BEFORE THE
ARKANSAS PUBLIC SERVICE COMMISSION

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

DIRECT TESTIMONY

OF

AHMAD FARUQUI, PH.D.

PRINCIPAL

THE BRATTLE GROUP

ON BEHALF OF

ENTERGY ARKANSAS, INC.

SEPTEMBER 19, 2016

I. BACKGROUND AND INTRODUCTION

Q. PLEASE STATE YOUR NAME, TITLE, AND BUSINESS ADDRESS.

A. My name is Ahmad Faruqui. 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 testifying before the Arkansas Public Service Commission ("APSC" or the "Commission") on behalf of Entergy Arkansas, Inc. ("EAI" or the "Company").

Q. PLEASE BRIEFLY DESCRIBE YOUR EDUCATIONAL, PROFESSIONAL, AND BUSINESS EXPERIENCE.

A. I have 40 years of academic, consulting and research experience as an energy economist. During my career, I have advised 135 clients in the energy industry, including utilities, regulatory commissions, government agencies, transmission system operators, private energy companies, equipment manufacturers, and information technology ("IT") companies. Besides the U.S., my clients have been located in Australia, Canada, Chile, Egypt, Hong Kong, Jamaica, Philippines, Saudi Arabia, South Africa, and Vietnam. I have advised them on a wide range of issues including cost-benefit analysis of advanced metering technologies, demand response, energy efficiency, rate design, load forecasting,

distributed energy resources, integration of retail and wholesale markets, and integrated resource planning. I have testified or appeared before several state, provincial and federal regulatory commissions and legislative bodies. I have been an invited speaker at major energy conferences in Africa, Asia, Australia, Europe, North America, and South America. Finally, I have authored, co-authored or co-edited more than 150 articles, books, editorials, papers and reports on various facets of energy economics. More details regarding my professional background and experience are set forth in my Statement of Qualifications, included as EAI Direct Exhibit AF-1.

Q. WHAT ARE YOUR RESPONSIBILITIES AS A PRINCIPAL OF THE BRATTLE GROUP?

A. I lead the firm's practice in helping clients understand and manage the changing needs of energy consumers.

Q. HAVE YOU PREVIOUSLY TESTIFIED IN REGULATORY PROCEEDINGS RELATED TO THE DEPLOYMENT OF ADVANCED METERING INFRASTRUCTURE ("AMI")?[1]

A. Yes. I testified in California on behalf of Pacific Gas & Electric Company and Southern California Edison, in Connecticut on behalf of Connecticut Light & Power, in Illinois on behalf of Ameren and Commonwealth Edison, in Maryland on behalf of Baltimore Gas & Electric and Pepco Holdings, Inc. and in Washington, D.C., also on behalf of Pepco Holdings, Inc.

Q. WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY?

A. The purpose of my testimony is to support the Company's application for an order finding the deployment of AMI to be in the public interest and an exemption from certain APSC rules. More specifically, I support the reasonableness of the methodology and assumptions used by EAI to quantify certain non-operational benefits associated with the Company's planned deployment of AMI, as described in the direct testimony of EAI witness Jay A. Lewis as "Other Benefits." The primary focus of my testimony is on the expected impacts of new, more detailed information

[1] For purposes of my testimony, AMI refers to advanced meters that enable two-way data communication, a secure and reliable communications network that supports two-way data communication, along with related and supporting systems, including a Meter Data Management System ("MDMS"), an Outage Management System ("OMS"), and a Distribution Management System ("DMS") – which, in the case of EAI, are planned to be integrated with its legacy IT systems via an Enterprise Service Bus ("ESB"). Similar deployments in other jurisdictions are sometimes referred to as an "Advanced Metering System" or "AMS." For simplicity, I use the term "AMI" throughout my testimony.

and enhanced tools (e.g., the ability to estimate a bill) that will be made available to customers as a result of the AMI deployment. The new information and enhanced tools provide customers with actionable information that would lead them to change their energy consumption in a manner that reduces electricity system costs and can lower customer bills.

I also review and comment on some other elements of the proposed AMI deployment. These are EAI's recommended advanced meter opt-out and the benefits arising from reductions in what is called "unaccounted for energy" ("UFE"). Throughout, I provide a general review of the overall methodological framework of these quantified benefits for consistency with established industry practices.

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. EAI's AMI deployment will provide significant benefits which, could not be achieved without upgrading its existing metering infrastructure. Customers will have access to new information about their energy use that previously could not be provided due to technological constraints of the legacy metering system. In response to this information – delivered through a web portal, text alerts, and email notifications – customers are expected to change their energy consumption and manage their usage in a way that will save on fuel and capacity costs, and ultimately reduce bills for all customers.

EAI's AMI deployment will also allow EAI to reduce the current level of UFE. Within the electricity industry, the term UFE is used to refer to technical losses in the electricity system from sources like line and transformation losses, as well as non-technical losses resulting from electricity that is consumed by customers but not metered nor billed by the utility, typically due to metering malfunction or theft. The improved metering accuracy provided by AMI will help EAI mitigate non-technical UFE and reduce situations where customers are receiving electricity but not paying for their full energy use. Addressing non-technical UFE should also lead to less overall electricity consumption, which will result in a net reduction in total electricity costs for all customers.

EAI's methodology for estimating the expected impacts of these features of the AMI deployment is consistent with that of utilities in other jurisdictions. The assumptions used in the Company's analysis align well with the recent experience of these other utilities, much of which has been validated through empirical assessment of AMI pilot projects and full-scale AMI rollouts.

EAI's proposed opt-out recommendation would provide residential customers with the option to keep their existing meter (subject to certain safety and accuracy tests) or, if an advanced meter has already been installed, switch from an advanced meter to a non-advanced meter, as long as those customers are willing to cover their share of the associated cost of maintaining a legacy metering system, including manual meter

reads each month. EAI's recommendation is consistent with that of many other U.S. utilities. EAI's proposal would provide a pragmatic degree of choice to its customers, even though only a small number are likely to decide to opt out from having an advanced meter installed at their home.

Overall, the aspects of the AMI deployment that I have reviewed are reasonable, consistent with current industry practices, and demonstrate that EAI's AMI deployment will provide significant benefits to its customers.

Q. HOW IS YOUR TESTIMONY ORGANIZED?

A. The remainder of my testimony is organized as follows. Section II provides an overview of AMI experience in the U.S. Section III is an assessment of the expected benefits of the new information and enhanced tools that will be provided to customers as a result of EAI's AMI deployment. Section IV discusses other assumptions in the AMI deployment. Section V summarizes the conclusions of my review of certain aspects of the AMI deployment.

II. AMI EXPERIENCE IN THE UNITED STATES

Q. HOW COMMON IS AMI IN THE U.S.?

A. According to the most recent publicly available information, nearly 50 million U.S. households have advanced meters, accounting for more than 45 percent of all meters.[2] Oklahoma Gas & Electric has deployed over 850 thousand advanced meters in Oklahoma and Arkansas. There are also many examples of large utility AMI deployments in EAI's neighboring states in the Southern U.S. For instance, AMI has been deployed to over 7 million customers across Texas. Southern Company has deployed advanced meters to more than 4 million customers in Georgia, Alabama, and Florida. Florida Power & Light has separately installed nearly 5 million advanced meters in Florida.

There has been continued growth in adoption of advanced meters over the past decade. I expect this growth trend to continue as utilities replace legacy metering systems and modernize their power grids. If the meter adoption rate continues to follow the historical trend, the vast majority of all electricity customers in the U.S. would have advanced meters by the time EAI has finished its deployment.[3]

[2] EIA, Form EIA-826, "Advanced Metering" as of June 2016, *available at*: https://www.eia.gov/electricity/data/eia826/#ammeter.

[3] According to a 2015 Federal Energy Regulatory Commission ("FERC") report, there were around 13 million advanced meters in the U.S. in late-2009 and 50 million advanced meters by mid-2014. This implies average annual installations of around 8 million advanced meters per year. *See* FERC, 2015 Assessment of Demand Response and Advanced Metering, Staff Report, December 2015, p. 3, *available at* http://www.ferc.gov/legal/staff-reports/2015/demand-response.pdf.

Q. WHY HAVE ADVANCED METERS BECOME SO COMMON AMONG U.S. UTILITIES AND ALSO AMONG UTILITIES LOCATED OVERSEAS?

A. Utilities and regulators across the industry have recognized that new digital infrastructure is needed to modernize the grid so that utilities can keep up with advancements in energy technologies on both the supply- and demand-side. AMI unlocks many benefits, both operational and customer-facing, which can reduce costs and improve reliability and quality of service for all customers. In its most recent annual report on advanced metering, the FERC Staff states that "…deployment of advanced meters continues to progress throughout the nation's electric system, providing support for two-way communications networks that utilities can use to improve electric system operations, enable new technological platforms and devices, and facilitate consumer engagement."[4]

Q. HOW WILL THE DEPLOYMENT OF ADVANCED METERS IMPROVE THE CUSTOMER EXPERIENCE?

A. First, an upgraded metering system will enable the growing trend toward – and need for – greater customer engagement. For instance, rooftop solar PV installations are growing quickly in many regions of the U.S.

[4] *See FERC (2015), p. 5.*

Participation in demand response programs has also increased significantly in the past decade,[5] and many consumers are purchasing smart appliances, such as internet-connected digital thermostats.[6] In short, utility customers are becoming more engaged consumers of energy, and AMI has become necessary to support this level of engagement.

Second, as I discuss throughout my testimony, the deployment of AMI will provide customers with access to new information that could not be provided through the existing metering system. Customers will be able to develop a better understanding of their energy consumption and when it occurs. In addition, they will receive various tips and alerts that will improve their overall experience as an energy consumer, and if followed, can result in lower individual customer bills.

Third, as quantified in Mr. Lewis' testimony, there are expected to be bill savings for all customers resulting from an overall reduction in consumption as a result of the new information about customers' energy usage available through AMI. Further, all customers will benefit from the operational cost savings provided by AMI.

[5] *See FERC (2015), p. 17.*

[6] For instance, a survey of 1,600 customers in North America found that "50% of people [are] saying they plan to buy at least one smart home product in the next year (U.S. intent is slightly higher at 54%)". *See* Icontrol Networks, 2015 State of the Smart Home Report, June 2015 p. 3, *available at* https://www.icontrol.com/wp-content/uploads/2015/06/Smart_Home_Report_2015.pdf In addition, Berg Insight, a Swedish market research firm, reports that the number of smart thermostats in North America and Europe more than doubled in 2014. Their "Smart Homes and Home Automation" report also forecasts that this number will grow at a compound annual growth rate of 64.2 percent during the next five years. *See* David Murphy, "Smart Thermostat Sales Double in a Year," Mobile Marketing, January 12, 2015, *available at* http://mobilemarketingmagazine.com/smart-thermostat-sales-double-in-a-year/, accessed August 31, 2016.

III. THE IMPACTS OF NEW INFORMATION AND ENHANCED TOOLS IN EAI'S AMI DEPLOYMENT

Q. PLEASE DESCRIBE THE NEW INFORMATION AND ENHANCED TOOLS THAT WILL BE MADE AVAILABLE AS A RESULT OF EAI'S AMI DEPLOYMENT.

A. There are two aspects to what EAI is proposing to implement. The first is the incorporation of more detailed, time-differentiated usage data into the Company's customer web portal, which can be accessed through the internet by computer or mobile device.[7] In other words, through their computer or mobile device, customers will have access to enhanced usage and billing information, targeted energy saving tips, and other features like the ability to set targeted bill and usage alerts, which collectively comprise a robust resource of energy management information for electricity customers. EAI witness Oscar D. Washington explains these features in more detail in his direct testimony.

The second aspect is the implementation of a peak event notification program for electricity customers, also described by

[7] Data collected by the U.S. Census Bureau shows that internet access has increased over time. In 1997, 18.0 percent of households reported home internet use. By 2013, these estimates had increased to 74.4 percent. For the state of Arkansas, 65.7 percent were reported to have access to high-speed internet. I would expect this trend to continue, meaning internet access may be higher by the time the Company's AMI deployment is expected to start in 2019. *See* Thom File and Camille Ryan, "Computer and Internet Use in the United States: 2013," United States Census Bureau, November 2014, p. 4 and 10, *available at*: http://www.census.gov/content/dam/Census/library/publications/2014/acs/acs-28.pdf.

Mr. Washington. To reduce electricity demand during the small number of hours of the year that drive the system peak, notifications would be sent to customers encouraging a voluntary, temporary reduction in electricity use. My understanding is that these messages could be sent in anticipation of a peak event by text and/or email (subject to an opt-out procedure and applicable legal requirements related to such communication channels). The program is expected to include post-event feedback, educating customers about the extent to which they reduced their peak electricity consumption, and which is only possible with the time-differentiated usage data produced by AMI. Following the AMI deployment, customers would be enrolled in the notification program, although as I understand it, customers can choose to not receive such notifications if they wish.

Q. HOW WILL THE NEW INFORMATION AND ENHANCED TOOLS BENEFIT CUSTOMERS?

A. The incorporation of the AMI data into the Company's web portal will give customers access to detailed and more up-to-date energy usage information to help them make better informed decisions about their usage. I expect some customers to reduce their overall electricity consumption in response to this enhanced information. Similarly, I expect some customers to reduce their peak demand when notified of peak events. The impacts of the information made available by AMI through the web portal and peak event notification program will translate into cost

savings for EAI and ultimately for its customers. In the short run, the reduction in total electricity consumption will result in a reduction in fuel and variable operations and maintenance costs. In the longer-term, lower system peak demand should reduce fuel and capacity costs.

Q. WHAT HAS EAI ESTIMATED WILL BE THE IMPACTS OF THE NEW INFORMATION AND ENHANCED TOOLS ON ELECTRICITY USAGE?

A. EAI has estimated that the new information and enhanced tools made available through the web portal will lead to an overall reduction in residential and commercial electricity consumption of between 1.5 percent and 2.0 percent. EAI used the mid-point of that range (1.75 percent) to calculate consumption reduction benefits, as discussed by Mr. Lewis. EAI has assumed that these energy savings will occur uniformly during peak and off-peak periods, resulting also in a proportional peak demand reduction of 1.5 to 2.0 percent. EAI used 1.75 percent as the midpoint of this range to calculate peak demand-related benefits as well. The peak event notifications are expected to lead to an additional reduction in residential peak demand of approximately 0.4 percent, with no associated energy savings. These assumptions are summarized in Table 1 and are discussed in more detail by Mr. Lewis. Mr. Lewis quantifies the net present value of these impacts in his direct testimony.

Table 1
Impact of New Information and Enhanced Tools on Residential and Commercial Electricity Use

	Energy Savings	Peak Demand Savings
Web portal	1.75%	1.75%
Peak notifications	0.00%	0.38%
Total	1.75%	2.13%

Q. IN GENERAL, IS THERE EVIDENCE THAT CUSTOMERS RESPOND TO MORE DETAILED INFORMATION ABOUT THEIR ELECTRICITY USAGE?

A. Yes, there is empirical evidence in academic journal articles and industry reports indicating that customers respond to detailed information about their energy consumption. The studies have analyzed a variety of ways in which this energy information can be provided to customers. For instance, more than a dozen utility pilot projects implemented over the past decade found that customers reduce energy consumption when provided with new information that is displayed electronically and is easily accessible.[8] The means to display the information could be a screen reporting

[8] Many of these studies are summarized in Ahmad Faruqui, Sanem Sergici, and Ahmed Sharif, "The Impact of Informational Feedback on Energy Consumption – A Survey of the Experimental Evidence," *Energy*, 2010, *available at:* http://www.myaztech.ca/wp-content/uploads/faruqui_impactoffeedback_2010.pdf. *See also* Sarah Darby, "The Effectiveness of Feedback on Energy Consumption: A Review for Defra of the Literature on Metering, Billing, and Direct Displays," Environmental Change Institute at the University of Oxford, April 2006, *available at:* http://www.eci.ox.ac.uk/research/energy/downloads/smart-metering-report.pdf.

instantaneous energy use, an "orb" that glows different colors depending on energy consumption levels, or a web-based platform that the customer accesses from a computer or mobile device. Additionally, firms that offer a platform for certain types of energy efficiency programs, like OPower, have observed significant energy reductions when providing utility customers with bill inserts that compare their consumption to that of similarly-situated neighbors.[9] There have also been studies specifically on the impacts of providing AMI usage data through a web portal, similar to the capability that EAI proposes in its AMI deployment, which I will summarize later in my testimony.

Importantly, these studies have found that customers respond to new energy consumption information even in the absence of changes in price. Simply being better informed about their energy use in conjunction with new tools like targeted text alerts and conservation tips is enough to induce energy savings among some customers. Changes in the pricing structure, or the adoption of new home automation technologies, would further enhance response.

[9] Studies have indicated that OPower's programs reduce residential electricity use by two percent on average. A full library of OPower's measurement and verification reports can be found here: https://opower.com/resource_type/verification-reports/.

Q. IS EAI'S ASSUMED ELECTRICITY IMPACT FROM THE AMI USAGE DATA MADE AVAILABLE THROUGH THE WEB PORTAL AND RELATED ENERGY MANAGEMENT INFORMATION REALISTIC?

A. Yes. An estimate of 1.5 percent to 2.0 percent savings in energy consumption is reasonable and consistent with evidence from other jurisdictions. As I noted previously, Mr. Lewis has used an estimate of 1.75 percent, which is within this range. I am aware of similar estimates that have been developed by other utilities.

For instance, Potomac Electric Power Company ("Pepco") recently detected energy savings of 1.73 percent from a similar full-scale web-based offering.[10] The utility's offering is centered primarily around more detailed and time-specific information about each customer's electricity consumption, which is provided through both a web portal and the customer's bill. Pepco has offered this AMI information in Maryland since Spring 2013.[11] Pepco filed an empirical assessment of the impacts of its web-based AMI information as part of cost recovery proceedings before the Maryland Public Service Commission ("Maryland PSC"). I led the assessment of Pepco's AMI-enabled energy savings and have submitted testimony to the Maryland PSC in support of that analysis.[12]

[10] See *Direct Testimony of Ahmad Faruqui on behalf of Potomac Electric Power Company, Maryland Public Service Commission* – Case No. 9418, April 19, 2016, p. 10.
[11] Additionally, Pepco Holdings began offering a web portal in its Delmarva Maryland jurisdiction in Fall 2014.
[12] *See* Faruqui (2016).

Baltimore Gas & Electric ("BGE") has offered new AMI-enabled usage information to its customers since Fall 2012. BGE's offering includes interactive online tools, usage alerts, weekly usage emails, and home energy reports. BGE has reported energy savings of between 1.38 and 1.5 percent resulting from the provision of this information.[13]

Many other utilities that have deployed AMI included assumptions about the impacts of web-based AMI information in their AMI business cases. In some cases, such as those of BC Hydro and Southern California Edison, the assumed impacts reached 2.0 percent.[14] In the case of Entergy New Orleans' ("ENO") web-based AMI pilot, impacts were estimated to be 1.8 percent.[15] But what makes the Pepco and BGE cases particularly relevant is that they reflect actual impacts that were measured on an *ex post* basis. They are statistically significant estimates observed from customers across the utilities' entire respective service territories.

[13] An evaluation by Navigant Consulting identified a 1.38 percent impact, and testimony by BGE witness William Pino refers to a 1.5 percent impact. *See* Navigant Consulting Inc., Smart Energy Manager Program – 2015 Evaluation Report, prepared for Baltimore Gas Electric, March 11, 2016, p. ii. *See also* Direct Testimony of William B. Pino on behalf of Baltimore Gas & Electric Company, before the Maryland Public Service Commission – Case No. 9406, November 6, 2015, p. 38.

[14] BC Hydro, *Smart Metering & Infrastructure Program Business Case*, p. 28, *available at* https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/projects/smart-metering/smi-program-business-case.pdf.

Southern California Edison, *Rebuttal Testimony Supporting Edison SmartConnect Deployment Funding and Cost Recovery, California Public Utilities Commission,* , – Application No. 07-07-026, February 19, 2008, p. 11.

[15] ENO conducted a pilot program in 2011 and 2012 evaluating customer behavior in response to advanced metering and other technologies for low-income customers. While the average impact of the pilot was estimated to be 1.8 percent, the result was not considered to be statistically significant. This could be due to the relatively small number of participants in the pilot. *See* Navigant Consulting Inc., *Entergy New Orleans SmartView Pilot, Final Evaluation Report*, August 30, 2013, Table ES-2, p. v. Additionally, ELL conducted a small pilot, but it did not include the types of information-only treatments that I am analyzing in my testimony.

Q. DID PEPCO AND BGE HAVE PRE-EXISTING ENERGY EFFICIENCY OR DEMAND-SIDE MANAGEMENT PROGRAMS ("EE/DSM") WHEN THEY DEPLOYED AMI?

A. Yes. Both utilities offered robust EE/DSM portfolios prior to AMI deployment, and continue to do so.[16] The utilities have been working for years to achieve what I would consider to be substantial energy savings targets in Maryland.[17]

Q. ARE THE ENERGY SAVINGS ESTIMATES ASSOCIATED WITH BGE'S AND PEPCO'S WEB PORTALS INCREMENTAL TO THE IMPACTS OF THE UTILITIES' EE/DSM PROGRAMS?

A. Yes. The energy savings that are associated with BGE's and Pepco's web portals are entirely incremental to the energy savings that are attributable to the utilities' EE/DSM programs. In the Pepco study, which I led, I structured the analysis such that it isolated the impact of the web-based AMI information and excluded any effect from existing EE/DSM programs.

[16] For more information on the utility EE/DSM offerings in Maryland, see the Pepco MD website: http://www.pepco.com/my-home/save-money-and-conserve-energy/efficiency-rebates-and-incentives-and-programs/md-customers/. Also see the BGE website: http://www.bgesmartenergy.com/.
[17] For more information, see the EmPOWER website: http://energy.maryland.gov/pages/facts/empower.aspx.

I did not conduct the cited analysis for BGE, but I have reviewed the final report describing the methodology in that analysis.[18] It is my understanding that the BGE study similarly excluded the impacts of existing EE/DSM programs when quantifying the energy savings associated with web-based AMI information.

Q. IN ADDITION TO OVERALL ENERGY SAVINGS, EAI HAS ASSUMED THAT THE AMI INFORMATION ACCESSIBLE VIA THE COMPANY'S WEB PORTAL WILL LEAD TO PEAK ELECTRICITY DEMAND REDUCTIONS. IS THEIR ESTIMATE REALISTIC?

A. Yes, EAI's estimate of 1.5 to 2.0 percent peak demand savings for residential and commercial customers due to incorporation of AMI data into the web portal is reasonable. Specifically, EAI has assumed that peak demand savings attributable to the accessibility of AMI data via a web portal is proportional to energy savings on a percentage basis. This assumption is consistent with that of other utility business cases and reasonable relative to recent empirical evidence.[19]

Three independent studies of behavioral energy efficiency programs have looked specifically at the extent to which peak savings differ from energy savings. The studies were conducted by Lawrence

[18] *See* Navigant Consulting Inc. (2016).
[19] Both the BGE and Pepco studies that I mentioned previously assumed proportional energy and peak savings.

Berkeley National Laboratory ("LBNL"),[20] DNV-GL (on behalf of the California Public Utilities Commission),[21] and The Cadmus Group (on behalf of PPL Electric).[22] The studies evaluated actual load data for customers who were provided information about how their energy use compares to similarly-situated neighbors. I would expect the programs evaluated in these three studies to elicit the same type of response when that information is accessed through a web portal; in both instances, customers are responding to general information about their energy use as opposed to information that would be specific to the time of day.

All three of the studies found that peak savings were proportionally greater than energy savings. One likely reason is that customers tend to have more discretionary load during peak hours (e.g., air-conditioning or lighting in unoccupied rooms), and thus more opportunity for savings. The LBNL study elaborates on this point:

> These results show that this pilot program rollout resulted in savings that are higher during peak hours. It is particularly interesting because the savings disproportionately increase during the peak hours. Without hourly data, one assumption

[20] Annika Todd et al, "Insights from Smart Meters: The Potential for Peak-Hour Savings from Behavior-Based Programs," Lawrence Berkeley National Laboratory Paper LBNL-6598E, March 2014, *available at* http://escholarship.org/uc/item/2nv5q42n#page-1.

[21] DNV-GL, "Review and Validation of 2014 Pacific Gas and Electric Home Energy Reports Program Impacts (Final Draft)," prepared for the California Public Utilities Commission, March 1, 2016, p. 30, *available at*: http://www.energydataweb.com/cpucFiles/pdaDocs/1441/Res3_1_PGE_HER2014_FINALdraft_forPublicComments.pdf.

[22] Based on evaluation of data supporting James Stewart and Pete Cleff, "Are You Leaving Peak Demand Savings on the Table? Estimates of Peak-Coincident Demand Savings from PPL Electric's Residential Behavior-Based Program," AESP working paper, 2014, *available at* http://aespnational2014.conferencespot.org/polopoly_fs/1.429338.1389116220!/fileserver/file/67651/filename/Session_3A_Peter_Cleff.pdf.

> that was commonly used (based on anecdotal evidence) was that this was not the case; that either the savings are spread out evenly in proportion to the electricity usage, or that savings are actually harder to achieve during peak hours.[23]

Thus, all of the available empirical evidence that I am aware of supports the conclusion that EAI has been conservative in its assumption that peak impacts of incorporating the AMI data into its web portal will be proportional to (and not greater than) energy savings.

Q. IN ADDITION TO PROVIDING NEW INFORMATION THROUGH A WEB PORTAL, EAI WILL SEND CUSTOMERS NOTIFICATIONS OF PEAK EVENTS. IS EAI'S ASSUMED IMPACT FROM THE PEAK NOTIFICATIONS REALISTIC?

A. Yes. In fact, the estimate of a 0.4 percent peak demand reduction among residential and commercial customers is conservative relative to studies elsewhere. The peak demand impacts of such notifications have recently been tested through pilot programs. Some utilities have begun to consider offering these notifications as an alternative to conventional demand response programs which require installing control equipment on individual sources of load like an air conditioner or pool pump.

In some cases, these notifications are being deployed on a full-scale basis. Most recently, the California Independent System Operator ("CAISO") issued "flex alerts" to customers in California in

[23] Todd et al (2014), pp. 6-7.

response to higher than expected demand driven by high temperatures, concerns about natural gas shortages at the Aliso Canyon storage facility, and challenging grid conditions caused by nearby wildfires.[24]

Several studies have estimated the impacts of these pilot programs in the past few years. I have identified seven such studies. Much like EAI's proposed method of deployment, most of these programs appear to have been rolled out on a default basis, meaning all participants were automatically enrolled in the program.[25] Aggregate peak demand reductions identified in the studies ranged from 1.7 percent to 5.8 percent.[26] The impacts estimated in each study are summarized in Figure 1, with EAI's assumption shown for comparison purposes. Full citations to all seven studies are provided in EAI Direct Exhibit AF-2 attached to my direct testimony.[27]

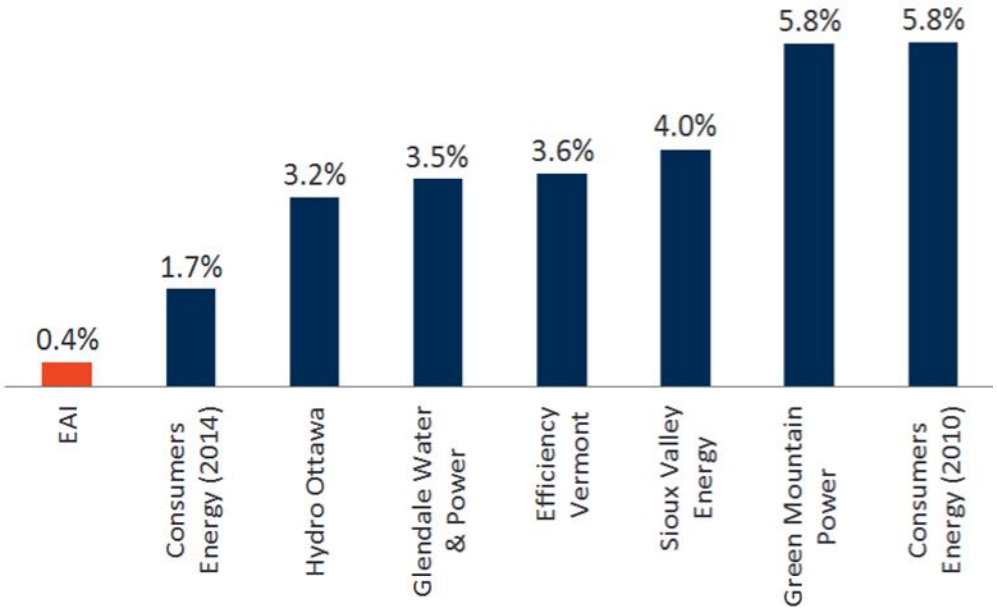
[24] Kassia Micek, "CAISO Calls on Consumers to Conserve Electricity," *Platts*, June 20, 2016, *available at* http://www.platts.com/latest-news/electric-power/houston/caiso-calls-on-consumers-to-conserve-electricity-21758647, last accessed September 2, 2016.

[25] Based on my review of the seven pilot studies shown in Figure 1, I believe only the Consumers Energy (2010) pilot included opt-in deployment. I believe all the other six pilot programs, including the Consumers Energy (2014) pilot, automatically enrolled customers to receive peak event notifications.

[26] While some of these seven pilots included a subset of customers receiving a financial incentive to reduce peak usage, all of the values provided in Figure 1 are based off information-only peak event notification programs.

[27] Note that the source document for the Consumers Energy (2014) result identifies the utility as CMS Energy, which is a holding company. The only utility subsidiary of CMS Energy is Consumers Energy, so I refer to the utility as Consumers Energy in Figure 1.

Figure 1
Residential and Commercial Peak Demand Reductions from Behavioral Demand Response Programs



Notes:
[1] Value for EAI is assumption from AMI cost-benefit analysis.
[2] Results for Green Mountain Power were not determined to be statistically significant.
[3] For pilots that reported a range of impacts, the midpoint of the range is shown.
[4] Impacts are average across all pilot participants and can be reasonably scaled to the class as a whole.

EAI's assumed residential and commercial peak impact of 0.4 percent is conservative relative to the range of findings of the pilots summarized in Figure 1. While I believe a higher assumed impact could be justified, it makes sense to be somewhat conservative with this assumption given that the industry has not been studying the impacts of these programs for as long as some other types of programs such as web portals.

IV. OTHER ASPECTS OF EAI'S AMI DEPLOYMENT

Q. WHAT OTHER ASPECTS OF THE AMI DEPLOYMENT HAVE YOU REVIEWED?

A. I have reviewed EAI's assumed reductions in UFE and the Company's recommendation regarding an advanced meter opt-out policy.

A. Benefits of UFE reduction

Q. WHAT IS "UFE"?

A. UFE reflects losses in the electricity system between the generator and customer meter. This includes line and transformation losses (or "technical losses") as well as electricity that is being consumed from the grid by customers but not metered nor billed by the utility (so-called "non-technical losses"). These non-technical losses could be due to meter malfunction, such as a meter that has slowed down over time or stopped working entirely. Or, non-technical losses could be caused by tampering and electricity theft. The cost of UFE, regardless of source, is borne by all customers as it effectively is treated as a system loss. This is further explained in Mr. Lewis' direct testimony.

Q. WHAT HAS EAI ASSUMED REGARDING THE BENEFITS OF REDUCTION IN UFE?

A. As discussed by Mr. Lewis, EAI has assumed that roughly one percent of residential and commercial energy sales are unaccounted for currently

due to non-technical UFE losses. EAI assumes it will be able to detect and address half of this one percent as a result of the AMI deployment. EAI further assumes that, once detected, half of this 0.5 percent, or 0.25 percent of all residential and commercial sales, will actually cease as a result of the detection, while the other half is converted to billable sales. Put another way, deploying AMI will allow EAI to improve fairness in revenue collection and reduce residential and commercial electricity consumption by 0.25 percent.

Mr. Lewis distinguishes two different types of benefits that this reduction in UFE will provide to EAI's customers. First, the 0.25 percent reduction in electricity consumption amounts to an avoided cost. That is electricity that EAI no longer needs to generate (or procure), so it translates into a cost reduction associated with the need for less fuel, which ultimately lowers the fuel adjustment for all customers. Next, the 0.5 percent UFE detection represents an overall improvement in fairness in revenue collection. As described above, the cost of that electricity was being borne by customers other than those who were consuming it. While there is not a net reduction in total system-level costs associated with correcting that until rates are next reset, it represents an improvement in fairness and equity and a reduction in bills for those customers who were previously unintentionally covering the cost of the undetected electricity consumption.

Q. ARE THESE UFE-RELATED BENEFITS CONSISTENT WITH ASSUMPTIONS YOU HAVE OBSERVED IN OTHER APPROVED UTILITY AMI DEPLOYMENT APPLICATIONS?

A. Yes. Reduced UFE is a common benefit cited within approved AMI deployment applications. In fact, in an informal survey of approved utility AMI deployment applications and AMI cost recovery proceedings over the past few years, I identified eight that quantified the benefit related to reduced UFE. Those utilities are Ameren Illinois, Baltimore Gas & Electric, BC Hydro, Commonwealth Edison ("ComEd"), Consolidated Edison, Duke Energy Ohio, a joint filing by the Hawaiian utilities, and Public Service Company of Oklahoma. A complete list of citations to each utility AMI cost-benefit analysis is provided in EAI Direct Exhibit AF-2.

Regarding the magnitude of the UFE reduction, I have found that EAI's assumed reduction is consistent with that of other utility AMI cost-benefit analyses. For instance, ComEd estimated 0.91 percent of sales to be non-technical UFE. Like EAI, ComEd assumed that half of this UFE would be detected through the use of AMI. Of the detected UFE, ComEd assumed that 50 to 80 percent would cease, resulting in a net reduction in electricity use of 0.23 to 0.36 percent.[28] This is similar to EAI's assumption of 0.25 percent.

[28] (0.91% non-technical UFE sales) X (50% detected via AMI) X (50% ceased consumption) = 0.23%, and 0.91% X 50% X 80% = 0.36%. See Black & Veatch, for Commonwealth Edison Company. *Advanced Metering Infrastructure (AMI) Evaluation- Final Report*, July 2011, p. 117.

I believe it is reasonable to expect that some portion of UFE will simply go away once it is detected. Customers may become more energy efficient or curtail illicit use of electricity when faced with the full cost of the electricity that they were previously consuming. There is a vast literature in energy economics which shows conclusively that customers consume less electricity when the price increases (or in this case their overall costs).[29]

Finally, I have noted that avoided peak demand associated with the reduced UFE could also be included as a benefit in EAI's cost-benefit analysis (similar to the avoided peak demand benefits from the web portal). EAI has not included this potential benefit of reduced UFE, focusing only on the avoided energy costs, and therefore the Company's estimate is conservative in this sense.

B. EAI's Opt-out Recommendation

Q. EAI HAS RECOMMENDED THAT RESIDENTIAL CUSTOMERS BE ALLOWED TO VOLUNTARILY "OPT OUT" OF HAVING AN ADVANCED METER. WHAT DOES THIS MEAN?

A. As Mr. Lewis describes in his testimony, EAI's opt-out recommendation is that residential customers could choose to avoid receiving an advanced

[29] See, for instance, Mark Bernstein and James Griffin, "Regional Differences in the Price-Elasticity of Demand for Energy," RAND Corporation Technical Report, 2005, *available at* http://www.rand.org/content/dam/rand/pubs/technical_reports/2005/RAND_TR292.pdf.

meter before their existing meter is replaced (subject to certain safety and accuracy tests), or could have their advanced meter (if already installed) replaced with a non-advanced electric meter. Those customers who opt out of the advanced meter would pay, in addition to standard residential rates and applicable riders, a fee that consists of an initial payment and a recurring monthly payment. The monthly fee would be designed to cover the costs of maintaining a redundant metering system as well as manually having their meter read each month. While not all utilities offer an opt-out option to their customers, allowing a customer to opt out is a common way to address the needs of the very small, but vocal minority of customers who have asserted privacy- or health-related concerns about advanced meters.

Q. DO YOU FEEL IT IS APPROPRIATE FOR EAI TO RECOMMEND THAT RESIDENTIAL CUSTOMERS SHOULD BE PROVIDED THE OPTION TO OPT OUT OF AN ADVANCED METER?

A. Yes. That said, the credible evidence that I have seen suggests that advanced meters do not pose a health risk to customers, do not improperly infringe on customer privacy, or otherwise represent a safety risk. For instance, The California Council on Science and Technology found that there are no adverse health effects associated with advanced

meters.[30] Advanced meters do not come anywhere near the Federal Communication Commission's ("FCC") established limits for radiofrequency ("RF") exposure.[31] And to the extent that some customers have privacy, data security, or other concerns in spite of EAI's data protection policies (as described by Mr. Griffith and Mr. Washington in their testimony), those customers would have the option to opt out of an advanced meter.

To address the views of customers who feel strongly about these issues, I do believe it is pragmatic for EAI to give them the option to avoid having an advanced meter record and transmit their energy usage as long as those customers agree to pay for the additional associated costs that EAI would incur.[32]

Q. DO YOU AGREE WITH EAI'S RECOMMENDATION FOR ESTABLISHING UPFRONT AND ON-GOING OPT-OUT FEES, AS DESCRIBED BY MR. LEWIS?

A. My understanding is that EAI is recommending to charge the full cost of opting out only to those customers who opt out of AMI, including

[30] California Council on Science and Technology, "Health Impacts of Radio Frequency Exposure from Smart Meters," CCST whitepaper, April 2011, *available at*: https://ccst.us/publications/2011/2011smart-final.pdf.

[31] Electric Power Research Institute, "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter," Report 1021126. December 2010, *available at*: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001021126.

[32] My understanding is that customers would be required to provide adequate notice and acknowledge via signed form that they have opted out of the advanced meter and accept the associated upfront and on-going fees.

administrative paperwork, the inspection of existing meters, the removal/installation of the relevant meter, customer service, manual meter reads, and billing each month. The cost would be spread equally across all customers who opt out, in the form of an up-front charge and a recurring monthly charge.

Conceptually, this approach makes sense. Otherwise, the customers who opt out would be unfairly subsidized by customers who accept a new advanced meter. Since customers that opt out still would receive benefits through reduced rates (due to reduced operational costs and fuel costs, for example), it is reasonable that opt-out customers should be required to pay other applicable residential rates and riders, including any APSC-approved recovery of the AMI deployment.

Q. WHEN PRESENTED WITH THE OPTION, WHAT PERCENTAGE OF CUSTOMERS HAVE TYPICALLY OPTED OUT OF AN ADVANCED METER OFFERING IN OTHER JURISDICTIONS?

A. Even in PG&E's Northern California service territory, where the most vocal opposition to advanced meters surfaced a few years ago, the percentage of customers who opted-out is only around one percent.[33] That is one of the highest opt-out rates that I am aware of. In other utility cases,

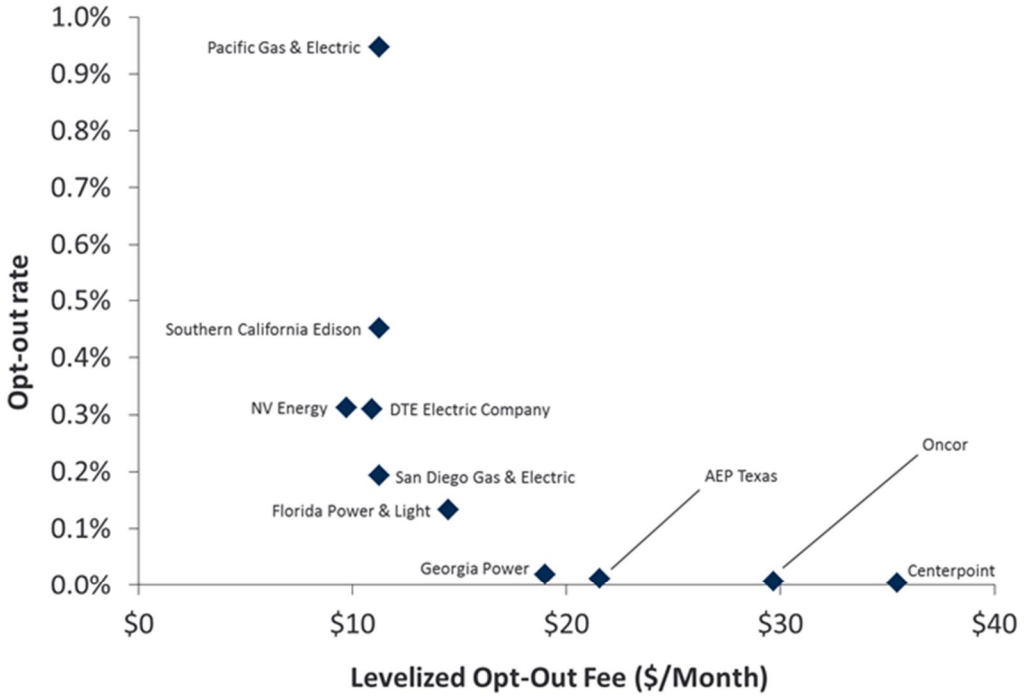
[33] That is 52,205 customers who were enrolled in PG&E's SmartMeter Opt-Out Program as of October 2015 out of a total of 5,518,718 customers. See *California Smart Grid – Annual Report to the Governor and the Legislature, in Compliance with Public Utilities Code 913.2, California Public Utilities Commission* (January 1, 2016), p. 17 and EIA Form EIA-826 (December 2015), "Sales and Revenue".

including other utilities in California, the opt-out rate is only a fraction of one percent. Only a very small portion of a utility's customers are expected to opt out of an advanced meter offering.

Figure 2 summarizes AMI opt-out rates from a number of North American utilities.[34] Because the opt-out rate is likely influenced in part by the magnitude of the opt-out fees,[35] I have included the on-going monthly fee on the horizontal axis.[36] Support for the information shown in this figure is provided in EAI Direct Exhibit AF-3 attached to my direct testimony.

[34] I reviewed the analysis in Mr. Lewis's testimony and Exhibit JAL-6 and have reproduced those opt-out rates here.
[35] Other factors that could influence the opt-out rate are the amount of time that has passed since the meter opt-out policy was put in place, differences in perceived risk from advanced meters across utility service territories, and the extent to which advanced meters enable various customer-side benefits that customers would not want to forgo by opting out.
[36] The fee is commonly composed of an initial, one-time payment plus an ongoing monthly payment. In these instances, I have levelized the one-time-payment over an assumed period of 60-months and added it to the monthly fee in order to create an average all-in monthly fee that is comparable across the utilities.

Figure 2
Opt-out Fees and Rates from Selected Utilities with Publicly Available Opt-out Data



Notes:
[1] Opt-out rates are calculated as the number of customers who opt out divided by total customers as of December 2015. Number of customers who opt out are based on the latest publicly available data, which spans a period from 2012 to 2016 depending on the utility.
[2] The initial opt-out fee has been levelized over an assumed 5-year period.

I have reviewed the estimated opt-out fee range in Mr. Lewis' testimony. Based on that review, I believe an assumed rate of 0.25 percent is reasonable relative to the utilities shown in Figure 2.

V. CONCLUSIONS

Q. WHAT DO YOU CONCLUDE ABOUT THE REASONABLENESS OF EAI'S AMI PROPOSAL?

A. Advanced metering is a necessary platform to keep up with customer expectations in the digital age and to facilitate the integration of new energy technologies on both sides of the customer's meter. EAI's methodological framework for assessing the costs and benefits of AMI is consistent with industry practices and includes reasonable assumptions that embody the latest available research on the topic. If anything, EAI has been conservative in its assessment of the many benefits of deploying AMI. In some cases, there are additional potential benefits of the AMI proposal which EAI has not quantified (*e.g.*, peak demand reductions due to reduced UFE). There are also additional new AMI-enabled programs, which EAI could offer in the future (e.g., dynamic pricing options). For these reasons, I believe the future realized benefits of EAI's proposed AMI deployment could be even higher than those quantified by Mr. Lewis.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes.

CERTIFICATE OF SERVICE

I, Laura R. Landreaux, do hereby certify that a copy of the foregoing has been served upon all parties of record by forwarding the same by electronic mail and/or first class mail, postage prepaid, this 19th day of September, 2016.

/s/ Laura R. Landreaux
Laura R. Landreaux

BEFORE THE
ARKANSAS PUBLIC SERVICE COMMISSION

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

EAI DIRECT EXHIBIT AF-1

STATEMENT OF QUALIFICATIONS

Ahmad Faruqui
Principal

San Francisco, CA | +1.415.217.1000 | Ahmad.Faruqui@brattle.com

Dr. Ahmad Faruqui is an economist with 40 years of academic, consulting and research experience in the efficient use of energy. He has assisted clients in the conceptualization, design, analysis, and evaluation of a wide range of programs related to advanced metering infrastructure, conservation voltage reduction, combined heat and power, demand charges, distributed energy resources, dynamic pricing, demand response, energy efficiency and newly emerging technologies, such as plug-in electric vehicles, rooftop solar, and distributed generation. He has provided regulatory support and testimony in proceedings related to these issues in 34 states, the District of Columbia and Canada.

He has assisted numerous utilities in carrying out cost benefit analysis, smart grid investments, and in developing business cases for advanced metering infrastructure. These have been carried out in California, Connecticut, Delaware, District of Columbia, Illinois, Maryland, and Michigan.

During the past decade, Dr. Faruqui has been at the forefront of experiments with dynamic pricing and enabling technologies. He serves on the U.S. Department of Energy's Technical Advisory Group for Customer Behavior Studies. He also co-authored a guide on how to evaluate smart grid demonstration projects and led a team of consultants that developed demand response potential estimates on a state-by-state basis for the Federal Energy Regulatory Commission (FERC) in 2009. His report entitled, "Time-Varying and Dynamic Rate Design," was published by The Regulatory Assistance Project (RAP) in 2012.

Dr. Faruqui's survey of the early experiments with time-of-use pricing in the U.S. is referenced in Professor Bonbright's treatise on public utilities. He managed the integration of results across the top five of these experiments in what was the first meta-analysis involving innovative pricing. Two of his dynamic experiments have won professional awards, and he was named one of the world's Top 100 experts on the smart grid by Greentech Media.

He has consulted with more than 135 energy organizations around the globe and testified or appeared before 19 state and provincial commissions and legislative bodies in the United States and Canada. He has also advised the Alberta Utilities Commission, the Edison Electric Institute, the Electric Power Research Institute, FERC, the Institute for Electric Efficiency, the Ontario Energy Board, the Saudi Electricity and Co-Generation Regulatory Authority, and the World Bank. His research on the energy behavior of consumers has been cited in Business Week, The Economist, Forbes, National Geographic, The New York Times, Fortune, the San Francisco Chronicle, the San Jose Mercury News, the Wall Street Journal, The Times (London) and USA Today. He has appeared on Fox Business News, National Public Radio and Voice of America.

Dr. Faruqui is the author, co-author or co-editor of four books and more than 150 articles, papers, and reports on efficient energy use. He has published in peer-reviewed journals such as Energy Economics, Energy Journal, Energy Efficiency, and the Journal of Regulatory Economics and trade journals such as The Electricity Journal and the Public Utilities Fortnightly. He has taught economics at San Jose State University, the University of California at Davis and the University of Karachi. He holds a an M.A. in

agricultural economics and a Ph. D. in economics from The University of California at Davis, where he was a Regents Fellow, and B.A. and M.A. degrees in economics from The University of Karachi, where he was awarded the Rashid Minhas Gold Medal in economics and the Government of Pakistan Overseas Scholarship.

AREAS OF EXPERTISE

- *Cost-benefit analysis of advanced metering infrastructure*. 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.

- *Regulatory strategy.* He 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.

- *Innovative pricing*. He has identified, designed and analyzed the efficiency and equity benefits of introducing innovative pricing designs such as dynamic pricing, time-of-use pricing and inclining block rates.

- *Demand forecasting and weather normalization*. He has pioneered the use of a wide 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 wide 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.

- *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. In addition, he has led a variety of professional seminars and workshops on public utility economics around the world and taught economics at the university level.

EXPERIENCE

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.

Innovative Pricing

- **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 reviews 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 discusses ways in which dynamic pricing can 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 includes 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 is international regulators in regions that are 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) in the summer of 2009. 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 from 2008 to 2011. 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.

- **Developed a Customer Price Response Model: Consolidated Edison**. 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 forecasting fuel 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

- **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 in June 2010.
- **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 in 2009, as required by the Energy Independence and Security Act of 2007.
- **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.

Demand Forecasting

- **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.** We conducted a strategic review of why sales had been lower than forecast in a year when economic activity had been brisk. We 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. We 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. We 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, we developed a base case forecast and several alternative case forecasts of electric energy consumption by end use and sector. We 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 are likely to operate in a competitive market, such as third-party energy service companies (ESCOS) 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

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.

California

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

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.

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.

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

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.

Illinois

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

Rebuttal Restimony 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

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

Kansas

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.

Maryland

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.

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.

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.

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.

Nevada

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.

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

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.

Pennsylvania

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.

Oklahoma

Rebuttal 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, 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 3, 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.

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

Presentations

1. "Time Variant Electricity Pricing: Theory and Implementation," Georgetown University's CSIS. A 90-minute panel session on time-variant pricing. Washington, DC, April 20, 2016. https://www.youtube.com/watch?v=0p6ZHaXszRQ

2. "Residential Demand Charges: An Overview," presented to EEI Rate Committee Meeting, Charlotte, NC, March 15, 2016.

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

4. "Imaging the Utility of the Future," presented to Commonwealth Edison Company, January 12, 2016.

5. "The Movement Towards Deploying Demand Charges for Residential Customers," NARUC 127th Annual Meeting, Austin, Texas, November 8, 2015.

6. "Comments on the Straw Proposal on behalf of the California Water Association," presented at the CPUC Workshop on Balanced Rates Rulemaking (R.) 11-11-0008, San Francisco, October 13, 2015.

7. "A Global Perspective on Time-Varying Rates," presented at the Stanford Bits & Watts Program, August 12, 2015. http://www.brattle.com/system/publications/pdfs/000/005/183/original/A_global_perspective_on_time-varying_rates_Faruqui_061915.pdf?1436207012

8. "The Case for Introducing Demand Charges in Residential Tariffs," presented to the Harvard Electricity Policy Group 79th Plenary Session, Washington, D.C., June 25, 2015.

9. "A Global Perspective on Time-Varying Rates," presented to the CAMPUT Energy Regulation Course, Kingston, Ontario, June 23, 2015.

10. "The Global Movement Toward Cost-Reflective Tariffs," presented at the EUCI Residential Demand Charges Summit, Denver, Colorado, May 14, 2015.

11. "Currents of Change in the Design of Tariffs for Distribution Networks," presented at Energy Network Association: Energy Transformed, Sydney, Australia, May 7, 2015.

12. "Points of Inflection Loom Ahead for Demand Response and Distributed Generation," presented at the Comverge Utility Conference, St. Petersburg, Florida, April 10, 2015.

13. "Time-Variant Pricing (TVP) in New York," presented at the Time-Variant Pricing Forum, NYU School of Law, New York, New York, March 31, 2015. http://www.sallan.org/Sallan_In-the-Media/2015/04/rev_agenda_time_variant_p.php

14. "The Evolving Futures of Demand Response and Distributed Generation," presented to Eastern Interconnection States Planning Council, Newark, New Jersey, March 5, 2015.

15. "The Impact of Distributed Generation on Electric Sales," resented to Eastern Interconnection States Planning Council, Newark, New Jersey, March 5, 2015.

16. "The Five Forces Shaping the Future of Demand Response (DR)," presented at the Demand Response Virtual Summit 2015, February 19, 2015.

17. "The Impact of an Uncertain Economic Outlook on Electric Utilities," presented at the New Mexico Economic Outlook Conference 2015, January 15, 2015.
http://www.bizjournals.com/albuquerque/news/2015/01/15/see-one-economists-view-on-why-electric-utilities.html

18. "The Re-emergence of Combined Heat and Power (CHP), presented at the NRRI Teleseminar, August 27, 2014.

19. "Moving Demand Response Back to the Demand Side," presented at the IEEE Power & Energy Society General Meeting, Harbor, Maryland, July 28, 2014.

20. "Price-Enabled Demand Response," presented to the Thai Energy Regulatory Commission, OERC, and Utilities Delegation, Boston, Massachusetts, July 16, 2014.

21. "Quantile Regression for Peak Demand Forecasting," with Charlie Gibbons, July 1, 2014.

22. "Strategies for Surviving Sub-One Percent Growth and the Emergence of the Energy Services Utility," presented at the 2014 UEC Summit, Coeur d'Alene, Idaho, June 24, 2014.

23. "The Emergence of the Energy Services Utility," presented at the North Carolina Electric Membership Corporation, June 5, 2014.

24. "Surviving Sub-One Percent Sales Growth,'' presented at the ACC Workshop, Phoenix, Arizona, March 20, 2014.

25. "The Customer-Side Benefits of Smart Meters," presented at the Smart Meter Symposium, Hong Kong, November 7, 2013.

26. "The Global Tao of the Smart Grid," presented at the 3rd Guangdong, Macau Power Industry Summit, Hong Kong, November 7, 2013.

27. "The Potential for Demand Response to Integrate Variable Energy Resources with the Grid," presented at the Joint CREPC/SPSC Meeting, San Diego, California, November 1, 2013.

28. "Policies for Energy Provider-Delivered Energy Efficiency in North America," with Jurgen Weiss, presented to The World Bank, October 17, 2013.

29. "Dynamic Pricing – The Bridge to a Smart Energy Future," presented at the World Smart Grid Forum, Berlin, Germany, September 25, 2013.

30. "Redefining California's Energy Future," presented at the Governor's Grid Conference, Palo Alto, California, September 10, 2013.

31. "Resolving the Crisis in Rate Design," presented at the EEI AltReg Webinar, August 2, 2013.

32. "Dynamic Pricing 2.0: The Grid-Integration of Renewables," presented at the IEEE PES GM 2013 Meetings, Vancouver, Canada, July, 23, 2013.

33. "The Clash of the Dynamic Pricing Titans: Faruqui v Toney – Part 1," Northwestern University's Kellogg Alumni Club. A two hour debate on the merits of dynamic pricing. San Francisco, CA, February 17, 2011. https://vimeo.com/20206833

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.

Technical Reports

1. *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.ieso.ca/Documents/reports/Final-Analysis-of-Ontarios-Full-Scale-Roll-Out-of-TOU-Rates.pdf

2. *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.

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

4. *Impact Evaluation of Ontario's Time-of-Use Rates: First Year Analysis,* with Sanem Sergici, Neil Lessem, Dean Mountain, Frank Denton, Byron Spencer, and Chris King, prepared for Ontario Power Authority, November 2013.

5. *Time-Varying and Dynamic Rate Design*, with Ryan Hledik and Jennifer Palmer, prepared for RAP, July 2012. http://www.raponline.org/document/download/id/5131

6. *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.
7. http://www.smartgridnews.com/artman/uploads/1/IEE_Benefits_of_Smart_Meters_Final.pdf

8. *Measurement and Verification Principles for Behavior-Based Efficiency Programs*, with Sanem Sergici, prepared for Opower, May 2011.
http://opower.com/uploads/library/file/10/brattle_mv_principles.pdf

9. *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.

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

11. *Demand-Side Bidding in Wholesale Electricity Markets.* With Robert Earle. Australian Energy Market Commission, 2008. http://www.aemc.gov.au/electricity.php?r=20071025.174223

12. *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.

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

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

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

16. *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.

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

18. *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.

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

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

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

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

23. *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.

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

25. *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.

26. *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.

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

Articles and Chapters

1. "An Economist's Dilemma: To PV or Not to PV, That Is the Question," *Electricity Policy*, March 2016. http://www.electricitypolicy.com/Articles/an-economists-dilemma-to-pv-or-not-to-pv-that-is-the-question

2. "Response to King-Datta Re: Time-Varying Rates," *Public Utilities Fortnightly*, March 2016.

3. "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.

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

5. "Impact Measurement of Tariff Changes when Experimentation is Not an Option – A Case Study of Ontario, Canada," *Energy Economics*, October 30, 2015.

6. "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

7. "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

8. "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.

9. "*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.

10. "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

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

12. "Study Ontario for TOU Lessons," *Intelligent Utility*, April 1, 2014. http://community.energycentral.com/community/energy-biz/study-ontario-time-use-tou-lessons

13. "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.

14. "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.

15. "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.

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

17. "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

18. "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.

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

20. "Surviving Sub-One-Percent Growth," *Electricity Policy*, June 2013. http://www.electricitypolicy.com/articles/5677-surviving-sub-one-percent-growth

21. "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

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

23. "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. http://www.energydelta.org/mainmenu/edi-intelligence-2/our-services/quarterly-2/edi-quarterly-vol-4-issue-1

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

25. "Dynamic Pricing for Residential and Small C&I Customers," presented at the Ohio Public Utilities Commission Technical Workshop, March 28, 2012. http://www.brattle.com/_documents/UploadLibrary/Upload1026.pdf

26. "Green Ovations: Innovations in Green Technologies," with Pritesh Gandhi, *Electric Energy T&D Magazine*, January-February 2012. http://www.electricenergyonline.com/?page=show_article&mag=76&article=618

27. "Dynamic Pricing of Electricity and its Discontents" with Jennifer Palmer, *Regulation*, Volume 34, Number 3, Fall 2011, pp. 16-22. http://www.cato.org/pubs/regulation/regv34n3/regv34n3-5.pdf

28. "Smart Pricing, Smart Charging," with Ryan Hledik, Armando Levy, and Alan Madian, *Public Utility Fortnightly*, Volume 149, Number 10, October 2011. http://www.fortnightly.com/archive/puf_archive_1011.cfm

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

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

http://spark.fortnightly.com/sitepages/pid58.php?ltemplate=intro_archive&pageId=58&lcommtypeid=6&item_id=33

31. "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.

32. "Better Data, New Conclusions," with Lisa Wood, *Public Utilities Fortnightly*, March 2011, pp. 47-48. http://www.fortnightly.com/archive/puf_archive_0311.cfm

33. "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

34. "Dynamic Pricing and Low-Income Customers: Correcting misconceptions about load-management programs," with Lisa Wood, *Public Utilities Fortnightly*, November 2010, pp. 60-64. http://www.fortnightly.com/archive/puf_archive_1110.cfm

35. "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.

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BEFORE THE
ARKANSAS PUBLIC SERVICE COMMISSION

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

EAI DIRECT EXHIBIT AF-2

CITATIONS TO RELEVANT STUDIES

EAI Direct Exhibit AF-2 – Citations to Relevant Studies

Full citations for the pilots referred to in "Figure 1: Residential Peak Demand Reductions form Behavioral Demand Response Programs" are listed below.

Utility	Citation
Consumers Energy (2014)	Brandon, Alec, John List, Robert Metcalfe, and Michael Price. *The Impact of the 2014 Opower Summer Behavioral Demand Response Campaigns on Peak-Time Energy Consumption.* University of Chicago/University of Georgia (June 28, 2014): 4.
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Public Service Company of Oklahoma	Supplemental Rebuttal Testimony of Derek S. Lewellen on behalf of Public Service Company of Oklahoma. Corporate Commission of Oklahoma – Case No. PUD 201300217 (July 15, 2014): Exhibit DSL-SR1, p. 1.

BEFORE THE
ARKANSAS PUBLIC SERVICE COMMISSION

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

EAI DIRECT EXHIBIT AF-3

SUMMARY OF OPT-OUT RATES AND FEES

EAI Direct Exhibit AF-3 – Summary of AMS Opt-out Rates and Fees

Data for Figure 2: Opt-out Rates and Fees from Selected Utilities with Publically Available Opt-out Data

	Utility	Opt-out Rate	Up-front Fee	Monthly Fee	Levelized Monthly Fee
		[A]	[B]	[C]	[D]
[1]	Pacific Gas & Electric	0.95%	$75.00	$10.00	$11.25
[2]	Southern California Edison	0.45%	$75.00	$10.00	$11.25
[3]	NV Energy	0.31%	$52.86	$8.82	$9.70
[4]	DTE Electric Company	0.31%	$67.20	$9.80	$10.92
[5]	San Diego Gas & Electric	0.19%	$75.00	$10.00	$11.25
[6]	Florida Power & Light	0.13%	$89.00	$13.00	$14.48
[7]	Georgia Power	0.02%	$0.00	$19.00	$19.00
[8]	AEP Texas	0.01%	$153.75	$19.00	$21.56
[9]	Oncor	0.01%	$179.83	$26.69	$29.69
[10]	CenterPoint	0.00%	$159.25	$32.80	$35.45

Sources and Notes:

[A]: Calculated as the number of customers who chose to opt-out ÷ total customers.
Source for number of customers who opt-out are listed below.
Total customers data from EIA Form 826 (December 2015), "Sales & Revenue".
For [8]-[10], total meter counts from the "Advanced Metering" section are used instead (customer count data is not available in the "Sales & Revenue" database for those Texas distribution utilities because they do not directly serve retail customers).

[D]: Levelized monthly fee includes monthly fee plus up-front fee levelized over 5 years (60 months).

[1A]: *California Smart Grid – Annual Report to the Governor and the Legislature, in Compliance with Public Utilities Code 913.2.* California Public Utilities Commission (January 1, 2016): 17.

[1B]–[1C]: Electric Schedule E-SOP – Residential Electric SmartMeter (TM) Opt-Out Program. Pacific Gas & Electric. Effective January 1, 2015. Cal. PUC Sheet No. 35105-E.

[2A]: *California Smart Grid – Annual Report to the Governor and the Legislature, in Compliance with Public Utilities Code 913.2.* California Public Utilities Commission (January 1, 2016): 17.

[2B]–[2C]: Schedule ESC-OO – Edison SmartConnect Opt-out. Southern California Edison Company. Effective February 6, 2015. Cal. PUC Sheet No. 56208-E.

[3A]: Prepared Direct Testimony of Gary P. Smith on behalf of Nevada Power Company. Nevada Public Utilities Commission – Docket No. 14-050004 (May 2, 2014): footnote 6, p. 17.

[3B]–[3C]: Schedule NSMO-1 – Non-Standard Metering Option Rider, Residential Service. Nevada Power Company. Effective March 14, 2014. PUCN Sheet No. 11B.

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[8A]: *AEP Texas Central Company and AEP Texas North Company Compliance Report.* Public Utility Commission of Texas – Docket No. 44129. July 7, 2016.

[8B]–[8C]: Tariff for Electric Delivery Service, Schedule 6.1.2 Discretionary Charges – Non-Standard Meter Installation Charges. AEP Texas Central Company and AEP Texas North Company. Effective July 7, 2014.
The values shown are for AEP Texas Central Company. The values for AEP Texas North Company are of similar magnitude but slightly higher.

[9A]: *Compliance Report of Oncor Electric Delivery Company LLC.* Public Utility Commission of Texas – Docket No. 44129. July 15, 2016.

[9B]–[9C]: Tariff for Retail Delivery Service, Schedule 6.1.2 Discretionary Charges, July 17, 2014. Sheet 1.
Oncor appears to charge different opt-out fees to customers with a standard (non-AMS) meter who choose not to have an AMS meter installed, and those who have already received an AMS meter and want to revert to a standard meter. The fees shown are for customers without an AMS meter.

[10A]: *CenterPoint Energy Houston Electric, LLC Compliance Report.* Public Utility Commission of Texas – Docket No. 44129. January 7, 2016.

[10B]–[10C]: Rate Schedule 6.1.2 Discretionary Charges – Non-Standard Meter Installation Charges. CenterPoint Energy, Inc. Effective July 7, 2014. Sheet No. 6.15.