PJM Interconnection, L.L.C.
2750 Monroe Boulevard
Audubon, PA 19403

Chenchao Lu
Assistant General Counsel
T: (610) 666-2255 | F: (610) 666-8211
Chenchao.Lu@pjm.com

October 18, 2022

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, N.E. Room 1A
Washington, D.C. 20426

Re: Modernizing Wholesale Electricity Market Design, Docket No. AD21-10-000
Report of PJM Interconnection, L.L.C.

Dear Secretary Bose,

Pursuant to the Federal Energy Regulatory Commission's ("FERC" or the "Commission") April 21, 2022 Order Directing Reports issued in the above-captioned proceeding,[1] PJM Interconnection, L.L.C. ("PJM") hereby submits this report in response to the questions posed by the Commission. PJM's answers to each of the specific Commission questions in the Order Directing Reports is included in Appendix A of this filing.[2]

I. INTRODUCTION

The objective of competitive wholesale electricity markets is to efficiently reinforce grid reliability and achieve a reliable power system at the lowest reasonable cost. The PJM energy and ancillary services ("E&AS") markets, in conjunction with PJM's other markets, have produced great benefits for customers by providing reliable service, producing competitive wholesale prices, reducing emissions, shifting investment risks from loads to investors, and incentivizing low cost investments and operations. In total, PJM's markets have resulted in an estimated annual savings

[1] *Modernizing Wholesale Electricity Market Design*, 179 FERC ¶ 61,029 (2022) (hereafter, the "Order Directing Reports").

[2] In this submittal, PJM is also including responses to questions raised separately in Commissioner Christie's concurrence.

of $3.2−4 billion to consumers.[3]

While much time and effort have been spent discussing reforms to PJM's energy and capacity markets, far less time has been invested in ancillary service market design. As it stands in PJM, ancillary service markets may not be used to their full potential and therefore enhancements to these markets may be appropriate. Such reforms could help ensure the markets can better reflect the demand for and value of ancillary services needed to maintain reliability in a transparent manner both now and through the energy transition.

The shifting electricity system resource mix and the growing quantity of distributed energy resources are causing a rise in uncertainty and volatility in PJM markets and operations. This is compounded by the growing concern over the amount of thermal generation retirements that are anticipated, particularly given that Intermittent Resources[4] that are replacing thermal resources are not comparable in terms of flexibility and dispatchability. To proactively address these concerns, PJM is performing analysis to quantify the impact of the projected retirements. With the impending integration of large quantities of Intermittent Resources, the intermittent and distributed nature of a growing portion of the PJM system will further emphasize the challenge of energy and fuel security. Additionally, these new resources will increase reliance on accurate forecasting and the need to properly incentivize, schedule, and compensate for flexibility.

PJM expects the following drivers will influence a need for market design evolution:

- Increase in Intermittent Resources;[5]
- Increase in hybrids and Energy Storage Resources;

[3] PJM, *PJM Value Proposition* (2019), https://www.pjm.com/-/media/about-pjm/pjm-value-proposition.ashx.

[4] For purposes of this submittal, capitalized terms not defined herein shall have the meaning as contained in the PJM Open Access Transmission Tariff, Amended and Restated Operating Agreement of PJM Interconnection, L.L.C., or the Reliability Assurance Agreement Among Load Serving Entities in the PJM Region.

[5] As of November 30, 2021, there were 215,000 MW of Intermittent Resources in the PJM interconnection queue (or approximately 94% of the MW in the queue).

- Changes in load patterns, such as increased citing of large data centers within the PJM footprint and changes in work patterns due to increased telecommuting;
- Increased need for "just in time" fuel delivery; and
- Increased and changing participation of distribution and load response resources.

With PJM's unique topology and geography, along with the expectation of changes to the resource mix, PJM will be faced with different operational needs compared with other RTOs/ISOs. Specifically, PJM expects to see significant wind and solar penetration within the next five to ten years. Further, the replacement of thermal resources with smaller and less dispatchable Intermittent Resources in varying locations will result in changes to congestion patterns and transfers of energy. With higher penetration of Intermittent Resources in the PJM footprint and neighboring systems, historical transfer levels will continue to shift and vary over both the longer term and on an operational basis. These PJM specific changes will drive a need for unique reforms to the PJM market.

More particularly, it will be increasingly important in the future for resources to have the capability to operate flexibly. For Market Participants to offer and operate resources in a flexible manner, PJM's markets will need to provide the proper locational pricing signals for Market Participants to invest capital in the resources with the capabilities needed by system. These investments are equally important in the retention of existing resources and the construction of new ones that provide PJM with the necessary reliability services it needs. Ultimately, as explained in the responses to the Commission's questions in Appendix A, new market frameworks are needed to improve the operational and investment price signals that will drive efficient solutions to the increased need for flexibility, while providing sufficient lead time to allow efficient replacement resource and transmission development. Some of the most critical types of flexibility that PJM sees a need for on the system within the next five and ten years is: (1) the ramping capability of resources, and (2) the ability to commit and decommit resources in a relative short

period of time, both of which will require examination for reforms of PJM's existing E&AS markets.

As PJM embarks on E&AS reforms for the changing resource mix, there are a number of market design principles in which the reforms will be developed around. PJM published a set of market design guiding principles[6] in 2018 as part of PJM's price formation efforts. These principles, which have been genericized and updated below to address a broader potential set of solutions, continue to be important as the system needs evolve:

- Ancillary service and energy prices reflect system conditions and appropriately value scarcity;
- Ancillary service demand curves that reflect their reliability value;
- Accurate measurement of all ancillary services;
- Resources assigned ancillary services are incentivized to provide them when deployed;
- Market power is mitigated;
- Social welfare is maximized;
- Simplicity in market design where possible;
- Solutions that are nimble with evolution;
- Market rules that are non-discriminatory;
- Rules that encourage robust participation and create efficient market results;
- Proper locational market signals that guide optimal investments; and
- Transparency.

Large efforts by PJM staff and stakeholders have been undertaken in response to the energy transition to ensure PJM is proactive in addressing these changes and maintaining system reliability and effective markets. To that end, PJM has published a number of papers and conducted ongoing studies detailed in the following reports:

- Reliability in PJM: Today and Tomorrow;[7]
- PJM's ongoing "Energy Transition in PJM" analysis;
    - Energy Transition in PJM Framework for Analysis;[8]

[6] Energy Price Formation Senior Task Force, *Price Formation* (Dec. 14, 2018), https://www.pjm.com/-/media/committees-groups/task-forces/epfstf/20181214/20181214-item-04-price-formation-paper.ashx.

[7] PJM, *Reliability in PJM: Today and Tomorrow* (Mar. 11, 2021), https://pjm.com/-/media/library/reports-notices/special-reports/2021/20210311-reliability-in-pjm-today-and-tomorrow.ashx.

[8] PJM, *Energy Transition in PJM Framework for Analysis* (Dec. 15, 2021), https://www.pjm.com/-/media/library/reports-notices/special-reports/2021/20211215-energy-transition-in-pjm-frameworks-for-

  - Energy Transition in PJM Emerging Characteristic of a Decarbonizing Grid;[9]
- PJM's Grid of the Future;[10]
- Offshore Wind Transmission Study Phase 1;[11] and
- Reliability Product Attribute Review.[12]

Details of the above published papers, ongoing studies and stakeholder initiatives will be discussed further in the questions below.

II. NEXT STEPS

As further explained in the responses below, PJM is already actively engaged with its stakeholders to reform the existing planning rules, as well as to enhance energy, ancillary services, and capacity market rules that will provide appropriate market signals for the changing resource mix. Given that PJM stakeholders are already proactively exploring reforms to facilitate the transition to the grid of the future, the Commission should refrain from initiating any orders to show cause that may undermine the active stakeholder discussions. Although PJM believes that the details of specific proposals are initially best left to the stakeholder process, PJM does propose that the Commission issue a policy statement that would detail the Commission's priorities and interest in the above-identified issues and its expectations that these issues would be timely addressed through specific RTO filings. The details of this proposed policy statement are outlined

---

analysis.ashx.

[9] PJM, *Energy Transition in PJM: Emerging Characteristic of a Decarbonizing Grid* (May 17, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220517-energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx.

[10] PJM Planning Division, *PJM's Grid of the Future: PJM's Regional Planning Perspective* (May 10, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220510-grid-of-the-future-pjms-regional-planning-perspective.ashx.

[11] PJM, *Offshore Wind Transmission Study: Phase 1 Results* (Oct. 19, 2021), https://www.pjm.com/-/media/library/reports-notices/special-reports/2021/20211019-offshore-wind-transmission-study-phase-1-results.ashx.

[12] PJM Operating Committee, *Resource Reliability Attribute & Additional Attribute Description* (Feb. 10, 2022), https://www.pjm.com/-/media/committees-groups/committees/oc/2022/20220210/20220210-item-16-reliability-products-and-service-assessment-post-meeting.ashx.

in response to Question #12 below.

III. CONCLUSION

The Commission should accept PJM's report detailed in Appendix A of this filing as responsive to the Commission's April 21, 2022 Order Directing Reports.

Respectfully submitted,

/s/ Chenchao Lu

Craig Glazer
Vice President – Federal Government Policy
PJM Interconnection, L.L.C.
1200 G Street, N.W.
Suite 600
Washington, D.C. 20005
(202) 423-4743
Craig.Glazer@pjm.com

Chenchao Lu
Assistant General Counsel
PJM Interconnection, L.L.C.
2750 Monroe Boulevard
Audubon, PA 19403
(610)-666-2255
Chenchao.Lu@pjm.com

APPENDIX A

PJM RESPONSES TO QUESTIONS PRESENTED IN THE ORDER DIRECTING REPORTS

I. PJM REPSONSES TO QUESTIONS PRESENTED BY THE COMMISSION'S QUESTIONS

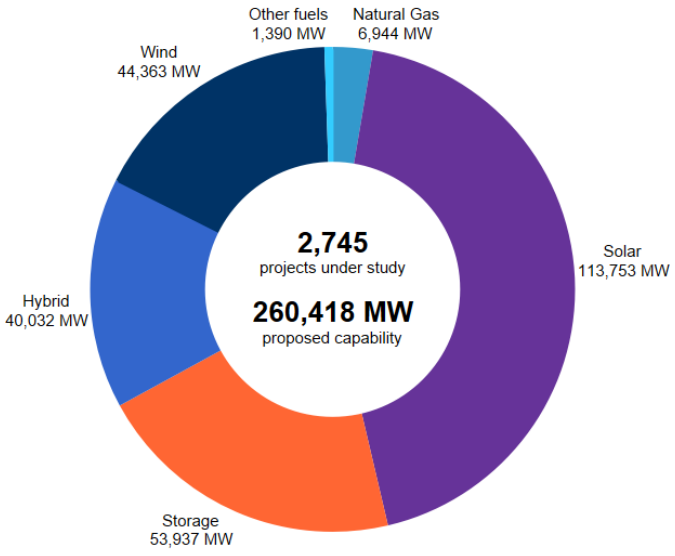
A. Current System Needs

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? 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? 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? RTO/ISO materials, such as previously published RTO/ISO whitepapers or previous filings with the Commission, may be incorporated by reference as needed. What specific resource capabilities could address these needs (e.g., dispatchable generation)?*

PJM Response:

PJM and the electric industry at large are in an unprecedented time of energy transition. The shifting electricity system resource mix, including the retirement of thermal resources and the growing quantity of distributed energy resources, are causing a rise in uncertainty in PJM markets. As demonstrated by PJM's Interconnection queue in Figure 1, PJM expects to see a much larger percentage of intermittent and distributed generation serving PJM load.

Figure 1. PJM Interconnection Queue as of October 17, 2022.



With the increased integration of Intermittent Resources and the intermittent and

distributed nature of such resources on the PJM system, further emphasis is needed on (1) the challenges of energy and fuel assurance on the system, (2) increased reliance on accurate forecasting and (3) the need to properly incentivize and compensate for flexibility attributes.

As the grid dynamics change, it is important to continue to evaluate the needed attributes to manage reliability, and ensure that markets can continue to incentivize the needed products and services to ensure the reliability to the system. PJM is committed to studying and taking action on the system needs for reliability and market efficiency and has (1) initiated forward-looking studies to identify potential impacts and reliability needs of the system and (2) defined and is tracking reliability attributes needed for the system.

More particularly, in 2021, PJM published the first of a series of studies titled "Energy Transition in PJM: Frameworks for Analysis."[13] That study was updated in the second iteration in 2022, titled "Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid."[14] This study was based on a multiphase, multiyear effort to study the potential impacts associated with the evolving resource mix. This "living study" will identify gaps and opportunities in the current market construct and offer insights into the future of market design, transmission planning and system operations. Key findings and recommendations pertinent to this area are the following:

- Simulation results indicated an increased need for operational flexibility, with steeper ramps, frequent dispatch of generators to their economic minimum and lower capacity factors for natural gas and coal resources.
- Reliability attributes are essential for maintaining system balance and supporting the reliable operation of the grid.
- Electrification shifts the seasonal resource adequacy risk to winter.
- Retail rate design and energy storage become increasingly important with electrification.
- The integration of renewable resources increases the need for balancing resources to meet forecasted ramping requirements.
- Energy storage enhances operational flexibility, but seasonal capacity and energy constraints require transmission expansion, longer-term storage and other emerging technology.

Further, in the recent Energy Transition study,[15] PJM focused on an increased need for ramping against net load. Net load represents the amount of balancing energy that will be required from dispatchable resources to counter the natural decrease in production from non-dispatchable renewable resources. For example, as the sun sets, solar resources generate less energy in the late

[13] PJM, *Energy Transition in PJM: Frameworks for Analysis* (Dec. 15, 2021), https://pjm.com/-/media/committees-groups/committees/mrc/2021/20211215/20211215-item-09-energy-transition-in-pjm-whitepaper.ashx.

[14] PJM, *Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid* (May 17, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220517-energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx; *see also* PJM, *Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid*, https://www.pjm.com/-/media/committees-groups/committees/mc/2022/20220517-annual/item-06---renewable-integration-study-ris-20---presentation.ashx.

[15] PJM, *Energy Transition in PJM: Frameworks for Analysis* (Dec. 15, 2021), https://pjm.com/-/media/committees-groups/committees/mrc/2021/20211215/20211215-item-09-energy-transition-in-pjm-whitepaper.ashx.

evening and another resource needs to replace the production to continue to serve load reliably. In the study, PJM found that under higher renewable penetration levels, net-load ramping needs could be as much as 20 GW/hour.[16]

Reliability attributes are essential for maintaining system balance and supporting the reliable operation of the electric grid. The electric industry, at large, has detailed the importance and need for these reliability attributes.[17] PJM's reliability product attribute study[18] included a holistic look at all system needs for the evolving grid, with many of these attributes relevant to E&AS reforms. With a particular focus on evolving resource portfolios and increased penetration of intermittent resource technologies, PJM has identified a number of attributes for review over the next five to ten years that will serve the system across the operational and planning time horizons.

- **Inertia (instantaneous)** refers to the energy stored in large rotating generators and is a factor in helping to minimize a frequency drop if/when a sudden loss of generation occurs. This minimizes the nadir or the frequency drop immediately following the disturbance. As the resource mix changes and rotating generators (normally driven by conventional fossil fuel resources) are replaced with intermittent and distributed generation, system inertia will decrease potentially driving a need for synthetic inertia or additional primary frequency response.

- **Primary Frequency Response (PFR) (seconds – 10s of seconds)** is the inherent response of resources and load to locally detect and arrest changes in frequency. It is an automatic, locally detected response by resources that is not driven by any centralized system and begins within seconds after a frequency excursion. It is essential to stopping a decline in frequency and preventing the activation of automatic Under-Frequency Load Shedding (UFLS) safety net. The fast, inherent response will become increasingly important as we see an increase in frequency deviations and a decrease in system inertia. Resources with active and appropriately configured governors will be needed to support the necessary PFR for the system.

- **Regulation (minutes - 10s of minutes)** is the requirement of generators to control Area Control Error (ACE) and frequency deviations. As uncertainty on the system increases due to larger intermittent and distributed generation integration, regulation will need to be examined to ensure the signals and requirements are appropriate to maintain system balance.

---

[16] PJM, *Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid*, at 22 (May 17, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220517-energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx.

[17] NERC, *Essential Reliability Services: Whitepaper on Sufficiency Guidelines* (Dec. 2016), https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSWG_Sufficiency_Guideline_Report.pdf.

[18] PJM Operating Committee, *Resource Reliability Attribute & Additional Attribute Description* (Feb. 10, 2022), https://www.pjm.com/-/media/committees-groups/committees/oc/2022/20220210/20220210-item-16-reliability-products-and-service-assessment-post-meeting.ashx.

- **Reactive Capability and Supply (minutes - hours)** is the physical capability for a generator to supply reactive support to the grid and the actual supply of reactive power as needed (*i.e.*). The ability to follow a voltage schedule and demonstrate performance. As conventional generator retirements occur and the resource mix changes, adequate reactive capability needs to be maintained and the correct market pricing needs to be in place.

- **Load Following/Dispatchable (hours)** is the ability for a generator to receive and respond, in real time, to a dispatch signal to adjust the MW output of the resource. With increased grid uncertainty, the ability to follow PJM's dispatch signal will be increasingly important to grid reliability; the incentives and penalties for following dispatch will need to be reviewed to ensure the correct market rules are in place.

- **Ramping and Commitment Flexibility (hours – days)** is a reliability attribute that measures the ability for upward or downward control by resources and for a unit to turn on and off quickly and frequently in a single operating day. The characteristics that commonly determine a resource's flexibility are ramp rate, cycling capability, quick start time and low minimum run times. If these attributes are not valued, acquired and compensated, new replacement flexible resources may not develop and the system will lose this needed flexibility with the retirement of existing resources that are utilized to serve load at times when renewables may not have an energy source or times of unexpected system volatility (*i.e.*, large unit trips, load variations, etc.).

- **Fuel Assurance (days – seasons)** considers the ability of a balancing authority to withstand disruptions to fuel supply chains and delivery mechanisms that hinder generator performance. If these attributes are not valued, acquired and compensated in the near term, there could be retirements of traditional resources that are necessary to serve load without timely replacement of such assets at times when renewables are not able to produce electric energy.

- **Energy Assurance (days – seasons)** refers to the concept of managing energy assurance to account for variability in solar irradiance and wind speed. This is a factor for both longer-term planning as well as near-term operations. The focus will be on looking at enhanced accuracy of wind/solar forecasting that relies on accurate and consistent data reporting from resources.

B. <u>Expected Changing System Needs</u>

2. *Referring to the system needs identified in answering question 1, how does the RTO/ISO expect those system needs to change over the next five years? Over the next 10 years? What does the RTO/ISO expect the magnitude of those system needs to be in five years? In 10 years?*

PJM Response:

PJM's system needs, both in attribute and magnitude, will change over the next five to ten

years as the resource mix evolves. Specifically, penetration levels of renewable resources, integration of distributed energy resources, and scheduled retirements, among other things, will change the system needs. Additionally, there are many external developments that will further accelerate changes to the grid and system needs as a result of state and federal policies, technological changes, and electrification to name a few. PJM is actively studying many hypothetical and forecast system resource scenarios to identify the system needs and potential implications for market products. In parallel, the PJM Planning Committee is considering changes to the analysis methodology for generation deliverability to more accurately reflect the evolving resource mix under winter and light load conditions.

In the near term, PJM continues to examine reliability risks that could be introduced by the evolving resource mix. For instance, Intermittent Resources may experience short-term forecast error that could require replacement from other synchronized resources in order to balance the system. Further, the transition from thermal resources to inverter-based resources would reduce the amount of inertia-based primary frequency response available for system control as well. Increased variability in generation output could require higher requirement levels or new signal designs within frequency regulation services.

Over the next five to ten years, as the levels of electrification increase, PJM expects the resource adequacy risk to begin to shift to the winter season. Today, about 95% of the load-loss risk is experienced in the summer season, but as much as 80% of the risk could shift to winter by 2035, under an electrification scenario. Winter season evening peaks are projected to have higher demand ramps and last longer than today's load shapes, with as much as 60% of the load-loss risk concentrated in the last four hours of the day. These developments call into question the use of the Loss of Load Expectation metric to set its resource adequacy targets. In general, this metric focuses on peak load conditions to determine a reliability target. As the system changes, the reliability risks will also change, and therefore it should not be assumed that the highest risk hours only coincide with peak load hours. This shift necessitates exploration of other resource adequacy metrics to set PJM's reliability target.

The need for more accurate capacity accreditation will also change over the next decade. As the load-loss risk moves to the evening hours, solar resources are unable to provide energy in those hours, resulting in larger drops in Effective Load Carrying Capability ("ELCC") for that resource class. From the Energy Transition study, in an electrification scenario, solar resources' average ELCC drops from 32% to 6%, which could drastically decrease their capacity contribution.[19] PJM expects that the shift in risk hours will also impact the accreditation levels for other resource classes.

Referring to the system needs and reliability attributes that PJM numerated in Question 1, timelines for potential changing needs and the necessary attributes are detailed below:

[19] PJM, *Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid*, at 3 (May 17, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220517-energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx.

System Need	Resource Attribute	The need as attributable to changes in the resource mix and customer load profiles	Timeline for reforms in PJM Markets
Inertia (seconds)	Rotating generators with inherit inertia Synthetic inertia or fast frequency response	An increase in renewables and decrease in rotating generators will inherently reduce inertia. PJM's frequency response analysis and oscillation detection using highly granular PMU data, in addition to NERC Resource Subcommittee analysis, there are no near term concerns with inertia in the EI.	Monitoring: 10 years
Primary Frequency Response ("PFR"): (seconds)	Governor response Headroom and Footroom	PJM has observed that PFR has been declining for the last decade due to a variety of factors, but at present there is not a need for Immediate action. It is recommended that we continue to track unit response to frequency events and reactivate PFRSTF if needed. In addition, continue to monitor related industry activities, including the revisions to the BAL003 Standard that are currently being drafted to include generator obligations for PFR performance.	Monitoring: 5 years Reforms: 10 year
Reactive Capability and Supply: (minutes)	Voltage support	Reactive capability and voltage support is critical to the reliability of the grid. Currently, FERC and PJM requirements do not require non-synchronous generators to provide a full range of reactive capability when their output is at or near 0 MW even though they are still connected to the grid and capable of providing reactive support. With a changing resource mix that will at times involve transferring energy over longer distances depending upon local vs regional meteorological conditions (*i.e.*, cloudy in parts of the RTO but sunny in others), local reactive support will be needed. Utilizing the reactive support from non-synchronous generators that are not capable of	Potential reforms: actively underway

		providing their full (or any) MW output would help ensure local voltage and reliability is maintained.	
Regulation (minutes - 30 minutes)	Ability to follow AGC, fast and flexible resources	As additional forecast uncertainty is introduced to near-term operations and energy dispatch by the changing resource mix, there will be a need for additional regulation to account for these uncertainties	Reforms: actively underway
Load Following/ Dispatchable (hours)	The ability for a generator to receive and respond, in real time, to a dispatch signal to adjust the MW output of the resource.	With more potential volatility on the system, it is important to ensure that resources follow dispatch as closely as possible. If resources have the capability to follow but do not, this may result in reliability issues (load/gen imbalance) or a need to unnecessarily increase the amount of existing regulation and/or reserve PJM procures.	Reforms: within the next 5 years
Flexibility: (hours/days)	turn on and off quickly and frequently in a single operating day: • cycling capability; • quick start time; • low min run times; and • Upward or downward control by resources.	System flexibility will be necessary to respond to more dramatic changes in known and forecastable system conditions, but also increases in uncertainty due to a higher penetration of renewable resources and load variations.	Reforms: within the next 5 years
Fuel Assurance: (days/seasons)	Fuel Security the ability of a resource to maintain economic maximum energy output for 72 hours, based on the definition of fuel-limited resources within the PJM Manual 13: Emergency Operations Attachment C.	If fuel assurance is not valued, acquired and compensated in the near term, there could be retirements or inadequate investments of resources that are necessary to serve load at times when Intermittent Resources may not have an energy source.	Reforms: Actively underway
Energy Assurance:		A key component to maintaining energy assurance is have accurate wind and	Reforms: Actively

(days/seasons)		solar forecasts. In addition, we may need to update reserve procurement procedures for times of high uncertainty (icing, wind cut-off) depending upon geographic clustering of new resources.	underway

2.1 *In answering, please provide a high-level overview of the methods used to develop the system needs forecast over the next five years and over the next 10 years. Please provide a high-level discussion of any industry trends that are particularly important to the RTO's/ISO's forecast, such as electric vehicle adoption, behind-the-meter distributed energy resource deployment, increased demand response participation and price-responsive load, growth in transmission infrastructure, and other trends. In evaluating the impact of such industry trends, how does input from efforts by states, local agencies, and utility programs inform that analysis?*

PJM Response:

PJM's load forecast development process incorporates many industry trends and expectations that drive the need for transmission expansion to assure system reliability. Distributed Energy Resources (DER) are not new to PJM, nor to regional grid planning. Since its New Services Queue process began in the late 1990s, PJM has integrated DER that have included hydro, natural gas, landfill gas (methane), diesel, oil, waste, wood byproducts, storage, wind, solar and hybrid facilities. But, while PJM has integrated DER into its wholesale market, DER can also operate outside it and PJM's New Services Queue process. Accounting for approximately two-thirds of all DER interconnection requests, these non-wholesale facilities typically fall under state regulations (*i.e.*, outside the jurisdiction of PJM's FERC-approved Tariff) and include the following:

- **Behind-the-meter generation (load reducer)** – This DER output offsets load under owner's control; any excess power is not injected past the meter onto the distribution system.
- **Electric vehicles (EVs)** – Vehicles with battery storage capability can inject into or withdraw power from the distribution system in a controlled manner.
- **Backup generation** – Such generation can operate in islanded mode to serve owner's load during a distribution system outage.
- **Retail generation –** A distribution company, municipality or cooperative may develop such generation to serve their system load but it does not inject power onto the transmission system.
- **Net metering** – Generation in excess of load is netted against that purchased off local distribution system over some defined period of time.
- **Storage as distribution system tool** – Installed by a distribution company, municipality or cooperative, this storage can absorb power and inject it onto local distribution systems when called upon.

In the past few years, PJM has been seeing unprecedented data center load growth in a number of areas of its footprint. This demand from new data centers is expected to continue beyond 2027 and well into 2037. PJM's annual load forecast for 2022 included updated data center forecasts showing very strong load growth, with one transmission zone showing as much as 3.5% zonal load growth per annum over the next four years. The upcoming 2023 Forecast will likely also reflect additional data center load growth in other areas of the PJM system for both the near and long terms.

Electrification is another industry trend that is reflected within PJM's forecasting. Electrification is the process of converting an end-use load that uses fossil fuels (or other non-electric energy sources) to electricity. This most commonly refers to vehicles and transportation, but can also refer to home and business uses for ambient heating, water heating, cooking and other activities. Transportation and heating could have the greatest future grid impact on load forecast and load shape.[20]

More specifically, PJM generates forecasts based on residential, commercial and industrial sector models, which in-turn produce heating, cooling, and weather-driven electric demand models. The forecasts then incorporate non-weather sensitive historical information, plug-in electric vehicle participation forecasts, and behind-the-meter solar levels, which produce energy and peak load forecasts for the PJM RTO and its transmission zones. PJM also incorporates specific utility load additions into its analysis, such as natural gas processing and data center growth. While PJM is accounting for such changes in load patterns, the pace of such changes is difficult to predict and could be substantially accelerated through policies such as the Inflation Reduction Act and other government actions. As a result, more coordination with the EIA, among others, to enhance load forecasting may be appropriate.

Over the next 10 years, winter load growth (0.7%/year) is expected to outpace summer load growth (0.4%/year), which is due to a lack of behind the meter solar impact on winter peaks and modest growth expectations in electric heating. The expected peak load impact from electric vehicle deployments is generally low (1.8 GW added by 2032) but deployments are expected to accelerate over the 10 - 15 year timeframe.[21]

Public data from the EIA, as well as commercially available data from Moody's Analytics, IHS Markit, and Itron are essential to inform the analysis. Additional details on the forecast development process are available in PJM's load forecast report(s) as well as the PJM Load Forecast Supplement.[22]

---

[20] PJM Planning Division, *Grid of the Future: PJM's Regional Planning Perspective*, Section 4, at 28-33 (May 10, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220510-grid-of-the-future-pjms-regional-planning-perspective.ashx.

[21] PJM notes that the changes in governmental actions, such as the Inflation Reduction Act, have the potential to further accelerate the expected load pattern changes.

[22] PJM, *PJM Load Forecast Report* (Jan. 2022), https://www.pjm.com/-/media/library/reports-notices/load-forecast/2022-load-report.ashx; PJM Resource Adequacy Planning Department, *2022 Load Forecast Supplement* (Jan. 2022), https://www.pjm.com/-/media/planning/res-adeq/load-forecast/load-forecast-supplement.ashx.

Within the Energy Transition study,[23] PJM developed several scenarios that incorporated data from many entities, including states programs, public information, and utilities stated plans. Starting with the load levels forecasted by PJM's resource adequacy process, the study also forecasted the amount of renewable energy that would be required to meet the state Renewable Portfolio Standard (RPS) requirements across PJM's 14 jurisdictions. This energy could be provided by a mixture of solar, windfarm, hydroelectric, nuclear, landfill gas, and other generator sources depending on the varying program definitions. The study was also informed by other public forecasts (such as the EIA Annual Energy Outlook and NREL Wind Prospector), and private forecasts (such as IHS Markit North American Power Market Outlook) to determine the nameplate capability required to provide the energy levels, as well as expectations of demand response participation levels. Based on supply expansion and retirement expectations, PJM staff then conducted ELCC-based reliability assessments on the portfolio to determine capacity needs. The study executed production cost stimulations to estimate energy market outcomes and determine operational risks for the resultant portfolios.

The study incorporated several industry trends that could affect operational reliability. Solar resources are dependent on solar radiance for their energy production, which restricts their production to daylight hours, and adds variability to their output as a function of local cloud patterns. As storage costs are expected to decrease over the next 10 years, a number of solar plants may elect to hybridize with battery storage to increase their dispatchability; with enough storage capability, energy injection could be deferred to hours of the day with greater load-risk. The study assumed increases in grid-scale battery projects as well, but the energy storage capacity could limit their operational capabilities, indicating needs for longer look-ahead periods and knowledge of state of charge levels. These are elements that could affect short-term forecasts for real-time energy balancing and long-term forecasts for the purpose of identifying transmission projects to assure grid reliability. Additionally, changes in governmental actions, such as the Inflation Reduction Act, have the potential to further affect such forecasts.

2.2 *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?*

PJM Response:

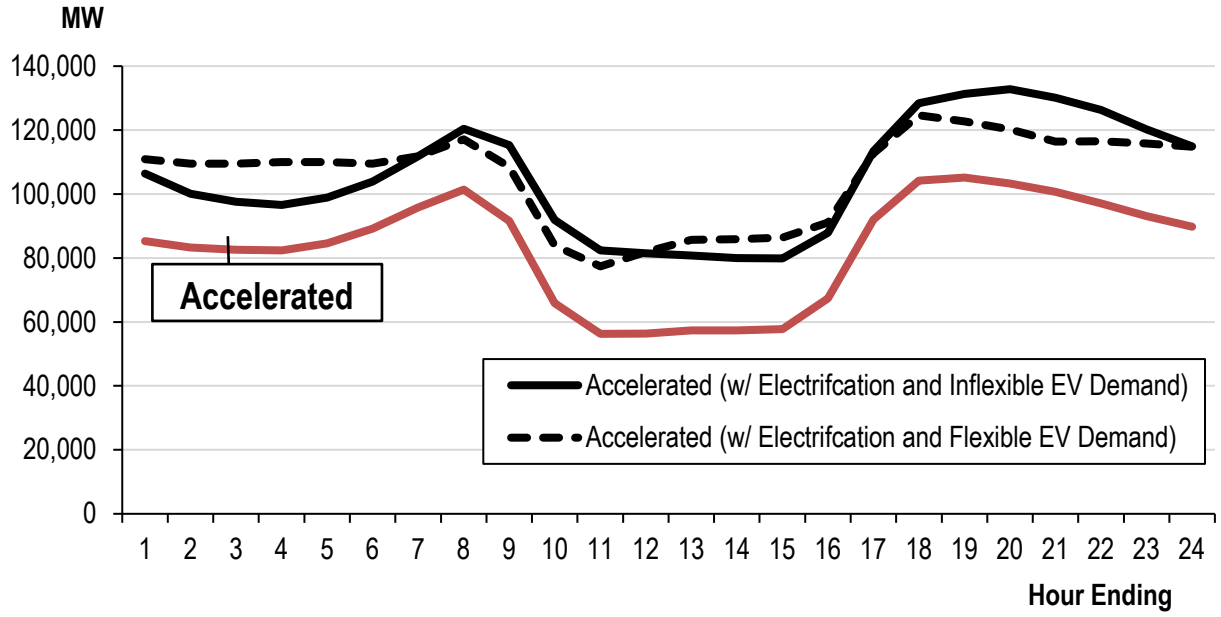
From a resource adequacy perspective, the summer mid-day load peak is expected to continue to be the greatest reliability risk under current forecasts over the next ten years. As PJM transitions to a larger renewable resource portfolio mix with an increasingly electrification trend, it is expected that the winter net peak will become a greater challenge over the next ten to fifteen years. Solar participation in PJM's portfolio is expected to grow over the next ten years, with some forecasts as high as 26 GW nameplate of solar resources by 2030. While these resources may experience a falling resource adequacy accreditation under an ELCC construct, the real-time energy production is expected to create greater net load ramp impacts. Combined with growth in onshore/offshore wind projects, the net load up-ramp created by these resources is expected to be

[23] PJM, *Energy Transition in PJM: Framework for Analysis* (Dec. 15, 2021), https://pjm.com/-/media/committees-groups/committees/mrc/2021/20211215/20211215-item-09-energy-transition-in-pjm-whitepaper.ashx.

the largest from hour ending 1600 to hour ending 1900, corresponding to the solar fall-off, leading into dusk.

Figure 2, which is from the Energy Transition in PJM study, shows that the shape of PJM's winter period evening peak is also expected to change under an electrification transition because of growing levels of electric vehicle deployment. A typical vehicle owner may drive to their work place, plug in their vehicle when they arrive, and begin charging coincident with the morning peak. Likewise, plugging their electric vehicle to charge upon returning to home aligns with the ramp up into evening peak, adding to the net load ramp requirements. As the evening ramp grows, load-loss risk increases under higher renewable participation levels. The duration of the winter evening peak is expected to grow as well, from hour ending 1700 to hour ending 2200, which could provide challenges to storage-limited resources needing to continuously output over longer periods of time.

Figure 2. Winter Load Shape with Electrification.



3. *What new system needs not already described, if any, does the RTO/ISO expect to emerge over the next five years? Over the next 10 years? What are the drivers of those new system needs? Are those new system needs quantifiable, and if so, please provide information on how you have quantified those needs.*

PJM Response:

More Accurate Forecasting: Short term load forecasting will become increasingly divergent from historical consumer behavior. Additionally, increases of behind the meter generation will result in increased loads that do not typically follow the load forecast for the overall transmission zone. This leads to constraint identification and control issues as loads are not necessarily at their maximum coincident with the overall zonal load. Load forecasting improvements will be needed in the future to capture such variations, and PJM is already working on analyzing and

implementing some of these needed changes to improve quality, accuracy, and consistency of forecast input data and enhance processes to maximize value and quality of forecast data.

Extreme Weather Performance: Being able to maintain system reliability during extreme weather events is important, and the frequency of extreme weather conditions and volatility are expected to increase in the future. As the future resource mix becomes more variable and of limited duration compared to a mix with more traditional fossil fuel resources, evaluating and preparing for these events will be important in the forward market and real-time E&AS markets. Additionally, it may become necessary to coordinate more with neighboring systems during extreme events having a more localized impact within the PJM footprint, which may require increased interregional transfer capability as discussed in PJM's responses to the RM21-17 NOPR.[24]

Visibility of Distribution Energy Resources: Need for greater visibility of DER will drive changes in modeling of DER in planning and operations and require greater coordination with retail utilities/state commissions. Currently the deployment of DERs is relatively modest in most parts of PJM, and therefore the real time impacts have been limited. With the expectation of DER expansion, particularly with DER aggregations, PJM is working with utilities to more accurately reflect the DERs in the models as generation, and not just as reducing load.

Transmission: PJM anticipates that the expansion of renewable resources to meet state public policies will drive the need for more transmission. PJM has conducted scenario studies to consider different offshore wind scenarios that also included achieving all other state polices for renewable resources. While it is noted that new transmission will be needed, PJM data has shown that most resources locate within 100 miles or less of load centers, such that it is not finding long transmission lines are necessary to support the future resource mix.

Black Start: Black start capability is necessary to restore the PJM transmission system following a system-wide blackout. PJM black start resources are able to self-start and close to a de-energized bus within three hours without electrical assistance from the grid or stay online and operate at reduced levels when automatically disconnected from the grid. As the resource mix evolves in the next five or ten years, a focus on black start adequacy will continue to be monitored to ensure that we have the appropriate resources available for black start scenarios.

C. Reforms to RTO/ISO Markets and Operations to Manage Expected Changing System Needs

4. *Discussions at the technical conferences and in comments noted failures of E&AS market designs to incent resources to offer and perform in a manner that meets system needs that are present now or expected to emerge in the near-term. However, we note that much of the discussion indicated that system needs will*

[24] *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection*, Initial Comments of PJM, Docket No. RM21-17-000 (Aug. 17, 2022); *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection*, Reply Comments of PJM, Docket No. RM21-17-000 (Sept. 19, 2022).

continue to change significantly beyond the near-term, which could increase the adverse impacts of current flaws in E&AS market designs. Such increases in adverse impacts, such as insufficient operational flexibility in real-time, could threaten reliability and could also increase out-of-market actions and associated impairments to price formation.

Referring to the changing system needs discussed in questions 2 and 3, 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?

PJM Response:

PJM's fundamental market framework is strong, built upon the existing capacity and E&AS markets. Additionally, PJM operates the system reliably and cost-effectively through transparent prices, and providing appropriate price signals to the market place. However, over the long term, there may be certain market products and compensation schemes that may need to be enhanced to ensure that PJM continues to maintain a strong market framework that will ensure the continued procurement of sufficient flexible resources that are appropriately compensated and incentivized.

Specifically, because the existing markets were not designed to address the system needs of the future, certain resource attributes that may be necessary in the future may not be properly incented under the existing rules. Examples of this, among others, are (1) the current regulation market, where PJM is currently examining signal design, bi-directional (up and down) markets, and regulation requirements, to ensure the system needs of the future are met; and (2) re-examining whether additional reserves will need to be procured to address the uncertainty and anticipated ramping needs for the system.

Additionally, PJM anticipates roughly a doubling of the net load ramp needs in the long term future,[25] while also facing an online resource mix that may at times be significantly more limited in its ability to ramp up (*e.g.*, periods of time where wind and solar alone meet the load). Moreover, greater wind and solar deployment will increase the level of intrahour uncertainty. Therefore, PJM's existing market rules may not adequately procure nor adequately compensate the intrahour flexibility capability needed in the future. To address this future need, PJM is actively investigating the metrics around system flexibility in order to initiate the appropriate reforms in the future by examining ramping needs, directional products (up & down regulation and ramping)

[25] *See e.g.*, PJM, *Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid*, Table 2 (May 17, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220517-energy-transition-in-pjm-emerging-characteristics-of-a-decarbonizing-grid-white-paper-final.ashx.

and fuel and energy assurance.

PJM will also need to ensure adequate flexibility to address ramp needs in the "interhour" timeframe of 60-minutes to 24-hours. This time frame is well suited to the generator turn-on/turn-off decisions and storage scheduling decisions that are characteristic of the "unit commitment" process. Today, PJM enjoys the benefits of a very large pool of resources that inherently provides significant flexibility in this timeframe—there is more headroom from the online fleet, and more units to turn on and off. Furthermore, most generation technologies are capable of turning on and off according to PJM's direction in this timeframe.

The various stages of unit commitment (the day-ahead energy market; the subsequent reliability assessment and commitment run; and various intermediate-term commitment runs) would therefore address expected ramps in this timeframe, as well as changes to those expectations as the forecasts evolve over the course of the day. While the PJM Energy Transition study does not identify interhour net load ramp profiles that challenge the capabilities of the expected fleet, it is not inconceivable that these could emerge, or there may be evolution of the net load ramp profile between the day-ahead commitment and subsequent commitments that are difficult to adapt.

Demand flexibility will be another important piece of PJM Markets. Many forms of demand are inherently able to provide flexibility of the sort envisioned above. These types of loads are expected to increase in the coming years, potentially providing a significant source of flexibility. For example, electric vehicles are often plugged in to charge for many hours (whether at home or at work), and can be charged at various power levels throughout that time while still filling the battery (in the case of V2G technology, those charge power levels can include discharge back to the grid capability).[26] Similarly, the demands of electric heat and cooling features inherent in flexibility, as buildings can be preheated or precooled to avoid demand during periods of high need, and storage-tank water heaters can be charged up during times of low prices or to provide a reserve.[27] PJM E&AS markets are currently agnostic to participation from generators or load, a feature which should be and will be retained as markets evolve.

With insufficient procurement and compensation of the flexibility needed to address future system needs, there is a risk of a shortfall of such capabilities, whether through inefficient failure to retain existing resources with such capabilities, or failure to attract new resources. This could entail infeasible energy market solutions and potential reliability risks. Reforms to the E&AS markets could be designed to mitigate against this risk, without bias towards resource retention versus new entry. While the resource mix and load shapes may evolve relatively slowly, and the emergence of any reliability or efficiency impacts (absent market reform) may not be significant in the short term, they will almost certainly increase with time. It is important to stay ahead of these evolutions such that markets signal the need for these services before a shortage causes

[26] Such resources are currently registered to provide frequency regulation in PJM, but this technology may be capable of providing other flexibility products as well.

[27] In PJM today, electric water heaters likewise provide frequency regulation and (to a limited extent) reserves, while building heat and cooling provides reserves. *See e.g.*, PJM Demand Side Response Operations, *Markets Activity Report: March 2022*, Figure 11 and Figure 12 (Mar. 9, 2022), https://www.pjm.com/-/media/markets-ops/dsr/2021-demand-response-activity-report.ashx.

reliability issues.

5. *Much of the discussion at the technical conferences and in comments about planned reforms concerned near-term reforms that the RTO/ISO is currently developing with stakeholders or has recently implemented to manage system needs emerging in the near-term. However, much of the discussion signaled that system needs will continue to change significantly over time beyond the near-term. The following questions seek to understand how the RTO/ISOs are considering and working to identify and address longer-term future needs through E&AS market reforms.*

   Referring to the changing system needs discussed in questions 1, 2, and 3, what planned E&AS market reforms is the RTO/ISO contemplating or other stakeholder processes, if any, is the RTO/ISO conducting related to meeting those expected changing system needs? How will those specific reforms or stakeholder processes help the RTO/ISO meet those expected changing system needs?

PJM Response:

As discussed in the answers above, PJM is actively engaging with its stakeholders on many analyses, studies, and market design reforms to address the changing system needs. To that end, PJM has proactively performed a number of forward looking studies to determine the system needs under a given set of conditions, to allow for appropriate market, operations, or planning changes or reforms.

The "Energy Transition in PJM" studies is a multiphase, multiyear effort to study the potential impacts associated with the evolving resource mix. This "living study" will identify gaps and opportunities in the current market construct and offer insights into the future of market design, transmission planning and system operations. PJM has already published two phases of this study with a number of recommendations and findings,[28] discussed throughout our response.

PJM has also recently published "PJM's Grid of the Future" where PJM looked to identify anticipated impacts of current industry trends (renewable integration, electrification, disturbed energy resources, etc.) on generation, transmission and load and develop a grid of the future road map for planning the PJM system.[29]

In conjunction with the studies, PJM has stakeholder initiatives ongoing in the stakeholder

[28] PJM, *Energy Transition in PJM Framework for Analysis* (Dec. 15, 2021), https://www.pjm.com/-/media/library/reports-notices/special-reports/2021/20211215-energy-transition-in-pjm-frameworks-for-analysis.ashx.

[29] PJM Planning Division, *Grid of the Future: PJM's Regional Planning Perspective* (May 10, 2022), https://www.pjm.com/-/media/library/reports-notices/special-reports/2022/20220510-grid-of-the-future-pjms-regional-planning-perspective.ashx.

process to discuss the E&AS related reforms. Namely:

Changing Resource Mix

- Distributed Energy and Inverter Based Resource Subcommittee – This group is discussing topics for reform on the integration and wholesale participation of (1) energy storage resources, (2) hybrid resources, and (3) distributed energy resources.[30]
- Renewable Dispatch – This working item under the PJM Operating Committee is discussing reforms to improve the dispatch of renewable resources in PJM.[31]
- Opportunities for Generators with co-located load – This initiative at the PJM Markets Implementation Committee is looking at participation in PJM markets for co-sited data centers at existing generator sites.[32]

Ancillary Services

- Regulation Market Design Sr. Task Force – This group is looking at reforms to ensure the right incentives are signaled in the regulation market and the needed service is provided from regulation resources in the future.[33]
- Reactive Power Compensation Task Force – This group is evaluating the standards for the provision of reactive service and the mechanism that provides for the opportunity to be compensated for reactive service, including the examination of the expansion of Lost Opportunity Cost (LOC) revenue rules to renewable resources.[34]

Market Signals & Incentives

- Operating Reserve Clarification for Resources Operating as Requested by PJM – This working item under the PJM Market Implementation Committee is investigating opportunities to clarify and/or enhance rules governing the calculation of Balancing Operating Reserve credits paid to supply resources determined to be operating as requested by PJM, which may be incentivizing inflexibility.[35] As part of this effort, there are also opportunities to strengthen incentives for supply resources to operate consistent with PJM's directions.
- Electric Gas Coordination Sr. Task Force – This group is discussing improvements to the PJM wholesale electric markets to mitigate impacts of misalignment between gas and electric market in recognition that the need for greater flexibility from gas-fired resources will increase with the continued growth of Intermittent Resources.[36]

---

[30] PJM - Distributed Energy and Inverter Based Resource Subcommittee, https://www.pjm.com/committees-and-groups/subcommittees/dirs.aspx.

[31] PJM – Operating Committee, https://www.pjm.com/committees-and-groups/committees/oc.aspx.

[32] PJM - Markets Implementation Committee, https://pjm.com/committees-and-groups/committees/mic.aspx.

[33] PJM - Regulation Market Design Sr. Task Force, https://www.pjm.com/committees-and-groups/task-forces/rmdstf.

[34] PJM - Reactive Power Compensation Task Force, https://www.pjm.com/committees-and-groups/task-forces/rpctf.

[35] PJM - Markets Implementation Committee, https://pjm.com/committees-and-groups/committees/mic.aspx.

[36] PJM - Electric Gas Coordination Senior Task Force, https://www.pjm.com/committees-and-groups/task-

Resource Adequacy and Forward Markets

- Resource Adequacy Sr. Task Force – This group is taking a holistic review of the capacity market with a focus on nine key work activities with a wide range of topics including: assessment of reliability risks, the metric and target level, capacity resource qualifications and accreditation, performance incentives and requirements, obligations in the energy market, and seller-side market power mitigation rules.[37]
- Clean Attribute Procurement Sr. Task Force – This group is coordinating a comprehensive discussion between the Organization of PJM States, Inc. (OPSI), Competitive Policy Achievement Staff Working Group (CPAWG), PJM stakeholders and PJM staff around enhancements to enable states and other willing buyers to procure clean resource attributes, on a voluntary basis, through a regional and centralized procurement or market.[38]

Planning Reforms

- Queue Reforms – PJM filed major reforms to its interconnection study process to transition from a first come/first served approach to a first ready/first served.[39] The changes will enable PJM to more efficiently process the burgeoning number of queue requests driven by renewable public policies.
- Load Forecast Methodology – PJM recently engaged an outside expert to review the load forecast methodology for potential enhancements.[40] The consultant identified several recommendations to improve the forecast to better model future load growth, such as moving from a daily to an hourly forecast to reflect the higher variability of the load.
- Generator Deliverability Process Enhancements – PJM is working with stakeholders to update its generator deliverability test, a key study performed for all new generation, in order to more accurately model the renewable generation during time periods which may be more challenging with a variable/limited duration resource mix.[41]
- Incorporation of ELCC into determination of Capacity Interconnection Rights (CIRs) – PJM is working with stakeholders to update its processes to incorporate ELCC methodology in the process for determining the interconnection rights for a generator to assure "but-for" costs are properly reflected for new interconnection

---

forces/egcstf.

[37] PJM - Resource Adequacy Senior Task Force, https://www.pjm.com/committees-and-groups/task-forces/rastf.

[38] PJM - Clean Attribute Procurement Senior Task Force, https://pjm.com/committees-and-groups/task-forces/capstf.aspx.

[39] *PJM Interconnection, L.L.C.*, Tariff Revisions for Interconnection Process Reform, Docket No. ER22-2110-000 (June 14, 2022).

[40] PJM, *2022 PJM Model Review: Final Report* (2022), https://www.pjm.com/-/media/committees-groups/subcommittees/las/2022/20220912/pjm-model-review-final-report-from-itron.ashx.

[41] PJM – Planning Committee, https://www.pjm.com/committees-and-groups/committees/pc.

requests.[42]

PJM will continue analysis and engagement with stakeholders on current E&AS and Planning reforms and forward looking analysis for future system needs. PJM is planning on also developing metrics and a tracking system for grid needs to inform market reforms that provide the proper incentives for future system needs.

6. *Several commenters questioned the incentives created by current E&AS market designs and planned E&AS market reforms. Commenters raised many market design considerations as important for ensuring that E&AS markets incentivize resources to offer and perform in ways that support system needs. For example, some commenters argue that some E&AS market designs pay resources who make no contribution to satisfying system needs or encourage behavior that creates challenging conditions for operators. Commenters also discussed whether current compensation schemes for ancillary services products, such as using opportunity costs, will continue to be appropriate as the resource mix evolves over time. Over the next five years, and over the next 10 years, how well will existing RTO/ISO market designs together with planned reforms adequately incentivize resource behaviors that will enable the RTO/ISO to meet its changing system needs?*

PJM Response:

A significant challenge PJM faces over the next five to ten years is the disorderly retirement of resources that provide needed ancillary services. The limitations in how these resources are priced today could well add to the premature and disorderly retirement of these needed resources that are not priced accurately in today's markets. Modeling and pricing the actual flexibility needed to operate the system instead of only the standard 10- and 30-minute reserve requirements is a critical first step in addressing this market shortcoming. As has been stated, PJM does not believe that it has flexibility problems today and therefore it should be expected that in the near-term, the price of the additional flexibility procured would be low. We view this to be the right answer at this time given the current fleet demographics in PJM.

The value in addressing this issue now is that prices for this additional flexibility will rise slowly as the fleet transitions and send early price signals on the increasing value of flexibility. This is critical to avoiding the disorderly retirement of resources. If PJM continues on the current path, one that assumes no flexibility is needed beyond the standard 10- and 30-minute reserve requirements, the resources providing that flexibility today for free are assumed to not be needed for reliability, and when they retire there is no transparent signal indicating the consequence of their retirement which is declining flexibility.

Given this, the current design is not necessarily well suited to incentivize the appropriate

[42] PJM – Capacity Interconnection Rights (CIR) for ELCC Resources, https://www.pjm.com/committees-and-groups/issue-tracking/issue-tracking-details.aspx?Issue=83aadda8-b6c1-4630-9483-025b6b93fc28.

investments to maintain the necessary flexibility to maintain reliability. Thus, reforms are needed that are generally in the direction of explicitly valuing the different types of flexibility necessary to operate the system. This means going beyond the conventional 10- and 30-minute reserve requirements similar to the actions in this area that have already been undertaken by SPP, MISO and CAISO.

6.1 *Discussions at the technical conferences and in comments emphasized the importance of having E&AS products match the time horizon and direction of system needs and uncertainties through shorter-term products (e.g., fast frequency response products and 10- or 15-minute ramp product), and longer-term products (e.g., multi-hour ramp products). However, commenters also noted that RTO/ISO system needs vary, and no "one-size-fits-all" E&AS reform currently exists to meet the unique needs of each RTO/ISO. We are requesting additional details on how the RTOs/ISOs plan to tailor their E&AS market reforms to their unique needs and why the reforms they are considering are appropriate to meet their expected system needs.*

How will existing E&AS market designs together with planned E&AS market reforms create appropriate incentives for existing resources to respond to system needs on operational time horizons (e.g., instantaneously, within five minutes, within 10 or 15 minutes, within one to four hours, etc.), and in the appropriate direction (up versus down)?

PJM Response:

With PJM's unique topology and geography, along with the expectation of upcoming resource changes, PJM will be faced with different operational needs compared with other RTOs/ISOs. In particular, the significant replacement of thermal resources with smaller and less dispatchable Intermittent Resources in varying locations will result in changes to congestion patterns and transfers of energy. With higher renewable penetration levels in the PJM footprint, and neighboring systems, historical transfer levels will continue to shift and vary over both the longer term and on an operational basis. These PJM specific changes will drive a need for unique reforms to the PJM market.

To that end, PJM has developed a framework for analyzing the system needs and developed action plans for market reforms and monitoring as detailed in responses to questions 1-3 above. More particularly, the framework creates appropriate incentives for resources to respond to the system on the needed operational time horizon (minutes, hours, etc) and appropriate direction (up vs. down).

The current co-optimization of E&AS markets and the market reform principles that PJM has detailed are designed to ensure that the correct pricing signals are sent to the marketplace. The resources providing the highest-value product should be provided appropriate compensation for doing so. Additionally, the market products should appropriately align with system needs (example: reforms for bi-directional (up/down) products). As noted in previous responses, the

current products and quantities may not fully capture all of the necessary flexibility needed to maintain system reliability and as such reforms are needed. The table included from PJM's reliability attribute analysis demonstrates how different products and services can target the time horizons that the system needs.

Inertia	**PFR**	**Regulation**	**Reactive**	**Ramping**	**Load Following**	**Flexibility**	**Fuel Assurance**	**Energy Assurance**
(instant)	(seconds)	(minutes)	(hours)	(hours)	(hours)	(days)	(days/season)	(day/season)
	Up/Down	Up/Down	Lead/Lag	Up/Down	Up/Down			

6.2 *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.*

How will existing E&AS market designs together with planned E&AS market reforms 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?

PJM Response:

E&AS and capacity markets work together to provide both operational signals as well as signals for efficient investment, maintenance, and retirement. The starting point must be to ensure the real-time and day-ahead price signals enable operation of the resources that are on the system most effectively and efficiently. Such price signals help ensure that efficient operation of resources is incentive compatible (that is, aligned with suppliers' profit-maximizing motives).

Efficient price signals additionally ensure resources are compensated according to the value that they provide to the system in any given operating interval. At times, especially when PJM is short of one or more reserve products, the incremental or marginal value provided to the system by an increment of the product may exceed the marginal cost or opportunity cost of providing it. At these times, it is appropriate that compensation to resources providing the high-value product is high. This is the structure of the existing E&AS markets, and future reforms will serve to strengthen this structure to ensure prices continue to reflect value in the future while ensuring appropriate safeguards against the exercise of market power and its impact on the goal of ensuring just and reasonable rates.

System conditions may evolve in such a way that certain reserve products often carry high prices, and/or volatility of energy prices may increase, reflecting increased volatility of underlying supply/demand fundamentals. These pricing patterns provide economic incentives for entry of

new flexible resources, and for retention of existing flexible resources. In fact, the expectation of future revenues for resources providing flexibility provides a control signal for efficient entry and exit:

- When expected prices of flexibility ancillary services are high, suppliers anticipate higher net revenues from flexible resources, sufficient to recover fixed costs, and thus market participants make needed investments to construct new flexible resources and remain in service.
- When expected prices of flexibility ancillary services are lower, suppliers anticipate lower net revenues for flexible resources, incentivizing fewer or no new construction of flexible resources and exacerbate premature retirements of flexible resources where the going-forward avoidable costs of continued operation exceed expected revenues.

As long as expected flexibility-based revenues reflect value to the system, and there are no undue barriers to entry, this control signal will yield efficient outcomes. For example, flexible resources will only economically retire when and where their going-forward avoidable costs of continued operation exceed the value that they provide to the system, if the value they provide to the system is reflected in such resources' expected revenues.

There are two additional reasons why the legacy modeling of pricing solely based on lost opportunity cost is not workable in the future. First, the need for strong performance incentives for providing ancillary services, which likely means strong penalties for failure to perform. Penalties on their own may create risk-related marginal costs for suppliers to provide the services that are unrelated to opportunity costs. Second, there may be additional costs necessary, such as the prearrangement of fuel, so that if called, resources committed for reserves can deliver energy. Consideration of the appropriate means to address these potential costs is a needed subject of review within the PJM stakeholder process in the near future.

6.2.1 How will existing E&AS market designs together with planned E&AS market reforms create an efficient long-run price signal for investment in new resources with the capabilities necessary to meet changing system needs?

PJM Response:

As detailed above, the existing E&AS market design together with the planned E&AS market reforms over the next five and ten years should work together to create an efficient long run price signal for investments in new resources with the capabilities necessary to meet the changing system needs. E&AS and capacity markets work together to provide both operational signals as well as signals for investment, maintenance, and retirement. PJM's ability to send the efficient long run price signals stems from providing the system with the correct real-time and day-ahead price signals that accurately use the resources on the system most effectively and efficiently. Such resources should be compensated based on their value to the system. Additionally, it is important that the E&AS market reforms provide ancillary service products and price signals to reflect the system capabilities that are needed and value the flexibility and reliability of resources.

6.3 *Panelists agreed on the importance of establishing demand curves for ancillary service products carefully and rigorously but disagreed on the best approach, particularly with regard to using VOLL in such demand curves. While some panelists argued that VOLL should be the basis for all demand curves, others highlighted shortcomings of VOLL and suggested alternative approaches. Given the importance of defining demand curves for ancillary service products, further clarification of how such curves will be defined in future E&AS market reforms is needed.*

Regarding E&AS products for which the RTO/ISO is contemplating reforms, to what extent will the reforms ensure that the E&AS products have well-defined demand curves that are rigorously designed to reflect system needs and transparently specify the quantity demanded by the market?

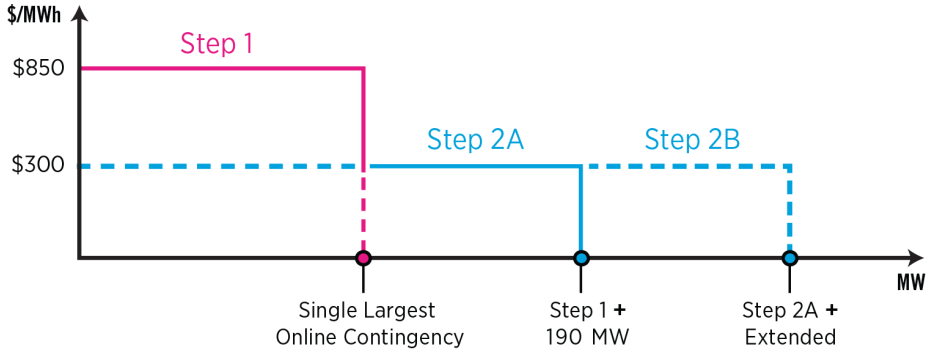
PJM Response:

It is important to energy market design to establish demand curves for ancillary services that are well defined and accurately reflect the system needs and transparency of the market demand. PJM is reliant on accurate and effective price signals to incentivize penetration and competition of all resources to provide flexibility. Defining a demand curve is intended to be the key mechanism for setting and signaling shortage pricing in the PJM region. These signals will allow system operators to take actions to maintain the minimum reliability requirements up to the highest defined price on the demand curves, after which system operators would enter into emergency actions to maintain energy balance and reserves. If the demand curves do not reflect the correct pricing, operators may need to take manual actions in order to maintain reserves, but such actions will not be reflected in clearing prices.

In PJM's reserve markets today, real-time reserves are cleared using a two-step Operating Reserve Demand Curve (ORDC). Under the current market rules, these ORDCs take the general shape of a vertical curve with step functions. When the Minimum Reserve Requirement (MRR) cannot be met, the reserve shortage is priced using the "penalty factor" specified in the applicable ORDC. Because PJM co-optimizes energy and reserves, the penalty factor can be also included in the calculation of the energy price such that when the system is unable to meet its reserve requirement, energy prices are intuitively high. The graphic below demonstrates PJM's current Synchronized Reserve Demand Curve.[43]

[43] In Figure 3, the Synchronized Reserve megawatts demanded in the red portion of the curve, labeled Step 1, are determined by the real-time megawatt output of the single largest online contingency. This quantity criterion is the MRR and has been in place since 2012, when shortage pricing was implemented. The penalty factor of Step 1, $850/MWh, is based on analysis of the out-of market make-whole payments made for reserves from an operating event in 2007. The blue portions of the Synchronized Reserve demand curve, Steps 2A and 2B, were both added more recently (in 2017 and 2015, respectively). The purpose of Step 2A was to add a smaller step on the curve to avoid system volatility due to large swings in price for small changes in reserve amounts that would have occurred with just Step 1. PJM implemented this change to the ORDC in response to Order No. 825, which required PJM and others to price all reserve shortages, even those that are transient in nature. Step 2B was added as a result of a package that was approved by PJM members that originated in the Energy and Reserve Pricing and Interchange Volatility special sessions of the Market Implementation Committee. The purpose of this optional step was to create the ability to

Figure 3.



There are limitations of the current reserve requirement demand curves that will need to be explored for reforms in the next five or ten years. PJM's current two-step ORDC curve quantities do not meet PJM's anticipated system needs due to the uncertainties and volatility around load, wind, interchange, solar forecasts, and unanticipated plant outages. The PJM dispatchers currently attempt to address such uncertainties, in order to meet the system need, through scheduling bias or other out-of-market actions. PJM dispatchers take these actions to manage the possibility that real-time conditions departing from those forecasts could harm PJM's ability to meet the current two-step reserve requirement. However, such actions by PJM dispatchers are not currently reflected in the demand curves and clearing prices, which ultimately increase out of market payments.

Looking out over the next five to ten years, the uncertainties around load, wind, interchange, solar forecasts, and unanticipated plant outages are expected to further increase. PJM will require reforms to enable capturing these uncertainties in the determination (formation) of demand curves and other market reforms that incentivize flexibility, so that the price signals to the market place will be reflective of more progressive and severe emergency actions that the PJM operator would take prior to shedding load. It will be extremely important to incorporate these uncertainties into the clearing of the Day-ahead and Real-time Energy Markets via either the reserve demand curves or other market reforms that incentivize flexibility to form the proper price.

6.4 *Many commenters raised concerns regarding the risk that E&AS market reforms will pay the incorrect resources, for example, paying all resources instead of resources that actually contribute to resolving system needs. Given the importance of ensuring appropriate incentives and compensation to resources that contribute to satisfying system needs, further clarification of how future E&AS market reforms will ensure appropriate compensation (e.g., that only resources that help operators meet system needs are paid) is needed.*

Regarding E&AS products for which the RTO/ISO is contemplating reforms, to what extent will the reforms ensure that the E&AS products direct compensation to resources that contribute to satisfying the particular system need(s) the product

extend the reserve requirement when PJM operators took actions to schedule additional reserves during conservative operations.

is designed to address and not to resources that do not make such contributions?

PJM Response:

It is important to ensure that reforms to any E&AS product directly compensate resources that contribute to satisfying the particular system need(s) that the product is designed to address, and not to resources that do not make such contributions. This is in support of operational reliability needs and efficient energy market design. The product's needs must be clearly defined and a market construct developed to have clear market and pricing signals to resources for entry, exit and participation. Qualification and performance requirements are also essential to the development of E&AS products to provide a clear and transparent expectation on the product and system needs.

In the PJM E&AS framework, it is also important to signal to resources the product need(s) and value with respect to the remaining E&AS products. The co-optimized, nested, cascading product design PJM and other ISO/RTOs have implemented in E&AS markets is a critical piece of providing the right pricing signals to the market place**.** In this model, prices for each ancillary service move in a rational manner ensuring that the highest quality product have the highest price and the lowest quality product has the lowest. It also ensures that the energy opportunity cost of providing an ancillary service is fully captured within the energy price, so that following dispatch instructions is profit maximizing for that resource. This is necessary for maintaining incentive compatibility.

PJM interprets the phrase, "resources that actually contribute to resolving system needs," as attempting to identify only those resources providing a particular ancillary service such that no other resource on the system has an increase or decrease in revenues due to the procurement of a particular ancillary service. For ancillary service products that should be co-optimized with energy in the energy markets to minimize procurement costs, it is not clear how to meet the aforementioned objective without removing co-optimization itself. However, using the same co-optimization method in the procurement of resources results in prices that are incentive compatible with the dispatch solution because it allows resources to profit-maximize. Therefore, it incentivizes resources to follow dispatch instructions. When ancillary services and energy are co-optimized, not only is the procurement cost of both minimized, but the price of energy can be impacted because resources may be removed from the supply stack for energy and used for ancillary services. This may change the energy price due to the need for ancillary services and causes changes in revenues for many resources on the system because the price of energy moves with the need for ancillary services. This phenomenon has existed since the implementation of the co-optimized energy and reserve markets and has been a cornerstone of the PJM markets and others across the country. For those reasons, PJM supports the continued use of this model for those ancillary services that are procured jointly with energy.

By specific example of designing ancillary service products to directly compensate resources that contribute to satisfying the particular system need(s), and not compensate resources who do not make such contributions, PJM is currently undergoing a regulation market redesign in our stakeholder process via the Regulation Market Redesign Sr. Task Force. In this task force, PJM and its stakeholders are developing solutions to (1) address current market design flaws that

do not properly signal and compensate resources relative to the contributions they are providing and (2) ensure the regulation market design is appropriate to support system reliability in the future, in light of the changing resource mix and system needs.

Under PJM's current regulation design, the regulation market utilizes two regulation signals (RegD and RegA) in the dispatch of the regulation product. Using two signals, but clearing them in a single market with a single requirement, requires an accurate marginal rate of substitution to be utilized in the clearing optimization in addition to accurately reflecting that value in settlements. The benefits factor, which translates RegD fast moving MW into RegA traditional MW, is being incorrectly applied in the optimization, leading to an incorrect calculation of the contribution of RegD to the total effective regulation. Furthermore, the benefits factor is used inconsistently in pricing and settlements. This results in a misalignment of the appropriate incentives and compensation to resources that contribute to satisfying system needs. As regulation becomes increasing more important with the integration of Intermittent Resources, it is critical that the appropriate incentive signals are sent to the market, and that PJM has made the regulation market redesign a strategic priority for market reforms.

6.5 *Discussions at the technical conferences and in comments raised the possibility that there is some discrimination in current E&AS markets and stressed that any future reforms should not introduce further discrimination. Given the importance of avoiding undue discrimination in E&AS markets reforms and the disagreement about the degree of undue discrimination in E&AS markets, further clarification on how RTOs/ISOs will avoid or eliminate undue discrimination in future E&AS market reforms is needed.*

Regarding E&AS products for which the RTO/ISO is contemplating reforms, including reforms to resource eligibility rules, to what extent will the reforms ensure that the E&AS products permit all resources technically capable of providing a product or service to offer to do so?

PJM Response:

For all current and future E&AS product reforms, PJM will ensure that the products permit all resources technically capable of providing a product or service to offer to do so. Ensuring that all PJM markets are open and non-discriminatory is a critical component of market design. PJM's current E&AS markets are non-discriminatory, and provide opportunity for participation by all resources, and resource types, that are technically capable of providing the product or service. By demonstration:

- PJM has implemented an "ancillary only" resource model to ensure resources are capable of providing services can do so.
- PJM has non-discriminatory models for ESRs (Order 841), DERS (Order 2222), and Hybrid resources.

Changes to the PJM E&AS markets will continue to provide non-discriminatory opportunity for participation. It is an important guiding principle PJM upholds to define technical

needs and performance and qualification requirements, and to not define markets as resource specific.

Further, PJM is committed to fostering innovation that promotes system reliability and efficient markets. The value of emerging technology is important to solving the problems/challenges of the changing system needs (DR, ESR, etc.).

7. *Discussions at the technical conferences and in comments identified challenges to existing RTO/ISO operational practices and corresponding solutions, such as improvements in forecasts and tools to assist operators that RTOs/ISOs are developing or plan to develop. While discussions centered on changing operational practices such as these in the near-term, other discussions indicated that system needs and the associated operational challenges will continue to change significantly beyond the near-term. As such, more clarification about how RTOs/ISOs intend to improve operational practices beyond the near-term is needed.*

   Referring to the changing system needs discussed in questions 2 and 3, how does the RTO/ISO expect to alter its operational practices, if at all, in order to successfully manage changing system needs over the next five years and over the next 10 years?

PJM Response:

There are a number of operational changes that will need to occur as the resource mix continues to change within the PJM footprint and the Eastern Interconnection as a whole. From a day-ahead and real-time perspective, significant improvements to wind and solar forecasting will be needed, as well as potentially maintaining additional generation reserves to account for forecasting errors and during periods of forecast volatility (*i.e.*, partially cloudy days, storms, icing, snow and snow slip, etc.). Improvements will also be required to the load forecast to consider additional impacts from behind the meter generation and EV charging behaviors. Further operational considerations, dispatch/control tools, procedures and market rules will also be needed if/when more smart technologies are deployed at the consumer level that would allow for control of the demand side. PJM is already implementing changes in each of these areas to be prepared for these developments.

PJM has also considered the impacts of the changing resource mix when preparing to operate the system several days, weeks and months ahead of the actual operating day. New challenges arise in these time frames with developing comprehensive operating plans to ensure all system operating limits/interconnection reliability operating limits ("SOLs/IROLs") are identified and managed due to the volatility and uncertainty introduced by Intermittent Resources. PJM has taken steps to modify our analysis procedures to perform new sensitivity studies to consider multiple scenarios of wind and solar output. These studies also consider all planned generation and transmission outages. But more importantly, this highlights the growing complexity with being able to reliably plan and perform maintenance and upgrades to existing infrastructure. Additional analysis tools and computing power will be required to mitigate these concerns as more

uncertainty and volatility are introduced by the changing resource mix that may not provide a consistently dependable source of energy that can be used to control system flows within limits.

At a regional level, it will also be more important than ever to understand the larger weather patterns and impacts they will have on Intermittent Resources outside of the PJM footprint. This will be a key input to analyze and prepare for shifting interchange patterns that will result, and times will shift drastically from day to day and intra-day as weather fronts move across the eastern United States. In addition to this analysis, future enhancements will need to be pursued to existing Reliability Coordinator to Reliability Coordinator and Balancing Authority to Balancing Authority coordination to ensure interconnection frequency and inertia levels are maintained, and SOLs/IROLs are managed as the generation patterns change.

7.1 How does the RTO/ISO expect to meet challenges related to forecasting customer loads and variable energy resource outputs?

PJM Response:

There are a number of challenges PJM and the industry are facing or expect to face related to forecasting customer loads and variable energy resource outputs. Traditionally, the largest component of operational uncertainty has been customer demand, which has been driven by human behavior. However, as we see the increases in behind the meter variable energy resources, electrification of customer load, new and expanded EV charging stations, in addition to increases to grid connected Intermittent Resources and additional storage, it becomes evident that the sources of operational uncertainty are growing exponentially.

The first area PJM is working on to address these challenges is improvements to the near-term (*i.e.*, 7-day outlook) load forecasting process. PJM has explicitly developed load forecasts that identify and incorporate the impacts of behind the meter solar. By parsing out the electric demand from the solar injection, we are able to provide incremental improvements to the traditional load forecasting in many cases. In future years, PJM will need to expand on this as behind the meter solar installations increase and as EV charging stations and their unique load patters are identified. However, even by separating out the various areas for forecasting, each maintains its own area of forecasting error risk which may entail the need for additional generating reserves or reserve products to mitigate.

In addition to the load/behind the meter forecasts, PJM will also need to ensure accurate and reliable forecasts for grid connected solar and wind resources. Historically the majority of PJM generation has been able to be scheduled by PJM with a very high degree of certainty in that performance. However, with increases in grid-connected variable energy resources, PJM will not only need to account for the uncertainty on the customer side, but also for uncertainty of the output of these generators. This is yet another source of operational uncertainty and risk that will need to be mitigated and reserve products will be crucial in that process.

Another area of activity PJM is working on is to address these challenges with evaluation and enhancements to E&AS markets. Specifically, PJM is addressing resource adequacy and load forecasting enhancements for future planning. Stakeholder initiatives are also underway for

renewable resources operations, ensuring the business rules are in-line with reliability and system needs, and evaluation of ancillary services quantities (regulation and reserves) that are being reviewed to see if they need to account for the additional variability and uncertainty that PJM will see in the future.

7.2 What model improvements, new operational tools, refinements to existing operational practices, or market software enhancements, if any, does the RTO/ISO expect to develop and/or deploy?

PJM Response:

Model improvements, new operational tools, refinements to existing operational practices and market software enhancements are important to continue to operate the grid reliably and efficiently. PJM is always evaluating these areas for enhancements and improvements for performance and efficiency benefits; this is a continuous effort that PJM will continue, in coordination with PJM staff, PJM stakeholders, vendors and other RTO/ISOs. PJM's current improvement and enhancements that PJM plans to develop and deploy are as follows:

Model Improvements

- **Combined Cycle model:** Allowing flexibility in offering and operating combined cycle models in the multiple configurations that they are able to operate in.
- **Energy Storage Resource optimization:** Allowing PJM to account for state of charge for storage and hybrid-storage resources to better utilize these resource's flexibility and optimize market outcomes.
- **Hybrid resource model**
- **Implicit model for Distributed Energy Resources:** Integration of implicit model and nodal load forecast for scalability of distribution resources.

Forecasting & Operational Tools and procedures

- **Load Forecast Improvements**
- **Operational tools/practices:** As customer demand and electric utilization changes in the coming years, coupled with more variable energy resources and potential retirements of traditional resources, PJM will need to consider an expanded energy adequacy analysis and associated operating. Currently, PJM's process ensures energy adequacy on a day ahead basis. However, if reserve margins are smaller due to significant retirements in traditional generating resources and/or if there is more of reliance on gas-fired generation for balancing services, PJM may need to perform energy analysis that looks several days/weeks ahead to allow time for additional actions and communications to be made to address operational concerns that may arise. This may include scheduling of longer lead generation, changes to reserve quantities, additional communications with natural gas pipelines, public appeals, etc.

8. *Some discussions in the comments and technical conferences noted that while many RTOs/ISOs are creating new E&AS products to incentivize flexibility,*

existing E&AS market designs might be incentivizing inflexibility. Some discussions specifically referred to uplift payment policies and operational parameters such as economic minimums as creating incentives for inflexibility. Given the importance of E&AS markets incentivizing resource capabilities and performance that help to meet system needs, more information about how future reforms will address possible incentives for inflexibility is needed.

Beyond the reforms discussed in answering questions 4-7, what other reforms to current RTO/ISO E&AS market rules may be required in the future given the RTO's/ISO's expected changing system needs and shortcomings of current E&AS market designs? Why? For example, are changes to resource eligibility rules for ancillary services or uplift policies expected to be necessary?

PJM Response:

PJM believes that having the right uplift policies in place to incent flexibility, and more precisely disincentivize inflexibility, and following PJM dispatch are important now. These policies will continue to be necessary with the expected changing system. Uplift is intended to function as one of the incentives for generation owners to offer their energy to the PJM energy market for dispatch based on short run marginal costs and to operate their units as directed by PJM operators. PJM's current rules consist of credits to be paid to ensure that resources are not economically disadvantaged by following PJM's direction, and charges or penalties to further incent flexible behavior. While the foundational constructs of PJM's uplift rules are sound, there are improvements that can be made to strengthen those principles. For example, PJM is developing rules and processes that disqualify resources for uplift credits when they do not adequately follow PJM dispatch instructions or operate outside of their specific, required parameters. Additionally, the PJM stakeholders are exploring ways to enhance dispatchablility rules, specifically for Intermittent Resources, and ensuring that the correct charge rates are being applied to sufficiently incent resources to follow dispatch instructions.[44] These examples, among others are enhancement that will further disincentivize inflexibility by allowing uplift to be collected.

Further, the uplift rules will need to be reformed to model the potential market reforms over the next five and ten years. As PJM contemplates development of new ancillary services markets, as detailed in questions 1-3, or reforms to execute the energy market (*e.g.*, multi-interval dispatch and pricing), it will be important to consider the incentive compatibility effects of these designs vis-a-vis flexibility, including interaction with uplift rules.

While PJM believes properly structured uplift rules are important, PJM views this to be good due diligence rather than a solution to fully valuing the reliability needs of the system through markets and avoiding the disorderly retirement of needed resources.

[44] Examples of such potential reforms include requirements for updated parameter limitations for Intermittent Resources, removing the curtailment flag in operations, and increasing critical parameter updates to every five-minute interval.

D. Other Potential Reforms

9. *Despite the focus of the E&AS technical conferences on E&AS markets, several panelists and commenters expressed support for the continued use and importance of capacity markets and potentially new resource adequacy constructs to satisfy future system needs. Given the focus of the record thus far on potential E&AS market reforms to satisfy operational flexibility needs and other system needs, the Commission would like to give RTOs/ISOs and other commenters the opportunity to comment on other possible reforms beyond E&AS market reforms that should be considered to meet changing system needs.*

   For RTOs/ISOs that administer a capacity market, what capacity market reforms, if any, is the RTO/ISO considering to meet expected system needs in the future? For RTOs/ISOs that do not administer a capacity market but rely on a different resource adequacy construct, what reforms, if any, is the RTO/ISO considering to that construct to meet changing system needs?

PJM Response:

Given the unprecedented resource transition repeatedly referenced in this response, PJM is carefully analyzing the overall resource adequacy needs of its region in the coming years. Traditional, fossil-fueled resources are forecasted to retire due to both policy and economic drivers and the pace of resource additions is less certain given the fluctuating rate at which resources in the interconnection queue achieve commercial operation. Considering also the forecasted increase to the region's demand from the addition of large data centers and the trend toward electrification, there is risk to overall resource adequacy in the coming years. PJM is therefore currently working with our stakeholders to review our capacity market construct and explore potential reforms needed to support future system needs in the Resource Adequacy Sr. Task Force. This is a large undertaking by PJM and stakeholders to identify needed reforms to meet the expected system needs in the future and maintain resource adequacy and reliability. The following reforms are being discussed:

- **Reliability Risk and Risk Drivers** - Determine the types of reliability risks and risk drivers to be considered by the capacity market and how they should be accounted for.
- **Procurement Metric and Level** - Determine the desired procurement metric and level to maintain the desired level of reliability.
- **Performance Assessment** - Determine the performance expected from a capacity resource.
- **Qualification and Accreditation** - Determine the qualification and accreditation of capacity resources.
- **Obligations of Capacity Resources -** Determine the desired obligations of capacity resources.

- **Enhancements to the Capacity Procurement Process** - Determine if there are needed enhancements to the capacity procurement process.
- **Remaining Design Seasonal Resource Adequacy Construct** - As applicable, determine any remaining design details for a seasonal capacity market construct not addressed in other KWAs.
- **Supply-Side Market Power Mitigation Rules** - Determine if supply-side market power mitigation rules in the capacity market need to be enhanced.
- **Fixed Resource Requirement (FRR) Rules** - Determine if the Fixed Resource Requirement (FRR) rules need to be synchronized with any changes made.

9.1 What new capacity accreditation methods, if any, is the RTO/ISO considering for its resource adequacy processes? How will such new capacity accreditation methods help the RTO/ISO satisfy expected changing system needs?

PJM Response:

PJM believes accurately assessing the capacity contribution of resources is essential to maintaining a reliable system under the changing resource mix and risk profiles of the future.

PJM recently reformed its capacity accreditation methodology in 2021 for certain types of Generation Capacity Resources (*i.e.*, Intermittent Resources, Limited Duration Resources, and Combination Resources) to use an ELCC analysis in determining capacity value contributions. This change to the accreditation process provides significant improvement to the prior method for these resource types, particularly under the changing resource mix and system needs of the future. Importantly, the ELCC methodology: (1) recognizes the diminishing returns associated with greater levels of deployment for most ELCC Resource types to ensure the region does not become over-dependent on a single resource type with inherent limitations; (2) recognizes the synergistic relationship among distinct resource types, potentially facilitating greater provision of reliability from the various resource classes pooled together across the PJM Region than what those same classes could provide in isolation; and (3) evolves with a changing load shape to account for changes in the future grid such as greater electrification of heating and transportation.

Furthermore, capacity accreditation is one of the key topics currently under discussion with stakeholders at the RASTF. As part of that effort, PJM and stakeholders are exploring potential enhancements to the accreditation methods for all resources types. These include discussion of:

- How we capture and account for weather-driven correlated outage risks of generation resources;
- Refinement and potential expansion of the ELCC methodology, or similar analysis, to use in determining the accredited capacity value for all resource types, including thermal generation and demand response;
- Changing the ELCC methodology from average to marginal;
- Alternative metrics to EFORd; and
- Requiring demonstration of fuel security as part of being accredited as a Capacity Resource.

These potential reforms under discussion at the RASTF on accreditation are ultimately intended to improve the accounting of each resource's contribution to resource adequacy under a changing system. Historically, resource adequacy risk has been tightly coupled with periods of peak demand, falling in the summer for the PJM system. Under higher penetration levels of renewable and storage resources, an evolving demand side (*e.g.*, increased electrification), we see those patterns of risk changing to hours outside the gross summer peak and across different seasons of the year. Similarly, availability of our resource mix is increasingly influenced by weather and correlated outage impacts, particularly during more extreme winter weather. Improving how we capture correlated outages and shifting risk profiles in our accreditation methods will provide for a more reliable system in the future and allow for better competition between a more diverse generation fleet.

9.2 What new products that value flexible attributes, if any, should be introduced in resource adequacy constructs, including capacity markets? Would such a change support adequate price signals for the investment and/or retention of resources with the capabilities needed to address emerging needs?

PJM Response:

PJM believes it is appropriate that any new products needed to maintain operational reliability be efficiently procured and priced in the operating timeframe first, before considering a forward procurement. In general, transparent price signals that are aligned with real-time system conditions will best incentivize optimal operations and investments.

Forward procurements of new products valuing flexible capacity or capability should only be considered if the real-time prices do not incentivize sufficient investments in the resources that can provide the products. Just like the capacity market can complement price signals in the operating timeframe to incentivize efficient investment and retirement decisions, forward procurement of certain flexibility capability could do the same if necessary.

PJM believes that further reforms to properly value flexibility in the operational timeframe is a necessary first step in ensuring that reserves are appropriately procured and priced in the operating timeframe. It is necessary to implement changes such as these prior to considering a forward procurement process.

10. *While this proceeding focused on RTO/ISO markets, several panelists and commenters noted challenges to meeting RTO/ISO system needs that arise from sources beyond the RTO/ISO markets themselves. Panelists and commenters noted potential reforms necessary to address challenges related to coordination between adjacent balancing authorities, coordination between transmission and distribution operations, and inflexibility in the fuel supply of certain resources. Given the lack of record thus far on these challenges and potential reforms, more information is needed to ensure RTOs/ISOs can continue to meet system needs as*

they evolve in the future and identify and address any obstacles to that objective.

What reforms beyond those to the RTO's/ISO's tariff(s) does the RTO/ISO believe might be needed to address expected changing system needs?

PJM Response:

Maintaining grid reliability in the increased uncertainty, clean-energy transition will require changes, in concert, beyond the individual RTO tariff(s). Elaborated in the sub questions below, reforms in NERC standards, and enhancing coordination for balancing authorities, transmission-distribution and electric-gas coordination will provide a foundation to address the expected changing system needs.

10.1 What reforms to reliability requirements, such as reforms to NERC standards, might be necessary?

PJM Response:

Reforms to NERC reliability standards may need to evolve with the changing resource mix, to continue to support system reliability. As the system and resource mix changes, NERC standards will need to be continuously reviewed, and reforms should be made to areas that fit within NERC's mission to ensure reliability.

The NERC process has tended in recent years toward developing 'least common denominator' solutions. Moreover, although there should remain a separation between the development of market rules and reliability standards, the two should not remain wholly divorced from one another particularly in the standard development process. Otherwise, as has been seen in the development of the recent winterization standard, the least common denominator characteristic of the NERC standard development process has forced the markets or states to have to address matters that should be part of a consistent baseline of reliability requirements across the nation. A more rigorous baseline coming out of the NERC stakeholder process would avoid one system unduly leaning on its neighbors and putting pressure on market designs and/or states to address core reliability requirements that should be part of a uniform baseline across each Interconnection if not the nation.

10.2 What reforms to policies for coordinating operations with adjacent balancing authority areas in both RTO/ISO and non-RTO/ISO regions might be necessary?

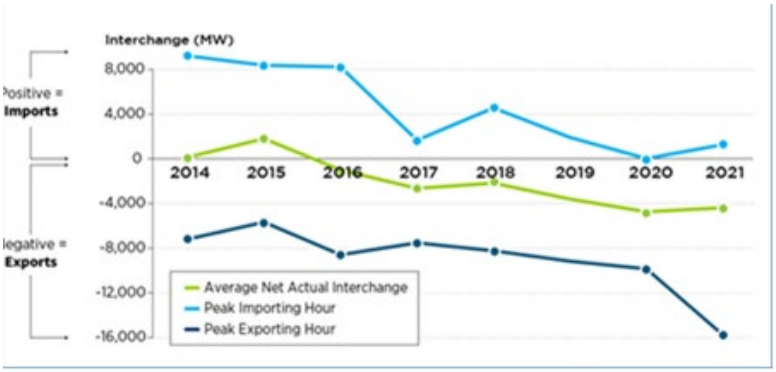
PJM Response:

With increased system volatility, there is an opportunity for adjacent Balancing Authorities to increase and improve real-time coordination and shared reserve agreements. Allowing for further neighbor coordination will enhance system reliability, particularly in the extreme system operations cases. These coordination efforts should be developed between neighboring entities, and in general should be set up in a unique fashion to serve those regional system needs. Here too, a baseline of standards from NERC or a clear policy from this Commission would be helpful to

frame those discussions and avoid wholly disparate arrangements among neighbors that do not reflect the interconnected nature of the Interconnection as a whole.

Also, as discussed in PJM's comments in RM21-17,[45] PJM provided recommendations that the Commission consider development of a robust standardized interregional transfer capability methodology that would inform future interregional transmission coordination to help ensure that there is adequate transfer capability between regions. As the resource mix evolves to include more renewable generation, robust transfer capability may enhance both reliability and resilience as the grid faces more extreme weather events and other related challenges. As each individual Balancing Authority ("BA") develops additional renewable resources, there will be periods of the day where all BAs will be producing significant excess low cost energy for export. PJM believes that a common metric (and planning driver to support transmission expansions to meet that metric) would, in addition to enhancing reliability, have the ancillary benefit of allowing for increased import and export of renewable generation across the regions in other hours of the year without the Commission facing legal challenges that it is forcing development of new transmission to accommodate one particular type of generation. In addition, PJM continues to work collaboratively with its neighbors to improve transfer capability along its seams. For example, under extreme weather conditions such as the February 2021 Cold Snap, PJM was able to export an unprecedented amount of electricity to its neighboring southwest regions. Under similar conditions, *i.e.*, the 2014 Polar Vortex, PJM relied on the same strong ties to import peak energy into PJM.

Figure 4.



10.3 What actions should the Commission consider taking to encourage coordination between the electricity transmission and distribution system operators in order to address challenges arising from limited visibility into distribution-connected resources?

PJM Response:

Transmission and distribution system coordination and the necessary cooperative federalism associated were at the forefront of Order 2222 and PJM's compliance filing. It will be

[45] *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection*, Initial Comments of PJM, Docket No. RM21-17-000 (Aug. 17, 2022).

important as the framework for transmission and distribution coordination is developed and refined by the Commission to clearly define the boundaries between federal and state jurisdiction, and provide RTOs the ability to define the appropriate market rules needed for reliable operations integrating distributed-connected resources into PJM's wholesale markets. An example of this would be market rules proposed for nodal aggregation of DER Aggregation resources to allow for accurate constraint control on PJM's system. Lastly, allowing for regional differences to define the coordination is needed between utilities, resources, and PJM to ensure all of the needed data and coordinate can occur to verify safe and reliable operations prior to resource operations in PJM Markets (and not directing a narrow ability for coordination, *i.e.*, pre-registration for DERA in Order 2222).

10.4 What reforms to other services within the Commission's jurisdiction, such as natural gas transportation services, should the Commission consider in order to improve operational flexibility in the fuel supply?

PJM Response:

PJM detailed in its Comments in RM21-17 its proposal that would have the Commission challenge each region to detail its enhanced reliability issues and develop a plan for addressing those.[46] One issue highlighted by PJM in those Comments was enhanced gas/electric planning coordination. Much has been done to improve gas/electric coordination in real time operations, but the coordination of future needs of each industry in the development of long-term plans has not received similar attention. More coordination of the interconnection process and the baseline planning processes with the needs and build-out plans of the gas pipeline system would help to create a better record of identified need that could enhance (if not substitute for) today's precedent agreement model for the determination of need for new pipeline expansions. For these steps to move forward, PJM has outlined a three part "road map" in its Comments in that docket and urges their consideration.

PJM supports and is participating in the NAESB Gas Electric Harmonization efforts to address Recommendation No. 7 from the Joint FERC/NERC Winter Storm Uri report, and sees values to reliability for the Commission to consider reforms resulting from this effort. Within this effort is the consideration of potential new or enhanced natural gas supply and transportation services intended to improve reliable delivery. Additionally, as a general matter, the Commission should take into consideration the gas supply reliability needs of the ISO/RTO when evaluating new pipeline projects. PJM's proposal in RM 21-17 would allow for that to happen in an orderly way across the nation without requiring a wholesale revision of the precedent agreement model for the determination of need in pipeline proceedings.

11. *While the questions in this order have asked about a five-year and 10-year time horizon, what activities, if any, is the RTO/ISO undertaking to consider changing system needs that could materialize beyond the 10-year time horizon?*

[46] *Id*.

PJM Response:

PJM is committed to studying and taking action on the system needs for reliability and market efficiency. In 2021, PJM published the first of a series of studies "Energy Transition in PJM: Frameworks for Analysis." In 2022, PJM released the second iteration of this study "Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid." This is a multiphase, multiyear effort to study the potential impacts associated with the evolving resource mix. This "living study" will identify gaps and opportunities in the current market construct and offer insights into the future of market design, transmission planning and system operations.

PJM, in collaboration with states has performed scenario studies to assess the impact of interconnecting large amounts of renewable generation. In 2021, PJM completed a phase 1 of an offshore wind study that included reliability analysis and economic analysis for varied offshore wind injections, along with added wind and solar resources to meet state targets. In 2022, PJM is in the process of conducting a second phase of analysis to additional scenarios that considers updates to a number of assumptions, including retirements. In addition to offshore wind transmission studies, PJM is also working on grid of the future scenario studies that assume an accelerated case with renewables exceeding state goals. PJM expects to apply any findings from these studies to inform what future planning analysis and potential changes to the planning process may be appropriate.

In addition to the scenario studies that PJM has performed or are underway, PJM is very supportive of a long-term forward-looking approach to transmission planning, which PJM discussed in great detail in its comments in RM21-17.

12. *If RTO/ISO market design changes beyond the RTO/ISO's planned E&AS market reforms discussed in answering questions 4-7 are necessary to manage expected changes in system needs, how can the Commission best assist RTOs/ISOs and their stakeholders in reforming their markets in the future?*

PJM Response:

The Commission will play a key role in the grid transformation over the next five to ten year time horizon. ISOs/RTOs have done a significant amount of thinking, analysis, and coordination on the topic of E&AS reform in light of the changing resource mix.

Although the Technical Conference illustrated the differences among regions, there is no doubt at a higher policy level that the issues are common across the nation, albeit proceeding at a somewhat different pace among the regions. For example, issues such as the need to incent flexibility, designing specific products and pricing to incent that flexibility, gas/electric coordination and ensuring proper price signals for obtaining appropriate amounts of reserves are not limited to any one specific RTO or ISO region. Thus, although deference needs to be paid to allow for the development of solutions in each region, the Commission should not simply be in a passive stance awaiting the submission of Section 205 filings and reactively adjudicating them

individually. Such an approach could lead to disparate results given the Commission's binary "accept or reject" powers under Section 205.

Therefore, to proactively assist in reforming the E&AS markets, as it has done previously with its Price Formation Policy Statement, the Commission should use the tool of Policy Statements to set forth the overall direction and key areas, which are the subject of near term RTO stakeholder action. Importantly, the Policy Statement should not prescribe solutions, but should instead indicate that based on the record of this proceeding, it is supportive of and wants to see reforms in the following areas:

- Development of a suite of products that incent needed flexibility on the system;
- Pricing that supports the development of these products in a manner which incents those units that can provide needed services while not, at the same time, disturbing the need for E&AS markets to work together to incent units to follow dispatch instructions;
- Capacity market reforms that focus on ensuring the appropriate accreditation value of all resources based on their relative contribution to the reliability needs of the system and their level of fuel security to meet those reliability needs; and
- Gas/Electric planning coordination that would ensure that the determination of need for pipeline expansions is appropriately informed by both RTO/ISO interconnection queues and the baseline long term planning process.

A policy statement outlining the Commission's expectations would help to focus RTOs and their stakeholders on these issues at a time when there are countless issues that could distract from their development. Moreover, such a Policy Statement, if adopted on a bipartisan basis, could ensure a level of continuity in the Commission's direction that would further incent the industry to move proactively. The use of Policy Statements have been helpful in the past and, thus, PJM urges the issuance, for notice and comment, of a draft Policy Statement at the above level of detail based on the record gathered in this proceeding. In this way, the Commission can help advance these reforms in a proactive manner; allowing RTOs to put in place market reforms for expected reliability needs and not putting the RTOs in a position when reactive measures need to be taken to address degraded reliability situations.

II. PJM REPSONSES TO QUESTIONS PRESENTED BY COMMISSIONER CHRISTIE

1. *Are the RTO/ISO markets compensating dispatchable resources appropriately in all markets? Are pricing policies causing premature retirements of dispatchable resources that may threaten reliability (as the MISO Midwest results may indicate)?*

PJM Response:

As mentioned in the comprehensive responses to 6.2, 6.2.1, 6.3 and 6.4, E&AS and capacity markets work together to provide both operational signals as well as signals for efficient

investment, maintenance, and retirement. In PJM, the three year forward capacity market has provided an investment signal that has allowed for the retention of needed thermal resources while also recognizing the capacity value contribution of renewable resources, particularly those who can "boost" their capacity value through the addition of storage. The markets working together have proven their long term effectiveness. One key example is the smooth transition that was accomplished within the PJM region to the imposition of the EPA Mercury and Air Toxics Rule. Approximately 22,000 MW of older coal fired generation were retired, but were quickly replaced by approximately 22,000 MW of more efficient natural gas generation that had a far better emissions profile.[47] Moreover, because of the competitive nature of the PJM markets, that transition was accomplished at little increased cost (and in fact declining overall costs during the period when the MATS rule was being implemented) to customers. There is no basis to simply discard the market construct given its past successful management of challenging transitions such as the MATS rule transition outlined above.

PJM believes the nested, cascading product design implemented in E&AS markets is a critical piece of providing the right pricing signals to the market place in the near-term time horizon. However, there remains opportunity to strengthen these pricing signals by:

- Establishing demand curves for ancillary services that are well defined and accurately reflect the system needs and transparency of the market demand to incentivize penetration and competition of all resources to provide flexibility.
- Instituting qualification and performance requirements that provide a clear and transparent expectation on the product and system needs.
- Identifying attributes important to reliability in the near- and long-term time horizon so they can be valued, acquired and compensated to mitigate premature retirements of existing resources with the needed attributes.

2. Are intermittent and hybrid resources compensated appropriately to ensure reliability?

PJM Response:

As mentioned in the comprehensive responses to 6.4 and 6.5, PJM's current E&AS markets are non-discriminatory, and provide opportunity for participation by all resources, and resource types, that are technically capable of providing the product or service. Additionally, PJM's capacity market utilizes the ELCC approach, which allows PJM to gauge how much capacity it may accept from providers of renewables, storage and hybrid resources while ensuring resource adequacy. In general, a resource that contributes a significant level of capacity during high-risk hours (*i.e.*, hours with very high electricity demand and low wind or solar output) will have a higher capacity value under ELCC than a resource that delivers the same capacity during low-risk hours. These risk hours may vary as the resource mix changes (e.g., more wind and solar is installed) and hours of high demand evolve (*e.g.*, wide-scale electric car charging at night). For

[47] PJM, *Response of PJM Interconnection, L.L.C. to House Committee on Energy and Commerce*, at 7 (Oct. 11, 2019), https://www.pjm.com/-/media/library/reports-notices/testimony/20191011-pjm-response-to-house-ec-climate-inquiry-on-greenhouse-gas-regulation.ashx.

these reasons, PJM does not believe that there is evidence that suggests hybrid resources are being compensated inappropriately at this time.

3. *Is it appropriate to continue to use LMP in energy and capacity markets? Does the continued use of LMP threaten reliability as the generation mix changes? Does the use of LMP ensure that consumers get the benefit of low clearing prices? Is there a better pricing model than LMP in RTO/ISO markets to achieve reliability and fairness to consumers?*

PJM Response:

Independent analysis has repeatedly proven that Locational Marginal Pricing (LMP) is the best method for pricing the energy markets.[48] As noted in those analyses, LMP accurately accounts for actual operating conditions and reflects the price of energy at discrete locations across the grid. LMP serves to reinforce reliability by capturing physical limitations on the transmission system and controlling congestion on the grid through market signals. Since LMP accounts for the cost of energy by geographic location across the grid, LMP patterns over time encourage new economic development and investment by generators, transmission system operators and customers. LMP signals new generation sources to consider locating in areas where they may receive higher prices. Additionally, LMP encourages the construction of new transmission facilities where they are needed for the most economical delivery of power to historically congested areas, serving as a catalyst for grid upgrades. When the LMP does not sufficiently incentivize or compensate resources in the operating timeframe, the capacity market can complement LMP by providing a forward price signal that incentivizes efficient investment and retirement decisions. While there are opportunities to improve the way LMPs are calculated by improving the mathematical modeling, PJM believes the LMP model is fundamental to the efficient operation of energy markets.

4. *Are capacity markets appropriate to use for resource adequacy? If not, is there a better alternative to capacity markets? Should capacity markets be purely residual or mandatory?*

PJM Response:

Capacity markets continue to be appropriate to use for resource adequacy. As noted in response to Commissioner's first question above, the forward capacity market was instrumental in PJM being able to rapidly absorb and transition from the impact of the EPA MATS rule at minimal cost to customers and no disturbance in reliability. However, as mentioned in responses 9, 9.1, 9.2 and others, reforms are necessary and underway. More specifically, in PJM, there are currently two groups discussing potential capacity reforms. The Resource Adequacy Sr. Task Force is

[48] William W. Hogan, *Electricity Market Design and Zero-Marginal Cost Generation*, Current Sustainable/Renewable Energy Reports (Feb. 24, 2022), https://doi.org/10.1007/s40518-021-00200-9; *see also Regional Transmission Organizations.*, Order No. 2000, FERC Stats. & Regs. ¶ 31,089 (1999) (cross-referenced at 89 FERC ¶ 61,285 (1999)), *order on reh'g*, Order No. 2000-A, FERC Stats. & Regs. ¶ 31,092 (2000) (cross-referenced at 90 FERC ¶ 61,201 (2000)), *aff'd sub nom. Pub. Util. Dist. No. 1 of Snohomish Cty. v. F.E.R.C.*, 272 F.3d 607 (D.C. Cir. 2001).

taking a holistic review of the capacity market with a focus on nine key work activities with a wide range of topics. Meanwhile the Clean Attribute Procurement Sr. Task Force is coordinating a comprehensive discussion between the Organization of PJM States, Inc., Competitive Policy Achievement Staff Working Group, PJM stakeholders and PJM staff around enhancements to enable states and other willing buyers to procure clean resource attributes, on a voluntary basis, through a regional and centralized procurement or market.

PJM does not envision proposing a fully mandatory capacity market. Rather, PJM intends to maintain the existing paradigm that enables utilities to opt out of the capacity auctions through the Fixed Resource Requirement alternative. Such an approach has demonstrated adequate procurement of resource adequacy and without any shortfalls as witnessed recently in other markets that are purely residual.

5. *How will compliance with Order No. 2222 mandating the participation and compensation of aggregated distributed energy resources (DERs) in RTO/ISO markets affect the answers to questions 1-4 above?*

PJM Response:

DERs provide an added suite of products that can help ensure reliability rather than sole reliance on central station generation or pure demand response. In that way, it is a promising development. Moreover, PJM's proposal works to integrate those resources into the wholesale markets in a manner that ensures that they can provide significant reliability value. Key to PJM's approach is ensuring that aggregated DERs both have requirements similar to other capacity resources while also being able to enjoy the revenues that all qualifying capacity resources can realize in those markets. That integration ultimately benefits all customers, both those with DERs at their facilities and those that continue to depend on the RTO to ensure resource adequacy. PJM does not anticipate any necessary updates to its compliance with Order No. 2222 given that the DER participation model was designed to adhere with the market principles discussed herein.

CERTIFICATE OF SERVICE

I hereby certify that I have this 18th day of October, 2022 caused a copy of the foregoing document to be served upon each person designated on the official service list compiled by the Secretary in this proceeding.

/s/ Chenchao Lu
Chenchao Lu
Assistant General Counsel
PJM Interconnection, L.L.C.
2750 Monroe Boulevard
Audubon, PA 19403
(610) 666-2255
Chenchao.Lu@pjm.com