

## EXHIBIT 1

**UNITED STATES OF AMERICA  
BEFORE THE  
FEDERAL ENERGY REGULATORY COMMISSION**

|                                               |   |
|-----------------------------------------------|---|
| <b>North Dakota Public Service Commission</b> | ) |
| <b>Montana Public Service Commission</b>      | ) |
| <b>Arkansas Public Service Commission</b>     | ) |
| <b>Mississippi Public Service Commission</b>  | ) |
| <b>Louisiana Public Service Commission</b>    | ) |
|                                               | ) |
| <b>Complainants,</b>                          | ) |
|                                               | ) |
| <b>v.</b>                                     | ) |
|                                               | ) |
| <b>Midcontinent Independent System</b>        | ) |
| <b>Operator, Inc.</b>                         | ) |
|                                               | ) |
| <b>Respondent</b>                             | ) |

**Docket No. EL25-\_\_-000**

**TESTIMONY OF  
WILLIAM HOGAN**

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WILLIAM HOGAN  
FILED ON BEHALF OF THE  
CONCERNED COMMISSIONS**

**I. INTRODUCTION AND QUALIFICATIONS**

**Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.**

A. My name is William Hogan. My business address is 79 John F. Kennedy Street Cambridge,  
MA 02138.

**Q. PLEASE DESCRIBE YOUR EDUCATION AND PROFESSIONAL  
BACKGROUND.**

A. I am the Raymond Plank Professor of Global Energy Policy (Emeritus), John F. Kennedy  
School of Government, Harvard University. For thirty years I was the Research Director  
for the Harvard Electricity Policy Group (HEPG) involved in the design and support for  
efficient electricity markets ranging from effective designs for real-time operations to

1 include the necessary elements to support efficient investments. My Curriculum Vitae is  
2 attached as Appendix A.

3 **Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?**

4 A. I have been asked to review the assumptions used and the cost-benefit analysis that the  
5 Midcontinent Independent System Operator Inc. (MISO) conducted, and its Board of  
6 Directors (Board) relied upon, to justify approval of a group of transmission projects (the  
7 Tranche 2.1 projects) as Multi-Value Projects (MVP) in MISO's Transmission Expansion  
8 Plan (MTEP) for 2024.

9 **Q. WHAT DID YOU CONCLUDE ABOUT MISO'S ANALYSIS?**

10 A. MISO's assumptions and cost-benefit analysis contain several significant defects. The best  
11 estimates are that correcting these defects would result in estimated costs substantially in  
12 excess of benefits and, thereby, disqualify these projects as MVPs that support both central  
13 planning and cost allocation. My testimony below describes the underlying theory and  
14 details the main assumptions, approach, and analysis in the MISO report.

15 **Q. WHY IS AN ACCURATE TRANSMISSION COST-BENEFIT ANALYSIS**  
16 **NEEDED?**

17 A. In the United States, a major objective of electricity restructuring, especially after the  
18 Energy Policy Act of 1992, was to support as much as possible the operation of wholesale  
19 markets including provisions for open access and use of the transmission system. The basic  
20 principles included defining and separating the elements of the system that were natural  
21 monopolies, such as coordination of unit commitment and real-time dispatch, from  
22 investments and operating choices, such as for individual generations and load, that could  
23 respond to efficient market prices.

1           Efficient market pricing would support welfare maximization through bid-based  
2 security-constrained economic dispatch with locational marginal prices.<sup>1</sup> Expectations of  
3 market pricing and returns would support new investment in generation and load. In some  
4 cases, the same efficient market prices could also support incremental investment in small-  
5 scale transmission infrastructure through the acquisition of financial transmission rights.

6           For most individual investments, market conditions can be taken as given and the  
7 impact of benefits and costs would be internalized by the investing entity. If all the costs  
8 and benefits can be assigned to one party, for example, as in the case of a radial line  
9 connecting a generator or load to the grid, the transmission costs would be the  
10 responsibility of the party. The planner would need only check that there were no material  
11 adverse effects. There would be no need for justification of the particular costs and benefits  
12 or assignment of responsibility to otherwise uninvolved market participants.

13           Given many such small investments, there could be a material effect on the returns  
14 to other participants in markets. But this would be just a normal operation of markets, and  
15 no party has any property right in preserving existing market prices and system utilization.  
16 A prominent exception to the underlying theory appears in the case of large-scale  
17 transmission infrastructure that would materially affect many generators and loads at  
18 different locations. A central problem for markets arises because of the significant  
19 economies of transmission scale and scope. The economies of scale imply that welfare-  
20 maximizing transmission solutions are not fully defined by the marginal conditions that  
21 would apply with efficient operating prices after the investment. The economies of scope

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<sup>1</sup> Hogan, W. W. 2018. A Primer on Transmission Benefits and Cost Allocation. *Economics of Energy & Environmental Policy*, 7, <http://www.iaee.org/en/publications/eeeparticle.aspx?id=202>.

1 imply that such transmission investment would affect the resulting market costs and  
2 benefits of many or all the participants in the system and thus present an insurmountable  
3 coordination problem for efficient transmission investment.

4 The incentive problems are similar to those that would arise with a situation where  
5 market participants have material market power. The exercise of market power would  
6 affect all market participants with shifts in costs and benefits, and the results would deviate  
7 from the goal of welfare maximization.

8 The result is a continuation of a role for a central planner for most or all large-scale  
9 transmission investments, overseen by regulators protecting the public interest. In the  
10 present context the central planner is MISO. The broad framework seeks efficient  
11 transmission investment that supports welfare maximization of the whole system and a  
12 transmission cost allocation mechanism consistent both with this goal of welfare  
13 maximization and with market choices for other than large-scale transmission.

14 MISO's current consideration for the Tranche 2.1 transmission expansion is an  
15 important case illustrating the basic elements of this broader framework. The next section  
16 outlines issues that arise in applying the transmission cost-benefit analysis to align with the  
17 welfare maximization framework for cost-benefit analysis and cost allocation.

18 **Q. WHAT ARE THE MAIN ELEMENTS OF THE THEORETICAL FRAMEWORK**  
19 **OF COST-BENEFIT ANALYSIS AND BENEFICIARY PAYS APPLIED TO THE**  
20 **CASE OF LARGE-SCALE TRANSMISSION EXPANSION?**

21 A. The basic elements of welfare maximization applied to the electricity system include a  
22 number of key features that would guide investment and cost allocation.

**Q. WHAT IS THE RELEVANCE OF LOCATIONAL SUPPLY (GENERATORS) AND DEMAND (LOAD)?**

A. The transmission system connects generators and loads at different locations. Regional Transmission Organizations (RTO) like MISO use security-constrained economic dispatch, a key feature of the welfare-maximizing real-time market design to develop efficient locational prices. The generator's benefit is the profit arising from the difference between its dispatch costs and the revenue from the sale of power at its locational price. The loads benefit is the difference between the value of a load and the payment for power at its locational price. A third welfare component is that congestion and loss surplus at the difference in the locational prices that accrues to the grid to support the associated financial transmission rights or is credited directly or indirectly to loads.

Absent complete vertical integration in a single entity, the distribution of net costs and benefits could vary substantially for the various market participants. The effects on generators will be different than on loads, and the benefits will vary by type and location in the system.

**Q. WHAT ARE THE PRINCIPLES OF WELFARE MAXIMIZATION OF CONSUMER PLUS PRODUCER SURPLUS?**

A. With no transmission constraints and perfect information, welfare maximization in the short run is equivalent to maximizing the summation of the benefits to generators (producer surplus) and the benefits to load (consumer surplus). In the presence of transmission constraints, welfare maximization adds the value of transmission congestion and loss surplus.

1           The policy objective of efficient markets and welfare maximization is a focus on  
2           the total benefits but is silent on the distribution of the benefits. Market participants such  
3           as the loads, generators, and transmission right owners will face different costs and  
4           benefits.

5   **Q.   WHAT COSTS SHOULD BE INCLUDED IN THE FORWARD INVESTMENT**  
6   **MODEL?**

7   A.   In real-time, investment costs are sunk and would not affect market bids, dispatch or prices.  
8           Day-ahead or similar near-term unit commitment decisions would be relevant because they  
9           are lumpy decisions, but these are not the same thing as investment costs. Looking forward,  
10          sunk investment costs are excluded from the welfare analysis.

11           Importantly, all investments that are not sunk are avoidable and should be included  
12          in the forward-looking evaluation of costs and benefits of building and operating the  
13          system. This reality creates a strong interplay between different kinds of investments,  
14          future operating conditions, and costs in the system. A key purpose of transmission  
15          investment is to facilitate load and generation investment. The interaction is of central  
16          importance. Hence, changing one will change the costs and benefits of the other.

17   **Q.   HOW DOES COST-BENEFIT ANALYSIS DEPEND ON COMPARING A BASE**  
18   **CASE AND AN EXPANSION CASE?**

19   A.   The basic structure of a transmission cost-benefit analysis compares a Base Case without  
20          the subject transmission investment and an Expansion Case that includes the subject  
21          transmission plan. The transmission investment will materially affect the location and  
22          scale of generation and load investment. The benefits of the transmission appear by  
23          comparing the future investment and operating costs for all load and generation in the two

1 cases. There will also be an associated differential in the benefits for various loads,  
2 generators, and transmission right holders. These benefits would constrain the resulting  
3 transmission investment cost allocation under the beneficiary-pays principle.

4 The regulator would need to enforce the requirement that the total benefits exceed  
5 the costs, preventing lumpy transmission investment that is beneficial for some but not for  
6 the whole system as would be required by the welfare maximization principle. The  
7 summation of the present value of the change in benefits between the Base and Expansion  
8 Case for market participants would define the total benefit that should adhere to the Golden  
9 Rule of exceeding the costs of the transmission investment.

10 **Q. HOW WOULD A COST-BENEFITS ANALYSIS INCORPORATE MULTIPLE**  
11 **BENEFITS?**

12 A. The initial discussion around the Federal Energy Regulatory Commission (FERC) Order  
13 1000 identified multiple types of benefits under the headings of Economics, Reliability,  
14 and Public Policy. The existence of multiple sources of benefits is not the same thing as  
15 separating transmission line investments into different types. All transmission lines will  
16 affect all types of benefits. The welfare-maximizing analytical framework does not  
17 distinguish benefits among types of lines other than the difference between sunk and future  
18 investments.

19 **Q. HOW SHOULD A TRANSMISSION EXPANSION COST-BENEFIT ANALYSIS**  
20 **ADDRESS THE VALUE OF EXTERNALITIES?**

21 A. Externalities are the costs or benefits of an economic activity that affect third parties who  
22 are not directly involved in the transaction. Air pollution is a typical example. Externalities

1 are a special example of benefits and costs that lie at the center of public policy discussions.  
2 The valuation of externalities could enter the cost-benefit analysis in different ways.

3 In the case of national policies that affect the entire market, the policy can be  
4 included in both the Base and Expansion Cases. For example, a national production tax  
5 credit (PTC) for renewables would be included as a reduction in input cost for the  
6 renewable technologies. The difference in total costs between the Base and Expansion  
7 Cases would reflect the net after-PTC costs to the market participants. But the cost to the  
8 national taxpayer would not normally be included as benefit adjustment for the  
9 transmission investment.

10 Similarly for a separate carbon benefit, a national carbon price could be included  
11 as an input cost in the Base and Expansion Cases and would affect the difference in the  
12 total net benefits. But the payments for the emissions, which would go to the national  
13 taxpayer, would be costs for the transmission case.

14 The difference in environmental costs between the Base Case and the Expansion  
15 Case would be part of the benefits of transmission. But the valuation of these benefits  
16 depends on the specification of the beneficiaries and the extent to which the costs have not  
17 been internalized.

18 The essential characteristic of externalities is that they impose costs on others  
19 without being internalized in the decisions of market participants. For example, the Social  
20 Cost of Carbon (SCC) often recognizes that the environmental costs of carbon emissions  
21 are borne by all the citizens of the world. For any single country, or especially a small  
22 region like MISO, the implied cost of its own emissions would be dramatically lower. In  
23 the case of North Dakota, the state policy is that the appropriate price is zero. Therefore,

1 the selection of the appropriate price of carbon depends in part on a policy decision on the  
2 delineation of the beneficiaries.

3 Hence, the central planner needs to identify the appropriate set of beneficiaries,  
4 such as all the world or only the participants in the MISO market. Then for these market  
5 participants the appropriate cost of carbon would be identified. The difference between  
6 this deemed social cost of carbon and the already internalized cost of carbon would  
7 determine the environmental costs unaccounted for in the market model. This change in  
8 emissions between the Base Case and Expansion case would be valued at this difference in  
9 price as the additional environmental benefit that is not included in the market models and  
10 would be part of the relevant transmission cost benefit analysis.

11 **Q. HOW WOULD THE THEORY OF COST-BENEFITS ANALYSIS ADDRESS THE**  
12 **PRESENCE OF UNCERTAINTY?**

13 A. Forward-looking evaluation of electricity system investments faces substantial uncertainty  
14 about the long-term future. Present value calculations with risk-adjusted discount rates  
15 applied to expected outcomes account for some of this uncertainty. However, relying on  
16 the discount rate as the only proxy for uncertainty is not a sound approach for broad  
17 evaluations of national or international policies. There may be more concern about the  
18 implications of different futures for large-scale transmission projects.

19 A preferred approach would be to characterize the uncertainty with probability  
20 distributions over future relevant scenarios. Ideally, the scenario tree would accommodate  
21 sequential resolution of uncertainty where only a subset of investment decisions would be  
22 fixed in early years, and future decisions would change according to the updated events.

1 The full characterization of the scenarios and the associated probabilities embedded in the  
2 optimization model provides a conceptual appeal but would be only approximated with  
3 current computational tools and knowledge.

4 **Q WHAT ARE THE STEPS IN THE APPLICATION OF COST-BENEFIT**  
5 **ESTIMATION?**

6 A. For a single scenario of input parameters, a forward-looking model could calculate the  
7 costs and benefits of generation and load investments and determine the associated prices  
8 and revenues for the market participants. For the Base Case, the transmission system  
9 would be fixed at the transmission infrastructure for in-place and already approved projects  
10 where the investment costs are sunk. For the Expansion Case the transmission system  
11 would be fixed at the anticipated expansion as though it had been approved and the  
12 transmission investment costs treated as sunk.

13 The present value of the costs and benefits would be calculated for market  
14 generation, loads and transmission rights holders by location, first for the Base Case and  
15 then for the Expansion Case. The differences in benefits for the generators, loads and  
16 transmission rights holders would define the individual net benefits or costs for the market  
17 participants. The sum of the individual values would define the total net benefits of the  
18 transmission expansion.

19 If the total net benefits (the difference between the Base Case and the Expansion  
20 Case total benefits) are less than the incremental transmission costs, then the investment  
21 would not meet the Golden Rule of benefits exceeding costs. If the net benefits are greater  
22 than the incremental transmission costs, then the transmission investment improves social  
23 welfare.

1           The beneficiaries-pay principle would not assign any of the incremental  
2           transmission investment costs to those for whom the benefits are negative. The incremental  
3           transmission investment costs would be assigned to those loads and generators that would  
4           benefit in the Expansion Case compared to the Base Case. The benefit-cost test of the  
5           Golden Rule ensures that these total benefits will be greater than the costs and allow for a  
6           possibly substantial degree of flexibility for a “roughly commensurate” cost allocation.

7   **Q   WHAT IS THE IMPORTANCE OF USING EX ANTE DECISIONS AND**  
8   **ATTRIBUTIONS?**

9   A.   The cost-benefit allocation for market-based generation and load compares the forward-  
10       looking estimate of investment, dispatch, and prices. For individual load and generation  
11       that are market based, these individual investment costs will be sunk once made and there  
12       is no reassignment of those costs based on realized outcomes. To be compatible with this  
13       market setting, the investment costs in large transmission projects would also become sunk.  
14       The analogous allocation of these transmission sunk costs according to the beneficiary-  
15       pays principle would not change based on realized market outcomes. The value of  
16       incremental financial transmission rights would change based on realized market outcome,  
17       but once the costs are sunk, there would be no reallocation of the transmission investment  
18       costs based on the realized market outcomes. This has implications for rate design with  
19       multipart fixed and variable pricing.

20   **Q.   HOW WOULD COST-BENEFIT ANALYSIS AND BENEFICIARY-PAYS**  
21   **ANALYSIS WORK IN PRACTICE?**

22   A.   The conceptual framework that follows from cost-benefit principles and welfare  
23       maximization is too difficult to implement as a single computationally tractable tool. In

1 practice, MISO as the planner must resort to judicious application of important but more  
2 limited models that approximate the key features of the choices at hand.

3 An essential element of the theoretical framework is to maintain mutual consistency  
4 between the investment profiles in load, generation and transmission. Given a fixed  
5 transmission network, there will be one pattern of efficient investment, dispatch and prices  
6 for load and generation. Given another transmission network, there would be a different  
7 pattern. The essence of determining the benefit of a large-scale transmission investment is  
8 in the comparison of the pattern of efficient investment, dispatch and prices for load and  
9 generation for the Base Case and the Expansion Case.

10 This requires close attention to what is included and consideration for what is  
11 excluded from any individual model. For example, in the MISO case the Electric  
12 Generation Expansion Analysis System (EGEAS) model is used as the starting generation  
13 capacity expansion model to meet assumed load growth. However, the EGEAS model  
14 does not include a representation of the transmission system. Hence, the assumed  
15 generation investment profile would be inconsistent with Base Case and the Expansion  
16 Case formulations outlined in theory. This stands at the core of the application of the cost-  
17 benefit analysis and there must be some adjustment to make the generation investment  
18 profile consistent with the relevant transmission cases.

19 The PROMOD model is used to estimate the anticipated production costs of the  
20 dispatch over the horizon of the analysis. This model provides estimates of dispatch and  
21 pricing that would contribute to the cost-benefit analysis. But the model takes the  
22 generation investment, load and transmission configuration as fixed. Hence, to the extent  
23 that the load and generation investment profiles do not reflect the impact of the

1 transmission configuration, so too the PROMOD model will not capture the intended  
2 change in dispatch and pricing needed to calculate total costs and benefits and the  
3 distribution across market participants. Similar comments apply to the Power System  
4 Simulator for Engineering (PSSE) model applied to the analysis of reliability power flows.  
5 To be consistent with the cost-benefit framework, these models need a complementary  
6 analysis to make the load and generation investment costs and locations consistent with the  
7 assumed transmission system, first in the Base Case and then in the Expansion Case. **These**  
8 **alternative projections for load and generation must treat the future investment costs**  
9 **as avoidable.** Further, these would be based on the analysis by the planner, and not simply  
10 by the elicitation of plans from the market participants. Given the context of large changes  
11 in the transmission system, where otherwise uneconomic claims about the future could  
12 influence the outcome of the cost-benefit analysis and the associated transmission cost  
13 allocation, MISO as the central planner must provide an analysis that does not depend on  
14 the conflicted interests of the market participants. Otherwise, there would be no need for  
15 central planning, and we could revert to the market solution. But the market solution is  
16 unavailable due to the economies of scale and scope for large transmission projects.

17 If there is a treatment of uncertainty, with multiple scenarios about economic  
18 conditions across the footprint, there would need to be a similar adjustment in the Base  
19 Case and Expansion Case proxies for generation and load.

20 These would be minimum requirements for an analysis that involves large-scale  
21 changes in the transmission configuration. By contrast, smaller scale transmission  
22 investment where the party or parties paid the cost would internalize the generation and  
23 load investment and costs. Subject only to a minimal test that the transmission investment

1 did not reduce the capacity of the grid, such as with adding parallel weak lines, the planner  
2 need not consider the economic tradeoffs. But for large-scale transmission investments,  
3 with shifting costs and benefits among many market participants, it is incumbent on the  
4 planner to develop consistent profiles for efficient load and generation investments in the  
5 Base and Expansion Cases.

6 **Q. WHAT ARE YOUR MAJOR ISSUES IN THE MISO ANALYSIS?**

7 A. The MISO analysis does not adhere to the cost-benefit framework as outlined above, and  
8 the result has a significant effect on the overall cost-benefit analysis. The main effects  
9 appear in calculating generation capacity costs, determining the reliability impacts, and in  
10 evaluating the effects of externalities, all of which lead MISO to overstate the benefits of  
11 Tranche 2.1.

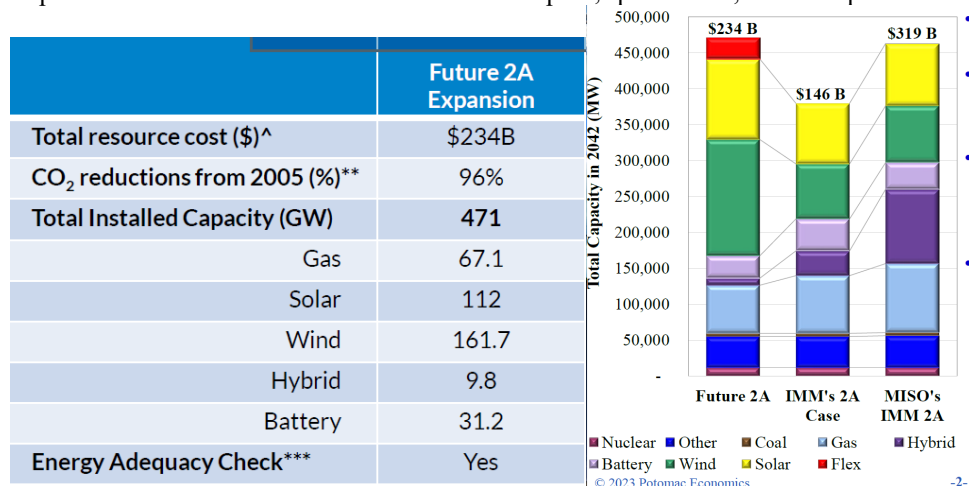
12 **Q. WHAT ARE THE ISSUES WITH THE MISO'S CALCULATION OF THE**  
13 **AVOIDED CAPACITY-RELATED BENEFITS THAT CAUSE THE BENEFITS TO**  
14 **BE OVERSTATED?**

15 A. The MISO avoided capacity cost benefit calculation for the Tranche 2.1 transmission is  
16 distorted in several respects. The most fundamental mistake in the MISO benefit analysis  
17 is that the benefit analysis starts with a set of additional resources, Future 2A generation,  
18 that is not yet built, or even planned and approved by state regulators, in most cases, and  
19 assumes that those costs are sunk when calculating the benefits of the Tranche 2.1  
20 transmission. The cost of the Future 2A generation that MISO assumes will be built is

substantial, around \$234 billion.<sup>2</sup> In the absence of the transmission expansion, much of this generation would likely not be built, so the generation profile is inconsistent with the definition of the Base Case.

MISO then develops a transmission plan to deliver the output of the Future 2A generation to load and calculates the cost of the transmission that MISO believes is needed to enable the Future 2A generation to be used to meet load. This is the Tranche 2.1 projects with a cost of \$21,868 million in \$2024USD capital costs (\$28,525 million in \$2024USD total cost used in cost benefit analysis including O&M expense and carrying costs, based on a 7.10% discount rate).<sup>3</sup> In effect, the MISO approach treats a large fraction of the future generation investment as being the same in the Base Case as in the Expansion Case, which is incorrect.

<sup>2</sup> LRTP Workshop, MISO LRTP Futures Review, September 24, 2024, slide 31; LRTP Workshop, IMM Presentation, Reconciling the IMM's Future 2A Scenario, December 1, 2023, slide 2. \$234B for Future 2A Expansion Net Present Value inclusive of capital, production, fixed Operations and Maintenance.



<sup>3</sup> MTEP24 Report, Table 2.35, p. 162.

Total Portfolio Cost: \$21,868M in \$2024USD, see also p. 80: “Tranche 2.1 portfolio includes 24 projects across the MISO Midwest subregion, estimated at \$21.8 billion. The projects are targeted to go in service from 2032 to 2034.”

1           The avoided capacity cost benefit calculation is assigned 90% of the cost of the  
2           22.8 GW of additional generation sited closer to load that MISO concludes would be  
3           needed to meet load if the Tranche 2.1 transmission were not built.<sup>4</sup> However, in this  
4           benefit calculation, MISO treats the cost of the unbuilt Future 2A generation as sunk and  
5           does not take into account the cost of the amount of generation included in the Future 2A  
6           resource mix that would not be needed if 22.8 GW of generation were built closer to load.  
7           Furthermore, the underlying Future 2A Scenario used to identify MISO's transmission  
8           needs and quantify the transmission benefits is distorted for a number of reasons.

9   **Q.    WOULD YOU EXPLAIN THESE DISTORTIONS?**

10   **A.**   First, MISO uses a capacity expansion model, EGEAS, that selects mostly intermittent  
11           renewable resources<sup>5</sup> to meet all future system needs because: (1) the reliability value  
12           (accreditation) of renewables is overstated, (2) the market value of dispatchable resources  
13           is ignored, and (3) the cost of the transmission needed to deliver the output of the Future  
14           2A generation to load is not considered in developing the Future 2A Resource mix and  
15           location. In fact, the Futures 2A resource mix and locations are determined before MISO  
16           analyzes transmission needs. MISO states in the MTEP24 Report "MISO forecasts and  
17           sites generation resources, as well as load and energy growth. MISO then analyzes the

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<sup>4</sup>       LRTP Tranche 2.1, Benefits Analysis Results Review, September 25, 2024, p. 11.

      "LRTP Tranche 2.1 avoids the need for 22.8 GW of capacity in addition to F2A resources and provides a 20-year present value benefit of \$16.3B." The other 10% of the cost is assigned to the "Capacity Savings from Reduced Losses" metric.

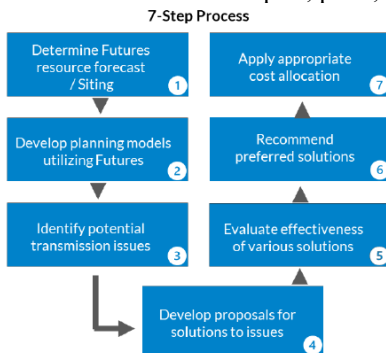
<sup>5</sup>       See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.1, and LRTP Workshop, MISO LRTP Futures Review, September 24, 2024, p. 15. See 20230428 LRTP Workshop Item 03b MISO F2A Installed Capacity Additions and Retirements628703 excel file for model-built resource detail. The excel file allows FTI to calculate 85.2+27.6 GW wind and solar, respectively, constitutes 67% of the 169.4 GW of model-built capacity.

ability of the transmission system to perform reliably and safely in delivering resources economically to load, recognizing member and state goals across the entire footprint.”<sup>6</sup>

Figure 1 from the LRTP Tranche 2 Business Case Metrics Methodology Whitepaper, September 23, 2024, section 4.1, shows the starting point for the avoided capacity cost benefit calculation on the far left “LOLE model based on Futures 1A and 2A generation expansions.” Figure 1 also shows that benefits are calculated in steps on the left side of the figure before the flex capacity is added to the model.

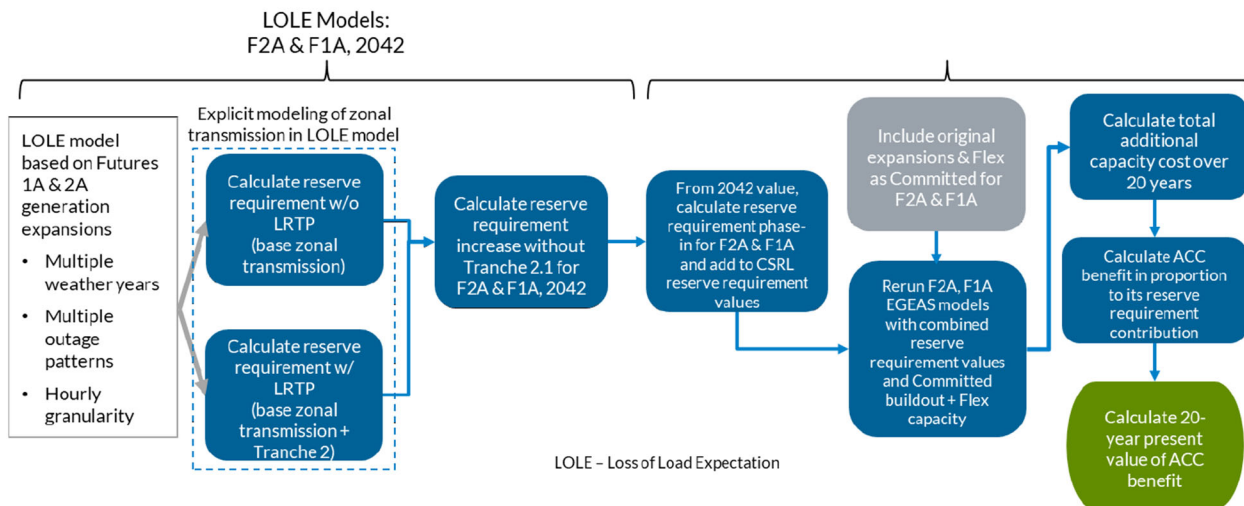
Figure 1 does not show any step that eliminates any Future 2A generation that is not needed after adding 22.8 GW of generation closer to load. Moreover, because the avoided capacity cost benefits are calculated before the flex capacity is added to the model, there is no assessment of how much of either the Future 2A generation or 22.8 GW of additional generation would be needed if the flex capacity were available.<sup>7</sup>

<sup>6</sup> See MTEP24 Report, p. 25, see also Figure 2.2.



<sup>7</sup> See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024 section 4.1, (there are no page numbers but it would be p. 7). “PLEXOS models are based on Future 2A scenario resources and include Future 1A scenario for evaluating benefit robustness” Figure 2 in section 4.1 similarly does not show any step eliminating Future 2A generation that would not be built absent the Tranche 2.1 transmission because it is not needed to meet the resource adequacy requirement with the additional 22.8 GW of generation added to the resource mix. Finally, the EGEAS expansion analysis notes in step 5, section 4.1 “With the *built-in F2A resources*, the revised reserve requirement yields an additional expansion.” Italics added. Figure 1 also appears in MTEP24 Report, p. 149.

Hogan Figure 1



Source: Figure 1- Process for calculation of Avoided Capacity Cost benefits<sup>8</sup>

Hence, the Future 2A generation profile used to calculate the avoided capacity cost benefits is not consistent with either the Base Case or the Expansion Case of a properly structured benefits assessment. And, it does not appear that the EGEAS model considers the ability of the Future 2A resource mix to meet ancillary service requirements, or balancing needs, in determining the Future 2A resource mix.

Given the volatile output profiles of intermittent renewables, a system saturated with them will have greater transmission needs than a system with a mix of dispatchable resources that can be used to manage network flows and balance variations in net load.

Second, in calculating the cost of the 22.8 GW of generation that MISO concludes must be sited closer to load absent Tranche 2.1 transmission, MISO does not consider how much of this generating capacity could be provided by the gas fired generation MISO removed from the resource mix based on accelerated retirement timelines in Future 2A

<sup>8</sup> L RTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.1, at 7.

1 relative to Future 1.<sup>9</sup> To the extent that the capacity needs identified by MISO could be  
2 met simply by delaying the retirement of existing generation, the added cost would simply  
3 be the going forward costs of the existing generation.

4 Third, after including this Future 2A generation portfolio that was developed to  
5 meet load and resource adequacy requirements, and which was the basis for the Tranche  
6 2.1 transmission in the model, MISO determined with PROMOD modeling that the Future  
7 2A generation portfolio was not capable of meeting load in many hours,<sup>10</sup> presumably at  
8 least in part because the EGEAS model used inflated capacity values for the intermittent

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<sup>9</sup> See Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, November 1, 2023, p. 21 and Table 2. It is noteworthy that the retirement date for combined cycles was accelerated 5 years between Future 1A and Future 2A while the retirement date for other gas fired generation such as gas turbines was accelerated by a decade relative to Future 1A.

<sup>10</sup> MTEP24 Report, Table 2.35, p. 31; LRTP Workshop, Future 2A Energy Adequacy & Siting, April 28, 2023. The inability of this resource mix that was developed by MISO using the EGEAS model to meet resource adequacy requirements to meet load was at least in part due to the fact that MISO did not adjust resource type accreditation factors in the EGEAS model as the amount of the resource type in the overall resource mix increased. See LRTP Tranche 2 Futures Refresh, Assumptions Book, April 27, 2023, p. 4. [; MTEP24 Report, p. 29.

“PROMOD, a production cost modeling tool providing hourly (annual) chronological security-constrained unit commitment and economic dispatch, identified **generation shortfalls for three to four hours per day** during twilight hours (before sunrise or at sunset) in up to 26 days of the modeled year, with a maximum shortfall of 29 GW in a single hour. To address this energy shortfall, 29 GW of supplemental low- or no-emitting, high availability resource additions, referred to as Flex for Flexible Attribute Units, were needed to ensure energy adequacy during these time periods. This is reflected in the shaded areas of both graphs in Figure 2.6: Energy Adequacy Analysis for Flexible Attribute Units.”

LRTP Workshop, Future 2A Energy Adequacy & Siting, p. 5: “MISO utilized PROMOD for a chronological energy adequacy validation because EGEAS uses a load duration curve without sequential hours.”

MISO focuses on the chronological feature of PROMOD, which is relevant for unit commitment, but the key feature for energy adequacy is likely its probabilistic modeling of intermittent output rather than the EGEAS modeling solely based on overstated capacity values

resources while ignoring the interaction with transmission requirements.<sup>11</sup> In developing the Future 2A resource mix with the EGEAS model, MISO used a fixed capacity accreditation value for wind over the entire horizon and used slowly declining capacity factors for solar. These values are those used in the 2022 Planning Resource Auction and are the same values used in the 2022 Regional Resource Assessment, which reflect the 2022 resource mix and accreditation design.<sup>12</sup> In none of these studies did MISO attempt to calculate the capacity accreditation value of wind and solar generation for the assumed Future 2A penetration levels.

|          | PV/DGPV | Wind   | Hybrid | Battery |
|----------|---------|--------|--------|---------|
| 2023     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2024     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2025     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2026     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2027     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2028     | 47.00%  | 16.60% | 57.00% | 97.50%  |
| 2029     | 44.00%  | 16.60% | 54.00% | 95.00%  |
| 2030     | 41.00%  | 16.60% | 51.00% | 92.50%  |
| 2031     | 38.00%  | 16.60% | 48.00% | 90.00%  |
| 2032     | 35.00%  | 16.60% | 45.00% | 87.50%  |
| 2033     | 32.00%  | 16.60% | 42.00% | 85.00%  |
| 2034     | 29.00%  | 16.60% | 39.00% | 82.50%  |
| 2035     | 26.00%  | 16.60% | 36.00% | 80.00%  |
| 2036     | 23.00%  | 16.60% | 33.00% | 77.50%  |
| 2037     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2038     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2039     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2040     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2041     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2042     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| Average: | 34.30%  | 16.60% | 44.30% | 86.90%  |

MTEP24 Report p. 29: Accreditation: Capacity accreditation was based on the approved 2022 Planning Resource Auction and shifts over time based on the Renewable Integration Impact Assessment (RIIA).

See MISO Futures Refresh Assumptions Book, March 3, 2023 section 3c and MISO 2022 Regional Resource Assessment Technical Appendix, p. 4, Table 1.

“The reserve capacity of solar photovoltaic (PV), hybrid, and battery declined over the study horizon. Figure 3 shows the assumed values for each year. **Wind is held constant at 16.6%.**”

**Q. HOW DID MISO ADDRESS THE RELIABILITY GAP IDENTIFIED BY ITS PROMOD MODELING IN ESTIMATING BENEFITS?**

A. To address the reliability gap identified by the PROMOD runs, MISO added 29.8 GW of unspecified “Flex” capacity resources after the Future scenario was populated by EGEAS. The “Flex” capacity is a new type of dispatchable capacity assumed to have low or zero emissions and the costs of a Combustion Turbine (CT).<sup>13</sup> This type of capacity does not exist at present. It is obviously not known if it will exist by 2040, nor is it known what it might cost, so MISO assumed the cost of a gas combustion turbine which might be a lower bound.

**Q. WHAT ARE THE IMPLICATIONS FOR MISO’S BENEFITS ASSESSMENT OF ADDING 29.8 GW OF FLEXIBLE CAPACITY AFTER DEVELOPING THE FUTURE 2A GENERATION PORTFOLIO AND THE TRANCHE 2.1 TRANSMISSION PORTFOLIO?**

A. The addition of 29.8 GW of flex generation renders the Base Case invalid. One can see in Hogan Figure 1 above that the 29.8 GW of flex capacity was added to Future 2A **after** MISO had used the EGEAS model to determine the Future 2A portfolio and after MISO had estimated that 22.8 GW of generation sited closer to load would be needed to meet

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<sup>13</sup> The 29.8 GW of flex capacity was treated as gas-powered Reciprocal Internal Combustion Engine (RICE) units. See LRTP Workshop, MISO LRTP Futures Review, September 24, 2024, slides 13 and 15. However, the MTEP24 Report describes the “Flex” units as “potential generation that is highly available, highly accredited, low- or non-carbon-emitting and long in duration. Flex resources could be, but are not limited to the following: Reciprocal Internal Combustion Engine (RICE) units, long-duration battery (>4 hours), traditional peaking resources, combined cycle with carbon capture and sequestration, nuclear Small Modular Reactors (SMRs), green hydrogen, enhanced geothermal systems, and other emerging technologies.” See MTEP24 Report, p. 31 and LRTP Workshop, Future 2A Energy Adequacy & Siting, April 28, 2023, p. 5.

LRTP Workshop, Future 2A Energy Adequacy & Siting: “Economic modeling will utilize CT costs and technical parameters, with refinements as needed to maintain consistency of economic dispatch in PROMOD.”

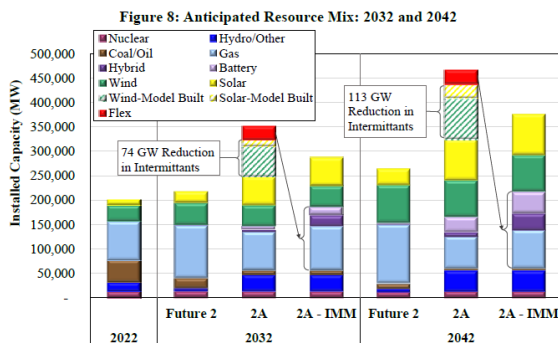
Planning Resource Auction (PRA) resource adequacy requirements. Since the flex resources would naturally satisfy many, if not all, of MISO's reliability needs, the quantity of intermittent renewables that would have been predicted by EGEAS should have fallen sharply. For example, Potomac Economics, the Independent Market Monitor (IMM), produced a Futures case that estimated this effect, which reduced the assumed entry of intermittent renewable resources by 113 GW and lowered the costs of the case by \$88 billion.<sup>14</sup>

<sup>14</sup> 2023 State of the Market Report for the MISO Electricity Markets, p. 14-16, additionally states:

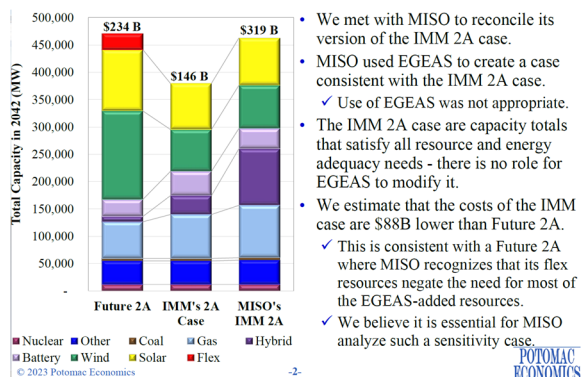
"The much more realistic IMM-modified 2A case:

- Lowers costs by \$88 billion compared to MISO's Future 2A;
- Satisfies the States' carbon goals and MISO's energy adequacy needs; and
- Is much more consistent with MISO's market incentives that are based on the attributes needed by the system."

Additionally, the graphic on p. 14 of the 2023 State of the Market Report for the MISO Electricity Markets states "Intermittents 113 GW Reduction in Intermittents" over the IMM Future 2A for 2042 cumulative additions.



LRTP Workshop, IMM Presentation, Reconciling the IMM's Future 2A Scenario, December 1, 2023, slide 2: Shows the \$88 billion cost difference.



1           Two aspects of this process highlight the fact that the MISO benefit analysis raises  
2           questions about the basic formulation of the evaluation of the need for the Tranche 2.1  
3           transmission. The first is that in developing the Future 2A generation plan MISO did not  
4           take account of the transmission costs needed to deliver that Future 2A generation to load,  
5           nor the ability of that resource mix combined with the new transmission to meet load.

6           Second, after determining that the Future 2A generation was not able to meet load  
7           and that an additional 29.8 GW of flex capacity was needed to reliably meet load, MISO  
8           did not rerun something like the EGEAS model but with attention to transmission  
9           constraints to determine how much of the Future 2A generation would not be needed to  
10          meet Resource Adequacy requirements or to meet load with the flex capacity in operation.  
11          Nor did MISO revisit how much of the Tranche 2.1 transmission would be needed to meet  
12          load with the 29.8 GW of flex capacity included in the capacity mix and consequently  
13          MISO did not assess the reduced amounts of Future 2A generation needed to meet resource  
14          adequacy requirements.<sup>15</sup>

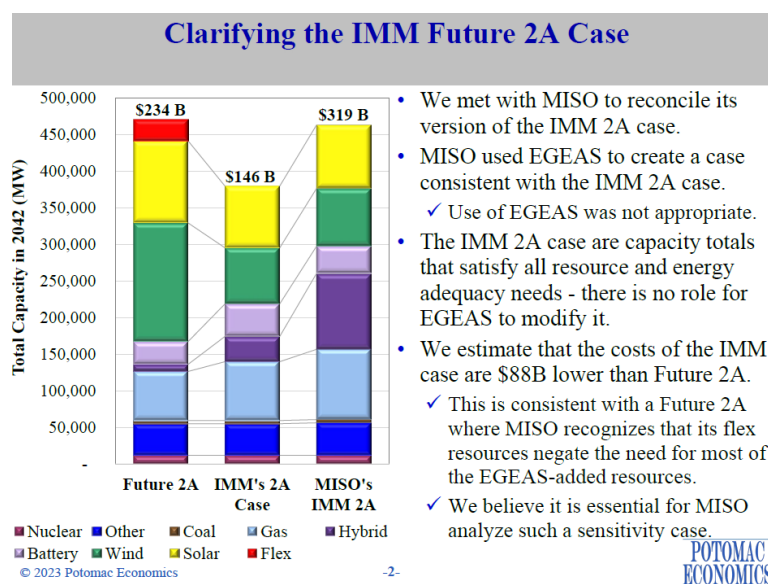
15          The IMM specifically pointed out the need to undertake this analysis in a  
16          December 1, 2023, presentation, contrasting the \$88 billion dollar excess cost of Future 2A  
17          generation relative to a “Future 2A where MISO recognizes that its flex resources negate  
18          the need for most of the EGEAS added resources.”<sup>16</sup>

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<sup>15</sup> See discussion of Figure 1 in the MISO LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.1.

<sup>16</sup> LRTP Workshop, IMM Presentation, Reconciling the IMM’s Future 2A Scenario, December 1, 2023, slide 2.

MISO asserted in the Futures 1A report that “Flexible attribute units do not displace the need for previously identified resources and, instead, supplement them in periods of energy inadequacy.”<sup>17</sup> However, this is apparently simply a statement of what MISO assumed, rather than an explanation of why MISO did not reduce the Future 2A generation after adding 29.8 GW of additional flex capacity with a high accreditation value. MISO provides no basis for that decision. If the flex generation had an accreditation value of only 80%, 29.8 GW of flex generation would eliminate the need for the 85.2 GW of wind and 27.6 GW of solar generation in the Futures 2A resource mix based on the resource accreditation values used in the EGEAS study.<sup>18</sup> MISO asserts that the flex resources would have a capacity value of 97% or more which would obviate the need for even more of the Future 2A generation in meeting load.<sup>19</sup>



Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, p. 20.  
 $29.8 * 80\% = 23.84 \text{ GW}$   $85.2 \text{ GW wind} * 0.16 = 13.632 \text{ GW capacity} + 27.6 \text{ GW solar} * 0.2 = 5.52 \text{ GW capacity}$  for a total of slightly less than 19.2 GW accredited capacity.  
 Planning documents show that Flex Units would equal 29 (rounded) accredited GW capacity in 2042, while installed capacity additions of Flex Units will sum to 29.8 GW by 2042. This results in an accreditation factor of at least  $29/29.8 \text{ GW} = 97\%$ . See Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, Table 14, p. 108, and LRTP Workshop, Future 2A Energy Adequacy & Siting. April 28, 2023, p. 8.

Hence, the MISO assessment of the need for the Future 2A generation and the Tranche 2.1 transmission missed material elements of the foundational Base Case. The Future 2A generation and the Tranche 2.1 transmission do not appear to have been an output of MISO's benefit analysis; they were a predetermined input.

**Q. WHAT ARE THE CONSEQUENCES OF THIS ELEMENT OF MISO'S APPROACH TO CALCULATING TRANCHE 2.1 TRANSMISSION BENEFITS?**

A. The consequence of this approach is that in calculating the benefits of the Tranche 2.1 transmission, MISO treats the cost of building the Future 2A capacity as sunk, but this generation has not been built and much is not even planned, much less approved by regulators. **These costs are not sunk.** This material analytical oversight makes the overall cost-benefit analysis inconsistent with the basic elements of the welfare-maximization requirements.

To calculate two large benefit categories, Avoided Capacity Costs and Capacity Savings from Reduced Losses, MISO then compares the cost of the Tranche 2.1 transmission that would be needed to enable the Future 2A generation to be dispatched to meet load, to the cost of the generation that would be needed if the Tranche 2.1 transmission were not built (\$30,009 million nominal capital costs for 22.8 GW of additional generation),<sup>20</sup> while Future 2A generation was assumed to be built and sited in the same

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<sup>20</sup> See MTEP24 Report, p. 148.

"The addition of Tranche 2.1 projects alleviates the constraint violations and avoids the need for more capacity above what is included in the Future 2A scenario."  
Both Avoided Capacity Costs and Capacity Savings from Reduced Losses calculations result in an increase in reserve requirement value (%) (8.76% for additional capacity needed to meet 0.1 day/year LOLE for Avoided Capacity Costs, and for the change in system losses expressed as a percentage of system load i.e. 1% PRM for Capacity Savings from Reduced Losses). The combined 9.75% PRM value is translated into 22.8 GW of additional generation, which for Avoided Capacity Costs represents necessary generation to meet

1 locations assumed in the initial analysis, despite the additional 22.8 GW of generation the  
2 MISO benefits assessment assumes would be built to meet load if the Tranche 2.1  
3 transmission were not built.<sup>21</sup>

4 This change in the generation siting patterns without the Tranche 2.1 transmission,  
5 and the reduced need for the Future 2A generation to be sited in locations from which it  
6 cannot be delivered with 22.8 GW of generation sited close to load, should not be ignored  
7 in a benefit analysis (as MISO does).

8 Accounting for the change in siting and the materially reduced amount of Future  
9 2A generation that is needed would reduce several classes of benefits MISO estimates from  
10 the Tranche 2.1 transmission. First, siting generation closer to load would reduce both  
11 classes of transmission loss benefits. Second, and most importantly, siting generation  
12 where it is needed and deliverable with the current bulk power system will reduce or  
13 eliminate the “avoided capacity cost” benefits. MISO finds that 22.8 GW of new capacity

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resource adequacy standards, while for Capacity Savings from Reduced Losses represents the benefit of reduced system losses using generation investment as a proxy for valuing additional GWs. The nominal capital cost for this 22.8 GW is \$30,009 million, which subject to carrying costs (varying from 6.5-15.8% by year and technology over the 2035-2051 period) and a 7.10% discount rate result in \$22,088 million net present value in \$2032USD. This \$22,088 value is allocated between the two benefit metrics based on the PRM value that drove the initial analysis: 90% (8.76% / 9.76%) is allocated to Avoided Capacity Costs, resulting in \$19,825 million in \$2032USD or \$16,271 million in \$2024USD for the 7.10% discount rate, 20-year net present value case. See LRTP Tranche2.1 Detailed Business Case Analysis F2A final portfolio excel spreadsheet and LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, pp. 5-16.

Avoided Capital Costs: “The LOLE analysis is performed using the seasonal CIL/CEL values without LRTP portfolio to compute the LOLE for the modeled resources, and an incremental amount of perfect capacity (or load) is then added until the 0.1 d/y annual LOLE is reached. The same analysis is repeated using the seasonal CIL/CEL values with LRTP portfolio to determine the incremental amount of capacity needed to reach the 0.1 d/y annual LOLE and the difference is calculated as the capacity savings. It is the difference that reflects the impact of LRTP transmission – the absolute amount of capacity addition needed to meet the 0.1 d/y annual LOLE target is not relevant to the benefit calculation.” *See also* LRTP Tranche 2.1 Detailed Business Case Analysis F2A final portfolio excel spreadsheet, “D\_ACC\_CSRL\_Det” tab.

<sup>21</sup> See discussion above of Hogan Figure 1 and Figure 1 in the MISO LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.1.

sited close to load is needed to reliably meet load, primarily because a large share of the Future 2A generation is not deliverable without Tranche 2.1 transmission.

MISO does not compare the cost of (i) the Future 2A generation assumed to be built based on the EGEAS model that would not be needed if the 22.8 GW of additional generation MISO modeled were built closer to load (perhaps in the range of \$88 billion),<sup>22</sup> to (ii) the \$21.40<sup>23</sup> billion assumed cost of the 22.8 GW of generation that MISO calculates would be needed if the Tranche 2.1 transmission were not built. The asserted benefit from the transmission is more likely a negative number.<sup>24</sup>

**Q. HOW SHOULD MISO HAVE CALCULATED THE ASSESSMENT OF AVOIDED CAPACITY TRANSMISSION BENEFITS?**

A. A proper analysis would have revised the generation planning model, addressed the impacts of transmission constraints in the Base Case, and determined how much of the Future 2A generation would not be needed if the additional 22.8 GW of generation were built closer to load as assumed in the MISO benefit analysis. This is not a complicated insight. This highlights an obvious gap in the cost-benefit analysis.<sup>25</sup>

A more appropriate cost-benefit calculation would be to compare (i) the cost of the Future 2A generation plus the cost of the Tranche 2.1 transmission to (ii) the cost of the 22.8 GW of alternative generation additions that would be needed without the Tranche 2.1

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<sup>22</sup> 7.1% discount rate, over 20 years in 2024\$.

<sup>23</sup> 7.1% discount rate, over 40 years in 2024\$.

<sup>24</sup> \$16,271 + \$1,857 = \$18,128 million; \$19,210 + \$2,193 = \$21,403 million. See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, p. 35.

<sup>25</sup> This analysis would require first rerunning the EGEAS model with modifications to approximate transmission constraints to determine how much of the Future 2A generation would not be needed if the Flex capacity added to the resource mix by MISO was built and then calculating how much more of the Future 2A generation would not be needed if the additional 22.8 GW of generation assumed by MISO in its benefit calculation were built.

1 transmission projects, the cost of any transmission required to deliver that capacity to load,  
2 plus the cost of any Futures 2A generation needed to meet load that is substantially  
3 deliverable without the Tranche 2.1 transmission.

4 We do not have the MISO data needed to carry out this calculation, but the IMM has carried  
5 out a similar calculation.

6 **Q. ARE THERE ANY OTHER ANALYSES THAT INFORM US AS TO THE ACTUAL**  
7 **MAGNITUDE OF THE AVOIDED CAPACITY COST BENEFIT?**

8 A. The IMM developed a model of generation that would be built without Tranche 2.1  
9 transmission, which replaced some of the EGEAS' model-built resources, and reported that  
10 the generation cost savings alone relative to the Future 2A generation was \$88 billion.<sup>26</sup>  
11 This assessment implies that the Tranche 2.1 transmission is uneconomic on its face as the  
12 generation it would deliver is itself uneconomic.

13 **Q. WHAT IS YOUR UNDERSTANDING OF HOW THE IMM CARRIED OUT ITS**  
14 **ASSESSMENT?**

15 A. The IMM's 2A case replaced model-built renewables with gas, hybrid, and battery  
16 resources.<sup>27</sup> The IMM case includes lower capacity accreditation values for wind and solar  
17 generation than MISO had assumed in its assessment.<sup>28</sup> This is consistent with the IMM's  
18 observation that "MISO assumes unrealistically high capacity accreditation levels for

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<sup>26</sup> MISO IMM comments on LRTP Tranche 2 Benefit Analysis, October 30, 2024, p.4; 2023 State of the Market Report for the MISO Electricity Markets, p. 16.

<sup>27</sup> 2023 State of the Market Report for the MISO Electricity Markets, p. 15.

"Figure 8 includes an alternative to the Future 2A (i.e., the IMM 2A case) that accepts MISO's assumptions on "committed resources", which includes almost 160 GW of intermittent resources, but it assumes a more realistic mix of gas resources, hybrid resources, and battery storage will be added to meet MISO's energy and resource adequacy requirements.<sup>12</sup>

<sup>12</sup> "We do this by replacing the amount of accredited capacity MISO assumed that the new intermittent resources would provide with natural gas, hybrid, and battery resources."

<sup>28</sup> 2023 State of the Market Report for the MISO Electricity Markets Analytical Appendix, p. 16.

intermittent resources in the EGEAS model.”<sup>29</sup> In late 2023, the IMM met with MISO to rerun EGEAS with the IMM 2A case to confirm that its capacity totals satisfy all resource and energy adequacy needs. Potomac concluded that “MISO recognizes that its flex resources negate the need for most of the EGEAS-added resources.”<sup>30</sup>

**Q. HAS MISO PROVIDED ANY ASSESSMENT OF THE IMM’S ANALYSIS?**

A. Yes. In response to the IMM’s assessment MISO raises arguments about diversity benefits produced by the Tranche 2.1 transmission.<sup>31</sup> However, MISO did not offer any analysis supporting this argument. MISO offers a limited response to the IMM about peak load diversity and connecting the generation between two zones.<sup>32</sup> But that is not the purpose of Tranche 2.1 transmission. It is about connecting remote intermittent resources to load. MISO appears to have determined the Tranche 2.1 transmission based on delivering the Future 2A generation to load without any assessment of diversity benefits.

First, the relevant diversity metric is meeting net load. MISO did not analyze this or even discuss net load and supply variability in the response in the benefits analysis. MISO did not estimate the additional supply that the Tranche 2.1 transmission would provide to each MISO region during high net load conditions with the existing resource mix, as it simply added transmission to meet the local clearing requirement for each Load Resource Zone.<sup>33</sup> Similarly, MISO did not assess any diversity benefit provided by

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<sup>29</sup> 2023 State of the Market Report for the MISO Electricity Markets, p. 15.

<sup>30</sup> LRTP Workshop, IMM Presentation, Reconciling the IMM’s Future 2A Scenario, December 1, 2023, slide 2.

<sup>31</sup> MISO Response to IMM Memo, pp. 4, 11-12.

<sup>32</sup> Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, November 1, 2023, p.14.

<sup>33</sup> Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, November 1, 2023, p. 50.

“Resources were sited to ensure each Local Resource Zone (LRZ) met its Local Clearing Requirement (LCR) on an estimated accredited capacity basis in each milestone year. The Planning Reserve Margin Requirement

1 locating 22.8 GW of generation closer to load and not building the Tranche 2.1 transmission  
2 to the diversity benefit from building the Future 2A generation remote from load and then  
3 building the Tranche 2.1 generation. If the Future 2A generation is built at the same  
4 location as existing intermittent resources, there may be little or no reduction in net load  
5 diversity. The diversity benefit depends on the correlation of the intermittent resource  
6 output at the two locations at times of high net load, which MISO does not appear to have  
7 assessed.

8 MISO offers an example of a two-bus model in which there is generation at the  
9 load. A more relevant assessment would have determined the additional supply made  
10 available from other regions under high net load conditions.

11 **Q. WHAT IS YOUR ASSESSMENT OF MISO’S ASSERTION THAT THE FUTURE**  
12 **2A GENERATION PORTFOLIO IS CONSISTENT WITH MEMBER PLANS?**

13 A. MISO has asserted that the IMM’s case is not compatible with member state and utilities  
14 renewable energy requirements because the IMM assumed that a utility in a state without  
15 a renewable requirement could count renewable generation for its own goals and sell the  
16 renewable energy credits to a utility within a state with state-wide goals.<sup>34</sup>

17 This is a remarkable assertion. If the added cost of just part of the Future 2A  
18 generation is \$88 billion to meet the Renewable Portfolio Standard (RPS) goals of some

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(PRMR) for each LRZ was evaluated and some manual adjustments to resource siting was made to address any significant surplus or deficits on an LRZ-level basis.”

MISO Response to IMM Memo, pp. 4, 12-13.

“However, the IMM scenarios treated the Renewable Energy Credits (RECs) for utilities without a state goal as fungible; MISO assumed that those goals were additive to other state goals. For example, Montana does not have state clean energy goals, however Montana Dakota Utility (MDU) does. The IMM expansion assumed that MDU would sell their renewable energy credits to a utility in a state with a renewable goal; MISO assumed that MDU’s renewable energy would not be designated for another utility.”

1 states, this is more than 10 times the carbon benefits using an \$85/metric ton cost of carbon,  
2 implying that the RPS programs that MISO would build transmission for are based on a  
3 cost of carbon in excess of \$850. This \$850/metric ton carbon cost to meet RPS  
4 requirements is in addition to the added cost of meeting load with intermittent resources  
5 rather than gas or coal. It is remarkable that MISO apparently considers it a regional  
6 economic benefit to build transmission to meet the RPS standards of utilities or states based  
7 on an \$850 or higher carbon cost.

8 Another core element of MISO's discussion of the Future 2A resource mix is that  
9 these plans are consistent with member plans.<sup>35</sup> However, consistency with member plans  
10 is not a stipulation of the cost-benefit analysis theory. To the contrary, it is precisely  
11 because the case of large-scale transmission with economies of scope and scale can create  
12 distortion in participant decisions that there is a need for the central planner and the  
13 oversight regulator to look to the fundamentals of generation, load and transmission  
14 investments. Were this not the case, there would be no need for central planning and  
15 mandated cost allocation.

16 It appears that the members whose plans are being considered by MISO are the  
17 regulated utilities that would include this transmission cost in their rate base and would not  
18 use a 3% discount rate to determine the cost of capital for their investment. It is noteworthy  
19 that in Table 1 in the MISO Futures Report,<sup>36</sup> a number of utilities in Missouri, Iowa,  
20 Indiana, and Montana are identified as having aggressive decarbonization goals, but the  
21 state goals are modest. Moreover, Table 1 does not even list North Dakota and South

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<sup>35</sup> MISO Response to IMM Memo, pp. 1-8.

<sup>36</sup> Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, November 1, 2023, p.14.

1 Dakota. A further observation is that if the Future 2A resources accurately reflect MISO  
2 utility generation plans, MISO has shown that these plans in aggregate would not reliably  
3 meet load. This implies in turn that the resource plans of some utilities are not capable of  
4 meeting load even with any diversity benefit provided by Tranche 2.1 transmission.

5 One possible implication of this finding is that with this information MISO utilities  
6 would develop a different resource mix that might not need all or any of the Tranche 2.1  
7 transmission and might in fact need a completely different set of transmission investments.  
8 This ties back to the observation above that with the 29.8 GW of flex capacity added to the  
9 resource mix, some of the Future 2A generation might not be needed. If this is the case,  
10 MISO should be planning transmission to meet these revised needs.

11 Another possible implication is that some utilities in the MISO footprint are in  
12 effect facing a resource mix that is incapable of meeting their net load, even with the  
13 diversity benefit, and will out of necessity be “leaning on the pool”. If the Tranche 2.1  
14 transmission has the effect of enabling this leaning, the benefits to some utilities of that  
15 leaning is not a regional benefit and should not be assigned to others by MISO.

16 **Q. WHY HAVE YOU CONCLUDED THAT MISO ESTIMATES OF RELIABILITY**  
17 **BENEFITS ARE BASED ON AN INCOMPLETE ANALYSIS?**

18 A. As discussed above, the avoided capacity cost assessment includes the cost of the  
19 additional 22.8 GW of generation that MISO projects would be needed absent the Tranche  
20 2.1 transmission investment.

21 However, the reliability assessment does not include this additional generation in  
22 evaluating reliability needs. A valid evaluation of the reliability benefits would either  
23 include: (1) the 22.8 GW of additional capacity MISO concludes would be needed under

1 the avoided capacity cost analysis or, perhaps more realistically, (2) the alternative  
2 generation portfolio and siting that the IMM had developed.<sup>37</sup>

3 If Tranche 2.1 transmission investments were not made, and the alternative  
4 generation built, the alternative generation would of course be sited to meet these reliability  
5 needs. Hence, there would be no reliability benefits to the Tranche 2.1 transmission because  
6 the reliability issues would be addressed by the generation that would be built if the Tranche  
7 2.1 transmission was not built. This MISO assessment of reliability benefits to the Tranche  
8 2.1 transmission, while ignoring the supply provided by the 22.8 GW of additional  
9 generation MISO itself models as being built if the Tranche 2.1 transmission was not built,  
10 is a material flaw in the MISO analysis.

11 **Q. DOES THE MISO RELIABILITY ANALYSIS TAKE ACCOUNT OF THE 29.8 GW**  
12 **OF FLEX GENERATION THAT WOULD BE BUILT TO MAINTAIN**  
13 **RELIABILITY IN ADDITION TO THE FUTURE 2A GENERATION?**

14 A. It appears that MISO includes the 29.8 GW of flex capacity in the resource mix it uses to  
15 evaluate reliability, but MISO apparently restricts the flex capacity from being dispatched  
16 up or down to resolve many of the modeled post contingency overloads.<sup>38</sup> Hence, it  
17 appears that the reliability impacts MISO identifies are a result of MISO restricting the  
18 dispatch of the available generation, rather than any need for additional generation or  
19 transmission. MISO imposes some kind of emissions constraint on the dispatch when these  
20 contingencies are binding, which is what requires load shedding. The load shedding in the

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<sup>37</sup> David Patton Memorandum to Midcontinent ISO, July 15, 2024, re. Concerns and Recommendations for the Tranche 2 Benefit Methodologies, p. 1.

<sup>38</sup> See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.9 Figure 31, Thermal and Flex generation is fixed for P2 and P7 contingencies.

1 MISO benefits analysis is not due to a lack of generation or transmission. MISO states in  
2 step 2 of section 4.9 of its methodology whitepaper that

3 “Renewable energy targets are also summed across the hours represented by the  
4 study models to apply limits on the number of hours permitted for displacement  
5 of renewables with the increased dispatch of thermal generation. This enforces  
6 the renewable energy production levels that are established by the Futures  
7 expansion.”<sup>39</sup>

8 This does not make economic or environmental sense. Even at the highest estimates of the  
9 cost of CO2 emissions there is no reason to restrict the dispatch of thermal generation in the  
10 small number of hours in which the temporary dispatch of additional thermal generation is  
11 needed to maintain reliability.

12 At the low-end value of lost load of \$3,500 per MWh, the reliability cost of not  
13 dispatching thermal generation that emits CO2 with a cost of even \$50 or \$100/MWh dwarfs  
14 the carbon costs. The imbalance would be even more extreme using a \$10,000 value of lost  
15 load.<sup>40</sup> What MISO has termed reliability benefits of Tranche 2.1 are better described as the  
16 reliability costs of some members’ assumed dispatch policies. MISO indicates that it would  
17 shed load to avoid violating a member’s renewable dispatch policies. Furthermore, since  
18 MISO describes the flex resources as hypothetical “low- or non-carbon emitting” resources,<sup>41</sup>

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<sup>39</sup> See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.9, step 2.

Similarly, MISO LRTP Tranche 2 Benefit Metrics Development, April 26, 2024, states on slide 6 with respect to the reliability dispatch that “Generation redispatch includes thermal resources . . . Must respect member renewable targets – limit on hours of redispatch” slide 20.

<sup>40</sup> See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.9, step 6.

<sup>41</sup> See, e.g., MTEP24 Report p. 31.

1 it is not apparent why their dispatch should be restricted in any case, yet MISO restricts the  
2 upward dispatch of flex resources as well as thermal resources in its load shedding models.<sup>42</sup>

3 **Q. ARE THERE ANY OTHER ELEMENTS OF MISO'S ASSESSMENT OF**  
4 **RELIABILITY BENEFITS THAT ARE INCOMPLETE?**

5 A. Yes. MISO quantifies this reliability benefit based on the cost of load shedding that would  
6 be needed to resolve the reliability issues.<sup>43</sup> In MISO's benefits assessment there is a large  
7 amount of assumed load shedding. In actual practice, known reliability issues would not  
8 be resolved by planning to shed large amounts of load. Instead, these types of reliability  
9 issues are identified and addressed in near-term planning processes. The solutions could  
10 include incremental transmission upgrades, voltage support equipment, or generation  
11 investment such as the 22.8 GW of extra generation assumed in the MISO avoided capacity  
12 cost benefit calculation. It is the cost of these alternative strategies for addressing reliability  
13 issues that is the relevant benefit to building the Tranche 2.1 transmission, not the  
14 hypothetical and expensive load shedding assumed in the MISO benefits assessment.

15 Therefore, a valid analysis of potential reliability benefits of the Tranche 2.1  
16 transmission would include identifying the costs of any investments needed to address the  
17 reliability issues, after recognizing the mitigating effects of the 22.8 GW alternative  
18 generation portfolio MISO assumes would be built absent the Tranche 2.1 transmission. It

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<sup>42</sup> See LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, section 4.9 Figure 31, Thermal and Flex generation is fixed for P2 and P7 contingencies.

<sup>43</sup> "4.9 Mitigation of Reliability Issues" see LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, pp. 36-44.

"For all base case study cases, the identified issues and the aggregate load redispatch amount are tabulated for each study scenario. The total load shedding is then multiplied by the relevant number of hours for that scenario to obtain the amount of load shedding (MWh) avoided. This total value is multiplied by the Value of Lost Load (VOLL) to obtain the financial value of the benefit of mitigation of reliability issues."

1 is the costs of these alternative mitigation strategies that would be needed if Tranche 2.1  
2 were not built that would be the relevant benefit.

3 It is possible that the 22.8 GW of additional generation that MISO assumed would  
4 be built in calculating the avoided capacity cost benefits would not resolve all these  
5 reliability issues. MISO did not consider these reliability issues in developing the  
6 additional generation resource portfolio. However, market participants would do so in the  
7 actual market. Furthermore, if some of those reliability issues required a transmission  
8 solution, the relevant cost would be the cost of the transmission solution, not the cost of  
9 load shedding.

10 Overall, the MISO reliability benefit analysis ignores the 22.8 GW of generation  
11 that MISO assumes would be built if the Tranche 2.1 Transmission were not built, ignores  
12 the MISO Transmission Expansion Plan (MTEP) transmission and storage projects that  
13 could be built if there were remaining reliability issues, and ignores operator actions that  
14 could be undertaken to solve any remaining reliability issues.

15 Moreover, the reliability analysis double counts environmental benefits by  
16 restricting the hours of operation of thermal units in the redispatch in addition to the  
17 overstated carbon benefits.<sup>44</sup>

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<sup>44</sup> LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, p. 40.

“Renewable energy targets are also summed across the hours represented by the study models to apply limits on the number of hours permitted for displacement of renewables with the increased dispatch of thermal generation. This enforces the renewable energy production levels that are established by the Futures expansion.”

1 **Q. HAVE YOU CONCLUDED THAT THE ENVIRONMENTAL BENEFITS**  
2 **CALCULATED BY MISO ARE OVERSTATED? PLEASE EXPLAIN.**

3 A. Yes, the environmental benefits are materially overstated. Correcting the approach for  
4 comparing the Base Case without the subject transmission to an Expansion Case with the  
5 new transmission would reveal a problem in the calculation of the environmental benefits.  
6 The Federal Production Tax Credit (PTC) for renewable energy presents an estimate of the  
7 implied value of the environmental benefits. In addition, any binding state Renewable  
8 Portfolio Standard (RPS) would establish a set of constraints that would be included in the  
9 Base Case. With an RPS accompanied by a corresponding load purchase requirement for  
10 renewable credits, the comparison in the Base Case and the Expansion Case would account  
11 for the environmental effects of established state and Federal public policies.

12 Further accounting for carbon emissions evaluated at any selected SCC requires  
13 making explicit certain important and unavoidable policy decisions. First, this would mean  
14 establishing the relevant environmental beneficiaries as either the world population or  
15 some smaller group. Second, the social cost of carbon for that group would be reduced by  
16 the price already internalized in the market through various pricing or subsidy policies.  
17 This netting would be required to avoid either double counting or assuming adoption of  
18 policies which are not in place. Recent Federal legislation, passed after the MISO analysis,  
19 increases the uncertainty about the implied cost of carbon emissions already embedded in  
20 the Base Case.

21 MISO's low-end benefits of \$7.2 billion utilizes an SCC of \$85/metric ton, an  
22 estimate based on a global damage calculation. This exceeds the value of carbon implied  
23 by the production tax credits currently paid to renewable energy resources, presumably

1 based on their value in reducing carbon emissions. The IMM has estimated the PTC-  
2 equivalent carbon price as approximately \$50/ metric ton.<sup>45</sup> Ignoring netting and keeping  
3 all other factors constant, reducing the cost of carbon from \$85 to \$50/metric ton as a proxy  
4 for the value implied by the PTC reduces the benefit from \$7,230 million to \$4,253 million  
5 in 2024 dollars (for a 20-year NPV, 7.1% discount rate).<sup>46</sup>

6 The maximum decarbonization benefit asserted by MISO of \$28.31 billion is based  
7 on a Minnesota Public Utilities Commission \$248/metric ton value of carbon in 2024  
8 dollars.<sup>47</sup> At the other end of the spectrum, North Dakota uses a \$0/metric ton value for  
9 carbon.<sup>48</sup> MISO notes in the MTEP24 Report that 75% of MISO load is served by members  
10 with ambitious decarbonization and/or renewable energy goals,<sup>49</sup> but members refers to  
11 utilities, not state policies.

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<sup>45</sup> David Patton, Potomac Economics, Memorandum to Midcontinent ISO, “Concerns and Recommendations for the Tranche 2 Benefits Methodologies, July 15, 2024.

<sup>46</sup> Calculation based on methods in LRTP Tranche2.1 Detailed Business Case Analysis F2A final portfolio excel spreadsheet.

<sup>47</sup> LRTP Tranche 2 Business Case Metrics, Methodology Whitepaper, September 23, 2024, p. 33, Figure 25.

|                   | Federal | MN PUC   |
|-------------------|---------|----------|
| 2024\$/metric ton | \$85    | \$248.67 |

<sup>48</sup> Externalities are specifically prohibited from being considered under North Dakota Century Code (NDCC) Section 49-02-23 <https://ndlegis.gov/cencode/T49C02.pdf>  
Externalities would include things such as the social cost of carbon.

IRPs are enabled in NDCC Section 49-05-17, and in rules under North Dakota Administrative Code (NDAC) Section 69-09-12 <https://ndlegis.gov/information/acdata/pdf/69-09-12.pdf>  
Similar to the law above, the rules prohibit externalities.

North Dakota had a 10% renewable energy objective under NDCC Section 49-02-28, however it was repealed under 2025 Senate Bill 2359 <https://ndlegis.gov/assembly/69-2025/regular/bill-actions/ba2359.html> This bill was passed by the North Dakota House and Senate, and signed by the Governor. It will become effective 8/1/25.

<sup>49</sup> See MTEP24 Report, p. 29.

1 By comparison, accepting the global estimate of \$85 and netting an implied \$50  
2 PTC internalization would provide a price of \$35/metric ton, a 60% reduction to the low-  
3 end estimate for the environmental valuation.

4 Furthermore, with a consistent comparison of the Base Case and the Expansion  
5 Case under currently established policies considered by MISO, and only regional rather  
6 than global carbon damages, there would be essentially no incremental carbon benefit.

7 **Q. WHAT IS YOUR OVERALL ASSESSMENT OF MISO'S TRANCHE 2.1**  
8 **TRANSMISSION BENEFIT ASSESSMENT?**

9 A. MISO's avoided capacity cost benefit calculation is inconsistent with the basic principles  
10 of cost-benefit analysis. In contrast, Potomac Economics' calculations indicate that the  
11 avoided capacity cost benefits are zero. If there are any avoided capacity cost benefits,  
12 they need to be shown in a valid cost-benefit analysis that accounts for the cost of the  
13 Future 2A generation that would not be needed if the Tranche 2.1 transmission was not  
14 built and the additional 22.8 GW of generation assumed by MISO was built closer to load.

15 Likewise, it is clear that reliability benefits are essentially zero. If these two  
16 "benefits" calculated by MISO are restated to be zero, the Tranche 2.1 transmission costs  
17 greatly exceed the remaining benefits.

18 The true benefits are even lower if (i) a more accurate net cost of carbon is used to  
19 calculate carbon benefits, and (ii) all the other classes of benefits are calculated based on  
20 an alternative generation investment scenario without the Tranche 2.1 transmission. In  
21 particular, the losses related benefits would be lower if the 22.8 GW of additional  
22 generation were built closer to load and less Future 2A generation built.

**Q. HOW DOES CORRECTING THESE ELEMENTS OF MISO’S BENEFIT ASSESSMENT IMPACT THE OVERALL COST BENEFIT RATIO?**

A. Correcting the avoided capacity cost (including capacity savings from reduced losses and the mitigation of reliability issues for obvious flaws in the analysis) and using a \$85/metric ton cost of carbon reduces the high-end estimate of the benefit-to-cost ratio to only 0.68. Using a carbon cost consistent with the production tax credit results in a benefit-to-cost ratio of only 0.55. This is conservative because it appears that the actual avoided capacity cost impact would be negative as discussed above, not \$0.

*Hogan Figure 2<sup>50</sup>*

| <b>Footprint Benefits - 20-Year NPV, 7.1%, 2024\$, in \$ billions</b> |                |           |                 |           |
|-----------------------------------------------------------------------|----------------|-----------|-----------------|-----------|
|                                                                       | <b>Low End</b> |           | <b>High End</b> |           |
|                                                                       | MISO           | Corrected | MISO            | Corrected |
| Avoided Capacity Costs                                                | \$16,271       | \$0       | \$16,271        | \$0       |
| Capacity Savings from Reduced Losses                                  | \$1,857        | \$0       | \$1,857         | \$0       |
| Congestion and Fuel Savings                                           | \$8,148        | \$8,148   | \$8,148         | \$8,148   |
| Energy Savings from Reduced Losses                                    | \$1,632        | <\$1,632  | \$1,632         | <\$1,632  |
| Reduced Transmission Outage Costs                                     | \$76           | \$76      | \$76            | \$76      |
| Reduced Risks from Extreme Weather Impacts*                           | \$394          | \$394     | \$1,124         | \$1,124   |
| Avoided Transmission Investment                                       | \$1,228        | \$1,228   | \$1,228         | \$1,228   |
| Mitigation of Reliability Issues*                                     | \$14,821       | \$0       | \$42,345        | \$0       |

<sup>50</sup> Table produced from analysis using the MISO’s excel “LRTP Tranche 2.1 Detailed Business Case Analysis F2A final portfolio excel spreadsheet” as the source.

|                       |                 |                     |                  |                     |
|-----------------------|-----------------|---------------------|------------------|---------------------|
| Decarbonization**     | \$7,230         | <\$4,253            | \$28,308         | <\$7,230            |
|                       |                 |                     |                  |                     |
| <b>Total Benefits</b> | <b>\$51,657</b> | <b>&lt;\$15,730</b> | <b>\$100,990</b> | <b>&lt;\$19,438</b> |
| <b>Total Costs</b>    | <b>\$28,575</b> | <b>\$28,575</b>     | <b>\$28,575</b>  | <b>\$28,575</b>     |
| B/C Ratio             | 1.81            | <0.55               | 3.53             | <0.68               |

\*VOLL: min=\$3,500, max=\$10,000

\*\*Carbon Price for MISO columns: min=\$85, max=\$248.67

\*\*Carbon Price for Corrected columns: min=\$50, max=\$85

1 **Q. HAVE YOU IDENTIFIED ANY OTHER ISSUES WITH MISO’S EVALUATION**  
2 **OF TRANCHE 2.1 TRANSMISSION BENEFITS?**

3 A. Yes. I have identified two other issues with the MISO’s evaluation of transmission benefits  
4 that while related to some of my observations above are distinct issues.

5 **Q. WHAT IS THE FIRST OF THESE ISSUES?**

6 A. The EGEAS model simply evaluated capacity to meet resource adequacy requirements.  
7 Not only did it ignore transmission constraints and the cost of building transmission,<sup>51</sup> it

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<sup>51</sup> Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, November 1, 2023, p. 2; LRTP Workshop, Future 2A Energy Adequacy & Siting, April 28, 2023, p. 3.

Series1A\_Futures: “PROMOD, a production cost modeling tool, provided hourly (annual) chronological security-constrained unit commitment and economic dispatch, to identify any energy adequacy shortfall needs that may not have been captured in the MISO Series 1A Future 2A expansion results produced by EGEAS, an unconstrained (transmission-less) non-chronological resource expansion modeling tool.” “LRTP Workshop, Future 2A Energy Adequacy & Siting: MISO utilized PROMOD for a chronological energy adequacy validation because EGEAS uses a load duration curve without sequential hours

- Model: MISO LRTP Future 2A Model (2042)
- Simulation: A “Copper Plate” analysis, which is a full year hourly dispatch simulation, without transmission constraints
- Reporting: Frequency and magnitude of hourly Emergency Energy”

1 did not assess whether the resource mix it developed would meet MISO ancillary service  
2 requirements or enable the MISO to balance real-time variations in net load.

3 Our review of the very terse description of the MISO PROMOD modeling<sup>52</sup> provides no  
4 indication that the PROMOD model accounted for ancillary service requirements or the  
5 amount of ramp capacity that would be needed to balance variations in intermittent  
6 resource output.

7 This omission is another reason to question whether the Future 2A generation mix  
8 modeled by MISO would be approved by regulators and actually built.

9 **Q. WHAT IS THE SECOND ISSUE WITH THE MISO BENEFIT ASSESSMENT?**

10 A. The IMM has pointed out, and MISO acknowledged, that the MISO EGEAS model used  
11 current accreditation factors for intermittent resources and did not adjust these accreditation  
12 factors over time for changes in the resource mix.<sup>53</sup> This failure to adjust accreditation  
13 factors over time to reflect changes in the resource mix is an important factor explaining

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<sup>52</sup> MTEP24 Report pp. 35-39 and 43-45; Midcontinent Independent System Operator, Inc., MISO Futures Report: Series 1A, November 1, 2023, p. 2.

<sup>53</sup> LRTP Tranche 2 Futures Refresh, Assumptions Book, April 27, 2023, p. 4.

|          | PV/DGPV | Wind   | Hybrid | Battery |
|----------|---------|--------|--------|---------|
| 2023     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2024     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2025     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2026     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2027     | 50.00%  | 16.60% | 60.00% | 100.00% |
| 2028     | 47.00%  | 16.60% | 57.00% | 97.50%  |
| 2029     | 44.00%  | 16.60% | 54.00% | 95.00%  |
| 2030     | 41.00%  | 16.60% | 51.00% | 92.50%  |
| 2031     | 38.00%  | 16.60% | 48.00% | 90.00%  |
| 2032     | 35.00%  | 16.60% | 45.00% | 87.50%  |
| 2033     | 32.00%  | 16.60% | 42.00% | 85.00%  |
| 2034     | 29.00%  | 16.60% | 39.00% | 82.50%  |
| 2035     | 26.00%  | 16.60% | 36.00% | 80.00%  |
| 2036     | 23.00%  | 16.60% | 33.00% | 77.50%  |
| 2037     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2038     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2039     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2040     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2041     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| 2042     | 20.00%  | 16.60% | 30.00% | 75.00%  |
| Average: | 34.30%  | 16.60% | 44.30% | 86.90%  |

[

1        why MISO found that the Future 2A resource mix that was developed to meet resource  
2        adequacy requirements could not meet load. MISO added 29,800 MW of “Flex” capacity  
3        to the Future 2A capacity mix so that the generation mix was able to reliably meet load.  
4        However, MISO did not go back and rerun the EGEAS analysis using corrected  
5        accreditation factors. This might have caused the EGEAS model to select a materially  
6        different resource mix to meet resource adequacy requirements.

7        **A.    WHAT IS THE SUMMARY OF THIS REVIEW OF THE MISO APPLICATION OF**  
8        **COST-BENEFIT ANALYSIS FOR TRANSMISSION EXPANSION?**

9        Q.    The need for a cost-benefit analysis arises for large-scale transmission because of the  
10        presence of large economies of scale and scope that affect the future evolution of all  
11        elements of the electricity system. The theoretical framework emphasizes the need to  
12        develop alternative forecasts for generation and load that would be consistent with the Base  
13        Case and an Expansion Case. Although complete perfection is unattainable, the MISO  
14        approach for the Tranche 2.1 expansion embodies material assumptions that are  
15        unnecessarily inconsistent with the basic principles. Reasonable estimates of the alternative  
16        futures and the associated costs would produce a substantial change in the MISO cost-  
17        benefit analysis wherein the costs of the proposed transmission would not be justified by  
18        the estimated benefits.

19        **Q.    DOES THIS CONCLUDE YOUR TESTIMONY?**

20        A.    Yes.

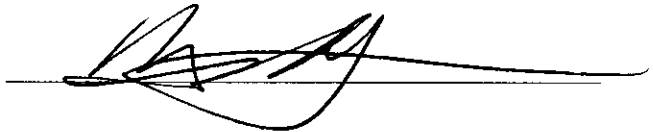
**UNITED STATES OF AMERICA  
BEFORE THE  
FEDERAL ENERGY REGULATORY COMMISSION**

**Midcontinent Independent System )  
Operator, Inc.**

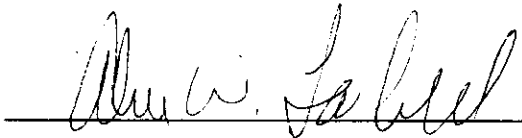
**Docket No. EL25- -0000**

**VERIFICATION OF DR. WILLIAM W. HOGAN**

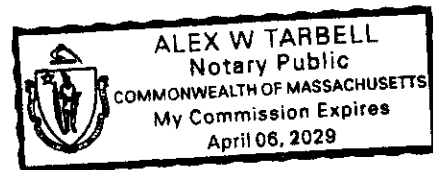
Dr. William W. Hogan, being first duly sworn, deposes and states that he is the Dr. William W. Hogan referred to in the foregoing document entitled "Affidavit of Dr. William W. Hogan", that he has read the same and is familiar with the contents thereof, and that the testimony set forth therein is true and correct to the best of his knowledge, information, and belief.



Subscribed and sworn to before me, the undersigned notary public, this 26 day of July 26, 2025.



Notary Public



## APPENDIX A

## WILLIAM W. HOGAN

### PERSONAL DATA

Born: 1944, Holyoke, Massachusetts  
 Address: Harvard Kennedy School  
 Harvard University  
 79 John F. Kennedy Street  
 Cambridge, MA 02138  
[william\\_hogan@harvard.edu](mailto:william_hogan@harvard.edu)  
<http://www.whogan.com>

### EDUCATION

BS United States Air Force Academy, 1966  
 MBA University of California, Los Angeles, 1967  
 PhD University of California, Los Angeles, 1971

### PROFESSIONAL EXPERIENCE

2025 - Raymond Plank Professor of Global Energy Policy (Emeritus), Harvard Kennedy School, Harvard University, Cambridge, Massachusetts  
 2019 - 2025 Raymond Plank Research Professor of Global Energy Policy, Harvard Kennedy School, Harvard University, Cambridge, Massachusetts  
 2006 - 2019 Raymond Plank Professor of Global Energy Policy, Harvard Kennedy School, Harvard University, Cambridge, Massachusetts  
 2011- FTI Consulting, Boston, Massachusetts  
 1999 - 2011 Director, LECG, LLC, Cambridge, Massachusetts  
 1998 - 2006 Lucius N. Littauer Professor of Public Policy and Administration, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts  
 1989 - 1999 Senior Advisor, Putnam, Hayes and Bartlett, Inc., Cambridge, Massachusetts  
 1987 - 1998 Thornton Bradshaw Professor of Public Policy and Management, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts  
 1982 - 1990 Chairman, Public Policy Program, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts  
 1980 - 1997 Director, Putnam, Hayes and Bartlett, Inc., Cambridge, Massachusetts  
 1978 - 1987 Professor of Political Economy, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts  
 1978 - 1986 Director, Energy and Environmental Policy Center, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts  
 1976 - 1978 Adjunct Professor of Research and Scholarship, Department of Engineering-Economic Systems and Department of Operations Research, Stanford University, Stanford, California; Executive Director, Energy Modeling Forum  
 1975 - 1976 Deputy Assistant Administrator for Data and Analysis, Federal Energy Administration  
 1974 - 1975 Director, Office of Quantitative Methods, Federal Energy Administration  
 1973 - 1974 Acting Director, Modeling Division, Office of Energy Data and Analysis, Dept. of Interior  
 1971 - 1973 Instructor, U.S. Air Force Academy, Department of Economics and Management  
 1969 - 1971 PhD, Department of Quantitative Methods, Graduate School of Management, Univ. of California, Los Angeles; Chairman: Dr. Arthur Geoffrion; Dissertation: "Optimization and Convergence of Extremal Value Functions Arising from Structured Nonlinear Programs"  
 1968-1969; 1975 Instructor, Associate Professor (part-time), George Washington University  
 1967-1969 Operations Research Analyst, U.S. Air Force, Pentagon

## HONORS

National Academy of Engineering, 2021

Adelman-Frankel Award, United States Association for Energy Economics, October 2011

Norges Handelshoyskole (Norwegian School of Economics), Doctor *Honoris Causa*, 2011

International Association for Energy Economics (IAEE), Award for Outstanding Contributions to the Profession, 2005

Contributor, 50<sup>th</sup> Anniversary Issue, Operations Research (50:1, January-February 2002)

President's Award, Institute for Operations Research and Management Sciences (INFORMS) for long-term research with significant impact and influence on society and public policy (2000)

Distinguished Service Award (2000), Center for Business and Government, John F. Kennedy School of Government, Harvard University

Best Paper Award (1997) The Energy Journal: "A Market Power Model with Strategic Interaction in Electricity Networks."

Distinguished Service Award for Service to the Electric Utility Industry (1995), Public Utility Research Center, University of Florida

Distinguished Service Award (1975), Special Award for Exceptional Service (1976), Federal Energy Administration

Alumni Award, Outstanding Doctoral Student, University of California, Los Angeles (1971)

Outstanding Cadet Award, Engineering Management, U.S. Air Force Academy (1966)

## ACTIVITIES AND ORGANIZATIONS

Visiting Committee, Institute for Data, Systems, and Society, MIT, 2018-

Future of Energy, Harvard University: Energy and Environmental Policy, Co-Chair, 2008-

Management Science and Engineering Department, Stanford University: Visiting Committee 2002-2003

Journal of Regulatory Economics: Editorial Board, 2002-

Royal Society for the Encouragement of Arts, Manufactures & Commerce, London: Fellow, 2000-2004

National Regulatory Research Institute, Ohio State University, External Review Team, 1997-2001

Energy Economics: Editorial Board, 1996-

Electricity Journal: Editorial Advisory Board, 1994-

Resource and Energy Economics: Editorial Board, 1993-1998

H. John Heinz School of Public Policy and Management, Carnegie Mellon University: Advisory Board, 1992-2000

Electric Power Research Institute: Advisory Group for Economics, 1992-1993

Committee for Economic Development: Advisor, Design Committee on Energy and the Environment, 1990-1993

Project on Economic Reform in Ukraine: Director, 1990-1997

MIT Center for Technology, Policy and Industrial Development: Advisory Board, 1987-1996

National Research Council, Commission on Engineering and Technical Systems: Energy Engineering Board, 1986-1989

The Sawhill Commission (New York State) for the Investigation of the Public Power Option for the Long Island Lighting Company, 1986

Center for Acid Rain and Clean Air Policy Analysis, National Governors' Association: Board of Directors, 1985

International Association for Energy Economics: President, 1985

National Petroleum Council: Committee on U.S. Petroleum Refining, 1984-86

Harvard Real Estate and Planning Board: Faculty Advisory Council, 1984-2019

Gas Research Institute: Advisory Council, 1983-2000; Board of Directors, 1991-2000

Aspen Institute for Humanistic Studies: Energy Steering Committee, 1983-

Harvard Real Estate Corporation: Director, 1982-1983

The Energy Journal: Editorial Board, 1981-

Public Policy and Public Management Case Project: Editorial Board, 1979-1987

Operations Research: Editor, Energy and Environment, 1978-1982

Resources and Energy: Advisory Editor, 1979

National Center for Energy Systems Analysis: Advisory Board, 1979-1981

Argonne National Laboratories: Advisory Board, Energy and Environment Systems Division, 1979-1981

Undergraduate Mathematics Applications Project: Steering Committee, 1979-1981

Energy Modeling Forum, Chairman, Steering Committee, 1978-1987

Texas National Energy Modeling Project: National Advisory Board, 1978-1980

University of Texas, Center for Energy Studies: Advisory Panel, 1977-1979

International Association for Energy Economics (IAEE), 1978-

ORSA: Special Interest Group on Energy Application, Chairman, 1977-1978

Electric Power Research Institute: Supply and Demand Advisory Task Force, 1974-1976

The Mathematical Programming Society, 1971-

The Institute of Operations Research and Management Sciences (INFORMS), 1967-

## **STUDY GROUPS**

Beyond LCOE External Advisory Board, Department of Energy, 2019-

Task Force to Support the Quadrennial Energy Review, Secretary of Energy Advisory Board, 2014-2016

Committee on Accelerating Deployment of Clean Energy and Energy Efficiency Technologies, National Academy of Sciences Energy Study, 2013-2016

MIT Grid Study, 2009-2011

Harnessing Renewable Energy, 2009-2010

Populism and Natural Resources: An Energy Policy Agenda, Mossavar-Rahmani Center for Business and Government, Harvard Kennedy School, Harvard University, 2006-2009

Repsol YPF-Harvard Kennedy School Fellows Program, Director, 2002-2006

Initiative on the Future of Electricity, Edison Electric Institute, 1999

Independent Expert Review Panel, U. S. Energy Information Administration Review of the Economic Effects of the Kyoto Protocol, 1998

Electric Utility Market Reform Task Force, Massachusetts Dept of Energy and Resources, 1994-1995

Harvard Electricity Policy Group, Research Director, 1993-

Repsol YPF - Harvard Seminars in Energy Policy, Co-Chair, 1988-

Energy Modeling Forum Working Groups: Energy and the Economy (Chairman), 1976-1977; Coal in Transition, 1977-1978; Electric Load Forecasting, 1977-1979; Demand Elasticities (Chairman), 1978-1980; Oil and Gas Supply, 1979-1982; World Oil Models, 1980-1982; Energy Shocks, 1982-1984; Industrial Energy Demand, Conservation and Interfuel Substitution, 1984-1986; International Oil Supplies and Demands, 1989-1991.

Energy Efficiency: A New Agenda, Task Group, American Council for an Energy Efficient Economy, 1988

Harvard Study on the Future of Natural Gas 1984-1985

Diesel Impacts Study Committee, National Research Council, 1979-1981

Resources for the Future: Energy, the Next Twenty Years, sponsored by the Ford Foundation, 1978-1979

Modeling Resources Group, Committee on Nuclear and Alternative Energy Systems, National Academy of Sciences, 1976-1977.

## BOOKS AND ARTICLES

“Computation of Convex Hull Prices in Electricity Markets with Non-Convexities using Dantzig-Wolfe Decomposition,” with Panagiotis Andrianesis, Dimitris Bertsimas, and Michael C. Caramanis. *IEEE Transactions on Power Systems*, Volume: 37, Issue: 4, July 2022.

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“Priorities for the Evolution of an Energy-Only Electricity Market Design in ERCOT” (with Susan Pope), May 9, 2017.

*The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies* (committee member, National Academies of Science, Engineering, and Medicine book), September 2016.

“Virtual Bidding and Electricity Market Design.” *The Electricity Journal*, June 2016.

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“Electricity Markets and the Clean Power Plan,” *The Electricity Journal*, November 2015.

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"Oil Tariff Policy: An Overview," (with Harry Broadman), Energy Systems and Policy, Vol. 12, 1988.

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Lower Oil Prices: Mapping the Impact (with Bijan Mossavar-Rahmani et al.), Harvard University Energy and Environmental Policy Center, 1988.

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"Energy Security and Oil Market Risk Analysis" (with Paul N. Leiby.) In Energy Decisions for the Future: Proceedings of the Eighth Annual International Conference of the IAEE, Mitsuru Miyata and Kenichi Matsui, editors, Tokyo, 1986.

"Patterns of Energy Use." In Energy Conservation: Successes and Failures, John C. Sawhill and Richard Cotton, editors, The Brookings Institute, 1986.

"Energy and Economy: Global Interdependences," Energy Journal, Vol. 6, No. 4, 1985.

"Integrated Fuel and Investment Planning: Methods and Process" (with Charles Mann, Susan Manning, and Darrell Smith.) In Models in the Decision Making Process: Planning Under Uncertainty, Andrew Kydes, editor, North-Holland, 1985.

"Energy, the Economy, and Oil Security." In Improving U.S. Energy Security, Richard Gonzales, et al, editors, Ballinger Publishing Co., 1985.

"Energy Policy." In Energy Resources and National Policy: The Reagan Approach, Paul R. Portney, editor, Urban Institute Press, 1984.

"Oil Stockpiling: Help Thy Neighbor," Energy Journal, Vol. 4, No. 3, 1983.

"Methods and Algorithms for Combining Energy Models: Optimization in a Network of Process Models", (with John Weyant). In Energy Models and Studies, Studies in Management Science and Systems, B. Lev, editor, Vol. 20, 1983.

Caught Unawares: the Energy Decade in Retrospect, with Martin Greenberger, et al., Ballinger Publishing Company, 1983.

"Alternatives to Transfer of Large-Scale Models." In Large Scale Energy Models, Robert M. Thrall, Russell G. Thompson, and Milton L. Holloway, editors, Westview Press, 1983.

"Policies for Oil Importers." In OPEC Behavior and World Oil Prices, J. Griffin and D. Teece, editors, George Allen and Unwin, London, 1982.

"On Convergence of the PIES Algorithm for Computing Equilibria," with B. H. Ahn, Operations Research, Vol. 30, No. 2, 1982.

Decision Analysis of Regulating Diesel Cars, National Academy Press, 1982.

"Combined Energy Models." In Advances in the Economics of Energy and Resources, Vol. 4, John. R. Moroney, editor, JAI Press, 1982.

"Energy and Security Policy." In Toward A New U.S. Industrial Policy?, Michael L. Wachter and Susan M. Wachter, editors, University of Pennsylvania Press, 1981.

"Import Management and Oil Emergencies." In Energy and Security, David Deese and Joseph Nye, editors, Ballinger Publishing Co., 1981.

"Aggregate Elasticity of Energy Demand," with the EMF Working Group, The Energy Journal, Vol. 2, No. 2, 1981.

"Gasoline, Prices, Taxes and Demand." In The Dependence Dilemma: U.S. Gasoline Consumption and America's Security, Daniel Yergin, editor, Center for International Affairs, Harvard University, 1980.

"Economic Growth and Higher-Priced Energy." In Energy in America: Fifteen Views, S. Ramo, editor, Center for the Study of the American Experience, University of Southern California, 1980.

"Alternatives to Transfer of Large-Scale Models," Simulation, April 1980.

Background Papers for Energy: The Next Twenty Years, contributor, H. Landsberg, editor, Ballinger Press, 1980.

"Capital Energy Complementarity in Aggregate Energy-Economic Analysis," Resources and Energy, Vol. 2, North-Holland Publishing Company, 1979.

Energy: The Next Twenty Years, contributor. A Ford Foundation/Resources for the Future Report, Ballinger Press, 1979.

Energy Information: Description, Diagnosis, and Design, editor and contributor. Stanford Institute for Energy

Studies, Stanford University, 1979.

"Energy and Economic Growth." In Energy Conservation and Public Policy, John Sawhill, editor, Prentice-Hall, 1979.

"The Energy Modeling Forum: A Communication Bridge," in K.B. Haley, Operational Research, '78, North-Holland Publishing Company, 1979.

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"Energy-Economy Interactions: The Fable of the Elephant and the Rabbit?" with Alan S. Manne. In Modeling Energy-Economy Interactions - Five Approaches, Charles J. Hitch, editor, Resources for the Future Research Papers, 1977. Also in Advances in the Economics of Energy and Resources, Robert S. Pindyck, editor, JAI Press, 1978.

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"Coordination of Two-Level Organizations with Multiple Objectives," (with A. Geoffrion.) In Techniques of Optimization, edited by A.V. Balakrishnan, Academic Press, 1972.

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## **SELECTED RECENT WORKING PAPERS AND OTHER DOCUMENTS**

*Selected recent works among many available on Professor Hogan's website:*

<http://www.whogan.com>

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Electricity Market Design Flaws and Market Manipulation. February 3, 2014.

CAISO Energy Imbalance Market Straw Proposal: Comments. June 26, 2013.

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Multiple Market-Clearing Prices, Electricity Market Design and Price Manipulation. March 31, 2012.

The Future of the Electric Grid: An Interdisciplinary MIT Study, December 2011. Study Participant.

Electricity Market Reform: Market Design and Extended LMP. NHH Workshop on Pricing in Deregulated Energy Markets presentation, Voss, Norway. November 28, 2011.

Energy Security and Energy Policy, Energy: Transition to a Sustainable Future presentation, part of the 2011 Industrial Physics Forum, Nashville, TN, October 31, 2011.

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"McCullough's Critique of the New York Electricity Market," William W. Hogan and Scott Harvey, a report for NYISO. December 22, 2009.

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"Texas Nodal Market Design: Observations and Comments," Presentation, ERCOT Energized Conference,

Austin, TX. May 2, 2008.

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Before the Federal Energy Regulatory Commission, Response to the Commission's Inquiry Regarding Regional Transmission Organizations, FERC Policy on Regional Transmission Organizations: Comments in Response to the Notice of Proposed Rulemaking, Docket No. RM99-2-000, August 16, 1999.

Before the Federal Energy Regulatory Commission, Protest of Calpine Corporation to Amendment No. 19 to the ISO Tariff of the California Independent System Operator Corporation, Docket No. ER99-3339-000, July 27, 1999

Before the Federal Energy Regulatory Commission, Protest of the Coalition Supporting Pro-Competitive Interconnection Policies to Amendment No. 19 to the ISO Tariff of the California Independent System Operator Corporation, Docket No. ER99-3339-000, July 27, 1999.

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Before the Federal Energy Regulatory Commission, Statement on the Commission Review of the New England Power Pool Congestion Management System and Multi-Settlement Proposals, Docket No. ER99-2335-000, April 19, 1999.

Before the Federal Energy Regulatory Commission, Statement on Behalf of PJM Interconnection, L.L.C. In the Matter of Old Dominion Electric Cooperative vs. PJM Interconnection, L.L.C., Docket No. EL99-9-000, December 1998.

Before the State of New Jersey Board of Public Utilities, Testimony on Behalf of GPU Energy In the Matter of the Energy Master Plan Phase II Proceedings to Investigate the Future Structure of the Electric Power Industry and In the Matter of the Electric Restructuring Plans Filed by ... GPU Energy, Public Service Electric and Gas Company, and Rockland Electric Company, Respectively, Regarding Their Electric Restructuring Plans. Docket Nos. EX94120585Y, EO97070457, EO97070460, EO97070463, EO97070466, May 1998.

Before the Federal Energy Regulatory Commission, "FERC Policy on Independent System Operators, Supplemental Comments," re the Inquiry Concerning the Commission's Policies on Independent System Operators, Docket No. PL98-5-000, May 1998.

Before the Federal Energy Regulatory Commission, Statement at the Conference on the Commission's Policies on Independent System Operators, Docket No. PL98-5-000, April 1998.

Before the High Court of New Zealand, Auckland Registry, Commercial List, Affidavit on Behalf of Transpower New Zealand Limited In the Matter Between Mercury Energy Limited and Transpower New Zealand Limited, CL No. 1/98, March 1998

Before the Federal Energy Regulatory Commission, Comments on Behalf of the Gas Research Institute, Re the January 21, 1998 Stipulation and Agreement Concerning GRI Funding, Docket Nos. RP97-391-000, RP97-149-002, and RM97-3-000 (Not Consolidated), February 1998.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of the New York Member Systems, Supplemental Filing to the Comprehensive Proposal to Restructure the New York Wholesale Electric Market, Docket Nos. ER97-1523-000, OA97-470-000 and ER97-4234-000 (not consolidated), December 1997.

Before the State of New Jersey Board of Public Utilities, Testimony on Behalf of GPU Energy Restructuring Plan Petition, Docket No. EO97070460, July 1997.

Before the Pennsylvania Public Utility Commission, Testimony in the Case of the Pennsylvania Electric Company, Re: Public Policy Benefits and Issues of Electric Restructuring in Pennsylvania, Docket No. R-00974009, June 1997.

Before the Federal Energy Regulatory Commission, Comments for the Public Conference on the Future Funding of Research and Development (R&D) in the Natural Gas Industry and the Appropriate Role of the Gas Research Institute in Funding R&D, Docket No. RP97-149-000, March 1997.

Before the Department of Revenue, State of Alaska, Testimony on Behalf of Exxon Corporation and Certain Affiliated Companies, Case Load No. 94925, March 1997.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of the Member Systems of the New York Power Pool, in the matter of Agreements to Form an Independent System Operator, New York Power Exchange, and New York State Reliability Council, and to Provide Statewide Transmission Service, Docket No. ER97- , January 1997.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of the PJM Supporting Companies in the matter of Compliance of the Pennsylvania-New Jersey-Maryland Interconnection with Order No. 888, Docket No. OA97-\_\_ -000, December 1996.

Before the Federal Energy Regulatory Commission, "Capacity Reservation Open Access Transmission Tariffs," Response to Notice of Proposed Rulemaking, Docket No. RM96-11-000, October 1996.

Before the Federal Energy Regulatory Commission, "Capacity Reservation Open Access Transmission Tariffs," Comments for the Technical Conference Concerning Capacity Reservation Open Access Transmission Tariffs, Notice of Proposed Rulemaking, Docket No. RM96-11-000, September 1996.

Before the Federal Energy Regulatory Commission, "WEPEX: Building the Structure for a Competitive Electricity Market, " Comments for the Technical Conference Concerning WEPEX Proposals of Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company, August 1996.

Before the Pennsylvania Public Utility Commission, Testimony re the Investigation into Electric Power Competition, Docket No. I-940032, February 1996.

Before the Federal Energy Regulatory Commission, Comments for the Technical Conference Concerning Independent System Operators and Reform of Power Pools Under the Federal Power Act, Docket Nos. RM95-8-000 and RM94-7-001, January 1996.

Before the Pennsylvania Public Utility Commission, Response to Questions re the Investigation into Electric Power Competition, Docket No. I-940032, November 1995.

Before the Commercial Arbitration Tribunal, Statement on Behalf of Esso Australia Resources Ltd. (A.R.B.N. 000 444 860) and BHP Petroleum (North West Shelf) Pty. Ltd. (A.C.N. 004 514 489) in the Matter of Natural Gas Contracts, October 1995.

Before the Public Utilities Commission of the State of California, Response to Coordinating Commissioner Ruling, Proposed Policies Governing Restructuring California's Electric Service Industry and Reforming Regulation, Docket Nos. R.94-04-031 and I.94-04-032, October 1995.

Before the Federal Energy Regulatory Commission, "Electricity Transmission Policy and Promoting Wholesale Competition." Initial Response to the Notice of Proposed Rulemaking Regarding Promoting Wholesale Competition Through Open-Access Non-Discriminatory Transmission Services by Public Utilities, Docket No. RM95-8-000, August 1995.

Before the Federal Energy Regulatory Commission, "Coordination for Competition in an Electricity Market." Response to an Inquiry Concerning Alternative Power Pooling Institutions Under the Federal Power Act, Docket No. RM94-20-000. March 1995.

Before the Wyoming Oil and Gas Commission, State of Wyoming, Testimony on Behalf of Exxon Company, U.S.A. in the Matter of Venting of CO<sub>2</sub> at the La Barge (Shute Creek) Gas Plant, Lincoln County, Wyoming, 1994.

Before the Commercial Arbitration Tribunal, Testimony on Behalf of Esso Australia Resources Ltd. (A.R.B.N. 000 444 860) and BHP Petroleum (North West Shelf) Pty. Ltd. (A.C.N. 004 514 489), in the matter of Natural Gas Contracts, September 1994.

Before the New Mexico State Legislature, Interim Resource Planning Committee, Comments on Electric Industry Restructuring, September 1994.

Before the California Public Utilities Commission, Hearing on Electric Restructuring, Comments on Market Institutions in the Restructured Electric Industry, "An Efficient Bilateral Market Needs A Pool," August 1994.

Before the Pennsylvania House of Representatives, Consumer Affairs Committee, Comments on Electric Industry Restructuring, July 1994.

Before the United States House of Representatives, Energy and Power Subcommittee Hearing, Comments on Electric Industry Restructuring, July 1994.

Before the California Public Utilities Commission, Comments on the Order Instituting Rulemaking and Order Instituting Investigation: on the Commission's Proposed Policies Governing Restructuring California's Electric Services Industry and Reforming Regulation, R.94-04-031 and I.94-04-032, June 1994.

Before the Federal Energy Regulatory Commission, Comments for a Technical Conference on Responses to the Inquiry Concerning the Commission's Pricing Policy for Transmission Services Provided by Public Utilities Under the Federal Power Act, Docket No. RM93-19-000, April 1994.

Before the Federal Energy Regulatory Commission, Response to the Inquiry Concerning the Commission's Pricing Policy for Transmission Services Provided by Public Utilities Under the Federal Power Act, Docket No. RM93-19-000, November 1993.

Before the California Public Utilities Commission, Sur-surrebuttal Testimony on Behalf of Pacific Gas and Electric Company in the Matter of the Canadian Gas Reasonableness Proceeding, Application No. 91-04-003, August 1992.

Before the Office of Hearings and Appeals, U.S. Department of Energy, Testimony on Behalf of Amoco Oil Company et al in the matter of Special Refund Procedures: The 341 Tract Unit of the Citronelle Field, Case No. LFX-0006, July 1992. Cross Examination, January 1993.

Before the California Public Utilities Commission, En Banc Session on Core Procurement Issues, Comments on Behalf of Pacific Gas and Electric Company on Evaluating L.D.C. Gas Procurement Practices, Applications R.90-02-008 and R.88-08-018, February 1992.

Before the California Public Utilities Commission, Rebuttal Testimony on Behalf of Pacific Gas and Electric Company in the Matter of Canadian Gas Reasonableness Issues, 1988-1990, Application No. 91-04-003, February 1992.

Before the United States Senate Foreign Relations Subcommittee on European Affairs, Testimony at the Hearing on Consolidating Free-Market Democracy in the Former Soviet Union, September 1991.

Before the Department of Revenue, State of Alaska, Testimony on Behalf of Exxon Corporation in the Matter of Exxon Corporation and Certain Affiliated Companies, 1978 Oil and Gas Corporate Income Tax, Case No. 86102, May 1991.

Before the Federal Energy Regulatory Commission, Response to Notice of Public Conference and Request for Comments on Utility Issues, ["Transmission Capacity Rights for the Congested Highway: A Contract Network Proposal"] Docket No. PL91-1-000, April 1991.

Before the Public Utilities Commission of California, Testimony on Behalf of Pacific Gas and Electric Company, Order Instituting Rulemaking 88-08-018, in the Matter of an Integrated Capacity Priority Program Proposal, December 1990.

Before the United States House of Representatives Government Operations Committee, Testimony on the Economic and Energy Security Implications of the Persian Gulf Crisis, September 1990.

Before the United States District Court for the Eastern District of Texas, Tyler Division, Testimony on Behalf of Exxon Corporation in the Matter of Exxon Corporation vs. Jarvis Christian College, et al., Docket No. CA No. TY-80-432-CA, (consolidated action), March 1990.

Before the Massachusetts Public Utility Commission, Testimony on Behalf of the Petitioning Gas Companies in the Generic Investigation of Ratemaking Treatment of Environmental Costs Incident to Gas Manufacturing, Docket No. DPU 89-161, November 1989; Rebuttal Testimony on Behalf of the Petitioning Gas Companies, Docket No. DPU 89-161, March, 1990.

Before the Federal Energy Regulatory Commission, Comments on the Federal Energy Regulatory Commission's Proposed Policy Statement on Gas Inventory Charges, Docket No. PL-89-1-000, July 1989.

Before the Federal Energy Regulatory Commission, Statement on Behalf of Designated Marketing Companies in the Case of the Natural Gas Pipeline Company of America, Docket No. RP88-209-000, February 1989.

Before the New Mexico Public Service Commission, Testimony on Behalf of the Public Service Company of New Mexico in the Matter of Prudence of Costs Incurred by Public Service Company of New Mexico in Construction of the Palo Verde Generating Station, Case No. 2087, January 1989.

Before the Federal Energy Regulatory Commission, Comments on the Notice of Proposed Rulemaking re Regulations Governing Bidding Programs, Docket No. RM88-5-000, July 1988.

Before the Federal Energy Regulatory Commission, Answering Testimony on Behalf of Citizens Energy Corporation in the case of the Natural Gas Pipeline Co. of America, Docket Nos. RP87-141-000 et al., December 1987.

Before the California Energy Commission, Biennial Fuels Report Hearing on the Impact on Increased U.S. Oil Imports on California's Energy Vulnerability and Security, June 1987.

Before the Louisiana Public Service Commission, Rebuttal Testimony on Behalf of Gulf States Utilities Company, Prudence Phase, Docket No. U-17282, May 1987.

Before the Public Utility Commission of Texas, Rebuttal Testimony on Behalf of the Gulf States Utilities Company for Authority to Change Rates and Inquiry into the Prudence and Efficiency of the Construction of the River Bend Nuclear Generating Station, Docket Nos. 7195 and 6755, April 1987.

Before the United States Department of Energy, Office of Hearings and Appeals, Post Hearing Reply Brief on Behalf of Cities Service Oil and Gas Corporation on the Issue of Restitution, Case Nos. HRO-0285, HRH-0285, April 1987.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of the California Public Utilities Commission in the case of Mojave Pipeline Company, et al, Docket Nos. CP85-437-000, et al, (Phase 1), March 1987.

Before the United States Department of Energy, Office of Hearings and Appeals, Testimony on Behalf of Cities Service Oil and Gas Corporation, Docket No. HRO-0285, December 1986.

Before the Pennsylvania Public Utility Commission, Rebuttal Testimony on Behalf of The Duquesne Light Company, Docket No. R-860378, November 1986.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of Gulf States Utilities Company, Docket No. ER86-558-000, October 1986.

Before the Public Utility Commission of Texas, Testimony on Behalf of Gulf States Utilities Company on the Issue of Prudence in the Construction of the River Bend Nuclear Generating Station, Docket No. 6755, June 1986.

Before the Massachusetts Department of Public Utilities, Comments on Behalf of Western Massachusetts Electric Company on Pricing and Rate-making Treatment to be Afforded New Generating Facilities Which Are Not Qualifying Facilities, Docket No. DPU 86-36, April 1986.

Before the Pennsylvania Public Utility Commission, Rebuttal Testimony on Behalf of the Philadelphia Electric Company, Docket No. R-850152, February 1986; Sur-Surrebuttal Testimony on Behalf of the Philadelphia Electric Company, Docket No. R-850152, March 1986.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of New England Power Company, Docket Nos. ER85-646-001, ER85-647-001, January 1986.

Before the Public Utility Commission of Texas, Testimony on Behalf of Gulf States Utilities Company on the issue of Rate Changes, et al., Docket Nos. 6477, 6525, and 6660, September 1985.

Before the United States Senate Committee on Energy and Natural Resources, Comments on Future Electricity Needs, July 1985.

Before the Federal Energy Regulatory Commission, Comments on Behalf of The Maryland People's Counsel on Notice Requesting Supplemental Comments Re: Regulation of Natural Gas Pipelines After Partial Wellhead Decontrol, Docket No. RM85-1-000, July 1985.

Before the Federal Energy Regulatory Commission, Testimony on Behalf of Maryland People's Counsel in the case of Columbia Gas Transmission Company, et al., Docket No. TA 82-1-21-000, February 1985.

Before the Pennsylvania Public Utilities Commission, Testimony on Behalf of the Philadelphia Electric Company, Docket No. 1-840381, December 1984; Rebuttal Testimony on Behalf on Philadelphia Electric Company, Docket No. 1-840381, March 1985.

Before the United States Department of Energy, Office of Hearings and Appeals, Comments on Behalf of Beacon Oil Co. et al, on Market Effects of Payment of Exception Orders, September 1984.

Before the United States Department of Energy, Office of Hearings and Appeals, Testimony on Behalf of the States of Colorado et al, Stripper Well Exemption Litigation/ Refiner Evidentiary Hearing, Case No. HFH-0026, September 1984.

Before the Federal Energy Regulatory Commission, Comments on Behalf of The Maryland People's Counsel, Inquiry on Impact of Special Marketing Programs on Natural Gas Companies and Consumers, Docket No. RM84-7-000, August 1984.

Before the Federal Energy Regulatory Commission, Comments at Hearings on Special Marketing Programs, Docket No. RM84-7-000, February 1984.

Before the United States Senate, Subcommittee on East Asian and Pacific Affairs, Comments on the Export of Alaska Oil, July 1983.

Before the Public Utility Commission, State of New Hampshire, Testimony on Behalf of the Public Service Company of New Hampshire, Docket No. DE 81-312, May 1983.

Before the Interstate Commerce Commission, Testimony on Behalf of Delmarva Power and Light Company v. Consolidated Rail Corporation, Docket Nos. 38329, 38330, January 1983.

Before the United States Senate Committee on Finance, Comments on Recycling and Oil Shocks, December 1981.

Before the United States Senate Committee on Finance, Comments on Oil Taxes and Oil Emergencies, December 1980.

## **SPEECHES, CONFERENCES AND OTHER ACTIVITIES**

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, June 2019.

Speaker, China Electric Power Research Institute, Beijing, June 2019.

Speaker, National Energy Administration of China, Beijing, June 2019.

Speaker, State Grid Corporation of China, Beijing, June 2019.

Panelist, Greening Investments in BRI Countries: Opportunities and Challenges, Tsinghua University, Beijing, June 2019.

Speaker, China Power Market International Summit, Beijing, June 2019.

Panelist, WIRES retreat, Boston, MA, May 2019.

Keynote, EUCI Wholesale Power Markets' Price Formation conference, Philadelphia, PA, May 2019.

Panelist, Skadden Energy Conference, Washington, DC, April 2019.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Half Moon Bay, CA, March 2019.

Speaker, Yes Energy User Group Summit, Boulder, CO, February 2019.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Palm Beach, FL, December 2018.

Keynote, Platts 11<sup>th</sup> Annual Nodal Trader Conference, New York, NY, October 2018.

Panelist, World Bank, Washington, DC, September 2018.

Panelist, IAEE conference, Groningen, Netherlands, June 2018.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, June 2018.

Panelist, Energy Bar Association, Washington, DC, June 2018.

Panelist, Skadden Energy Conference, Washington, DC, April 2018.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Washington, DC, March 2018.

Speaker, Yes Energy User Group Summit, Boulder, CO, March 2018.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Palm Beach, FL, January 2018.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Calgary, AB, October 2017.

Keynote, Gas and Power Institute, Houston, TX, September 2017.

Panelist, The Future of Power Markets in a Low Marginal Cost World, Washington, DC, August 2017.

Speaker, Public Utility Commission of Texas, Austin, TX, August 2017.

Keynote, Chile Energy Day, Washington, DC, June 2017.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, June 2017.

Panelist, Edison Electric Institute convention, Boston, MA, June 2017.

Panelist, Federalist Society “State ‘Around Market’ Action and FERC: The End of Competitive Wholesale Electric Markets?” conference, Washington, DC, April 2017.

Keynote speaker, EUCI “Price Formation Issues in Wholesale Energy Markets” conference, Baltimore, MD, April 2017.

Panelist, Skadden Energy Conference, Washington, DC, March 2017.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Savannah, GA, March 2017.

Speaker, Enel Group Foundation Talks, Rome, January 2017.

Panelist, Hawaii International System Science Conference, Waikoloa, HI, January 2017.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Scottsdale, AZ, December 2016.

Panelist, National Conference of State Legislatures Capitol Forum, December 2016.

Moderator, New England Legal Foundation CEO Forum, Boston, MA, December 2016.

Distinguished Speaker Series, MIT Energy Initiative, November 2016.

Moderator, Platts Annual Nodal Trader Conference, New York, NY, October 2016.

Panelist, Organization of PJM States annual meeting, October 2016.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Washington, DC, October 2016.

Panelist, Institute for Data, Systems, and Society, MIT, September 2016.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, June 2016.

Panelist, “Designing Markets for a Decarbonizing Power System,” MIT Energy Institute, Cambridge, MA, May 2016.

Panelist, Electric Power Supply Association annual meeting, Chicago, IL, April 2016.

Keynote Speaker, National Capitol Area Chapter, United States Association for Energy Economics, April 2016.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Washington, DC, March 2016.

Speaker, FERC Legacy Series, Washington, DC, February 2016.

Panelist, Energy Mexico 2016, Mexico City, January 2016.

Speaker, UCLA IPAM workshop, Los Angeles, CA, January 2016.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Palm Beach, FL, December 2015.

Keynote speaker, MIT Center for Energy and Environmental Policy Research workshop, Cambridge, MA, November 2015.

Panelist, New England Energy Policy Summit, Cambridge, MA, October 2015.

Panelist, EUCI conference, Cambridge, MA, September 2015.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Washington, DC, June 2015.

Panelist, Skadden Energy Roundtable, Washington, DC, June 2015.

Speaker, Energy Bar Association, Newark, NJ, June 2015.

Keynote speaker, Associated Electric Cooperative annual meeting, Branson, MO, June 2015.

Panelist, A Symposium on Market Power and Market Manipulation in Energy Markets, Washington, DC, May 2015.

Speaker, Workshop on the Analysis and Management of Energy and Environmental Policy, Cambridge, MA, April 2015.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Half Moon Bay, CA, March 2015.

Speaker, Symposium on Mexico's Energy Reforms, Tufts University, Medford, MA, February 2015.

Speaker, Harvard National Model United Nations, Boston, MA, February 2015.

Speaker, EU Electricity Markets for Renewable Integration workshop, DIW Berlin, January 2015.

Panelist, Energy Bar Association meeting, Washington, DC, January 2015.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, New Orleans, LA, December 2014.

Keynote speaker, Platts Nodal Trader Conference, New York, NY, October 2014.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, October 2014.

Speaker, USAEE Breakfast Energy Series of Talks, Washington, DC, July 2014.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, June 2014.

Panelist, NYISO 2014 Energy Conference, New York, NY, June 2014.

Panelist, Restructuring the Electricity Sector in Japan, Brookings Institution, March 2014.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Santa Monica, CA, February 2014.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Tucson, AZ, December 2013.

Panelist, NARUC annual conference, Orlando, FL, October 2013.

Panelist, EUCI Scarcity Pricing Conference, Baltimore, MD, November 2013.

Panelist, NECA, Power Markets Conference, Westborough, MA, October 2013.

Keynote speaker, Platts Nodal Trader Conference, New York, NY, October 2013.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, September 2013.

Keynote speaker, Nexant User Conference, San Diego, CA, September 2013.

Panelist, Aspen Energy Forum, Aspen, CO, July 2013.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Calgary, AB, June 2013.

Speaker, Electricity Market Design on Two Sides of the Atlantic, CEEPR, MIT, May 2013.

Panelist, Austin Electricity Conference, April 2013.

Panelist, Gulf Coast Power Association, Houston, TX, April 2013.

Speaker, Skadden Enforcement and Compliance Conference, Washington, DC, March 2013.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Dana Point, CA, March 2013.

Speaker, 40<sup>th</sup> Annual Public Utilities Research Center conference, University of Florida, Gainesville, February 2013.

Keynote speaker, The Economics of Energy Markets Conference, Toulouse, France, January 2013.

Speaker, International Experience in Transmission Planning and Delivery conference, Imperial College, London, UK, January 2013.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Washington, DC, December 2012.

Speaker, International Association of Energy Economics conference, Austin, TX, November 2012.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, October 2012.

Speaker, Energy Compliance Network, Houston, TX, October 2012.

Speaker, Australian Competition and Consumer Commission regulatory conference, Brisbane, July 2012.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, June 2012.

Speaker, Geopolitics of Natural Gas Workshop, Baker Institute, Rice University, Houston, TX, May 2012.

Speaker, Weston Roundtable Series, University of Wisconsin, Madison, WI, April 2012.

Speaker, Pressing Issues in World Energy Policy, University of Florida, Gainesville, FL, March 2012.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Santa Monica, CA, February 2012.

Speaker, Projects & Money 2012 conference, New Orleans, LA, January 2012.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Dallas, TX, December 2011.

Speaker, NHH Workshop on Pricing in Deregulated Energy Markets, Voss, Norway, November 2011.

Panelist, BP/Harvard Kennedy School Symposium on Energy, Climate and Security Policy. Cambridge, MA, November 2011.

Speaker, Energy: Transition to a Sustainable Future, part of 2011 Industrial Physics Forum, Nashville, TN, October 2011.

Keynote speaker, Independent Oil Marketers Association of New England, Westborough, MA, October 2011.

Conference Co-Chair and panelist, Harvard Electricity Policy Group Plenary Session, Nashville, TN, September 2011.

Panelist, Aspen Energy Policy Forum, Aspen, CO, July 2011.

Panelist, "Institutions, Efficiency and Evolving Energy Technologies," International Association for Energy Economics, June 2011.

Keynote speaker, The Economics of Energy Markets Conference, Toulouse, France, June 2011.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Washington, DC, May 2011.

Panelist, "EPRG Spring Research Seminar: Renewable Energy Policy," Robinson College, University of Cambridge, UK.

Panelist, "Overcoming Barriers to Smart Grids & New Energy Services," University of Texas, Austin, TX.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Rancho Palos Verdes, CA, February 2011.

Moderator, "New Realities: Russia's Natural Gas Sector in Light of Shale Gas and LNG Advances," Russian Energy Conference, Harvard University, December 2010.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Tucson, AZ, December 2010.

Panelist, "Are the Wholesale Power Markets Delivering Benefits – An Open Forum Discussion," Northeast Energy and Commerce Association "Looming Changes in ISO New England's Power Markets" conference, November 2010.

Keynote Speaker, Boston Cleantech Venture Day, “Electricity Market Reform: Market Design, Smart Pricing and the Green Agenda,” Boston, MA, November 2010.

Panel moderator, Chasing the Balance: Our Energy Future, Harvard Business School, October 2010.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, October 2010.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Santa Monica, CA, May 2010.

Panelist, “Fair Pricing: A Conference on Ethics and Dynamic Pricing,” Rutgers Business School, Newark, NJ, April 9, 2010.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Santa Monica, CA, February 2010.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Austin, TX, December 2009.

Speaker, Singapore Electricity Roundtable, “Competitive Electricity Markets – Trends and Developments,” Singapore, November 17, 2009.

Speaker, Exelon/Energy Bar Association workshop on Scarcity Pricing, Washington, DC, October 16, 2009.

Speaker, MIT Operations Research Center Seminar Series, October 15, 2009.

Keynote Speaker, National Energy Policy Institute conference on “Power for the 21<sup>st</sup> Century: Reinventing America’s Power Grid,” Tulsa, OK, October 7, 2009.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, October 2009.

Speaker, Elforsk Market Design and SAEF conference, “Design of Competitive Electricity Markets, Stockholm, Sweden, September 17-18, 2009.

Speaker, EUCI Conference on “FTRs – Where are We Now?,” Washington, D.C., July 2009.

Speaker, White House Council on Environmental Quality, Washington, D.C., July 2009.

Lecturer, Infrastructure in a Market Economy, Harvard Kennedy School, Cambridge, MA, July 2009.

Speaker, Aspen Institute: 2009 Energy Policy Forum, “The Goals: An Electricity Grid for 21<sup>st</sup> Century,” July 2009.

Conference Co-Chair, Harvard Electricity Policy Group 55<sup>th</sup> Plenary Session, Cambridge, MA, May 2009.

Panelist, “Scarcity Pricing and Solutions,” Exelon Power Team, Kennett Square, PA, May 2009.

Panelist, “Disrupting the Status Quo in Electric Energy Management,” Boston University, Brookline, MA, May 2009.

Presenter, “Smart Grid Regulation,” GE Energy, Atlanta, GA, May 2009.

Keynote speaker, “Stimulating Energy Symposium”, Harvard University, Cambridge, MA, May 2009.

Panelist, "Regulation and Electricity Markets," Western Power Trading Forum, New York, NY, April 2009.

Press release of study: Alternative Power Market Proposals Reflect Fundamental Misunderstandings of RTO Markets, FERC, Washington, DC, April 2009.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, La Jolla, CA, March 2009.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Atlanta, GA, December, 2008.

Panelist, "Energy Policy and Energy Interdependence," Hudson Institute, Washington, DC, Nov. 18, 2008.

Moderator, "Challenges in Energy Law and Litigation," LECG XPRT Forum, Santa Barbara, CA, November 14, 2008.

Participant, "Dubai, Summit on the Global Agenda," Dubai, United Arab Emirates, November 7-9, 2008.

Panelist, "NECA 2008 Power Markets Conference, Westboro, MA, October 30, 2008.

Panelist, "Energy Policy Challenges: Is the Past Prologue?," Resources for the Future, Washington, DC, October 29, 2008.

Participant, Harvard University Sustainability Celebration with Harvard President Drew Faust and Al Gore, Cambridge, MA, October 22, 2008.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Chicago, IL, October, 2008.

Panelist, "Powering the Future: Key Energy Issues for the Next Administration," Technology Policy Institute, Washington, D.C., September 26, 2008.

Steering Committee Co-Chair and Panelist, Harvard Kennedy School workshop, "Acting in Time on Energy Policy," Cambridge, MA, September 18-19, 2008.

Speaker, NYISO Annual Board Retreat, Rye, NY, September 14, 2008.

Keynote Presenter, PSEG Executive Session, "Electricity Market Design: Regulation and Market Reforms," Newark, NJ, August 11, 2008.

Speaker, Aspen Institute: 2008 Energy Policy Forum, "Climate Change and the Electricity Sector," July 2008.

Panelist, "Advancing Sustainability in the Oil and Gas Industry," World Petroleum Congress, Madrid, Spain, July 2, 2008.

Keynote Presenter, IDEI Conference: The Economics of Energy Markets, "Market-Clearing Electricity Prices and Energy Uplift," Toulouse, France, June 20, 2008.

Presenter, "Acting in Time: Regulating Wholesale Electricity Markets," Federal Energy Regulatory Commission Conference on Competition in Wholesale Power Markets, May 8, 2007.

Speaker, "Electricity Market Design: Coordination, Pricing and Incentives," ERCOT Energized Conference, Austin, TX, May 2008.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, May 2008.

Panelist, "Challenges for Long-Term Energy Models," Energy Information Administration Conference, Washington, DC, April 6-8, 2008.

Keynote Speaker, 15<sup>th</sup> Annual U.S.-Japan Symposium, "Stability and Sustainable Growth in the Asia/Pacific Region," Harvard Kennedy School, Cambridge, MA, March 18, 2008.

Panelist, "Reliability and Competition: The Price of Reliability?," Independent Power Producers of Alberta 2008 Annual Conference, Banff, Alberta, Canada, March 10, 2008.

"Electricity Market Design: Coordination, Pricing and Incentives," Faculty Research Seminar, Harvard Kennedy School, Cambridge, MA, March 5, 2008.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Boulder, CO, February 28-29, 2008.

"Electricity Market Design: Coordination, Pricing and Incentives," Energy Policy Research Seminar, Harvard Kennedy School, Cambridge, MA, February 12, 2008.

Keynote Presenter, La Asociación Española para la Economía Energética (AEEE), Bilbao, Spain, January 2008.

Conference Co-Chair, Harvard Electricity Policy Group Plenary Session, Los Angeles, CA, December 2007.

Co-Chair, Kennedy School of Government, Harvard University, "Populism and Natural Resources" workshop, Cambridge, MA, November 2007.

Panelist, Harvard University, "Climate Engineering" workshop, Cambridge, MA, November 2007.

Speaker, Kennedy School of Government Alumni Refresher, Harvard University, "Electricity Market Design(s): Public Purposes and Policy Analysis," Cambridge, MA, November 2007.

Speaker, Club de Madrid "Energy and Democracy" conference, "Democratizing Energy," Madrid, Spain, November 2007.

Speaker, 27<sup>th</sup> USAEE/IAEE North American Conference, "Electricity Hybrids: Mixed Market Designs and Infrastructure Investments," Houston, TX, September 2007.

Speaker, Edison Electric Institute, 2007 Transmission and Wholesale Markets School, Madison, WI, July 2007.

Speaker, Real Colegio Complutense en Harvard, "Energy Industry Restructuring," Cambridge, MA, July 2007.

Speaker, 2007 Aspen Energy Policy Forum, "Electricity Markets – Where Are We Going?" July 2007.

Conference Co-Chair, Harvard Electricity Policy Group 47<sup>th</sup> Plenary Session, Cambridge, MA, June 2007.

Speaker, 14<sup>th</sup> Annual New England Energy Conference and Exposition, "Moving Into a Secure and

Competitive Future," Mystic, CT, May 2007.

Discussant, 15<sup>th</sup> Economia Panel Meeting, Yale University, New Haven, CT, May 2007.

Conference Co-Chair, Harvard Electricity Policy Group 46<sup>th</sup> Plenary Session, Laguna Beach, CA, March 2007.

Speaker, Institut D'Economie Industrielle, Toulouse, Conference on the Economics of Energy Markets, Toulouse, France, January 2007.

Conference Co-Chair, Harvard Electricity Policy Group 45<sup>th</sup> Plenary Session, Dallas, TX, December 2006.

Speaker, University of Massachusetts INFORMS Seminar, Electricity Market Restructuring and Operations Research, Amherst, MA, October 2006.

Speaker, EUCI Conference on Transmission Reliability, Washington D.C., October 2006.

Conference Co-Chair, Harvard Electricity Policy Group 44<sup>th</sup> Plenary Session, Cambridge, MA, September 2006.

Conference Co-Chair, XVI Repsol YPF - Harvard Seminar on Energy Policy, Energy Markets, Security, Transparency, Barcelona, Spain, September 2006.

Keynote Speaker, 26<sup>th</sup> USAEE/ IAEE Annual North American Conference, Ann Arbor, MI, September 2006

Speaker: Edison Electric Institute, Transmission Market and Design Course, University of Wisconsin-Madison, Madison, WI, July 2006.

Keynote Speaker, Independent Power Producers Society of Alberta, Canada (IPPSA), Roundtable re Electricity Restructuring, Long-term Adequacy, Market Design, Calgary, Canada, June 2006.

Conference Co-Chair, Harvard Electricity Policy Group 43<sup>rd</sup> Plenary Session, Cambridge, MA, June 2006.

Speaker, Real Colegio Complutense - Harvard, Seminar on Government Restructuring: Privatization, Regulation and Competition, Cambridge MA, June 2006.

Speaker, Plenary Session, New England Conference of Public Utility Commissioners (NECPUC), Rockport, ME, June 2006.

Keynote Speaker, Infocast Conference on Open Access Transmission Tariff (OATT) Reform, Washington, D.C., June 2006.

Commentator, Conference on Venezuelan Economic Growth 1970-2005, Center for International Development, Harvard University, Cambridge MA, April 2006.

Speaker, University of California Energy Institute, POWER Conference, Berkeley, CA, March 2006.

Conference Co-Chair, Harvard Electricity Policy Group 42<sup>nd</sup> Plenary Session, La Jolla, CA, March 2006.

Speaker, Florence School of Regulation, Workshop on the Role and Status of Power Exchanges, European University Institute, Florence, Italy, January 2006.

Speaker, New York Independent System Operator, Workshop on Transmission Investments in Deregulated Markets, Albany, NY, December 2005.

Conference Co-Chair, Harvard Electricity Policy Group 41<sup>st</sup> Plenary Session, Atlanta, GA, December 2005.

Speaker, The Association of Power Exchanges [APEX] 2005 Annual Conference, Orlando, FL, November 2005.

Speaker, EUCI Conference on "Open Access: Are We There Yet?" Washington, D.C., October 2005.

Speaker, EUCI Conference on Transmission Investments and Reliability, Brewster, MA, September 2005.  
Conference Co-Chair, Harvard Electricity Policy Group 40<sup>th</sup> Plenary Session, Cambridge, MA, September 2005.

Speaker, IAAE European Energy Conference, European Energy Markets in Transition, Bergen, Norway, August 2005.

Speaker, NARUC Electricity Committee Summer Conference, Austin, TX, July 2005.

Conference Co-Chair, Speaker, XV Repsol YPF - Harvard Seminar on Energy Policy, Making Energy Policy Work, Lisbon, Portugal, June 2005.

Speaker, IDEI Conference on the Economics of Electricity Markets, Toulouse, France, June 2005.

Conference Co-Chair, Harvard Electricity Policy Group 39<sup>th</sup> Plenary Session, Cambridge, MA, May 2005.

Speaker, McDermott, Will & Emery Energy Conference, Washington, D.C., April 2005.

Conference Co-Chair, Harvard Electricity Policy Group 38<sup>th</sup> Plenary Session, San Diego, CA, March 2005.

Speaker, American Antitrust Institute, Conference on Open Access Revisited: Lessons Learned, Arlington, VA, January 2005.

Speaker, Carnegie-Mellon University, Workshop on Electricity Transmission in Deregulated Markets, Pittsburgh, PA, December 2004.

Conference Co-Chair and Speaker, Harvard Electricity Policy Group Plenary Session, Austin TX, December 2004.

Conference Co-Chair, Harvard Electricity Policy Group 37<sup>th</sup> Plenary Session, Austin, TX, December 2004.

Speaker, IEEE/PSCE Power Systems Conference & Exposition, New York, NY, October 2004.

Conference Co-Chair, Harvard Electricity Policy Group 36<sup>th</sup> Plenary Session, Cambridge, MA, October 2004.

Speaker, IAAE European Conference on Modeling Energy Economics and Policy, Zurich, Switzerland, September 2004.

Speaker, EEI Market Design and Transmission Pricing School, Madison, WI, July 2004.

Conference Co-Chair, XIV Repsol YPF-Harvard Seminar on Energy Policy, Managing Energy Markets, A Coruña, Spain, June 2004.

Conference Co-Chair, Harvard Electricity Policy Group 35<sup>th</sup> Plenary Session, Cambridge, MA, May 2004.

Speaker, EUCI Conference on Preventing the Next Blackout, Washington D.C., April 2004.

Speaker, Panel Chair, U. Richmond Law School, Merhige Center of Environmental Law, Conference on The Blackout of 2003: What's Next? Richmond, VA, April 2004.

Conference Chair, Speaker, IEA Workshop on Transmission Network Reliability in Competitive Electricity Markets, Paris, France, March 2004.

Conference Co-Chair, Harvard Electricity Policy Group 34<sup>th</sup> Plenary Session, San Diego, CA, March 2004.

Speaker: CIDE-CRE Seminar: Energy Regulatory Developments in North America, Mexico City, Mexico, January, 2004.

Speaker, Infocast Transmission Executive Forum: Unlocking Transmission Investment, Washington D.C., January, 2004.

Speaker, IDEI Conference on Competition and Coordination in the Electricity Industry, Toulouse, France, January 2004.

Conference Co-Chair, Harvard Electricity Policy Group 33<sup>rd</sup> Plenary Session, Point Clear, AL, December 2003.

Session Chair, Conference on Wholesale Power Markets in New England, NECA, Boston, MA, November, 2003.

Speaker, New Directions in Regulation Seminar, Kennedy School of Government, Cambridge MA, October 2003.

Conference Co-Chair, Harvard Electricity Policy Group 32<sup>nd</sup> Plenary Session, Cambridge, MA, September 2003.

Speaker, EEI Market Design and Transmission Pricing School, Madison, WI, July 2003.

Session Chair, Aspen Institute Summer Energy Forum, Aspen, CO, July 2003.

Speaker, Standard and Poors 2003 Utility and Energy Conference, New York, NY, June 2003.

Speaker, ESAI Northeast Locational Energy Roundtable, Wakefield, MA, June 2003.

Speaker, 10<sup>th</sup> Annual Spring Energy Conference, NECA, Mystic, CT, June 2003.

Keynote Speaker, VII Latin American Energy Regulatory Entities Association (ARIAE) annual meeting, Oaxaca, Mexico, May 2003.

Conference Chair, XIII Repsol YPF-Harvard Seminar on Energy Policy, Salamanca, Spain, May 2003.

Conference Co-Chair, Harvard Electricity Policy Group 31<sup>st</sup> Plenary Session, Cambridge, MA, May 2003.

Speaker, 20<sup>th</sup> Annual Platts User Conference, Amelia Island, FL, April 2003.

Speaker, Conference on Deregulation in a Turbulent World, Maguire Energy Institute, Southern Methodist University, Dallas TX, April 2003.

Speaker, Conference on Electricity Deregulation: Where to From Here? Bush Presidential Conference Center, Texas A&M University, College Station, TX, April 2003.

Conference Co-Chair, Harvard Electricity Policy Group Special Session on Transmission, Cincinnati, OH, April 2003.

Speaker, EIA 2003 National Energy Modeling System, Annual Energy Outlook Conference, Washington D.C., March 18, 2003.

Speaker, U.S. Department of State-sponsored videoconference from Australia, "Creating a Competitive Electricity and Gas Market." Cambridge, MA, USA and Canberra, Australia, February 2003.

Conference Co-Chair, Harvard Electricity Policy Group 30<sup>th</sup> Plenary Session, Palm Springs, CA, January 2003.

Speaker, Center for Energy and Environmental Policy Research, MIT, Workshop, Cambridge, MA, December 2002.

Session Co-Chair, Harvard Electricity Policy Group Special Session on Western Issues, Denver CO, December 2002.

Speaker, Nordic Energy Research Council, Conference on Electricity Market Reforms, Experiences and Lessons for the Future, Copenhagen, Denmark, November 2002.

Keynote Speaker, US Combined Heat and Power Association, 3d Annual Conference, Boston, MA, October 2002.

Panel Chair, ABA Section of Environment, Energy and Resources, Fall Meeting. Panel on FERC Rulemaking and Orders on RTO Development and Wholesale Electricity Market Structure," Portland, OR, October 2002.

Conference Co-Chair, Harvard Electricity Policy Group 29<sup>th</sup> Plenary Session, Cambridge, MA, September 2002.

Speaker, Harvard Business School Senior Executive Program/ E.ON Academy, Boston, MA, August 2002.

Speaker, Christensen Associates Conference on Connecting Wholesale and Retail Electricity Markets, Denver, CO, August 2002.

Speaker, EEI Market Design and Transmission Pricing School, Madison, WI, July 2002.

Speaker, 25<sup>th</sup> Annual IAEE International Conference, Aberdeen, Scotland, June 2002.

Conference Co-Chair, Harvard Electricity Policy Group 28<sup>th</sup> Plenary Session, Cambridge, MA, May 2002.

Speaker, Platts RDI User Conference, Amelia Island, Florida, April 2002.

Speaker, ABA Antitrust Section Spring Meeting, Washington, D.C., April 2002.

Conference Co-Chair, Harvard Electricity Policy Group Special Session, Atlanta, GA, April 2002.

Speaker, Carnegie-Mellon-Stanford Workshop on Energy Research Programs, Washington D.C. April 2002.

Keynote Speaker, USAEE /SAIS Washington Energy Policy Conference: New Developments in Electric Market Restructuring" Washington D.C., May 2002.

Speaker, Center for Research in Regulated Industries, Rutgers University, Advanced Workshop in Regulation and Competition, 21<sup>st</sup> Annual Eastern Conference, Newport, RI, May 2002.

Speaker, Harvard-Japan Project on Energy and the Environment, Tokyo Conference, Tokyo, Japan, January 2002.

Conference Co-Chair, Harvard Electricity Policy Group 27<sup>th</sup> Plenary Session, San Diego, CA, January 2002.

Keynote Speaker, ESAI Roundtable on Northeast Power Prices, Wakefield, MA, January 2002.

Keynote Speaker, Iberdrola Group Conference on Ten Years of Electricity Liberalization and Restructuring: Lessons Learned and Future Challenges, Madrid, Spain, December 2001.

Speaker, Commission de Regulation de l'Electricite, France, Conference on Market Design in Restructured Electricity Markets, Paris, France, November 2001.

Conference Co-Chair, Harvard Electricity Policy Group Special Session on Market Design, Cambridge, MA, September 2001.

Session Chair, National Association of Attorneys General, Energy Conference, Boston, MA, November 2001.

Speaker, Eighth Annual Kentucky Utility Conference, Lexington, KY, October 2001.

Conference Co-Chair, Harvard Electricity Policy Group, 26<sup>th</sup> Plenary Session, Washington, D.C., September 2001.

Speaker, Conference on Reform in the Mexican Electricity Industry, CIDE, Mexico City, September 2001.

Speaker, N.E. Environmental Protection Agency, Conference on "Keeping the Lights On and the Air Clean: Making the Energy-Environment Connection in New England," Cambridge, MA, July 2001.

Seminar Co-Chair, XII Repsol YPF - Harvard Seminar on Energy Policy, Energy Liberalization and Regulation: Revisiting Objectives and Results, Palma de Mallorca, Spain, July 2001.

Conference Co-Chair, Aspen Institute Program on Energy, the Environment, and the Economy, Forum on Energy Supplies and the Infrastructure, Aspen, CO, June 2001.

Conference Co-Chair, Harvard Electricity Policy Group 25<sup>th</sup> Plenary Session, Cambridge, MA, June 2001.

Speaker, Hale and Dorr Energy Group, Session on California and the Lessons for Massachusetts, Boston, MA, June 2001.

Speaker, Princeton University International Workshop on Privatization, Regulatory Reform, and Corporate Governance, Princeton, NJ, June 2001.

Speaker, EEI Transmission Policy Task Force Workshop, Milwaukee, WI, June 2001.

Speaker, 20th Annual Conference, Center for Research in Regulated Industries, Rutgers University, Tamiment, PA, May 2001.

Speaker, Conference on the Texas Electric Market and How It Compares to the California Market, University of Texas at Austin, TX, May 2001.

Speaker, NY State Associated Press Conference, Syracuse, N.Y., April 2001.

Speaker, American Power Conference, Chicago, IL, April 2001.

Conference Co-Chair, Harvard Electricity Policy Group Special Session, Cambridge, MA, April 2001.

Speaker, National Energy Marketers Conference, Washington, D.C., April 2001.

Speaker, Utilicon Conference, Auckland, New Zealand, March 2001.

Speaker, AEI/ Brookings Joint Center Conference, "The California Electricity Market Meltdown: The End of Deregulation?" Washington, D.C., March 2001.

Conference Co-Chair, Harvard Electricity Policy Group 25<sup>th</sup> Plenary Session, San Diego, CA, February 2001.

Conference Co-Chair, Speaker, Harvard-Japan Project on Energy and the Environment, Tokyo, January 2001.

Conference Co-Chair, Speaker, XI Repsol YPF - Harvard Seminar on Energy Policy, Buenos Aires, Argentina, December 2000.

Conference Co-Chair, Harvard Electricity Policy Group Special Session on RTOs, Houston, TX, December 2000.

Speaker, Infocast Conference on Congestion and Parallel Path Issues, Washington, D.C., November 2000.

Speaker: Energy Bar Association MidYear Meeting, Washington D.C., November 17, 2000.

Speaker, Northeast Power Coordinating Council, General Meeting 2000 on Restructuring Reliably, Boston, MA, September 2000.

Conference Co-Chair, Harvard Electricity Policy Group 23<sup>rd</sup> Plenary Session, Boston, MA, September 2000.

Speaker, IAAE Conference "Towards an Integrated European Energy Market," Bergen, Norway, August 2000.

Speaker, Workshop for Markets for Electricity Economics and Technology (MEET), Palo Alto, CA, August 2000.

Conference Co-Chair, Aspen Institute Energy Forum on the Future Structure of the Energy Industry, Aspen, CO, July 2000.

Speaker, Conference on "Market Surveillance in Ontario's Wholesale Electricity Market," Toronto, Ontario, Canada, June 2000.

Speaker, Conference on "The New Energy in the New Millennium in Asturias," Oveido, Spain, June 2000.

Speaker, Northeast Energy and Commerce Association Annual Conference: "Emerging Energy Markets: the Future is Now," Boxborough, MA, May 2000.

Conference Co-Chair, Harvard Electricity Policy Group 22<sup>nd</sup> Plenary Session, Cambridge, MA, May 2000.

Discussant, Brookings Conference on Economic Activity in Latin America, New York University, New York, NY, May 2000.

Speaker, EEI/ Energy Daily Conference on Market Monitoring, Washington, D.C., May 2000.

Keynote Speaker, National Regulatory Agency on Electrical Energy (ANEEL), Brazil, International Teleconference on Strategic Development, Belo Horizonte, Brazil and Cambridge, MA, April 2000.

Speaker, IIT/ American Power Conference 2000, "What Is the Optimum Structure for the Midwest Grid?" Chicago, Illinois, April 2000.

Speaker, International Bar Association, Section on Energy and Natural Resources Law 2000, Hong Kong, April 2000.

Speaker, Infocast Conference on Maximizing the Value of Transmission Assets," Washington, D.C., April 2000.

Speaker, POWER Research Conference on Electricity Industry Restructuring, University of California, Berkeley, CA, March 2000.

Conference Co-Chair, Harvard Electricity Policy Group Special Session on Transition, Dallas, TX, March 2000.

Speaker, Christian A. Johnson Distinguished Lecture Series, "Making Markets for Power," Colby College, Waterville, ME, March 2000.

Speaker, Cantor Lecture Series 2000 on Energy and Society, Royal Society for the Encouragement of Arts, Manufactures & Commerce (RSA), London, UK, February 2000.

Speaker, Harvard-Japan Project on Energy and the Environment, Tokyo Conference, Tokyo, Japan, January 2000.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group 21<sup>st</sup> Plenary Session, St. Helena, CA, January 2000.

Conference Co-Chair, Speaker: Harvard Electricity Policy Group Special Session on the State of the Wholesale Market: Reliability and Regional Trade, Chantilly, VA, November 1999.

Speaker, EEI Transmission Policy Task Force Meeting, Denver, CO, November 1999.

Speaker, Conference on the Impacts of Congestion Pricing on Competitive Markets, Washington, D.C., November 1999.

Speaker, Northeast Interregional ISO Coordination Conference, Albany, NY, October 1999.

Speaker, ISO New England Board of Directors Meeting, Chatham, MA, October 1999.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group 20th Plenary Session, Newport, RI, September 1999.

Speaker, Utility Futures Group Seminar, Energy Foundation, Chicago, IL, September 1999.

Speaker, Session Chair, XX USAEE North American Conference, Orlando, FL, August 1999.

Speaker, XVII Latin American Meeting of the Econometric Society, Latin American Electricity Restructuring, Cancun, Mexico, August 1999.

Speaker, NARUC Summer Meeting, Electricity Committee Session, San Francisco, CA, July 1999.

Speaker, Executive Session on Infrastructure in a Market Economy, Kennedy School of Government, Harvard University, Cambridge, MA, July 1999.

Speaker, Executive Session on Environmental Economics and Policy Analysis, Harvard Institute for International Development, Harvard University, Cambridge, MA, July 1999.

Speaker, International Program on Privatization and Regulatory Reform, Harvard Institute for International Development, Harvard University, Cambridge, MA, July 1999.

Speaker, Workshop on the Introduction to Energy Economics and Policy, sponsored by the Department of Energy, Mexico, Mexico City, Mexico, June 1999.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group 19th Plenary Session, Cambridge, MA, May 1999.

Speaker, Session Chair, Hudson Institute International Forum on Regulatory Policy: Regulators and the Regulated -- Making the Regulatory Process Work, Washington, D.C., April 1999.

Speaker, Conference on Independent Transmission Companies: A Better Alternative to ISOs? Las Vegas, NV, April 1999.

Speaker, Infocast Conference on Congestion Management, Washington, D.C., March 1999.

Conference Co-Chair, Harvard Electricity Policy Group, Special Session on Retail and Wholesale Transmission Markets, Washington, D.C., March 1999.

Speaker, Massachusetts Electric Restructuring Roundtable, Boston, MA, March 1999.

Speaker, New England Conference of Public Utilities Commissioners, Conference on Congestion Management, Nashua, NH, March 1999.

Speaker, ITAM Conference on Electricity Restructuring, Mexico City, Mexico, February 1999.

Speaker, EEI/Energy Daily Conference on Grid Regionalization, Washington, D.C., February 1999.

Speaker: IEEE Power Engineering Society Winter Meeting, New York, NY, February 1999.

Conference Co-Chair, Session Chair, Harvard Electricity Policy Group 18th Plenary Session: Retail Competition in Theory and in Practice, Carmel, CA, January 1999.

Speaker, Harvard-Japan Project on Energy and the Environment, Annual Conference, Tokyo, January 1999.

Speaker, Edison Electric Institute Chief Executive Conference, Phoenix, AZ, January 1999.

Session Chair, Speaker: Federal Energy Bar Association Mid Year Meeting, Washington, D.C., December 1998.

Conference Co-Chair, Speaker: Harvard Electricity Policy Group Special Seminar on Regional Boundaries, Regional Markets and Regional Institutions, Milwaukee, WI, November 1998.

Speaker, ICM Conference on ISOs, Chicago, IL, November 1998.

Speaker, Massachusetts Electric Utility Restructuring Roundtable, Boston, MA, October 1998.

Speaker, GPU Rate Conference, Short Hills, NJ, October 1998.

Keynote Speaker, Conference on Pricing and Tariffs: How Transmission Pricing and Constraints Will Impact Competitive Markets, Washington, D.C., September 1998.

Conference Co-Chair, Harvard Electricity Policy Group 17<sup>th</sup> Plenary Session, Cambridge, MA, September 1998.

Speaker, FACS Conference on Covering Electricity Restructuring, Bedford, MA, September 1998.

Speaker, Workshop on Environmental Economics & Policy Analysis, Harvard Institute for International Development, Cambridge, MA, July 1998.

Speaker, International Program on Privatization and Regulatory Reform, Harvard Institute for International Development, Cambridge, MA, July 1998.

Session Chair, Aspen Institute Program on Energy, the Environment, and the Economy, Aspen, CO, July 1998.

Speaker, Seminar on Electricity Deregulation, Università della Svizzera Italiana, Lugano, Switzerland, June 1998.

Conference Co-Chair, Session Chair, IX Repsol-Harvard Seminar on Energy Policy: "Geopolitics, Energy and the Future," Santiago de Compostela, Spain, June 1998.

Keynote Speaker, Conference on Transmission Pricing, Denver, CO, June 1998.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group 16<sup>th</sup> Plenary Session, on Looking to National Electric Restructuring Legislation, Cambridge, MA, May 1998.

Keynote Speaker, GE MAPS Users' Conference, Washington, D.C., May 1998.

Speaker, Province of Ontario, Market Design Committee, International Workshop on Electricity Restructuring, Toronto, Canada, May 1998.

Speaker, Conference on Antitrust and Anticompetitive Behavior: The New Rules of the Game for Electric Power, Washington, D.C., May 1998.

Conference Co-Chair, Harvard Electricity Policy Group and Managing the Atom Project: Workshop on Utility Restructuring and Nuclear Power, Boston, MA, April 1998.

Conference Co-Chair, Harvard Electricity Policy Group, Special Seminar on Independent System Operators, Portland, OR, April 1998.

Speaker, American Power Conference, 60th Annual Meeting, Technology: Focus for Competition and Globalization, Chicago, IL, April 1998.

Speaker, Progress and Freedom Foundation Conference on Creating Competitive Markets in Electricity: Progress in the States, Washington, D.C., March 1998.

Speaker, IEEE Power Engineering Society Winter Meeting, Tampa, FL, February 1998.

Speaker, LeBoeuf Lamb Greene & MacRae Seminar on the Introduction of Independent Power and the Restructuring of the Electricity Sector, San Francisco, CA, January 1998.

Conference Co-Chair, Harvard Electricity Policy Group, 15<sup>th</sup> Plenary Session, San Diego, CA, January 1998.

Speaker, Harvard-Japan Project on Energy and the Environment Tokyo Seminar, Tokyo, Japan, January 1998.

Speaker, NARUC-DOE Fifth National Electricity Forum, "Creating a New Industry," Washington, D.C., December, 1997.

Speaker, Conference on Antitrust and Anticompetitive Behavior, Washington, D.C., December 1997.

Speaker, Harvard-Ukrainian National Security Program, Harvard University, Cambridge, MA, December 1997.

Conference Co-Chair, Harvard Electricity Policy Group, Special Session on "Looking Ahead to the New Electricity Market: What Should Regulators Do?" Washington, D.C., November, 1997.

Speaker, USAEE North American Conference on International Energy Markets, Competition and Policy, San Francisco, CA, September 1997.

Conference Co-Chair, Harvard Electricity Policy Group 14<sup>th</sup> Plenary Session, San Diego, CA, September 1997.

Speaker, Energy Daily Annual Retail Competition Conference: Defining Yourself in the Retail Marketplace, Washington, D.C., September 1997.

Speaker, International Program on Privatization and Regulatory Reform, Harvard Institute for International Development, Cambridge, MA, July 1997.

Speaker, Workshop on Environmental Economics and Policy Analysis, Harvard Institute for International Development, Cambridge, MA, July 1997.

Conference Co-Chair, VIII Repsol-Harvard Seminar on International Energy Markets, Seville, Spain, June 1997.

Keynote Speaker, Midwest Governors' Conference Annual Meeting, Kansas City, KN, June 1997.

Speaker, Seminar on International Electricity Restructuring, University of Zurich, Switzerland, May 1997.

Speaker, New England Conference of Public Utility Commissioners, 50th Symposium, Newport, RI, May 1997.

Speaker, Meeting on Locational Marginal Pricing, Electric Clearing House, Houston, TX, May 1997.

Speaker, *The Electricity Journal* and National Economic Research Associates, Conference on Restructuring '97, Amelia Island, FL, April 1997.

Speaker, University of California Energy Institute, POWER Conference on Electricity Restructuring, Berkeley, CA, March 1997.

Speaker, Electric Power Research Institute, Workshop on Markets for Electricity: Economics and Technology, Stanford, CA, March 1997.

Conference Co-Chair, Harvard Electricity Policy Group, Seminar on Public Sector Strategies in a Restructured Electricity Industry, Nashville, TN, March 1997.

Speaker, Asia-Pacific Energy Forum, Sixth East Asia Electricity and Gas Forum, Tokyo, Japan, January 1997.

Speaker, Harvard-Japan Project on Energy and the Environment, Tokyo Conference, Tokyo, Japan, January 1997.

Conference Co-Chair, Harvard Electricity Policy Group, Plenary Session on ISO Governance, La Quinta, CA, January 1997.

Speaker, Massachusetts General Court Special Committee on Electric Utility Restructuring, Conference on Massachusetts Restructuring, Cambridge, MA, December 1997.

Speaker, Michigan State University Institute of Public Utilities, Conference on Surviving Regulatory Change and Competition, Williamsburg, VA, December 1997.

Speaker, Commonwealth of Virginia State Corporation Commission, Virginia Electricity Forum, Charlottesville, VA, November 1996.

Conference Co-Chair, Harvard Electricity Policy Group, Seminar on Regional Regulation, Cincinnati, OH, November 1996.

Keynote Speaker, Conference on Strategies for Structuring, Governing, and Operating Independent System Operators, Chicago, IL, October 1996.

Speaker, Southern Company College, Course on Emerging Competitive Energy Markets, Atlanta, GA, September 1996.

Conference Co-Chair, Harvard Electricity Policy Group, Plenary Session on Electricity Restructuring, Boston, MA, September 1996.

Speaker, Stockholm School of Economics, Conference on the Transition to a Deregulated and International Market for Electricity, Stockholm, Sweden, August 1996.

Speaker, National Association of Regulatory Utility Commissioners, Conference on ISOs and Regulation, Los Angeles, CA, July 1996.

Speaker, American Gas Association, Conference on Electric Industry Restructuring and FERC Order 888, Arlington, VA, July 1996.

Speaker, Aspen Institute Summer Energy Policy Forum, Aspen, CO, July 1996.

Speaker, Harvard Institute for International Development, Workshop on Environmental Economics and Policy Analysis, Cambridge, MA, June 1996.

Conference Co-Chair, Harvard Electricity Policy Group, Plenary Session on ISO Governance, Boston, MA, June 1996.

Speaker, Mid-America Regulatory Commissioners Conference, Assessing the Winds of Change, Chicago, IL, June 1996.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group, Plenary Session, Boston, MA, June 1996.

Speaker, Special Libraries Association, Annual Meeting, Boston, MA, June 1996.

Conference Co-Chair, Speaker, Repsol-Harvard Seminar on Energy Policy, Granada, Spain, May 1996.

Speaker, New England Conference of Public Utilities Commissioners, Annual Symposium, Manchester, VT, May 1996.

Speaker, Federal Energy Bar Association, Annual Meeting, Washington, D.C., May 1996.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group, Session on Residual Monopoly Services, Pittsburgh, PA, April 1996.

Speaker, U.S. Department of Justice/ Federal Trade Commission Workshop on Electricity Restructuring, Washington, D.C., April 1996.

Speaker, Centre for Global Energy Studies, Sixth Annual Conference, London, UK, April 1996.

Speaker, Electric Policy Research Institute, Conference on Innovative Approaches to Electricity Pricing, La Jolla, CA, March 1996.

Speaker, Harvard-Japan Project on Energy and the Environment, Tokyo Conference, Tokyo, Japan, January 1996.

Speaker, East Asian Electricity Restructuring Forum Conference, Bangkok, Thailand, December 1995.

Speaker, IEEE International Forum on Deregulation and Re-structuring in the Electric Power Sector, Belo Horizonte, Brazil, November 1995.

Speaker, Seminar on the Revolution in the Electric Power Industry, Carnegie Mellon University, Pittsburgh, PA, November, 1995.

Speaker, The New Hampshire General Court, The Retail Wheeling and Restructuring Study Committee, Concord, NH, November, 1995.

Speaker, Energy Policy Seminar, American Enterprise Institute, Washington, D.C., November, 1995.

Speaker, Indiana Energy Conference, Indianapolis, IN, November 1995.

Speaker: INFORMS National Meeting, New Orleans, LA, October 1995.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group Plenary Session, Chicago, IL, October 26-27, 1995.

Speaker, MIT Conference on Keeping the Lights On: Technical and Institutional Issues in a Restructured Electricity Industry, Cambridge, MA, October 1995.

Speaker, The Energy Council of Rhode Island, Annual Membership Meeting, Warwick, RI, October 1995.

Session Chair, Ninth Annual Northeast Electricity Policy Executive Session, Lenox, MA, October 1995.

Speaker, EPRI Conference on Achieving Success in Evolving Electricity Markets, Atlanta, GA, October 1995.

Speaker, North American Electric Reliability Council, Board of Trustees Meeting, Princeton, NJ, October 1995.

Speaker, National Conference of State Legislatures, Videoconference on Fuel for a Competitive Northeast, Washington, D.C., September 1995.

Speaker, Center for Business Intelligence, Conference on Valuing and Recovering Stranded Costs in the New Age of Competitive Power, Washington, D.C., September 1995.

Speaker, Jefferson Energy Foundation, Conference on Energy and Power: Succeeding in the New Competitive Era, Washington, D.C., September 1995.

Speaker, Institute for International Research, Conference on Transmission Access and Pricing: Responding to the FERC Mega NOPR, Washington, D.C., September 1995.

Speaker, Energy Generation Association, Summer 1995. Meeting, White Sulphur Springs, WV, July 1995.

Speaker, Aspen Institute on Energy, Environment, Economy, Conference on Electric Utility Industry Restructuring, Aspen, CO, July 1995.

Session Chair, International Association for Energy Economics, 18th International Conference, Washington, D.C., July 1995.

Speaker, Harvard Institute for International Development, Workshop on Energy Economics and Policy Analysis, Cambridge, MA, June 1995.

Conference Co-Chair, Speaker, Repsol-Harvard Seminar on International Energy Markets, S'Agaro, Spain, June 1995.

Speaker, University of Zurich, Institute for Economic Research, Seminar on Electricity Markets, Zurich, Switzerland, June 1995.

Speaker, East Asian Electricity Restructuring Forum, Beijing, China, May 1995.

Speaker, American Enterprise Institute, Energy Policy Forum, Washington, D.C., May 1995.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, May 1995.

Keynote Speaker, Public Utilities Research Center, University of Florida, Annual Conference on Market and Technological Convergence: Implications for Regulation, Gainesville, Florida, April 1995.

Speaker, Oak Ridge National Laboratories, Seminar on Electricity Transmission and Emerging Competition, Oak Ridge, Tennessee, April 1995.

Speaker, New Jersey Board of Public Utilities, Electric Power Industry Conference, Newark, N.J., March 1995.

Speaker, Electricity Consumers Resource Council, Workshop on Pools, Washington, D.C., February 1995.

Speaker, DOE National Energy Modeling Systems/ AEO Conference, Washington, D.C., February 1995.

Speaker, East Asian Electricity Restructuring Forum, Tokyo, January 1995.

Speaker, Harvard-Japan Conference on Energy and Environment, Tokyo, January 1995.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group Plenary Session, New Orleans, Louisiana, January 1995.

Speaker, New Jersey Board of Public Utilities, Conference on Electric Utility Restructuring, Newark, New Jersey, December 1994.

Speaker, Michigan State University, Institute of Public Utilities, 1994. Annual Conference, Williamsburg, VA, December 1994.

Speaker, New England Governors' Conference, Inc., Power Planning Committee, Meeting with New England Conference of Public Utilities Commissioners, Durham, NH, November 1994.

Speaker, University of Toronto, Faculty of Law, Seminar and Presentations, Toronto, Canada, November 1994.

Speaker, Federal Energy Bar Association, Mid Year Meeting on Turmoil for the Utilities, Washington, D.C., November 1994.

Speaker, U.S. Department of Energy/National Association of Regulatory Utility Commissioners, National

Electricity Forum, Washington, D.C., November 1994.

Speaker, Association of Edison Illuminating Companies, Power Generation Committee, Meeting, Boston, MA, October 1994.

Speaker, Edison Electric Institute, Fall Legal Conference, New Orleans, Louisiana, October 1994.

Speaker, National Independent Energy Producers, Fall Conference, White Sulfur Springs, West Virginia, October 1994.

Speaker, Wisconsin Public Utility Institute, Conference on Public Policies toward Competition in the Electric Power Industry, Madison, Wisconsin, October, 1994.

Speaker, American Enterprise Institute, Energy Policy Forum, Washington, D.C., September 1994.

Speaker, Energy Daily Conference on The Impact of Retail Competition on the Electric Markets, San Diego, CA, September 1994.

Speaker, Southern Company Executive Forum, Atlanta, Georgia, September 1994.

Session Chair, Aspen Institute Workshop on the Electric Industry Moves Into Competitive Markets, Aspen, Colorado, July 1994.

Speaker, National Association of Regulatory Utility Commissioners Committee on Electricity, Summer Meeting, San Diego, CA, July 1994.

Speaker, New York State Energy Research and Development Authority and Niagara Mohawk Conference on The Electric Industry in Transition, Albany, New York, June 1994.

Co-Chair, Speaker, Repsol-Harvard Conference on World Oil Markets, Barcelona, Spain, June 1994.

Speaker, TAPS Conference on Transmission, Washington, D.C., May 1994.

Speaker, Exnet Conference on Transmission Access and Pricing, Washington, D.C., April 1994.

Speaker, Joint Institute for Energy & Environment, University of Tennessee, Conference on Twenty Years After the Energy Shock: How Far Have We Come? Where Are We Headed? Knoxville, Tennessee, April 1994.

Speaker, Digital Equipment Corporation and Duke Engineering Conference on Utilities 2000, The Challenge of Change, Charlotte, North Carolina, March 1994.

Session Chair, National Independent Energy Producers Winter Meeting, Washington, D.C., January 1994.

Speaker, Harvard-Japan Project Conference on Energy and the Environment, Tokyo, Japan, January 1994.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group Plenary Session, San Diego, CA, January 1994.

Speaker, California Foundation on the Environment and the Economy, Executive Briefing on the British Electrical Energy System, San Francisco, CA, January 1994.

Speaker, Northeast Utilities Executive Planning Conference, Westbrook, Connecticut, November 1993.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, October 1993.

Session Chair, Harvard Northeast Utility Policy Executive Session, Southbury, Connecticut, October 1993.

Speaker, Canadian Association of Members of Public Utility Tribunals, Annual Conference, Ottawa, Canada, September 1993.

Speaker, Harvard University Fairbank Center Meeting, Economic Development in Southeast Asia, New York, September 1993.

Speaker, Session Chair, International Association for Energy Economics, Annual International Conference, Bali, Indonesia, July 1993.

Session Chair, Aspen Institute, Policy Issue Forum on Energy, Environment, and the Economy, Aspen, Colorado, July 1993.

Conference Co-Chair, Speaker, Harvard Electricity Policy Group Plenary Session, Cambridge, MA, July 1993.

Speaker, Center for Regulatory Studies, University of Illinois, Conference on Electric Transmission in the 1990s, Oak Brook, Illinois, May 1993.

Speaker, American Enterprise Institute, Energy Policy Forum, Washington, D.C., May 1993.

Speaker, Edison Electric Institute, Finance Committee Annual Meeting, New York, May 1993.

Participant, U.S. Office of Technology Assessment, Conference on Climate Treaties and Models, Washington, D.C., April 1993.

Speaker, Conference on Regional Transmission Groups: Creation, Regulation, Access, and Pricing, Washington, D.C., March 1993.

Speaker, American Bar Association Conference on Electricity Law and Regulation, Denver, Colorado, February 1993.

Speaker, Harvard-Japan Project Conference on Energy and the Environment, Tokyo, Japan, January 1993.

Speaker, Coopers & Lybrand Electric and Gas Industry Key Issues Forum, McLean, Virginia, December 1992.

Speaker, University of Rochester, W. Allen Wallis Institute of Political Economy, Inaugural Lecture Program, Rochester, New York, December 1992.

Speaker, Digital Equipment Corporation Conference on Achieving Business Excellence in Utilities, Atlanta, Georgia, November 1992.

Speaker, University of Toronto, Conference on The Post-Communist Transformation: Emerging Economic, Legal, and Business Implications, Toronto, October 1992.

Session Chair, Center for Business and Government, Harvard University, Northeast Electric Utility Policy Executive Session, Cooperstown, New York, October 1992.

Panel Member, Brookings Panel on Economic Activity, Brookings Institute, Washington, D.C., September 1992.

Speaker, Conference on Energy Cooperation in Central Asia and the Caucasus, Teheran, Iran, September 1992.

Speaker, Aspen Institute Forum on Environmental Policy and Governance: Economic Implications and Energy System Impacts, Aspen, Colorado, August 1992.

Speaker, Conference on Ukraine: The New Business Partner, Kiev, Ukraine, June 1992.

Speaker; Session Chair, IAEE Conference on Coping with the Energy Future: Markets and Regulations, Tours, France, May 1992.

Speaker, POWER Conference on Innovative Approaches to Energy and Environmental Planning in CA, Sacramento, CA, April 1992.

Speaker, International Bar Association, Section on Energy and Natural Resources Law Conference, Washington D.C., April 1992.

Session Chair Conference on Market-Based Mechanisms for Addressing Global Climate Change, Washington D.C., March 1992.

Speaker, National Independent Energy Producers Membership Meeting, Washington, D.C., January 1992.

Speaker, Harvard-Japan Conference on Energy and the Environment, Tokyo, Japan, January 1992.

Speaker, Symposium on Strategic Security of Ukraine, Kiev, Ukraine, December 1991.

Speaker, Royal Institute of International Affairs, Conference on Energy Policy: Market-Led or Government-Driven? London, December 1991.

Speaker, International Association of Energy Economics, North American Conference, Chicago, Illinois, November 1991.

Speaker, Edison Electric Institute, Strategic Planning Services Committee, Fall Conference, Washington D.C., November 1991.

Session Chair, Center for Business and Government, Harvard University, Northeast Electric Utility Policy Executive Session, Killington, Vermont, October 1991.

Speaker, Institute for East-West Security Studies Meeting on Economic Reform in Ukraine, New York, October 1991.

Speaker, Brookings Panel on Economic Activity, Symposium on the Soviet Economy after Communism, Brookings Institute, Washington, D.C., September 1991.

Speaker, American Bar Association, Section on Public Utility, Communications, and Transportation Law, Atlanta, Georgia, August 1991.

Speaker, Aspen Institute Forum on Oil, Energy Policy and National Security--After the Gulf Crisis, Aspen, Colorado, July 1991.

Speaker, Harvard-Repsol Conference on Oil Markets in the 1990s, Segovia, Spain, June 1991.

Conference Co-Chair, Project on Economic Reform in Ukraine, Conference on Military Conversion, Kiev, Ukrainian SSR, May 1991.

Speaker, Workshop on Social and Political Consequences of Decentralization and Privatization, Gdansk, Poland, April 1991.

Speaker, Harvard-Japan Project Conference on Energy and the Environment, Tokyo, Japan, January 1991.

Speaker, Conference on Infrastructure for the 1990.s, Harvard University, Cambridge, MA, November 1990.

Conference Co-Chair, Conference on Economic Reform in Ukraine, Harvard University, Cambridge, MA, November 1990.

Speaker, Workshop on Economic/Energy/Environmental Modeling for Climate Policy Analysis, MA Institute of Technology, Washington, D.C., November 1990.

Speaker, California Foundation on the Environment and the Economy, Conference on Electricity, Monterey, CA, May 1990.

Speaker, Independent Petroleum Association of America, Conference on Supply and Demand, Boston, MA, May 1990.

Speaker, Vinson & Elkins Seminar on Oil Markets, Houston, Texas, April 1990.

Speaker, American Gas Association Seminar on Gas Demand Modeling and Forecasting, Houston, Texas, February 1990.

Speaker, Harvard-Japan World Oil Market Study Seminar, Tokyo, Japan, January 1990.

Speaker, Harvard-Repsol Conference on International Energy, Toledo, Spain, November 1989.

Speaker, International Symposium on Petroleum Economics, Laval University, Quebec, September 1989.

Speaker, IAEE Conference on North American Natural Gas Supply and Markets, Denver, Colorado, September 1989.

Speaker, Harvard Utility Forum/ Harvard Gas Forum Seminar, Energy and Environmental Policy Center, Harvard University, Cambridge, MA, June 1989.

Speaker, California Public Utilities Commission, Workshop on Capacity Priority Allocation, San Francisco, CA, June 1989.

Conference Chair, Speaker, International Oil and Gas Conference, Energy and Environmental Policy Center, Harvard University, Cambridge, MA, June 1989.

Speaker, U.S. House of Representatives Energy Security Working Group meeting, Washington, D.C., May

1989.

Speaker, Federal Energy Regulatory Commission Hearings on Firm Natural Gas Transportation and Priority Capacity Allocation, Washington, D.C., March 1989.

Speaker, First Boston/Putnam, Hayes & Bartlett Utility CEO Forum, Key Largo, Florida, February 1989.

Speaker, Harvard Utility Forum/Harvard Gas Forum Seminars, Energy and Environmental Policy Center, Harvard University, Cambridge, MA, February 1989.

Speaker, American Bar Association, Electric Utilities Group, Conference on Electricity Pricing, San Francisco, CA, January 1989.

Speaker, Institut Francais du Petrole, Seminar on World Oil Markets, Paris, France, December 1988.

Speaker, Southwestern Legal Foundation, National Institute on Natural Gas Law, Dallas, TX, Nov. 1988.

Speaker, Putnam, Hayes and Bartlett Seminar on Law and Economics, Phoenix, Arizona, September 1988.

Speaker, Harvard-Japan World Oil Market Study Seminar, Tokyo, Japan, September 1988.

Session Chair, Gas Research Institute Energy Seminar, Hilton Head, South Carolina, August 1988.

Speaker, Oklahoma Independent Petroleum Association Conference, Tulsa, Oklahoma, July 1988.

Speaker, National Academy of Engineering Symposium on An Energy Agenda for the 1990s, Beckman Center, Irvine, CA, May 1988.

Speaker, Harvard-Repsol Seminar on International Energy, Toledo, Spain, April 1988.

Speaker, EEPC/ Texas Oil and Gas Seminar, Dallas, Texas, March 1988.

Speaker: University of Houston Conference on Oil Tariff Policy, Houston, Texas, March 1988.

Speaker, Harvard Utility Forum/ Harvard Gas Forum Seminar, Palm Beach, Florida, February 1988.

Speaker, Southern Economic Association Conference, Session on the Future of OPEC, Washington, D.C., November 1987.

Speaker, Boston Gas Company Planning Conference, New Seabury, MA, October 1987.

Speaker, Ashland Exploration Company Conference on Oil Market Development, San Antonio, Texas, October 1987.

Speaker, Harvard-Japan Project on International Oil, Seminar, Tokyo, Japan, October 1987.

Session Chair, Harvard Executive Session on Northeast Electric Power Policy, Martha's Vineyard, MA, September 1987.

Speaker, American Jewish Congress Governing Council, Effects of an Oil Tariff, New York, New York, September 1987.

Speaker, Stockholm School of Economics Seminar on International Energy Demand, Stockholm, Sweden, August 1987.

Session Chair, International Association of Energy Economists North American Conference on The Growth of Risk, Calgary, Canada, July 1987.

Speaker, South Texas College of Law, Advanced Oil and Gas Course, Houston, Texas, June 1987.

Speaker, New York University Energy Forum on U.S. and World Oil Reserves, New York, New York, June 1987.

Speaker, Potomac Electric Power Company Conference on Future Fuel Prices, Washington D.C., May 1987.

Speaker, International Oil and Gas Conference on Energy Security Revisited, Energy and Environmental Policy Center, Harvard University, Cambridge, MA, May 1987.

Speaker, Harvard/Federal Energy Regulatory Commission Seminar on Natural Gas Regulation, Cambridge, MA, May 1987.

Speaker, Northwestern University Conference on Petroleum Economics and Management, Evanston, Illinois, April 1987.

Speaker, Harvard Japan Oil Market Study Workshop, Harvard University, Cambridge, MA, March 1987.

Speaker, Washington Energy Conference on U.S. Energy Security, Johns Hopkins University School of Advanced International Studies, Washington, D.C., March 1987.

Panelist: Conference on Venezuela/ Energy Issues, Harvard Institute for International Development, Cambridge, MA, March 1987.

Speaker, Conference on Oil Tariff Policy, Washington D.C., December 1986.

Speaker, Session Chair, International Association of Energy Economists Eighth Annual North American Conference on the Changing World Energy Economy, Cambridge, MA, November 1986.

Speaker: Cabot Corporation Seminar on International Investments and Operations, Boston, MA, Oct. 1986.

Session Chair, World Energy Conference, 13th Congress, on Energy: Needs and Expectations, Cannes, France, October 1986.

Speaker, Session Chair, Harvard Executive Session on Northeast Electric Power, Martha's Vineyard, MA, September 1986.

Speaker, Aspen Institute Summer Forum on the Policy Implications of Declining Oil Prices, Aspen, Colorado, August 1986.

Speaker, The Johns Hopkins School of Advanced International Studies/ IAEE Workshop on The Oil Price Collapse: Impact on Demand, Washington, D.C., June 1986.

Speaker, Electric Power Research Institute Conference, Williamsburg, Virginia, May 1986.

Session Chair, Harvard International Oil Conference on Managing Oil Market Risk, Cambridge, MA, May 1986.

Speaker, RAND Conference on International Economic Surprises, Santa Monica, CA, December 1985.

Session Chair, EPRI/Harvard Workshop on Risk Management: Charting A Research Agenda for the Future, Cambridge, MA, October 1985.

Speaker, Executive Seminar at Stanford University: Energy Decisionmaking in the 80s, Stanford, CA, July 1985.

Speaker, Industrial Bank of Japan, Middle East Seminar, Tokyo, June 1985.

Speaker, International Association of Energy Economists Conference, Bonn, Federal Republic of Germany, June 1985.

Speaker, Interstate Natural Gas Association of America Conference, Colorado Springs, April 1985.

Speaker, Synfuels '85 Conference, sponsored by the National Council on Synthetic Fuels Production and Synthetic Fuels Research Institute, Hilton Head, South Carolina, April 1985.

Participant, Stanford University Trinational Energy Policy Workshop, Stanford CA, February 1985.

Speaker, Brookhaven Conference on Energy Planning Under Uncertainty, Brookhaven, New York, August 1984.

Speaker, RFF Conference on Energy Security, Washington, D.C., June 1984.

Speaker, Nordic Council Meeting on Energy Planning Under Uncertainty, Kungälv, Sweden, June 1984.

Speaker, Energy Bar Association, Washington, D.C., January 1984.

Speaker, American Economics Association, December 1983.

Speaker, ORSA/TIMS Meeting, Chicago, Illinois, November 1983.

Speaker, National Defense University, Washington, D.C., 1983.

Speaker, Stanford University Executive Session on Energy Investments in the 1980s, Stanford, CA, 1982.

Speaker, ORSA/TIMS, Joint National Meeting, CA, 1982.

Speaker, Brookings Institute Seminar, Washington, D.C., 1982.

Speaker, Workshop on Energy Policy in the US and China, Peoples Republic of China, 1982.

Speaker, Energy and Security Workshop, Tokyo, Japan, 1982.

Speaker, Department of Energy Symposium on DOE's New Integrated Forecasting System, Washington, D.C., 1982.

Speaker, Harvard University, Kennedy School of Government, Conference on Energy and Security in the 1980s, Cambridge, MA, 1982.

Speaker, Harvard University, Kennedy School of Government Executive Session on Nuclear Power and Energy Availability, Cambridge, MA, 1982.

Member, Synthetic Fuels Study Panel, Synthetic Fuels Corporation, 1982.

Speaker, Institute of Gas Technology, Conference on Energy Modeling, 1982.

Speaker, IAEE Panel on Synthetic Fuels Policy, Houston, Texas, 1982.

Speaker, European American Institute, 1981.

Speaker, Security Conference on Asia and the Pacific, 1981.

Speaker, Volvo Conference on European Energy Needs, 1981.

Speaker, Stanford Conference on Energy Productivity, Stanford, CA, 1981.

Speaker, Symposium on Modeling of Large-scale Systems, IIASA, Laxenburg, Austria, 1980.

Speaker, University of Southern CA, Center for the Study of the American Experience, Annenberg School of Communications, Conference on America in an Era of Plentiful But Higher-Priced Energy, 1979.

Speaker, TIMS/ORSA Meeting, New Orleans, Louisiana, 1979.

Discussant, Resources for the Future/NSF Conference on the Implications of Potential Resource and Environmental Constraints for Growth, San Francisco, CA, 1979.

Session Chair, The Institute of Management Sciences XXIV International Meeting, Honolulu, Hawaii, 1979.

Speaker, Alliance to Save Energy, Symposium, Dumbarton Oaks, Virginia, 1979.

Program Co-Chair, IAEE/RFF Conference on International Energy Issues, Washington D.C., 1979.

Speaker, Aspen Institute Conference on Governmental Issues Concerned with the Siting of Nuclear Waste, Aspen, Colorado, 1979.

Speaker, Triennial Meeting of the International Federation of Operations Research Societies, Toronto, Canada, 1978.

Speaker, Bay Area Chapter, International Association of Energy Economists, San Francisco, CA, 1978.

Speaker, 5th Annual Energy Technology Conference, Washington, D.C., 1978.

Speaker, IEEE Conference, New Orleans, 1977.

Speaker, American Economics Association Conference, New York, 1977.

Speaker, Annual Meeting of National Association of Business Economists, 1977.

Participant, Program Committee, Lawrence Symposium on Systems and Decision Sciences, 1977.

Speaker, TIMS Conference on Energy and the Economy, San Francisco, 1977.

Speaker, American Mathematical Society Short Course on Energy, 1976.

Participant, Washington Operations Research Council, 1976.

Participant, National Petroleum Refiners Association, 1975.

Participant, TIMS New York Regional Chapter, 1975.

Speaker, Energy Analysis Meeting of International Federation of Institutes of Advanced Study, 1975.

Participant, Friends of Optimization, 1975.

Participant, ORSA/TIMS Conference, Panel on Energy Use, New York, 1975.

Session Chair, ORSA/TIMS Conference, Panel on Large Energy Models, Las Vegas Nevada, 1975.