Maintaining the PJM Region's Robust Reserve Margins

A Critique of the PJM Report:
Energy Transition in PJM: Resource Retirements, Replacements and Risks

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Prepared by
James F. Wilson
WILSON ENERGY ECONOMICS

Prepared for
Sierra Club and Natural Resources Defense Council

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I. Executive Summary

PJM Interconnection, LLC ("PJM") is the regional transmission organization ("RTO") that coordinates wholesale electricity markets in the Mid-Atlantic area ("PJM Region"). PJM has embarked on a multiyear effort to study the potential impacts associated with the evolving electric generation resource mix in the transition to cleaner forms of energy in the PJM region, resulting in a series of "Energy Transition in PJM" reports.[1] PJM's goal with this analysis has been to identify gaps and opportunities in PJM's current wholesale market constructs and offer insights into the future of market design, transmission planning and system operations.[2] The first two reports in this series presented scenarios of the changing resource mix out to 2050, identified generator operational characteristics that will be needed to reliably operate the future system, and called attention to the need to accurately assess the reliability contributions of all resource types, among other emerging issues.

The first two reports in PJM's Energy Transition in PJM series did not raise concerns or even discuss PJM Region "reserve margins" (the total amount of capacity to meet customers' peak loads reliably). However, PJM's recent, third report, *Energy Transition in PJM: Resource Retirements, Replacements and Risks*[3] ("R4 Report"), focuses on reserve margin calculations for 2023 to 2030. Despite a history of high reserve margins, the R4 Report's scenarios suggest that the region could face drastically low reserve margins, jeopardizing resource adequacy and reliability, in the transition to clean energy between now and 2030. The R4 Report anticipates low reserve margins based on "balance sheet" calculations that simultaneously assume strong load growth, a fast pace of retirements, and a slow pace of new entry.[4]

This paper reviews and critiques the R4 Report's resource adequacy calculations. I conclude that PJM's simple balance sheet calculations are invalid, as they combine highly contradictory assumptions that cannot occur together. The calculations ignore the simple reality, repeatedly demonstrated over the history of PJM's energy and capacity markets, that the pace of retirements and new entry are interconnected through the price signals of PJM's "RPM" capacity market and other markets, and consistently result in procuring more than enough capacity to maintain reliability. Whenever reserve margins decline, RPM prices rise, and the market soon responds with some combination of additional entry and delayed retirements, returning the system to higher reserve margins and moderate capacity prices. The capacity market has consistently and effectively procured more than sufficient capacity, as PJM has repeatedly concluded in its reports on RPM auction results.[5]

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[1] PJM, *Energy Transition in PJM: Frameworks for Analysis,* December 2021, available here; *Addendum*, available here; *Energy Transition in PJM: Emerging Characteristics of a Decarbonizing Grid*, May 2022, available here; *Addendum*, available here.

[2] See, for instance, *Energy Transition in PJM: Frameworks for Analysis,* p. 1.

[3] PJM, *Energy Transition in PJM: Resource Retirements, Replacements and Risks*, February 2023, ("R4 Report"), available here. The R4 Report was discussed with stakeholders at a special workshop on March 28, 2023; PJM's presentation at that meeting is available here. PJM also published a Frequently Asked Questions document on April 21, 2023 ("R4 Report FAQ"), available here.

[4] See, for instance, R4 Report page 16, presenting scenarios under which reserve margins fall to 7% or 8% by 2028 and "may be insufficient to cover peak demand expectations" even with demand response.

[5] See, for instance, PJM new release February 27, 2023, *PJM Capacity Auction Procures Adequate Resources*, p. 1 (quoting CEO Manu Asthana: "The capacity auction continues to be our best tool to ensure reliability at competitive prices in PJM").

If anything, the RPM capacity market is overly conservative. Reserve margins have chronically been excessive, as will be shown later in this paper. Reserve margins need to decline toward the target levels needed for adequate reliability, and likely will in the coming years. And PJM has additional tools at its disposal, ignored in the R4 Report, to help keep reserve margins at acceptable levels (such procurement through the RPM "incremental" auctions,[6] and the "reliability backstop" provisions.[7]) Based on the invalid calculations presented in the R4 Report, PJM has needlessly worried stakeholders and policy makers with drastically low reserve margin scenarios that are highly unrealistic, as I will further explain in this paper.

The R4 Report briefly acknowledges the important challenges associated with the anticipated changes in the resource mix,[8] and that PJM and stakeholders are working to address them.[9] The Winter Storm Elliott experience in December 2022 suggests the urgency of efforts to bolster plant performance under extreme cold, fuel security, and winter resource adequacy.[10] The unrealistic scenarios in the R4 Report suggesting very low reserve margins draw attention away from the important issues around winter resource adequacy and the changing resource mix, and could lend support to unnecessary and misguided policies aimed at retaining high-cost, high-emission power plants,[11] contrary to federal and state policies that seek to require low- or no-emission generation.

The remainder of this paper is organized as follows. The next section explains how PJM's RPM capacity construct creates price signals that have effectively guided retirement and new entry decisions over many years. Sections III and IV provide a critique of the R4 Report's balance sheet calculations and assumptions. The final section explains why it is important for resource adequacy analysis to be realistic.

[6] RPM incremental auctions are held closer to the delivery year and afford PJM an opportunity to acquire additional capacity. See PJM Tariff Attachment DD Section 5.4.

[7] PJM Tariff Attachment DD Section 16, *Reliability Backstop* (providing that if RPM clears more than one percent below the target reserve margin PJM will investigate the causes and recommend corrective actions; and if this occurs for three consecutive delivery years PJM can hold a Reliability Backstop Auction to procure additional capacity).

[8] R4 Report p. 17 ("The composition and performance characteristics of the resource mix will ultimately determine PJM's ability to maintain the reliability of the bulk electric system.")

[9] R4 Report p. 17 ("Managing the energy transition through collaborative efforts of PJM stakeholders, state and federal agencies, and consumers will ensure PJM has the tools and resources to maintain reliability.")

[10] PJM's preliminary analysis of the Winter Storm Elliott event with substantial supporting information is available here. PJM expects to provide "lessons learned" from the event in May 2023 with a full report in July 2023.

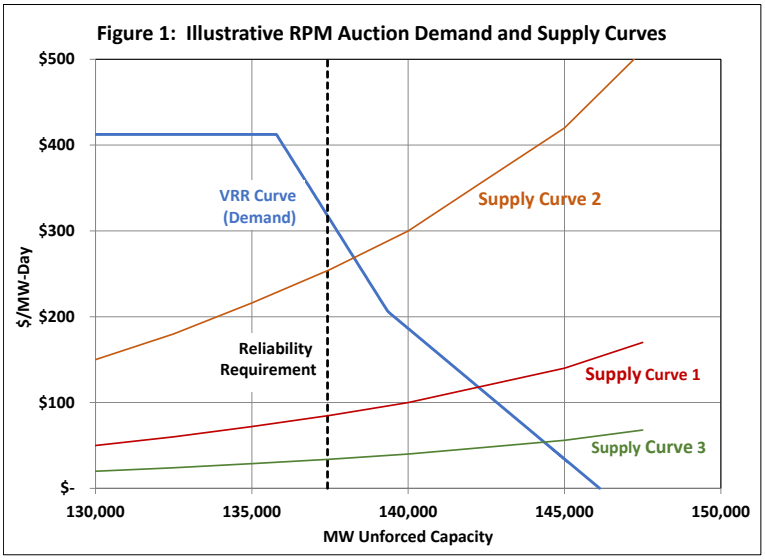
[11] As one recent example, see the *Commission Order* in West Virginia Public Service Commission Case No. 22-0793-E-ENEC, April 24, 2023, available here, pp. 7-9 ("Moreover, suggestions by some intervenors that there are no existing or expected reliability problems in PJM have recently been rejected by PJM. [*footnote citing to R4 Report*] In fact, PJM has recently studied the reliability quality of its near-term power supply and found that reliability is impacted by over-reliance on intermittent resources, mostly solar and wind... In addition to reserve margins that are far below the historical margins in PJM, the PJM Report 2023, shows that by 2026 all of the capacity reserves in PJM will be intermittent resources or voluntary customer curtailments, neither of which can be dispatched when needed as is the case with thermal generation resources.") citing the R4 Report, in support of a proposal to subsidize a coal-fired plant to keep it in operation one additional year, from June 1, 2023 to May 31, 2024).

II. Resource Adequacy, Reserve Margins and Capacity Prices in the PJM Region

One of PJM's core goals is to ensure that its wholesale markets will provide adequate total electric generating capacity to meet customer peak loads plus a "reserve margin," to account for plant outages and other uncertainties. PJM's wholesale energy and ancillary services markets, and related bilateral markets, are the main sources of revenue for generation on the PJM system, while PJM's Reliability Pricing Model ("RPM") capacity construct is intended to provide the additional, "missing money" needed to achieve resource adequacy targets.[12] Thus, RPM plays a pivotal role in ensuring resource adequacy; the R4 Report completely ignores this in its balance sheet calculations.

Under RPM, PJM holds annual auctions to acquire capacity commitments for the "delivery year" three years into the future (for example, the RPM auction held in May 2018 acquired commitments for the period from June 1, 2021 through May 31, 2022).[13] The RPM auctions use a sloped "demand curve" for capacity that is positioned based on PJM's forecast of future peak load plus the target reserve margin, and the capacity price that is considered needed to attract the construction of new power plants (this price parameter is called "Net CONE"). The capacity "supply curve" for each auction is based on price offers from the owners of eligible power plants and providers of demand response and energy efficiency resources. In the RPM auctions, the intersection of the sloped demand curve and the supply curve determines the capacity price, cleared quantity, and reserve margin for the future delivery year.[14] This is illustrated in Figure 1, in which "Supply Curve 1," shown in red, clears at about $120/MW-day.

Figure 1: Illustrative RPM Auction Demand and Supply Curves

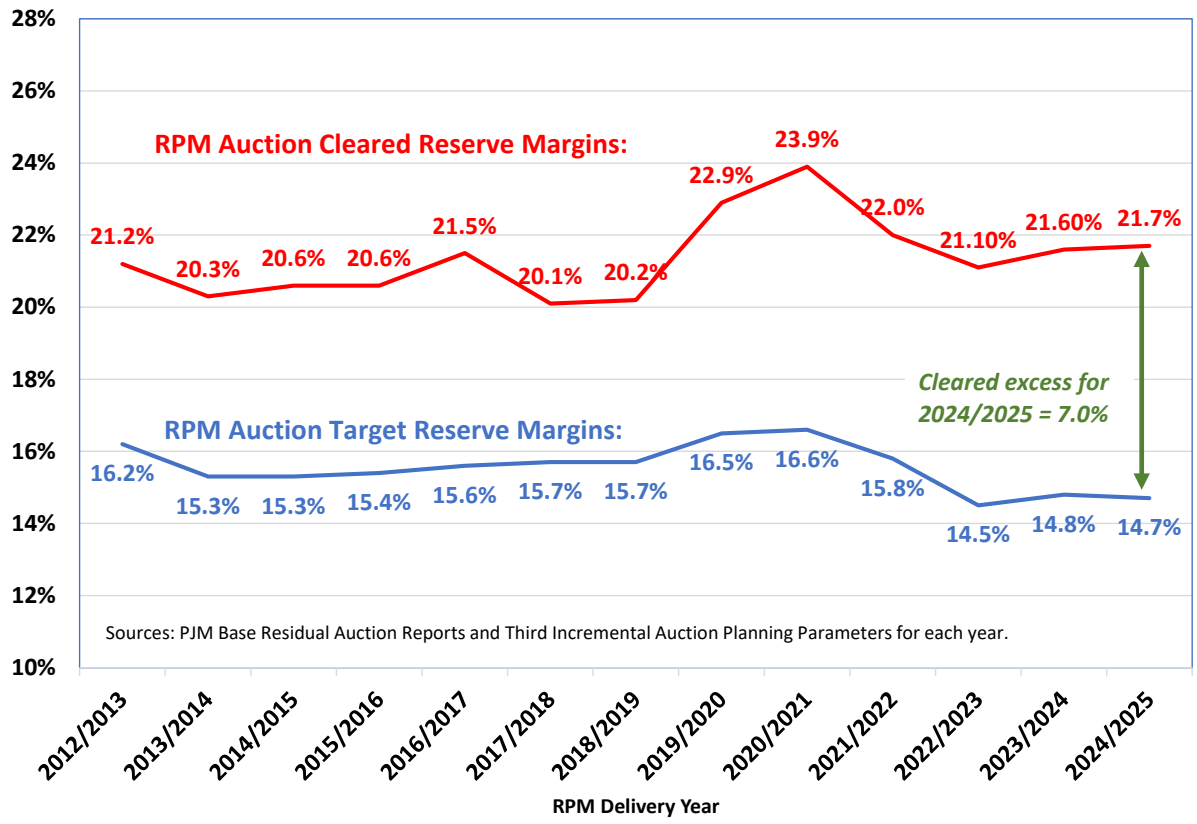


The sloped RPM demand curve results in clearing prices that signal whether additional capacity is needed on the PJM system. When capacity is relatively scarce or expensive (shifting the supply curve up and left; Supply Curve 2 in Figure 1), the sloped demand curve ensures that the auction will clear at a higher price, creating a price signal and incentive for market participants to delay retirements, upgrade existing plants, build new plants, and develop demand response. At times when capacity is abundant and low cost (shifting the supply curve down and right; Supply Curve 3 in Figure 1), as has been the case recently, the sloped demand curve results in RPM clearing more capacity and at a lower clearing price, which reduces incentives for new plants and encourages high-cost existing plants to retire.

[12] For a more extensive discussion of the importance of energy and ancillary services markets and the different roles of these markets and the capacity market see Wilson, James F., *"Missing Money" Revisited: Evolution of PJM's RPM Capacity Construct*, prepared for the American Public Power Association, September 2016, available here.

The RPM mechanism has worked in the past to maintain reserve margins at high levels. Figure 2 shows that while the target installed reserve margins for the RTO Region have generally been around 15% or 16% of the forecast peak load (the blue line in Figure 2), the RPM auctions have regularly cleared significantly more – reserve margins of 20% or more (red line). So while the target reserve margins of about 15% or 16% of peak load represent the capacity PJM believes it needs to reliably operate the system, RPM has consistently drawn commitments that are far in excess of these targets. Note that the actual reserve margins and excess capacity in the delivery year have been even larger, because the final load forecast and actual, weather-normalized peak loads are generally lower, and because thousands of MW of additional resources that fail to clear in each RPM auction nevertheless continue to operate as "energy-only" resources on the PJM system.

Figure 2: RPM Base Residual Auction Target and Cleared Reserve Margins



In a 2020 report, I explained that this over-procurement is a result of RPM auction design features and inaccurate peak load forecasts.[15] I also explained that the excessive capacity commitments and reserve

[13] Recent and upcoming auctions are less than three years forward due to delays that have occurred for various reasons. PJM intends to return to a three year forward schedule in a few years.

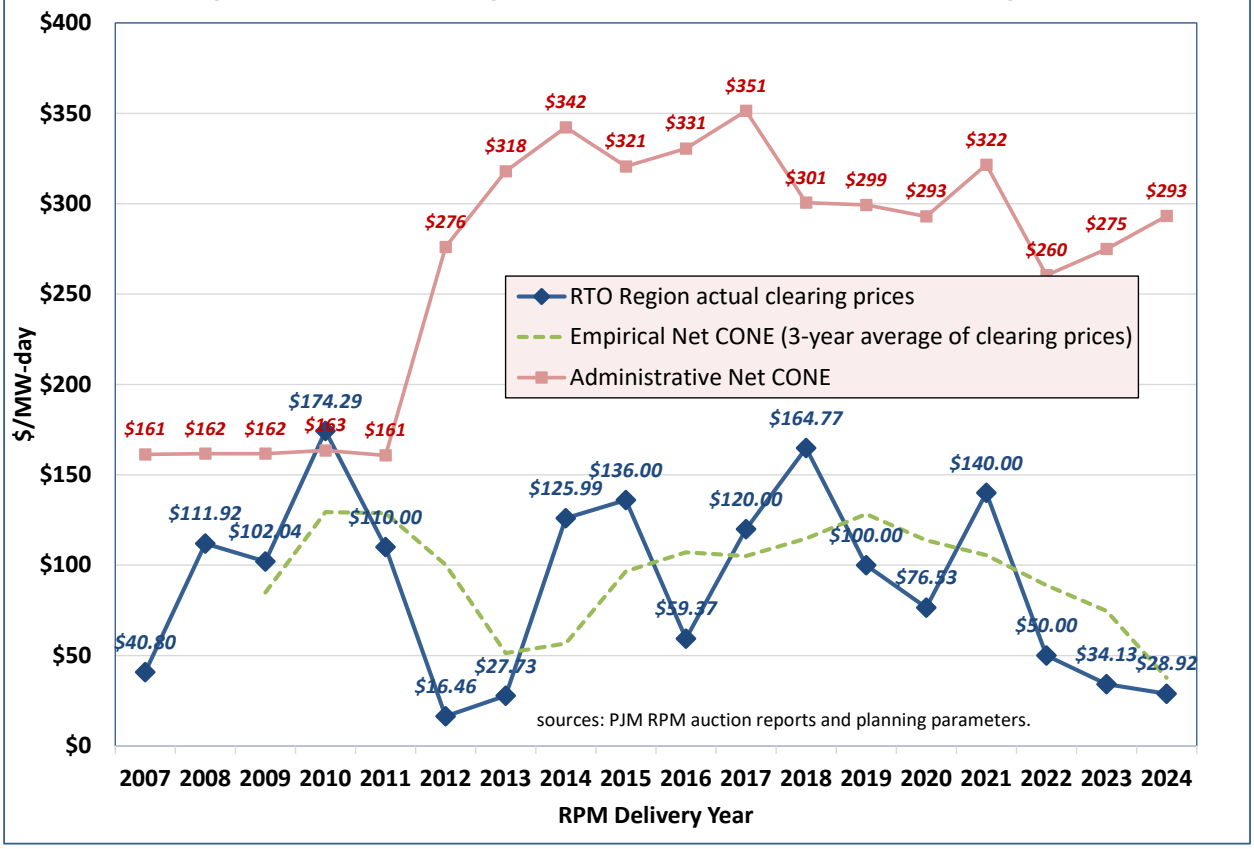
[14] The actual delivery year reserve margins can be somewhat different (usually higher) due to updated load forecasts and adjustments to capacity commitments through additional, "incremental" RPM auctions.

[15] Wilson, James F., *Over-Procurement of Generating Capacity in PJM: Causes and Consequences*, February 2020, prepared for Sierra Club and Natural Resources Defense Council ("Over-Procurement Report"), available here.

margins harm consumers and markets.[16] The over-procurement and excessive reserve margins have continued to the present, with the most recent RPM auction providing a 21.7% reserve margin for the 2024-2025 delivery year, far above the target of 14.7% for adequate reliability.[17]

As noted above, RPM auction reserve margins are linked to RPM capacity prices through the sloped demand curve used in the auctions; high reserve margins go with low capacity prices, and low reserve margins lead to high capacity prices. Figure 3 shows the history of RPM capacity prices for the RTO Region (blue line). Consistent with the high reserve margins shown in Figure 2, capacity prices have generally been rather low, and far below the administrative Net CONE values (shown in red in Figure 3) that are supposed to represent the prices needed to attract new entry.

Figure 3: RPM Clearing Prices and Net CONE Values (RTO Region)



The RPM mechanism has worked to maintain high reserve margins despite various stresses that have arisen from time to time. As an example of the mechanism at work, the PJM Region experienced a wave of retirements in the 2012 to 2015 time frame, largely driven by emissions regulations, when close to 22,000 MW retired.[18] Despite these retirements, PJM reserve margins remained high (as shown in Figure 2), primarily due to the construction of a similar quantity of new gas-fired power plants in the PJM region

[16] Over-Procurement Report, pp. 10-13.

[17] PJM, *2024/2025 RPM Base Residual Auction Results*, available here (stating at p. 2 that the RPM auction result represents a 21.7% reserve margin for the PJM region, compared to the resource adequacy target of 14.7%).

[18] R4 Report p. 6.

at about the same time.[19] The market functioned as intended, encouraging new, more efficient plants to replace older, uneconomic ones.

Figure 3 also shows that following RPM auctions that result in relatively high prices, the auction price has always declined sharply the following year, suggesting that market participants react quickly to RPM price signals (and also to changes in RPM demand, and to changes in energy price expectations), increasing supply to bring prices back to moderate levels. RPM prices for the RTO Region have risen above $130/MW-day four times in the eighteen years shown in Figure 3 (in 2010, 2015, 2018, 2021), and in each instance the price fell by over $60/MW-day the following auction, to an average of $80/MW-day. This dynamic has resulted in capacity prices that have been relatively stable on three-year-average basis, as shown in Figure 3 (green dashed line), and reserve margins that have been well above targets, as shown in Figure 2. RPM has been shown over eighteen years to be quite robust and resilient.

It is worth noting that for RPM to clear near the target reserve margin, the capacity price would have to rise to over $300/MW-day on the sloped demand curve, roughly ten times recent clearing prices.[20] This huge increase in the capacity price would serve as a very strong incentive for relatively more new entry and for delay of retirement plans, despite the reserve margin being near the target.

Figures 2 and 3 show that RPM has consistently cleared very high reserve margins at prices well below Net CONE, including in the most recent auction held in February 2023 for the 2024/2025 delivery year. The causes of over-procurement, discussed in my 2020 report, have only partially been corrected at this time.[21] Thus, it is important to keep in mind going forward that if reserve margins decline toward target levels, raising capacity prices, this will bring the results closer to the desired procurement, which will be beneficial to consumers and the markets. The R4 Report worries that "For the first time in recent history, PJM could face decreasing reserve margins…";[22] if so, this would represent a needed correction rather than present a cause for concern.

Looking forward, there will be more retirements, perhaps even the R4 Report's estimate of 40 Gigawatts ("GW") through 2030,[23] as federal and state policies encourage moving away from high-cost and high-emitting resources. However, PJM's generation interconnection queues reflect a far greater quantity of potential new resources: over 17 GW of natural gas-fired resources, and over 200 GW of renewable and renewable-storage hybrid resources.[24] The changing resource mix in PJM, as in other regions across North America and around the world, will necessitate changes to market mechanisms and planning methods to accommodate the new resources while maintaining reliable operations, as the earlier reports in the

[19] This same observation (that the retirements during this period were matched by new entry) was made by PJM in its October 18, 2022 report in response to questions posed by the Federal Energy Regulatory Commission in FERC Docket No. AD21-10, *Modernizing Wholesale Electricity Market Design*, p. 38.

[20] See, for instance, PJM, *Planning Period Parameters for the 2024-2025 Base Residual Auction*, available here.

[21] Over-Procurement Report pp. 4-10; see also Wilson, James F., *Affidavit in Support of the Comments of the Public Interest Entities*, filed October 21, 2022 in FERC Docket No. ER-22-2984 (RPM Quadrennial Review), pp. 7-15.

[22] R4 Report p. 17.

[23] R4 Report p. 17.

[24] R4 Report p. 2.

Energy Transition in PJM series discussed. The final section of this paper identifies the PJM stakeholder processes that are addressing these challenges.

III. Critique of the R4 Report's "Balance Sheet" Reserve Margin Calculations

In this context of a long history of over-procurement, high reserve margins, and moderate capacity prices, PJM released its R4 Report with "balance sheet" resource adequacy calculations to 2030. Balance sheet calculations are common in the Integrated Resource Plan filings of vertically integrated utilities, where they are typically used to show the amount of additional capacity that the utility, as the sole or central planner of capacity for its service territory, must build or acquire to keep reserve margins at target levels. Balance sheet calculations will typically show the capacity the utility expects to have available over the coming years (reflecting current resources, retirements, and new additions), and its demand for capacity (based on a peak load forecast net of demand-side resources). Comparing the projected available capacity before additions to the projected demand for capacity results in projected reserve margins; Table 1 provides an example. Utilities may also apply the balance sheet method to evaluate scenarios of higher demand or fewer resources in order to identify when capacity additions may be needed. Thus, balance sheet calculations can be a useful communication tool under circumstances where a single entity is responsible for planning the future capacity balance.

Table 1: Example of "Balance Sheet" Reserve Margin Calculations
(Table 8 From Oklahoma Gas & Electric's 2021 Integrated Resource Plan)

Table 8 – Planning Reserve Margin (MW unless noted)

		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Capacity	Owned Capacity	6,702	6,534	6,534	6,323	6,259	5,856	5,856	5,856	5,856	5,371
	Purchase Contracts	47	47	47	47	47	47	47	47	47	16
	Total Capacity	6,749	6,581	6,581	6,370	6,306	5,903	5,903	5,903	5,903	5,386
Demand	Demand Forecast	6,303	6,313	6,379	6,431	6,491	6,543	6,589	6,626	6,630	6,659
	OG&E DSM	278	309	340	372	403	432	456	477	494	505
	Net Demand	6,025	6,004	6,039	6,059	6,088	6,111	6,133	6,149	6,136	6,154
Margin	Reserve Margin[12]	12%	10%	9%	5%	4%	-3%	-4%	-4%	-4%	-13%
Needs	Needed Capacity	0	145	183	417	514	942	967	985	970	1,507

The R4 Report refers to the application of a balance sheet approach in multiple places,[25] however, the balance sheet calculations were not provided, only the reserve margin results (R4 Report Table 1, reproduced here).[26] The reserve margin results were provided for the R4 Report's two new entry scenarios and two load forecast scenarios. Referring to the reserve margin calculations, the R4 Report states (pp. 16-17), "By the 2028/2029 Delivery Year and beyond, at Low New Entry scenario levels, projected reserve margins would be 8%... For the first time in recent history, PJM could face decreasing reserve margins, as shown in Table 1, should these trends – high load growth, increasing rates of generator retirements, and slower entry of new resources – continue."

[25] R4 Report pp. 2, 3, 4, 17.

[26] R4 Report FAQ #2 ("A data annex will not be provided given market-sensitive and licensing issues related to the content of the study.")

The fundamental and fatal flaw in PJM's balance sheet calculations is the simple fact that it ignores how PJM has designed its own wholesale markets, and in particular its RPM capacity market, to work. The projected lower reserve margins cannot occur without causing much higher capacity prices (as explained in the prior section, due to the sloped RPM demand curve). Higher capacity prices lead to slower retirements, faster new entry and higher reserve margins. The R4 Report makes calculations using projections of retirements, new entry, reserve margins and capacity prices that are contradictory in the context of PJM's RPM and other wholesale markets; as a result, the results presented in the R4 Report are not plausible or possible.[27]

Table 2: The R4 Report's Table 1 "Balance Sheet" Results (page 16)

Table 1. Reserve Margin Projections Under Study Scenarios

Reserve Margin	2023	2024	2025	2026	2027	2028	2029	2030
Low New Entry								
2023 Load Forecast	23%	19%	17%	15%	11%	8%	8%	5%
Electrification	22%	18%	16%	13%	10%	7%	6%	3%
High New Entry								
2023 Load Forecast	26%	23%	21%	19%	17%	16%	17%	15%
Electrification	25%	22%	20%	18%	15%	14%	14%	12%

Table 3 provides estimates of the RPM capacity prices that would result from the balance sheet reserve margins presented in Table 1 of the R4 Report shown above.[28] Under PJM's Low New Entry scenario that is projected to lead to an unprecedented[29] 15% reserve margin for the 2026 delivery year, the RPM clearing price would have to rise to approximately $338/MW-day, or ten times the prices in recent auctions. Even under the High New Entry scenario, the projected reserve margins correspond to much higher capacity prices in 2026 and beyond, which would stimulate additional new entry and delay of retirements.

The R4 Report assumed capacity prices would remain at recent low levels[30] even while reserve margins decline due to the fast pace of retirements and slow pace of new entry. These assumptions – a fast pace of retirements, a slow pace of new entry, low reserve margins and low capacity prices – are simply contradictory and ignore the basic market dynamic that ensures resource adequacy in the PJM region.

[27] R4 Report FAQ #22 acknowledges this flaw ("Does this report consider the price-signaling function of the capacity market? This study did not intend to forecast future capacity prices and its retention of existing capacity in the 2025–2030 time period as capacity margins are forecast to tighten.")

[28] The estimated RTO Region capacity prices shown in Table 3 are based on the corresponding reserve margins in the R4 Report's Table 1, the applicable RPM base residual auction demand curve shapes for future years (the shape changes in 2026-2027 as a result of the recent Quadrennial Review) and Net CONE set to $250/MW-day.

[29] The lowest RTO Region reserve margin resulting from an RPM base residual auction was 16.5% in 2010/2011. This was based upon a load forecast that was later substantially lowered, leading to a higher delivery year reserve margin. Since 2012/2013 all base residual auction reserve margins have been 20% or higher, as shown in Figure 1.

[30] R4 Report p. 10.

Lower reserve margins cannot occur without the much higher capacity prices that would lead to delays in retirements and a faster pace of new entry.[31]

Table 3: Capacity Prices Corresponding to The R4 Report's Reserve Margin Projections

$/MW-day	2023	2024	2025	2026	2027	2028	2029	2030
Low New Entry								
2023 Load Forecast	$34.13	$28.92	**$179**	**$338**	**$438**	**$438**	**$438**	**$438**
Electrification	$34.13	$28.92	**$235**	**$438**	**$438**	**$438**	**$438**	**$438**
High New Entry								
2023 Load Forecast	$34.13	$28.92	**$56**	**$64**	**$173**	**$251**	**$173**	**$338**
Electrification	$34.13	$28.92	**$87**	**$118**	**$338**	**$424**	**$424**	**$438**

Note: For 2023 and 2024, RTO Region prices from the applicable RPM base residual auctions are shown; for 2025 to 2030, the capacity prices were estimated based the corresponding reserve margins in the R4 Report's Table 1, the applicable RPM base residual auction demand curve shapes for future years (the shape changes in 2026-2027 as a result of the recent Quadrennial Review) and Net CONE set to $250/MW-day.

The R4 Report's reserve margin scenarios are unrealistic for additional reasons. Market participants are continually assessing all of PJM's markets and the potential need for resources, and planning retirements and new entry accordingly.[32] Whatever the capacity price might be, a decline in the reserve margin would also lead to expectations of relatively less supply and higher prices in forward energy markets, raising expectations for future revenue opportunities and encouraging market participants to retain existing resources and plan new ones.

IV. Critique of the R4 Report's Retirement, New Entry, and Peak Load Projections

While the fundamental flaw in the R4 Report's calculations is the neglect of market dynamics and use of contradictory assumptions, this section of the paper also comments on the details of the retirement, new entry, and load forecast projections. These projections are highly conservative; that is, they reflect a fast pace of retirements, a slow pace of new entry, and increases in peak loads that are highly speculative.

1. The Assumed Fast Pace of Retirements Could Occur Only if Reserve Margins Remain High

The R4 Report estimated annual retirements to 2030 based on a combination of various federal and state policies and also "economics" (estimated profitability based on energy and capacity price assumptions).[33] Much of the older and less efficient capacity on the PJM system retired over the 2012 to 2022 period; a

[31] PJM's own consultant, The Brattle Group, has made this point very clearly on various occasions. See, for instance, *Written Testimony of Dr. Kathleen Spees and Dr. Samuel Newell, Economic Impacts of the Expansive Minimum Offer Price Rule within the PJM Capacity Market,* filed August 20, 2021 in FERC Docket No. ER21-2582, pp. 19-20 Section C.3 ("Capacity Markets with Sloped Demand Curves Cannot Simultaneously Produce Low Prices and Poor Resource Adequacy.")

[32] For a more extensive discussion of the evidence that market participants are reacting to market conditions see, for instance, Wilson, James F., *Affidavit in Support of the Protests of DC-MD-NJ Consumer Coalition, Joint Consumer Advocates, and Clean Energy Advocates*, filed May 7, 2018 in FERC Docket No. ER18-1314, pp. 11-16.

[33] R4 Report pp. 5-10.

total of 47.2 GW, according to the R4 Report.[34] The R4 Report generally assumes the remaining plants considered at risk of retirement will be rather quick to choose retirement, with an additional 40 GW retiring over 2022 to 2030.[35] This is similar to the pace of retirements over the 2012 to 2022 period.

The R4 Report identifies retirement dates as driven by policy, economics, or a combination of policy and economics, with 10 GW in the last category. In the workshop to discuss the report, PJM staff acknowledged that the R4 Report's analysis generally assumed retirements would occur at the earliest dates suggested by policy or economics, while for many of the resources there is some flexibility for the retirements to occur later, especially if reliability is jeopardized.[36] The R4 Report also did not consider that in many instances the owners could keep the capacity in operation through fuel switching or additional environmental investments.

As an example of the R4 Report's conservative assumptions, the R4 Report assumes 4.4 GW of retirements in 2026 associated with the U.S. Environmental Protection Agency's Good Neighbor Plan, which limits emissions of nitrogen oxides from facilities in certain states to protect against harmful ozone pollution in downwind states.[37] Reducing these emissions typically involves the installation of well-established selective catalytic reduction technology. While the Good Neighbor Plan involves emission-trading programs to increase flexibility for the regulated industry, the R4 Report assumed that every electric generating facility that would face costs under the rule would retire. The report noted that EPA would finalize this rule on March 15, 2023; in fact, EPA's analysis accompanying the final rule finds that only 1.4 GW of generation in PJM would retire, on net, as a result of the rule; [38] and PJM acknowledges that the final rule moves the retirement date to 2030.[39] While PJM couldn't know the details of a forthcoming rulemaking, its overly conservative approach of assuming that every unit facing costs under the rule would retire, *and* its failure to timely update its report after publication of EPA's rule, contribute to an overall inaccurate picture of how the PJM generation fleet is likely to change over the coming decade.

The low prices in the last three RPM base residual auctions – $50.00, $34.13, and $28.92/MW-day for the RTO Region – to some extent result from recent substantial increases in energy prices and price expectations;[40] higher energy prices lead to lower needs for capacity revenue. However, the low capacity prices also show that the owners of existing capacity are not in a hurry to retire their resources.

[34] R4 Report p. 6.

[35] R4 Report p. 2.

[36] See, for instance, R4 Report FAQ #11, acknowledging that many of the policies studied in the report have "safety valve" provisions that would enable plants to operate additional years for reliability purposes.

[37] R4 Report page 7.

[38] U.S. Environmental Protection Agency, Resource Adequacy and Reliability Analysis, Technical Support Document (TSD) for the Final Federal Good Neighbor Plan for the 2015 Ozone National Ambient Air Quality Standards at Table. C4 (Mar. 2023), available here (showing 1.9 GW of coal retirements incremental to the base case in 2030, offset by fewer retirements among nuclear and other steam resources).

[39] R4 Report FAQ #12 (acknowledging that the final Good Neighbor Rule "moves the estimated retirement date of 4.400 MW from 2026 to 2030.")

[40] While peak period energy prices in PJM West have averaged well under $50/MWh for many years, forward prices are now over $60/MWh for 2025 through 2028.

Throughout the entire history of RPM we have repeatedly seen owners continue to operate even uneconomic resources, and even when the resources fail to clear in RPM and earn capacity revenue.

In addition to the large amount of capacity willing to accept quite low capacity prices, there has been over 9,000 MW of additional generation that offered but failed to clear in the auction in each of the last eleven RPM base residual auctions, and over 18,000 MW of uncleared generation in four of the last six auctions.[41] Much of this uncleared capacity does not retire. PJM's sensitivity analysis of the results of the most recent auction (for 2024-2025, which cleared at $28.92/MW-day) shows that removing 6,000 MW of low-cost supply from the supply curve for the RTO region would have reduced the total cleared quantity in the auction by less than 900 MW, and it would have raised the clearing price only to $56.26/MW-day; that is, a large amount of the uncleared capacity in the auction was also willing to accept quite low capacity prices.[42] While the pace of retirements may increase and reduce the current capacity overhang, this tendency for many owners to prefer to hold on for additional years if they have the flexibility to do so is unlikely to fundamentally change. Continued operation may entail losses, but once the retirement process is begun it is hard to reverse, and there is always hope that market conditions will improve.

It is also worth noting that with each announced retirement, the owners of other marginally economic plants will update their models to reflect the absence of the retiring plant, which will raise their expectations of energy and capacity prices and profits and make holding on another year more attractive. Developers of new plants will also update their models when a retirement is announced, which may lead them to accelerate their plans. Each announced retirement contributes to other marginal plants possibly holding on longer, and new projects possibly arriving sooner.

In addition, when a large plant retires, it leaves behind a local transmission system capable of delivering generation at that location to loads. New generation at or near the site can take advantage of the existing transmission capacity, which can both speed interconnection and lower its cost. The R4 Report's pessimistic retirement and new entry projections do not recognize this interaction, so this is an additional way the R4 Report's assumptions are both pessimistic and contradictory.

Note also that to the extent retirements are driven by state or federal policies, these policies are typically in place years in advance of the specified deadlines, so the market has plenty of time to anticipate the reduction in capacity and to plan replacements. This dynamic was seen in the wave of retirements over 2012-2015 that was matched with new entry and did not lead to declining reserve margins, as noted above. The EPA Good Neighbor policy and the Illinois Climate and Equitable Jobs Act contain 2030 deadlines, allowing plenty of time for the market to anticipate the reductions and plan replacements.

So while perhaps the rapid pace of retirements reflected in the R4 Report's retirement scenario could happen, the rapid pace would only occur in an environment of low capacity prices. But capacity prices can remain low only if reserve margins remain high, due to some combination of slow load growth and ample new entry. Accordingly, the R4 Report's retirements scenario either won't occur, or will occur with adequate reserve margins, contrary to the R4 Report's Table 1.

[41] PJM, 2024-*2025 RPM Base Residual Auction Report*, Table 6, available here.

[42] PJM, *Scenario Analysis for Base Residual Auction*, Scenario # 4 (remove 6,000 MW of supply from bottom of supply curve in region outside of MAAC), available here.

2. The Assumed Slow Pace of New Entry Could Occur Only if Reserve Margins Remain High

The R4 Report notes the enormous amount of capacity currently in PJM's interconnection queues – 290 GW – but estimated that only a tiny fraction of this capacity will actually be built, applying "commercial probabilities" of projects coming into service based on historical data.[43] Renewable capacity was further adjusted to reflect its resource adequacy value.[44] While there is presently 270 GW of renewable capacity in the queue, this was reduced to 13.2 GW of new capacity by 2030, and only 6.7 GW in capacity value terms.[45] Of the 17.6 GW of natural gas projects in the queue, of which 12 GW already have signed Interconnection Service Agreements, the R4 Report assumed only 3.8 GW would be built.[46] The R4 Report states that these pessimistic assumptions were "augmented" based on scenarios from S&P Global's North American Power Outlook, and additional capacity was added, however, no details were provided about how the assumed total quantity of new entry was determined.[47] It is unclear to what extent the Low and High New Entry Scenarios presented in the R4 Report reflect the low historical commercial probabilities of renewable resources or take into account the improving economics of such resources.[48]

The low historical commercial probabilities are based on a period of chronic over-forecasting of load, chronic high reserve margins, and low need for new entry. In the past, developers added projects to the interconnection queue only to see the need for the capacity evaporate as the load forecast was lowered and RPM cleared very high reserve margins. The R4 Report also assumed Demand Response (capacity provided by demand-side resources) would remain at current levels, despite its projection of declining reserve margins.[49] Were reserve margins to decline at all, the rate of project completions would very likely rise considerably, and additional demand response would develop. PJM's assumed very low rate of completion of renewable resources in the queue, especially under its Low New Entry scenario, also ignores the strong incentives put in place last year with the Inflation Reduction Act.[50]

[43] R4 Report pp. 11-12.

[44] Effective Load Carrying Capacity ("ELCC") fractions were applied, to reflect the likely contributions of resources to resource adequacy at times of system stress. The R4 Report used readily available capacity accreditation values from recent PJM reports, which are based on an average approach rather than the marginal approach PJM has proposed in the stakeholder process. However, this choice has little or no impact on the R4 Report's calculations, because reliability requirements are calculated based on actual plant performance, they do not use accreditation values. If accreditation values decline (as they typically do for some resources under a marginal approach compared to an average approach) the reliability requirement to satisfy a resource adequacy criterion, expressed in terms of the new accreditation approach, declines in a corresponding manner.

[45] R4 Report pp. 11-13.

[46] R4 Report p. 11.

[47] R4 Report p. 11.

[48] R4 Report FAQ #20 asked "How were the New Entry Scenarios Created"; the response referred to "a blend of the commercial probability analysis and the S&P Global Forecast," without providing further details.

[49] R4 Report FAQ #25.

[50] The Inflation Reduction Act provides long-term certainty for the Investment Tax Credit and Production Tax Credit, bonuses for locating in "energy communities" where coal-fired plants have retired, and many other new policies to encourage clean resources and energy storage.

A "High New Entry" scenario was also constructed,[51] based upon S&P Global's North American Power Outlook, Fast Transition sensitivity case.[52] Details of the Fast Transition scenario were also not provided and are not publicly available. However, a public Executive Summary shows that the focus was on 2050, with very little of the "fast transition" occurring by 2030, the end date of the period represented in the R4 Report.[53]

It is unclear to what extent PJM's projections under the High New Entry case account for state policies that aim to support development of new clean energy resources through renewable portfolio standards, procurement targets, and policies to support development of the transmission needed to bring these resources online. The R4 Report states that the S&P Global Fast Transition case "assumes carbon net neutrality by 2050 through the IRA and additional policies, such as state clean energy policies."[54] The reliance on a proprietary, nontransparent model to account for state clean energy policies is not reassuring that the contributions of those policies has been reflected. As a result, PJM comprehensively examined how state policies could affect retirements, but considered how federal and state policies could affect new entry to a lesser extent, thus creating a skewed analysis and perception of the overall impacts of policy action.

As with the R4 Report's retirements assumptions, while perhaps the rather slow pace of new entry reflected in the R4 Report's scenarios could happen, this could only happen in an environment of low capacity prices. But capacity prices can remain low only if reserve margins remain high, due to some combination of slow load growth and delayed retirements. Accordingly, these new entry scenarios either won't occur, or will occur with adequate reserve margins, contrary to the R4 Report's Table 1.

3. The Forecast of Rapidly Rising Peak Loads is Highly Speculative

The R4 Report used two RTO peak load forecasts that both suggest sharply rising peak loads; one from PJM's 2023 load forecast report ("2023 Forecast"), and another, much higher forecast to reflect faster electrification and additional data center loads.[55]

The PJM 2023 Forecast projects that RTO region summer peak loads will rise from recent levels under 150,000 MW to nearly 158,000 MW by 2030 (Figure 4). However, since 2008 through 2022, RTO peak loads have actually been trending downward or flat, as shown in Figure 4.[56]

[51] R4 Report p. 12.

[52] S&P Global, North American Power Outlook Fast Transition sensitivity case, Executive Summary available here.

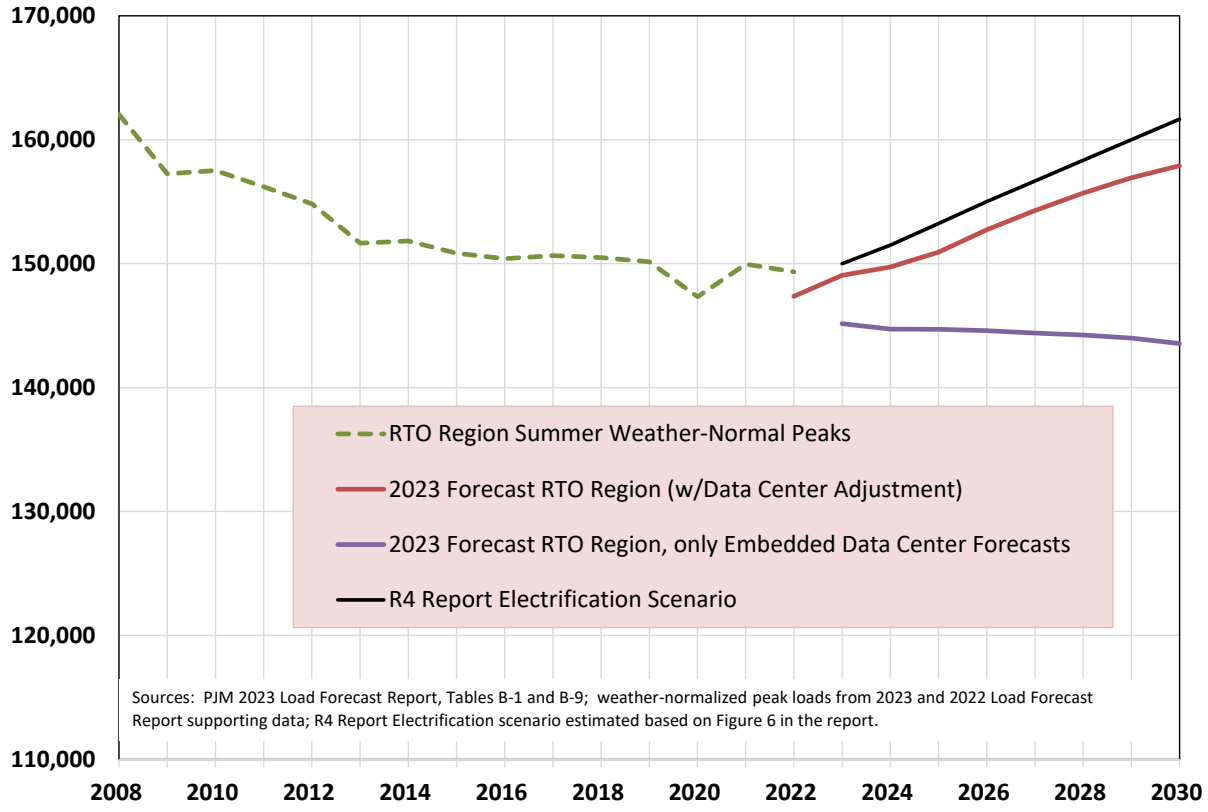
[53] S&P Global, North American Power Outlook Fast Transition sensitivity case, Executive Summary, page 5 (showing the U.S. generation mix to 2050, with the vast majority of the change occurring after 2030).

[54] R4 Report p. 12 footnote 20.

[55] R4 Report pp. 14-15.

[56] The figure shows historical peak loads on a "weather-normalized" basis: PJM's estimates of what the peak load would have been under typical peak day weather. This removes the impact of the actual weather in each year, which may have been hotter or less hot than the typical weather on the peak day, and reveals the underlying trend in the peak loads.

Figure 4: PJM's RTO Region Summer Peak Load Forecasts (MW)



Over many years, PJM has consistently (and incorrectly) forecasted that peak loads would rise.[57] PJM has recently made changes to its forecasting methodology that should improve accuracy, and recent forecasts (before the 2023 Forecast) have been flatter and more consistent with the recent trend. The PJM 2023 Forecast only increases due to the inclusion of a highly speculative projection of future data center construction.[58] While data center load i n PJM was under 4,000 MW in 2022, PJM's 2023 forecast assumes it grows to over 25,000 MW in 2038.[59] Beyond about 2027 or 2028, this forecast of data center construction, which is provided to PJM by Dominion Energy and other utilities,[60] is speculative and not supported by contractual commitments. In the past PJM was unwilling to include in its forecasts

[57] For a "rooster graph" of PJM's past load forecasts see Wilson, James F., *Affidavit in Support of the Comments of the Public Interest Entities*, filed October 21, 2022 in FERC Docket No. ER22-2984 (RPM Quadrennial Review), p. 13, available here.

[58] R4 Report pp. 14-15.

[59] PJM, *2023 Load Forecast Supplement*, available here, pp. 18-20.

[60] PJM, *2023 Load Forecast Supplement*, p. 20 (noting that this year, PJM requested of Dominion a long-term data center forecast).

speculative future data center construction beyond five years out;[61] PJM now accepts such speculation and relies on it as the basis for its forecast of rising rather than falling peak loads.

The lower, purple forecast line in Figure 4 shows PJM's forecast before the addition of the speculative data center amounts. This is PJM's forecast based on its load forecasting methodology and model, which includes a projection of future increases in data centers loads based on the historical trend in these loads.[62] With only such "embedded" data center growth, PJM's forecast continues to decline, consistent with the 15-year trend, although the decline is at a slow rate.

The R4 Report's balance sheet calculations also evaluate an even more speculative load forecast scenario that includes very aggressive assumptions about the peak load impacts of electrification, and may include yet more speculative data center loads (the highest, black line in Figure 4). The R4 Report confusingly describes this scenario as reflecting "updated electrification assumptions and accounting for new data center loads," even though the 2023 Forecast, documented in the 2023 load forecast report (the red line in Figure 4), already includes a very large upward adjustment for data center construction, as discussed above.

The electrification and additional data center assumptions reflected in this additional, extreme load scenario were never discussed with the PJM Load Analysis Subcommittee.[63] Furthermore, even if electrification moves rapidly forward in the PJM Region, state and federal policies, and PJM's market rules, will likely be modified to ensure that the impact on peak loads and capacity prices is mitigated by time-of-use pricing and other provisions to shift loads away from summer and winter peak hours.[64]

The current boom in data center construction is likely to continue for at least the next few years, however, it is uncertain how long this boom will continue, and to what extent new data centers will be located in the PJM footprint rather than elsewhere. In any case, PJM's data center scenarios, while highly

[61] See, for instance, PJM, *Dominion Data Center Adjustment for the 2018 Load Forecast Report*, p. 2 ("Projections are not available after 2022, so the assumption was made to keep data center load flat in the out year.") This file has been removed from the PJM web site.

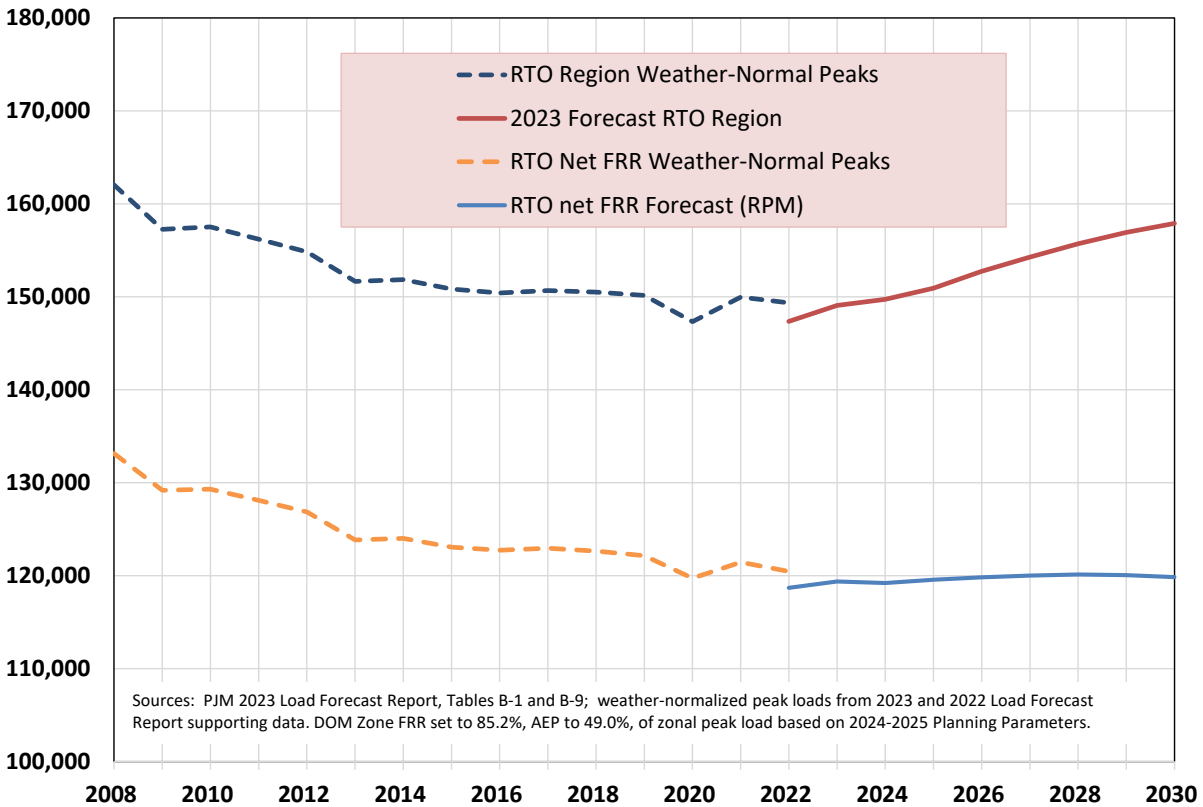
[62] PJM, PJM Load Forecast January 2023, Tables B-1 and B-9.

[63] See, for instance, PJM, *2023 Preliminary PJM Load Forecast*, Load Analysis Subcommittee, November 29, 2022, p. 22 (showing a very small addition for EVs), p. 29 (mentioning "electrification" at the end of the presentation as an "Area of Focus" in 2023.

[64] For example, Illinois CEJA contains numerous requirements to address peak demand, such as requiring the Illinois Commerce Commission to establish a performance metric for peak load reductions attributable to demand response programs, 220 ILCS 5/16-108.18(e)(2)(A)(ii), and requiring utilities to develop beneficial electrification plans that include efforts to reduce increases to peak demand, 220 ILCS 627/45(a). The Virginia State Corporation Commission has required Dominion and APCo to file transportation electrification plans that include assessments of the impact of transportation electrification on peak loads, and evaluate the need for managed charging and time of use tariffs to maximize grid benefits. Commonwealth of Virginia, ex rel. State Corporation Commission Case No. PUR-2020-00051, Ex Parte: Electrification of Motor Vehicles, Order Directing the Filing of Transportation Electrification Plans (June 15, 2022). The New Jersey Board of Public Utilities has proposed to limit incentives for medium and heavy-duty vehicle charging facilities to entities that "agree to participate in a managed charging program that directs most charging to off-peak periods." Notice in the Matter of Medium and Heavy Duty Electric Vehicle Charging Ecosystem, available here. In addition to these recent efforts by states to limit peak demand growth, there are many examples of retail rate designs to incentivize off-peak charging of electric vehicles. See, for instance, Baltimore Gas & Electric, EVsmart® Vehicle Charging Time of Use Rate, available here; PEPCO's Residential Time-of-Use Rate, available here.

speculative, are also largely irrelevant to PJM's resource adequacy analysis and RPM capacity market. The vast majority of the projected data center load is in the Dominion zone, where nearly all capacity is planned under a Fixed Resource Requirement ("FRR") plan outside of RPM by Dominion Virginia Power, a vertically-integrated utility.[65] Thus, whether or not data center loads will continue to increase in Virginia may be a concern for Dominion Virginia Power for its upcoming 2023 Integrated Resource Plan, and for Dominion's stakeholders and the Virginia Corporation Commission, such growth will have little affect on RPM requirements or clearing prices. Figure 5 shows an estimate of the RTO Region 2023 load forecast that PJM will use for future RPM auctions, where the FRR amounts in the Dominion Zone (about 85% of the zonal peak load), and the AEP Zone (wheere FRR is about 49%) have been removed.

Figure 5: RTO Region Summer Peak Load for RPM (Net DOM, AEP FRR; MW)



It is also the case that data centers require a high level of reliability, which they self-provide with on-site backup generation; they do not solely rely on the grid for reliability. The data centers may not be eligible to monetize their backup capacity as Demand Response capacity in RPM or through the Dominion FRR plan due to environmental regulations, capacity market rules, or other barriers. However, the owners

[65] See, for instance, PJM, *2024/2025 RPM* Base *Residual Auction Planning Period Parameters,* p. 1 footnote 2: "The total UCAP Obligation of all Fixed Resource Requirement (FRR) Entities is subtracted from the PJM RTO Reliability Requirement, and any applicable LDA Reliability Requirement, when determining the target reserve levels to be procured in each RPM BRA"; and the associated excel file, showing that nearly all of the Dominion zone load is FRR; these files available here.

would generally be willing to run their backup generators to prevent load shed if asked by PJM to do so, and if legally permitted to do so.

V. Why It's Important to Realistically Assess Resource Adequacy Risk

As noted in the opening paragraph of this paper, PJM has issued two earlier reports in preparation for the transition to cleaner forms of energy in the PJM Region, and is working collaboratively with stakeholders and state and federal authorities on its Energy Transition in PJM effort. The R4 Report can be understood to suggest that federal and state policies encouraging the closure and replacement of uneconomic and high-emitting power plants are creating a reliability problem. While PJM asserts that the intent of the R4 Report was to "inform discussions,"[66] the R4 Report's false alarm around future reserve margins is potentially a setback on the road to preparing for the transition in the resource mix.

This paper has shown that the existing PJM market mechanisms are robust, so retirements and new entry are likely to occur at paces consistent with resource adequacy. While there are many actions on the To Do list for future years, actions to encourage further operation of uneconomic power plants should not be one of them. To maintain resource adequacy and reliability, the priorities have been and should remain as indicated in PJM's two earlier Energy Transition reports and in various current PJM stakeholder processes:

- To get the generation interconnection queues moving again to allow new generation projects to move forward in a timely manner (PJM Interconnection Process Subcommittee).[67]
- To enhance winter risk analysis and bolster winter resource adequacy, including lessons learned from Winter Storm Elliott. This involves ensuring that resource accreditation reflects extreme conditions and correlated and upstream causes of outages, strengthening the incentives for winterization and fuel security, and enhancing the capacity market rules to procure a portfolio of resources that provides adequate winter resource adequacy (Critical Issue Fast Path process, Resource Adequacy Senior Task Force).
- To address various other resource adequacy and RPM capacity market issues, to ensure that resource economics, and therefore retirement and new entry decision-making, are based on an accurate assessment of the reliability value of all resources and system needs. This includes resource accreditation, resource performance incentives, market power mitigation rules, possible market rules for forward procurement of clean resource attributes, and other enhancements to the capacity market (Critical Issue Fast Path process, Resource Adequacy Senior Task Force, Clean Attribute Procurement Senior Task Force).
- To identify the need for resource attributes such as operating flexibility to operate the system reliably with a high penetration of renewable resources, and define products and market rules to

[66] R4 Report FAQ #15 ("… The intent of the study was to provide a simple analysis that compared potential exits, entry and demand requirements to inform discussions..."). PJM's rather untransparent analysis underpinning the R4 Report can be contrasted to a state IRP process, under which stakeholders would have access through discovery to all underlying data, including proprietary information, and opportunities for cross-examination of utility witnesses; or to a FERC process such as the RPM Quadrennial Review, where the utility's filing is supported by testimony, intervenors also submit testimony, and FERC staff may issue deficiency notices to gain additional information; or even to PJM's usual process of presenting its analysis to stakeholders for their review and feedback before finalization, which was not done here.

[67] The issue charges, schedules, and meeting materials for all PJM stakeholder processes can be found here.

procure them (Operating Committee, Regulation Market Design Senior Task Force, Distributed Energy and Inverter Based Resource Subcommittee, among other stakeholder groups)[68]

- To move toward more proactive approaches to regional and inter-regional transmission planning that anticipate future needs and ensure the grid expands in a timely and efficient manner (Planning Committee, Interconnection Process Subcommittee, Transmission Expansion Advisory Committee).

While there are challenges associated with the transition in the resource mix, there are also viable solutions that PJM and stakeholders are already at work developing. And while this work continues, the PJM markets will continue to send price signals that coordinate the pace of retirements and new entry.

[68] A quite thorough list of the PJM stakeholder processes engaged with the transition in the resource mix and the need for enhancements to energy and ancillary services markets is found in PJM's October 18, 2022 report in response to questions posed by the Federal Energy Regulatory Commission in FERC docket no. AD21-10, *Modernizing Wholesale Electricity Market Design*, pp. 15-18.

About the Author

James F. Wilson is an economist and independent consultant doing business as Wilson Energy Economics. He has forty years of consulting experience in the electric power and natural gas industries. Many of his past assignments have focused on the economic and policy issues arising from the introduction of competition into these industries, including restructuring policies, market design, market analysis and market power. Mr. Wilson has been involved in electricity restructuring and wholesale market design for over twenty years in PJM, New England, Ontario, California, MISO, New York, Russia, and other regions. He has a B.A. from Oberlin College and M.S. in Engineering-Economic Systems from Stanford University.

With regard to resource adequacy planning and capacity market design, Mr. Wilson has been involved in these issues in PJM, New England, California, the Midwest, and other regions. With respect to PJM's RPM capacity construct, he has prepared numerous affidavits, reports, and analyses of RPM and RPM-related issues. He has also been involved in the stakeholder processes around PJM load forecasting and capacity requirements studies for many years. Additional information and Mr. Wilson's CV are available at www.wilsonenec.com.