

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In re: Union Electric Company's 2014)	
Utility Resource Filing Pursuant to)	Case No. EO-2015-0084
4 CSR 240 – Chapter 22)	

SIERRA CLUB COMMENTS

Sierra Club, by and through counsel, hereby submits the attached comments, drafted by Dr. Ezra D. Hausman, on Ameren Missouri's 2014 Integrated Resource Plan ("IRP"). As Dr. Hausman explains in his comments, Ameren Missouri's IRP is deficient in a few key respects. Broadly, although Ameren Missouri contemplates existing and proposed environmental regulations, it fails to address the risk and cost implications of such regulations appropriately. These deficiencies violate 4 CSR 240-22.040.¹

Specifically, Ameren Missouri's treatment of future carbon regulations is deficient because it is both internally inconsistent and effectively assumes an 85% chance of a carbon cost of \$0 for its coal-fired generating units. Although 4 CSR 240-22.040(2)(B) directs Ameren to "specify a subjective probability," the Company's analysis must still be reasonable, and Ameren must fully "describe and document" the basis for its assumptions. For the reasons described in Dr. Hausman's comments, Ameren Missouri fails its mandate. In particular, the Company has

¹ See, e.g., 4 CSR 240-22.040(1): "The utility shall collect generic cost and performance information sufficient to fairly analyze and compare each of these potential supply-side resource options, including at least those attributes needed to assess capital cost, fixed and variable operation and maintenance costs, probable environmental costs, and operating characteristics." 4 CSR 240-22.040(2)(B) further explains: "The probable environmental costs of each potential supply-side resource option shall be quantified by estimating the cost to the utility to comply with additional environmental legal mandates that may be imposed at some point within the planning horizon. The utility shall identify a list of environmental pollutants for which, in the judgment of the utility decision-makers, legal mandates may be imposed during the planning horizon which would result in compliance costs that could significantly impact utility rates. The utility shall specify a subjective probability that represents utility decision-maker's judgment of the likelihood that legal mandates requiring additional levels of mitigation will be imposed at some point within the planning horizon. The utility, based on these probabilities, shall calculate an expected mitigation cost for each identified pollutant."

completely failed to evaluate in this IRP the “probable environmental costs” of EPA’s proposed Clean Power Plan and “describe and document” its analysis of the potential costs of that pending regulation on its coal-fired generating units, rendering this filing deficient under 4 CSR 240-22.040(2)(B).

Further, Ameren Missouri’s coal plant retrofit and retirement analysis is deficient because it inadequately considers the likelihood of increasingly stringent environmental regulations directly affecting the Company’s fleet. Among these deficiencies include Ameren’s failure to describe and document why it assumes that Flue Gas Desulfurization (“FGD”) technology will not be required at two of the four units at its Labadie plant and both units at its Rush Island plant, as well as why the Company’s thinking has changed since its 2011 IRP when FGD technology was assumed to be required at all of those units under both “moderate” and “aggressive” environmental scenarios. Similarly, Ameren also failed to describe and document why it assumes that Selective Catalytic Reduction (“SCR”) technology will not be required at any of the units at its Labadie and Rush Island plants, even as Ameren assumes that its Sioux plant will need a SCR in 2020. Ameren’s failure to “describe and document” any analysis of this issue also renders its IRP analysis deficient under 4 CSR 240-22.040(2)(B).

Ameren Missouri’s coal plant retirement and retrofit analysis is also deficient because the Company fails to analyze the possibility of accelerated retirement of individual generating units at different plants as one possible means to avoid costs of compliance with greenhouse gas and other environmental requirements. Rather, the Company’s IRP assumes that all units at a particular plant will retire on the same or a similar timeframe without providing any analysis to support that assumption.

Finally, Ameren Missouri fails to pursue all cost-effective energy efficiency, which is incompatible with 4 CSR 240-22.050 and 4 CSR 240-22.060.

Sierra Club respectfully requests that the Company agree to prepare, or the Commission order the Company to prepare, a revised triennial IRP filing that corrects the deficiencies identified briefly above and in more detail in the attached comments of Dr. Hausman.

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that a true and correct PDF version of the foregoing was filed on EFIS and electronically mailed to all counsel of record on this 2nd day of March, 2015.

/s/ Sunil Bector

Sunil Bector

Comments on Ameren Missouri’s 2014 Integrated Resource Plan (IRP)

Ezra D. Hausman, Ph.D.¹

Ezra Hausman Consulting

March 2, 2015

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¹ Dr. Hausman’s resume is attached as Exhibit EDH-1.

Overview

Ameren Missouri (Ameren or the Company) has produced its 2014 IRP at a critical time of transition in the U.S. power sector. It is now widely recognized that the “cheap” energy sources that have supported economic growth for decades—particularly coal-fired electricity generation—come with high long-term costs in damage to human health, the environment, and the Earth’s climate. Ameren Missouri currently owns and operates 5,364 MW of coal-fired generation, representing more than half of its generating capacity and producing more than two thirds of its annual energy. Ameren’s individual coal units date from the 1950’s to the mid-1970’s. The Company expects to retire the oldest and least efficient of these plants, the Meramec Energy Center, by 2022; however, all of the Company’s plants will require extensive and expensive environmental upgrades if they are to continue operating over the coming years and decades. These requirements are discussed by Ameren in Chapter 5 of its IRP, and the Company’s assumptions for future regulations and environmental retrofit costs are presented in the appendices to Chapter 5.

It is important to emphasize that the assumed dates and costs presented in Chapter 5 and its appendices are just that—the Company’s assumptions based on unknown future environmental regulations and associated emissions control requirements. According to the IRP,

Given the lack of certainty regarding the enactment of proposed regulations combined with the lack of specificity of regulations, which are under development but for which no proposed rule has been issued, Ameren Missouri has necessarily made certain good faith assumptions regarding potential future compliance measures.²

As acknowledged by the Company and as discussed below, it is certainly possible that Ameren has significantly underestimated these requirements. However, nowhere in its IRP does the Company address the risk and cost implications, nor the impact on the selection of its preferred plan, should this turn out to be the case.

Less fully documented in the IRP is the likely impact of future greenhouse gas regulations on Ameren’s fossil fleet, and especially its coal-fired generators. The EPA’s proposed “Clean Power Plan” sets emissions standards for existing power plants, while giving states considerable flexibility in how to implement and meet those standards. However the standards are met, they will require reductions in emissions intensity and/or emissions quantity from existing power plants, and will require deepest

² IRP Chapter 5, p.2.

reductions in emissions from coal-fired plants. Ameren’s proposed and alternative resource plans are not constrained by or compliant with the EPA’s Clean Power Plan. The Company notes that the proposed rule was issued late in Ameren’s IRP process, and the details and timing of the final rule remain in flux; however, as the Clean Power Plan is the only currently proposed federal carbon emissions rule, it provides the best available model of future regulation for resource planning purposes.

Across the United States, utilities are retiring coal plants in the face of increasing environmental compliance costs, the expectation of greenhouse gas emissions costs, and increased competition from low-cost resources including renewables, energy efficiency, and natural gas. In Missouri, Kansas City Power and Light (KCP&L) has announced plans to phase out the use of coal at six of its generating units between 2016 and 2021.³ In fact, all of the future scenarios considered by Ameren in its IRP process assumed a large number of coal plant retirements: between 50 and 70 gigawatts (GW) nationwide by 2020, and between 80 and 120 GW by 2030.⁴ For perspective, there are currently approximately 325 GW of operational coal plants in the United States.⁵

At the same time, the economic and operational outlook for non-polluting resources such as renewable energy and energy efficiency continues to improve. Ameren’s preferred plan recognizes the value of these resources, noting that “Wind energy resources exhibit the lowest cost on an LCOE basis among all candidate resource options.”⁶ Ameren’s “balanced” portfolio includes 400 MW of additional wind, 45 MW of solar, and 20 MW of small hydroelectric, but still falls far short of the goals set by voters under Proposition C in 2008.⁷ Ameren also proposes to continue its cost-effective energy efficiency programs at the so-called “Realistic Achievable Potential” (RAP) level.

Despite these moves towards development of low-carbon resources, and even with Ameren’s plans to retire its oldest and least efficient coal plant in 2022, the Company’s plan perpetuates its heavy dependence on coal-fired resources well into the 2030s and beyond. Ameren’s plan envisions billions of dollars of investment in environmental upgrades in order to continue operating these carbon-intensive resources in response to increasingly stringent rules to protect public health and the environment. At

³ KCP&L press release, January 20, 2015, available at <http://www.kcpl.com/about-kcpl/media-center/2015/january/kcpl-announces-plans-to-cease-burning-coal-at-three-plants>.

⁴ IRP, Chapter 9.

⁵ Based on EIA Form 860 data for 2012.

⁶ IRP Chapter 6, p.1. LCOE stands for “Levelized Cost Of Energy”.

⁷ Proposition C also included a 1% rate impact limitation; Ameren claims that this limit will be reached in 2018 (IRP Chapter 9, p.6).

the same time, Ameren anticipates that utilities around the country, including KCP&L, will reduce their exposure to coal plant costs and risks by retiring many of their own coal-fired generating units; but Ameren's plan continues to expose its own ratepayers to these risks for decades to come.

Ameren's plan is unlikely to comply with future federal greenhouse gas regulations. The Company readily acknowledges that its plan falls short of the recently proposed federal Clean Power Plan for reducing emissions from existing power plants. As the need for strong federal action on greenhouse gas emissions becomes increasingly clear, Ameren's plan will be commensurately at odds with the need to serve ratepayers in a carbon-constrained economy, and the Company will face increased costs and reliability challenges.

The impact of these dramatic changes in the resource planning environment is obscured by certain specific aspects of the Company's 2014 IRP. One particularly glaring deficiency is its treatment of CO₂ emissions costs in the plan evaluation and selection process; another is the Company's failure to consider the impact of more stringent pending and likely future environmental requirements on its coal fleet. These issues are discussed in detail below.

Plan selection process.

Ameren's IRP development process, described in Chapter 9 of the IRP, involved the selection of 19 primary plans for analysis; in addition, the Company performed "pre-analysis" on a certain number of factors (such as early retirement of Meramec and the Keokuk upgrade) to rule them out of further analysis. The resulting plans were subjected to testing under 15 future scenarios covering a range of values for load growth, gas prices, and carbon prices. Each plan was also tested against certain "critical independent uncertain factors." These factors are: DSM Impacts and Costs, Project Costs, Coal Prices, and ROE/Interest Rates.

Chapter 10 describes the scoring criteria and process, including the following components:

- Environmental / Renewable / Resource Diversity – 20%
- Financial / Regulatory – 20%
- Customer Satisfaction – 20%
- Economic Development – 10%
- Cost – 30%

Although cost nominally comprises only 30% of the overall score, it serves as the dominant consideration both because it is the single largest category, and because other categories can tend to counteract each other. For example, plans with additional nuclear energy would gain a point for “resource diversity”, but lose one of equal weight for “financial/regulatory risk”. Cost also carries the aura of being an objective, quantifiable metric; however, any projection of future cost is predicated on a wide range of assumptions about future economic drivers such as regulatory requirements. For these reasons, the determination of the cost score, represented as the Present Value of Revenue Requirements (PVRR), bears special scrutiny.

By testing each plan against 15 future scenarios and other uncertain cost drivers for its PVRR determination, Ameren is attempting to produce an analysis that is robust in the face of uncertainty about the future. As such, the definition and weighting of these future scenarios and factors is crucial to the outcome of the analysis. If any single critical parameter or its associated probability distribution carries a bias, this will have the effect of biasing the entire PVRR analysis. The larger the bias, the greater the distortion in the final result.

Ameren’s treatment of future carbon regulations is deficient because it is both internally inconsistent and effectively assumes an 85% chance of a carbon cost of \$0 for its coal-fired generating units.

Ameren’s PVRR analysis is deficient in its treatment of future regulation of greenhouse gas emissions in the United States. Of the 15 future scenarios modeled by Ameren, only five include a price of carbon emissions affecting Ameren’s fleet at any time during the planning horizon. Further, because of the weighting used by the Company, these five scenarios are represented with a combined probability of only 15%—meaning that the Company assumes an 85% chance of there being no cost of CO₂ emissions for Ameren through the end of its IRP planning period. Ameren’s “high cost” scenario, described as a price of \$53/ton starting in 2025, is given only a 3% probability of occurrence. At the same time, according to the Executive Summary of the 2014 IRP, Ameren expects “that costs to comply with EPA’s proposed Clean Power Plan [will] be higher than \$53/ton.”⁸

⁸ IRP, Executive Summary, p.11.

Ameren's cited source for its carbon emission costs is a paper produced by Synapse Energy Economics,⁹ of which I was a co-author. However, the Company has not applied these prices as intended or recommended by myself or by the other co-authors of this paper. Nor is the Company's treatment of this critical economic driver consistent with its own stated expectations regarding future greenhouse gas regulations.

Firstly, by the Company's own description, Ameren modeled carbon prices starting in 2025; the Synapse report's recommendation was that carbon prices should be modeled starting in 2020. By applying Synapse's prices but starting five years later than the date recommended by Synapse, Ameren effectively reduces the levelized¹⁰ price of carbon by approximately 20%. At the same time, Ameren acknowledges that under EPA's proposed Clean Power Plan, "much of the targeted 2030 reduction, 13% of the 21% final target, is required starting in 2020 due to interim targets included in the proposed rule. This means that more than 60% of the 2030 reduction goal must be met by 2020."¹¹ It is difficult to reconcile the Company's failure to consider any cost associated with CO₂ emissions prior to 2025 with its statements regarding the expected timing and cost of compliance with the EPA's currently proposed rule.

Secondly, the Synapse report explicitly recommends that its carbon price trajectories be used to represent the full range of future scenarios for regulation of greenhouse gases in the United States. In contrast, Ameren has modeled only a 15% chance of any carbon price at all, and only a 3% chance of its highest price projection—even while acknowledging that the "costs to comply with EPA's proposed Clean Power Plan [are] to be higher than \$53/ton."¹² That is, higher than the Company's highest price. Again, it is difficult to reconcile the Company's stated conclusion regarding the only currently proposed carbon rule with its modeling decision to assign a 3% probability to a \$53 price in 2025, and a zero probability to any price higher than \$53 in 2025.

Ameren does model alternative plans and scenarios that are in some ways reflective of a future carbon emissions policy. For its resource plans, the Company considers various expansions of low- or zero-carbon resources such as energy efficiency, nuclear power, and renewable energy. The planning

⁹ Synapse Energy Economics, "2013 Carbon Dioxide Price Forecast", updated as of November, 2013.

¹⁰ "Levelized" prices refer to a constant price that produces the same present value as a given time-varying stream of prices. This calculation facilitates the comparison of different streams of prices on a consistent basis.

¹¹ IRP Chapter 10, p.17

¹² IRP, Executive Summary, p.11.

scenarios include three levels of coal plant retirements, as noted above. However, by not explicitly representing either a price or a quantity constraint in 85% of the probability space for its PVRR analysis, the Company is modeling these greenhouse gas-related actions in a vacuum. The Company's own carbon-intensive resources are represented as magically unaffected by the economic drivers that are causing other utilities around the country to reduce their reliance on coal. These same economic drivers are leading Ameren itself to invest in low-carbon alternatives. What the Company's scenarios actually represent is a paradoxical case in which actions to reduce carbon emissions, taken by Ameren and other utilities, are undertaken in the absence of any policy imperative—the equivalent to modeling costs associated with mitigation, but with no underlying carbon emissions policy to justify these costs. Alternatively, Ameren's scenario can be viewed as an assumption that utilities other than itself will bear all of the costs of carbon regulations.

The Synapse report explicitly addresses the need to use realistic emissions prices for modeling and planning purposes, even if regulations do not take the form of an explicit tax or trading mechanism. In this case, it is necessary to model an “effective” price on carbon, representing the fact that under any regulatory scheme that limits total emissions, the right to emit becomes a limited commodity with an economic value. The recently proposed Clean Power Plan would impose such a limitation without an explicit price, but as noted above, Ameren readily acknowledges that it would impose an effective price—and that this price is higher than even the highest price modeled by the Company.

The impact of Ameren's misapplication of the Synapse CO₂ price forecasts is dramatic. While it is unrealistic for an outside expert to fully re-analyze the Company's plans, as a first step I have modified the Company's IRP workpapers by changing the probabilities associated with each scenario. In this way, I can determine how the ranking of plans would be different had the carbon-price scenarios been weighted differently.

For example, the Company's cases denoted as Plans “M” and “G” differ only in that Plan M reflects the retirement of the Labadie plant in 2023, while Plan G reflects continued investment in and operation of the plant. The 2023 date was chosen “based on the ability to avoid significant costs associated with environmental compliance or environmental risk,” and specifically, “the expected need for a scrubber in the 2020-2025 timeframe.”¹³ According to the Company's analysis, the present value

¹³ IRP Chapter 9, p.4.

revenue requirement for Plan M (Labadie retired) is \$3.6 Billion greater than that of Plan G (Labadie retrofit and continued operation).¹⁴

One way to investigate the impact of the Company's treatment of carbon prices is to compare the integrated PVRR including only those scenarios with a carbon price. Using only these scenarios—and taking the Company's carbon price assumptions as described in Chapter 2 of its 2014 IRP at face value—a very different picture emerges. If I include all of the carbon price scenarios (the bottom five “branches” of the Company's “probability tree” in Chapter 9 of the IRP) with the relative weightings given by Ameren, the advantage of Plan G over Plan M shrinks from \$3.6 Billion to under \$500 Million. If I consider only the Company's “High” carbon price scenario, the relative PVRR advantage flips, and Plan M shows a net *savings* of almost \$1 Billion relative to Plan G. Recall that, as noted above, the Company expects the cost of compliance with the only currently proposed plan to be in excess of its highest carbon price projection. Had this assumption and compliance with the EPA's Clean Power Plan been fully represented in the Company's IRP analysis, retirement of Labadie would have been the preferred option on a PVRR basis.

At least partly as a result of its deficient treatment of carbon emissions costs, Ameren's preferred plan anticipates continuing to operate the Labadie and Rush Island coal-fired generating stations into the 2040s, and the Sioux plant into the 2030s. This strategy runs counter to dominant trends in the electric sector nationwide, and even within Missouri. It is hard to understand why Ameren believes its coal operations will be unaffected by increasingly stringent regulations on this greenhouse gas-intensive fuel while others in the industry, including KCP&L, are turning towards less risky, cleaner forms of generation. One significant reason for this disconnect is Ameren's failure to adequately represent future costs associated with greenhouse gas emissions into its PVRR analysis.

Ameren's coal plant retrofit and retirement analysis is deficient because it inadequately considers the likelihood of increasingly stringent environmental regulations directly affecting the Company's fleet.

Ameren's plan includes “base retirement assumptions”, including retirement of the Meramec plant in 2022, the Sioux plant in 2033, and Labadie and Rush Island in the 2040s.¹⁵ In the intervening

¹⁴ Rebuttal testimony of Matt Michels, MPSC File No. ER-2014-0258, Dkt. No. 239, p.12.

years, the plan anticipates investments of hundreds of millions of dollars in environmental upgrades and other capital expenditures necessary to continue operating the plants.¹⁶ As noted above, the analysis assigns very little probability to CO₂ emissions costs, significantly underrepresenting likely future operational and economic constraints on these carbon-intensive resources. In addition, the Company has failed to consider the impact on its plan of possible more stringent environmental retrofit requirements relative to its reference case, despite acknowledging the substantial uncertainty in its projections:

Ameren Missouri's probable compliance timing and cost assumptions...are based on current, proposed and potential environmental regulations. Given the length of the IRP Planning window, the likelihood of changes in environmental laws and regulations, and the uncertainty surrounding labor and materials costs in the future, these assumptions could change substantially but represent Ameren Missouri's best estimate of these costs at this time.¹⁷

The projected operating lives of Ameren's resources other than Meramec¹⁸ into the 2030s and 2040s means that their economics and operations will be fundamentally affected by current and future environmental regulations, including regulations governing carbon emissions. Prudent planning would require consideration and analysis of a range of retirement options for each of these resources, under a range of regulatory scenarios, evaluating the costs and benefits of more aggressively reducing Ameren's carbon liability. For example, the Sioux plant is expected to be retired in 2033 according to the IRP, after expenditure of an additional \$244 Million on SCR technology in the 2020s. Ameren should evaluate the option of retiring one or both Sioux units and avoiding this upgrade cost, demonstrating under what environmental policy assumptions such an early retirement scenario would be beneficial to ratepayers.

Further, in its 2014 IRP, Ameren has assumed that it can meet future National Ambient Air Quality Standards (NAAQS) for SO₂ emissions while installing additional Flue-Gas Desulfurization (FGD) only on Labadie Units 3 and 4, and on neither of the Rush Island units. This assumption seems particularly optimistic, as the Missouri Department of Natural Resources recommended that a portion of Jefferson County—the portion in which Rush Island resides—be designated a nonattainment area for

¹⁵ IRP Chapter 4, Table 4.4.

¹⁶ IRP Chapter 5.

¹⁷ IRP Chapter 5, p. 21.

¹⁸ In the case of the Meramec plant, Ameren considered a number of retirement and fuel-switching scenarios, and provided the results in its IRP and associated workpapers. Because this analysis resulted in a planned retirement in 2022, it is relatively unaffected by the deficient treatment of carbon emissions prices and policy uncertainty in the PVRR analysis.

SO₂ under the NAAQS,¹⁹ and EPA has followed through on this designation.²⁰ In Ameren’s 2011 IRP, the Company assumed that FGD technology would be required on all of its coal-fired units, including all four units at Labadie and both units at Rush Island, for both its “moderate” and “aggressive” regulatory scenarios.²¹ No explanation has been provided for the dramatic change in outlook for the 2014 IRP—a glaring omission, particularly in light of Jefferson County already being designated non-attainment for SO₂ and the designation for Franklin County (which is home to the Labadie plant) not yet finalized by U.S. EPA.

Similarly, Ameren has assumed that it can meet all applicable NO_x emissions limitations by installing Selective Catalytic Reduction (SCR) technology on the Sioux units in 2020 in the reference case. The Company has not considered in its PVRR analysis the possibility that this technology will be required on the Labadie and Rush Island units, at an additional cost that could exceed \$100 Million per unit. In fact, SCR technology may be required at some or all of the Labadie or Rush Island units to comply with a range of pending and likely future Clean Air Act regulations, including future updates to ozone National Ambient Air Quality Standards and the Cross-State Air Pollution Rule, as well as future implementation of the Regional Haze Program. Ameren has failed to include in its 2014 IRP any analysis of whether these pending and likely future regulatory requirements will require SCR technology to be installed at either Labadie or Rush Island.

In general, Ameren’s analysis should transparently evaluate optimal retirement schedules based on a range of environmental and carbon policy assumptions; it should not mask the results by combining them into a single PVRR assessment, as Ameren has done in the current IRP. It should also evaluate the option of retiring individual units at different Ameren plants on an accelerated schedule, rather than only looking at retiring all units at any given plant on the same schedule, as a way of reducing Ameren’s liability for emissions of CO₂ and other pollutants, along with avoiding costly capital investments for environmental compliance. Using this approach, Ameren would provide a much more thorough and transparent analysis of the risks associated with continuing to invest in coal-fired generation.

Although acknowledging the regulatory uncertainty it faces, and fully aware of the risks for ratepayers this uncertainty presents, Ameren has failed to provide any analysis of how its critical

¹⁹ <http://www.epa.gov/oaqps001/sulfurdioxide/designations/region7r.html>. See also discussion in IRP Chapter 5, p.8.

²⁰ <http://www.epa.gov/oaqps001/greenbk/ancl.html>.

²¹ Ameren 2011 IRP, Chapter 8, p.20, Table 8.3.

environmental compliance assumptions affect the outcome of its PVRR analysis or the selection of its preferred plan. These deficiencies deprive the Commission and stakeholders of a thorough cost and benefit analysis of a full range of retirement scenarios, and they are a disservice to Ameren's ratepayers.

Considerations of Alternative Resources

Ameren's analysis finds that clean energy resources—including both energy efficiency and renewable energy—are cost competitive and often economically preferable relative to fossil resources. For example, the Company's PVRR analysis found that the highest level of energy efficiency investment considered, denoted "Maximum Achievable Potential", or MAP, resulted in a lower overall cost than its second-tier "Realistic Achievable Potential" Portfolio, or RAP. The Company's definition of these potential levels and its decision to include the lower level will be discussed in detail by other commenters;²² however, at the very least, these results suggest that the Company should pursue the highest levels of energy and cost savings from the continued development of demand-side resources, and that the Commission should ensure that the Company is not harmed financially in so doing. In contrast, the failure to pursue all cost-effective energy efficiency would be inconsistent with the Company's responsibility to pursue least-cost resource planning, and should not be acceptable to the Commission.

The Company further notes that wind power represents the lowest-cost new resource on an LCOE (levelized cost) basis.²³ This is consistent with utility experience throughout the region; for example, Westar Energy in Kansas has recently announced wind power purchases in the range of \$20-\$25 per MWh.²⁴ Power cooperatives in Texas have also recently purchased wind energy in the range of \$20-\$30/MWh.²⁵ Utility-scale solar power has also become cost-competitive with conventional resources in many areas of the U.S., with prices continuing on a downward trend. Northern States Power, for example, announced in September that its most recent solicitation for solar resources *in Minnesota* yielded offers for 15 projects, totaling 630 MW, at under \$85/MWh.²⁶ While the cost of these resources is partly dependent on tax laws and incentives at the time they are constructed, they have the

²² See comments of Natural Resources Defense Council in this Docket.

²³ IRP, Chapter 6.

²⁴ "Westar eyes wind power deal at about \$20/MWh", Megawatt Daily, November 7, 2014.

²⁵ "Texas co-ops ink deal for 101 MW of wind power", Megawatt Daily, November 26, 2014.

²⁶ "Solar prices 'very competitive,' NSP says", Megawatt Daily, September 4, 2014.

significant advantage of being immune to increases in fuel and emissions costs. Further, their relative economics will only improve under future greenhouse gas regulations.

Conclusions

Like other utilities, Ameren must develop resource and investment plans in the face of an uncertain future. The Company must base its analysis on projections of future changes in load, fuel costs, resource costs, and the regulatory environment. While such projections involve uncertainty, the Company has a responsibility to base its analysis and plans on the best available information, and to ensure that its plans are robust such that ratepayers will not be unduly harmed over a reasonable foreseeable range of future scenarios.

Ameren readily acknowledges that its coal-fired generators are not only subject to increasingly stringent and expensive environmental regulations today, but that these will continue to require billions of dollars of investment in the coming years. The Company acknowledges that there is considerable uncertainty over the nature and cost of technology that will be required to comply with these regulations. Further, the Company's planning scenarios assume certain impacts of the suite of environmental regulations, including CO₂ rules, resulting in the expected retirement of a large fraction of the U.S. coal fleet. However, Ameren has failed to adequately model or assess how its own coal-fired generators will be affected by such regulations. The result of this omission is a plan that continues the Company's reliance on coal and underinvests in the clean energy resources of the future.

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SUMMARY

I am an independent consultant in energy and environmental economics.

I have worked for over 17 years as an electricity market expert with a focus on market design and market restructuring, environmental regulation in electricity markets, and pricing of energy, capacity, transmission, losses and other electricity-related services. I have performed market analysis, offered expert testimony, led workshops and working groups, made presentations and participated on panels, and provided other support to clients in a number of areas, including:

- Economic analysis, price forecasting, and asset valuation in electricity markets, including dispatch model analysis and review of modeling studies
- Electricity and generating capacity market design
- Integrated Resource Planning and portfolio analysis
- Economic analysis of environmental and other regulations, including cap-and-trade regulation of CO₂, in electricity markets
- Quantification of the economic and environmental benefits of displaced emissions associated with energy efficiency and renewable energy initiatives
- Mitigation of greenhouse gas emissions from the supply and demand sides of the U.S. electric sector.

I have prepared reports and offered other expert services on these and other related topics for clients including federal and state agencies; offices of consumer advocate; legislative bodies; cities and towns; non-governmental organizations; foundations; industry associations; and resource developers.

I previously served as Vice President and Chief Operating Officer of Synapse Energy Economics, Inc. of Cambridge, Massachusetts. In addition to my consulting portfolio, this management role entailed responsibility for day-to-day operations of the company including overseeing finance, HR, communications & marketing, quality assurance, client service, and professional development of staff. I had overall responsibility for ensuring that project managers and project teams had the tools, information, and training they needed to successfully serve our client's needs and produce high-quality deliverables on time and on budget. I was also a resource available to any of our clients to address any issues of customer service, quality, or any other issues that may arise.

I hold a Ph.D. in atmospheric science from Harvard University, an S.M. in applied physics from Harvard University, an M.S. in water resource engineering from Tufts University, and a B.A. degree in psychology from Wesleyan University.

PROFESSIONAL EXPERIENCE

Ezra Hausman Consulting, Newton, MA. President, March 2014 – Present.

I provide research, analytical, and regulatory and litigation support services based upon my 15+ years experience in the electric power industry.

Synapse Energy Economics Inc., Cambridge, MA.

Chief Operating Officer, March 2011 – February 2014;

Vice President, July 2009 – February 2014;

Senior Associate, 2005-2009.

Conducted research, wrote reports, and presented expert testimony pertaining to consumer, environmental, and public policy implications of electricity industry regulation. Focus of work included:

- Economic analysis of electricity industry regulation and restructuring
- Efficient pricing of generating and transmission capacity
- Long-term electric power system planning and market design
- Price forecasting and asset valuation
- Impact of air quality and environmental regulations on electricity markets and pricing
- Energy efficiency and renewable energy programs and policies, including avoided emissions analysis
- Market power and market concentration analysis in electricity markets
- Consumer and environmental protection
- Regulation and mitigation of greenhouse gas emissions.

Charles River Associates (CRA), Cambridge, MA. Senior Associate, 2004-2005

CRA acquired Tabors Caramanis & Associates in October, 2004.

Tabors Caramanis & Associates, Cambridge, MA. Senior Associate, 1998-2004

Modeling and analysis of electricity markets, generation and transmission systems. Projects included:

- Several market transition cost-benefit studies for development of Locational Marginal Price (LMP) based markets in US electricity markets
- Long-term market forecasting studies for valuation of generation and transmission assets,
- Valuation of financial instruments relating to transmission system congestion and losses
- Modeling and analysis of hydrologically and electrically interconnected hydropower system operations
- Natural gas market analysis and price forecasting studies
- Co-developed an innovative approach to hedging financial risk associated with transmission system losses of electricity

- Designed, developed and ran training seminars using a computer-based electricity market simulation game, to help familiarize market participants and students in the operation of LMP-based electricity markets.
- Developed and implemented analytical tools for assessment of market concentration in interconnected electricity markets, based on the “delivered price test” for assessing market accessibility in such a network
- Performed regional market power and market power mitigation studies
- Performed transmission feasibility studies for proposed new generation and transmission projects in various locations in the US
- Provided analytical support for expert testimony in a variety of regulatory and litigation proceedings, including breach of contract, bankruptcy, and antitrust cases, among others.

Global Risk Prediction Network, Inc., Greenland, NH. Vice President, 1997-1998

Developed private sector applications of climate forecast science in partnership with researchers at Columbia University. Specific projects included a statistical assessment of grain yield predictability in several crop regions around the world based on global climate indicators (Principal Investigator); a statistical assessment of road salt demand predictability in the United States based on global climate indicators (Principal Investigator); a preliminary design of a climate and climate forecast information website tailored to the interests of the business community; and the development of client base.

Hub Data, Inc., Cambridge, MA. Financial Software Consultant, 1986-1987, 1993-1997

Responsible for design, implementation and support of analytic and communications modules for bond portfolio management software; and developed software tools such as dynamic data compression technique to facilitate product delivery, Windows interface for securities data products.

Abt Associates, Inc., Cambridge, MA. Environmental Policy Analyst, 1990-1991

Quantitative risk analysis to support federal environmental policy-making. Specific areas of research included risk assessment for federal regulations concerning sewage sludge disposal and pesticide use; statistical alternatives to Most-Exposed-Individual risk assessment paradigm; and research on non-point sources of water pollution.

Massachusetts Water Resources Authority, Charlestown, MA. Analyst, 1988-1990

Applied and evaluated demand forecasting techniques for the Eastern Massachusetts service area. Assessed applicability of various techniques to the system and to regional planning needs; and assessed yield/reliability relationship for the eastern Massachusetts water supply system, based on Monte-Carlo analysis of historical hydrology.

Somerville High School, Somerville, MA. Math Teacher, 1986-1987

Courses included trigonometry, computer programming, and basic math courses.

EDUCATION

Ph.D., Earth and Planetary Sciences. Harvard University, Cambridge, MA, 1997

S.M., Applied Physics. Harvard University, Cambridge, MA, 1993

M.S., Civil Engineering. Tufts University, Medford, MA, 1990

B.A., Wesleyan University, Psychology. Middletown, CT, 1985

FELLOWSHIPS, AWARDS AND AFFILIATIONS

President, Burr Elementary School Parent Teacher Organization, 2005-2007

UCAR Visiting Scientist Postdoctoral Fellowship, 1997

Postdoctoral Research Fellowship, Harvard University, 1997

Certificate of Distinction in Teaching, Harvard University, 1997

Graduate Research Fellowship, Harvard University, 1991-1997

Invited Participant, UCAR Global Change Institute, 1993

House Tutor, Leverett House, Harvard University, 1991-1993

Graduate Research Fellowship, Massachusetts Water Resources Authority, 1989-1990

Teaching Fellowships:

Harvard University: *Principles of Measurement and Modeling in Atmospheric Chemistry; Hydrology; Introduction to Environmental Science and Public Policy; The Atmosphere.*

Wesleyan University: *Introduction to Computer Programming; Psychological Statistics; Playwriting and Production.*

Professional affiliations

Member, American Association for the Advancement of Science

Member, American Economic Association

EXPERT TESTIMONY AND SERVICES

New Jersey Board of Public Utilities (Docket No. GO14121412) – Ongoing

Expert witness on behalf of the New Jersey Division of Rate Counsel, reviewing cost effectiveness and program design of New Jersey Natural Gas Company “SAVEGREEN” energy efficiency program.

United States District Court for the Eastern District of Missouri (Civil Action No. 4:11-CV-00077) – Ongoing

Expert witness on behalf of the United States Department of Justice on clean air act enforcement case.

Missouri Public Service Commission (File No. ER-2014-0258) – Ongoing

Expert witness on behalf of the Sierra Club in Ameren Missouri rate case.

Arizona Corporation Commission (Docket No. E-01345A-11-0224) – 2014

Expert witness on behalf of the Sierra Club regarding Arizona Public Service petition for rate treatment for acquisition of an additional ownership share of the Four Corners generating units.

Missouri Public Service Commission (Docket No. ET-2014-0085) – 2013

Testimony on behalf of the Missouri Solar Energy Industries Association regarding Union Electric (d/b/a Ameren Missouri) motion to suspend payment of solar rebates.

Missouri Public Service Commission (Docket No. ET-2014-0059 and ET-2014-0071) – 2013

Testimony on behalf of the Missouri Solar Energy Industries Association regarding Kansas City Power and Light Company’s motions to suspend payment of solar rebates.

Puget Sound Energy (PSE) – 2012-2013

Expert participant in PSE’s 2013 IRP stakeholder process on behalf of the Sierra Club.

Washington Utilities and Transportation Commission (Docket Nos. UE-111048 and UG-111049) – 2011

Testimony on behalf of the Sierra Club regarding the cost of operating the Colstrip power plant and other power procurement issues.

Kansas Corporation Commission (Docket No. 11-KCPE-581-PRE) - 2011

Presented written and live testimony on behalf of the Sierra Club regarding Kansas City Power and Light request for predetermination of ratemaking principles.

Vermont Department of Public Service - 2011

Provided scenario analysis of the costs and benefits of various electric energy resource scenarios in support of the state Comprehensive Energy Plan.

Massachusetts Department of Energy Resources – 2009-2011

Served as expert analyst and modeling coordinator for analysis related to implementation of the Massachusetts Global Warming Solutions Act.

Iowa Office of Consumer Advocate – 2010-Present

Assisted Consumer Advocate in evaluating a proposed power purchase agreement for the output of the Duane Arnold nuclear power station.

Missouri Public Service Commission (Docket No. EW-2010-0187) – 2010

Expert participant on behalf of the Sierra Club in stakeholder process to develop a “demand side investment mechanism” in Missouri.

Louisiana Public Service Commission (Docket No. R-28271 Subdocket B) – 2009-2010

Expert participant on behalf of the Sierra Club in Renewable Portfolio Standard Task Force considering RPS for Louisiana.

Joint Fiscal Committee of the Vermont Legislature – 2008-2010

Serving as lead expert advising the Legislature on economic issues related to the possible recertification of the Vermont Yankee nuclear power plant.

Town of Littleton, NH – 2006-2010

Serving as expert witness on the value of the Moore hydroelectric facility.

Nevada Public Service Commission (Docket No. 08-05014) – August 2008

Presented prefiled and live testimony on behalf of Nevadans for Clean Affordable Reliable Energy regarding the proposed Ely Energy Center and resource planning practices in Nevada.

Mississippi Public Service Commission (Docket No. 2008-AD-158) – August 2008

Presented written and live testimony on behalf of the Sierra Club regarding the resource plans filed by Entergy Mississippi and Mississippi Power Company.

Kansas House of Representatives - Committee on Energy and Utilities – February 2008

Presented testimony on behalf of the Climate and Energy Project of the Land Institute of Kansas on a proposed bill regarding permitting of power plants. Focus was on the risks and costs associated with new coal plants and on their contribute to global climate change.

Vermont Public Service Board (Docket No. 7250) – 2006-2008

Prepared report and testimony in support of the application of Deerfield Wind, LLC. For a Certificate of Public Good for a proposed wind power facility.

Iowa Utilities Board (Docket No. GCU-07-1) – October, 2007 – January 2008

Presented wrtten and live testimony on behalf of the Iowa Office of Consumer Advocate regarding the science of global climate change and the contribution of new coal plants to atmospheric CO₂.

Nevada Public Service Commission (Docket No. 07-06049) – October 2007

Presented prefiled direct testimony on behalf of Nevadans for Clean Affordable Reliable Energy regarding treatment of carbon emissions costs and coal plant capital costs in utility resource planning.

Massachusetts General Court, Joint Committee on Economic Development and Emerging Technologies – July 2007

Presented written and live testimony on climate change science and the potential benefits of a revenue-neutral carbon tax in Massachusetts.

Town of Rockingham, VT – 2006-2007

Served as expert witness on the value of the Bellows Falls hydroelectric facility.

South Dakota Public Utilities Commission (Case No EL05-22) – June 2006**Minnesota Public Utilities Commission (Docket TR-05-1275) – December 2006**

Submitted prefiled and live testimony on the contribution of the proposed Big Stone II coal-fired generator to atmospheric CO₂, global climate change and the environment of South Dakota and Minnesota, respectively.

Arkansas Public Service Commission (Docket No. 06-070-U) – October 2006

Submitted prefiled direct testimony on inclusion of new wind and gas-fired generation resources in utility rate base.

**Federal Energy Regulatory Commission (Docket Nos. ER055-1410-000 and EL05-148-000)
– May-Sept 2006**

- Participant in settlement hearings on proposed capacity market structure (the Reliability Pricing Model, or RPM) on behalf of State Consumer Advocates in Pennsylvania, Ohio and the District of Columbia
- Invited participant on technical conference panel on PJM's proposed Variable Resource Requirement (VRR) curve
- Filed Pre- and post-conference comments and affidavits with FERC
- Participated in numerous training and design conferences at PJM on RPM implementation.

Illinois Pollution Control Board (Docket No. R2006-025) – June-Aug 2006

Profile and live testimony presented on behalf of the Illinois EPA regarding the costs and benefits of proposed mercury emissions rule for Illinois power plants.

Long Island Sound LNG Task Force – January 2006

Presentation of study on the need for and alternatives to the proposed Broadwater LNG storage and regasification facility in Long Island Sound.

Iowa Utilities Board (Docket No. SPU-05-15) – November 2005

Whether Interstate Power and Light's should be permitted to sell the Duane Arnold Energy Center nuclear facility to FPPE Duane Arnold, Inc., a subsidiary of Florida Power and Light.

PUBLICATIONS AND REPORTS

Hausman, E., *Risks And Opportunities for PacifiCorp in a Carbon Constrained Economy*, Produced on behalf of the Sierra Club, October 2014.

Hausman, E., *Risks And Opportunities For PacifiCorp - State Level Findings: Oregon*, Produced on behalf of the Sierra Club, October 2014.

Luckow, P., E. Stanton, B. Biewald, J. Fisher, F. Ackerman, E. Hausman, *2013 Carbon Dioxide Price Forecast*, Synapse Energy Economics, November 2013.

Stanton, E., T. Comings, K. Takahashi, P. Knight, T. Vitolo, E. Hausman, *Economic Impacts of the NRDC Carbon Standard: Background Report prepared for the Natural Resources Defense Council*, Synapse Energy Economics for NRDC, June 2013

Comings T., P. Knight, E. Hausman, *Midwest Generation's Illinois Coal Plants: Too Expensive to Compete? (Report Update)* Synapse Energy Economics for Sierra Club, April 2013

Stanton E., F. Ackerman, T. Comings, P. Knight, T. Vitolo, E. Hausman, *Will LNG Exports Benefit the United States Economy?* Synapse Energy Economics for Sierra Club, January 2013

Chang M., D. White, E. Hausman, *Risks to Ratepayers: An Examination of the Proposed William States Lee III Nuclear Generation Station, and the Implications of "Early Cost Recovery" Legislation*, Synapse Energy Economics for Consumers Against Rate Hikes, December 2012

Wilson R., P. Luckow, B. Biewald, F. Ackerman, and E.D. Hausman, *2012 Carbon Dioxide Price Forecast*, Synapse Energy Economics, October 2012.

Fagan B., M. Chang, P. Knight, M. Schultz, T. Comings, E.D. Hausman, and R. Wilson, *The Potential Rate Effects of Wind Energy and Transmission in the Midwest ISO Region*. Synapse Energy Economics for Energy Future Coalition, May 2012.

Hausman, E.D., T. Comings, “*Midwest Generation's Illinois Coal Plants: Too Expensive to Compete?*” Synapse Energy Economics for Sierra Club, April 2012.

Hausman, E.D., T. Comings, and G. Keith, *Maximizing Benefits: Recommendations for Meeting Long-Term Demand for Standard Offer Service in Maryland*. Synapse Energy Economics for Sierra Club, January 2012.

Keith G., B. Biewald, E.D. Hausman, K. Takahashi, T. Vitolo, T. Comings, and P. Knight, *Toward a Sustainable Future for the U.S. Power Sector: Beyond Business as Usual 2011*. Synapse Energy Economics for Civil Society Institute, November 2011.

Chang M., D. White, E.D. Hausman, N. Hughes, and B. Biewald, *Big Risks, Better Alternatives: An Examination of Two Nuclear Energy Projects in the U.S.* Synapse Energy Economics for Union of Concerned Scientists, October 2011.

Hausman E.D., T. Comings, K. Takahashi, R. Wilson, and W. Steinhurst, *Electricity Scenario Analysis for the Vermont Comprehensive Energy Plan 2011*. Synapse Energy Economics for Vermont Department of Public Service, September 2011.

Wittenstein M., E.D. Hausman, *Incenting the Old, Preventing the New: Flaws in Capacity Market Design, and Recommendations for Improvement*. Synapse Energy Economics for American Public Power Association, June 2011.

Johnston L., E.D. Hausman, B. Biewald, R. Wilson, and D. White. *2011 Carbon Dioxide Price Forecast*. Synapse Energy Economics White Paper, February 2011.

Hausman E.D., V. Sabodash, N. Hughes, and J. I. Fisher, *Economic Impact Analysis of New Mexico's Greenhouse Gas Emissions Rule*. Synapse Energy Economics for New Energy Economy, February 2011.

Hausman E.D., J. Fisher, L. Mancinelli, and B. Biewald. *Productive and Unproductive Costs of CO₂ Cap-and-Trade: Impacts on Electricity Consumers and Producers*. Synapse Energy Economics for National Association of Regulatory Utility Commissioners, National Association of State Utility Consumer Advocates, National Rural Electric Cooperative Association, and American Public Power Association, July 2009.

Peterson P., E. Huasman, R. Fagan, and V. Sabodash, *Report to the Ohio Office of Consumer Counsel, on the value of continued participation in RTOs. Filed under Ohio PUC Case No. 09-90-EL-COI*, May 2009.

Schlissel D., L. Johnston, B. Biewald, D. White, E. Hausman, C. James, and J. Fisher, *Synapse 2008 CO₂ Price Forecasts*. July 2008.

Hausman E.D., J. Fisher and B. Biewald, *Analysis of Indirect Emissions Benefits of Wind, Landfill Gas, and Municipal Solid Waste Generation*. Synapse Energy Economics Report to the Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, July 2008.

Hausman E.D. and C. James, *Cap and Trade CO₂ Regulation: Efficient Mitigation or a Give-away?* Synapse Energy Economics presentation to the ELCON Spring Workshop, June 2008.

Hausman E.D., R. Hornby and A. Smith, *Bilateral Contracting in Deregulated Electricity Markets*. Synapse Energy Economics for the American Public Power Association, April 2008.

Hausman E.D., R. Fagan, D. White, K. Takahashi and A. Napoleon, *LMP Electricity Markets: Market Operations, Market Power and Value for Consumers*. Synapse Energy Economics for the American Public Power Association's Electricity Market Reform Initiative (EMRI) symposium, "Assessing Restructured Electricity Markets" in Washington, DC, February 2007.

Hausman E.D. and K. Takahashi, *The Proposed Broadwater LNG Import Terminal Response to Draft Environmental Impact Statement and Update of Synapse Analysis*. Synapse Energy Economics for the Connecticut Fund for the Environment and Save The Sound, January 2007.

Hausman E.D., K. Takahashi, D. Schlissel and B. Biewald, *The Proposed Broadwater LNG Import Terminal: An Analysis and Assessment of Alternatives*. Synapse Energy Economics for the Connecticut Fund for the Environment and Save The Sound, March 2006.

Hausman E.D., P. Peterson, D. White and B. Biewald, *RPM 2006: Windfall Profits for Existing Base Load Units in PJM: An Update of Two Case Studies*. Synapse Energy Economics for the Pennsylvania Office of Consumer Advocate and the Illinois Citizens Utility Board, February 2006.

Hausman E.D., K. Takahashi, and B. Biewald, *The Glebe Mountain Wind Energy Project: Assessment of Project Benefits for Vermont and the New England Region*. Synapse Energy Economics for Glebe Mountain Wind Energy, LLC., February 2006.

Hausman E.D., K. Takahashi, and B. Biewald, *The Deerfield Wind Project: Assessment of the Need for Power and the Economic and Environmental Attributes of the Project*. Synapse Energy Economics for Deerfield Wind, LLC., January 2006.

Hausman E.D., P. Peterson, D. White and B. Biewald, *An RPM Case Study: Higher Costs for Consumers, Windfall Profits for Exelon*. Synapse Energy Economics for the Illinois Citizens Utility Board, October 2005.

Hausman E.D. and G. Keith, *Calculating Displaced Emissions from Energy Efficiency and Renewable Energy Initiatives*. Synapse Energy Economics for EPA website 2005

Rudkevich A., E.D. Hausman, R.D. Tabors, J. Bagnal and C. Kopel, *Loss Hedging Rights: A Final Piece in the LMP Puzzle*. Hawaii International Conference on System Sciences, Hawaii, January, 2005 (accepted).

Hausman E.D. and R.D. Tabors, *The Role of Demand Underscheduling in the California Energy Crisis*. Hawaii International Conference on System Sciences, Hawaii, January 2004.

Hausman E.D. and M.B. McElroy, *The reorganization of the global carbon cycle at the last glacial termination*. *Global Biogeochemical Cycles*, 13(2), 371-381, 1999.

Norton F.L., E.D. Hausman and M.B. McElroy, *Hydrospheric transports, the oxygen isotope record, and tropical sea surface temperatures during the last glacial maximum*. *Paleoceanography*, 12, 15-22, 1997.

Hausman E.D. and M.B. McElroy, *Variations in the oceanic carbon cycle over glacial transitions: a time-dependent box model simulation*. Presented at the spring meeting of the American Geophysical Union, San Francisco, 1996.

PRESENTATIONS AND WORKSHOPS

American Public Power Association: Invited expert participant in APPA's roundtable discussion of the current state of the RTO-operated electricity markets. October 2013.

California Long-Term Resource Adequacy Summit (Sponsored by the California ISO and the California Public Utility Commission): Panelist on "Applying Alternative Models to the California Market Construct." February 26, 2013.

ELCON 2011 Fall Workshop: "Do RTOs Need a Capacity Market?" October 2011.

Harvard Electricity Policy Group: Presentation on state action to ensure reliability in the face of capacity market failure. February 2011.

NASUCA 2010 Annual Conference: "Addressing Climate Change while Protecting Consumers." November 2010.

NASUCA Consumer Protection Committee: Briefing on the Synapse report entitled, "Productive and Unproductive Costs of CO₂ Cap-and-Trade." September 2009.

NARUC 2009 Summer Meeting: Invited speaker on topic: "Productive and Unproductive Costs of CO₂ Cap-and-Trade." July, 2009.

NASUCA 2008 Mid-Year Meeting: Invited speaker on the topic, "Protecting Consumers in a Warming World, Part II: Deregulated Markets." June 2008.

Center for Climate Strategies: Facilitator and expert analyst on state-level policy options for mitigating greenhouse gas emissions. Serve as facilitator/expert for the Electricity Supply (ES) and Residential, Commercial and Industrial (RCI) Policy Working Groups in the states of Colorado and South Carolina. 2007-2008.

NASUCA 2007 Mid-Year Meeting: Invited speaker on the topic, "Protecting Consumers in a Warming World" June 2007.

ASHRAE Workshop on estimating greenhouse gas emissions from buildings in the design phase: Participant expert on estimating displaced emissions associated with energy efficiency in building design. Also hired by ASHRAE to document and produce a report on the workshop. April, 2007.

Assessing Restructured Electricity Markets An American Public Power Association Symposium: Invited speaker on the history and effectiveness of Locational Marginal Pricing (LMP) in northeastern United States electricity markets, February, 2007.

ASPO-USA 2006 National Conference: Invited speaker and panelist on the future role of LNG in the U.S. natural gas market, October, 2006.

Market Design Working Group: Participant in FERC-sponsored settlement process for designing capacity market structure for PJM on behalf of coalition of state utility consumer advocates, July-August 2006.

NASUCA 2006 Mid-Year Meeting: Invited speaker on the topic, "How Can Consumer Advocates Deal with Soaring Energy Prices?" June 2006.

Soundwaters Forum, Stamford, CT: Participated in a debate on the need for proposed Broadwater LNG terminal in Long Island Sound, June 2006.

Energy Modeling Forum: Participant in coordinated academic exercise focused on modeling US and world natural gas markets, December 2004.

Massachusetts Institute of Technology (MIT): Guest lecturer in Technology and Policy Program on electricity market structure, the LMP pricing system and risk hedging with FTRs. 2002-2005.

LMP: The Ultimate Hands-On Seminar. Two-day seminar held at various sites to explore concepts of LMP pricing and congestion risk hedging, including lecture and market simulation exercises. Custom seminars held for FERC staff, ERCOT staff, and various industry groups. 2003-2004.

Learning to Live with Locational Marginal Pricing: Fundamentals and Hands-On Simulation. Day-long seminar including on-line mock electricity market and congestion rights auction, December 2002.

LMP in California. Series of seminars on the introduction of LMP in the California electricity market, including on-line market simulation exercise. 2002.

Resume updated March 2015