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. PURPOSE OF TESTIMONY

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. AMI PLAN – SOCIETAL BENEFITS

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

[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

[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

[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.