtual Speaker Forum, October 21, 2019.
- "Encouraging Rooftop Solar without Creating Cross-Subsidies," presented to SMUD, April 30, 2019.
- "Post-Modern Rate Design: The 'Secret Sauce' in Customer Engagement," presented at the Entergy Regulatory Conference, April 9, 2019.
- "Valuing and Compensating Distributed Energy Resources in ERCOT," with Ira Shavel and Yingxia Yang, prepared for the Texas Clean Energy Coalition, March 28, 2019.
- "2040: A Pricing Odyssey," presented at the EEI Spring Rates and Regulatory Affairs Committee Meeting, March 25, 2019.
- "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.

Attachment B: The Cross-Subsidy Calculation

The rate design options evaluated in this testimony are a three-part rate, a TOU rate, a grid access charge, a higher fixed charge, and a declining block volumetric rate. The calculation of the cross-subsidy across these rate designs consisted of three steps: designing revenue neutral rates, computing the revenue collected under those rate options, and calculating the resulting cross-subsidy.

First, I designed rates that would be revenue neutral rates to the residential class. In other words, in absence of any change in customer consumption, these rates would collect the same revenue as the existing two-part rate offered to residential customers. Next, I calculated the revenue that would be collected from residential DG customers under those rates. Finally, I compared the collected revenues under each of the rates to the cost to serve the residential DG class. The difference between those components is the cross-subsidy.

The data used in this analysis is consistent with the data used in my direct and rebuttal testimonies from Docket No. WSEE-328-RTS. The cost of service data and the billing determinants for the residential DG and non-DG classes span the period from July 2016 to June 2017. During that period, the Company had 156 residential DG customers. The cost to serve the residential DG class was $217,688, while the revenue collected by the class was

$133,994, only 62% of costs.[12] The inclining block rate for the residential class used to calculate the revenue neutral rates is shown in Table 1.

Table 1: Residential Standard Service Rate

	Winter	Summer
Basic Service Fee ($/month)	14.50	14.50
Energy charge ($/kWh)		
First 500 kWh	0.076833	0.076833
Next 400 kWh	0.076833	0.076833
All additional kWh	0.062804	0.084752

The revenue neutral rates I designed are summarized below:

- All rates (except for the "Higher fixed charge" rate design) have a fixed charge of $14.50/month, consistent with the basic service charge shown in Table 1.
- **Existing inclining block rate:** These charges are summarized in Table 1.
- **Three-part rate:** Fixed charge is $14.50/month; demand charges are based on the charges approved in the settlement in Docket No. 18-WSEE-328-RTS ($3.00/kW during winter and $9.00/kW during summer); I calculated an energy charge that would make the rate revenue neutral to the residential class. The energy charge I calculated is $0.051/kWh.

[12] See Table 1 of Faruqui Rebuttal Testimony, Docket No. 18-WSEE-328-RTS.

- **TOU rate:** Fixed charge is $14.50/month; I assumed a TOU on-peak/off-peak ratio of 2.5, which resulted in the revenue neutral TOU energy charges of $0.140/kWh (on-peak) and $0.056/kWh (off-peak).

- **Grid access charge:** In addition to the charges shown in Table 1, this rate option includes a monthly grid access charge of 3.00/kW. The average residential solar PV installed capacity in Kansas Central is 6.85 kW per customer.[13] A grid access charge of $6.50/kW would eliminate the existing cross-subsidy.

- **Higher fixed charge:** Fixed charge is increased to $19.50/month; the energy charges were calculated by scaling down the inclining block charges in Table 1 to make the rate revenue neutral.

- **Declining block rate:** Fixed charge is $14.50/month, declining block charges range from $0.060/kWh to $0.090/kWh depending on the consumption block.

[13] This information was provided by Evergy.