

1 | What system needs (type and magnitude) has the RTO/ISO experienced that are attributable to changes in the resource mix and customer load profiles? (FERC Q1)

The resource mix and load profiles in PJM are in the throes of a significant evolution that is placing new demands on the system and the PJM EAS markets that were not considered when originally developed. In response, PJM needs to continue its efforts to evolve existing EAS market products (and/or develop new ones) that can respond to the evolving system needs to ensure continued operational reliability as well as to inform policy makers and investors of the most efficient way to further decarbonize the grid while ensuring continued reliability. The evolution is well underway yet few market participants possess the system operating data needed to track hourly, daily, seasonal and other system operating trends and understand the impact the load and resource evolution is having on overall system operations or whether existing market are sufficient to ensure reliability in the face of these changes. Rather, we believe that PJM and its operators are in the best position in the first instance to understand, quantify and publicize the changing system needs and propose market-based means of addressing them.¹ In other words, PJM runs the system and has the most granular information on system operating uncertainty operators faces daily, across days and seasonally; the causes thereof; emerging trends (and likely future trends) in that uncertainty; and the adequacy of existing market-based tools to respond to the uncertainty. Thus, PJM should report this information in response to this question in as much detail as possible (e.g., provide specific anecdotes, information demonstrating trends, key assumptions, etc.) so that PJM can justify any market rule changes that are needed to ensure it has the tools necessary to preserve reliability.

It is clear that PJM states' pursuit of lower carbon emissions and cleaner air is driving not only a cleaner resource mix but one that is also increasingly intermittent given the operating characteristics of many of the resources being supported. This is evident in PJM's interconnection queue which is currently burgeoning with almost 70,000 MWs of solar resource interconnection requests alone; the queue is also flush with considerable interconnection requests from wind, storage and hybrid resources. (While not all of the interconnection requests will come to fruition, the state laws and other actions that are driving this resource mix evolution show no signs of diminishing.) In addition to shaping the resource mix by directly encouraging cleaner resources, PJM states also continue to take actions that will impact the resource mix in other ways (e.g., Pennsylvania recently began participating in RGGI which could impact the long-term economics for resources which must now reflect certain emissions costs in their offers). PJM states and their customers are also profoundly reshaping the load side of the equation by encouraging increasing levels of electrification, behind the meter resources, demand response, energy efficiency and similar load altering measures that further decarbonize the grid and impact system operating characteristics. Numerous Federal mechanisms (e.g., PTC/ITC) provide further encouragement for the resource and load evolution.

Collectively, these changes in the resource mix and on the load side are changing the way the grid operates and the demands placed on it. This evolution is introducing new and significant variables into system operations that are increasing the uncertainty faced by PJM operators as they dispatch the system. We understand through anecdotes from PJM that this uncertainty is a growing concern for

¹ Indeed, it is for this reason (i.e., access to the necessary system operating information) that FERC directed the RTO/ISOs to provide the reports in this docket. *See Modernizing Wholesale Electricity Market Design*, 179 FERC ¶ 61,029 (2022).

operators who are increasingly forced to take out-of-market actions to ensure reliability,² and we do not believe these concerns have been adequately addressed despite efforts by PJM to improve the situation. Nonetheless, operators should not be forced to continue taking out-of-market actions to keep the lights on. Rather, market-based products should be improved (and/or new products developed) and implemented so that the needed reserves and other services are incented and readily available through market-based mechanisms.

The folks who actually run the system and are most familiar with the operating issues – PJM and its operators – are in the best position to answer many of these FERC questions or at least to compile the information needed to understand the problem so that helpful solutions can be developed. PJM and its operators have the most complete understanding of (i) the magnitude of operating uncertainty PJM operators face, (ii) how that uncertainty changes throughout the hour, day and across seasons, (iii) how uncertainty has grown and changed in characteristics over time (and how it is expected to continue growing/changing as the resource/load evolution continues), (iv) what services would be most helpful in responding to that uncertainty, (v) what tools PJM operators rely on in response to that uncertainty (and expect to rely on in the future) in response,³ and (vi) related information. Thus, in responding to FERC’s request, PJM should interview its operators and study PJM operations to document the levels of supply and load uncertainty (including trends and future uncertainty expectations), the frequency and magnitude of load biasing and out-of-market actions that may result from load biasing or other reasons, the ability of existing market-based products to respond to evolving system needs and the services that would be most helpful in responding to them. PJM should compile a rigorous report documenting its findings of the operating problems we believe PJM operators are increasingly facing which can then be used by PJM, its stakeholders and FERC to develop and justify just and reasonable market-based solutions.⁴

(a) How do these system needs, including types and magnitudes of net load variability and uncertainty, vary over different time horizons in the E&AS markets? (FERC Q1)

See response to Question 1, above.

(b) For example, does a particular need exist within a real-time market interval, within an operating day, between day-ahead and real-time markets, across multiple days, and between seasons? Please include any references. (FERC Q1)

See response to Question 1, above.

² See, e.g., *PJM Interconnection, L.L.C.*, Docket No. EL19-58, Enhanced Price Formation in Reserve Markets of PJM Interconnection, L.L.C., Attachment E, Affidavit of Christopher Pilong (Pilong Affidavit), at ¶ 6 (Mar. 29, 2019) (describing PJM operator concern with “load forecasting, interchange forecasting, and generation performance/availability forecasting” uncertainties and describing out-of-market “biasing” actions taken by PJM operators in response).

³ For example, it would be useful to understand trends in fast-start resource dispatch throughout the day, across seasons and over the years, and how those trends correlate to the evolving resource/load mix.

⁴ In other words, PJM should develop an updated version of the Pilong Affidavit that is a comprehensive, detailed and rigorous analysis that is sufficient to support any changes as just and reasonable.

(c) What specific resource capabilities could address these needs (e.g., dispatchable generation)? (FERC Q1)

See response to Question 1, above.

(d) What time horizons, such as times of day (e.g., minutes, hours), days, or seasons, are expected to present the biggest challenges with respect to net load variability and uncertainty? Why? (FERC Q2.2)

See response to Question 1, above.

2 | Referring to the changing system needs discussed in the questions above, to what extent are current RTO/ISO E&AS market products and compensation schemes not designed to procure the resource capabilities needed to meet these expected changing system needs? To what extent are such prices and products unable to adequately compensate the resources possessing the capabilities necessary to meet these expected changing system needs? To what extent does the risk of disorderly retirements of resources with capabilities that are needed to address such needs (e.g., fast ramping dispatchable resources) increase if E&AS markets are not reformed? Why? (FERC Q4)

As described in the response to Question 1, above, policy makers and market participants both lack sufficient information to thoroughly understand all of the specific operating issues (or magnitude thereof) PJM faces now (or expects in the future) as a result of the evolving resource/load mix or how well the currently available market-based tools can be relied on to meet all the operating issues. Nonetheless, based on the information available, we believe these issues to be considerable and growing and that EAS market products are inadequate to address them in PJM.

For example, PJM currently lacks specific ramping, flexibility or other tailored reserve-like services to respond to changing system needs. And to the extent PJM has a market for traditional reserve services, the market structure is wholly inadequate to ensure that needed operating reserves will be reasonably incented in the long-term. Specifically, PJM's current operating reserves market fails to reasonably compensate reserves, fails to provide a sufficient quantity of reserves and, as such, will fail to incent the level of reliability expected during times of system stress.⁵ As a result, resources that could provide operating reserves services will be signaled to retire, resulting in increasing levels of out-of-market actions by PJM operators, undermined market signals (which will only exacerbate the problem) and increased long-term costs for consumers. The PJM system remains vulnerable even with respect to its basic reserve product, making it all the more important for PJM to provide clear evidence of its control room concerns and out-of-market activity so that shortfalls in the existing reserves market can be corrected through an improved reserves product that is fully justified at FERC.

⁵ See, e.g., *PJM Interconnection, L.L.C.*, Request for Rehearing of Exelon Corporation and Exelon Generation Company, Docket Nos. EL19-58, ER19-1486 (Jan. 21, 2022). PJM shares concerns with respect to the adequacy of the existing reserve product and has also sought rehearing in these dockets, noting that "PJM remains concerned whether the existing Operating Reserve Demand Curves and Reserve Penalty Factors are adequate to ensure the proper reserve market response." *PJM Interconnection, L.L.C.*, Request for Rehearing of PJM Interconnection, L.L.C., Docket No. EL19-58, at p. 2 (Jan. 21, 2022).

3 | Over the next five years, and over the next 10 years, how well will existing RTO/ISO market designs adequately incentivize resource behaviors that will enable the RTO/ISO to meet its changing system needs? (FERC Q6)

As described in response to Question 2, basic operating reserves services are not adequately incented currently in PJM; the problem will only grow worse over the next five and 10 years unless it is addressed. We also believe that PJM should consider other reserve-like products (e.g., co-optimized ramping), so its operators have sufficient market-based tools to respond to system needs as the system evolves. Indeed, PJM noted in a recent whitepaper,⁶ “[m]arket reforms are needed to incentivize flexibility and mitigate uncertainty.”⁷ However, improvements can only be made to existing market products and/or new products developed, if PJM provides sufficient data and evidence of the problem and the inadequacy of existing market mechanisms to support and justify the needed changes as just and reasonable, and more comprehensive justification is needed than is provided in that whitepaper.

4 | Parties presented different views on whether the widespread use of opportunity cost-based ancillary service pricing will continue to sufficiently incent and compensate resources for meeting system needs as the resource mix and system needs evolve in the future. Given the critical role RTO/ISO resources play in meeting system needs, more information on how E&AS markets will provide adequate compensation for these costs is needed. Will existing E&AS market designs create sufficient fixed cost recovery under existing pricing methods (i.e., opportunity costs, shortage pricing, etc.) for resources to make needed investments, remain in service, and continue to offer the capabilities necessary to meet changing system needs? (FERC Q6.2)

Opportunity-cost pricing, a core principle of basic economics, remains a sensible and appropriate means of incenting the operating reserves and reserves-like services needed to ensure reliability in the face of increasing operating uncertainty. Resources providing operating reserves and reserve-like ancillary services must in many cases forgo the sale of energy so that they can provide reserves, which physically take the form of unloaded capacity on online or offline generating resources that have invested in quick start capability (or the equivalent for demand response and storage resources).

Some (including FERC in asking this question) seem to suggest that increasing levels of intermittent resources will drive energy market clearing prices to \$0, simultaneously reducing to \$0 the opportunity cost that would be available to incent resources to provide the needed ancillary services.⁸ This hypothetical example ignores a number of key economic feedback mechanisms and nuances that would

⁶ *Emerging Transition in PJM: Emerging Characteristics of a Decarbonizing Grid*, May 17, 2022 (available at [20220517-energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx](https://www.pjm.com/~/media/committees-and-panels/energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx).) (PJM Whitepaper). While the PJM Whitepaper provides helpful insights into some of PJM’s operating concerns as the resource/load profiles evolve, it lacks the rigor that would be needed to support and justify a filing at FERC.

⁷ *Id.* at 2; *see also id.* at 4, 18 and 21-22 (describing inadequacy of the existing ORDC curve PJM uses in procuring operating reserves and the need for other flexible/ramping products in PJM).

⁸ *See* Question 2 on Panel 3 of the September 12, 2021 Conference in this docket; September 14, 2021 Testimony in this docket, at p. 48 (ISO-NE suggests opportunity cost pricing may not be appropriate signal as it might not cover all supplier costs); *but see id.* at p. 22 (NYISO suggests that opportunity cost pricing can be an appropriate approach).

cause the situation to likely play out very differently in the real world. First, energy prices need to support the commitment and operation of all resources that provide services needed to reliably operate the system. In a world where energy prices are always \$0, dispatchable generation that provides a large amount of the needed reserve products will simply not commit and run. Because those resources will be needed to provide the reserves necessary to manage the high level of intermittent resources in the example, the co-optimized market price of energy and operating reserves will rise to a level that supports their commitment and operation. In other words, the dispatchable resources are the truly marginal resources that should set price, and that price will not necessarily be \$0 in all hours even with a large level of intermittent resources (unless the system operator resorts to extreme levels of out-of-market intervention).

Second, while it is certainly possible, and appropriate, that in some time intervals the reserve price may be \$0, in a world with a high level of intermittent resources it is likely that the price for reserves (and energy) would be quite volatile but, on average over time, produce revenues sufficient to support the commitment, operation, and retention of reserve-capable resources, assuming a well-structured market without undue out-of-market activity. Indeed, in such a world an effectively designed demand curve for operating reserves can play an important role in incenting operating reserves and reserves-like service. If the demand curve captures the value of providing reserves when needed, resources will be incented to provide those reserve and reserves-like services, so they can capture that revenue. In addition, by shifting any ancillary services demand curve to the right and including a slope so that ancillary services can be purchased even before a shortage is reached, the demand curve will incent investment in ancillary services even before an extreme situation is encountered.

5 | Will existing E&AS market designs create an efficient long-run price signal for investment in new resources with the capabilities necessary to meet changing system needs? (FERC Q6.2.1)

No. As described in response to Question 2, PJM’s market design and products do not presently encourage adequate levels of basic operating reserves services. The problem will only grow worse over the next five and 10 years unless it is addressed. Present operating reserves products can be improved, so PJM operators have sufficient market-based tools to respond to system needs. Alternatively, PJM should consider other reserve-like products (e.g., ramping) to satisfy evolving operating needs (so long as they are procured through market mechanisms that are co-optimized with energy and ancillary services markets).⁹ However, improvements can only be made to existing market products and/or new

⁹ We note that many of the increasing concerns with renewable intermittency can be addressed through enhancements to existing operating reserve products. In other words, a set of wind or solar resources in the same geographic area and effected by the same weather conditions could be viewed as a “unit” for purposes of establishing the reserves requirement; when the wind drops or the clouds roll in unexpectedly, the drop in “unit” output would trigger a reserve event. Nonetheless, if there is a preference that separate categories of ancillary services be developed to address the increasing intermittency concerns, PJM can develop individual products accordingly. We note that if new ancillary services are to be implemented to procure such additional categories of ramping, flexibility or other services, they must be carefully coordinated and calibrated with all other ancillary services to ensure consistent market results. Regardless of whether new products are to be developed, PJM should still consider whether its exiting operating reserves are sufficient for the services they are intended to cover.

products developed, if PJM provides sufficient data and evidence of the problem in its response to FERC to support and justify the development of needed changes as just and reasonable.

6 | Should ancillary service products be co-optimized with energy so that the assignments and prices for ancillary services align with energy prices? (variation of FERC Q6.4)

Yes. Co-optimization is consistent with PJM's longstanding, FERC-approved mechanism for procuring energy and ancillary services. This long-standing practice is based on the principle that co-optimizing market-based procurement of reserves and reserves-like products with the energy markets will incent all resources to be available and economically indifferent to operator dispatch instructions whether they are called upon to provide energy or ancillary services at the time they are most needed (i.e., during a shortage event). That is, the price signal provided through co-optimization will incent resources to invest as necessary to ensure they are available during a shortage whether they are providing energy, reserves, some other reserves-like product or a combination of services.

Absent co-optimization of energy and reserves, total production costs will increase as out-of-market lost opportunity costs must be paid to units with reserves commitments, and energy supply will become incrementally scarcer as a consequence of committing a unit for reserves. Energy and reserves prices should transparently reflect the trade-off of committing units for necessary reliability services.

7 | Referring to the changing system needs discussed in question 1, are there any operational practices in PJM that should be reviewed/alterd to successfully manage changing system needs over the next five years and over the next 10 years? (FERC Q7)

As noted in prior responses, we understand that out-of-market actions by PJM operators continue and could be on the rise in response to increasing levels of system uncertainty. PJM should work to eliminate or at least reduce this practice as routine and potentially increasing levels of out-of-market activities to procure needed reliability services undermines market efficiencies, discourages investment in needed resources, undermines market transparency and creates unhedgable uplift, among other issues.¹⁰ Thus, as part of its response PJM should provide details on the frequency, magnitude, evolving trends and root causes for operators' practice of relying on out-of-market actions. This information will enable PJM and its stakeholders to develop market products that can replace or at least minimize the need for operators to continue to rely on any out-of-market practices.¹¹

In addition, PJM should consider how improvements in transmission system planning, operations and maintenance can also play a role in alleviating system reliability concerns as the resource/load mix evolves. For example, more frequent and rigorous studies of transmission system topography could reveal opportunities for transmission solutions to be implemented to relieve congestion or otherwise ensure the most efficient dispatch (and minimized need for out-of-market actions). In addition,

¹⁰ PJM appears to agree that reliability solutions should be obtained through markets. See Transcript of the September 14, 2021 Conference in this docket, at p. 81 (noting that PJM believes it "is necessary to make sure that that the additional capability that is needed [to address uncertainty] is actually valued in the market").

¹¹ We understand that the practice of relying on such out-of-market tools is necessary to ensure the lights stay on; however, a better, more sustainable path would be to understand the circumstances where out-of-market actions are taken and to develop market products that can more effectively respond to them so such practice can be minimized.

transmission and generation outage planning should be carefully studied and coordinated to minimize the potential for anomalous and unanticipated EAS market results (e.g., Northern Neck).

8 | Beyond those already asked, are there other E&AS market reforms necessary? (FERC Q8)

PJM has made clear its need for additional flexibility beyond what can be obtained through the current operating reserve mechanism.¹² As noted above, PJM's current reserve market can be reformed to incentivize the needed flexibility or PJM can develop new flexibility products to address the need (again, provided such new products are procured on a market basis and co-optimized with existing EAS products). But continuing to ignore the issue is untenable.

9 | What is the capacity market's role in incentivizing resources with specific attributes vs solely procuring to meet a total reliability requirement? (FERC Q9.2)

EAS markets should remain the focus for procuring any services needed for operational reliability. Such focus is consistent with the design for all of the existing ancillary services (other than with respect to scheduling and reactive services which are too administrative or local in nature to be conducive to effective market procurement). EAS markets are granular and precise, providing clear price signals for services that are needed to preserve system security in the operating day, the location of such services, the duration of the need, and the amounts that are needed. Capacity markets, on the other hand, are blunt tools designed to ensure resource adequacy. Capacity markets signal the need for investment to be available in the delivery year, but do not provide a strong signal for real time performance. Capacity markets are also intended to provide any missing money as a result of EAS market inefficiencies. By focusing on developing efficient and effective EAS products in the first instance, PJM and its stakeholders can minimize reliance on complicated capacity constructs attempting to make up missing money.¹³

10 | Are there actions outside of the Tariff that should be considered? (FERC Q10) (a) NERC standards (b) Gas market (c) JOAs

As discussed in response to Questions 5 and 8, above, existing operating reserves mechanisms are insufficient in PJM, and the situation will only worsen as the resource/load evolution continues. PJM needs to improve existing reserve products and/or develop new ones to resolve the situation. In addition, if other mechanisms, such as gas-electric market coordination, can be improved to help the situation, then PJM should consider pursuing those as well. However, it should only do so after it has put in place the basic market tools that it needs.

Also, as described above, PJM should study and define the operating reliability issues it is facing and suggest solutions rather than waiting for others' solutions -- that may or may not help PJM with its particular circumstances -- to be forced upon it. For example, if PJM believes the transmission system should meet enhanced/new technical standards (e.g., NERC standards) to satisfy PJM reliability

¹² PJM Whitepaper at 4 (pointing out the PJM's current operating reserve market "fails to capture the rise in uncertainty driven by the penetration of renewable resources . . . [and] also fails to send long-term market signals to incentivize flexibility"); *see also id.* at 21-22 (describing ramping concerns in PJM).

¹³ The focus on the EAS markets also seems consistent with PJM's preferences. *See, e.g.,* September 14 Transcript at p. 26 (PJM expressing the preference "that we get the incentives in the real time timeframe correct").

concerns, PJM should proactively develop and support such standards, not merely react to proposals that may not be helpful in addressing its situation.

11 | Please provide any additional comments or responses to FERC questions you believe PJM should consider