

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

PJM Interconnection, L.L.C.

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Docket No. ER21-2582-000

**Reply Affidavit
Of
Roy J. Shanker, Ph.D.**

On Behalf of the

PJM Power Providers Group

Submitted September 20, 2021

1. My name is Roy J. Shanker. My address is P. O. Box 1480, Pebble Beach, California, 93953. I am the same Roy Shanker who previously submitted an affidavit in this proceeding.

2. I have been retained by the PJM Power Providers Group to review the answer of PJM Interconnection L.L.C.'s ("PJM"), and specifically the comments of Dr. Peter Cramton regarding my critique of his model and results (August 20th Affidavit). This brief reply highlights some of the major flaws in his answer.¹

3. Despite Dr. Cramton's attempt in his reply to address the concerns I raised, his analysis continues to be flawed and should largely be ignored by the Commission or returned to PJM and its stakeholder process for further development. The Cramton analysis is based on an incomplete and untested model that relies on assumptions that are highly speculative at best and overall inconclusive by his own admission. The Cramton affidavit reaches no conclusion, failing to differentiate between the proposed "narrow" MOPR and status quo "broad" MOPR. As presented, this lack of distinction either represents intrinsic model limitations that cannot adequately distinguish between how Dr. Cramton characterized the two MOPR designs, or the fact that in Dr. Cramton's assumed equilibrium and set of assumptions there is no difference between the two scenarios. Neither alternative supports a determination by the Commission that PJM's proposed change is just and reasonable. In its current form, I would conclude that Dr. Cramton's analysis is of little value to the Commission's decision-making and should be ignored.

I. Cramton's Model Calibration and Benchmarking Remain Flawed and Unsupported

4. In my August 20th Affidavit, I appropriately observed the model presented by Dr. Cramton was not validated. Dr. Cramton retorted that "the model was calibrated with the PJM 2019 data. This model produced 2019 results that are consistent with the

¹ Although I have been retained by the PJM Power Providers Group, the views expressed in this reply are mine and do not necessarily reflect the views of any P3 members with respect to any issue.

PJM 2019 market data.”² He referred to this as a “careful calibration.”³ If one “carefully” reviews his affidavit and the now provided Working Paper for the term calibration, it is very clear that he does not mean validation by any means. This characterization is more than a play on words. In general (and seemingly exclusively), Dr. Cramton and his co-authors use the term “calibrate” to identify how they designated and confirmed *inputs* to the model, not outputs vis a vis any specific results. Thus, calibration in Dr. Cramton’s eyes relates to finding as accurate as possible *inputs* to the model, not the validity of the outputs. Indeed, in his reply remarks there is a distinction between calibrating with PJM data for inputs and the asserted “calibration” to market results.

5. Calibrating inputs and validation for market results and outputs are two very different concepts. For example, historic PJM data on load shape and peak load and LMPs might have been used as inputs to the model as “calibration,” but the ability to replicate LMPs or other market pricing results (e.g. capacity prices) as proof of validation is not demonstrated in the Cramton model beyond superficial statements. Without a validation of the market results, the impact of PJM’s proposal cannot be determined.

6. Dr. Cramton and his co-authors use the same terminology regarding calibration to refer to model inputs in his Working Paper as well.⁴ As far as I could determine the purported calibration versus PJM 2019 *market* results is presented as a fact for the first time in Dr. Cramton’s September 7th reply, and without any reference or verification to a validation process that I could identify. Further, the use of the term “calibration,” even in that context, may refer to inputs to his model, not outputs (e.g. those

² See Cramton Reply at paragraph 13.

³ Id. Dr. Cramton also qualifies this with the statement that the model is “most powerful at comparing out comes from two closely related scenarios....”(Id.) I will address the lack of merit of this statement later. (See paragraphs 12-22 below.)

⁴ See the discussion in Cramton Reply paragraphs 39 and 40 fully referring to calibration in the context of input data, never in the context of market results. Also see reply footnote 38 referring to calibration in terms of PJM data on expectations of future state sponsored resources. *The ten pages of the Cramton Working Paper (Working Paper) discussion of calibration is presented at pages 48-57, and is fully dedicated to describing the sources of input data and assumptions, it does not present any validation or benchmarking versus historical results.*

historic market results were inputs into his statistical estimation of an energy market proxy function). The language is ambiguous.

7. Further, even if we make the dubious leap that calibration, as used by Dr. Cramton, is equivalent to my concerns regarding validation and benchmarking, his reply and original affidavit fall very short. A wide range of unanswered questions emerge associated with this seemingly absolute declaratory (and unsupported) statement that the model was “tested.”⁵ First, what does Dr. Cramton mean by “consistent with PJM market data?” Did he replicate the results of the energy market, the capacity market, or both? Without any further explanation, the conclusion is that he did not. Further, assumptions about the validation of the quantities of new entry MWs and retirements are not provided. Dr. Cramton simply says his model is tested specifically against PJM market results, but there are no indications of this testing other than his assertion. (Also note Dr. Cramton has limited the amount of these entry/exit quantities exogenously, again without justification vis a vis his model results.)⁶ Again, we must conclude that absent any explanation and detail, such “testing” is just an assertion. As discussed above, with respect to the large set of all comments related to “calibration,” apparently Dr. Cramton is talking about input data, not validation. While I do not challenge input data in my August 20th Affidavit, I remain highly skeptical of his conclusions regarding the ambiguous statements related to testing or validation with respect to “market results”.

8. Dr. Cramton offers no credible explanation of the validation of outputs and results, the test design, what was measured, the metric of comparison, or even the nature of the market results being compared (e.g., were these nodal energy market values, summary values for PJM’s energy market as a whole, five-minute intervals or annual

⁵ See Cramton Reply at paragraph 12. “The model was extensively tested throughout the nineteen months of development. Each model component was tested first with small test cases that were easy to understand and then with full-scale test scenarios. This rigorous testing was a primary factor in the development time.” This statement is the only representation of “extensive test[ing].” No other details exist that I could find, even on the internet, (where searches appear to be dispositive to Dr. Cramton).

⁶ See Working Paper at page 47, referring to the process to estimate entry and exit: “We repeat these steps until all existing plants are selected or the number of retiring MW is above a threshold—a *model parameter*.” Emphasis added.

system wide averages.) For the RTO capacity values, Dr. Cramton again assumes no binding locational constraints.⁷ If this were the case, he failed to explain what kind of summary statistic he created for historical locational capacity prices that would be used for validation. Even if he matched in some manner actual energy and capacity market results (highly unlikely given the above questions), it is not clear how the results of any single year links to the estimation of his model of the markets' profitability in terms of long-term, entry and exit decisions beyond simply saying some form of exponential smoothing was used.⁸ Those market revenue determinations reflect the present value of a string of profits in future years which is the key element of Dr. Cramton's model.⁹ But Dr. Cramton does not address any of these questions. Moreover, he offers that he conducted test cases, however, not a single test case or test design is described in his affidavits or the work paper.¹⁰ His validation is presumably "take my word for it," or a circular exercise of comparing one model function to another. Accurate validation requires much more than Dr. Cramton provides.

9. Dr. Cramton evades the real questions surrounding the credibility of his analysis. However, for the sake of argument, assuming he did conduct the type of benchmarking or validation I suggested, his analysis still suffers from serious omissions that cannot be ignored. For example:

⁷ See Working Paper at page 35. "We make three simplifying assumptions. First, transmission is assumed to be sufficiently robust so that transmission constraints never bind." Though I did not explore the issue further, the Cramton Model also overstates the value of renewable resources by ignoring any curtailments of such resources due to transmission. Id. at pages 13-14 "Renewable resources can be curtailed in the event of overproduction, but this is done as a last resort in response to transmission constraints. For this reason, we do not model the curtailment of renewables."

⁸ See Working Paper at page 42. For overall additions and retirements see Working Paper at page 46.

⁹ See Working Paper Figure 6.1, "Multi-Year Simulation".

¹⁰ Id. at page 12. "The model was extensively tested throughout the nineteen months of development. Each model component was tested first with small test cases that were easy to understand and then with full-scale test scenarios. This rigorous testing was a primary factor in the development time.

- Regarding energy market results, there is no explanation of how the energy market pricing model/proxy model can be tested if there are no transmission constraints and actual market data is all based on nodal pricing outcomes.
- Transmission limitations appear to be ignored entirely, which is completely disconnected from reality in the PJM footprint for energy and capacity pricing.
- PJM did not have an Operating Reserve Demand Curve in 2019 (when he suggests some undefined “calibration” occurred), yet Dr. Cramton dismisses this fact by assuming investors would simply assume that PJM had an ORDC. He does not explain how validation would account for this mismatch. The validity of this assumption, and the associated results are not addressed.

10. If part of the “market results” were the Capacity Market results for 2019, the question of what validation means versus calibration using these historical results remains unanswered. Is Dr. Cramton looking at the RPM/BRA results from 2016 (and the IA’s) that determine the entry and exit for Delivery year 2019 (which only includes June 1-December 31 of 2019)? Moreover, Dr. Cramton never distinguishes between calendar and delivery years. The distinction is important for purposes of validation in terms of recognizing actual historical data. Further, we cannot determine if Dr. Cramton looked at new entry in the 2016 BRA and the IA’s or if that distinction is even relevant to his model. How would the LDA’s and associated locational capacity pricing be represented for the purposes of validation of the overall net present value of anticipated entry and exit decisions? Would he recalculate the market clearing prices assuming no LDA? Would he use some sort of locational weighted capacity price average? Would he have formal third-party review?¹¹ How would he process information, if at all, about new entry offered in the BRA versus the IA’s? Given this plethora of unanswered questions, I struggle to find

¹¹ I don’t believe I would (or the Commission should) accept high-level presentations or discussions of extreme weather experiences as a form of formal peer review. I looked at those items prior to my initial comments and found their content more superficial than Dr. Cramton’s initial filing. See Cramton Reply at paragraph 10. Further, after searching I have found no mention or presentation prior to PJM’s initial filing of Dr. Cramton’s results to the PJM stakeholders prior to PJM’s initial filing. This observation should also be troubling to the Commission as well as the stakeholder community in general.

any value in Dr. Cramton's analysis without further explanation and validation. The Commission must recognize these limitations.

11. From the above, it should be obvious that what Dr. Cramton was talking about in general with the term calibration (i.e. model inputs) had nothing at all to do with the questions I previously raised versus validation and benchmarking. All of these types of questions would have had to be addressed if one were to engage in a real validation exercise (or represented in detail if actually conducted). Other than to state he did test the model, nowhere is there any mention of the types of questions I asked. As noted, the great majority of his responses and the underlying Working Paper were solely regarding calibration in terms of input data, not the ability of the model to replicate any historic behavior or results.¹² Thus, his reply comments on calibration are nothing more than a red herring designed to divert the Commission's attention from the numerous flaws in his analysis.

II. Dr. Cramton Does Not Understand the Purpose of the Test Case Design I Suggested

12. Dr. Cramton bases his results on the application of a comparison of cases with the broad MOPR versus the narrow MOPR using his model. Implicit in this comparison is the belief that such a comparison is valid. That is, whether the difference in the metric(s) of interest between the two cases is a reliable indicator of the change in the single change to the policy of interest. No information was presented as to whether such interval (difference) validation was conducted, other than an assertion by Dr. Cramton.

13. Dr. Cramton clearly understands the importance of validation and notes a major absolute value validation problem in his results regarding capacity pricing: "The model produces high capacity prices with both the narrow and broad MOPR. As discussed

¹² Even when "testing" the estimation of the proxy energy function, such testing is a comparison to the energy market detailed results of his energy market simulations, not actual market results. See Working Paper note at bottom of page 63. Also, this is not surprising given Dr. Cramton estimates the proxy energy function from the selective market simulations. It also is not clear if in doing this, what role the expansion of his energy cases he discusses at Working Paper page 59 (paragraphs 2-4) played in the testing process.

in the Working Paper (Cramton et al. 2021), gas units in the model earn lower energy profits than in the actual market and thus need high capacity payments to remain viable.”¹³ Indeed, his model has prices that may range up to as much as 5-7 times higher than have actually occurred (and 9 times higher for the next forecasted year).¹⁴ He offers this as a response to questions parties raised regarding how such gas units might remain viable in the future in the presence of subsidies.¹⁵

14. But at the same time he uses his model results to rebut issues regarding the new entry of gas, *he also notes that the absolute values produced by his model are not its most credible result.*¹⁶ This forces him to deflect criticisms about the extremely high capacity values the model produces by stating: “However, even with this careful calibration, the model is most powerful at comparing outcomes from two closely related scenarios, such as broad and narrow MOPR, *rather than to make absolute predictions*, such as the absolute capacity price in a particular year. The reason is that we are modeling a complex non-stationary process. Absolute values depend directly on the entire set of assumptions.”¹⁷

15. First, in the prior paragraphs we see Dr. Cramton say that the predicted high capacity prices are taken as indicators of the continued viability of by definition competitive gas units, but then he admits these same absolute capacity values must be questioned against the historical clearing prices in an effort to enhance the credibility of

¹³ See Cramton Reply at paragraph 42. “As discussed in the working paper (Cramton et al. 2021), gas units in the model earn lower energy profits than in the actual market and thus need high capacity payments to remain viable. A model approximates reality, *and discrepancies in absolute levels are unavoidable.*” Emphasis added, footnotes deleted.

This makes one curious as to why there is the associated deviation from real market results.

¹⁴ See Shanker Affidavit at paragraph 54 “For example, in Figure 4 of the Cramton Affidavit, capacity prices under the status quo (the broad MOPR) for year 2022 are approximately \$250/MW-day and for 2023 approximately \$370/MW-day. This is compared to PJM’s recent 2022-23 auction results of an RTO value of \$50/MW-day. For 2028, the model estimates a broad MOPR price of approximately \$425/MW-day and a narrow MOPR price of \$475/MW-day.”

¹⁵ See Cramton Reply at paragraph 42.

¹⁶ Id. at paragraph 13, “the model is most powerful at comparing outcomes from two closely related scenarios, such as broad and narrow MOPR, *rather than to make absolute predictions, such as the absolute capacity price in a particular year.*”

¹⁷ Id. at paragraph 13 (emphasis added).

the model when used to estimate interval differences in results. These arguments are internally inconsistent. Dr. Cramton can't have it both ways.

16. This is exactly why interval results need to be validated. For example, perhaps the low energy prices driving very high capacity prices to support natural gas are related to adding 50,000 plus of intermittent resources and 6,000 plus megawatts of nuclear resources that are insensitive to economics and offer energy and capacity as a price taker. In turn, perhaps this raises the question of whether his approach was the proper way to characterize the two MOPRs for comparisons, and whether the untested interval result have any validity at all, ignoring that negligible differences were found between the cases.

17. Regardless, Dr. Cramton appears to favor the conclusion that the difference between the broad and narrow MOPR scenarios is the strongest application of the model. He offers: "Relative comparisons across two scenarios in which only one feature is changed (broad to narrow MOPR) are much more robust since we vary a single parameter out of many dozens and look at the difference in relative terms."¹⁸

18. The problem with Dr. Cramton's approach is that he simply asserts that this strength in comparison of cases is true, *but he never proves it*. While in general I would agree that the application of a with/without test is a strong approach to identify or isolate the impact of a particular change, I would also point out *that confidence that the tool being employed is capable of producing valid interval (difference) results between two such model runs is required*. Dr. Cramton never supplies any validation to come to this conclusion. He merely offers that he conducted some unknown testing without providing any details or justifications. It is in this context that I recommended that six test cases, progressing from a standalone "without anything" base case to incremental additions such as carbon pricing, to ultimately a comparison of the differential impact of the broad and narrow MOPR in comparison to what would hopefully be a validated starting case. None of these tests were done. Again, if the Commission allowed for more time to fully understand the PJM proposal, these issues could be properly evaluated.

¹⁸ Id. Note that he ultimately concludes there is no material difference between these cases. Id. at. paragraph 43.

19. My testimony was intended to identify a reasonably simple way to approximate the more formal validation that one would expect Dr. Cramton to have conducted. For example, one might draw very different conclusions if we saw that in the comparison of a zero-carbon pricing case to a case including his hypothesized progression of carbon prices, virtually all of the state sponsored resources would have entered the market in any event. *This would make his further analyses of differences in the MOPR rule irrelevant, and possibly explain his results of no material difference between the two MOPR cases he compared.* Such a conclusion would reveal that his representation of carbon pricing subsumes the need for narrow MOPR, and at the same time eliminates any inferences from the subsequent MOPR cases he conducted.

20. Indeed Dr. Cramton admits as much in his Working Paper when his notes that carbon pricing in the model “[hastens] the pace of the transition] to achieving any climate goals.¹⁹ This type of statement emphasizes why testing the validity of using an interval metric is so important. Such a comparison would also assist the Commission’s understanding of the arguments being presented. But this important information remains absent from the record, and the omission is material to both understanding) the strength of the model in general to displaying differences in cases (validating its use for interval comparisons) and the key issues in this proceeding in particular regarding the MOPR design.

21. Simply stated, the validity of any interval comparison cannot just be assumed - the tool’s application and properties must be validated first. Dr. Cramton deflects the issue by saying it was appropriate to include a carbon price to represent future anticipations by investors. Whether it is an accurate forecast of investor anticipations or not was not the point. The issue was whether or not the model can produce valid interval

¹⁹ See Working Paper at page 13. “Our model demonstrates the power of carbon pricing in hastening the pace of the transition and measuring the cost of achieving any climate goal.” This comment is independent of any differentiation of between the two MOPR cases.

comparisons, and the cases I identified were a simple way to approach that.²⁰ Dr. Cramton did not do this type of validation.

22. This exact same logic applies to the discussion below regarding the characterization of the ORDC curve. Dr. Cramton is dismissive of the current uncertainty regarding whether or not such a design feature will even exist (though he says rational investors will assume its existence). But what he misses is the point that his conclusions regarding the presence or absence of the ORDC and the resulting broad/narrow MOPR comparison all rest on the unverified reliance of interval comparisons. As shown below this is particularly unjustified in the ORDC case.

23. The conclusion the Commission should draw is simple: the combination of the model forecasting extremely high absolute capacity market values and lack of validation of interval properties remains a fundamental problem with respect to determining the validity of the Cramton model results. These problems and concerns are amplified when one considers that Dr. Cramton finds very little difference between the application of the broad and narrow MOPR. Finding no material difference is not a very strong result. Simple assertions that this type of validation or testing work was done and references to YouTube appearances of past presentations (none of which were presented to the PJM stakeholders) are not sufficient. The Commission should demand more before it simply accepts Dr. Cramton's conclusions as valid.

24. While obviously the above raises great concern with respect to the model validity and its application, the specific results should also be considered with the previous two sections in mind. Dr. Cramton summarizes these, now somewhat meaningless, general conclusions in paragraph 43 of his reply. "The answer is that capacity prices are somewhat higher with the broad MOPR, and reliability is essentially the same, with price spikes slightly more prevalent in the narrow MOPR case." Similarly, he expresses the same

²⁰ Actually given Dr. Cramton has now identified the relatively low cost estimate of conducting a series of studies (See Reply at paragraph 36). I would prefer a more intensive interval validation procedure prior to any further utilization of the model by PJM.

conclusion several times in the Working Paper.²¹ Consequently, despite the protestations, I (and he) find that there is no material difference in the two cases. Further, his supporting analysis is at best supported by incomplete testing and validation of both the absolute values of the model results and the interval differences between model runs. This cannot possibly support any conclusion of just and reasonableness by the Commission.

III. Selected Other Specific Issues of Rebuttal

A. Transfers Among the Impacted Parties Are Not Considered

25. Dr. Cramton admits his analysis does not consider transfers despite the significant wealth transfers that PJM and other parties acknowledge.²² Perhaps Dr. Cramton does not see the relevance of transfers among the parties. Perhaps some of Dr. Cramton's indifference is related to the lack of resolution or impacts identified by his modeling. Regardless, it is clear that material monies are transferred under the change from the broad to narrow MOPR. Brattle, citing its unique access to internal PJM offer data and a more current and accurate view of the short-term penetration of the state sponsored programs, estimated this transfer at \$1.4 billion dollars per year from 2025-30 (plus a dead weight loss of \$0.3 billion annually).²³ In other words, the imposition of the proposed narrow MOPR and state subsidies transfers \$1.4 billion per year away from existing suppliers and creates the additional \$0.3 billion of dead weight loss inefficiency

²¹ For a more detailed discussion see Working Paper at page 68 “The introduction of the broad MOPR leaves net present values—and therefore entries, exits, and the evolution of the energy mix—largely unaffected. The broad MOPR lowers the net present value of onshore wind slightly in the first two years of the simulation and delays the date when storage and solar become economic by two years. These effects are small for two reasons. First, renewable resources and storage are already economic or near-economic at the beginning of the simulation (except for offshore wind). Thus, the broad MOPR is unlikely to bind, and once the resource clears, the offer floor drops from Net-CONE to Net-ACR, which is much lower.”

²² See Cramton Reply at paragraph 16. “I do not focus on the distribution of money among market participants.”

²³ See Brattle affidavit in this the PIO filing, at page 7. It is worth noting that Dr. Cramton did not rebut Brattle's finding.

versus the status quo. As argued by others that assume the correct starting point is not the status quo, but the world after the approval of the PJM narrow MOPR, the transfer is reversed. The fact that Brattle, who continually evaluates the PJM capacity market on behalf of PJM, has such different expectations from Dr. Cramton's model, particularly in the near term, should give the Commission great pause with respect to the Cramton model results and PJM's reliance on such results that basically say there is no difference between the broad and narrow MOPR.

B. Dr. Cramton Ignores Transmission Limits

26. Despite the obvious materiality, and the significant problems in properly validating the model to historical locational results, Dr. Cramton simply dismisses the relevance of any consideration of transmission limitations. Apparently, despite the relevance, he sees recognition of transmission, which is fundamental to the PJM locational modeling of energy and capacity, as an unnecessary complication. "Transmission is not modeled. Modeling transmission would be appropriate in a multi-decade model where transmission planning will add transmission to largely address persistent congestion. *That is not my model.* Adding transmission and the transmission planning process would greatly complicate our analysis."²⁴ He is correct, it is not his model, and his model explicitly ignores important locational considerations.²⁵ While Dr. Cramton waives off transmission limitations, the Commission should not ignore this reality of PJM's grid and market design which are highly dependent on locational energy and capacity constraints and price signals.

27. Transmission planning, the facilities to make feasible the types of renewable energy resources being considered, and their costs are a key part of PJM's

²⁴See Cramton Reply at paragraph 16, footnote omitted, emphasis added.

²⁵ For example, intermittent resource production is aggregated and does not reflect pricing or congestion differences. It is treated as if it were all at one location. "Only the total generation of renewables is relevant for market outcomes, not the individual units' efficiency and nameplate. All that matters is the aggregate production of solar and wind in each 5-minute interval. A unit's profits and performance are then proportional to its efficiency relative to the technology class'. See Working Paper at page 59. I have not considered yet if this causes a further complication and problem due to the lack of locational sensitivity in PJM's ELCC modeling."

current efforts to plan for this magnitude of potential changes.²⁶ Dr. Cramton's statement clearly indicates that his model *should have* included transmission characterization. His decision not to do so is more an issue of computational expedience than one of accuracy in the depiction of this specific policy question. By making this choice in the design of his model, Dr. Cramton directly limited its applicability to certain issues, e.g. where locational elements, constraints and costs are very important, such as for off-shore wind.

28. Apparently, Dr. Cramton is not aware of the important locational role of PJM's aggregate transmission planning and testing. This would include the Regional Transmission Expansion Planning Process (RTEP), the generator deliverability processes in PJM, and the load deliverability testing. The RTEP process considers multiple "drivers" in transmission planning (e.g., reliability, congestion/market efficiency, public policy, interregional coordination)²⁷ and coordinates with local supplemental transmission projects. Local/zonal load deliverability identifies transmission upgrades necessary to maintain the transfer capability into a zone (Capacity Emergency Transfer Limit) more than the established zonal import requirements (Capacity Emergency Transfer Objective).²⁸ Cost allocations for these projects differ by the nature of the driver. Generation deliverability for new generation projects results in obligations to build and pay for (without crediting) identified network upgrades to meet generation deliverability standards and recognition as a Capacity Resource.

29. Most importantly, Dr. Cramton does not explain how the costs of the network upgrades associated with more than 50,000 MWs of intermittent resources to be added by 2035 that he assumes, are fixed in his modeling.²⁹ PJM estimated that the

²⁶ See e.g. <https://www.pjm.com/-/media/committees-groups/committees/teac/2021/20210810/20210810-item-10-offshore-transmission-study-group-phase-1-results.ashx> and related Transmission Expansion Advisory Committee meeting materials. Materials are available for various meetings at <https://pjm.com/committees-and-groups/committees/teac.aspx>

²⁷ See high level description at <https://learn.pjm.com/three-priorities/planning-for-the-future/rtep> and PJM Manual 14B Section 2. <https://www.pjm.com/~media/documents/manuals/m14b.ashx>

²⁸ See PJM Manual 14B Attachment C.

²⁹ See Working Paper Table 6.5 page 55 (also cited in my Affidavit). See also Working Paper at page 62 "*Traditional nuclear, solar, onshore wind, and offshore wind are state-sponsored. Pump-storage and state-sponsored resources are assumed to remain in the market regardless of their economics.*" Emphasis added.

transmission upgrade costs for the 2035 for offshore wind facilities alone would cost \$3.2 billion dollars.³⁰ This does not include generator lead-lines or offshore facilities.³¹

30. While the cited PJM study made no assumptions as to cost allocation, these costs are real and must be paid for by consumers. But more importantly there is no reason to assume that the allocation of these costs would be the same between the broad and narrow MOPR cases. To the extent that resources receiving state subsidies would otherwise be infra-marginal with respect to entry, the projects would be expected to carry a greater share of transmission costs as compared to a world with the narrow MOPR, where most if not all of these costs would likely be allocated to a specific state and its residents based on the state's specific public policy and PJM's cost allocation for transmission driven by such policies.

31. Because Dr. Cramton ignored transmission and made the addition of such facilities independent of the broad or narrow MOPR (and their economics)³², these and similar costs of other renewable facilities are totally ignored (but not irrelevant). By ignoring transmission, he assumed away the consideration of billions of dollars of expense that someone will have to pay and may differ significantly in magnitude and allocation under the different MOPR cases. In essence, Dr. Cramton assumes that transmission costs are deemed sunk regardless of MOPR design or any other economic or policy factors. This assumption is not reasonable and should not be accepted by the Commission.

³⁰ See PJM Presentation <https://www.pjm.com/-/media/committees-groups/committees/teac/2021/20210810/20210810-item-10-offshore-transmission-study-group-phase-1-results.ashx> slide 14.

³¹ Id. at slide 7.

³² See Working Paper at page 55. "The MW amount of state-sponsored resources entering each year is based on PJM estimates and reported in Table 6.5. State-sponsored resources, including nuclear, are assumed to stay in the market regardless of their economics." See Working Paper at page 62: "Traditional nuclear, solar, onshore wind, and offshore wind are state-sponsored. Pump-storage and state-sponsored resources are assumed to remain in the market regardless of their economics."

C. Dr. Cramton Assumes That State Sponsored Resources Do Not Change With Economics, Policy or MOPR Design

32. As I just noted above, there is a strong correlation between disregarding billions of dollars of transmission impacts and the criticisms I made (unanswered by Dr. Cramton) that over 50,000 MW of intermittent resources and 6,000 MW³³ of nuclear generation will remain in the market regardless of MOPR policy.³⁴ His comparison of the broad versus narrow MOPR rests on his assumption that informed private investors will make reasoned estimates of future profits, and in doing so assumes that all those units will be built and operating regardless of the disposition of the MOPR, or for that matter, any changing economics for intermittent technologies or related transmission costs.³⁵

33. This makes no sense. Dr. Cramton assumes that investors will respond to changes in policy and adjust their investments accordingly, but that policymakers will ignore the market economics and will proceed with subsidies regardless of PJM policy, federal tax policy, state budgets, wholesale electric prices, or simply the basic economics of intermittent units. For example, as I initially commented, material intermittent resources cleared in the last PJM RPM BRA auction under the current MOPR.³⁶ It is illogical to assume that government policymakers will not respond to these changes and make corresponding changes to their state policies. There is no justification for Dr. Cramton's assumption that private investors will react to long-term fixed forecasted changes in economic circumstances, but states' policymakers will keep their policies

³³ See Cramton Working Paper Table 6.5 and Shanker Affidavit at paragraph 55.

³⁴ See Cramton Reply at paragraph 34. Note that this paragraph is also where Dr. Cramton erroneously conflates the case selection I identified to estimate the model validity for interval comparisons with general model assumptions.

³⁵ Id. at paragraph 34.

³⁶ Dr. Cramton's analyses come to this same conclusion regarding the economics of all state subsidized units except offshore wind. "Initially, the only new technology with a positive net present value is onshore wind. The net present value turns positive in 2021 for batteries, 2024 for solar, and 2029 for combined cycle with carbon capture and sequestration (entry follows after three years consistent with the planning horizon). Offshore wind never becomes profitable but enters the market because of states' support." See Working Paper at page 66.

fixed and be indifferent to such changes, even when they work to the detriment of the state and its ratepayers.

34. My observation is that Dr. Cramton assumes that the states will act in an irrational and uniformed manner. While states may certainly elect to continue policies that do not recognize changing market dynamics, it is unreasonable to assume that they will blindly continue with their policy choices of the past.³⁷

D. Dr. Cramton Completely Ignores the Impact of the ORDC.

35. Dr. Cramton's reply suggests that there is no impact from any changes to PJM's ORDC curve and associated payments in the energy market. He bases this on his general observation that an ORDC is a good design element, and a rational investor would assume its presence; and that because he is only considering the difference between the two MOPR cases, only capacity prices would change and his conclusion would be the same.³⁸

36. Regardless of the future of the ORDC, its impact or lack thereof cannot be ignored. Energy prices will be different from the existing results in both the narrow and broad cases with the removal or modification of the ORDC or the use of a different penalty factor. With a revised ORDC, energy margins will differ for infra-marginal units regarding the calculation of profits and thus entry should be expected to change depending on projected energy prices. As admitted by Dr. Cramton, the resulting capacity prices (as well as energy prices) will thus differ.³⁹

37. Similarly, Dr. Cramton justifies his assumption that there will be a meaningful carbon price by saying it was appropriate to include a carbon price to represent future anticipations by investors. But there is not a meaningful or uniform carbon price in all PJM states today and it is not clear when there will be a meaningful

³⁷ In 2011, New Jersey and Maryland were actively pursuing of policies of subsidizing new natural gas plants.

³⁸ See Cramton Reply at paragraphs 30-32.

³⁹ Id. at paragraph 32.

carbon price in all PJM states or for that matter how investors would interpret such a diversity of policies. As with the ORDC, energy margins will differ for infra-marginal units (including state sponsored resources) and thus entry should be expected to change depending on projected energy prices with or without carbon prices. The resulting capacity prices will thus also differ. In turn, one would expect the interval differences to be different between the two MOPR cases under varying carbon-pricing assumptions. Or, as I stated above, there may be no change at all in the cases because Dr. Cramton's initial assumption of a material carbon charge built into the base case subsumes all the changes in entry that might otherwise have been influenced by the MOPR design.

38. Dr. Cramton's conclusion reflects /assumes a very strong property for the model, that is, not only does he assert that interval comparisons valid when only one factor changes (e.g. the MOPR) but also such a difference is unaffected by material changes (apparently regardless of level) to the energy market (e.g. as the ORDC penalty goes from effectively zero to \$3000 or as meaningful carbon prices apply or not).

39. I am skeptical that the results of such broad/narrow MOPR new entry decisions would not be impacted for infra-marginal units as their energy margins change due to removal or modifications of the ORDC or carbon prices, particularly in the short run, where Brattle has identified very material transfers. To the extent this were true, it might amplify my concerns regarding the implications of Dr. Cramton's modeling.

40. Basically, Dr. Cramton is saying the new capacity entry and exit and price differential changes are in lock step between MOPR cases regardless of energy pricing design and magnitude. I would only expect this type of result if the model were somehow over constrained, or solely reflecting a long-term equilibrium solution. The former makes the model useless, and the later directly contradicts Brattle's result about the huge transfers based on changes in MOPR policy in the near term.

41. Again, Dr. Cramton has not validated that such changes in energy prices will result in a net zero difference in the comparison of cases (broad v narrow MOPR),

and the result is assumed, not proven.⁴⁰ Indeed, I do not believe such comparisons are even possible with the model in its current state and it may be quite difficult to address problems not anticipated in the original model design or cases developed for PJM.

E. Characterization of Batteries/Storage

42. Dr. Cramton makes the interesting statement that four 2-hour batteries are the equivalent of one 8-hour battery.⁴¹ This would only be so in a world with central and direct command and control of all battery units independent of relative economics, e.g. as if the units were all owned by a single cost of service party and centrally planned and dispatched. I would refer the Commission to PJM's ELCC filing and working group analyses that show distinct material differences between the ELCC of different duration batteries. And even these analyses assumed (inappropriately) that the battery dispatch would be optimized regardless of the economic requirements of the owner (e.g. the battery would be optimized for reliability even if it meant forgoing market revenues, behavior consistent with cost of service ownership, not market based competitive ownership).⁴² None of this is reflected by Dr. Cramton, and the resulting misrepresentation of ELCC, and the inherently different view of competitive market behavior invalidates results regarding relative decisions of not only storage but all competing products.

43. This concludes my reply. I have only offered comments on the most egregious comments of Dr. Cramton and any areas not addressed do not imply in any way my agreement or disagreement with his statements. However, it is clear to me, that Dr. Cramton's analysis remains incomplete, flawed, and unsupported. The Commission

⁴⁰ Id. at paragraph 32. "For example, if the reserve penalty factor were \$1000 or \$3000, rather than \$2000, the impact would be changed capacity prices, not in the relative outcomes between the broad and narrow MOPR. My conclusion would remain the same."

⁴¹ See Cramton Reply at paragraph. 48. In replying to a criticism regarding the use of 2 hour batteries only: "But four two-hour batteries can replicate the same outcome produced by one eight-hour battery with the same charging and discharging capabilities."

⁴² See e.g. one of numerous evaluation examples prepared by PJM: <https://www.pjm.com/-/media/committees-groups/committees/pc/2021/20210420-special/20210420-item-03b-how-effective-load-carrying-capability-works.ashx>

Here the material differences in ELCC values are shown for 4 v 8 hour batteries.

should either allow more time for his analysis to be properly vetted or dismiss its credibility entirely.

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

PJM Interconnection, L.L.C.)

Docket No. ER21-2582-000

AFFIDAVIT

I, Roy J. Shanker, do hereby swear and affirm under penalty of law that the statements in the foregoing Reply Affidavit of Roy J. Shanker, Ph.D. are true to the best of my knowledge, information and belief.

Executed this 20th day of September, 2021

/s/ Roy J. Shanker _____
Roy J. Shanker