UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Calpine Corporation, Dynegy In., Eastern Generation, LLC, Homer City Generation, L.P., NRG Power Marketing LLC, GenOn Energy Management, LLC, Carroll County Energy LLC, C.P. Crane LLC, Essential Power, LLC, Essential Power OPP, LLC, Essential Power Rock Springs LLC, Lakewood Cogeneration, L.P., GDF SEZ Energy Marketing NA, Inc., Oregon Clean Energy, LC and Panda Power Generation Infrastructure Fund, LLC	Docket Nos. EL 16-49-000
v.	
PJM Interconnection, L.L.C.	ER 18-1314-000
PJM Interconnection, L.L.C.	ER 18-1314-001
PJM Interconnection, L.L.C	EL 18-178-000 (Consolidated)

AFFDAVIT OF ROBERT McCULLOUGH

1. My name is Robert McCullough. My business address is 6123 S.E. Reed College Place, Portland, Oregon 97202. I have been active as an expert in the field of energy for the past thirty-nine years. I have testified before the Commission, in U.S. and Canadian courts, at state and provincial regulatory commissions, and before Congress on many occasions. My qualifications are Attachment 1 to this affidavit.

2. The current docket, EL18-178-000 (consolidated), addresses whether the Minimum Offer Price Rule (MOPR) should be expanded to address out-of-market subsidies. Specifically, whether the PJM Reliability Pricing Model should apply minimum offer rules to all generation with subsidies designed to supplement market prices, and how the Commission should design an FRR Alternative to assure just and reasonable capacity rates.

3. The June 29, 2018 Order assumes that out-of-market subsidies are leading to reductions in PJM's capacity market prices without reviewing either the economic theory or the facts. Neither supports FERC's assumptions.[1]

4. It first must be noted that the only significant resources currently receiving non-renewable energy credits (RECs) subsidies are in Northern Illinois in the ComEd LDA. The passage of the Illinois Future Energy Jobs Act and its subsequent implementation by the Illinois Power Agency and the Illinois Commerce Commission have provided substantial

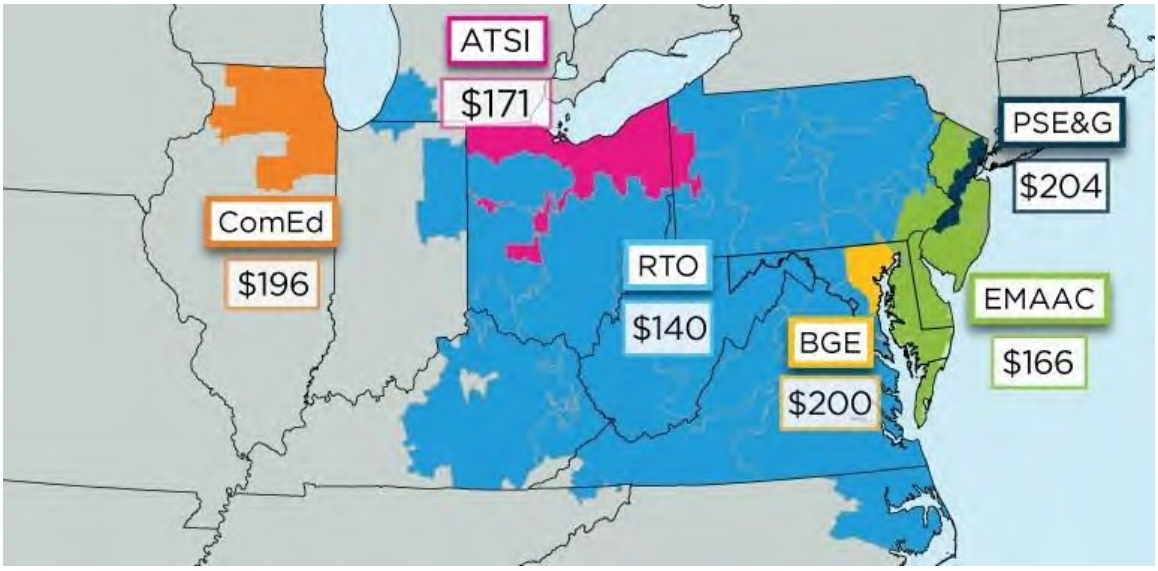
[1] 163 F.E.R.C. ¶ 61,236, June 29, 2018

subsidies, "zero emission credits" or ZECs, for two nuclear plants in the state, one of which is in the PJM region.[2]

5. Given the unique nature of the ComEd Zone, I will address the PJM capacity market first and then address the implications for subsidized resources.

PJM's Capacity Market in Northern Illinois

6. Notwithstanding the Illinois subsidies, capacity prices in Northern Illinois have not fallen. Prices increased in the most recent auction and are now the highest in the zones west of BGE.[3]



7. The basic premise as set out in the affidavits of Adam Keech and Anthony Giacomoni, submitted by PJM, is that the revenues from the Illinois ZEC program will reduce the marginal cost of providing capacity in the 2021-2022 RPM and that the PJM capacity market clearing prices will reflect this lower cost.[4] They assume a competitive market for capacity in Northern Illinois – apparently with little more than a cursory review of the underlying market structure.

8. Mr. Adam Keech submits the proof of his proposition by submitting a scenario that reduces the bid for the Quad Cities nuclear generating station to $0.00/MW/Day in the 2020-2021 auction. Since Quad Cities 1 and 2 had not cleared in this auction, this is equivalent to adding 1,203 MW to the supply curve for the ComEd zone. Shifting the supply curve to the right changes the marginal resource from $188.12/MW/Day to $170/MW/Day.[5]

[2] Public Act 099-0906, 99th Gen. Assemb. (Ill. 2016)
[3] PJM's Capacity Auction Attracts Diverse, Competitive Resources to Maintain a Reliable Grid, PJM, May 23, 2018
[4] Attachments E and F, PJM Capacity Repricing MOPR-Ex Proposal, April 9, 2018.
[5] Attachment 2 to Attachment E, Affidavit of Adam Keech, April 9, 2018.

9. Economic theory argues that in competitive markets generators are motivated to submit bids at marginal cost and that the efficient outcome is found when the supply curve matches the demand curve (Figure 1).

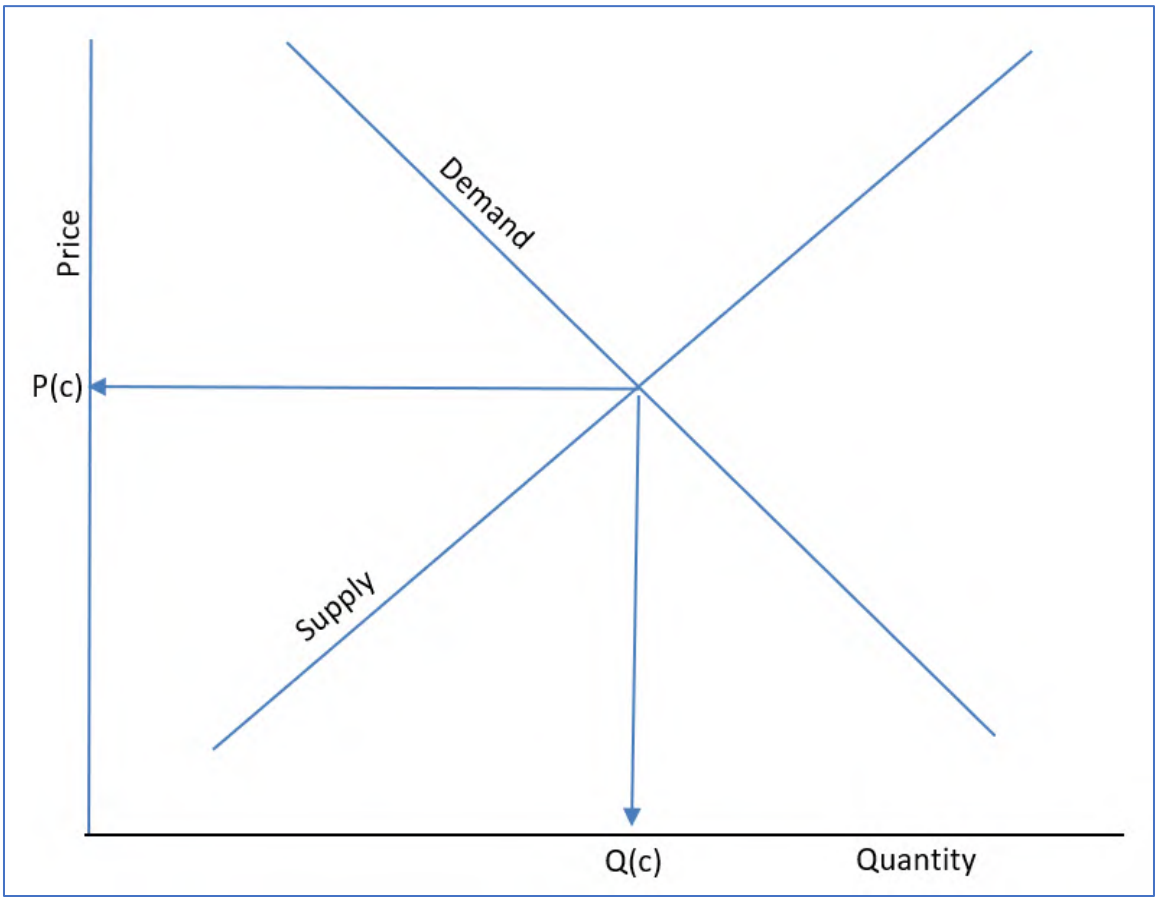


Figure 1: Competitive Supply and Demand

10. Mr. Keech's scenario follows the age-old presentation in introductory economics courses where the supply curve is shifted to the right, shown in Figure 2. The new supply curve, marked with a prime, produces a new competitive price, P(c)' and a new quantity Q(c)':

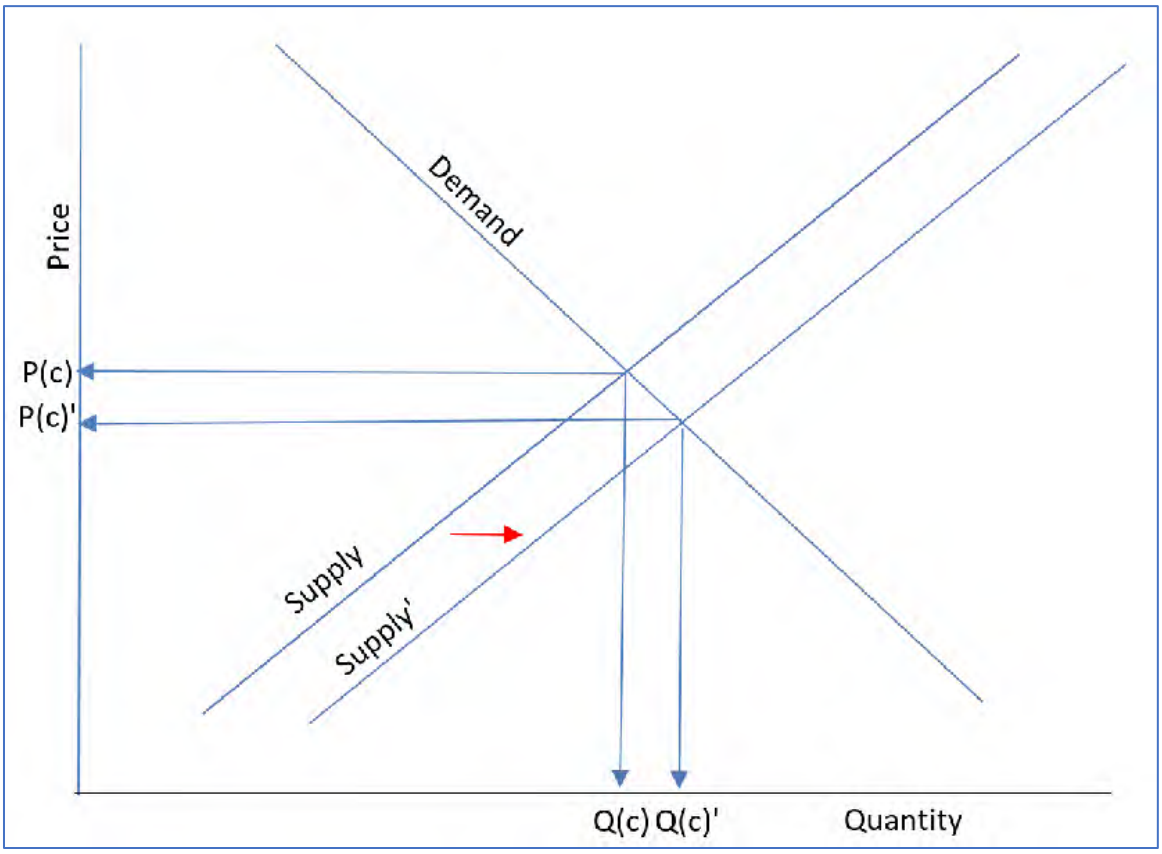


Figure 2: Supply Curve Shifted to the Right

11. When markets are not fully competitive, oligopolistic pricing is set by the intersection of the marginal revenue curve and the supply curve as in Figure 3. In the case of Northern Illinois, Exelon is a pivotal supplier with a high market share. Quantities are set by the intersection with the marginal revenue curve, not the supply curve:

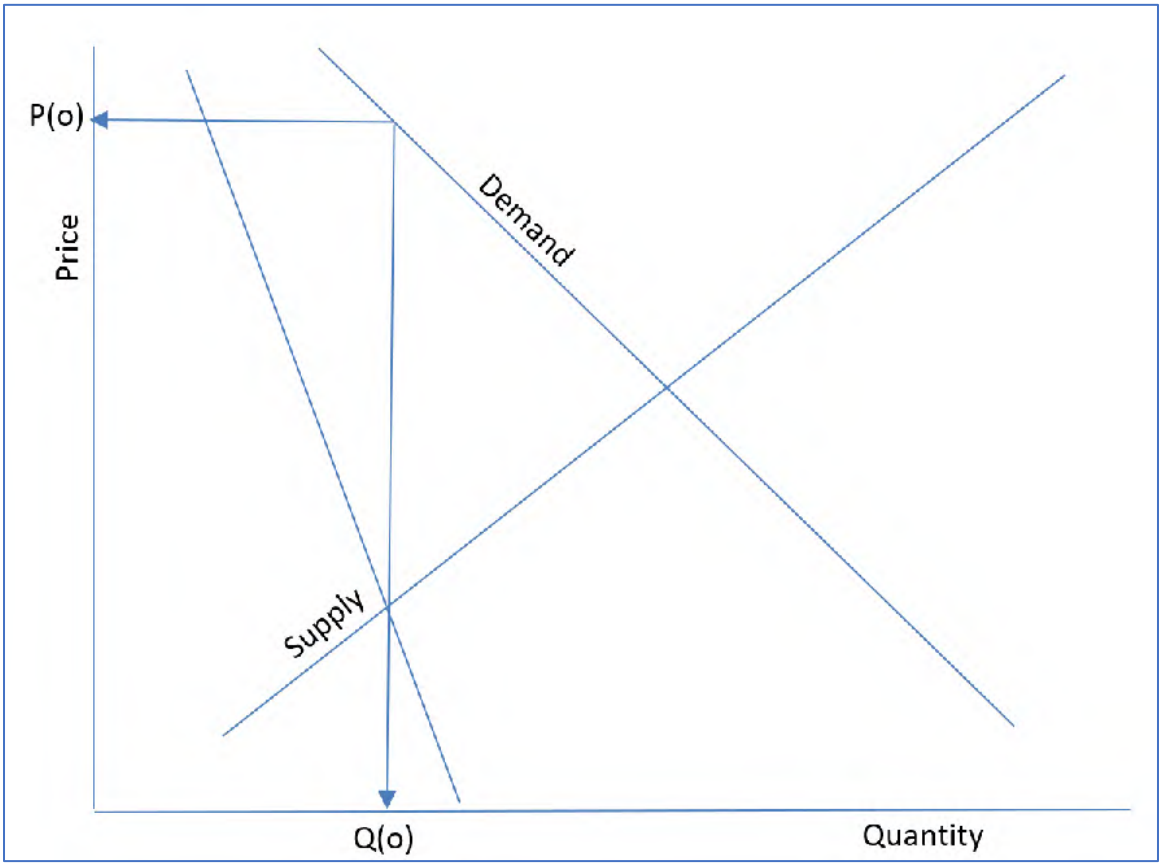


Figure 3: Oligopolistic Supply and Demand

12. In the chart above, prices are not set where the demand and supply curve intersect. Instead, a market participant with market power will maximize its position by reducing the quantity cleared in the market to Q(o) and reaping the higher price at P(o).

13. Mr. Keech's scenario is mathematically correct and consistent with the results in Scenarios 2, 3, 4, 5 available on PJM's web site for the 2020-2021 auction.[6] However, his scenario is not an appropriate economic analysis because rather than bid its subsidized units at $0 and allowed prices to fall, Exelon could be expected to have simply adjusted its bids on other plants in its portfolio in the ComEd Zone to offset the increase in supply and preserve the capacity price level. In fact, as shown below, this is exactly how Exelon adjusted to

[6] https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2020-2021-bra-scenario-analysis.ashx?la=en

the increase in supply resulting from the increased transmission capability between Northern Illinois and lower cost supplies from other PJM zones in the 2021/2022 auction.[7]

14. In the case of Mr. Keech's Attachment 2, the decrease from the actual market result of $188.12/MW/Day to $170.01/MW/Day would have cost Exelon $18.11/MW/Day across their entire fleet – a loss of $53.3 million. Exelon would have gained a small increase in capacity sales: 97 MW at $170.01 or $6 million. On net, Exelon would lose $47.3 million if they adopted this strategy. Not surprisingly, to avoid these losses, Exelon would be expected to have chosen to increase its bids for its Byron and Dresden facilities, increasing the market price from $188.12/MW/Day to $195.55/MW/Day.

15. It is interesting that adding three quarters of Quad Cities to the supply curve at $0/MW/Day has a larger impact on price than adding a greater amount 1,509.6 MW at the same price, as shown in PJM's scenarios (scenario 5).[8] This is yet another case where the results for Northern Illinois are "counter-intuitive."

16. When one generator has 42.19% of the zonal generation and the top three generators control 72.92% of the local generation, as is the case in the ComEd zone, the local market is highly concentrated. The Hirschfield-Herfindahl Index (HHI) for the Northern Illinois capacity market is calculated at 2,347.[9]

17. The PJM market monitor has identified potential market power and competition issues within the PJM capacity market yearly since the introduction of the Reliability Pricing Model in 2007.[10]

18. The Reliability Pricing Model does not require that generators bid at their marginal cost. Instead, generators may bid a price and quantity that maximizes their profits.

19. If market power was not present, we would have expected a significant decline in RPM prices in 2021-2022 given major changes in the Northern Illinois capacity market. The three major changes were the changes in the federal corporate tax rate under the Tax Cuts

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[7] 2021/2022 RPM Base Residual Auction Planning Period Parameters, page 4, Table 2 (CETL increased from 4,064 MW to 5,574 MW or 37%. https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2021-2022/2021-2022-rpm-bra-planning-parameters-report.ashx?la=en

[8] https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2020-2021-bra-scenario-analysis.ashx?la=en

[9] The U.S. Department of Justice Antitrust Division website states: "agencies generally consider markets in which the HHI is between 1,500 and 2,500 points to be moderately concentrated, and consider markets in which the HHI is in excess of 2,500 points to be highly concentrated." https://www.justice.gov/atr/herfindahl-hirschman-index

[10] PJM State of the Market 2007, Independent Market Monitor for PJM, page 228; PJM State of the Market 2008, Independent Market Monitor for PJM, page 249; PJM State of the Market 2007, Independent Market Monitor for PJM, page 299; 2010 State of the Market Report for PJM, page 351; 2011 State of the Market Report for PJM 85 2012 State of the Market Report for PJM Independent Market Monitor for PJM, page 129; 2013 State of the Market Report for PJM Independent Market Monitor for PJM, page 157; 2014 State of the Market Report for PJM Independent Market Monitor for PJM, page 179; 2015 State of the Market Report for PJM Independent Market Monitor for PJM, page 185; 2016 State of the Market Report for PJM Independent Market Monitor for PJM, page 213; 2017 State of the Market Report for PJM Independent Market Monitor for PJM, page 233; and PJM State of the Market 2018, Independent Market Monitor for PJM, page 258.

& Jobs Act; the ICC Order 17-0333 dated 09/11/2017 implementing the Future Energy Jobs Act; and the approval of several upgrades of transmission capacity into Northern Illinois, planned to be in service for the 2021-2022 delivery year. [11,12,13]

20. The outcome was actually the opposite to the forecasts from the PJM experts—in spite of significant cost reductions and the expansion of alternatives, the price in the ComEd zone increased from $188.12/MW/Day to $195.55/MW/Day.

21. While PJM's Base Residual Auction has many safeguards, it does not have an explicit ability to mitigate market power on the scale exerted by Exelon in Northern Illinois.

22. Exelon's 10,168 MW of unforced capacity are pivotal to the market.[14] It is impossible for Northern Illinois to meet its reliability requirements without Exelon's fleet of nuclear plants. Most importantly, the specific cost of any one of the plants is effectively irrelevant since four to five of those plants are required to meet the zone's reliability requirements. In a case like this, the impact of the ZEC revenues on the Quad Cities units is irrelevant to the outcome, because Quad Cities' bids are set in reference to a revenue maximizing, portfolio bidding strategy and not based on the marginal costs or individual revenues of each plant in isolation.

23. The chart in Figure 4 below shows my reconstruction of the ComEd Zone supply curve in the 2021-2022 Base Residual Auction:

[11] Tax Cuts and Jobs Act of 2017, Pub L. No. 115-97, 131 Stat. 2054.
[12] PJM Transmission Expansion Advisory Committee Market Efficiency Update, August 10, 2017 https://www.pjm.com/-/media/committees-groups/committees/teac/20170810/20170810-teac-market-efficiency-update.ashx
[13] Illinois Power Agency, Petition for Approval of the IPA's Zero Emission Standard Procurement Plan pursuant to Section 1-75(d-5)(1)(C) of the Illinois Power Agency Act, ICC Docket 17-0333, available at: https://www.icc.illinois.gov/docket/files.aspx?no=17-0333&docId=256557
See also https://www2.illinois.gov/sites/ipa/Pages/Prior_Approved_Plans.aspx.
[14] Unforced capacity or UCAP is the commodity transacted in the RPM Auctions. UCAP is an adjustment to ICAP or installed (nameplate) capacity that is defined by the PJM Glossary as UCAP = ICAP * (1 – EFORd) where EFORd is the Equivalent Forced Outage Rate for a specific generating unit based on its historical performance, or a class average such rate when unit-specific data is unavailable. The stated value has been inferred from PJM's 2021-2022 RPM Resource Model dated February 1, 2018, and from class average EFORd rates published online through PJM's Data Miner 2 (Equivalent Forced Outage Rates – Monthly) for years 2014-2017.

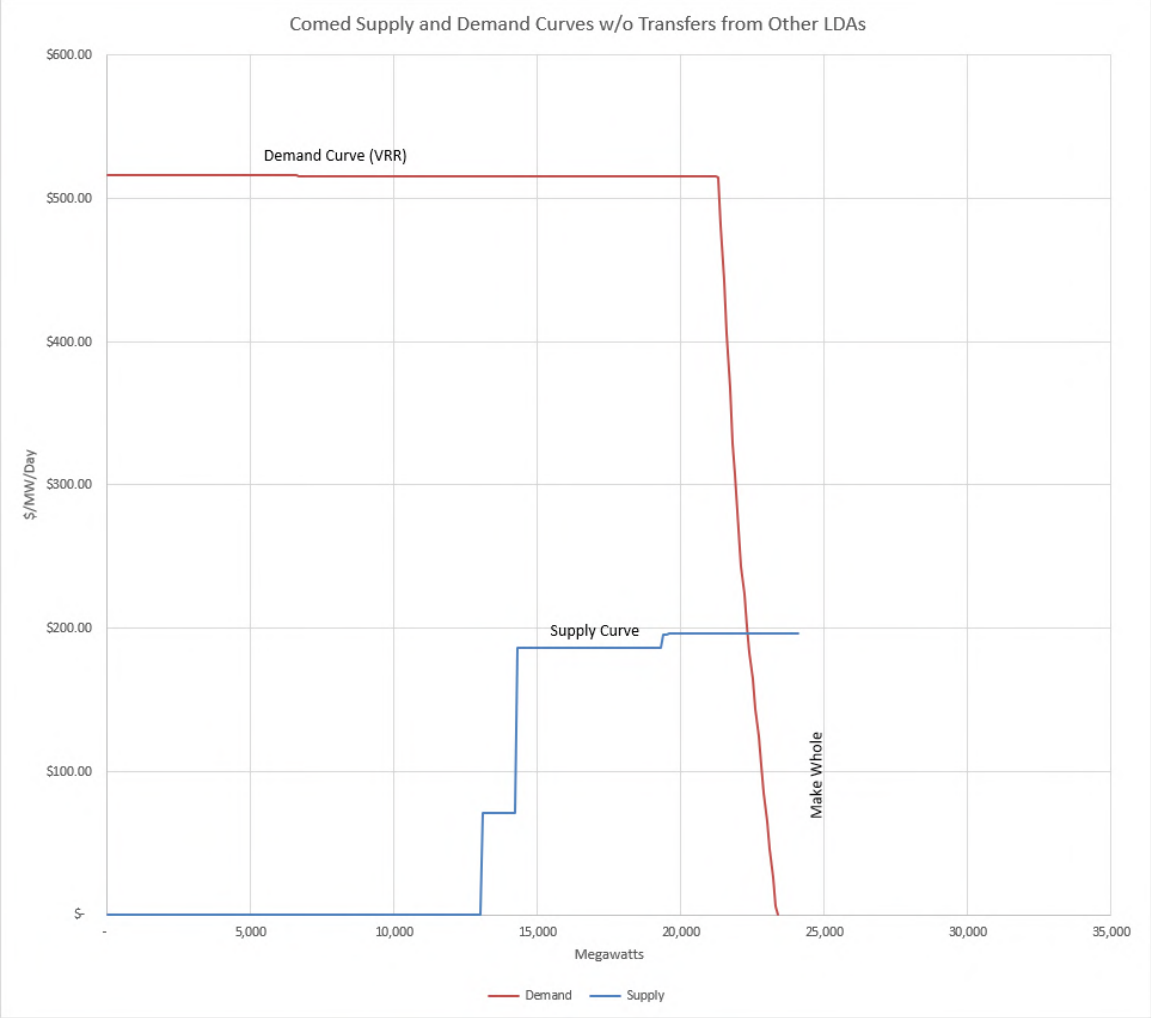

Figure 4: ComEd Supply and Demand

24. The demand curve in Figure 4 has been taken from the market monitor's revised Analysis of the 2021/2022 RPM Base Residual Auction.[15] Transfers from other PJM zones have been netted from the demand curve – following the approach taken by the Independent Market Monitor. Specific bid prices and quantities have been inferred from materials published by Exelon, PJM, and the Independent Market Monitor.[16,17,18]

25. Exelon, being the pivotal supplier, submits bids from its Illinois portfolio of 10,168 megawatts.[19] Exelon's May 24, press release identified the marginal plant as the Byron nuclear generating station. Absent other adjustments, the clearing price in the auction would reflect the Byron bid. Since Exelon's portfolio determines the market price, the

[15] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018, page 131.
[16] Exelon Announces Outcome of 2021‐2022 PJM Capacity Auction, Exelon, May 24, 2018.
[17] 2021/2022 RPM Base Residual Auction Results, PJM, May 23, 2018.
[18] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018.
[19] The stated value has been inferred from PJM's 2021-2022 RPM Resource Model dated February 1, 2018, and from class average EFORd rates published online through PJM's Data Miner 2 (Equivalent Forced Outage Rates – Monthly) for years 2014-2017.

actual bid for Quad Cities has no impact on the outcome. Quad Cities' capacity revenues will be set by the marginal Exelon resource. Exelon can also determine which plants will clear and which will not. In the 2020-2021 auction, Byron and the Dresden nuclear generating station cleared at a lower price.[20] In the current auction, Quad Cities cleared but Dresden did not clear even though the market clearing price increased in the most recent auction, and again, a portion of Byron cleared.

26. Exelon could have submitted bids based on its net Avoidable Cost Rate. This was analyzed by the Independent Market Monitor who concluded that the market clearing price would have fallen to $130.04/MW/Day had their offers been capped at net ACR.[21] This would not have been a rational choice for Exelon since a very small increase in its quantity cleared in the auction would not have offset the significantly lower clearing price.

27. PJM and the Independent Market Monitor have submitted a variety of scenarios based on the 2021-2022 BRA.[22,23,24] Logically, an attentive reader could carefully assemble the prices and quantities for each of these scenarios to model the supply curve for the ComEd zone. For example, PJM Scenario 2 removes 751.9 MW from the resources closest to the origin. The resulting price increases from $195.55/MW/Day to $196.21/MW/Day.

28. However, many of the scenarios give nonsensical results. In PJM Scenario 4, removing 1,503.7 MW of the least expensive resources actually reduces the market clearing price to $189.06/MW/Day. IMM Scenario 1 makes a very similar change, removing 1,510 MW of capacity transferred from other PJM zones. This also reduced the market price in the ComEd zone.

29. When PJM was asked about this apparent anomaly, they responded:

> As an example of the tariff language below, assume that the next lowest priced sell offer needed to clear up to the intersection point of an LDA or the RTO VRR demand curve is a 1,000 MW inflexible sell offer but only 20 MW of the offer is needed to reach the intersection point. If this sell offer were to clear the auction then the price of this sell offer would set the clearing price for the LDA or RTO and the resource would receive this clearing price for the 20 MW quantity that cleared against and up to the supply and demand intersection point, and the resource would receive an additional "make-whole" payment for the 980 MW portion of the block sell offer that extended beyond the intersection point. The make-whole payment associated with the "uncleared" portion of an inflexible sell offer at the margin must be considered in the cost of the solution when comparing this outcome to alternative solutions in determining the lowest cost solution. For example, an alternative and lower cost solution may be to "skip over" the

[20] Exelon Announces Outcome of 2020‐2021 PJM Capacity Auction, Exelon, May 24, 2017.
[21] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018, page 118.
[22] 2021/2022 Scenario Analysis for Base Residual Auction, PJM, September 4, 2018.
[23] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018, pages 10-20.
[24] MOPR/FRR Sensitivity Analyses of the 2021/2022 RPM Base Residual Auction, The Independent Market Monitor for PJM, September 26, 2018.

> inflexible block offer and instead clear a higher price sell offer of a flexible sell offer (i.e. a sell offer that only requires to be procured exactly the quantity that is needed to reach the intersection point of the supply and demand curve). Also, as described in the tariff language below, another alternative solution that must be considered in this case is one in which both the inflexible sell offer(s) as well as the flexible sell offer(s) are "skipped over" and the intersection point is set by "drawing" a vertical line up to the VRR curve from the MW quantity point at which the last resource cleared against the curve.[25]

30. The meaning of PJM's response is that the algorithm optimizing the BRA has three options:

    1. The algorithm can purchase an "inflexible" resource offer whose minimum generation is in excess of the total megawatts required by the demand curve. This might be similar to a chain smoker who will buy a whole carton of cigarettes just to smoke a single cigarette before he enters a no smoking area. Unneeded but still paid for capacity is called "make whole megawatts" in PJM parlance. The higher bid clears and the generator receives "make whole" payments as if the entire block were needed.

    2. The algorithm can drop the inflexible sell offer entirely from the solution.

    3. Finally, the algorithm can fail to meet the demand curve and estimate the market clearing price by finding the value on the demand curve equal to the total resources cleared before the inflexible offer was reached.

31. The PJM response gives the algorithm substantial discretion to select a clearing price and appears inconsistent with their own description of their model. However, the model description document on their web site is over a decade old and may no longer describe the calculations undertaken today.[26]

32. There is some concern that this explanation does not match the 2021-2012 auction facts terribly well. Exelon has stated that a portion of Byron did not clear.[27] PJM Scenarios 4 and 5 indicate that moving the supply curve to the left lowers the price to $189.06/MW/Day while moving the supply curve to the right lowers the price to $189.00/MW/Day.[28] While this would seem to indicate that the ComEd Zone experienced the first of the market adjustment options above, this is not consistent with the Excel sheet summarizing the 2021/2022 results which indicates no "make whole" costs were present in the zone.[29]

[25] Email to Long Truong, Assistant Attorney General, Illinois, September 11, 2018.
[26] RPM Optimization Formulation, PJM, December 12, 2007.
[27] Exelon Announces Outcome of 2021‑2022 PJM Capacity Auction, May 24, 2018.
[28] https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2021-2022/2021-2022-bra-scenario-analysis.ashx?la=en.
[29] https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2021-2022/2021-2022-base-residual-auction-results.ashx?la=en

33. This suggests that the algorithm's option 3 may have occurred during the 2021-2022 BRA. In this case, the last remaining inflexible sell offer was rejected – and the reported price represented a vertical line drawn upwards to the demand curve.

34. By all appearances, the PJM algorithm does not work well for constrained markets. This means that the reported market clearing price might or might not be the correct competitive price. In fact, the correct competitive price might well be one of several possible prices.

35. Prices from the various scenarios – both those of PJM and the two sets from the IMM -- do not define a traditional supply curve. The following chart illustrates prices and quantities that resemble a cloud of points rather than the traditional monotonic supply curve we see in actual markets.[30] The labels represent the explanations given for each scenario.

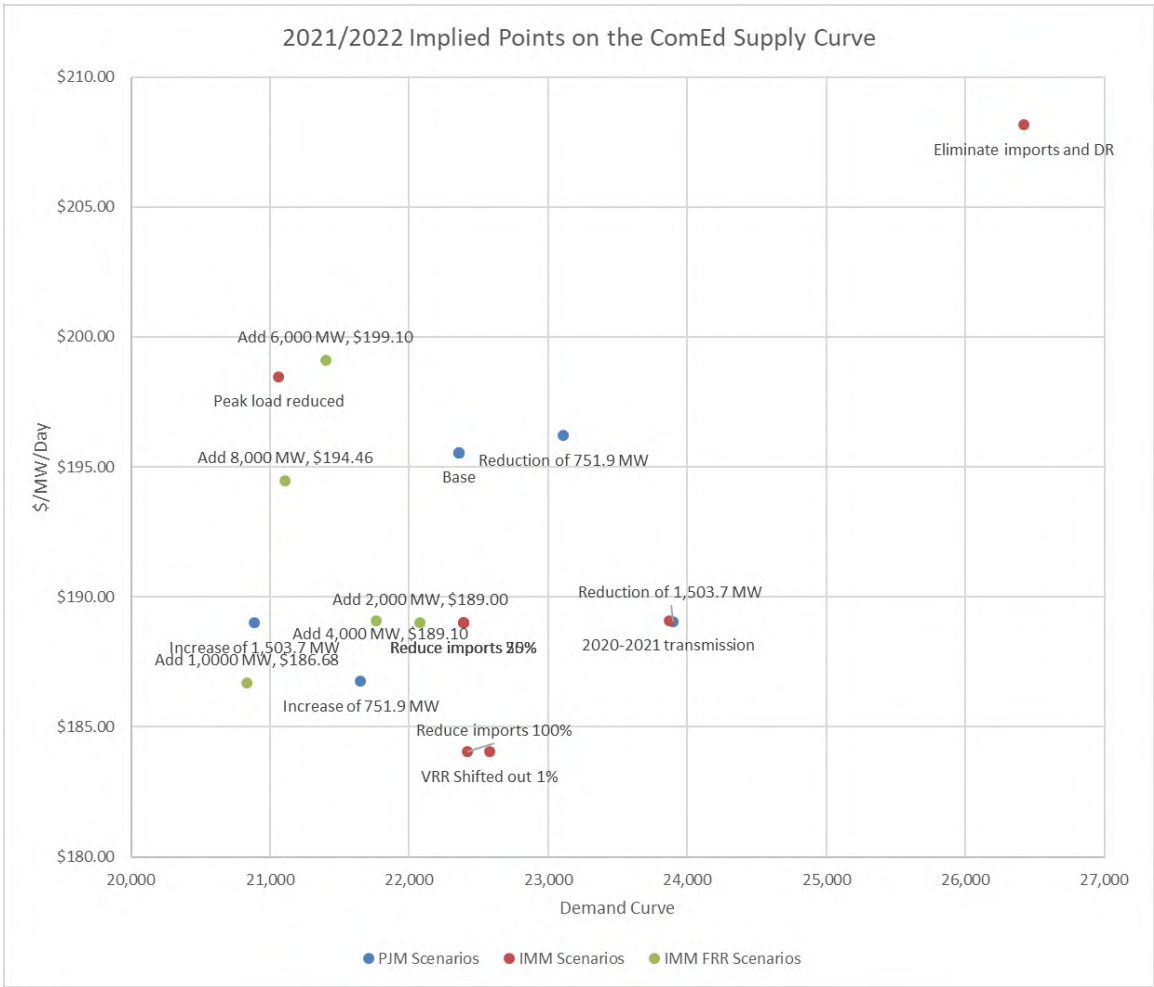

Figure 5: Implicit PJM and IMM Scenarios Supply Curve for ComEd

[30] Monotonicity is a mathematical term that describes quantities that always increase or always decrease. Markets are characterized by monotonic supply curves that reflect rising costs as output increases. Demand curves slope downwards and are monotonic since the quantity demand always falls as prices increase.

Supply curves are monotonic and upward sloping. The many scenarios depicted in Figure 5 represent prices and quantities that are neither monotonic nor upward sloping.

36. In the words of the IMM the current algorithm might experience a variety of problems:

> 1. Optimization Tolerance: All mixed integer programming solvers use numerical methods to determine the optimal solution. These methods are of finite arithmetic precision. Therefore, the search path and eventually the final solution depend on the chosen tolerance levels. In general, tighter tolerance levels are associated with longer computational times. One of the tolerance criteria used by mixed integer programming solvers is specified as a limit on the execution time. When execution time is a tolerance criterion, it is possible for solutions to diverge slightly, even with identical resource limit criteria, due to differences in the speed of the computers on which the solver is run.
>
> 2. Algorithm: The solution approach involves iteratively solving a mixed integer problem to locate the optimal solution given all the applicable business rules. The tolerance of the criteria used to evaluate feasible solutions in the iterative approach is also likely to affect the final solution. For example, using a slightly different criterion for the equilibrium point in the reconfiguration of the parent LDA's VRR curve could result in negligible impact on cleared quantities, but the impact on shadow prices and consequently marginal clearing prices could be substantial. The iterative approach where a sequence of the mixed integer problems are solved, contributes to the instability of the final solution.
>
> 3. Non-unique solution: It is possible for the BRA optimization problem to have non-unique solutions. Identical inputs could result in slightly different solutions with exactly the same objective value within the chosen tolerance levels each time the solution is calculated.[31]

37. The most likely problem involves the minimum bid quantity of inflexible sell offers. If all of the resources are submitted with the minimum capacity equal to their entire UCAP, the demand curve may intercept the supply curve more than once.

38. This is amply demonstrated by the various improbable scenario results, or, again, as the IMM says:

> The results of the scenario show that the ComEd price for the 2021/2022 RPM Base Residual Auction was higher than it would have been if the CETL had remained at the lower 2020/2021 CETL value.[32] This counter

[31] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018, page 137.

[32] A lower CETL value means fewer resources are available from other PJM zones.

intuitive price impact was a result of the interaction of the supply offers and the demand curve.[33]

39. In a constrained zone with a relatively small number of large resources, it is possible that the marginal resource may have set a minimum capacity level that does not allow the supply curve to just meet the demand curve. When only inflexible or very high-priced offers remain, none of the auction clearing procedures identified in RPM documents are likely to lead to the competitive optimal price predicted by economic theory. Any surplus beyond the demand curve is an exception to the normal economic analysis. The generator receives the full payment for the resource despite the fact that only a portion of its capacity is needed and the resulting "make whole" cost is allocated among consumers in the zone.

40. From materials supplied by PJM this seems to be a relatively unusual situation in unconstrained zones since the overall market is large relative to the size of the individual resources. In the ComEd zone inflexible sell offers appear to be relatively common.

41. Figure 6 illustrates a "make whole" adjustment (option one above). In this case, the algorithm determines that the optimal result is to purchase capacity at levels above the demand curve. The seller is reimbursed for the additional capacity by a payment that is recovered across all megawatts in the zone.

[33] Ibid., page 61.

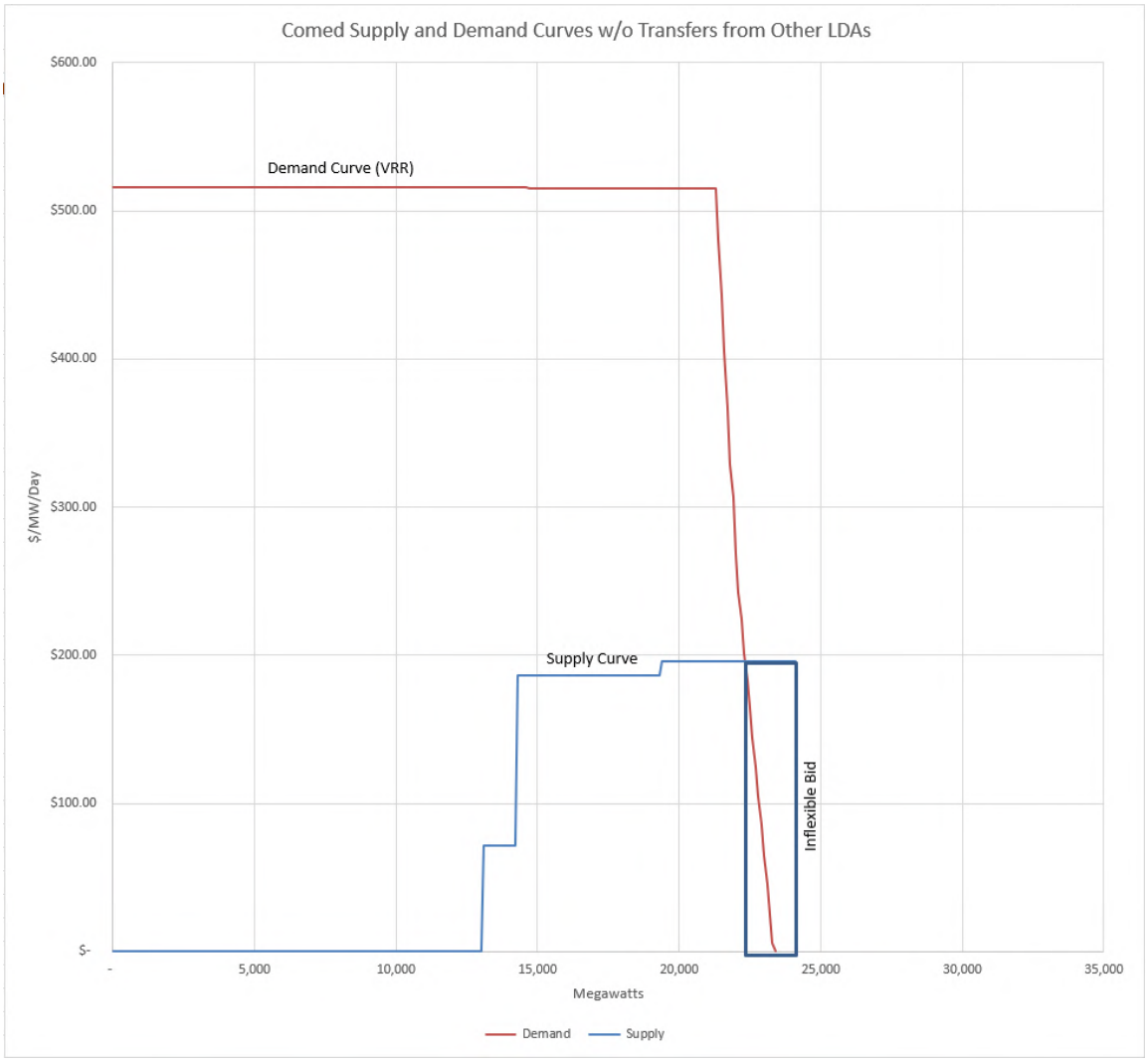

Figure 6: Illustration of "Make Whole" adjustment

42. Alternatively, the algorithm can choose to simply eliminate the inflexible bid and draw a line from the next highest bid up to the demand curve:

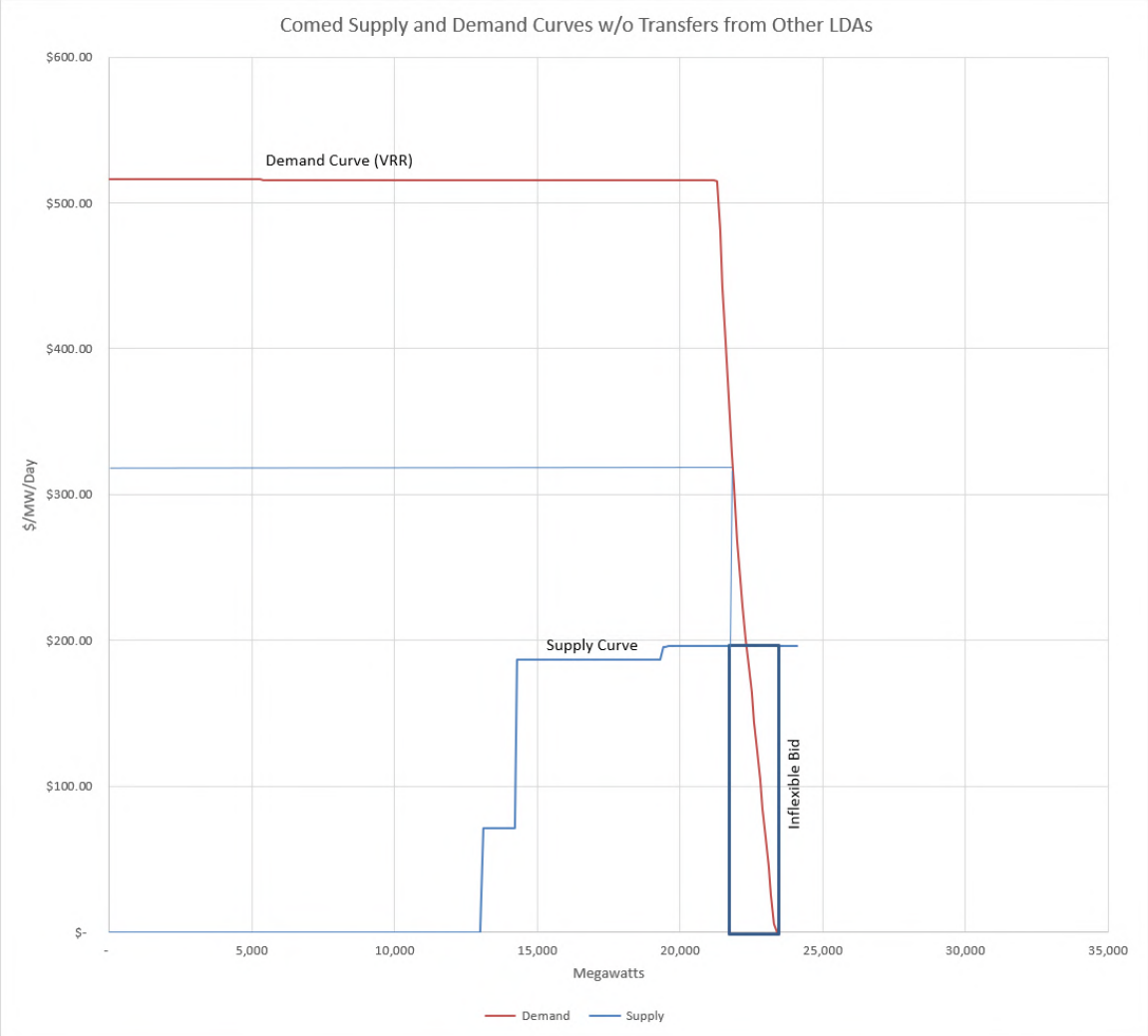

Figure 7: Make Whole Example with a Vertical Price Adjustment

43. The "make whole" construct poses quite a few problems for an optimization algorithm. As a general rule linear programming and its associated versions require that the supply and demand curves be monotonic.[34] The "make whole" rule does not lead to a monotonic supply curve. Each resource that sets its minimum capacity equal to the full capacity of the unit exposes consumers to a declining segment of the supply curve.

44. In the following example, two nuclear plants are placed at the top of the offer curve. Both plants are "make whole" candidates having inflexible sell offers that set their minimum capacity equal to their maximum capacity.

45. The marginal cost of each plant at low levels of capacity is very high. If the algorithm selects a plant for only a small number of megawatts, supply will equal demand at two

[34] A Dynamic Supply-Demand Model for Electricity Prices, Manuela Buzoianu et al., Carnegie Mellon University, 2005.

points – at the lowest level as the "make whole" cost forces marginal costs to very high levels, and slightly to the right as the marginal costs fall.

46. In this case there are several points where demand equals supply:

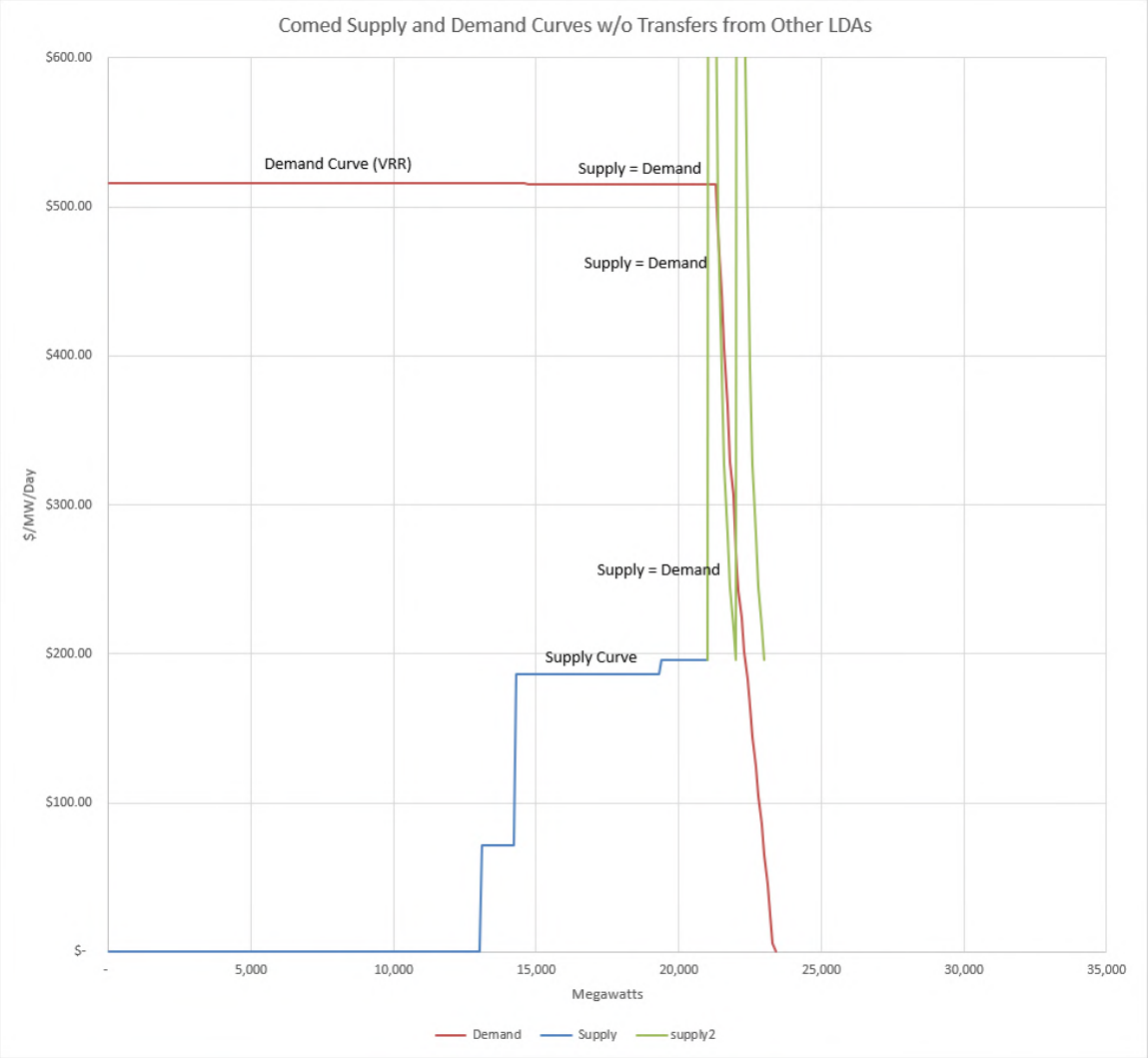

Figure 8: Illustration of Multiple Possible Solutions

47. The chart above demonstrates the problems raised in the IMM's discussion of problems with the current RPM algorithm – specifically his second and third issues:

    a. There may well be more than one possible solution and more than one possible price that meets the constraints; and,

    b. The algorithm may not converge to the best of the possible solutions.

48. Overall, it seems very likely that Northern Illinois is not well served by the existing algorithm. The IMM notes:

> In a competitive capacity market, there is no valid economic reason for capacity market sellers to specify a minimum MW quantity greater than 0 MW…. The MMU recommends that capacity market sellers be required to request the use of minimum MW quantities greater than 0 MW (inflexible sell offer segments) and that the requests should only be permitted for defined physical reasons….
>
> The MMU recommends improving the RPM solution method related to make whole payments. The MMU recommends changing the RPM solution method to explicitly incorporate the cost of make whole payments in the objective function.[35]

49. The price of Quad Cities is now irrelevant to the market clearing price in Northern Illinois. Quad Cities did clear in 2021-2022, but previously clearing plants -- Dresden and Byron -- did not. This is consistent with an economic withholding strategy familiar to any Econ 101 student. Again, as the IMM stated:

> However, the market power rules are not perfect and, as a result, competitive outcomes require continued improvement of the rules and ongoing monitoring of market participant behavior and market performance. Issues with the definition of the offer caps in the 2021/2022 BRA resulted in noncompetitive offers and a noncompetitive outcome.[36]

Evaluating MOPR Options

50. The EL18-178-000 (consolidated) Order reviewed PJM's Capacity Repricing and MOPR-Ex proposals. In addition, FERC recommended the possibility of extending the Fixed Resource Requirement (FRR) to the case of subsidized resources.[37,38]

51. FERC's discussion of the FRR option is interesting, but simply moves the thorny problem back to the state. In Northern Illinois where the same company dominates both the capacity market and owns the utility serving the major capacity loads, the FRR option opens the possibility of self-dealing. In the worst possible case, the FRR might well result in prices above competitive prices for consumers while depressing prices in the BRA.[39]

52. Given the complexity of the PJM capacity market – far more complex than the neighboring capacity market in MISO – it is critical that FERC apply clear and transparent rules to

[35] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018, pages 8 & 9.
[36] Ibid., page 2
[37] ORDER REJECTING PROPOSED TARIFF REVISIONS, GRANTING IN PART AND DENYING IN PART COMPLAINT, AND INSTITUTING PROCEEDING UNDER SECTION 206 OF THE FEDERAL POWER ACT, June 29, 2018, page 11.
[38] Ibid., page 6.
[39] See Monitoring Analytics, MOPR FRR Sensitivity Analyses of the 2021/2022 RPM Base Residual Auction (Sept. 26, 2018), Ihttp://www.monitoringanalytics.com/reports/Reports/2018/IMM_MOPR_FRR_Sensitivity_Analyses_Report_20180926.pdf

enable review and analysis of the capacity market data and results.[40] To address the problems cited by the Commission (price suppression) and the obligation to set rates that are just and reasonable, the Commission should require the release of capacity market data and expressly retain the offer cap currently in the PJM capacity auction to control market power.

53. The minimum price required under the MOPR should represent the cost the resource, or class of resources, requires to continue to operate after considering all revenues, including state authorized subsidies. A variety of options exist, but the most appropriate and precise approach for the minimum offer is the unit specific ACR, net of revenues.

54. A properly calculated offer cap as part of the MOPR requirement is critical to preserve competitive results in the RPM auctions and to addresses market power. Absent that cap, the capacity market in Northern Illinois will continue to clear at an uncompetitively high level irrespective of the ZEC subsidies. The IMM has cited problems with the current sell offer cap, and corrections to the calculation ("net CONE times B") are necessary for the capacity market to produce a competitive capacity price.[41]

55. For resources offered in the FRR Alternative, the correct cap on the capacity charge is also net ACR, reflecting both PJM revenues and the state revenues such as ZECs. This is necessary to return the Northern Illinois market to a state as close as possible to competitive conditions where capacity prices represent the net revenues needed to enable the resource to be a capacity resource, based on costs needed to operate but not covered by other revenues.

56. A number of options exist for the calculation of the ACRs:

First, utility accounting is based on the accounting rules of the Federal Energy Regulatory Commission. If the FRR is implemented as a MOPR alternative it should reflect the underlying cost data based on FERC accounting. The cost data for MidAmerica's share of Quad Cities is in their FERC Form 1. All ACR estimates should be public for purposes of determining a capacity price cap.[42]

Second, the use of NEI values to determine the ACR (cost) without a transparent basis for review is dubious since the bidders in PJM auctions are also participants in NEI. If the data from the Nuclear Enterprise Institute is made public, the concern over market participants influencing its development would be substantially reduced. At the same time, industry-wide information can utilize average or typical costs to mimic the discipline of a competitive market provided it is transparent and accurately reflects industry-wide cost structures.

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[40] MISO has implemented a similar, albeit far less complex, capacity market where masked bid data is available for review and the anomalous inflexible bid option is not present. Further, MISO releases masked bid data to the public for review 30 days after the conclusion of the annual auction. See: https://www.misoenergy.org/markets-and-operations/market-reports/.

[41] Analysis of the 2021/2022 RPM Base Residual Auction, Independent Market Monitor for PJM, August 24, 2018, pages 3-4.

[42] http://www.berkshirehathawayenergyco.com/assets/upload/regulatory-filing/2017%20FERC%20Form%201%20-%20Final.pdf

constrained zones, market power, and the details of the PJM algorithms must be part of any analysis.

58. This completes my Affidavit.

Signed and sworn under penalties of perjury this 2nd day of October, 2018.

Robert McCullough

Signed and Sworn before me this **2nd** day of **October**, 2018

Notary Public

OFFICIAL STAMP
EVGENIA A KAZAKOV
NOTARY PUBLIC - OREGON
COMMISSION NO. 942329
MY COMMISSION EXPIRES AUGUST 30, 2019

Robert McCullough – *Curriculum Vitae*

Principal
McCullough Research, 3816 S.E. Woodstock Place, Portland, OR 97202 USA

Professional Experience

1985-present	Principal, McCullough Research: provide strategic planning assistance, litigation support, and planning for a variety of customers in energy, regulation, and primary metals
1996-present	Adjunct Professor, Economics, Portland State University
1990-1991	Director of Special Projects and Assistant to the Chairman of the Board, Portland General Corporation: conducted special assignments for the Chairman in the areas of power supply, regulation, and strategic planning
1988-1990	Vice President in Portland General Corporation's bulk power marketing utility subsidiary, Portland General Exchange: primary negotiator on the purchase of 550 MW transmission and capacity package from Bonneville Power Administration; primary negotiator of PGX/M, PGC's joint venture to establish a bulk power marketing entity in the Midwest; negotiated power contracts for both supply and sales; coordinated research function
1987-1988	Manager of Financial Analysis, Portland General Corporation: responsible for M&A analysis, restructuring planning, and research support for the financial function; reported directly to the CEO on the establishment of Portland General Exchange; team member of PGC's acquisitions task force; coordinated PGC's strategic planning process; transferred to the officer's merit program as a critical corporate manager
1981-1987	Manager of Regulatory Finance, Portland General Electric: responsible for a broad range of regulatory and planning areas, including preparation and presentation of PGE's financial testimony in rate cases in 1980, 1981, 1982, 1983, 1985, and 1987 before the Oregon Public Utilities Commission; responsible for preparation and presentation of PGE's wholesale rate case with Bonneville Power Administration in 1980, 1981, 1982, 1983, 1985, and 1987; coordinated activities at BPA and FERC on wholesale matters for the InterCompany Pool (the association of investor-owned utilities in the Pacific Northwest) since 1983; created BPA's innovative aluminum tariffs (adopted by BPA in 1986); led PGC activities, reporting directly to the CEO and CFO on a number of special activities,

	including litigation and negotiations concerning WPPSS, the Northwest Regional Planning Council, various electoral initiatives, and the development of specific tariffs for major industrial customers; member of the Washington Governor's Task Force on the Vancouver Smelter (1987) and the Washington Governor's Task Force on WPPSS Refinancing (1985); member of the Oregon Governor's Work Group On Extra-Regional Sales (1983); member of the Advisory Committee to the Northwest Regional Planning Council (1981)
1979-1980	Economist, Rates and Revenues Department, Portland General Electric: responsible for financial and economic testimony in the 1980 general case; coordinated testimony in support of the creation of the DRPA (Domestic and Rural Power Authority) and was a witness in opposition to the creation of the Columbia Public Utility District in state court; member of the Scientific and Advisory Committee to the Northwest Regional Power Planning Council

Economic Consulting

2018 – present	Expert witness in West Moberly v British Columbia
2017-present	Advisor to the Coalition of East Side Neighborhoods on proposed Seattle area transmission
2017-present	Advisor to Enpex on power contract litigation
2017-present	Advisor to Peace Valley Landowners Association on Site C
2017-present	Advisor to North Pacific Paper Corporation (NORPAC) on power contracts and business strategy
2016-2017	Expert witness to the U.S. Department of Justice on nuclear rate case
2016-present	Advisor to the City of Logansport on utility project development and decision-making
2016	Expert testimony for Gratl and Company before the Supreme Court of British Columbia on costs of Site C project delay
2015-present	Advisor to Huu-ay-aht tribe on Sarita Bay LNG project in British Columbia

2015-2017	Analysis and expert testimony for Illinois Attorney General in official FERC complaint against MISO
2015-present	Advisor to Calbag Metals on generation project
2015-2016	Advisor to Oregon Department of Justice in the investigation of taxes owed the state by Powerex Corp.
2015	Economic analysis of the proposed 1100 MW hydro project, Site C, for the Peace Valley Landowner Association
2014-2015	Market analysis of the NYISO for the New York State Assembly
2014	Advisor to the Grand Council of the Cree on uranium mining in Quebec
2014-present	Support for the investigation of Barclays Bank
2013-present	Retained to do a business case analysis of the Columbia Generating Station by the Physicians for Social Responsibility
2013	Advisor to Environmental Defense Fund on gasoline and oil issues in California
2013	Advisor to Energy Foundation on Ohio competitive issues
2013	Export market review in the Maritime Link proceeding
2011	Consultant to Citizens Action Coalition of Indiana on Indiana Gasification LLC project
2010	Analysis and expert witness testimony for Block Island Intervenors concerning Deepwater offshore wind project
2010	Analysis for Eastern Environmental Law Center of 25 closed cycle plants in New York State
2010	Advisor on BPA transmission line right of way issues
2009-2010	Advisor to Gamesa USA on a marketing plan to promote a wind farm in the Pacific Northwest
2009-2010	Expert witness in City of Alexandria vs. Cleco
2009	Expert witness in City of Beaumont v. Entergy

2008-2009	Consultant to AARP Connecticut and Texas chapters on the need for a state power authority (Connecticut) and balancing energy services (Texas)
2008	Expert witness on trading and derivative issues in Barrick Gold litigation
2008-2014	Advisor to Jackson family in Pelton/Round Butte dispute
2007-2014	Advisor to the American Public Power Association on administered markets
2006-present	Advisor to the Illinois Attorney General on electric restructuring issues
2006-2007	Advisor to the City of Portland in the investigation of Portland General Electric
2006	Expert witness for Lloyd's of London in SECLP insurance litigation
2005-2007	Expert witness for Federated Rural Electric Insurance Company and TIG Insurance in Cowlitz insurance litigation
2005-2007	Advisor to Grays Harbor PUD on market manipulation
2005-2007	Advisor to the Montana Attorney General on market manipulation
2005-2006	Expert witness for Antara Resources in Enron litigation
2005-2006	Advisor to Utility Choice Electric
2004-2005	Expert witness for Factory Mutual in Northwest Aluminum litigation
2004	Advisor to the Oregon Department of Justice on market manipulation
2003-2006	Expert witness for Texas Commercial Energy
2003-2004	Advisor to The Energy Authority
2002-2005	Advisor to the U.S. Department of Justice on market manipulation issues
2002-2004	Expert witness for Alcan in Powerex arbitration

2002-2003	Expert witness for Overton Power in IdaCorp Energy litigation
2002-2003	Expert witness for Stanislaus Food Products
2002	Advisor to VHA Pennsylvania on power purchasing
2002	Expert witness for Sierra Pacific in Enron litigation
2002-2004	Advisor to U.S. Department of Justice
2002-2007	Expert witness for Snohomish PUD in Enron litigation
2002-2010	Expert witness for Snohomish in Morgan Stanley investigation
2001-2008	Expert witness for City of Seattle, Seattle City Light and City of Tacoma in FERC's EL01-10 refund proceeding
2001-2008	Advisor to VHA Southwest on power purchasing
2001-2005	Advisor to Nordstrom
2001-2005	Advisor to Steelscape Steel on power issues in Washington and California
2001	Advisor to California Steel on power purchasing
2001	Advisor to the California Attorney General on market manipulations in the Western Systems Coordinating Council power markets
2000-2007	Expert witness for Wah Chang in PacifiCorp litigation
2000-2001	Expert witness for Southern California Edison in Bonneville Power Administration litigation
2000-2001	Advisor to Blue Heron Paper on West Coast price spikes
2000	Expert witness for Georgia Pacific and Bellingham Cold Storage in the Washington Utilities and Transportation Commission's proceeding on power costs
1999-2002	Advisor to Bayou Steel on alternative energy resources
1999-2000	Expert witness for the Large Customer Group in PacifiCorp's general rate case

1999-2000	Expert witness for Tacoma Utilities in WAPA litigation
1999-2000	Advisor for Nucor Steel and Geneva Steel on PacifiCorp's power costs
1999-2000	Advisor to Abitibi-Consolidated on energy supply issues
1999	Expert report for the Center Helios on Freedom of Information in Québec
1999	Advisor to GTE regarding Internet access in competitive telecommunication markets
1999	Advisor to Logansport Municipal Utilities
1998-2001	Advisor to Edmonton Power on utility plant divestiture in Alberta
1998-2001	Energy advisor for Boise Cascade
1998-2000	Advisor to California Steel on power purchasing
1998-2000	Advisor to Nucor Steel on power purchasing and transmission negotiations
1998-2000	Advisor to Cominco Metals on the sale of hydroelectric dams in British Columbia
1998-2000	Advisor to the Betsiamites on the purchase of hydroelectric dams in Québec
1998-1999	Advisor to the Illinois Chamber of Commerce concerning the affiliate electric and gas program
1998	Intervention in Québec's first regulatory proceeding on behalf of the Grand Council of the Cree
1998	Market forecasts for Montana Power's restructuring proceeding
1997-2004	Expert witness for Alcan in BC Hydro litigation
1997-2003	Advisor to the Manitoba Cree on energy issues in Manitoba, Minnesota and Québec; Advisor to the Grand Council of the Cree on hydroelectric development
1997-1999	Advisor to the Columbia River Intertribal Fish Commission on Columbia fish and wildlife issues

1997-1998	Advisor to Port of Morrow regarding power marketing with respect to existing gas turbine plant
1997-1998	Expert witness for Tenaska in BPA litigation
1997	Advisor to Kansai Electric on restructuring in the electric power industry (with emphasis on the California markets)
1996-1997	Bulk power purchasing for the Association of Bay Area Cities
1996-1997	Advisor to Texas Utilities on industrial issues
1996-1997	Expert witness for March Point Cogeneration in Puget Sound Power and Light litigation
1996	Advisor to Longview Fibre on contract issues
1995-2000	Bulk power supplier for several Pacific Northwest industrials
1995-1999	Advisor to Seattle City Light on industrial contract issues
1995-1997	Advisor to Tacoma Utilities on contract issues
1995-1996	Expert witness for Tacoma Utilities in WAPA litigation
1994-1995	Advisor to Idaho Power on Southwest Intertie Project marketing
1993-2001	Northwest representative for Edmonton Power
1993-1997	Expert witness for MagCorp in PacifiCorp litigation
1992-1995	Advisor to Citizens Energy Corporation
1992-1994	Negotiator on proposed Bonneville Power Administration aluminum contracts
1992	Bulk power marketing advisor to Public Service of Indiana
1991-2000	Strategic advisor to the Chairman of the Board, Portland General Corporation
1991-1993	Chairman of the Investor Owned Utilities' (ICP) committee on BPA financial reform
1991-1992	Financial advisor on the Trojan owners' negotiation team

1991	Advisor to Shasta Dam PUD on the California Oregon Transmission Project and related issues
1990-1991	Advised the Chairman of the Illinois Commerce Commission on issues pertaining to the 1990 General Commonwealth Rate Proceeding; prepared an extensive analysis of the bulk power marketing prospects for Commonwealth in ECAR and MAIN
1988	Facilitated the settlement of Commonwealth Edison's 1987 general rate case and restructuring proposal for the Illinois Commerce Commission; reported directly to the Executive Director of the Commission; responsibilities included financial advice to the Commission and negotiations with Commonwealth and interveners
1987-1988	Created the variable aluminum tariff for Big Rivers Electric Corporation: responsibilities included testimony before the Kentucky Public Service Commission and negotiations with BREC's customers (the innovative variable tariff was adopted by the Commission in August 1987); supported negotiations with the REA in support of BREC's bailout debt restructuring
1981-1989	Consulting projects including: financial advice for the Oregon AFL-CIO; statistical analysis of equal opportunity for Oregon Bank; cost of capital for the James River dioxin review; and economic analysis of qualifying facilities for Washington Hydro Associates
1980-1986	Taught classes in senior and graduate forecasting, micro-economics, and energy at Portland State University

Education

Unfinished Ph.D.	Economics, Cornell University; Teaching Assistant in micro- and macro-economics
M.A.	Economics, Portland State University, 1975; Research Assistant
B.A.	Economics, Reed College, 1972; undergraduate thesis, "Eurodollar Credit Creation"

Areas of specialization include micro-economics, statistics, and finance

Papers and Publications

December 26, 2017	"Taking the Path Less Followed", *Vancouver Sun*
November 21, 2017	"Updating Bonneville's Strategic Plan"
October 30, 2017	"Site C Proponents Fall Prey to Sunk Costs Fallacy", Vancouver Sun
August 22, 2017	"Lessons from Manitoba Hydro's Financial Problems"
June 22, 2017	"Trump plan to sell BPA lines misguided"
April 11, 2017	"Affordable power or Site C power: British Columbia must choose"
February 28, 2017	"My View: Trade tariffs would hurt Americans", *The Portland Tribune*
January 8, 2017	"Many lives of Jordan Cove may have come to an end", *The Oregonian*
July 22, 2016	"Balancing an aging Hanford nuke plant against cheaper firm market power purchases", *The Oregonian*
July 7, 2016	"More roads needed to handle growth", *The Portland Tribune*
July 7, 2016	"Close the expensive Columbia Generating Station", *The Oregonian*
June 29, 2016	"Our future is in green energy, not aging, costly nuclear plants", *The Seattle Times*
May 12, 2016	"Diesel tax on heavy trucks is the right move", *The Portland Tribune*
May 2016	"Aspirational Planning: A Statistical Model of Hawthorne Bridge and Tilikum Crossing Bicycle Ride Counts", *Hatfield Graduate Journal of Public Affairs 1(1).*
January 19, 2016	"A good time for a sensibly managed Portland gas tax", *The Oregonian*
October 15, 2015	"A plan to fix Portland's roads", *The Portland Oregonian*
June 2015	"Estimating the Longevity of Commercial Nuclear Reactors", *Public Utilities Fortnightly*

December 2014	"Nuclear Winter", *Electricity Policy*
July 2013	"Mid-Columbia Spot Markets and the Renewable Portfolio Standard", *Public Utilities Fortnightly*
April 14, 2013	"Selling Low and Buying High", *The Oregonian*
December 2012	"Are Electric Vehicles Actually Cost-Effective?", *Electricity Policy*
November 30, 2012	"Portland's Energy Credits: The trouble with buying 'green'", *The Oregonian*
July 2009	"Fingerprinting the Invisible Hand", *Public Utilities Fortnightly*
February 2008	Co-author, "The High Cost of Restructuring", *Public Utilities Fortnightly*
March 27, 2006	Co-author, "A Decisive Time for LNG", *The Daily Astorian*
February 9, 2006	"Opening the Books", *The Oregonian*
August 2005	"Squeezing Scarcity from Abundance", *Public Utilities Fortnightly*
April 1, 2002	"The California Crisis: One Year Later", *Public Utilities Fortnightly*
March 13, 2002	"A Sudden Squall", *The Seattle Times*
March 1, 2002	"What the ISO Data Says About the Energy Crisis", *Energy User News*
February 1, 2001	"What Oregon Should Know About the ISO", *Public Utilities Fortnightly*
January 1, 2001	"Price Spike Tsunami: How Market Power Soaked California", *Public Utilities Fortnightly*
March 1999	"Winners & Losers in California", *Public Utilities Fortnightly*
July 15, 1998	"Are Customers Necessary?", *Public Utilities Fortnightly*
March 15, 1998	"Can Electricity Markets Work Without Capacity Prices?", *Public Utilities Fortnightly*
February 1998	"Coping with Interruptibility", *Energy Buyer*

January 1998	"Pondering the Power Exchange", *Energy Buyer*
December 1997	"Getting There Is Half the Cost: How Much Is Transmission Service?", *Energy Buyer*
November 1997	"Is Capacity Dead?", *Energy Buyer*
October 1997	"Pacific Northwest: An Overview", *Energy Buyer*
August 1997	"A Primer on Price Volatility", *Energy Buyer*
June 1997	"A Revisionist's History of the Future", *Energy Buyer*
Winter 1996	"What Are We Waiting for?" *Megawatt Markets*
October 21, 1996	"Trading on the Index: Spot Markets and Price Spreads in the Western Interconnection", *Public Utilities Fortnightly*

McCullough Research Reports

April 20, 2018	"Privatizing BPA's Assets and Liabilities"
April 12, 2018	"ASC 980 and the Decision to Complete Site C"
March 1, 2018	"Are Bitcoin Miners Suitable Electric Loads?"
February 14, 2018	"FY 2019 Update: Privatization of Bonneville Power Administration's Transmission Assets"
January 23, 2018	"Update of the CGS costs and implications"
November 21, 2017	"Updating Bonneville's Strategic Plan"
November 16, 2017	"Response to Questions Posed by the Deputy Minister of British Columbia What we have learned from the BCUC's Final Report"
November 2, 2018	"What we have learned from the BCUC's Final Report"
October 23, 2017	"Site C Inquiry Situation Report"
October 10, 2017	"Problems with British Columbia Hydro's F1.11 Response"
October 10, 2017	"Problems with British Columbia Hydro's F1.8 Response"
October 10, 2017	"Problems with British Columbia Hydro's F1.7 Response"

October 10, 2017	"Problems with British Columbia Hydro's F1.6 Response"
October 2, 2017	"Our answer to BC Hydro's question 16"
October 2, 2017	"Our answer to BC Hydro's question 20"
September 28, 2017	"A reflection on sunk costs"
September 28, 2017	"Our answer to BC Hydro's questions 46 and 47"
September 24, 2017	"Our answer to BC Hydro's question 22"
September 21, 2017	"British Columbia Utilities Commission's Preliminary Findings"
September 13, 2017	"What we have learned about Site C"
September 11, 2017	"Deloitte LLP's Two Site C Reports"
August 22, 2017	"Lessons from Manitoba Hydro's Financial Problems"
June 13, 2017	"Privatization of Bonneville Power Administration's Transmission Assets"
May 8, 2017	"Response to Public Power Council staff comments on replacing the Columbia Generating Station with lower cost renewables"
April 3, 2017	"Who actually pays for the Columbia Generating Station?"
February 15, 2017	"Replacing the Columbia Generating Station with Renewable Energy"
November 14, 2016	"Review of 'Economic Analysis of Proposed Changes to the Single Dwelling Zone Development Standard'"
October 5, 2016	"The Falling Price of Renewable Energy Relative to Conventional Generation"
October 3, 2016	"Statistical Evidence on the Increase in Portland Home Values Correlated with Historic Districts"
September 5, 2016	"Why are House Prices so high in the Portland Metropolitan Area?"
July 8, 2016	"Historic District Econometric Literature Review"
June 21, 2016	"Columbia Generating Station (CGS) Market Update"

November 19, 2015	"Market Cost of the Columbia Generating Station During the FY 2014/2015 Refueling Cycle"
September 30, 2015	"Decrypting New York's "Secret" Electric Bids"
September 9, 2015	"Market Power in West Coast Gasoline Markets: September Update"
September 8, 2015	"August 10, 2015 PADD 2 Gasoline Spike at BP Whiting's Pipestill 12"
July 23, 2015	"Market Power in West Coast Gasoline Markets: July Update"
June 23, 2015	"Market Power in West Coast Gasoline Markets: June Update"
May 25, 2015	"Site C Business Case Assumptions Review"
April 7, 2015	"2015 Paducah Update"
April 6, 2015	"Market Power in West Coast Gasoline Markets: April Update"
March 23, 2015	"Market Power in West Coast Gasoline Markets"
March 20, 2015	"Daniel Poneman and the Paducah Transaction"
January 2, 2015	"Data and Methodological Errors in the Portland Commercial Street Fee"
December 15, 2014	Report to the Bureau d'audiences publiques sur l'environment (BAPE), "Uranium Mining in Quebec: Four Conclusions"
February 11, 2014	"Energy Northwest's Revised Analysis of the Paducah Fuels Transaction"
January 25, 2014	"Energy Northwest Losses in the 2013 Forward Purchase of Nuclear Fuel"
January 2, 2014	"Review of the November 2013 Energy Northwest Study"
December 11, 2013	"Economic Analysis of the Columbia Generating Station"
February 21, 2013	"McCullough Research Rebuttal to Western States Petroleum Association"
November 15, 2012	"May and October 2012 Gasoline Price Spikes on the West Coast"

June 5, 2012	"Analysis of West Coast Gasoline Prices"
October 3, 2011	"Lowering Florida's Electricity Prices"
July 14, 2011	"2011 ERCOT Blackouts and Emergencies"
March 1, 2010	"Translation" of the September 29, 2008 NY Risk Consultant's Hydraulics Report to Manitoba Hydro CEO Bob Brennan
December 2, 2009	"Review of the ICF Report on Manitoba Hydro Export Sales"
June 5, 2009	"New York State Electricity Plants' Profitability Results"
May 5, 2009	"Transparency in ERCOT: A No-cost Strategy to Reduce Electricity Prices in Texas"
April 7, 2009	"A Forensic Analysis of Pickens' Peak: Speculation, Fundamentals or Market Structure"
March 30, 2009	"New Yorkers Lost $2.2 Billion Because of NYISO Practices"
March 3, 2009	"The New York Independent System Operator's Market-Clearing Price Auction is Too Expensive for New York"
February 24, 2009	"The Need for a Connecticut Power Authority"
January 7, 2009	"Review of the ERCOT December 18, 2008 Nodal Cost Benefit Study"
August 6, 2008	"Seeking the Causes of the July 3rd Spike in World Oil Prices" (updated September 16, 2008)
April 7, 2008	"Kaye Scholer's Redacted 'Analysis of Possible Complaints Relating to Maryland's SOS Auctions'"
February 1, 2008	"Some Observations on Societe Generale's Risk Controls"
June 26, 2007	"Looking for the 'Voom': A Rebuttal to Dr. Hogan's 'Acting in Time: Regulating Wholesale Electricity Markets'"
September 26, 2006	"Did Amaranth Advisors, LLC Attempt to Corner the March 2007 NYMEX at Henry Hub?"
May 18, 2006	"Developing a Power Purchase/Fuel Supply Portfolio: Energy Strategies for Cities and Other Public Agencies"

April 12, 2005	"When Oil Prices Rise, Using More Ethanol Helps Save Money at the Gas Pump"
April 12, 2005	"When Farmers Outperform Sheiks: Why Adding Ethanol to the U.S. Fuel Mix Makes Sense in a $50-Plus/Barrel Oil Market"
April 12, 2005	"Enron's Per Se Anti-Trust Activities in New York"
February 15, 2005	"Employment Impacts of Shifting BPA to Market Pricing"
June 28, 2004	"Reading Enron's Scheme Accounting Materials"
June 5, 2004	"ERCOT BES Event"
August 14, 2003	"Fat Boy Report"
May 16, 2003	"CERA Decision Brief"
January 16, 2003	"California Electricity Price Spikes"
November 29, 2002	"C66 and Artificial Congestion Transmission in January 2001"
August 17, 2002	"Three Days of Crisis at the California ISO"
July 9, 2002	"Market Efficiencies"
June 26, 2002	"Senate Fact Sheet"
June 5, 2002	"Congestion Manipulation"
May 5, 2002	"Enron's Workout Plan"
March 31, 2002	"A History of LJM2"
February 2, 2002	"Understanding LJM"
January 22, 2002	"Understanding Whitewing"

Testimony and Comment

June 1, 2018	Four Rebuttal affidavits for West Moberly v British Columbia.
January 31, 2018	Expert report affidavit West Moberly v British Columbia
November 30, 2017	Presentation to the British Columbia Cabinet on Site C
October 13, 2017	Testimony before the British Columbia Utilities Commission on Site C
June 7, 2017	Testimony before the U.S. Court of Claims on Nuclear Storage Costs
December 14, 2016	Testimony to the U.S. Court of Federal Claims on behalf of the U.S. Department of Justice regarding nuclear rate case
February 10, 2016	Testimony before the Supreme Court of British Columbia on the costs and benefits of delaying Site C dam
August 24, 2015	Testimony to the New York State Public Service Commission on behalf of the New York State Legislative Assembly
May 29, 2015	Testimony before the Federal Energy Regulatory Commission on behalf of Illinois Attorney General Lisa Madigan
December 15, 2014	Testimony before the Bureau d'audiences publiques sur l'environment (BAPE) in Quebec, "Uranium Mining in Quebec: Four Conclusions"
November 15, 2012	Testimony before the California State Senate Select Committee on Bay Area Transportation on West Coast gasoline price spikes in 2012
July 20, 2010	Testimony before the Rhode Island Public Utility Commission on the Deepwater offshore wind project
April 7, 2009	Testimony before the U.S. Senate Committee on Energy and Natural Resources on "Pickens' Peak"
March 5, 2009	Testimony before the New York Assembly Committee on Corporations, Authorities and Commissions, and the Assembly Committee on Energy, "New York Independent System Operators Market Clearing Price Auction is Too Expensive for New York"

February 24, 2009	Testimony before the Energy and Technology Committee, Connecticut General Assembly, "An Act Establishing a Public Power Authority" on behalf of AARP
September 16, 2008	Testimony before the U.S. Senate Committee on Energy and Natural Resources, "Depending On 19th Century Regulatory Institutions to Handle 21st Century Markets"
January 7, 2008	Supplemental Comment ("The Missing Benchmark in Electricity Deregulation") before the Federal Energy Regulatory Commission on behalf of American Public Power Association, Docket Nos. RM07-19-000 and AD07-7-000
August 7-8, 2007	Testimony before the Oregon Public Utility Commission on behalf of Wah Chang, Salem, Oregon, Docket No. UM 1002
February 23 and 26, 2007	Testimony before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. EL03-180
October 2, 2006	Direct Testimony before the Régie de l'énergie, Gouvernement du Québec on behalf of the Grand Council of the Cree
August 22, 2006	Rebuttal Expert Report on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. H-01-3624
June 1, 2006	Expert Report on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. H-01-3624
May 8, 2006	Testimony before the U.S. Senate Democratic Policy Committee, "Regulation and Forward Markets: Lessons from Enron and the Western Market Crisis of 2000-2001"
December 15, 2005	Direct Testimony before the Public Utility Commission of the State of Oregon on behalf of Wah Chang, Wah Chang v. PacifiCorp in Docket UM 1002
December 14, 2005	Deposition before the United States District Court Western District of Washington at Tacoma on behalf of Federated Rural Electric Insurance Exchange and TIG Insurance Company, Federated Rural Electric Insurance Exchange and TIG Insurance Company v. Public Utility District No. 1 of Cowlitz County, No. 04-5052RBL
December 4, 2005	Expert Report on behalf of Utility Choice Electric in Civil Action No. 4:05-CV-00573

July 27, 2005	Expert Report before the United States District Court Western District of Washington at Tacoma on behalf of Federated Rural Electric Insurance Exchange and TIG Insurance Company, Federated Rural Electric Insurance Exchange and TIG Insurance Company v. Public Utility District No. 1 of Cowlitz County, Docket No. CV04-5052RBL
May 6, 2005	Rebuttal Testimony before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No.EL03-180, et al.
May 1, 2005	Rebuttal Expert Report on behalf of Factory Mutual, Factory Mutual v. Northwest Aluminum
March 24-25, 2005	Deposition by Enron Power Marketing, Inc. before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No.EL03-180, et al.
February 14, 2005	Expert Report on behalf of Factory Mutual, Factory Mutual v. Northwest Aluminum
January 27, 2005	Supplemental Testimony before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. EL03-180, et al.
April 14, 2004	Deposition by Enron Power Marketing, Inc. and Enron Energy Services before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No.EL03-180, et al.
April 10, 2004	Rebuttal Testimony on behalf of the Office of City and County Attorneys, San Francisco, California, City and County Attorneys, San Francisco, California v. Turlock Irrigation District, Non-Binding Arbitration
February 24, 2004	Direct Testimony before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No.EL03-180, et al.
March 20, 2003	Rebuttal Testimony before the Federal Energy Regulatory Commission on behalf of the City of Seattle, Washington, Docket No. EL01-10, et al.
March 11-13, 2003	Deposition by IdaCorp Energy L.P. before the District Court of the Fourth Judicial District of the State of Idaho on behalf of Overton Power District No. 5, State of Nevada, IdaCorp

	Energy L.P. v. Overton Power District No. 5, Case No. OC 0107870D
March 3, 2003	Expert Report before the District Court of the Fourth Judicial District of the State of Idaho on behalf of Overton Power District No. 5, State of Nevada, IdaCorp Energy L.P. v. Overton Power District No. 5, Case No. OC 0107870D
February 27, 2003	Direct Testimony before the Federal Energy Regulatory Commission on behalf of the City of Tacoma, Washington and the Port of Seattle, Washington, Docket No. EL01-10-005
October 7, 2002	Rebuttal Testimony before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. EL02-26, et al.
October 2002	Expert Report before the Circuit Court of the State of Oregon for the County of Multnomah on behalf of Alcan, Inc., Alcan, Inc. v. Powerex Corp., Case No. 50 198 T161 02
September 27, 2002	Deposition by Morgan Stanley Capital Group, Inc. before the Federal Energy Regulatory Commission on behalf of Nevada Power Company and Sierra Pacific Power Company, Docket No. EL02-26, et al.
August 8-9, 2002	Deposition by Morgan Stanley Capital Group, Inc. before the Federal Energy Regulatory Commission on behalf of Nevada Power Company and Sierra Pacific Power Company, Docket No. EL02-26, et al.
August 8, 2002	Deposition by Morgan Stanley Capital Group, Inc. before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. EL02-26, et al.
June 28, 2002	Direct Testimony before the Federal Energy Regulatory Commission on behalf of the City of Tacoma, Washington, Docket No. EL02-26, et al.
June 25, 2002	Direct Testimony before the Federal Energy Regulatory Commission on behalf of Public Utility District No. 1 of Snohomish County, Washington, Docket No. EL02-26, et al.
June 25, 2002	Direct Testimony before the Federal Energy Regulatory Commission on behalf of Nevada Power Company and Sierra Pacific Power Company, Docket No. EL02-26, et al.

May 6, 2002	Rebuttal Testimony before the Public Service Commission of Utah on behalf of Magnesium Corporation of America in the Matter of the Petition of Magnesium Corporation of America to Require PacifiCorp to Purchase Power from MagCorp and to Establish Avoided Cost Rates, Docket No. 02-035-02
April 11, 2002	Testimony before the U.S. Senate Committee on Commerce, Science and Transportation, Washington DC
February 13, 2002	Testimony before the U.S. House of Representatives Subcommittee on Energy and Air Quality, Washington DC
January 29, 2002	Testimony before the U.S. Senate Committee on Energy and Natural Resources, Washington DC
August 30, 2001	Rebuttal Testimony before the Federal Energy Regulatory Commission on behalf of Seattle City Light, Docket No. EL01-10
August 16, 2001	Direct Testimony before the Federal Energy Regulatory Commission on behalf of Seattle City Light, Docket No. EL01-10
June 12, 2001	Rebuttal Testimony before the Public Utility Commission of the State of Oregon on behalf of Wah Chang, Wah Chang v. PacifiCorp in Docket UM 1002
April 17, 2001	Before the Public Utility Commission of the State of Oregon, Direct Testimony on behalf of Wah Chang, Wah Chang v. PacifiCorp in Docket UM 1002
March 17, 2000	Rebuttal Testimony before the Public Service Commission of Utah on behalf of the Large Customer Group in the Matter of the Application of PacifiCorp for Approval of Its Proposed Electric Rate Schedules and Electric Service Regulations, Docket No. 99-035-10
February 1, 2000	Direct Testimony before the Public Service Commission of Utah on behalf of the Large Customer Group in the Matter of the Application of PacifiCorp for Approval of Its Proposed Electric Rate Schedules and Electric Service Regulations, Docket No. 99-035-10

Presentations

May 15, 2018 "The Tower of Bitcoin"

April 11, 2018	"Breakdown and Post-Analysis of the Site C Review"
January 26, 2018	"Prudency, Recovery, and Rates", Site C Summit
December 11, 2017	"Final Decision Review", PVLA Press Conference
January 23-24, 2017	"Are Electric Markets Obsolete?", Buying & Selling Electric Power Conference, Seattle, Washington
December 3, 2015	"Ozymandias: Seventeen years of administered markets, high costs, and poor eligibility", Utility Markets Today, Rockville, Maryland
May 6, 2014	"Economic Analysis of the Columbia Generating Station", Energy Northwest, Boise, Idaho
April 30, 2014	"Economic Analysis of the Columbia Generating Station", Portland State University, Portland, Oregon
April 22, 2014	"Economic Analysis of the Columbia Generating Station", Clark County, Vancouver, Washington
January 9, 2014	"Economic Analysis of the Columbia Generating Station", Northwest Power & Conservation Council, Portland, Oregon
January 1, 2014	"Economic Analysis of the Columbia Generating Station", Bonneville Power Administration, Portland, Oregon
December 2, 2013	"Economic Analysis of the Columbia Generating Station", Skamania, Carson, Washington
December 1, 2013	"Peak Peddling: Has Portland Bicycling Reached the Top of the Logistic Curve?" Oregon Transportation Research and Education Consortium, Portland, Oregon
July 12, 2013	"Economic Analysis of the Columbia Generating Station", Tacoma, Washington
June 21, 2013	"Economic Analysis of the Columbia Generating Station", Seattle City Light, Seattle, Washington
January 29, 2013	"J.D. Ross (Who)", Portland Rotary Club, Portland, Oregon.
January 13, 2011	"Estimating the Consumer's Burden from Administered Markets", American Public Power Association conference, Washington, DC
October 15, 2009	"The Mysterious New York Market", EPIS, Tucson, Arizona

October 14, 2009	"Do ISO Bidding Processes Result in Just and Reasonable Rates?", legal seminar, American Public Power Association, Savannah, Georgia
June 22, 2009	"Pickens' Peak Redux: Fundamentals, Speculation, or Market Structure", International Association for Energy Economics
June 5, 2009	"Transparency in ERCOT: A No-cost Strategy to Reduce Electricity Prices in Texas", Presentation at Texas Legislature
May 8, 2009	"Pickens' Peak", Economics Department, Portland State University
April 7, 2009	"Pickens' Peak: Speculators, Fundamentals, or Market Structure", 2009 EIA energy conference, Washington, DC
February 4, 2009	"Why We Need a Connecticut Power Authority", presentation to the Energy and Technology Committee, Connecticut General Assembly
October 28, 2008	"The Impact of a Volatile Economy on Energy Markets", NAESCO annual meeting, Santa Monica, California
April 1, 2008	"Connecticut Energy Policy: Critical Times…Critical Decisions", House Energy and Technology Committee, the Connecticut General Assembly
May 23, 2007	"Past Efforts and Future Prospects for Electricity Industry Restructuring: Why Is Competition So Expensive?", Portland State University
February 26, 2007	"Trust, But Verify", Take Back the Power Conference, National Press Club, Washington, DC
May 18, 2006	"Developing a Power Purchase/Fuel Supply Portfolio"
February 12, 2005	"Northwest Job Impacts of BPA Market Rates"
January 5, 2005	"Why Has the Enron Crisis Taken So Long to Solve?", Public Power Council, Portland, Oregon
September 20, 2004	"Project Stanley and the Texas Market", Gulf Coast Energy Association, Austin, Texas
September 9, 2004	"Back to the New Market Basics", EPIS, White Salmon, Washington

June 8, 2004	"Caveat Emptor", ELCON West Coast Meeting, Oakland, California
June 9, 2004	"Enron Discovery in EL03-137/180"
March 31, 2004	"Governance and Performance", Public Power Council, Portland, Oregon
January 23, 2004	"Resource Choice", Law Seminars International, Seattle, Washington
January 17, 2003	"California Energy Price Spikes: The Factual Evidence", Law Seminars International Seattle, Washington
January 16, 2003	"The Purloined Agenda: Pursuing Competition in an Era of Secrecy, Guile, and Incompetence"
September 17, 2002	"Three Crisis Days", California Senate Select Committee, Sacramento, California
June 10, 2002	"Enron Schemes", California Senate Select Committee Sacramento, California
May 2, 2002	"One Hundred Years of Solitude"
March 21, 2002	"Enron's International Ventures", Oregon Bar International Law Committee, Portland, Oregon
March 19, 2002	"Coordinating West Coast Power Markets", GasMart, Reno, Nevada
March 19, 2002	"Sauron's Ring", GasMart, Reno, Nevada
January 25, 2002	"Deconstructing Enron's Collapse: Buying and Selling Electricity on The West Coast", Seattle, Washington
January 18, 2002	"Deconstructing Enron's Collapse", Economics Seminar, Portland State University
November 12, 2001	"Artifice or Reality", EPIS Energy Forecast Symposium, Skamania, Washington
October 24, 2001	"The Case of the Missing Crisis" Kennewick Rotary Club, Kennewick, Washington
August 18, 2001	"Preparing for the Next Decade"
June 26, 2001	"Examining the Outlook on Deregulation"

June 25, 2001	Presentation, Energy Purchasing Institute for International Research (IIR), Dallas, Texas
June 6, 2001	"New Horizons: Solutions for the 21st Century", Federal Energy Management-U.S. Department of Energy, Kansas City, Kansas
May 24, 2001	"Five Years"
May 10, 2001	"A Year in Purgatory", Utah Industrial Customers Symposium-Utah Association of Energy Users, Salt Lake City, Utah
May 1, 2001	"What to Expect in the Western Power Markets this Summer", Western Power Market Seminar, Denver, Colorado
April 23, 2001	"Emerging Markets for Natural Gas", West Coast Gas Conference, Portland, Oregon
April 18, 2001	"Demystifying the Influence of Regulatory Mandates on the Energy Economy" Marcus Evans Seminar, Denver, Colorado
April 4, 2001	"Perfect Storm", Regulatory Accounting Conference, Las Vegas, Nevada
March 21, 2001	"After the Storm 2001", Public Utility Seminar, Reno, Nevada
February 21, 2001	"Future Imperfect", Pacific Northwest Steel Association, Portland, Oregon
February 12, 2001	"Power Prices in 2000 through 2005", Northwest Agricultural Chillers, Bellingham, Washington
February 6, 2001	Presentation, Boise Cascade Management, Boise, Idaho
January 19, 2001	"Wholesale Pricing and Location of New Generation Buying and Selling Power in the Pacific Northwest", Seattle, Washington
October 26, 2000	"Tsunami: Market Prices since May 22nd", International Association of Refrigerated Warehouses, Los Vegas, California
October 11, 2000	"Tsunami: Market Prices since May 22nd", Price Spikes Symposium, Portland, Oregon
August 14, 2000	"Anatomy of a Corrupted Market", Oregon Public Utility Commission and Oregon State Energy Office, Salem, Oregon

June 30, 2000	"Northwest Market Power", Governor Locke of Washington, Seattle, Washington
June 10, 2000	"Northwest Market Power", Oregon Public Utility Commission and Oregon State Energy Office, Salem, Oregon
June 5, 2000	"Northwest Market Power", Georgia Pacific Management
May 10, 2000	"Magnesium Corporation Developments", Utah Public Utilities Commission
May 5, 2000	"Northwest Power Developments", Georgia Pacific Management
January 12, 2000	"Northwest Reliability Issues", Oregon Public Utility Commission

Volunteer Positions

2015-Present	Board member, Portland State University Master in Public Policy Advisory Committee
2016-2017	Eastmoreland Neighborhood Association, Treasurer
2013-2016	Eastmoreland Neighborhood Association, President
2013-2017	Southeast Uplift Neighborhood Coalition, President
2013-Present	City of Portland Office of Management and Finance Advisory Committee
1990-Present	Chairman, Portland State University Economics Department Advisory Committee