Continued Discussion on Conceptual Design

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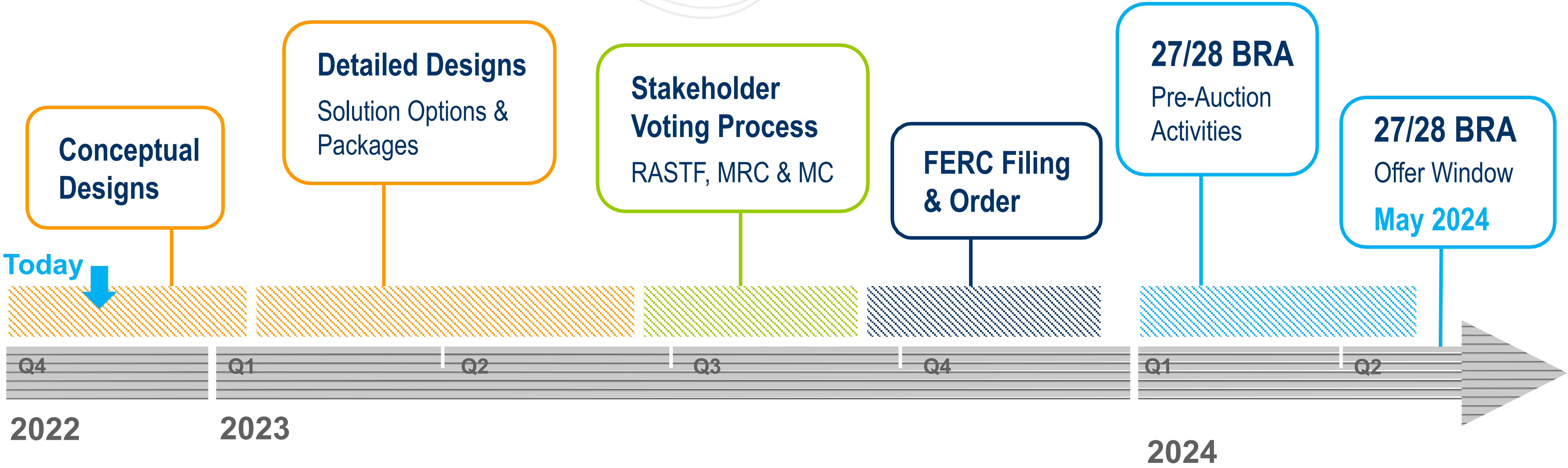
RASTF Work Plan Timeline for 27/28 BRA Implementation



PJM Conceptual Design

- PJM shared perspectives on high-level conceptual design and solution options across a number of KWAs at the August 31 RASTF meeting (presentation link) and included in the design template (link).

- Focused on reforms to better achieve two primary objectives of the capacity market:
  - **Reliability:** Supports procurement of sufficient capacity to meet our resource adequacy targets
  - **Efficiency:** Embraces competitive principles, and provides transparent price signals for efficient entry and exit of resources
    - Facilitates competitive, least-cost procurement of resources

Goal of Today's Presentation

- Continue working on conceptual design options for capacity market reform.
- Advance the discussion on certain key design elements and options under consideration for Capacity Accreditation (KWA #5) and Performance Assessments (KWA #4).
  - Marginal vs. Average approaches for accreditation
  - Performance expectations, assessment timing, etc.

Accreditation

PJM Conceptual Design: Accreditation Discussion

PJM's conceptual design on capacity accreditation includes:

- Move to a "marginal" accreditation approach for all resource types using a single consistent model/analysis framework (e.g., ELCC)
- Accounting of all uncertainty sourced on the supply-side in the accreditation with improvements to resource adequacy risk modeling

For today's meeting, focusing on the move to a "marginal" approach and some of the implications or conforming changes of accreditation reforms	Deeper dive on modeling specifics of resource availability/supply-side risks (particularly for thermals) at future meeting

Accreditation Overview

- Capacity accreditation quantifies the amount of capacity product a resource is qualified for.
- Within PJM's conceptual design, the capacity market and product continues to focus on resource adequacy and procurement of sufficient resources to satisfy the loss-of-load criteria, today based on an LOLE metric (addressing load shed risk).
- As such, capacity accreditation serves to capture a resource's contribution to resource adequacy, or expected ability to perform during times of system risk.
- Accreditation allows for a single, substitutable market product (i.e., accredited capacity or UCAP) to be used across resources with disparate operating characteristics, where one MW of the qualified product can be exchanged for any other MW of qualified product on the margin while maintaining equivalent resource adequacy outcomes.
- Accredited capacity sets the maximum quantity of the product that can be sold or otherwise used for capacity for a given resource.

How Accreditation Fits in the Capacity Product Definition

- Within PJM's conceptual design, the capacity product is generally defined as the commitment or obligation of a firm, physical resource to perform when needed by PJM, particularly during times of stressed system conditions (or load shed risk).

- Qualification requirements and accreditation of capacity are components of the definition that help ensure offered capacity is physical and firm, deliverable to load, and designed to value capacity resources consistent with their relative contributions to system reliability.

- Ultimately, the accreditation of a resource is based on a forecast model, and the actual contribution of a resource during the delivery year may be more or may be less than the accredited amount.
  - This may get captured and reflected in the accreditation for a future year.
  - This may also get captured in adjustments to capacity revenues during the delivery year through performance assessments.

Effective Load Carrying Capability (ELCC) Review

ELCC can be used to determine a resource's contribution to resource adequacy, or impact on the reliability criterion (e.g. LOLE, EUE)

- Measures the additional load that can be supported by an incremental increase in generation while maintaining the same level of reliability
- Often used to determine a percentage of nameplate capacity of a resource or set of resources that yields the same reliability outcome as that of "perfect capacity" (e.g., 100 MW nameplate of solar with an ELCC of 60% would be expected to provide the same reliability value as 60 MW nameplate of "perfect capacity")

Utilizes an hourly probabilistic model that simulates uncertainty in resource availability and load

- Focuses on hours of load shed risk and contribution of resources during those hours
- Inputs to determine resource availability in the model include outage rates, energy storage limitations, output profiles, etc.
- Able to capture correlated outage impacts, diminishing reliability value with higher penetration of certain resources, synergies among different unit types (e.g., solar and storage), etc.

Average vs. Marginal ELCC

Generally speaking, ELCC approaches can be described as either **average** or **marginal**.

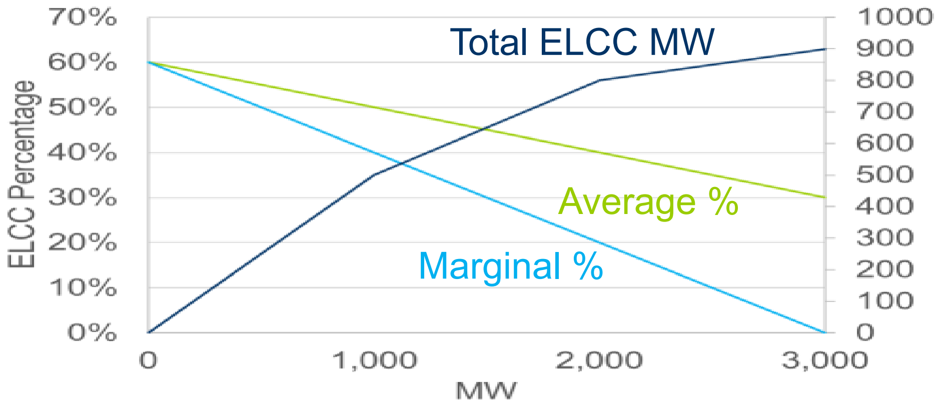
Average

- Accreditation is based on the **aggregate** reliability contribution of a portfolio or class of resources.
- PJM aggregate-total approach derives class ratings by allocating all of the reliability value of the aggregate of all ELCC Resources using an allocation factor ("Delta Method"); class value allocated to individual units based on unit-specific performance adjustments.

Marginal

- Accreditation is based on the **incremental** reliability contribution of a resource for a given portfolio of resources.

Nameplate (MW)	Total ELCC (MW)	Avg-Total ELCC (%)	Marginal ELCC (%)
1	0.6	60%	60%
1,000	500	50%	40%
1,001	500.4	49.99%	40%
2,000	800	40%	20%
2,001	800.2	39.99%	20%
3,000	900	30%	0%
3,001	900	29.99%	0%



Benefits of a Marginal Accreditation Approach

- Encourages cost-effective investment and retirement of resources
- Aligns the accredited value with expected performance during high-risk hours in operations (which is necessarily on the margin)
- Allows for a substitutable product definition where accredited capacity/ UCAP can be exchanged on the margin with no expected change in reliability
- Interactions between resource types are more naturally reflected in accreditation values
  - Synergies and diminishing reliability value among resources implicitly captured in marginal approach (no need to allocate diversity benefits to classes)

Benefits of a Marginal Accreditation Approach (cont'd)

Encourages cost-effective investment and retirement of resources

Illustrative Example

- Suppose Resource X and Y have average and marginal ELCC values as shown in the table below.
  - 1 nameplate MW of Resource X adds the equivalent reliability value of 0.2 MW of perfect capacity.
  - 1 nameplate MW of Resource Y adds the equivalent reliability value of 0.8 MW of perfect capacity.
- Investment in Resource Y is 4x more effective in reducing load shed risk (per nameplate MW).
- Investment in Resource Y is 3x more costly (per nameplate MW).

Net Impact: Resource Y provides the more cost-effective solution with cost per added reliability value (reduction in load shed risk) being 75% that of Resource X – aligned with compensation and incentives under marginal approach.

Marginal clears the most cost-effective solution, while average clears the cheaper $/MW UCAP solution but pays more $ per reliability improvement.

			AVERAGE APPROACH			MARGINAL APPROACH		
Resource	Nameplate MW	Cost ($/MW-Day, Nameplate)	ELCC %	UCAP MW	Cost ($/UCAP)	ELCC %	UCAP MW	Cost ($/UCAP)
Resource X	100	$50	40%	40 MW	$125	20%	20 MW	$250
Resource Y	25	$150	80%	20 MW	$187.50	80%	20 MW	$187.50

Benefits of a Marginal Accreditation Approach (cont'd)

Aligns the accredited value with expected performance during high-risk hours in operations (which is necessarily on the margin)

Illustrative Example (solely intended to show the concept and not represent future outcomes)

- Assume a resource mix and level of solar penetration that has resulted in expected hours of load shed risk shifting entirely into the evening hours after the sun has set.
- The marginal ELCC of solar in this scenario will be zero (next MW of nameplate solar provides no reduction in load shed risk given all risk occurring outside of solar performance hours).
- Suppose average ELCC of solar is 10% in this scenario, such that every MW nameplate of solar is accredited 0.1 MW of capacity value or UCAP.
- Marginal accredited value (and compensation) is consistent with expected performance of solar resources during the high-risk hours for that year and given portfolio.
- Average accredited value is above the expected performance level of solar during the high-risk hours.

This systematic misalignment results in expected net penalties for solar resources.

		AVERAGE APPROACH		MARGINAL APPROACH	
Resource	Nameplate	ELCC %	UCAP MW	ELCC %	UCAP MW
Solar X	1	10%	0.1 MW	0%	-

Benefits of a Marginal Accreditation Approach (cont'd)

Allows for a substitutable product definition where accredited capacity/UCAP can be exchanged on the margin with no expected change in reliability

Illustrative Example: Assume the reliability metric used in accreditation is Expected Unserved Energy (EUE) in MWh.

- Suppose perfect capacity provides an incremental reliability improvement (reduction in EUE) of 20 MWh.

  i.e., 1 MW nameplate of perfect capacity has a marginal reliability impact of 20 MWh EUE.

- Suppose Resource X has an average ELCC of 40% and marginal ELCC of 20%.

  The incremental reliability value is 20% that of perfect capacity (reduction in EUE of 4 MWh per nameplate MW).

- Suppose Resource Y has an average and marginal ELCC of 80%.

  The incremental reliability value is 80% that of perfect capacity (reduction in EUE of 16 MWh per nameplate MW).

- Under average, exchanging 1-for-1 UCAP MW between Resources X and Y can impact reliability.
  - Resource X: 2 nameplate MW = 0.8 MW UCAP; Incremental reliability impact = 2x (4 MWh EUE) = 8 MWh EUE
  - Resource Y: 1 nameplate MW = 0.8 MW UCAP; Incremental reliability impact = 16 MWh EUE
  - Exchange of UCAP results in different changes to reliability

- Under marginal, exchanging 1-for-1 UCAP MW between Resources result in same reliability.
  - Resource X: 4 nameplate MW = 0.8 MW UCAP; Incremental reliability impact = 4x (4 MWh EUE) = 16 MWh EUE
  - Resource Y: 1 nameplate MW = 0.8 MW UCAP; Incremental reliability impact = 16 MWh EUE
  - Exchange of UCAP results in equivalent impact on reliability

Benefits of having a 1-for-1 exchange rate for UCAP MW:

- Improves fungibility of the product
- Provides the same compensation to individual resources that provide the same improvement to system reliability

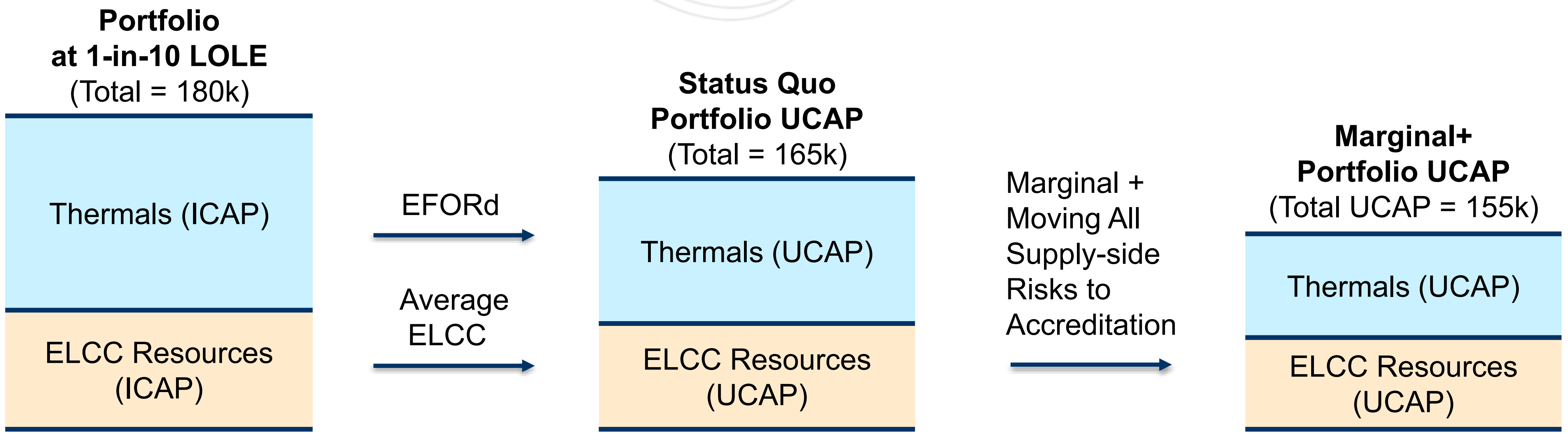
		AVERAGE APPROACH		MARGINAL APPROACH	
Resource	**Nameplate**	**ELCC %**	**UCAP MW**	**ELCC %**	**UCAP MW**
Resource X	2	40%	0.8 MW	20%	0.4 MW
Resource Y	1	80%	0.8 MW	80%	0.8 MW

Accreditation Reforms: Impact on Other Areas

Procurement Target in UCAP	• Impacted by moving the accounting of certain supply-side risks accounted for on the demand-side today into accreditation • Impacted by moving from average to marginal accreditation approach
Prices that rely on UCAP	• Market Seller offers can be impacted on a $/MW-day (UCAP) basis • Administrative prices may be impacted on a $/MW-day (UCAP) basis, such as the reference resource Net CONE used in setting prices on the demand curve
Performance obligations	• Can impact the baseline for which performance assessments are measured against

Impact on Procurement Target (in UCAP)

Illustrative Example



Procurement target in UCAP changes depending on accreditation approach; however, still the same portfolio that meets the 1-in-10 LOLE standard

Performance Assessments

Issues With Current Construct

Some of the issues and concerns raised with the current capacity performance design:

– Lack of clarity and transparency in the rules (e.g., what units fall into the assessment, treatment of ancillary services in actual performance calculations, rules on excusals from shortfalls)

– Potential misalignment in real-time incentives from energy market pricing and PAI penalty/bonus

– Concerns with the current penalty rate – calculated as Net CONE divided by expected number of PAIs in a year (currently 30 hours assumed) – and whether it's sufficiently high to incentivize investment in units, given low frequency of PAIs since CP was implemented

Conceptual Framework for Performance Assessments

Previous PJM education* described the rules governing PJM Capacity Performance assessments but did not provide a conceptual framework for interpreting the design of the performance assessment rules.

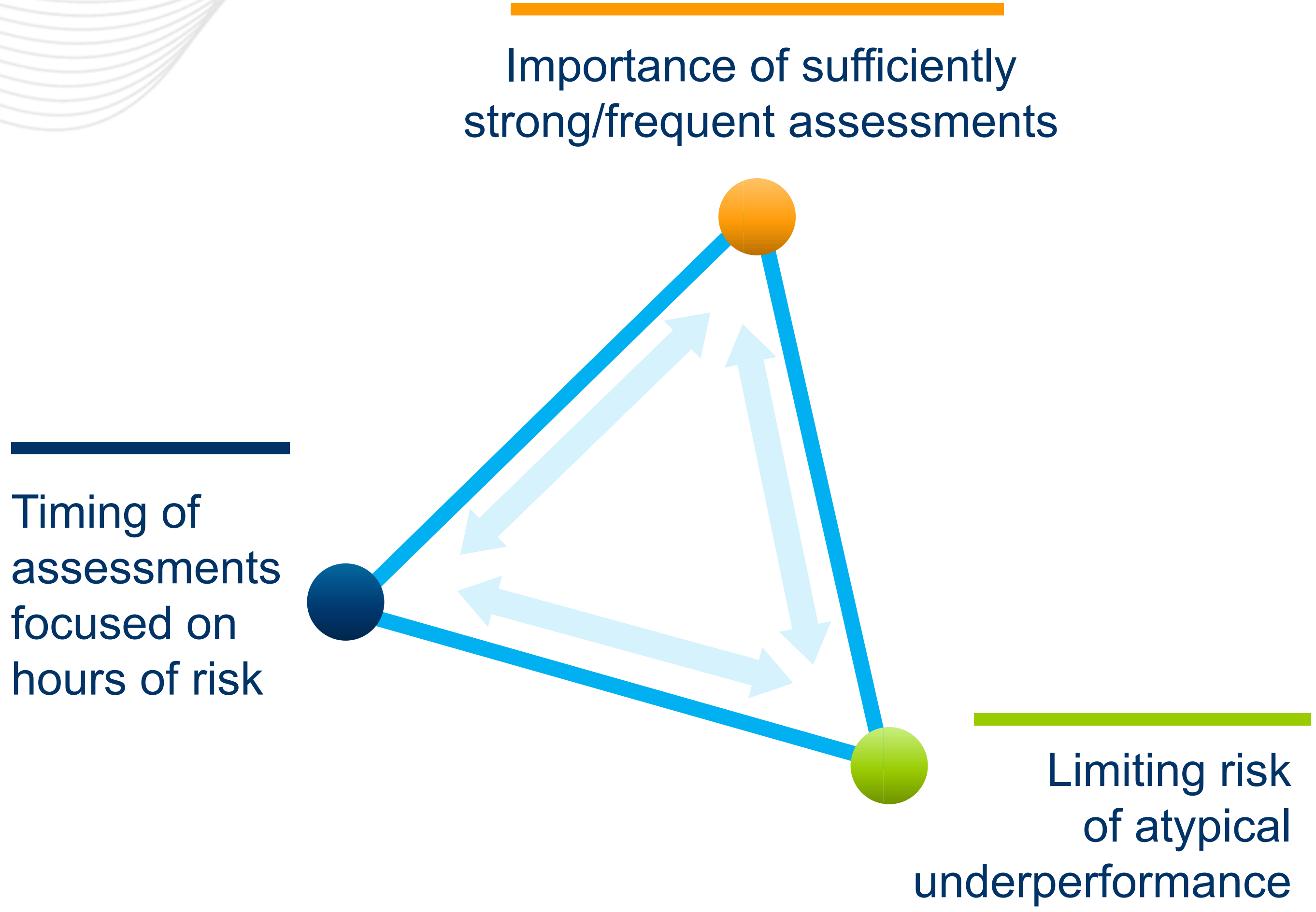
One such framework for the current construct is as follows:

- The capacity market is a true two-settlement market
- There is a real-time capacity product whose price is administratively determined:
  - **Zero**, most of the time
  - **Non-zero and high**, at the performance penalty rate, during PAIs
- Capacity is first transacted forward in the BRA and IAs, with deviations between the amount of real-time capacity product provided and the committed amount sold forward re-settled at a high price during PAIs

* *April 11, 2022, PJM [Education on Capacity Resources](#)*

Performance Assessments

There exists a tension across at least three natural design criteria for performance assessments, requiring compromise across them.



Timing of Performance Assessment Intervals

Performance Assessment Intervals

Only during loss of load hours	Only during reserve shortages	Only based on emergency actions	Based on emergency and pre-emergency actions	Locationally when nodal LMP exceeds a threshold value (e.g., $850/MWh) that is indicative of scarcity, stressed system or local conditions	During "stress" conditions as above, supplemented with additional intervals to meet a certain number (e.g., 30) of PAIs every year, based on ex-post (end of delivery year) hours with tightest supply cushion	During many (e.g., several hundred) predetermined hours	During all hours

Considerations for Performance Penalty Rate

As expected number of PAIs increases, performance penalty rate required to align forward and real-time capacity markets decreases.

Performance penalty rate could be relatively static or depend on auction clearing prices.

Status Quo	More Flexible	Most Flexible
Relatively static value based on Net CONE *PPR = **Net CONE** / 360 settlement intervals*	Recalculate penalty rate annually based on recent historical clearing prices (e.g., average of last three years) *PPR = **Recent auction clearing prices** / expected PAIs*	Recalculate penalty rate dynamically after auction is cleared based on auction clearing prices for relevant delivery year *PPR = **Current auction clearing prices** / expected PAIs*

How should the baseline "expected" performance for a given PAI be determined?

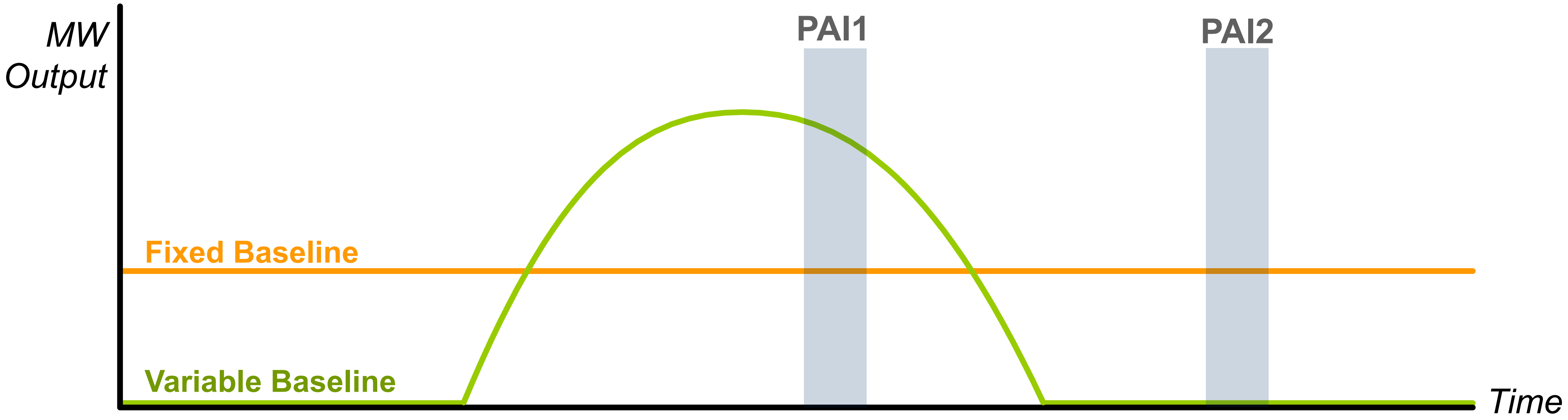
(i.e., What is the 8760 hourly quantity of the real-time capacity product that resources sell forward in the BRA or IA?)

Status Quo	More Flexible	Most Flexible
Flat, UCAP-based baseline (adjusted for balancing ratio, etc.)	**Performance baseline reflects varying output level/capability** over time, consistent with assumptions used in ELCC model to determine resource accreditation; baseline is predetermined for delivery year	**Baseline is dynamic** based on meteorological data; penalties only assessed for weather-correlated resources when performance is below that which is expected, given the meteorological conditions

Example: Flat vs. Variable Performance Baseline

Relative to a fixed baseline, a variable baseline would introduce a higher requirement during certain PAIs and a lower requirement during others.

This is consistent with the concept of a resource selling forward a variable quantity of the real-time capacity product aligned with capabilities assumed in ELCC.



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