Monitoring Analytics, LLC
2621 Van Buren Avenue, Suite 160
Valley Forge Corporate Center
Eagleville, PA 19403
Phone: 610-271-8050
Fax: 610-271-8057

Monitoring Analytics

DATE: **August 16, 2023**

TO: **RASTF/CIFP/PJM Board of Managers**

FROM: **IMM**

SUBJECT: **Executive Summary of IMM Capacity market design proposal: Sustainable Capacity Market (SCM)**

No proposal to change the capacity market design can solve all the issues in the capacity market or all the issues that affect the operation of the capacity market. The SCM proposal is designed to address several key issues in the capacity market design in an incremental approach, building on the basic RPM design. For example, the SCM proposal explicitly leaves the treatment of DR and EE as status quo.[1]

Key Elements of SCM Proposal for Capacity Market Design

The SCM proposal for capacity market design is intended to replace the current Capacity Performance (CP) design and its associated PAI and penalty structure, and to replace the ELCC basis for defining the capacity of individual units. The SCM approach focuses on the actual availability of resources to provide energy when defining reliability and when defining compensation and when defining incentives. The SCM provides strong, consistent, repeated, and predictable incentives for performance.

The basic elements of the SCM design are:

1. Capacity offered in the forward capacity market, ACAP (available capacity), is (ICAP * MEAF), where MEAF is the modified equivalent availability factor.
2. Capacity market prices are single annual clearing prices by constrained LDAs determined per existing market rules defining LDA constraints.
3. Capacity market clearing process uses the expected hourly availability (HACAP) that in aggregate results in the annual MEAF.
4. Capacity is paid in the delivery year only when available to produce energy, by hour.
5. Capacity resources are subject to biannual testing on a schedule determined by PJM that would include the results of economic operations.
6. Capacity resources that fail to start when called by PJM, or fail a PJM test, will not receive hourly capacity payments from the time of the last successful start to the next successful start.

[1] The more complete explanation of the IMM proposal is presented in a memo forthcoming on August 18, 2023. <www.monitoringanalytics.com> The current version of that memo is dated June 13, 2023, with the subject line "Capacity market design proposal: Sustainable Capacity Market (SCM)."

7. Must offer requirement in the capacity market applies to all existing capacity resources, except demand resources.[2]
8. Must offer requirement in the energy market means that all committed capacity resources must offer all capacity at committed ICAP/CIR MW in a combination of the energy, ancillary services and reserve markets, consistent with availability.
9. Market seller offer cap (MSOC) remains equal to net ACR using the existing definition of ACR and its components. The definition of a competitive offer is the marginal cost of capacity, net ACR, where ACR includes an explicit accounting for the costs of mitigating risk, including the risk associated with capacity market nonperformance, and the relevant avoidable costs of acquiring fuel, including natural gas. CPQR is part of gross ACR and is subject to offset by net revenues from the energy and ancillary services markets.

SCM Proposal Overview

The SCM proposal for the capacity market is a return to basics. The only purpose of the capacity market is to make the energy market work. That means three specific things. The capacity market needs to define the total MWh of energy that are needed to reliably serve load, calculated as the hourly peak loads plus a reserve margin. This is the reliability analysis, which needs to be hourly and to incorporate generation and transmission availability and outages on a realistic basis (recognizing observed availability and correlations among outages). The capacity market needs to provide the missing money. The capacity market needs to allow all capacity resources the opportunity to cover their annual net avoidable costs to ensure the economic sustainability of the reliable energy market. The capacity market is essential for retail competition as defined by each PJM state because it provides flexible access to capacity for retail suppliers of all sizes.

Capacity does not provide reliability. A supply of available energy greater than demand provides reliability. Capacity is not more valuable on some days or in some hours than others. The PJM capacity market design has paid all capacity resources exactly the same price per MW of UCAP in every hour since its inception in 2007. Energy is more valuable on some days and in some hours and that value equals the LMP in those hours resulting from the operation of the energy market and the ancillary services markets plus the price in the reserve markets.

Capacity is not a thing. Capacity does not power light bulbs or refrigerators or air conditioners. The only real product provided in wholesale power markets is energy. Capacity is a concept designed to make the energy market work. The concept of capacity is needed in the overall market design, given the requirement that the system must include a reserve margin and therefore that the energy market will almost always be long and therefore that revenues from the energy market will not support a self sustaining overall market design.

[2] Demand resources includes EE and PRD resources.

The MW capacity value of a resource requires that the resource produce energy equal to its ICAP whenever it can, in the case of an intermittent resource, and whenever it is called on by PJM, in the case of a thermal resource. The obligation of a capacity resource, whether intermittent or thermal, is to be available to provide as much energy as possible and to operate when called on. That is the essential link between the energy and capacity markets.

The metric for whether a capacity resource is meeting its obligation is its availability to generate energy. The reasons for the lack of availability do not matter. A capacity resource is either available to generate energy or it is not. Regardless of the reasons, capacity resources would not be paid when they are not available. This is not a penalty. This is payment for performance. No one expects solar resources to be available in the middle of the night. Under the SCM, solar resources do not have a performance obligation in the middle of the night and solar resources will not be paid for capacity in the middle of the night.

Availability

Average Availability in the Forward Capacity Market Auctions

Offers in the forward capacity market auctions would be based on availability. This new, inclusive definition of average annual availability is termed the modified equivalent availability factor (MEAF). The MEAF includes derates for all reasons, including for example forced outages, maintenance outages, planned outages, ambient derates, lack of solar radiance and lack of wind. The historical MEAF for intermittent resources and for thermal resources incorporates all reasons for nonavailability including ambient conditions and outages of all types. If a unit is unavailable, it is unavailable.

The analog of UCAP in the SCM design is available capacity (ACAP). The average hourly ACAP that a resource can sell in the forward capacity market equals (MEAF * ICAP).

Offer prices will be the marginal cost of capacity, net ACR, subject to the existing rules on the MSOC, including the current definition of CPQR. Offer prices will be on a dollar per MW of ACAP basis consistent with expected HACAP MW for each hour in the delivery year, where ACAP is ICAP * MEAF.

Hourly Availability in the Forward Capacity Market Auctions

While annual availability is a key metric for defining offer prices, even a correctly defined annual availability metric does not address hourly availability or comparability among resources. For example, a solar resource that is 45 percent available will never be available in the middle of the night while a thermal resource could be available in any hour of the year, subject to outages and fuel availability and derates.

The solution is to clear the annual capacity market, accounting for the expected availability of resources on an hourly basis. The hourly availability of capacity to produce energy is HACAP

MW (hourly available capacity MW). Accounting for expected hourly availability is required in order to address the first purpose of the capacity market which is to procure enough capacity to ensure that energy will be available to reliably serve load in every hour. The purpose of accounting for hourly availability is not to set an hourly price for capacity but to ensure that the system will be reliable in every hour based on expected demand and expected availability of resources to provide energy to reliably meet the demand. The capacity product is still an annual product, but both demand and supply vary by hour.

Accounting for hourly availability on a locational and resource specific basis more accurately defines availability than offering capacity based on derating by a simple class average, non-locational availability factor.

The defined market clearing process results in a single annual clearing price for each constrained LDA based on the marginal resources and using the existing CETO/CETL rules.

Hourly Availability in the Delivery Year

The current capacity market design pays capacity resources the same hourly capacity price every hour of the year, regardless of availability. That design does not provide appropriate incentives to be available.

Rather than penalizing capacity resources for nonperformance at extreme and arbitrary penalty values only during emergencies (defined PAI events), capacity resources should be paid the hourly price of capacity only to the extent that they are available during the operating day to produce energy or provide reserves, as required by PJM on an hourly basis, up to the full ICAP value of their cleared capacity. This is a positive performance incentive based on the market price of capacity rather than a penalty based on an arbitrary assumption. This would mean that capacity resources are paid to provide energy and reserves based on their full ICAP and are not paid a bonus for doing so.

This positive incentive approach would also end the need for complex CPQR calculations based on an unsupported penalty rate and assumptions about the number and timing of PAI.

Under SCM, in addition to paying resources only when they are available, resources that do not start when called by PJM will have to return all hourly capacity payments back to the last time the resource started or was successfully tested and until the next time the unit successfully starts. All successful starts that lead to output at full ICAP count as starts, regardless of whether the units are self scheduled or called by PJM. This provides an incentive for units to manage this risk by starting periodically which results in a higher probability of starting when needed by PJM. This is a strong incentive that puts the risk within the control of generators to manage.

In the delivery year, resources are paid for capacity on an hourly basis if they are available and not paid for capacity if they are not available. The settlement is hourly and based on hourly

available MW multiplied by the annual capacity market clearing price ($/MW-year in ACAP terms) divided by 8,760 (the number of hours in a year).

In the delivery year, a resource will receive at least its annual net ACR if it performs consistent with its expected annual availability. If a resource is more available than expected, it will receive more than its net ACR and if a resource is less available than expected, it will receive less than its net ACR.

Market Clearing

Significant parts of the basic capacity market clearing process would remain unchanged. As in the current design, the capacity market will clear three years in advance of the delivery year. As a result, and as in the current design, the inputs to the auction are informed estimates. Resources offer capacity based on the net ACR divided by their ACAP. The market clearing process does not use the MEAF to define the expected hourly availability of resources. The market clearing process uses the expected hourly availability (HACAP) that in aggregate results in the annual MEAF. PJM will continue to optimize the distribution of planned outages and maintenance outages. Forced outages will be assigned based on history. The use of historical performance data will incorporate the correlations between temperature and outages and therefore capture correlated outages. The availability of intermittent resources will also be based on history.

The historical availability of intermittent resources is the basis for the expected hourly distribution of availability in the forward capacity market clearing process. Use of multiple years of history for thermal and intermittent resources results in a distribution of availability linked to the distribution of temperature/weather data. Use of Monte Carlo simulation methods incorporating historical experience will result in defined hours of unserved energy. The ex ante demand for capacity will be defined to be the capacity that limits the hours of unserved energy to the target value.

The demand for capacity in each hour is a function of PJM load forecasts plus the reserve margin necessary to meet the target level of reliability. The model can work with any metric for reliability, including expected unserved energy (EUE) or the loss of load expectation (LOLE) or loss of load hours (LOLH). EUE is a preferred reliability metric because it is explicitly an hourly metric.

The market clearing is an optimization with the objective function of minimizing the costs of meeting the hourly demand for the entire delivery year.

The SCM design recognizes that the initial clearing of the market is one step to a final clearing of the market that helps ensure that the capacity market results produce reliable outcomes. The hourly availability of resources in the initial market clearing is the expected value of

availability, based on history. But achieving that target level of reliability (EUE) results from simulating a range of availabilities based on historical data from multiple years and the inclusion of all resources expected to be available during the delivery year. Under the SCM design, after the initial market clearing, the simulations are run again, using only the cleared resources from the initial market clearing. If the resultant EUE is in excess of the target, additional capacity is purchased from the offered supply curve until the target EUE is reached. The second step is essential to validate that the market clearing will meet the target reliability. This step is a key part of risk modeling.

The highest cost resource required to meet the demand in any hour will set the annual clearing price. All cleared resources will receive the annual clearing price on a dollar per MW of ACAP basis, if the resources perform consistent with their expected availability. Actual revenues are determined by actual availability in the delivery year. Customers will pay the total actual cost of capacity, reflecting the annual clearing price and the hourly availability of each resource, with locational accuracy.

The clearing process will result in locational prices as a function of locational supply and demand fundamentals, including the existing approach to CETO/CETL values. Under the proposed approach, the CETO/CETL and local demand will explicitly and correctly recognize the resources that offer into the auction and their locational characteristics, including expected locational availability. The clearing process works with the existing definitions of LDAs.

Testing

Stronger requirements for testing are part of an effective and efficient solution to the incentive issue. The SCM approach includes testing at least twice per year, once in cold weather and once in hot weather, without advance warning and with the timing and conditions of the test at PJM's sole discretion. The testing should be designed to replicate the conditions under which PJM would call these resources. The testing would respect all the parameters of the tested resources. Testing could include the results of economic operations. The current testing program is ineffective and fails to actually test the ability of units to start when called on unexpectedly.

Firm Fuel Requirement

Given the range of fuel procurement options, it is not possible to define or require specific fuel procurement arrangements. There are transportation issues with all fuel types, particularly in extreme weather. For example, multiple gas pipelines can have delivery issues, regardless of the firmness of the tariff service, commodity gas may be unavailable regardless of the contract, and onsite fuel can freeze.

The actual historical performance of units under defined temperature/weather conditions is the primary source of data about units' availability which is in part a function of fuel supply arrangements.

The exact specification of fuel supply characteristics cannot be solved by changes to the capacity market. The issues related to the definition of firm gas transportation and commodity gas need separate attention, regardless of the capacity market design. The gas/electric coordination issues cannot be solved by changes to the capacity market.

Must Offer Requirement in the Capacity Market

All existing generation capacity resources have a must offer requirement, including thermal, intermittent, and storage resources.

Prior to the implementation of the capacity performance design, all existing capacity resources, except DR and EE, were subject to the must offer requirement. There is no reason to exempt intermittent and capacity storage resources, including hydro, from the must offer requirement. The same rules should apply to all capacity resources. The purpose of the must offer rule, which has been in place since the beginning of the capacity market in 1999, is to ensure that the capacity market works based on the inclusion of all demand and all supply, and to prevent the exercise of market power via withholding of supply. The purpose of the must offer requirement is also to ensure equal access to the transmission system through CIRs (capacity interconnection rights). If a resource has CIRs but fails to use them by not offering in the capacity market, the resource is withholding and is also denying the opportunity to offer to other resources that would use the CIRs. For these reasons, existing resources are required to return CIRs to the market within one year after retirement. The same logic should be applied to intermittent and storage resources. The failure to apply the must offer requirement will create increasingly significant market design issues and market power issues in the capacity market as the level of capacity from intermittent and storage resources increases. The failure to apply the must offer requirement consistently could also result in very significant changes in supply from auction to auction which would create price volatility and uncertainty in the capacity market and put PJM's reliability margin at risk. The capacity market was designed on the basis of a must buy requirement for load and a corresponding must offer requirement for capacity resources. The capacity market can work only if both are enforced.

It is not clear why intermittents and storage were exempted to date, but as the role of intermittents and storage grows it is essential to reestablish the must offer obligation for all resources. The capacity market has included balanced must buy and must sell obligations from its inception.

Must Offer Requirement in the Energy, Ancillary Services and Reserve Markets

All committed generation capacity resources have a must offer requirement in the energy, ancillary services and reserve markets equal to committed ICAP, subject to availability for intermittent resources. This is the essential link between the energy market and the capacity market. There is no reason to have a capacity market without this requirement.

The obligations of committed generation capacity resources currently include the requirement to offer their full available ICAP in the day-ahead energy market every hour of every day and to produce as much energy as they are capable of producing when economic or are dispatched by PJM. As defined in a stakeholder process, the energy market must offer obligation for intermittent resources would be based on the mean of each unit's forecast output by hour.[3] The need for the energy from capacity is not limited to one peak hour or five peak hours. Customers require energy from capacity resources all 8,760 hours per year.

MSOC

The definition of a competitive offer is the marginal cost of capacity, net ACR, where ACR includes an explicit accounting for the costs of mitigating risk, including the risk associated with capacity market nonperformance, and the relevant avoidable costs of acquiring fuel, including natural gas. CPQR is part of gross ACR and is subject to offset by net revenues from the energy and ancillary services markets. No change to the definition of CPQR is needed. PJM's proposal that CPQR not be offset by net energy and ancillary service revenues is inconsistent with the basic PJM capacity market design. CPQR is a cost like any other and can be covered by energy and ancillary services revenues.

The experience of Winter Storm Elliott and the associated penalties changed the calculation of the CPQR risk mitigation component of the ACR offer caps. Incorporating the Elliott data in the history used to calculate an appropriate CPQR led to very large CPQR values for some poorly performing resources. Correctly calculated maximum CPQR values increased from less than $10 per MW-day to about $50 per MW-day while some participants proposed CPQR values in excess of $100 per MW-day. This impact illustrates the circular logic of the CP model. The CP model creates arbitrarily high penalty rates which affect CPQR which increase the ACR market seller offer caps. The risk is created by the CP model and then the cost to mitigate that risk is compensated within the CP model. Under the SCM approach, the arbitrarily and extreme penalties would be eliminated and therefore the impact on CPQR and the impact on capacity market clearing prices would be eliminated. There would continue to be risk and there would

[3] *See* "Renewable Dispatch - Presentation," PJM presentation to the Markets and Reliability Committee. (May 31, 2023) <https://www.pjm.com/-/media/committees-groups/committees/mc/2023/20230531/20230531-consent-agenda-c---1-renewable-dispatch--presentation.ashx>.

continue to be a cost to mitigate that risk, but the risk would be fundamental to the operation of the market rather than based on an assumption about the correct clearing price.

PJM proposes a significant change in the review of MSOCs. PJM would make PJM the primary reviewer and decision maker in the review of the MSOCs. PJM's proposal would significantly diminish the role of the MMU in reviewing proposed MSOCs and making market power determinations. Under the status quo, if there is a disagreement, both the market seller and the MMU submit proposed MSOC values to PJM. PJM must choose between the two proposals and cannot negotiate with the seller. The seller and the MMU can continue to discuss differences, exchange additional data and come to an agreement about the appropriate MSOC. FERC has the final decision making authority if a disagreement remains and PJM selects one option.

PJM's proposal would inappropriately substitute PJM for the MMU in making decisions about market power.

Incentives

The incentive/penalty issue is core to all the capacity market design issues considered in the CIFP process. Abstract discussions of incentives and penalties led some to the conclusion that if high prices provide incentives at times, then even higher prices or extreme penalties are even better incentives. One of the lessons of the winter storms Uri and Elliott, in very different market designs, is that extreme prices and penalties do not have the intended incentive effect and do have a destructive effect, in the energy market and in the capacity market. There is no reason to bankrupt generators or force generators into early retirement. There is no reason to bankrupt customers or impose impossible bills on customers. There is no reason to permit the exercise of market power. There is no reason to create lengthy litigation. That is not the basis for a reasonable, sustainable design consistent with investment incentives and customer confidence.

The use of capacity market penalties rather than energy market incentives creates risk. This risk is not risk that is fundamental to the operation of a wholesale power market. This is risk created by the CP design in order, in concept, to provide an incentive to produce energy during high demand hours that is even higher than the energy market incentive. When that artificial risk is included in capacity market prices, customers pay to cover it.

The goal of incentives is to increase the likelihood that resources will be available to produce energy when called on. Paying resources only when they are available provides an important incentive to perform at all times. Paying resources only when they are available is a long term, predictable incentive for performance. This is a positive performance incentive based on the market price of capacity rather than a penalty.

If units' capacity market revenue depends on investing in making generators more reliable in every hour, the units are more likely to be available at times of high stress. Ongoing capacity market revenue is essential to the economic viability of generating resources in PJM. Linking payment of those revenues to hourly performance is a strong incentive to invest in reliability.

The approach to incentives in the SCM design is intended to provide strong, consistent, repeated, and predictable incentives for performance through a combination of paying only when resources are available and stronger testing requirements. These elements create a strong incentive to invest in maximum availability, including availability during high stress hours.

On a routine basis (in the absence of infrequent PAI), the CP model provides no incentives for performance. Units are paid their equal hourly capacity price regardless of performance. The CP approach provides no incentive to perform when markets are tight but there is no defined emergency or PAI. The failure of CP incentives to result in improved unit performance has the perverse effect of increasing the probability of PAI emergencies. The absence of regular, ongoing incentives in the CP approach means less maintenance which results in failures under extreme circumstances.

The important difference between the SCM proposed design and the current CP design is that under the proposed SCM design, capacity resources are not paid the hourly capacity price when the resources are not available in an hour. Under the existing design, capacity resources are paid the same hourly capacity price in every hour even when resources are on long term planned outages, when resources are on maintenance outages, when resources are on forced outages and when thermal or intermittent resources are not capable of producing energy equal to ICAP as a result of ambient conditions.

Conclusion

The SCM proposed changes to the capacity market design are simple. The capacity market clearing process accounts for the expected hourly, locational availability of individual resources. In the delivery year, capacity resources are paid only when they are available.

In the forward looking capacity market clearing process that defines the resources needed to provide the target level of energy reliability, it is essential to have resource specific, locational hourly availability in order to match resource availability with the reliability objective. A simple assumption of average annual availability, or the assumption of an equivalent perfect resource at a derated MW value, will not accurately reflect actual expected availability.

In the delivery year, it is essential to pay for capacity only when it is available to produce energy. The proposed SCM design matches payment with availability to produce energy and ensures the opportunity for all resource types to cover their net avoidable costs if their actual

availability matches their expected availability. The result is to provide a long term, stable incentive for investment in maintenance and investment in new, reliable resources.

PJM has the historical data and the computational ability to implement an hourly approach. Any forward looking capacity market design should include an hourly approach, regardless of the other market rules layered on to it. The hourly approach by itself does not necessarily include all the components of the MMU's SCM design.

Implementation of the SCM design is not a question of working out the details of hourly reliability analysis or hourly unit availability or matching the two in a way that addresses risk. The details can be developed so that the approach is clear and transparent to all market participants, including suppliers and customers. The question is about the desired end state.

The proposed hourly approach does not represent the end point of the evolution of the capacity market design. The proposed hourly approach does not address all the existing and expected issues in the capacity market design. But it is an essential step forward. As intermittent penetration grows and new technologies evolve, it is not logical to assume that there will only be two relevant periods during which hourly availability is essential. Those hours will likely increase to encompass different times of day and different days within the year. The hourly approach does not predetermine the critical hours. The hourly approach does not predefine the contributions of different resources and resource types. The hourly approach creates the flexibility to handle those changes while leaving the flexibility to address other questions and issues as they arise.

The hourly approach is a natural evolution in the capacity market design, given the increased heterogeneity of resources. The hourly approach is essential in light of the growing role of intermittent resources which, unlike thermal resources, are not available in every hour.[4] The hourly approach provides a flexible way for demand resources to participate. The hourly approach also provides appropriate performance incentives to thermal resources by rewarding resources that are available and reducing payments to those that are not available. The hourly approach also explicitly recognizes that a small number of summer hours are not the only focus of reliability. PJM has recently recognized that there can be reliability issues in the winter.[5] The

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4 See "Update on Reliability Risk Modeling," presented at May 30, 2023 meeting of Critical Issue Fast Path - Resource Adequacy State 2. <https://www.pjm.com/-/media/committees-groups/cifp-ra/2023/20230530/20230530-item-03---reliability-risk-modeling.ashx>.

5 Ibid.

hourly model does not depend on identifying the days or season in advance.[6] The market results reflect the hourly demand and the hourly availability of supply.

The definition of reliability and the supply of capacity has always been based on the reality of hourly availability, but that hourly dimension has been only implicit to date. The SCM design makes explicit what has always been implicit. The SCM does not make the market more complicated. The SCM reveals the actual underlying details so that the issues in the market can be made explicit and addressed directly.

[6] See "PJM Capacity Market Fuel Assurance Accreditation Concept," presented at June 1, 2023 meeting of Critical Issue Fast Path - Resource Adequacy State 2. <https://www.pjm.com/-/media/committees-groups/cifp-ra/2023/20230601/20230601-item-05a---pjm-fuel-security-proposal-concept--cifp.ashx>.