Ameren Exhibit 5.0RH

ILLINOIS COMMERCE COMMISSION

DOCKET No. 12-0244

DIRECT TESTIMONY ON REHEARING

OF

DR. AHMAD FARUQUI

Submitted on Behalf Of

AMEREN ILLINOIS COMPANY
d/b/a Ameren Illinois

JUNE 28, 2012

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I. INTRODUCTION

Q. Please state your name and business address.

A. My name is Dr. Ahmad Faruqui, Ph.D. My business address is 201 Mission Street, Suite 2800, San Francisco, CA 94105.

Q. By whom are you employed and in what capacity?

A. I am a principal with *The Brattle Group* (*Brattle*). *Brattle* provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governments around the world. We combine in-depth industry experience and rigorous analyses to help clients answer complex economic and financial questions in litigation and regulation, develop strategies for changing markets, and make critical business decisions. Our Utilities Practice provides a wide range of consulting services that span all segments of the power industry, from generation to retail. Our clients include utilities, state and federal commissions, independent system operators and regional transmission operators.

Q. Please describe your education and relevant work experience.

A. The focus of my consulting practice is on the evaluation of the net benefits that can be provided to society as a whole by the deployment of the smart grid inclusive of advanced metering infrastructure. During the past decade, I have testified on these issues in a variety of states including California, Colorado, Connecticut, the District of Columbia, Illinois, Indiana, Maryland, and Pennsylvania. I have also appeared before regulatory and legislative bodies in Alberta, Arkansas, California, Delaware, Kansas, Minnesota, and Ontario. My clients have included utilities, state and federal commissions, independent system operators, regional transmission organizations, governments, equipment manufacturers, other private entities and international organizations such as the International Energy Agency and the World Bank. Besides the US, I have consulted with clients in Australia, Canada, Egypt, Hong Kong, Jamaica, Saudi Arabia and Philippines and spoken at international conferences in Australia, Brazil, France, Korea, and Ireland. All together, I have three decades of research and consulting experience in the field of energy economics. I hold a doctorate in economics and a master's degree in agricultural economics from the University of California at Davis, where I served as a Regents Fellow, and bachelor's and master's degrees in economics from the University of Karachi, both with the highest honors. I have published more than a hundred articles, papers and books on energy issues. Complete details are contained in my Statement of Qualifications, attached as an Appendix to this testimony.

II. <u>PURPOSE OF TESTIMONY</u>

Q. What is the purpose of your direct testimony on rehearing in this proceeding?

A. The purpose of my direct testimony on rehearing is to describe ***Brattle's*** assessment and quantification of the customer and societal benefits (referred to as societal benefits in the remainder of this testimony) of the Advanced Metering Infrastructure (AMI) Plan presented on rehearing by Ameren Illinois Company d/b/a Ameren Illinois (Ameren Illinois or AIC).

Q. Please summarize *Brattle's* analysis of the societal benefits that will be realized from Ameren Illinois' AMI Plan.

A. We ran a base case and several sensitivities around that base case to capture uncertainties associated with customer participation and the rate of AMI deployment. The nine cases arise from interacting three ways of deploying AMI in the Ameren Illinois footprint with three levels of customer participation in various customer-side activities. It is important to note that while we are including all the costs associated with customer-side activities, we are not assuming that Ameren Illinois is necessarily the provider of these services. They could be provided by third parties, or by Ameren Illinois or simultaneously by both. Societal benefits need not be provided from only one source.

Focusing on the scenario that envisions an 8-year rollout of AMI to 62% of Ameren Illinois' electric customers, with smart meters deploying between the 2014 and 2019 time frame, and assuming the medium rate of customer participation, we find that net societal benefits will amount to $574 million in nominal dollars and $338 million in net present value terms. Net-benefits across all nine cases range from $283 million to $1.035 billion in nominal dollars and from $166 million to $725 million in net present value dollars. In summary, net societal benefits are positive across all nine cases.

Q. Are you sponsoring any exhibits with your direct testimony?

A. Yes. I am sponsoring the following exhibits:

- Ameren Exhibit 5.1RH: Customer Classes
- Ameren Exhibit 5.2RH: Relevant Terms
- Ameren Exhibit 5.3RH: Program Participation Rates
- Ameren Exhibit 5.4RH: Per Customer Impact
- Ameren Exhibit 5.5RH: Technology Costs

- Ameren Exhibit 5.6RH: Summary of Costs and Benefits by Value Stream and Metric
- Ameren Exhibit 5.7RH: Nominal Sum of Net Benefits, 2013-2032, by Scenario

III. <u>AMI PLAN – SOCIETAL BENEFITS</u>

Q. Please describe the role *Brattle* has played in reviewing the AMI Plan that Ameren Illinois has submitted on rehearing.

A. ***Brattle*** developed estimates of the net societal benefits that are likely to be enabled by the roll-out of AMI by Ameren Illinois. We performed these assessments using our *iGrid* model. The model was calibrated to Ameren Illinois conditions using data from Ameren Illinois and a variety of other data sources.

Q. What is the *iGrid* model?

A. The *iGrid* model is proprietary software owned by ***Brattle*** to assess the costs and benefits of the value streams that are enabled by the smart grid. It was developed in one of our consulting engagements a few years ago and has continued to evolve with time. It has been successfully used in analyses such as the one presented with my testimony. I address the model in more detail later in my testimony.

Q. Can you describe the experience *Brattle* has in assessing the costs and benefits of deploying electric AMI?

A. We have performed similar assessments for clients in a variety of other states including California, Connecticut, Delaware, the District of Columbia, Indiana, Maryland and Michigan. We have presented our results in regulatory proceedings and in a variety of workshops, seminars, and conferences. We have also published them in trade journals such as The Electricity Journal and the Public Utilities Fortnightly and in peer-reviewed journals such as Energy, Energy Policy, and the Journal of Regulatory Economics.

Q. What is your understanding of the Illinois legal and regulatory structure under which Ameren Illinois has submitted its AMI Plan?

A. Illinois recently passed the Energy Infrastructure Modernization Act (EIMA). Under EIMA, Ameren Illinois can participate in an infrastructure investment program that requires it to commit to significant incremental capital expenditures to upgrade and modernize its electrical distribution grid. A key component of EIMA is that participating utilities are required to present an AMI Plan to the Illinois Commerce Commission (ICC or Commission). Ameren Illinois submitted its initial AMI Plan to the Commission on March 29, 2012. The Commission, however, has not yet approved an AMI Plan for Ameren Illinois. In its May 29, 2012 order, the Commission found it could not approve the AMI Plan Ameren Illinois initially submitted, as the Commission could not find that the plan met the "cost beneficial" standard under EIMA.

Q. What is your understanding of the "cost beneficial" requirement that Ameren Illinois' AMI Plan must meet?

A. EIMA provides the "cost-beneficial" standard that an approved AMI Plan must meet. Section 16-108.6(a) provides:

> Cost-beneficial" means a determination that the benefits of a participating utility's Smart Grid AMI Deployment Plan exceed the costs of the Smart Grid AMI Deployment Plan as initially filed with the Commission or as subsequently modified by the Commission. This standard is met if the present value of the total benefits of the Smart Grid AMI Deployment Plan exceeds the present value of the total costs of the Smart Grid AMI Deployment Plan. The total cost shall include all utility costs reasonably associated with the Smart Grid AMI Deployment Plan. The total benefits shall include the sum of avoided electricity costs, including avoided utility operational costs, avoided consumer power, capacity, and energy costs, and avoided societal costs associated with the production and consumption of electricity, as well as other societal benefits, including the greater integration of renewable and distributed power resources, reductions in the emissions of harmful pollutants and associated avoided health-related costs, other benefits associated

with energy efficiency measures, demand-response activities, and the enabling of greater penetration of alternative fuel vehicles.

Q. In determining whether Ameren Illinois' AMI Plan is cost beneficial, what benefits has *Brattle* reviewed?

A. We examined several categories of societal benefits including those derived from demand response (DR), energy efficiency (EE), plug-in electric vehicles (PEV), distributed generation and integration of distributed generation and renewable energy sources. For each category, we quantified (where it was possible to do) the avoided capacity and energy costs, avoided carbon emissions, and avoided gasoline costs.

Q. Have you quantified all of these societal customer benefits?

A. We have quantified societal benefits for demand response, energy efficiency and plug-in electric vehicles, including the value of carbon reduction. For distributed resources, we have focused on roof-top solar and have quantified the likely size of that resource but have not monetized it. We have also not quantified the benefits of integrating renewable energy resources into the grid using AMI. Quantification of these benefits would be speculative at this point.

Q. In your expert opinion and based on your prior experience in this field, is it reasonable to believe that these societal benefits will be realized from the AMI Plan presented on rehearing?

A. Yes.

Q. Is it also reasonable to believe that these societal benefits can be quantified?

A. Yes, there is sufficient data from pilot programs to do that quantification.

Q. Does the AMI Plan presented on rehearing contain sufficient detail to reasonably project and quantify these societal benefits?

A. Yes, I believe it does. We have included information on both costs and benefits, by year, for a wide range of programs. Both costs and benefits have been developed on a per-customer basis and then multiplied by an estimate of the number of participating customers to get total costs and benefits. The benefits have been quantified in several categories including avoided capacity (generation, transmission and distribution) and energy costs, avoided carbon emissions and avoided gasoline costs.

Q. Please describe the model *Brattle* utilized to assess and quantify the societal benefits of Ameren Illinois's AMI Plan.

A. The model is called *iGrid*, and it is written in Microsoft Excel. The model allows both benefits and costs of various AMI-enabled programs to be evaluated. The user has to provide a description of the programs, and their annual costs and benefits per participating customer. The user also has to provide a projection of the number of participating customers. The model then computes the aggregate impact of each program by year on kW peak demand, energy consumption, and gasoline consumption (for plug-in electric vehicles). The user is required to input values for several metrics that will then be used to estimate benefits, such as avoided capacity and energy costs, the price of carbon and the price of gasoline.

For this analysis, the *iGrid* model was tailored to five of Ameren Illinois' customer classes or subclasses: Residential, Small Commercial and Industrial (C&I), Medium C&I, Large C&I, and Very Large C&I. The rate classes and sizes of the classes are shown in Ameren Exhibit 5.1RH.

Q. Is this a model that *Brattle* has used in the past to assess the societal benefits of electric AMI deployment?

A. Yes, we have used it in several similar assessments.

Q. What material assumptions did you make to calculate the societal costs and benefits from the deployment of electric AMI?

A. To determine the anticipated reductions in peak load and energy usage, we made assumptions about the rate of customer participation, the impact of each program on the participating customer's peak demand and energy consumption, and the costs of these programs. We also made various assumptions regarding the electric vehicle market and the vehicle market in the absence of these electric vehicles. To calculate the carbon benefit, we used assumptions about the carbon emissions associated with energy generation and the carbon price in each year of the forecast. Finally, to determine the resulting benefits from the changes in peak load and energy usage, we used Ameren Illinois' assumptions regarding the avoided cost of capacity and energy.

Q. What types of demand response and energy efficiency programs did you envision for each customer class?

A. We envisioned that all residential customers will be eligible to earn a Peak Time Rebate (PTR) for electricity curtailed during critical peak hours. If they don't curtail their usage during critical peak hours, they will not receive a rebate or a penalty, and will continue to pay for usage at the standard rate. We also assume that suppliers will be offering Critical Peak Pricing (CPP) rates in which higher prices apply during peak hours on critical days and a discounted price applies during off-peak hours. For both PTR and CPP, a certain number of customers with central air conditioning will also have enabling technologies in place that boost their price responsiveness. Examples include In Home Displays (IHDs), Programmable Communicating Thermostats (PCTs), or Home Energy Management Systems (HEMS) and these will provide augmented load reductions during peak hours. In Home Displays are digital displays in a customer's home or business that shows rates, usage, and other relevant information, often in real-time. PCTs are smart thermostats that can transmit information between the utility or other third party service provider and the device wirelessly and which allow the relevant end-use equipment to be controlled remotely. Home (or Business) Energy Management Systems control all of the smart devices in a home or business. Some residential customers will join Ameren Illinois' existing PowerSmart Pricing (PSP) program, while others will choose a Direct Load Control (DLC) program. Finally, we envision that a small set of residential customers will buy electric vehicles in response to the incentives created by a TOU rate and smart charging enabled by a Home Energy Management System.

Small C&I customers will also have access to a CPP rate, with or without enabling technology, and participate in Direct Load Control. Medium, Large, and Very Large C&I customers will have the option to participate in CPP or CPP with Automated Demand Response (ADR). Ameren RH 5.2 contains definitions for each of the programs and technologies.

Q. Please describe *Brattle's* assumptions concerning dynamic rate and energy efficiency participation.

A. Participation rates in the DR and EE programs described above are laid out in Ameren Exhibit 5.3RH. For the Residential class, 10% of customers with smart meters will enroll in Power Smart Pricing (PSP) by 2032.[1] These do not include the existing PSP participants; instead, this percent represents the customers that will participate in PSP due to AMI. We assume that 1.3% of Residential customers with smart meters will enroll in a CPP rate without enabling technology, with another 0.7% participating in CPP with an IHD, another 0.7% participating in

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[1] Henceforth, all participation rates are expressed as percent of the customer class with smart meters, rather than the percent of the entire customer class.

CPP with an IHD and PCT, and another 0.3% participating in CPP with a HEMS and PCT. In total, 23.3% of Residential customers with smart meters will be on a PTR rate, again with some of those with IHDs and some with both IHDs and PCTs. We assume that 0.8% of the population will have TOU and HEMS to allow them to smart charge their electric vehicle. Another 2.9% will be on a DLC program. That leaves 60% of Residential customers who have smart meters but are not on any DR or EE program.

For Small C&I customers, we assumed that 2.9% of the population will be on a CPP rate and 2.9% will be on a DLC program, which are the same assumptions that we made for the Residential class. Again, some of the customers on the CPP rate also have displays and PCTs. However, the Small C&I customers will not have the option to join PTR, PSP, or TOU. For Medium and Large C&I customers, we assumed that a total of 3% will be on a CPP rate, roughly half with Automated Demand Response. Finally, we assumed that Very Large customers will have double the participation rates in CPP as do the Medium and Large customers.

For all programs, we assumed that participation in each program starts at 0% in 2016 and follows the "S" curve growth pattern that is commonly found in the literature on market diffusion to reach the targets described above by 2032.

Q. Please describe *Brattle's* assumptions concerning the per-customer impact of each program.

A. The assumptions regarding the per-customer impacts of each program for Residential and Small C&I customers are shown in Ameren Exhibit 5.4RH. These CPP and PTR assumptions are based on *Brattle*'s *Arc of Price Responsiveness* database, which summarizes the relationship between demand response and the peak to off-peak price ratio as observed in more than a hundred pilot programs. In this case, we assumed that Ameren Illinois customers will be offered a CPP rate with an 8:1 price ratio (consistent with the assumption in the report published by the FERC Staff in 2009, A National Assessment of Demand Response Potential, which is referenced below) and that the PTR will offer an equivalent price ratio. Based on the relationships contained in the *Arc*, the expected peak reduction would be 18% with no enabling technology, 22% with a PCT device, and 45% with a Home/Business Energy Management System. The DLC reduction is based on the assumption that DLC usually produces a 1 kW reduction, and 30% of DLC devices usually fail. With AMI, those 30% will be detected sooner and can be fixed, yielding a benefit of 0.3 kW (or 9%) per customer. The PSP reduction is based on Navigant's evaluation of the PSP program, which found a per customer reduction of roughly 0.5 kW or 15%.[2] Residential and Small C&I customers are also expected to reduce their daily energy usage as a result of being on dynamic rates with and without enabling technologies. The amounts are based on assumptions used in previous ***Brattle*** work for the Institute for Electric Efficiency.[3]

The peak reductions for these C&I customers are assumed to be 7% with the CPP rate alone and 14% with CPP plus Automated Demand Response. These assumptions are based on the 2009 FERC DR Assessment.[4] There are no energy savings associated with CPP or CPP with ADR.

Q. Please describe *Brattle*'s assumptions concerning the costs of these programs.

A. The assumptions for Residential and Small C&I technology costs are shown in Ameren Exhibit 5.5RH. In prior work for the Institute for Electric Efficiency, we had developed cost

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[2] Navigant, "Power Smart Pricing 2010 Annual Report," Prepared for Ameren Illinois, April 26, 2011 and further annualized updates provided to The Brattle Group.
[3] "The Costs and Benefits of Smart Meters for Residential Customers," by Ahmad Faruqui, Douglas C. Mitarotonda, Lisa Wood, Adam Cooper, and Judith Schwartz, IEE Whitepaper, The Edison Foundation, July 2011.
[4] Federal Energy Regulatory Commission, "A National Assessment of Demand Response Potential," June 2009.

estimates for the enabling technologies.[5] We polled a small group of experts to update these estimates, both to reflect current market conditions and future market conditions. Given that these technologies are based on digital electronics, we project costs will decline significantly over the next two decades, in consort with the type of technological innovation that normally occurs in digital technologies and due to economies of scale. In 2012, we estimate that an IHD (or equivalent display in a small business) will cost $50 nominal dollars, a PCT will cost $150, and a Home (or Business) Energy Management System will cost $400. In the first ten years of the forecast, nominal technology costs decrease at a rate of 16% per year. In the next ten years, the costs decrease at a rate of 8% per year. The nominal costs in 2012 and 2032 are shown in Ameren Exhibit 5.5RH.

Q. Please describe *Brattle's* assumptions concerning electric vehicles.

A. AMI makes it possible to provide vehicle owners a chance to save money by charging during off-peak hours and taking advantage of time-of-use rates and automated smart charging equipment. For vehicle owners, who are also residential customers of electricity, this will reduce the price per mile driven and encourage the further adoption of electric vehicles, leading to savings in gasoline and carbon emissions.

Q. What are the costs of PEV?

A. It is widely expected that owners of electric vehicles will have to pay an electric vehicle premium, since PEVs are more expensive than conventional vehicles. However, this premium is also expected to decline with time. We assume the premium is $9,500 in 2012 and declining by the same rate of technical innovations discussed above. In addition, PEV owners will consume

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[5] "The Costs and Benefits of Smart Meters for Residential Customers," by Ahmad Faruqui, Douglas C. Mitarotonda, Lisa Wood, Adam Cooper, and Judith Schwartz, IEE Whitepaper, The Edison Foundation, July 2011.

electricity and thus would incur additional capacity, distribution, transmission, and carbon costs.

Q. You have included avoided gasoline costs as a benefit. Isn't this counting the benefit of gasoline avoided by consumers who would have purchased PEV in the absence of AMI?

A. No. We only include benefits for the fraction of PEV owners who are motivated to purchase PEV by the reduction in electricity costs that AMI offers. We don't calculate any benefits for existing PEV owners, although they would benefit from lower electricity bills and reduce the peak time capacity, distribution, transmission, and carbon costs that the utility faces if AMI were installed.

Q. What fraction of PEV ownership do you attribute to AMI?

A. In the baseline scenario, we assume that among AMI enabled residential customers, 0.8% of vehicles by 2032 will be PEV attributable to AMI. That is equivalent to 0.7% of the entire vehicle fleet of AMI enabled customers.

Q. How do you derive this share?

A. Since we are unaware of any existing data showing how sensitive PEV sales are to electricity prices, we have derived this estimate by analogy, by examining the relationship between the sales of hybrid electric vehicles and gasoline prices. Like PEVs, these vehicles sell at a premium, but have lower costs per mile driven. Recent scholarly research using hybrid vehicle sales in the period 2000 to 2006 showed that as the price of gasoline increased by 1%, the quantity of fuel efficient hybrid vehicles sold increased by 0.86%.[6] We have used this relationship to estimate the sensitivity of PEV sales to electricity price. Recent models of PEV charging costs show that dynamic rates can allow consumer savings of 35 to 64% over charging

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[6] Gallagher, Kelly S. & Erich Muehlegger (2011): "Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology", *Journal of Environmental Economics and Management,* Vol. 61, Issue 1, pp 1–15.

under flat electricity rates.[7] To be conservative, we use a savings rate of 23%, which is two-thirds of the lower bound of the estimated savings rate. Plugging this vehicle charging price change into our model, we get that a 23% reduction in price will lead to a 20% increase in PEV sales. Using the same EIA estimates of future oil prices that we use elsewhere in our model, Becker, Sindhu & Tenderich estimate that PEV's will constitute 24% of the light vehicle fleet in 2030.[8] We halve this number to better reflect PEV penetration predictions filed with the ICC in 2010 by Ameren Illinois.[9] In Illinois light vehicles accounted for 90% of all vehicle miles traveled in 2010.[10] Thus we can say that approximately 11% of the entire fleet in 2030 will be PEVs. If lower charging prices enabled by AMIs leads to a 20% increase in PEV sales, then this sums up to a 2.1% PEV share of all vehicles attributable to AMI. Erring on the side of caution, we halve this number again, and then reduce it by one-third to get to the baseline case, which has a PEV penetration among AMI customers of 0.7%. If we attribute this entirely to residential customers, the residential participation rate among AMI enabled customers is 0.8%, as shown in Ameren Exhibit 5.3RH.

Q. Please describe *Brattle* assumptions concerning carbon.

A. We assumed that on average, there are 0.8 tons of carbon emitted per MWh.[11] This value is used to quantify the expected reduction in carbon emissions that follows from a result of lower

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[7] Faruqui, Ahmad, Ryan Hledik, Armando Levy & Alan Madian (2011): "Smart Pricing, Can time-of-use rates drive the behavior of electric vehicle owners?," *Public Utilities Fortnightly,* October 2011, pp.38-45.

[8] Becker, Thomas, Ikhlaq Sidhu & Burghardt Tenderich (2009): "Electric Vehicles in the United States: A New Model with Forecasts to 2030", Center for Entrepreneurship & Technology (CET) Technical Brief, available online at http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf

[9] Ameren Illinois (2010): "Ameren PEV Assessment Report", available online at http://www.icc.illinois.gov/electricity/pev.aspx

[10] Illinois Department of Transportation (2011): "Illinois Travel Statistics", available online at http://www.dot.state.il.us/travelstats/2011_ITS.pdf

[11] This assumption is based the 2016 forecasts for generation and CO_2 emissions in the 2011 MISO Transmission Expansion Plan.

energy consumption that arises from EE programs. For the electric vehicle calculations, we quantify the change in carbon emissions in the peak and off-peak periods as well as the change in carbon emissions due to less gasoline usage. The peak hour emissions rate is assumed to be 0.7 metric tons of carbon per MWh and the off-peak rate is 0.9 metric tons. These assumptions are based on the assumption that off-peak generation is 100% coal and on-peak generation is 50% coal and 50% gas, and they are consistent with the average MISO estimate. Gasoline also has an associated emissions rate. We assumed that there are 20 pounds of carbon emitted per gallon. The price of carbon, which was provided by Ameren Illinois, is assumed to be zero until 2025, at which point it is $30 in nominal terms.

Q. Please describe *Brattle's* assumptions concerning the avoided costs of capacity and energy.

A. We used data provided by Ameren Illinois. The avoided generation, distribution and transmission capacity costs are consistent with Ameren Illinois' previous AMI filing. We use the annual average avoided energy cost for an around the clock product provided by Ameren Illinois.

Q. Please describe how *Brattle* determined the net societal benefits of the Ameren Illinois AMI Plan.

A. The *iGrid* model calculated the expected peak reduction and energy savings that are expected as a result of the DR and EE programs and electric vehicles. The participation rates were combined with the per customer impact to attain the aggregate program peak reductions and energy savings. From there, the avoided cost of generation, distribution, and transmission capacity and the avoided cost of energy were used to calculate the benefits from avoided peak load and energy usage. A reduction (or, in the case of PEV, an increase) in energy usage is associated with a proportional reduction (or increase) in carbon emissions. The benefits from carbon emissions were therefore calculated based on the amount of carbon emissions reduced multiplied by the carbon price in a given year. For electric vehicles, the net benefits take into account the costs associated with increased electricity usage from charging electric vehicles and the savings associated with the avoided cost of gasoline, as described in detail above. After we produced the annual nominal net benefits, we calculate the nominal sum of net benefits from 2013 to 2032, as well as the net present value of benefits in 2013.

Q. Are there any other societal benefits of AMI that you have not yet quantified?

A. Yes, there will be a large amount of renewable energy resources coming online in Illinois in the near future. Demand response, made possible by AMI, presents an additional opportunity for integrating these resources into the grid.

Q. Are you able to quantify how much generation will come from renewable resources in 2032?

A. Yes. Illinois's Renewable Portfolio Standard (Public Act 095-0481) mandates that 25 percent of Ameren Illinois power generation mix must come from renewable resources in the compliance year 2025-2026. Of this, at least 75% must come from wind power and 6% from solar PV. So by 2032 at least 25% of Ameren Illinois' power will come from renewables.

Q. What makes renewables different from traditional forms of generation?

A. Both wind and solar generation have variable and less predictable production characteristics than traditional thermal generation sources. The generation output from these resources varies with seasonal, diurnal and synoptic weather patterns that are neither regular, nor fully predictable. For example wind patterns can change from minute to minute, leading to short-term forecast errors. For this reason, integrating renewables into the grid will require increases in the quantity and quality of flexible resources needed for reliable grid operation.

Q. What role does AMI have in integrating these resources into the grid?

A. By allowing customers to respond to changing supply conditions, demand response can become an additional tool in managing variable generation. This can easily be done through a combination of dynamic pricing and automated power management technology. For example, a smart-charging PEV can be set to charge only when the wind blows at night, eliminating the need to run additional thermal resources to meet a constant energy demand.

Q. Have you quantified these benefits?

A. No, demand response's ability to meet rapidly changing generation conditions depends on technologies and legislation that are still in their infancy.[12] At this stage, quantifying these benefits would be speculative. However, it is clear that the benefits of allowing customers to respond to variable generation do exist, and will increase as more renewables are put onto the grid.

Q. Did you quantify the amount of roof-top solar installations that are likely to be installed in 2030?

A. Yes.

Q. Can you describe the approach?

A. We selected a low and a high solar adoption scenario from an existing multiple scenario solar capacity prediction model.[13] These scenarios were chosen since they most closely mirrored assumptions used elsewhere in the societal benefits model such as including net metering

[12] Capper, Peter, Andrew Mills, Charles Goldman, Ryan Wiser & Joseph H. Eto (2012) "An Assessment of the Role Mass Market Demand Response Could Play in Contributing to the Management of Variable Generation Integration Issues", *Energy Policy*, forthcoming.
[13] Drury, Easan, Paul Denholm & Robert Margolis (2010): "Modeling the U.S. Rooftop Photovoltaics Market", NREL conference paper presented at the American Solar Energy Society (ASES) National Solar Conference 2010.

(enabled by AMI) and a price for carbon emissions.[14] The Low Adoption scenario assumes that physical PV system costs will remain relatively high (as projected by the EIA). The High Adoption scenario assumes that the price of PV will fall to meet the US Department of Energy's Solar Technology Energy Program (SETP) cost targets. In the Low Adoption scenario, US cumulative rooftop capacity is predicted to be between 30 and 40 GW in 2030. In the High Adoption scenario, US cumulative rooftop capacity is predicted to be between 160 and 200 GW in 2030. To be conservative, we took the upper bound of the Low Adoption scenario and the lower bound of the High Adoption scenario as point estimates.

This gives a range of potential solar PV capacity in the US. We can divide this by the size of an average solar PV system to get the cumulative number of installations in 2030. This yields a range of between 3 and 12 million cumulative solar installations across the entire US by 2030.[15]

To obtain Illinois's share of US solar installations we consider two different scenarios, a Business as Usual scenario and a Leapfrog scenario. In the Business as Usual scenario we base Illinois's 2030 share of US solar installations on their share of US solar capacity in 2010. In the Leapfrog scenario, we based Illinois's 2030 share of US solar capacity on their share of overall generation capacity in 2010. Since their share of US solar capacity was lower than their overall share of generation capacity (0.72% verse 3.43%) [16], they would have to grow faster than the national average to match their generation share by 2030.

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[14] Carbon price set to \$15/ton CO2 in 2012, then increases linearly to \$50/ton CO2 by 2025. Stays fixed at \$50/ton CO2 through 2030. This is different from the assumptions on carbon prices used in *Brattle's* own calculations elsewhere in the societal benefit analysis.

[15] The average residential rooftop solar system installed in 2010 was approximately 6KW, while the average non-residential system was approximately 80KW. 90%of 2010 system installations were residential.

[16] DOE (2011): "2010 Renewable Energy Data Book", available online at http://www.nrel.gov/analysis/pdfs/51680.pdf and EIA (2012): "State Renewable Electricity Profiles 2010". Available online at http://205.254.135.7/renewable/state/pdf/srp2010.pdf

Finally, to get Ameren Illinois's share of Illinois solar capacity, we multiply all figures by Ameren Illinois customer share of approximately 25%.

Q. What were the results?

A. In the Low Adoption scenario, installations ranged from 5,373 in the Business as Usual scenario to 21,490 in the Leapfrog scenario. In the High Adoption scenario, installations ranged from 25,627 in the Business as Usual scenario to 102,507 in the Leapfrog scenario.

Q. How does AMI deployment affect the adoption of roof-top solar?

A. It encourages the more efficient penetration of roof-top solar, by improving the connection with the grid and by allowing the provision of time-of-use rates.

Q. Did you monetize the benefits that would flow from the installation of roof-top solar?

A. No, we just estimated the potential number of installations.

Q. What are the results of *Brattle's* analysis of the societal benefit of the AMI Plan?

A. We find that the AMI Plan will provide positive net benefits across a range of scenarios about the pace and scope of AMI deployment and about the likely customer acceptance of AMI-enabled programs. The net benefits associated with the 8-year deployment scenario which features medium rates of customer acceptance amount to $574 million in nominal terms and $338 million in net present value terms. These baseline results are shown in Ameren Exhibit 5.6RH. Across the range of nine cases, the net benefits range from $283 million to $1.035 million in nominal terms and from $166 million and $725 million in net present value terms, as shown in Ameren Exhibit 5.7RH.

Q. Why is it reasonable for the Commission to assume that the AMI Plan will produce a net societal benefit?

A. The AMI Plan is based on a strong theoretical foundation and sound empirical work that harnesses the insights from a wide range of pilots that have been conducted in the United States, Canada, Europe and elsewhere. The assumptions are similar to those that have been used in other AMI filings throughout the US.

IV. <u>CONCLUSION</u>

Q. Does this conclude your direct testimony on rehearing?

A. Yes, it does.

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Dr. Ahmad Faruqui is an expert on the customer-facing aspects of the smart grid. He has performed cost-benefit analysis for electric utilities in two dozen states and testified before a dozen state and provincial commissions and legislative bodies. He has designed and evaluated some of the best known pilot programs involving dynamic pricing and enabling technologies and his early experimental work with time-of-use pricing is cited in Bonbright's canon.

He has assisted the Ontario Energy Board in evaluating the provincial deployment of time-of-use pricing and the Alberta Utilities Commission in responding to a ministerial inquiry into the smart grid. He has also assisted the Saudi Arabian regulator in developing a Kingdom-wide plan for introducing demand response.

Earlier, he assisted the FERC in the development of the "National Action Plan on Demand Response" and in writing "A National Assessment of Demand Response Potential." He co-authored EPRI's national assessment of the potential for Energy Efficiency and EEI's report on quantifying the benefits of dynamic pricing. He has assessed the benefits of dynamic pricing for the New York Independent System Operator, worked on fostering economic Demand Response for the Midwest ISO and ISO New England, reviewed demand forecasts for the PJM Interconnection and assisted the California Energy Commission in developing load management standards. His report on "The Impact of Dynamic Pricing on Low Income Customers" was published last fall by the Institute for Electric Efficiency.

The author, co-author or editor of four books and more than 150 articles, papers and reports, he holds a doctoral degree in economics from the University of California at Davis.

AREAS OF EXPERTISE

- *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.

- *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.

- *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 before state commissions in California and Iowa and helped clients testify before commissions in Colorado, Delmarva, the District of Columbia, Georgia, Maryland, Minnesota, and Ontario, Canada. He has made presentations to the California Energy Commission, the California Senate, the Congressional Office of Technology Assessment, 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

Demand Forecasting

- *Comprehensive Review of Load Forecasting Methodology: Large Regional Transmission Organization (RTO).*

  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.

- *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 Response

- *National Assessment of Demand Response Potential: Federal Energy Regulatory Commission.*

  Led a team of consultants to assess the economic and achievable potential for demand response programs on a state-by-state basis. The assessment was filed with the U.S. Congress, as required by the Energy Independence and Security Act 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 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.

Innovative Pricing

- *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 C&I customers.

- *Dynamic Pricing Pilot Design and Impact Evaluation: Mid-Atlantic Utility.*

  Designed and evaluated the 2009 Smart Energy Pricing (SEP) pilot, which was designed to measure the impacts of PTR on residential and small commercial and industrial (C&I) customer consumption patterns. In addition to the PTR rates, the pilot tested the impacts of smart thermostats and the Energy Orb. Also, designed the 2010 SEP pilot and conducted the impact evaluation study after the pilot was completed in September 2010. SEP 2010 was designed to measure the impact of direct feedback in conjunction with PTR on residential customers' consumption patterns.

- *Impact Evaluation of a Residential Dynamic Pricing Experiment: Mid-Atlantic Utility.*

  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 the Energy Orb and 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: Large Eastern Utility.*

  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 an 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 Management

- *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.

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.

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

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.

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

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

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

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

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

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

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

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Customer Classes

Rate Class	Size	Label	Number (2012)	Smart Meters (2032)
DS1	Residential	Residential	1,057,980	681,616
DS2	Less than 150 kW	Small C&I	147,593	95,088
DS3a	150 kW to 399 kW	Medium C&I	3,331	2,146
DS3b	400 kW to 999 kW	Large C&I	1,242	800
DS4	1 MW and greater	Very Large C&I	831	535

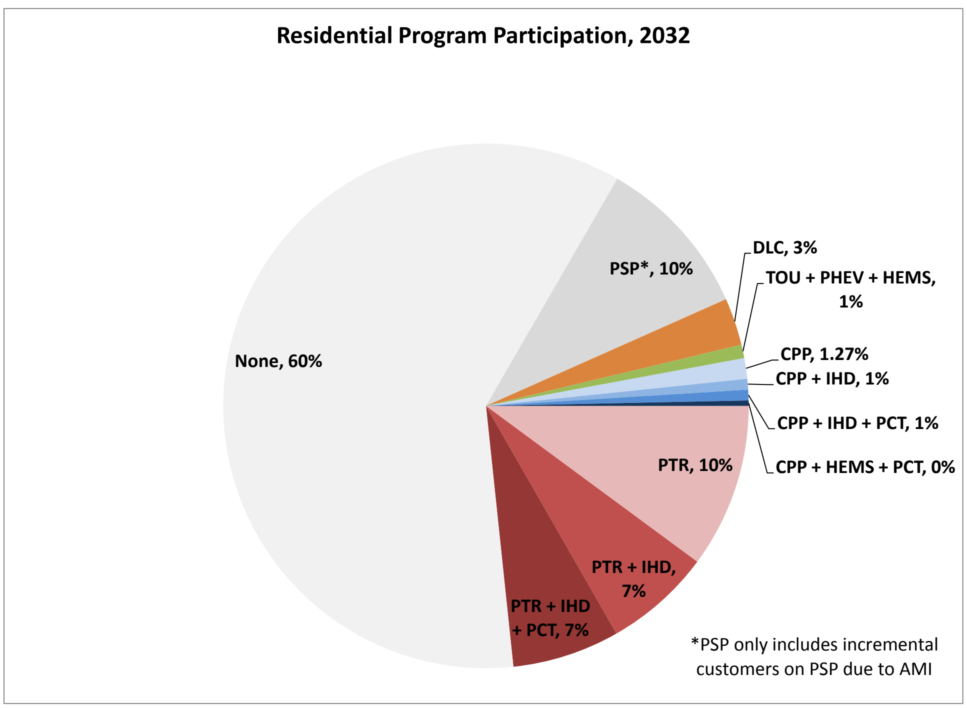
Relevant Terms

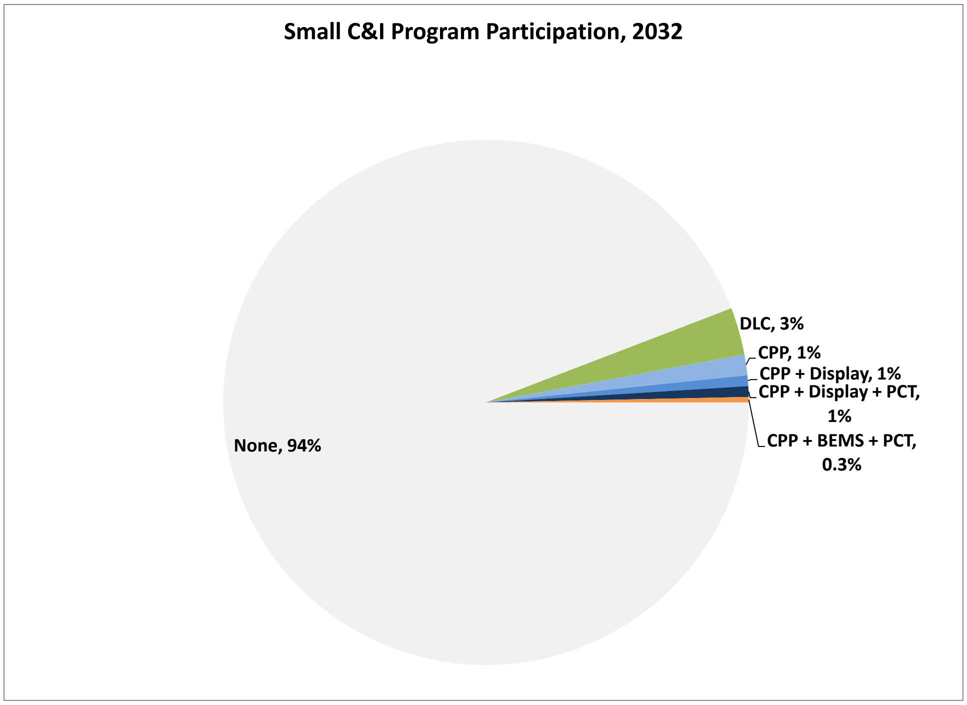
Acronym	Term	Definition
Rates & Programs		
PSP	Pow erSmart Pricing	Ameren's existing real-time pricing rate for residential customers
CPP	Critical Peak Pricing	A dynamic rate featuring a higher price during peak hours on critical days and a discounted price during all other off-peak hours
PTR	Peak Time Rebate	Customers receive a rebate for electricity curtailed during critical peak hours; If they do not curtail their usage during critical peak hours, they w ill not receive a rebate nor a penalty
TOU	Time of Use	A rate w ith a higher price on w eekday peak hours and a discounted price during off-peak hours
DLC	Direct Load Control	A program in w hich customers' air conditioning and other smart appliances are controlled by the utility or other third party service provider to reduce peak load
Technologies		
IHD	In-Home Display	A digital display in a customer's home or business that show s rates, usage, and other relevant information, often in real-time
PCT	Programmable Communicating Thermostat	A smart thermostat that can transmit information betw een the utility or other third party service provider and device w irelessly and w hich allow s the relevant end-use equipment to be controlled remotely
HEMS (BEMS)	Home (Business) Energy Management System	A system that controls all smart devices in a house or business
ADR	Automated Demand Response	A system that allow s utilities or other third party service providers to automatically curtail load in commercial and industrial facilities during peak hours
PEV	Plug-in Electric Vehicle	An automotive vehicle that is pow ered by an electric motor w hich runs on batteries that are charged periodically by being plugged into the electric grid

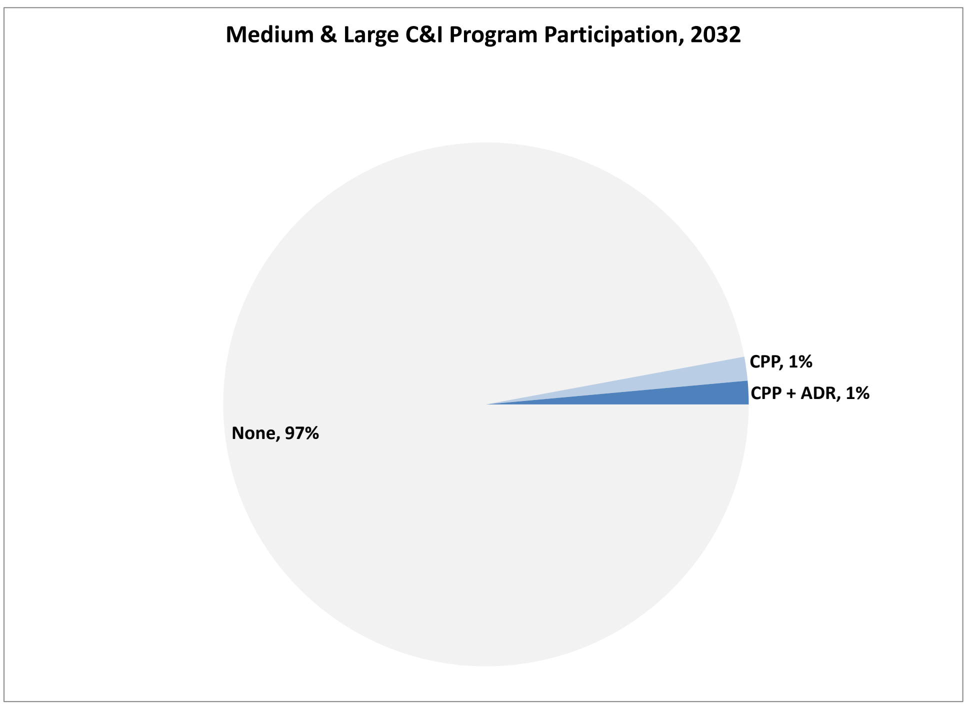
Exhibit 5.3

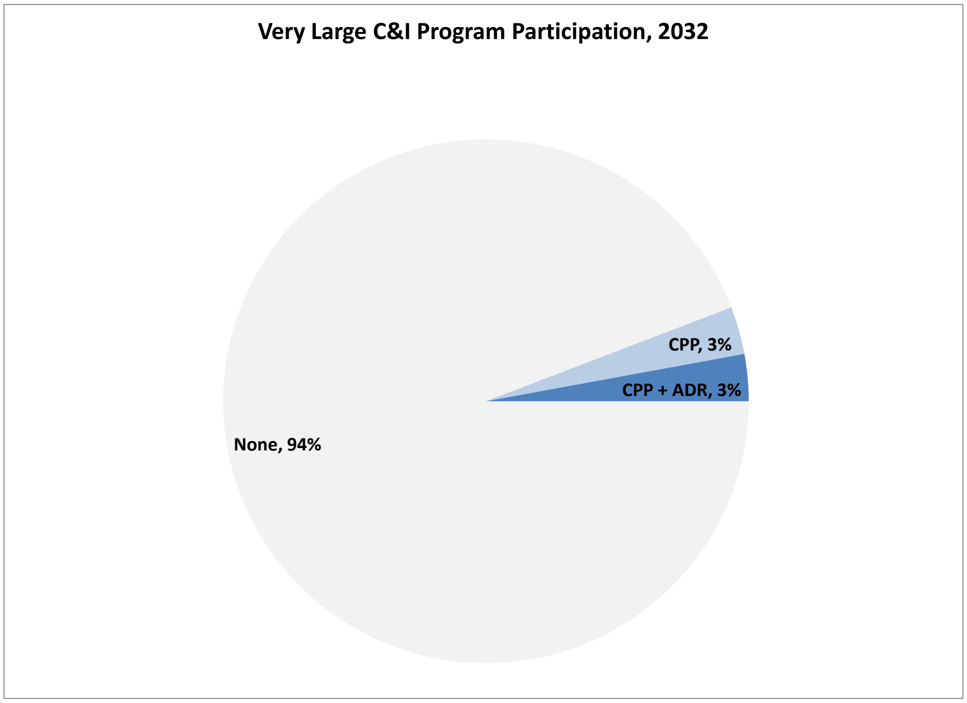
Program Participation Rates for Customers with Smart Meters, 2032

	Residential			
PSP	10.0%			*PowerSmart Pricing*
CPP	1.3%			*Critical Peak Pricing*
CPP + IHD	0.7%			*CPP w/ In Home Display*
CPP + IHD + PCT	0.7%			*CPP w/ In Home Display and Programmable Communicating Thermostat*
CPP + HEMS + PCT	0.3%			*CPP w/ Home Energy Management System and PCT*
PTR	10.1%			*Peak Time Rebate*
PTR + IHD	6.6%			*Peak Time Rebate w/ In Home Display*
PTR + IHD + PCT	6.6%			*Peak Time Rebate w/ In Home Display and PCT*
TOU + PEV + HEMS	0.8%			*Time of Use w/ a Plug-In Electric Vehicle and Home Energy Management System*
DLC	2.9%			*Direct Load Control*
No DR or EE	60.0%			*No demand response or energy efficiency programs*
	Small C&I			
CPP	1.3%			*Critical Peak Pricing*
CPP + Display	0.7%			*CPP w/ Display*
CPP + Display + PCT	0.7%			*CPP w/ Display and Programmable Communicating Thermostat*
CPP + BEMS + PCT	0.3%			*CPP w/ Business Energy Management System and PCT*
DLC	2.9%			*Direct Load Control*
No DR or EE	94.2%			*No demand response or energy efficiency programs*
	Medium C&I	**Large C&I**	**Very Large C&I**	
CPP	1.5%	1.5%	2.9%	*Critical Peak Pricing*
CPP + ADR	1.4%	1.4%	2.9%	*CPP w/ Automated Demand Response*
No DR or EE	97.1%	97.1%	94.2%	*No demand response or energy efficiency programs*




Small C&I Program Participation, 2032
DLC, 3%
CPP, 1%
CPP + Display, 1%
CPP + Display + PCT, 1%
CPP + BEMS + PCT, 0.3%
None, 94%


Medium & Large C&I Program Participation, 2032
CPP, 1%
CPP + ADR, 1%
None, 97%


Very Large C&I Program Participation, 2032
CPP, 3%
CPP + ADR, 3%
None, 94%

Per Customer Impact (Residential and Small C&I)

	Peak Reduction	Energy Savings
PSP	15.1%	0.5%
CPP	18.0%	0.5%
CPP + IHD	18.0%	2.0%
CPP + IHD + PCT	22.0%	2.0%
CPP + HEMS + PCT	45.0%	8.0%
PTR	18.0%	0.5%
PTR + IHD	18.0%	2.0%
PTR + IHD + PCT	22.0%	2.0%
DLC	9.0%	0.5%

Technology Costs (Residential & Small C&I)

	2012	2032
Display	$50	$4
Display + PCT	$150	$12
HEMS	$400	$33
HEMS + PCT	$550	$46

Summary of Costs and Benefits by Value Streams and Metrics

Nominal Sum 2013-2032	Capacity	Energy	Carbon	Gas	Total
DR					
Costs	$2,485,415	$0	$0	$0	$2,485,415
Benefits	$405,776,090	$0	$0	$0	$405,776,090
Net Benefits	**$403,290,675**	**$0**	**$0**	**$0**	**$403,290,675**
EE					
Costs	$0	$2,485,415	$0	$0	$2,485,415
Benefits	$0	$23,740,527	$10,314,452	$0	$34,054,979
Net Benefits	**$0**	**$21,255,112**	**$10,314,452**	**$0**	**$31,569,564**
PEV					
Costs	$0	$0	$0	$12,742,200	$12,742,200
Benefits	-$3,388,772	-$15,375,689	$1,077,758	$169,440,536	$151,753,834
Net Benefits	**-$3,388,772**	**-$15,375,689**	**$1,077,758**	**$156,698,336**	**$139,011,634**
Total					
Costs	$2,485,415	$2,485,415	$0	$12,742,200	$17,713,030
Benefits	$402,387,319	$8,364,838	$11,392,210	$169,440,536	$591,584,903
Net Benefits	**$399,901,904**	**$5,879,424**	**$11,392,210**	**$156,698,336**	**$573,871,874**

Present Value Sum 2013-2032	Capacity	Energy	Carbon	Gas	Total
DR					
Costs	$1,828,350	$0	$0	$0	$1,828,350
Benefits	$240,620,557	$0	$0	$0	$240,620,557
Net Benefits	**$238,792,208**	**$0**	**$0**	**$0**	**$238,792,208**
EE					
Costs	$0	$1,828,350	$0	$0	$1,828,350
Benefits	$0	$14,241,432	$5,664,733	$0	$19,906,165
Net Benefits	**$0**	**$12,413,083**	**$5,664,733**	**$0**	**$18,077,816**
PEV					
Costs	$0	$0	$0	$9,366,111	$9,366,111
Benefits	-$2,019,020	-$9,267,848	$592,955	$101,358,022	$90,664,110
Net Benefits	**-$2,019,020**	**-$9,267,848**	**$592,955**	**$91,991,911**	**$81,297,999**
Total					
Costs	$1,828,350	$1,828,350	$0	$9,366,111	$13,022,810
Benefits	$238,601,537	$4,973,584	$6,257,688	$101,358,022	$351,190,832
Net Benefits	**$236,773,188**	**$3,145,235**	**$6,257,688**	**$91,991,911**	**$338,168,022**

Nominal Sum of Net Benefits, 2013-2032, by Scenario

	Participation Scenario		
	High	Medium	Low
AMI Deployment Scenario			
8 Year - 62%	$860,807,810	$573,871,874	$286,935,937
10 Year - 62%	$849,269,487	$566,179,658	$283,089,829
15 Year - 100%	$1,251,658,080	$834,438,720	$417,219,360

Present Value of Net Benefits, 2013-2032, by Scenario

	Participation Scenario		
	High	Medium	Low
AMI Deployment Scenario			
8 Year - 62%	$507,252,034	$338,168,022	$169,084,011
10 Year - 62%	$498,613,222	$332,408,815	$166,204,407
15 Year - 100%	$724,756,542	$483,171,028	$241,585,514