BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

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| In re: Union Electric Company's 2017 Utility Resource Filing Pursuant to 4 CSR 240 – Chapter 22 | ) ) ) | Case No. EO-2018-0038 |

**SIERRA CLUB COMMENTS**

Sierra Club, by and through counsel, hereby submits the attached comments, drafted by Dr. Ezra D. Hausman, on Ameren Missouri's 2017 Integrated Resource Plan ("IRP"). As Dr. Hausman explains in his comments, Ameren Missouri's IRP is deficient in key respects. Broadly, Ameren Missouri underestimates the costs of existing and proposed environmental regulations and thus fails to address the risks and costs of continuing to operate its existing coal-fired generation fleet. These deficiencies violate 4 CSR 240-22.040.[1]

Ameren Missouri's IRP is deficient in several respects. First, 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, to the point where the IRP analysis is deficient under 4 CSR 240-22.040(2)(B). Ameren acknowledges that higher retirement rates are a nationwide phenomenon, but seems unable to consider that any marginal cost advantage its coal fleet may have over that of other utilities is for the very reason

[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."

that its plants lack up-to-date pollution controls. Nevertheless, Ameren expects to eventually spend $2 billion on environmental upgrades at Labadie and Rush Island, an expense that could be avoided by earlier retirements. Ameren also fails to consider or even mention possible future costs or operating restrictions associated with the January 2017 finding in federal court that it violated the Clean Air Act at the Rush Island plant in 2007 and 2010.

Second, an IRP must treat renewable energy and other supply-side options on an equivalent basis. 4 CSR 240-22.010(2)(A). In developing alternative resource plans a utility must examine cases that minimally and optimally comply with renewable energy mandates, and an "aggressive renewable energy resource plan." 4 CSR 240-22.060(3)(A)1, 2 and 5. The "RES Plus" portfolio Ameren uses in all its ARPs (except the mandated RES-only portfolio) envisions no addition of wind after the 700 MW Ameren plans to add by 2020 even though the company admits that wind has the lowest levelized cost of energy of any candidate resource option. Ameren is also unwilling to add solar, relying on 2013 information that ignores the steep drop in the cost of solar since that year. Accordingly, Ameren's plan is deficient.

Finally, Ameren Missouri's treatment of future carbon regulations is deficient because it assumes carbon prices so unreasonably low even in the "high" case, and with no carbon price at all before 2025, that it effectively nullifies the NPVRR advantages of early retirement of coal-fired generating units. Although 4 CSR 240-22.040(2)(B) directs Ameren to "specify a subjective probability" for probable environmental costs, 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 to comply with the rule.

## Public Participation

The fundamental objective of the resource planning process is to serve the public interest. 4 CSR 240-22.010(1) and (2). Ameren has consistently excluded the broader public by relying on the narrow definition of "stakeholder group" in 4 CSR 240-22.020(56), which is limited to intervenors in past and present Chapter 22 proceedings, Staff, and OPC. Such a strict interpretation runs counter to the broad "public input" requirement of 4 CSR 240-22.080(5). 240-22.080(5) requires that "[e]ach electric utility shall convene a stakeholder group to provide the opportunity for public input into electric utility resource planning in a timely manner that may affect the outcome of the utility resource planning efforts."

Nothing in the rule forbids the public from having a role in the development of an IRP. As it stands, intervenors must bear the expense of hiring counsel and the limitations on access to confidential information imposed by 4 CSR 240-2.135. The opportunity to submit public comments necessarily comes after the IRP is filed, when such comments are likely to have little if any influence. Before filing, Ameren holds a single stakeholder meeting and requires participants to sign a draconian Confidentiality Agreement that departs from 4 CSR 240-2.135 and subjects the "Disclosee" in the event of a breach to damages and other legal remedies, a bond, and liability for all Ameren's costs including attorneys' fees.

Sierra Club asks the Commission to improve opportunities for public involvement in utilities' long range planning, including considering the implementation of one or more public hearings where members of the public can have more meaningful input into energy decisions, similar to rate cases. Ameren's plan will have profound impacts on its 1.2 million customers and yet the overwhelming majority of those customers do not have a say in the plan.

## Conclusion

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; and that the Commission order the Company to conduct one or more public hearings to provide the opportunity for public input required by 4 CSR 240-22.080(5).

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 28th day of February, 2018.

/s/Henry B. Robertson
Henry B. Robertson

**Comments on Ameren Missouri's 2017 Integrated Resource Plan (IRP)**

Ezra D. Hausman, Ph.D.[2]
Ezra Hausman Consulting
February 28, 2018

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[2] Dr. Hausman's resume is attached as Exhibit EDH-1.

## INTRODUCTION

Many aspects of Ameren Missouri's ("Ameren", or the "Company") 2017 IRP demonstrate the Company's increasing understanding and appreciation of the ongoing nationwide transition in the electric energy sector towards clean, low- or zero-carbon resources and away from the polluting energy sources of the past. Ameren appears to recognize that the Company is not immune to these trends; as stated in Chapter 10 of the IRP, "One of Ameren Missouri's planning objectives is to transition our generation portfolio to one that is cleaner and more fuel diverse in a responsible fashion."

This evolving outlook is illustrated by many of the differences in Ameren's current expectations for future conditions compared to the Company's most recent triennial IRP from 2014. These differences include a significant increase in Ameren's expectations for coal plant retirements nationwide; specifically, Ameren's current "low retirements" case includes more retirements than its "high retirements" case from 2014.[3] Ameren also recognizes the economic benefits of low-cost renewable resources, finding that "wind energy resources exhibit the lowest cost on an LCOE basis among all candidate resource options without tax incentives."[4] In its 2017 IRP, Ameren recognizes the fact that gas prices are likely to remain far lower than the Company had previously projected, meaning that coal-fired generation will struggle to compete successfully with gas generation for the foreseeable future, even in the absence of carbon regulations. Accordingly, under any realistic future carbon price scenario, the economic challenges for coal are only more daunting.

Other aspects of Ameren's "planning environment" also suggest less of a need and lower value for Ameren's coal fleet. These include:

- A lower load projection than previously reported, including *negative* 0.48% annual load growth in the base case;
- A stronger capacity position relative to load. Figure 9.2 of the 2017 IRP illustrates that both Sioux and Meramec could be retired in 2020 with no need for additional

[3] See 2017 IRP Figure 2.6, reproduced as Figure 1 below.
[4] 2017 IRP, Chapter 6.

capacity; in addition, two Labadie units could be retired by 2027, again while maintaining a strong capacity position

Despite this general recognition of industry trends and expectations of reduced requirements to serve customers, Ameren maintains two intransigent blind spots that compromise its own resource planning process to the detriment of its customers.

First, Ameren appears to believe that the economic and environmental pressures that are driving the acceleration in coal plant retirements around the country, including in Missouri, will somehow bypass the Company's own coal-fired power plants, despite the high costs and risks of maintaining and operating these plants and the Company's long capacity position. In part, Ameren does this by obscuring the risks of additional environmental costs, as discussed in the next section of these comments.

Second, while Ameren generally includes a carbon price in its analyses, it does so by assuming such a low price, and at such a late start date for this policy driver, that it has almost no effect on the outcome. Ameren provides no substantive support for this low carbon price beyond the recommendations of its unidentified "subject matter experts."[5]

Both of these blind spots lead Ameren to base its plan on an unrealistically optimistic future for its coal plants, depriving it and its ratepayers of an opportunity to effectively and efficiently plan for the economic and regulatory environment of the future. Ameren's plan would continue to invest ratepayer funds on outdated technology based on poorly vetted or justified assumptions, ignoring or downplaying the risks the Company is taking on customers' behalf.

The factors and trends compromising the future viability of Ameren's coal plants are widely recognized throughout the United States, as well as within Missouri. Ameren's acknowledgement of these factors and trends can be found throughout the 2017 IRP. This makes it all the more puzzling that Ameren barely considers early coal plant retirement scenarios for itself, or the impact of a significant carbon price, even on a "what-if" basis. Despite all of its awareness of industry trends and its duty to its Commission and its ratepayers to plan for the future, in terms of its coal plants Ameren appears to be planning for the past.

[5] 2017 IRP Chapter 2, page 20.

## ECONOMIC CHALLENGES FOR AMEREN'S COAL PLANTS

For decades, coal plants have been facing increasing costs to continue operating as environmental regulations have addressed their considerable impacts on air and water quality, their toxic wastes, and their impacts on human health. Although these regulations and improving emissions control technology have been extremely successful in reducing emissions of several harmful pollutants, there is still a long way to go before standards such as "natural visibility" can be met, and before hazards to ground and surface waters, aquatic life, human health, and the climate are fully addressed. Ameren expects to spend over $2 billion in capital expenditures on the Labadie and Rush Island plants over the next 25 years – most of which could be avoided through earlier retirement of these units.[6]

Further, Ameren's projected costs are predicated on assumptions about future environmental regulations that may turn out to be unfounded. For example, Ameren notes that "[i]n the future, the EPA could revise the rule with lower caps on $SO_2$ and NOx emissions. If future revisions require additional reductions in the CSAPR $SO_2$ and/or NOx allocations, Ameren Missouri would evaluate compliance strategies that could include modified operation of existing generation resources as well as the installation of additional pollution control equipment at one or more of its facilities depending on the level of required reduction."[7] Such requirements could require hundreds of millions of dollars of additional investments, which are unlikely to be justifiable given the other economic challenges, discussed below, facing Ameren's coal fleet.

Ameren's IRP fails to note that in January 2017, federal judge Rodney Sippel of the Eastern District of Missouri found the Company to have violated the PSD and Title V provisions of the Clean Air Act (42 U.S.C. § 7401 *et seq.*) "by failing to obtain a preconstruction permit and install best available pollution control technology, among other requirements" at Rush Island Unit 1 in 2007 and Rush Island Unit 2 in 2010.[8] No remedy has yet been established for these violations, but Ameren's failure to evaluate or disclose the potential costs is a significant shortcoming to its overall analysis of these units.

[6] Attachment A to response to Sierra Club Data Request 001.
[7] Chapter 5 of 2017 IRP, page 4.
[8] Case No. 4:11-cv-00077-RWS Doc. #852. Filed: 01/23/17.

Ameren's "Planning Environment", discussed in Chapter 2 of the 2017 IRP, includes its assessment of the level of coal plant retirements throughout the United States in future years. Figure 1, reproduced from Figure 2.6 in the IRP, compares these retirement scenarios along with carbon price assumptions to those used in Ameren's 2014 IRP.

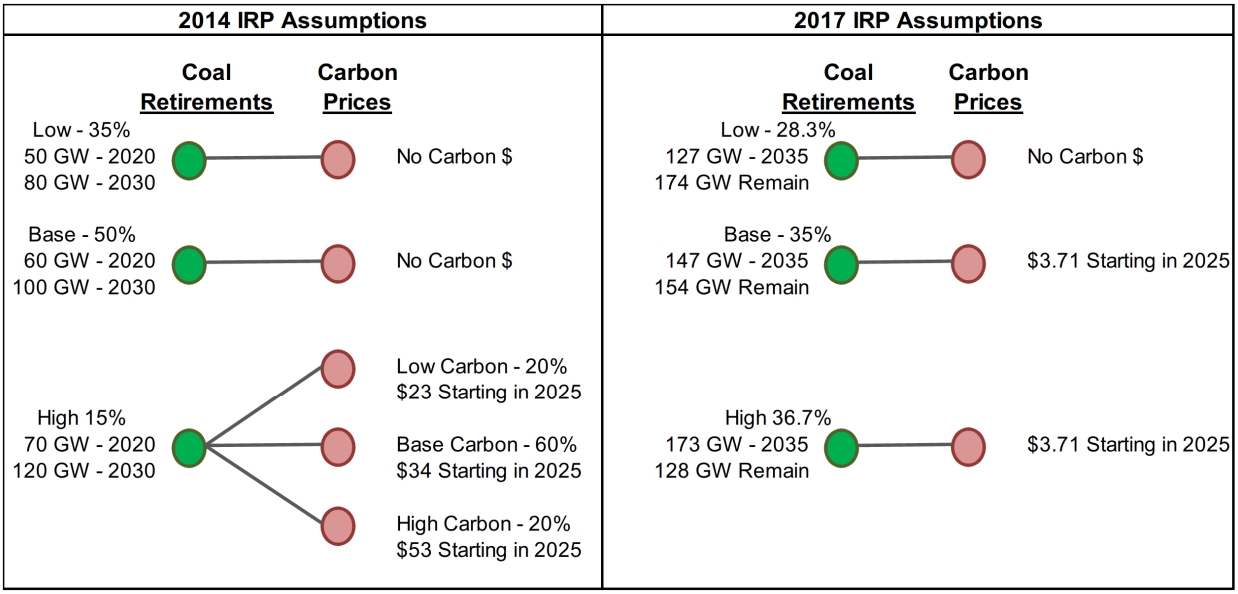


**FIGURE 1. US COAL PLANT RETIREMENT AND CARBON PRICE ASSUMPTIONS FROM AMEREN'S 2014 AND 2017 IRPS. REPRODUCED FROM FIGURE 2.6 OF AMEREN'S 2017 IRP.**

According to the IRP, "This dataset includes plant closures based on company announcements and Ventyx's analysis given current laws and regulations at the time of publishing the dataset used in the study" and Ameren's "previous coal plant retirement assumptions for three levels – low, base, and high – were updated based on review and multiple discussions with internal experts involved in environmental regulation and policy."[9]

The change in outlook is striking. In 2014, Ameren's "High" retirement scenario of 120 GW of retirements by 2030 was assigned only a 15% chance of occurrence. Today *all* of Ameren's retirement scenarios exceed this level, with at least 127 GW of retirements by 2035. Ameren assigns a 36.7% probability that the level of retirements will be 173 GW by 2035 – representing almost 60% of existing coal capacity. This is a continuation of a trend in Ameren's

[9] 2017 IRP Chapter 2, p. 19.

revised assumptions in this area – all retirement scenarios projected in 2014 were significantly higher than the "High" scenario considered in its 2011 IRP (35 GW retirement by 2030.)[10]

Ameren's expectations for increasing levels of near-term coal retirements come despite the diminished near-term prospects for significant carbon regulation under the current administration, and in spite of the Company's much lower projections for carbon prices – although Ameren appears to believe that these lower carbon prices are more likely to occur – as also seen in Figure 1. These coal plant retirements reflect the realities of the electricity marketplace, in which cleaner technologies that produce far lower impacts on human health and the environment are out-competing coal plants.

Further, Ameren could retire a significant part of its coal fleet, saving ratepayers hundreds of millions of dollars, without compromising its generating capacity position. Figure 2 illustrates this point – the green bars (indexed to right vertical axis) represent Ameren's capacity position *in excess of* MISO reserve requirements. Further, this represents a case with no new resources, including renewables and demand resources. This graph illustrates that the Sioux plant and Labadie 1 and 2 could be retired at least a decade earlier than Ameren plans without compromising Ameren's capacity position.

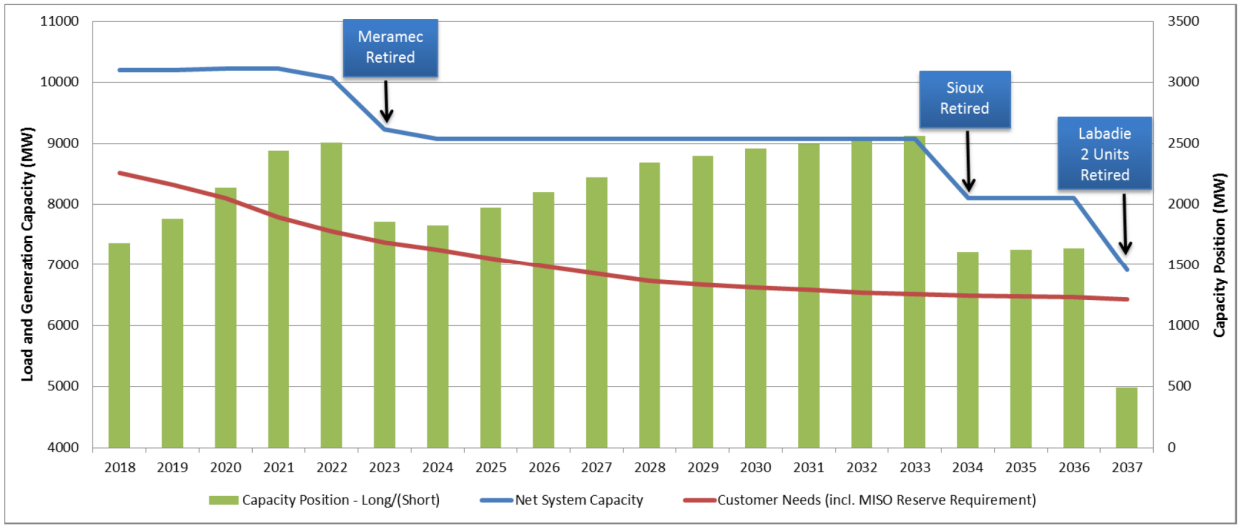


**FIGURE 2. AMEREN'S PROJECTED NET CAPACITY POSITION WITH NO NEW RESOURCES. GREEN BARS (RIGHT AXIS) REPRESENT AMEREN'S CAPACITY POSITION IN EXCESS OF MISO REQUIREMENTS. REPRODUCED FROM FIGURE 9.2 OF THE 2017 IRP.**

[10] See Figure 2.6 of Ameren's 2014 IRP for this comparison.

Yet despite Ameren's general understanding and representation of these trends, the Company would have us believe that there are no significant changes or challenges facing its own coal fleet comparable to the very significant changes driving coal plant retirements throughout the industry. Ameren has not presented a clear and transparent set of justifications that would allow the Commission or other parties to understand why the Company's assessment of its own coal plants' future viability has remained essentially unchanged despite the significant evolution in the economic environment represented in each successive triennial IRP, including the significantly reduced load outlook obviating the need for this excess capacity.[11]

### COMPETITION FROM GAS

While Ameren's 2014 IRP took into account the then-prevalent low gas prices, its underlying fuel price forecast suggested that gas prices would increase linearly to $6.75/MMBtu (in constant 2013$) in "base" case, $5.40 in "low" case, $8.10 in "high" case by 2034. Ameren's outlook today is quite different, suggesting persistently low (and perhaps extremely low) gas prices through the end of the planning period. A comparison of the gas price forecasts from 2014 and 2017 is shown in Figure 3.

It is hard to overstate the significance of this persistently lower gas price outlook in terms of the long-term potential for gas plants to outcompete coal plants. Greater competition from low-cost gas means both that coal plants will run many fewer hours, and that their output will be significantly less valuable during most or all of those diminished operating hours.

[11] The only "update" to Ameren's expected coal plant retirement dates since the 2014 IRP is that assumption, under the "preferred plan" in the 2017 IRP, that two Labadie units will retire in 2036. However, it is not clear if this represents a change in Ameren's outlook for these units as this date was outside the planning window for the 2014 IRP.

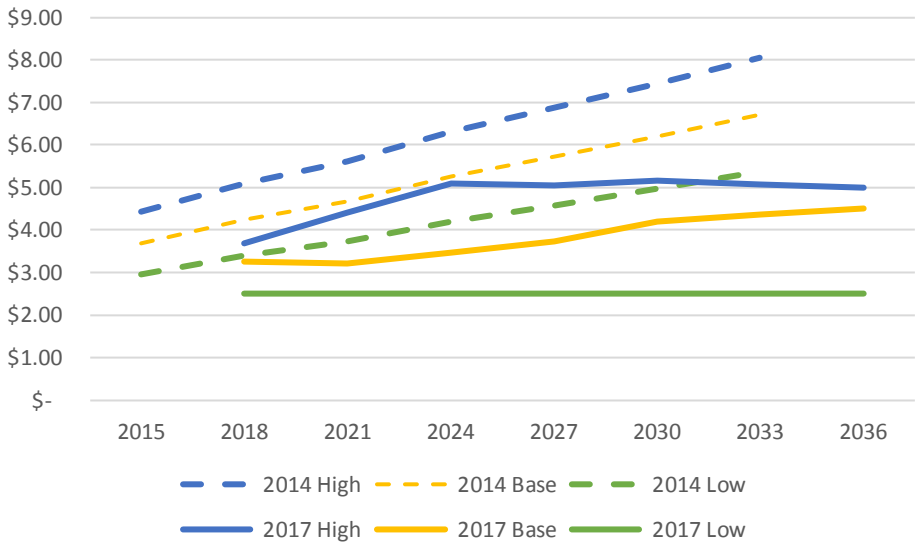


**FIGURE 3. COMPARISON OF GAS PRICE ASSUMPTIONS FROM 2014 AND 2017 AMEREN IRPS. ALL PRICES ARE SHOWN IN CONSTANT 2016$.**

## COMPETITION FROM RENEWABLES

Ameren has clearly recognized the potential for low-cost renewable energy sources to displace fossil resources with zero-marginal cost, zero-emissions energy. Ameren finds that "[w]ind energy resources exhibit the lowest cost on an LCOE basis among all candidate resource options without tax incentives."[12] As a result, Ameren finds that acquiring wind resources beyond the requirements of Missouri's RES requirements is part of its most cost-effective plan, including "700 MW of new wind resources in the next three years and 100 MW of new solar resources in the next ten years."[13] Ameren further notes that "[b]ecause costs for solar resources are expected to continue to decline, it is possible that these additional resources could be added at no additional cost, or perhaps a savings to customers, by the time implementation is considered…It is also possible that additional wind resources beyond those included in our plan could be beneficial to customers."[14]

While Ameren does not yet find solar energy to be similarly superior on a cost basis in the absence of incentives, this may reflect at least in part that the Company is working with outdated information. Chapter 6 of the IRP states that "[solar] cost assumptions from the 2013 Black and Veatch study were reviewed with internal subject matter experts and revised as

[12] 2017 IRP, Chapter 6.
[13] 2017 IRP, Chapter 10.
[14] Ibid.

appropriate." As with numerous other crucial inputs into Ameren's planning process, there is no detail provided regarding sources used for these revisions; however, there is ample evidence that 2013 information on solar costs has little applicability today.

For example, a September 18, 2017 publication from Moody's Investor Service[15] stated the following:

> **Renewable energy costs have fallen dramatically and will continue to do so.** Economies of scale and improving efficiencies have caused steep falls in capital costs, and hence levelized cost of energy (LCOE), from solar and wind. And those declines are continuing, especially for solar, where panel prices have fallen over 20% since late 2016.

Similarly, a recent Lawrence Berkeley National Laboratory (LBNL) study[16] quantified the rapid growth of solar installations by region throughout the United States, including the Midwest. The LBNL study reports that "[m]edian installed PV project prices within a sizable sample have steadily fallen by nearly 60% since the 2007-2009 period, to $2.7/WAC (or $2.1/WDC) for projects completed in 2015. The lowest 20th percentile of projects within our 2015 sample (of 64 PV projects totaling 2,135 MWAC) were priced at or below $2.2/WAC, with the lowest-priced projects around $1.7/WAC.

Figure 18 from the LBNL report, reproduced here as Figure 4, shows this dramatic trend reflected in solar PPA prices over the last decade.

[15] Moody's, *Global Renewables Focus* (Sep. 2017).

[16] Mark Bolinger et al., Lawrence Berkeley National Laboratory, *Utility-Scale Solar 2016: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States* (Sep. 2017), *available at* https://emp.lbl.gov/sites/default/files/utility-scale_solar_2016_report.pdf.

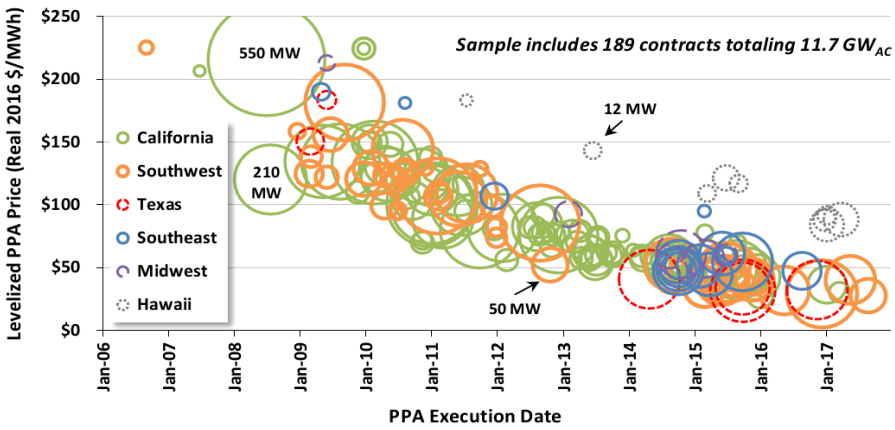


**Figure 18. Levelized PPA Prices by Region, Contract Size, and PPA Execution Date: Full Sample**

**FIGURE 4. DECLINING SOLAR PPA PRICES THROUGHOUT THE UNITED STATES. SIZE OF CIRCLES REFLECTS SIZE OF PPA (MW.)**

As with low-cost natural gas, zero-cost wind and solar have the potential both to reduce the need for Ameren's coal plants, and to lower the value of the energy they produce, rendering further investments in these plants less and less economically justifiable. However, and despite finding advantages in exceeding Missouri's RES requirements, Ameren does not consider any scenarios in which even more renewables are added to its system, despite a clear public preference for such resources as reflected in the Missouri RES, passed by ballot initiative in 2008, Ameren's own Green Tariff initiative, and the City of St. Louis's resolution to pursue 100% clean energy by 2035.[17] Additional renewables would further reduce the need for Ameren's coal-fired generation and could help customers avoid expensive future coal plant maintenance and retrofit costs. Ameren's failure to even consider higher levels of renewables leaves the Company and Missouri ratepayers behind while other regional utilities, such as Xcel energy, are taking advantage of the opportunity to save money by replacing aging coal plants with fuel- and emissions-free renewables.[18]

Given the dramatically improved outlook for competing resources – gas and renewables – between Ameren's 2014 IRP and the present, it is paradoxical that Ameren finds the viability of its coal fleet largely unaffected. In notable contrast, Kansas City Power and Light (KCPL) has

[17] "Aldermen pass resolution for St. Louis to pursue 100 percent clean energy by 2035", St. Louis Post-Dispatch, October 27, 2017. Available at http://www.stltoday.com/business/local/aldermen-pass-resolution-for-st-louis-to-pursue-percent-clean/article_3dcd5d0c-38c6-5d10-ba7e-4a76b2f4ecff.html.

[18] See for example, "Why a Big Utility Is Embracing Wind and Solar", New York Times Opinion Page, February 6, 2018. Available at https://www.nytimes.com/2018/02/06/opinion/utility-embracing-wind-solar.html.

clearly recognized the impact of these drivers on its coal fleet. In 2014, KCPL announced that it would retire 705 MW of coal by 2021;[19] in 2017, this was updated to 900 MW by 2018.[20] Why does Ameren believe its plants are immune to these trends? One reason is that Ameren appears to be underrepresenting the likely future environmental and compliance costs facing its coal fleet. Another may be found in another major change in Ameren's outlook: the assumed near absence of any future cost to emit $CO_2$ as represented in the 2017 analysis.

## LIP-SERVICE TREATMENT OF $CO_2$ EMISSIONS COSTS

There is no longer any serious dispute that the emission of $CO_2$ and other greenhouse gases into the atmosphere poses an extraordinary long-term threat to the environment, the economy, and human health. This fact has been confirmed by thousands of scientific studies from a wide range of disciplines,[21] affirmed by the Supreme Court of the United States in its December, 2009 "Endangerment" finding, and is widely recognized by policymakers and experts around the globe. While the current administration in the United States appears unlikely to meaningfully regulate or tax these emissions in the short term, it is unreasonable to assume that no attempt will be made to control these emissions and their associated damages through the end of Ameren's study period in 2036. However, Ameren has not even considered such a scenario in its long-term plan.

Ameren has given lip-service to the likelihood of future carbon emissions regulation by including a low carbon price in its "mid" and "high" retirement scenarios, as seen in Figure 1. In constant 2016 dollars, Ameren's assumed emissions price in both of these cases increases from $3.11 per ton in 2025 to $9.93 per ton in 2037 – prior to 2025, the price is zero. (In its 2014 IRP, Ameren assumed a carbon emissions price starting at $23 to $53 in 2025, although in that case it only applied to the 15% of scenarios with "high" carbon retirements.) Ameren's explanation for this significant shift in outlook, along with its source for the revised carbon prices are nowhere to be found in its 2017 IRP. Ameren states that "[t]o help frame the ongoing possibilities for carbon policy and regulation of GHG emissions, we examined reports from several research and consulting companies, such as IHS Cera, Synapse Energy Economics, Inc along with MISO

[19] https://www.kcpl.com/about-kcpl/media-center/2015/january/kcpl-announces-plans-to-cease-burning-coal-at-three-plants.
[20] https://www.kcpl.com/about-kcpl/media-center/2017/june/kcpl-continues-sustainability-commitment-by-announcing-retirement-of-six-units-at-three-power-plants.
[21] For a discussion, see https://climate.nasa.gov/scientific-consensus/.

studies of the CPP. We also reviewed the 2016 EIA reference case along with their alternative Clean Power Plan cases."[22] However, there is no indication of how Ameren used these sources to establish its carbon emissions price forecast, either in the IRP or in the Company's workpapers, except that it relied on "the views of [Ameren's] subject matter experts."[23]

Figure 5 shows the impact of Ameren's carbon price projection on the calculated Present Value of Revenue Requirements (PVRR) of its Preferred Resource Plan vs. four retirement scenarios. The impact of applying Ameren's carbon emissions price is shown numerically in Table 1: scenarios that include Ameren's carbon price have a PVRR that is about 2% higher than the PVRR of those that do not. For comparison,

[22] 2017 IRP, Chapter 2, page 18.
[23] 2017 IRP, Chapter 2, page 20.

Table 2 shows the difference in PVRR between each of the early retirement cases considered by Ameren and the base case. The retirement cases increase PVRR by between 0.1% and 2.7%. This suggests that had Ameren analyzed a scenario with a carbon price closer to the one used in 2014, the retirement scenarios would likely have been far superior on a PVRR basis.

Ameren's carbon price is so low that it makes essentially no difference in the ranking of candidate resource plans by PVRR, even though some plans are significantly more reliant on carbon-intensive resources than others. Put simply, Ameren has chosen to model only a carbon price scenario that would have essentially no impact on the future of coal plants, even though such plants represent one of the largest sources of carbon pollution. Ameren has not even considered any scenario in which federal policy would have a significant impact on electricity market economics.

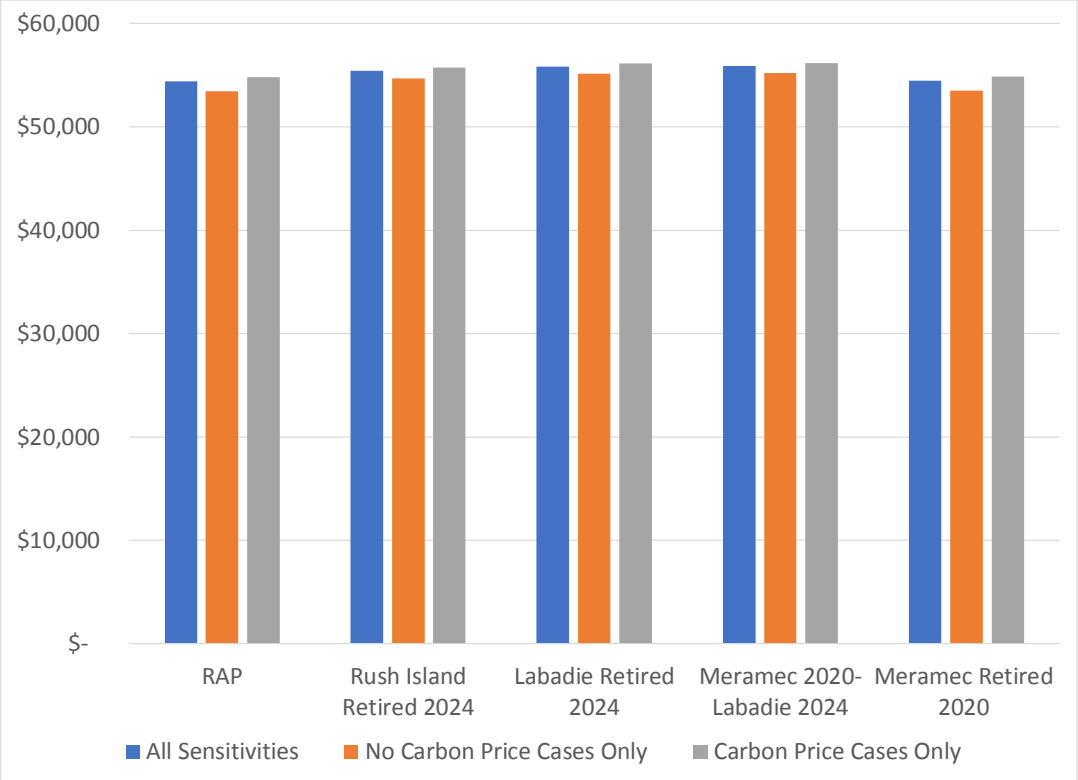


**FIGURE 5. IMPACT OF CARBON PRICE ASSUMPTION ON PVRR RESULTS FOR AMEREN SCENARIOS. "RAP" REPRESENTS AMEREN'S PREFERRED PLAN.** *DATA SOURCE: AMEREN 2017 IRP, TABLE 10.5.*

**TABLE 1. IMPACT OF INCLUDING AMEREN'S CARBON PRICE ON CALCULATED PVRR.** *DATA SOURCE: AMEREN 2017 IRP, TABLE 10.5.*

| Scenario | PVRR Impact of Ameren's Carbon Price |
|---|---|
| Preferred Plan | 2.6% |
| Rush Island Retired 2024 | 1.9% |
| Labadie Retired 2024 | 1.7% |
| Meramec 2020-Labadie 2024 | 1.8% |
| Meramec Retired 2020 | 2.6% |

**TABLE 2. PVRR COMPARISON BETWEEN AMEREN BASE CASE AND RETIREMENT SCENARIOS.** *DATA SOURCE: AMEREN 2017 IRP, TABLE 10.5.*

| Scenario | PVRR Relative to "RAP" Scenario |
|---|---|
| Preferred Plan | 0.0% |
| Rush Island Retired 2024 | 1.9% |
| Labadie Retired 2024 | 2.6% |
| Meramec 2020-Labadie 2024 | 2.7% |
| Meramec Retired 2020 | 0.1% |

Of course, it is impossible to know exactly what the outcome would be of a plan with a more realistic and effective carbon price, because the Company failed to perform any such analysis. As shown in Figure 6, the difference between Ameren's preferred plan and the early retirement scenarios is much smaller than the uncertainty in the individual plans. It is likely, given the cascade of economic factors diminishing the prospect of all coal plants in the US, including Ameren's, that the consideration of reasonable carbon prices would clearly illustrate the benefits of earlier retirement.

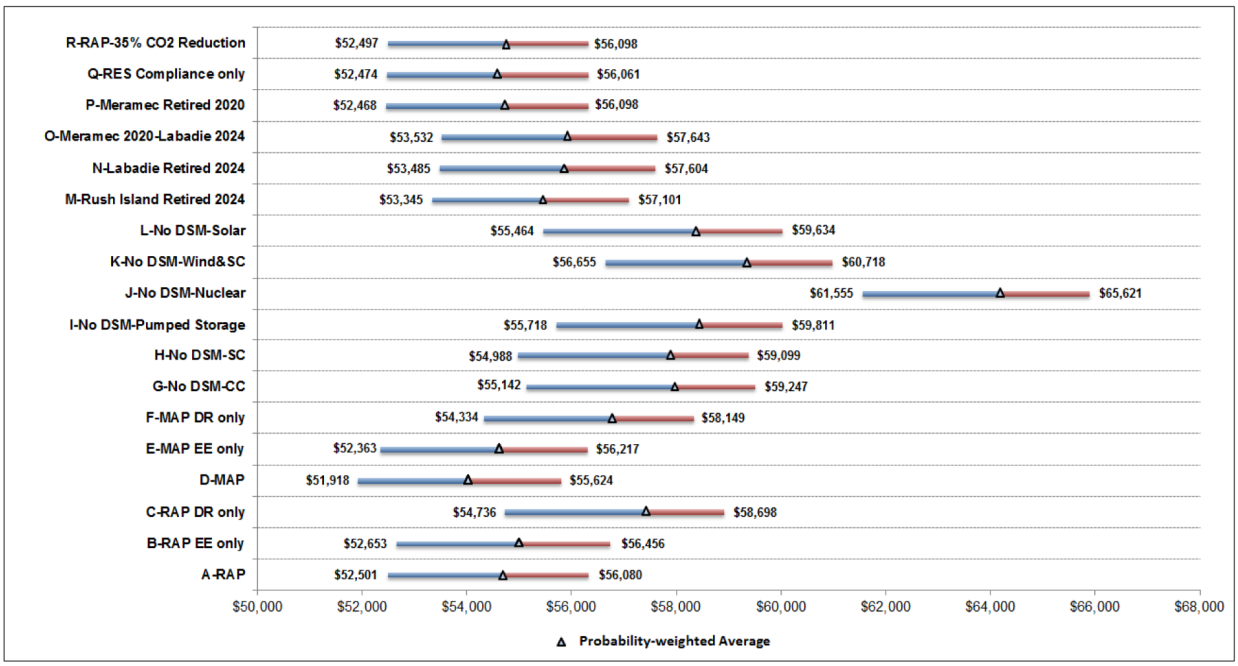

**FIGURE 6. EXPECTED VALUE, 5TH, AND 95TH PERCENTILES OF THE PVRR FOR EACH CANDIDATE PLAN, BASED ON AMEREN'S ANALYSIS. REPRODUCED FROM FIGURE 9A.24 OF AMEREN'S 2017 IRP. AMEREN'S PREFERRED PLAN "A" (IDENTICAL TO PLAN R) IS SHOWN AT THE BOTTOM.**

## CONCLUSION AND RECOMMENDATIONS

Ameren Missouri has a responsibility to produce a long-term plan to deliver reliable, cost-effective energy that recognizes the full range of likely economic and regulatory conditions the Company is likely to face over the coming decades. Ameren and all utilities know that the conditions that prevail today – in terms of fuel costs, available technology, environmental regulations, and other drivers of electricity market conditions – are likely to change in the coming years. As discussed in these comments, many of the assumptions about the future memorialized in Ameren's 2014 triennial IRP were already obsolete and had to be significantly revised for the current plan.

Because of this unavoidable uncertainty, Ameren not only analyzes a range of possible resource plans, but does so under a range of possible future conditions. These conditions include varying assumptions for load growth and gas prices, along with the cost of demand-side management and coal. The Company also considers a range of levels of coal retirements nationwide, and considers a very low and ineffective price on carbon emissions starting in 2025.

Ameren's plan is deficient in that it fails to justify or document many of the underlying assumptions that will profoundly affect the operating environment of the future, and it fails to disclose or consider the risks of higher-than-anticipated costs for maintaining and operating its coal fleet in compliance with all environmental regulations in the coming decades. This omission includes failing to consider costs that may derive from Ameren's liability for violations of the Clean Air Act in 2007 and 2010.

As part of Ameren's failure to thoroughly consider future environmental costs, the Company limited its consideration of a carbon emissions price to a scenario that would have no impact on the economics of its coal plants. The future of greenhouse gas regulations is one of the most consequential uncertainties facing the US electric sector, and it is one to which coal-dominated utilities such as Ameren are acutely exposed. It is not reasonable to assign zero probability to a scenario in which the US government takes action to address this profound threat to our national security and economy. While the current administration may not be disposed to

bold action in this area, it is likely that as costs and damages further accumulate a future administration will take effective action, well within the time frame of Ameren's 20-year plan. Ameren's IRP unreasonably gives no consideration to this scenario.

As a result, Ameren's plan yields a result that is almost nonsensical: while recognizing that economic and regulatory factors are driving coal plants all over the country into retirement much faster than Ameren assumed even in 2014 (which was itself much faster than assumed in 2011) Ameren still plans to invest billions of ratepayer dollars to keep its own coal fleet running – without disclosing how high these costs may eventually rise. Ameren does so in the face of an expectation of negative load growth and a long capacity position that significantly exceeds MISO reserve margin requirements throughout the study period. Even under Ameren's favorable and poorly supported assumptions, Ameren's "preferred plan" is only marginally preferable to its early retirement scenarios. Had Ameren considered the full suite of compliance costs it may face in the coming years, or the probability of facing an effective carbon price during its planning period, it is likely that the early retirement scenarios would have prevailed.

At a minimum, Ameren should re-run its model with the "high case" environmental compliance costs, along with the carbon price assumptions it used in 2014. The Company and various stakeholders may disagree on the likelihood of these scenarios, but Ameren should not foreclose the discussion by omitting them entirely from its analysis. Planning under uncertainty means that the full range of reasonably likely future conditions should be considered. It is not reasonable to artificially constrain some of the most consequential costs and risks for the future of coal plants from the Company's analysis.

# Exhibit EDH-1

## Ezra D. Hausman, Ph.D.

I am an independent consultant in energy and environmental economics.

I have worked for 20 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, provided 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
- Dispatch and planning model analyses, and review of modeling studies
- Electricity and generating capacity market design and analysis
- Energy efficiency program and cost/benefit analysis
- Integrated Resource Planning and portfolio analysis
- Economic analysis of environmental and other regulations, including regulation of greenhouse gas emissions, in electricity markets
- Quantification, regulation and mitigation of greenhouse gas emissions associated with the supply and demand sides of the U.S. electricity sector
- Quantification of the economic and environmental benefits of displaced emissions associated with energy efficiency and renewable energy initiatives
- Expert representation and participation in stakeholder processes
- Clean Air Act determinations and enforcement.

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 client's needs and to 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.

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. in psychology from Wesleyan University.

**PROFESSIONAL EXPERIENCE**

**Ezra Hausman Consulting,** Newton, MA. President, March 2014 – Present.
I provide research, analysis, expert testimony, and policy support services in regulatory, litigation, and stakeholder processes covering a wide range of electric sector and electriciuty market issues. The focus of my consulting work includes:

- Interaction of air quality and environmental regulations with electricity markets
- Analysis and implementation of the Clean Power Plan and other greenhouse gas rules
- Clean Air Act enforcement support
- Long-term electric power system planning and market design
- Energy efficiency and renewable energy programs and policies
- Avoided emissions analysis
- Regulation and mitigation of greenhouse gas emissions
- Consumer and environmental protection
- Efficient pricing of generating and transmission capacity
- Market power and market concentration analysis in electricity markets
- Economic analysis of electricity industry regulation and restructuring

**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. Provided expert support and representation in planning, greenhouse gas mitigation, and other stakeholder processes.
- As Vice President and Chief Operating Officer, I was also responsible for day-to-day operations of the company, quality assurance, client service, and professional development of staff.

**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
As a member of the modeling group, developed and maintained dispatch modeling capability in support of electricity market consulting practice.

Performed 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.

## 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

**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.*

***Community Service***

*Academic Mentor and Athletic Coach,* SquashBusters Boston, 2014 - Ongoing
*Judge,* Cleantech Open innovation competitions, 2015-2016
*President*, Burr Elementary School Parent Teacher Organization, 2005-2007

**EXPERT TESTIMONY AND SERVICES**

**New Jersey Division of Rate Counsel – 2016-Ongoing**
General policy and stakeholder support on matters related to energy efficiency, renewable energy, and electrification of transportation in New Jersey.

**New Jersey Board of Public Utilities – 2014-Ongoing**
Expert witness on behalf of the New Jersey Division of Rate Counsel, reviewing and providing testimony on cost effectiveness and program design of various New Jersey gas utility energy efficiency programs.

**Florida Public Service Commission (Docket No. 20170225-EI) – 2017-Ongoing**
Expert witness on behalf of the Sierra Club in FPL Determination of Need proceeding.

**North Carolina Utilities Commission (DOCKET NO. E-7, SUB 1146) – 2017-Ongoing**
Expert witness on behalf of the Sierra Club in Duke Energy Carolinas rate case.

**North Carolina Utilities Commission (DOCKET NO. E-2, SUB 1142) – 2017**
Expert witness on behalf of the Sierra Club in Duke Energy Progress rate case.

**Idaho Public Utilities Commission (Case No. AVU-E-17-01) – 2017**
Expert witness on behalf of the Sierra Club in Avista Corporation rate case.

**Iowa Utilities Board (Docket No. RPU-2017-0002) –- 2017**
Expert witness on behalf of the Sierra Club for Interstate Power and Light petition for ratemaking principles for proposed 500 MW wind project.

**Washington Utilities and Transportation Commission (Dockets UE-170033 and UG-170034) – 2017**
Expert witness on behalf of the Sierra Club in Puget Sound Energy (PSE) rate case.

**Clean Power Plan Modeling in PJM and MISO – 2016-2017**
Participation on behalf of the Sustainable FERC Project in ISO initiative to model scenarios for state compliance with federal greenhouse gas mitigation rules.

**California ISO/PacifiCorp Market Integration – 2015-2017**
Technical support to Sierra Club in stakeholder review and participation in all relevant proceedings in California.

**United States Department of Justice – US District Court Dallas, TX Division (U.S. vs. Luminant Generation Company, LLC, and Big Brown Power Company, LLC) – Ongoing**
Expert witness on behalf of the United States Department of Justice on clean air act enforcement case.

**United States Department of Justice – US District Court for the Eastern District of Missouri (Civil Action No. 4:11-CV-00077) – 2013-2016**
Expert witness on behalf of the United States Department of Justice on successful prosecution of clean air act case.

**Missouri Public Service Commission (Case No. EO-2015-0084) – 2014-2015**
Expert services in support of Sierra Club's participation in integrated resource planning process.

**Missouri Public Service Commission (File No. ER-2014-0258) – 2014-2015**
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 Comission (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 Comission (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.

**Eastern Interconnect Planning Collaborative (EIPC) – 2012-2013**
Expert support on behalf of coalition of NGO stakeholders in transmission and resource planning process, including development and review of modeling assumptions and interim results, and development of comments.

**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 – 2010-2011**
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 $CO_2$.

**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 $CO_2$, 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**
Prefile 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**
Presented written and live testimony on whether Interstate Power and Light's should be permitted to sell the Duane Arnold Energy Center nuclear facility to FPLE Duane Arnold, Inc., a subsidiary of Florida Power and Light.

**PUBLICATIONS AND REPORTS**

Hausman, E., The Worst of Both Worlds: Why the Ohio Legislature's OVEC Bailout Bill would Harm Consumers, Impede Competition, Increase Pollution, and Impair the Health and Welfare of Ohioans for Decades. White paper produced on behalf of The Sierra Club, June 2017.

Hausman, E., Risks and Opportunities for PacifiCorp - State Level Findings: Utah, 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.

Hausman, E., Risks and Opportunities for PacifiCorp in a Carbon Constrained Economy, 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* Synpase 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.* Synpase 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 $CO_2$ 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 $CO_2$ 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 $CO_2$ Regulation: Efficient Mitigation or a Give-away?* Synapse Enegy Ecomics 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 $CO_2$ 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.*** Led a series of seminars on the introduction of LMP in the California electricity market, including on-line market simulation exercise. 2002.

Resume updated December 2017