Discussion on Potential Solution Options for the Accreditation Issue Charge

ELCCSTF

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Today's Presentation

Continue discussion on potential solution options for the Accreditation Issue Charge

- Review key accreditation design principles, motivation in moving to the marginal ELCC construct, and concerns raised in the Issue Charge surrounding investment incentives

- Discuss potential solution options that increase investment incentives within the current accreditation framework, and review results of sensitivities under the "Weighting Approach"

- Discuss potential reforms that may provide greater certainty in ELCC accreditation and/or allow market participants to better manage potential changes in ELCC accreditation between the time of the BRA and the final ELCC values determined for a Delivery Year

12/20/24 ELCCSTF Presentation

Review: Key Accreditation Design Principles

- Reflects resources' expected contribution to resource adequacy and ability to perform during periods of reliability risk during the Delivery Year
- Captures correlated outage risks and the relationship between weather, load, and resource performance
- Compensates resources in a manner that incentivizes cost-effective investment and retirement of resources
- Accredits different resource types and resources in a non-discriminatory manner
- Sufficiently transparent and stable to enable investors to make informed decisions when considering going forward investments

Review: ER24-99 Accreditation Reforms

The accreditation methodology approved in the ER24-99 FERC proceeding addressed a number of shortcomings under the prior approach:

1. Replaced the average accreditation metric (e.g. EFORd for thermals) to one more closely aligned with resources' expected contribution to resource adequacy and performance during critical periods

2. Captured correlated outage risks and how resource performance varies with temperature, particularly during extreme winter weather conditions

3. Applied a more consistent accreditation methodology across different resource types

4. Provided a framework to capture changes in resources' contribution to reliability as the fleet composition, load profiles, and patterns of reliability risk evolve over time

Review: Concern of Diluted Investment Incentives

The Accreditation Issue Charge discusses the marginal ELCC approach as a necessary step forward in moving to and having accreditation more closely align the value of capacity with the performance of resources during critical periods, but raises concerns of diluted investment incentives under the new methodology with three main areas of focus.

Historical look-back period: Today, a large proportion of the reliability risk and accreditation is based on performance from 10 years ago during a few days of the 2014 Polar Vortex, raising concerns and uncertainty about what investors can do to improve their resource accreditation going forward.

Performance Day	LOLH Share
1/7/2014	43.2%
12/24/2022	11.9%
1/8/2014	4.2%
1/28/2014	2.1%
12/26/2022	1.9%
1/22/2014	1.8%
7/18/2012	1.7%
12/25/2022	1.5%
7/17/2012	1.2%
6/29/2012	0.9%
10/30/2012	0.9%
1/31/2019	0.7%
12/23/2022	0.5%
6/29/2021	0.4%
7/25/2016	0.4%
8/25/2020	0.4%
7/7/2012	0.4%
7/19/2012	0.3%
7/18/2013	0.3%
7/17/2013	0.3%

About 75% of the LOLH is concentrated in 20 **performance days**:

- 9 in the winter
- 11 in the summer

Unit-specific performance adjustments: The current performance adjustment relies on historical performance hours beyond those that experience loss-of-load risk, which can dampen the impact of future performance on accreditation and the investment incentive for the resource.

New resource accreditation: New resource accreditation relies on historical class average performance for the missing years back to 2012, which can understate the expected performance and resource adequacy value of newer, more advanced technology, thereby dampening the incentives for new resource investment.

Review: Potential Approaches to Improve Investment Incentives

Focusing today on further discussion and analyses of the two options outlined below.

Shorten Performance History	May provide more immediate feedback of resource investment and performance changes into accreditation, but PJM has concerns in entirely removing a portion of the already limited number of performance observations we have back to 2012 during extreme weather conditions.
Weighting Approach	This approach puts greater emphasis in the risk and accreditation analysis on more recent observations of performance within each temperature bin, thereby increasing the impact of more recent observations of performance during periods of extreme weather or reliability risk to each resource's capacity value.
Administrative Review	This approach would enable resource owners to provide support or evidence of investments made in their units for review, and allow changes to past outage and performance history for the unit to reflect the investment.
Unit-Specific ELCC	This approach would move from a class-based ELCC accreditation approach to a unit-specific approach for all resources, which narrows the sample size of performance observations used to derive each resource's accredited value and puts greater emphasis on each individual unit's performance during hours of risk. At this time, PJM is concerned that the drawbacks of this approach (decreased sample size of performance and increased volatility) outweighs the benefits.

Weighting Approach: Motivation

Reflect improved performance in accreditation and risk model as it happens, and quicker than status quo

- Under status quo all historical days in a temperature-performance bin are weighted equally when making Monte Carlo draws
- By using a weighting approach, more recent historical days in a temperature-performance bin can receive a higher weight, making such days to be more likely to be drawn by the Monte Carlo (and therefore, older historical days in a bin, less likely to be drawn)

Temperature Bin Overview

Current Weather History to derive Load Scenarios: Historical weather scenarios captured back to 1993 (~ 30 years), consistent with the weather history used in PJM's Load Forecast Model

- Discussed extending the weather history in the model beyond 30 years during the CIFP stakeholder process and explored potential approaches to calibrate the extended history for climate change, but ultimately landed that more time and work was needed in this area

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Current Performance History: Historical observations of class and resource performance captured back to 2012

- During the CIFP stakeholder process PJM decided to use performance back to 2012 because around that year the system started seeing increasing deployment of renewable resources and because such historical period included days where the PJM had seeing significant risk due to high level of outages (i.e. January 2014 Polar Vortex and to a lesser extent February 2015)

Current Approach to Simulate Performance on a specific Weather Day

- All days back to June 1st 1993, are grouped in temperature bins based on daily minimum RTO-THI for winter days and daily maximum RTO-THI for summer days
- As the model goes over the 30 years of load scenarios, day by day, resource performance is drawn via Monte Carlo for a day by sampling performance from days located in the same temperature bin (but only from those days after May 31st, 2012)

Approach to Weight Years: Exponential Smoothing (ES)

As an example, let's assume there are 11 historical days in a temperature-performance bin from 11 different Delivery Years

Delivery Year Rank (Performance Temperature bin)	Weight	alpha = 0.1	alpha = 0.05
1	α	0.1000	0.0500
2	$\alpha(1-\alpha)$	0.0900	0.0475
3	$\alpha(1-\alpha)^2$	0.0810	0.0451
4	$\alpha(1-\alpha)^3$	0.0729	0.0429
5	$\alpha(1-\alpha)^4$	0.0656	0.0407
6	$\alpha(1-\alpha)^5$	0.0590	0.0387
7	$\alpha(1-\alpha)^6$	0.0531	0.0368
8	$\alpha(1-\alpha)^7$	0.0478	0.0349
9	$\alpha(1-\alpha)^8$	0.0430	0.0332
10	$\alpha(1-\alpha)^9$	0.0387	0.0315
11	$\alpha(1-\alpha)^{10}$	0.0349	0.0299

Interpretation:
If alpha=0.1, the Monte Carlo method will sample 0.1/0.0387, which is 2.6 times more often from performance in a day in Delivery Year Rank 1 than from performance in a day in Delivery Year Rank 10

How Weighting using ES Impacts the Monte Carlo Sampling in a Temperature-Performance Bin

For example, let's use the 9 historical days in the coldest bin used in the analysis of the 25/26 BRA planning parameters

Sampling weight calculated for each Date

Date	DY	DY Rank	Weight (alpha=0.05)	Weight (alpha=0.1)	Weight (alpha=0.25)
1/31/2019	2018/19	1	0.05	0.1	0.25
1/30/2019	2018/19	1	0.05	0.1	0.25
2/24/2015	2014/15	2	0.0475	0.09	0.1875
2/20/2015	2014/15	2	0.0475	0.09	0.1875
2/16/2015	2014/15	2	0.0475	0.09	0.1875
1/8/2015	2014/15	2	0.0475	0.09	0.1875
1/28/2014	2013/14	3	0.0451	0.081	0.1406
1/22/2014	2013/14	3	0.0451	0.081	0.1406
1/7/2014	2013/14	3	0.0451	0.081	0.1406

Expected sampling from each Date (out of 100 samples)

Date	Status Quo	Weight (alpha=0.05)	Weight (alpha=0.1)	Weight (alpha=0.25)
1/31/2019	11.11	11.76	12.45	14.95
1/30/2019	11.11	11.76	12.45	14.95
2/24/2015	11.11	11.17	11.21	11.22
2/20/2015	11.11	11.17	11.21	11.22
2/16/2015	11.11	11.17	11.21	11.22
1/8/2015	11.11	11.17	11.21	11.22
1/28/2014	11.11	10.60	10.09	8.41
1/22/2014	11.11	10.60	10.09	8.41
1/7/2014	11.11	10.60	10.09	8.41
Total	**100**	**100**	**100**	**100**

As the alpha value increases the older observations in the bin
(from Jan. 2014) are less likely to be drawn in the Monte Carlo sampling
(e.g., 8.41 < 10.09 < 10.6)

Weighting Approach: Sensitivity Analysis

- Inputs / Assumptions for Weighting Approach Sensitivity Analysis
  - Based on 2026/27 BRA case from June 2024
    - Note: The resulting parameters from such case will no longer be used due to the postponement of that BRA
  - PJM decided to merge the two coldest temperature bins because it was likely that an approach weighing more recent performance more heavily would result in WSE performance, located in the second coldest bin, to contribute more risk than the PV1 performance, located in the coldest bin (and such an outcome would be counterintuitive if we believe that the worst system conditions during winter should occur during days in the coldest bin)
  - PJM used ES with 3 different alpha values (0.05, 0.1 and 0.25) to determine the sampling weights in each of the temperature-performance bins

Weighting Approach: Sensitivity Analysis (cont'd)

	LOLH Risk Contribution of Jan 7 2014 Performance Pattern	LOLH Risk Contribution of Dec 24 2022 Performance Pattern	LOLH Risk Contribution of Winter 2013/14 Performance Pattern	LOLH Risk Contribution of Winter 2022/23 Performance Pattern	Overall Winter LOLH Share	IRM
Status Quo	37.5%	13.3%	51.5%	17.5%	71.3%	18.6%
Alpha = 0.05	18.0%	27.3%	37.7%	35.9%	75.6%	18.7%
Alpha = 0.10	14.7%	29.7%	33.4%	41.4%	76.6%	18.7%
Alpha = 0.25	10.0%	44.1%	20.8%	58.4%	81.1%	19.0%

- The weighting approach (with the 3 alpha values) reduces the LOLH Risk Contribution of Jan 7, 2014 and Winter 2013/14 Performance Pattern relative to Status Quo
- As the alpha value increases, the LOLH Risk Contribution of Jan 7, 2014 and Winter 2013/14 Performance Pattern decreases. Conversely, the LOLH Risk Contribution of Dec 24, 2022 and Winter 2022/23 Performance Pattern increases.
- As the alpha value increases, the overall winter LOLH share increases. In other words, winter becomes riskier than summer. This is because several of the high forced outage observations in the "hottest" bins have occurred in the past and are less likely to be drawn in the summer temperature-performance bins.
- As the alpha value increases, the IRM increases. This effectively means that the model observes more overall risk when more recent observations have a higher sampling weight in each temperature-performance bin.

Weighting Approach: Conclusions

- The Weighting Approach using Exponential Smoothing (ES) to the Delivery Year Rank observations within a temperature-performance bin effectively decreases the LOLH Risk Contribution of older performance observations relative to newer ones
  - The degree of such decrease depends on the value of the parameter alpha.
- Because LOLH Risk Contribution is the key factor driving ELCC accreditation resulting from the ELCC model, we can conclude that the Weighting Approach using ES could also result in accreditation values that are more heavily impacted by recent performance during extreme weather
- There are other impacts to consider when deciding the “best” alpha value. For instance, the IRM, which can provide a measure of overall system risk.

All options reviewed for the administrative approach have both benefits and concerns without a clear winner

- Shifting the risk within each ELCC Class provides the same risk pattern, but may result in some resources receiving less UCAP MW

- Changing, rewriting, or adding to the observed behavior, risks under accounting the correlated outage patterns, and can change total system risk patterns. In the extreme it could shift total system risk from winter to summer

- Any proposed design change should maintain a reasonable representation of correlated outage risk

Qualified Investment

	Description
Qualified Investment	A Generator Owner invests into a Generator with the intent to fix a problem, beyond regular maintenance, that was leading to outages during extreme winter periods.
Work in progress	1. How to credit the resource to account for the Qualified Investment 2. How to confirm owner has made an investment that is expected to improve investment going forward, i.e. prevent paper capacity a) Hired Consultant certify investment, GO certifies investment, alternative administrative process to verify outcome b) How to Require evidence for a minimum capital investment to qualify c) Reversal of rewrite if continued poor performance d) Incremental MW gained subject to an increase penalty exposure through higher penalty rates, and total stop loss
Result	Resource receives additional UCAP MW relative to before the Qualified Investment

1) Credit Resources
Hypothetical Example: Status Quo

- This example walks through how PJM could update accreditation for a resource due to a Qualified Investment.
- The table below represents the status quo for a hypothetical ELCC Class.
- In this hypothetical ELCC Class, there are four units, each with an Installed Capacity (ICAP) of 100 MW. This results in a total ICAP of 400 MW for the entire class. The total Unforced Capacity (UCAP) for the ELCC Class is 300 MW.
- The ELCC Class Rating is 75%, and each unit is given a Resource Adjustment Factor (RAF) to reflect that unit's total UCAP

Unit [A]	ICAP MW [B]	ELCC Class Rating [C]	Resource Adjustment Factor [D]	Accredited UCAP MW [B]x[C]x[D]
Unit #1	100	75%	126.7%	95
Unit #2	100	75%	113.3%	85
Unit #3	100	75%	80.0%	60
Unit #4	100	75%	80.0%	60
Total	400			**300**

1) Credit Resources
Option 1: Keep Total Class UCAP Constant

- Unit 3 receives a Qualified Investment
- Maintaining the same ELCC Class Rating, PJM adjusts the Resource Adjustment Factor [E] and [F] to reflect this investment.
- Unit 3 increases its Accredited UCAP, but all other resources lose Accredited UCAP MW
- This outcome penalizes all units that do not pursue additional investment

Unit [A]	ICAP MW [B]	ELCC Class Rating [C]	Resource Adjustment Factor [D]	Administrative Resource Adjustment Factor [E]	Final Resource Adjustment Factor [F] = [E]*Avg[D]/Avg[E]	Accredited UCAP MW [B]x[C]x[F]
Unit #1	100	75%	126.7%	126.7%	120.6%	90.5
Unit #2	100	75%	113.3%	113.3%	107.9%	81.0
Unit #3	100	75%	80.0%	100.0%	95.2%	71.4
Unit #4	100	75%	80.0%	80.0%	76.2%	57.1
Total	400					**300**

1) Credit Resources
Option 2: Increase Total Class UCAP

- Unit 3 receives a Qualified Investment
- Allow changes to the ELCC Class Rating and all Resource Adjustment Factors to reflect this investment.
- Unit 3 increases its Accredited UCAP, and all other resources remain constant
- This results in additional UCAP, but no longer aligns with risk modeling for calculating FPR, IRM, ELCC Class Ratings, and underlying risk metrics

Unit [A]	ICAP MW [B]	ELCC Class Rating [C]	Resource Adjustment Factor [D]	Accredited UCAP MW [B]x[C]x[D]	New Accredited UCAP MW [E]	New ELCC Class Rating [F]=Sum[E]/Sum[B]	New Resource Adjustment Factor [G] = [E]/[B]/[F]
Unit #1	100	75%	126.7%	95	95	78.8%	120.6%
Unit #2	100	75%	113.3%	85	85	78.8%	107.9%
Unit #3	100	75%	80.0%	60	75	78.8%	95.2%
Unit #4	100	75%	80.0%	60	60	78.8%	76.2%
Total	400			**300**	**315**		

1) Credit Resources
Option 3: Rewrite Performance History

- Unit 3 receives a Qualified Investment
- Allow changes to the Unit 3’s performance history.
- Unit 3 increases its Accredited UCAP, and other resources may or may not change
- This results in additional UCAP, and aligns with risk modeling
- This risks losing correlated risk outage patterns and improperly shifting risk between seasons

Unit [A]	ICAP MW [B]	ELCC Class Rating [C]	Resource Adjustment Factor [D]	Accredited UCAP MW [B]x[C]x[D]
Unit #1	100	79%	119.4%	94
Unit #2	100	79%	108.0%	85
Unit #3	100	79%	95.2%	75
Unit #4	100	79%	77.5%	61
Total	400			**315**

1) Credit Resources Weighting and Administrative Adjustment

	Option 1: Total Class UCAP Constant	Option 2: Total Class Increase UCAP	Option 3: Rewrite History, Shifting Accredited UCAP
Benefits	Increases generator UCAP with Qualified Investment	Increases generator UCAP with Qualified Investment	• Increases generator UCAP with Qualified Investment • Consistency with risk modeling and UCAP calculation
Concerns	• Penalizes all units that do not pursue additional investment • Inconsistency with risk modeling and UCAP calculation	• Misaligns risk modeling and UCAP accreditation • Market outcomes would not reflect underlying risk patterns • Inconsistency with risk modeling and UCAP	• Risks under valuing correlated risk patterns • Performance history rewrite could improperly shift seasonal risk

PJM currently prefers Option 3: Rewrite History

How To Rewrite Unit Performance History

Upper bound of updated performance history must be less than 100% as there is still inherent risk.

- **Unlimited Resources**: For Unlimited Resources calculate an average EFORd accounting for random outages only, discounting weather-related outages; to be applicable after date of investment corresponding to relevant GADs codes. PJM is considering to update the unit performance history result in an expected performance history of EFORd

- **Variable Resources**: PJM is considering to update the unit performance history to an updated backcast reflecting the investment with data from a vendor

- PJM is considering to rewrite specific unit performance history outage levels for specific events with a "Random EFORd" equal to either the unit's EFORd or class specific EFORd

	Future Investment	Historic Investment
Unlimited	Class specific EFORd	Unit-specific EFORd of 1 or 5 year value

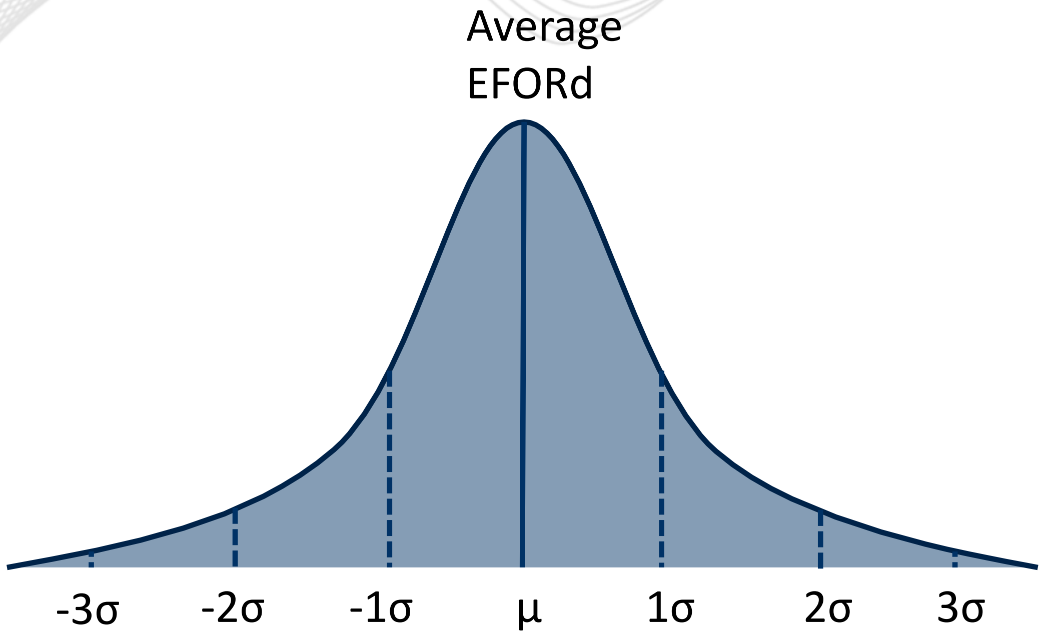
Rewrite specific outage level for specific events with a random EFORd for the unit, that would have been impacted by the qualified investment

Concern: This change could overstate expected performance, which could negate correlated outage risk and improperly shift risk between seasons.

1) Credit Resources Random EFORd

- PJM would simulate a Random EFORd based on a normal distribution centered around EFORd during specific pre-investment events that occurred on specific historical dates
- PJM would provide the EFORd for each unit and estimate a standard deviation (likely class based)
- This means PJM may not use the average EFORd value every time that the specific pre-investment historical date is randomly drawn in the corresponding performance bin; instead, an EFORd value based on the above EFORd

Random EFORd is a more reasonable approach to "rewrite" pre-investment history as it may be unreasonable to assume that there is a 0% chance that the unit can have a forced outage post-investment



Example: A generator has a 5% EFORd, and 1% standard deviation

μ=5% σ=1%

2.a) Confirming Qualified Investments
Certification of Qualified Investments

Qualified Investments are rewarded to resources that are able to certify a problem was fixed

- PJM needs a way to validate the Qualified Investment occurred in order to be willing to provide additional UCAP MW

	Option 1: Self Certify	Option 2: External Consultant Certify	Option 3: Self Certify & PJM Validation Process
Benefits	Requires fewest parties to validate Qualified Investment	Puts onus on an expert willing to certify the Qualified Investment will yield better expected performance	Same as Option 1 with PJM validation
Concerns	• May not be robust enough to provide PJM with certainty of Qualified Investment impact • Would require large market exposure to deter	• Unclear who external consultant would be • Could become too administratively complex	• Unclear how PJM would validate Qualified Investment • Could become too administratively complex

Requiring a minimum capital investment threshold would allow the benefits of a Qualified Investment only to resources that have a sizable investment

- A minimum capital investment threshold will provide greater certainty to PJM that the resource adequately addressed the underlying performance issues
- Unclear how much is an appropriate minimum capital investment threshold

2.c) Confirming Qualified Investments Future Performance Expectations

- Resource that have a qualified investment are expected to perform better than previously observed behavior
- Resource that have a qualified investment but continues to behave similar to before the investment occurred risk reverting to the previously observed values
- If the average performance observed after the qualified investment is less than the previous average performance of the resource, PJM will revert performance history, and incremental MW may be subject to an additional penalty

2.d) Confirming Qualified Investments Additional Market Risk with Participation

Another way to help ensure that submitted Qualified Investments are expected to increase performance of the resource, the owner could bear additional market risk by offering the higher UCAP.

- Incremental UCAP MW gained through a Qualified Investment could be subject to additional market exposure
- Subject incremental UCAP MW gain to an increased market exposure by increasing the resource’s PAI penalty rate and stop loss (The current stop loss is 1.5 x Clearing Price)
- Without increased market exposure, PJM may face the risk of over accredited resources and removing too much correlated outage risk

Shortfall of 0.1 MW to Incremental UCAP MW gained could face increased market exposure

Qualified Investment Conclusions

The discussed approach for a Qualified Investment approach may allow resources to immediately realize generator improvements which results in additional UCAP

Benefits	Concerns
• May allow immediate realization of improvement to generator resulting in additional UCAP • Balance between increased resource accreditation and market exposure	• Administrative burden and subjectivity of improvements may be too great • Rewriting history shifts resource risk to PJM modeling assumptions • EFORd replacement does not capture correlated risks observed during extreme weather events • Increased penalty rates and stop loss may be difficult for resources to mitigate • Potential to shift seasonal risk patterns without observed behavior of performance • High level of participation could limit model's ability to capture correlated outage risks even when recently observed on the system

Risk of Accredited UCAP Decreasing between the BRA and Final Values for a DY

Concern that has been raised:

Most existing generators have a must offer requirement in the BRA for their full accredited UCAP value, as determined using the ELCC analysis run prior to the BRA. That accredited UCAP value gets updated over time based on the latest ELCC analysis for the relevant Delivery Year, with the final value being determined just prior to the 3rd IA. When the final accredited UCAP value falls below the amount committed in the BRA, which may be driven by factors unrelated to a decrease in ICAP or performance of the resource, the resource owner is subject to deficiency charges at roughly 120% their capacity revenue for the shortfall MW when they are unable to procure replacement capacity. Market sellers are looking for reforms to address that uncertainty and risk, particularly given it may be difficult or not possible to procure the replacement capacity when the system is tight.

Example

Generator A is accredited at 100 MW UCAP and clears the full amount in the BRA at a clearing price of $250/MW-day. Accreditation is then updated prior to the 3rd IA and due to changes in system risk profiles, the final accreditation of the resource is 90 MW UCAP. If unable to procure replacement capacity, the resource owner would be subject to a daily deficiency charge for the 10 MW UCAP shortfall times $300/MW-day (1.2x BRA price)

Risk of Accredited UCAP Decreasing between the BRA and Final Values for a DY (cont'd)

Potential options to help address the uncertainty / risk of a lower final accredited value:

1) Lock in accreditation values, or certain inputs into the accreditation, at the time of the BRA.

2) Allow market sellers to price in the risk of lower accredited UCAP and deficiency charges in their sell offers

3) Allow market sellers to offer at a level below the full accredited UCAP at the time of the BRA (e.g. based on a minimum of recent and forecasted ELCC values, or X percentage below the full accredited amount)

4) Differentiate between ICAP and UCAP driven deficiencies. For UCAP deficiencies, lower the penalty rate to 100% of the clearing price to remove sellers' exposure to deficiency penalties that exceed the auction revenues being paid for the shortfall MW.

Each of these options come with different pros and cons to consider and discuss. We would appreciate your feedback and thoughts on these (or any alternatives that may help address the concern)

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