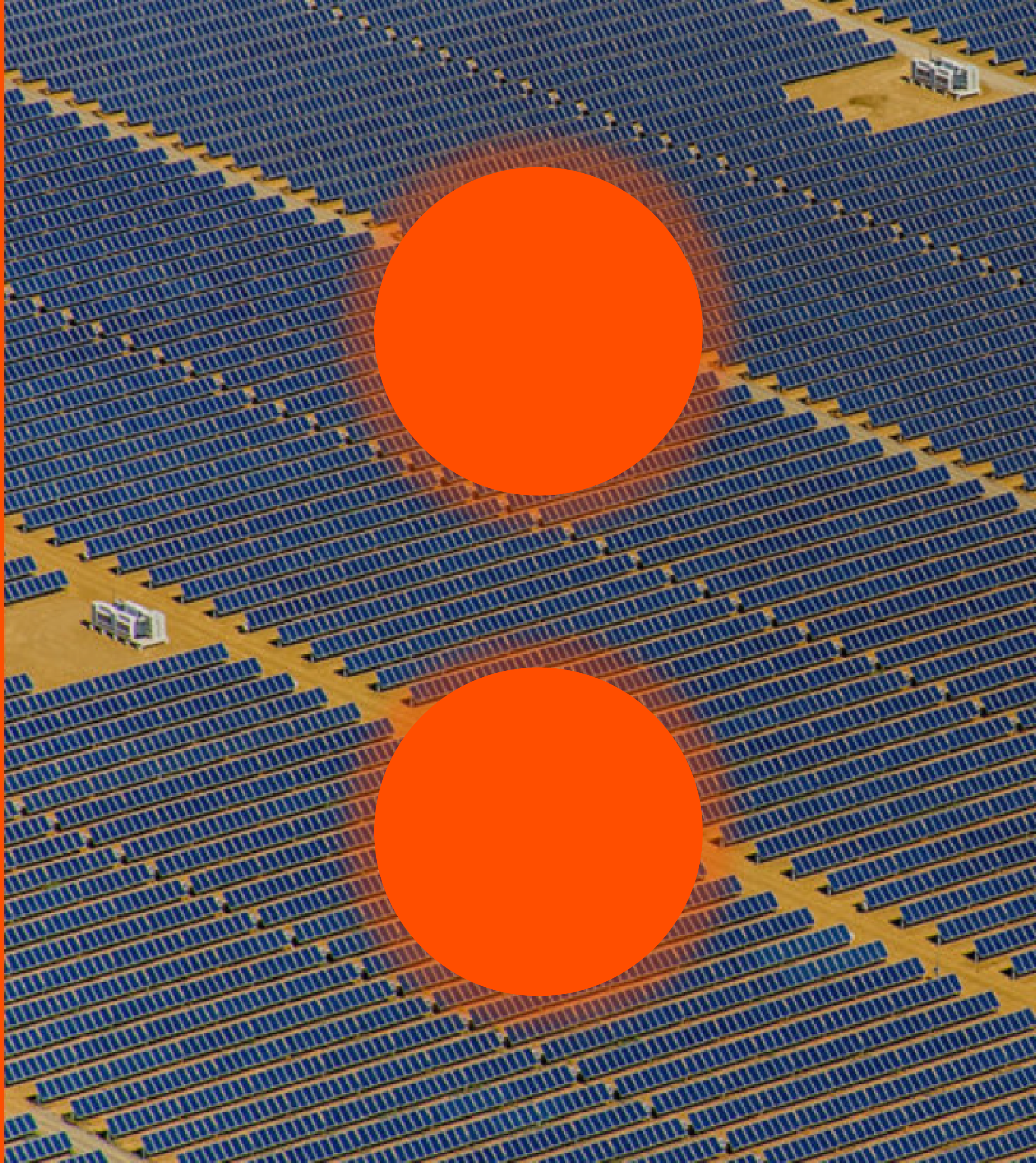
MN8

PJM RA – High Level Design Concept

You Got Power



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RASTF Objectives

As we stated in our presentation on October 11 and in line with PJM's framing, we believe that the primary objective of a Resource Adequacy (RA) construct should be:

- **System Reliability:** supports sufficient resources to meet reliability targets
- **Market Efficiency:** embraces competitive principles and provides transparent price signals for efficient entry and exit

Process considerations

We agree that a holistic approach is needed to address the full range of KWAs taken up in the RASTF.

However, useful distinctions can be made between KWAs and related reform options that can inform process/approach.

Categories	Description	Process Implications
Interdependent Reforms	Reforms that impact and are impacted by decisions made vis-à-vis other, inter-related reforms and cannot be thoroughly assessed in isolation – e.g., capacity qualification and accreditation, performance assessment, and capacity resource obligations are intimately related, and changing any one of these has ramifications for the others.	A deliberate process and framework is needed for these KWAs & reform options that allows for systematic evaluation with consideration for critical interdependencies.
Independent Reforms	Reform decisions that are not meaningfully impacted by other reforms, nor do they meaningfully impact other reforms – e.g., procurement metrics.	These reforms can largely be assessed in isolation.
No-regrets Reforms	Certain items are widely recognized as material issues and can be productively worked on without knowing the end-point vis-à-vis other KWAs – most notably, reliability risk modelling, particularly in the case of thermal resources: • Thermal accreditation is an issue that is widely recognized as deficient today and in need of urgent reform • No-regrets progress can be made on thermal capacity resource reliability risk modelling without knowing where the various other KWAs land • This will require material effort given the substantive nature of the enabling modelling architecture and the lack of precedent elsewhere • This modelling bedrock is necessary to permit analysis of the implications of other related decisions (e.g., marginal/average)	Improvements in the modelling of reliability risks, particularly in the case of thermal resources, can and should be pursued in isolation and should begin promptly

Thermal and other reliability risk modelling – a no-regrets undertaking

Of all of the issues, **deficiencies in the current thermal accreditation framework are the most unambiguous threat to both system reliability and market efficiency.** This is clear from analyses presented by PJM at earlier RASTFs.

1) PJM highlighted over-accreditation of thermals under the status quo; this leads to inaccurate price signals and "exchange rates"

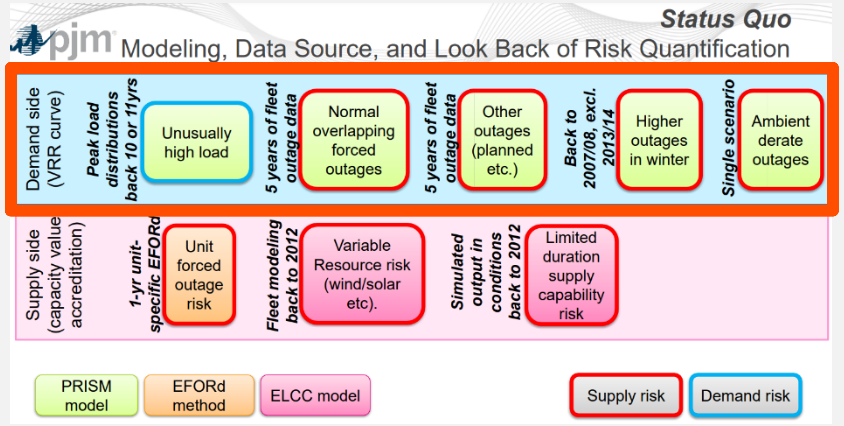
Risks	Source	Accounting of Risk
Load Uncertainty	Demand	Demand-side (FPR)
Random Thermal Forced Outages	Supply (thermals)	Accreditation (EFORd)
Variable Resource Risks	Supply (e.g. wind/solar)	Accreditation (ELCC)
Limited Duration Resource Risks	Supply (e.g. battery)	Accreditation (ELCC)
Normal Variability in Random Thermal Forced Outages	Supply (thermals)	Demand-side (FPR)
Thermal Planned & Maint. Outages	Supply (thermals)	Demand-side (FPR)
Thermal Winter Correlated Outages	Supply (thermals)	Demand-side (FPR)
Ambient De-rates (Summer)	Supply (thermals)	Demand-side (FPR)

Uncertainty	FPR Impact	UCAP Impact
Ambient Derates	0.0143	2,150
Maintenance Outages	0.0099	1,500
Outage Variability	0.0003	450
Planned Outages	0	0
Winter-weather Outages	0	0
TOTAL	0.0272	4,100

Taken together, these analyses by PJM identify **>4 GW of thermal performance risks that are captured on the demand side (FPR) today as opposed to the supply side** (accreditation)

2) The values presented above likely under-estimate incremental thermal risks under current accreditation rules, due to the **patchwork approach to thermal risk quantification today:**

- *Ambient derates* based on a single scenario;
- *Normal overlapping forced outages* and *Other outages (planned etc.)* based on 5 years of fleet outage data
- *High outages in winter* modelling excludes the most material 'event' in recent history (2013/2014)



Sources: Thermal Outages Data Analysis; Capacity Value Accreditation Concepts in the Reliability Pricing Model (RPM)

ERCOT: material thermal performance risk beyond EFORd

Recent analysis done by Astrapé Consulting of the ERCOT market found thermal ELCCs that were far below the values captured by 1-EFORd

Battery	Solar	Wind	Thermal	Cold Weather	Fuel	Winter ELCC (%)	Summer ELCC (%)	Winter UCAP/ Winter CDR Rating (%)	Summer UCAP/ Summer CDR Rating (%)
0	0	0	2024	Base	None	89.6%	89.8%	94.6%	93.9%
0	0	0	2024	Base	Include Fuel	87.5%	89.8%	94.9%	93.9%
0	0	0	2024	2011	None	87.5%	89.8%	94.9%	93.9%
0	0	0	2024	2011	Include Fuel	83.5%	89.5%	95.0%	94.0%
0	0	0	2024	2011 and 2021	None	78.0%	89.6%	95.1%	94.0%
0	0	0	2024	2011 and 2021	Include Fuel	67.7%	89.6%	95.1%	94.0%
2024	2024	2024	2024	Base	None	89.9%	90.8%	96.1%	94.4%
2024	2024	2024	2024	Base	Include Fuel	87.9%	90.7%	96.3%	94.4%
2024	2024	2024	2024	2011	None	87.9%	90.7%	96.3%	94.4%
2024	2024	2024	2024	2011	Include Fuel	83.4%	90.7%	96.6%	94.4%
2024	2024	2024	2024	2011 and 2021	None	78.9%	90.8%	96.9%	94.4%
2024	2024	2024	2024	2011 and 2021	Include Fuel	69.3%	90.8%	97.1%	94.4%

ELCC-based Values **EFORd-based Values**

Highlights:

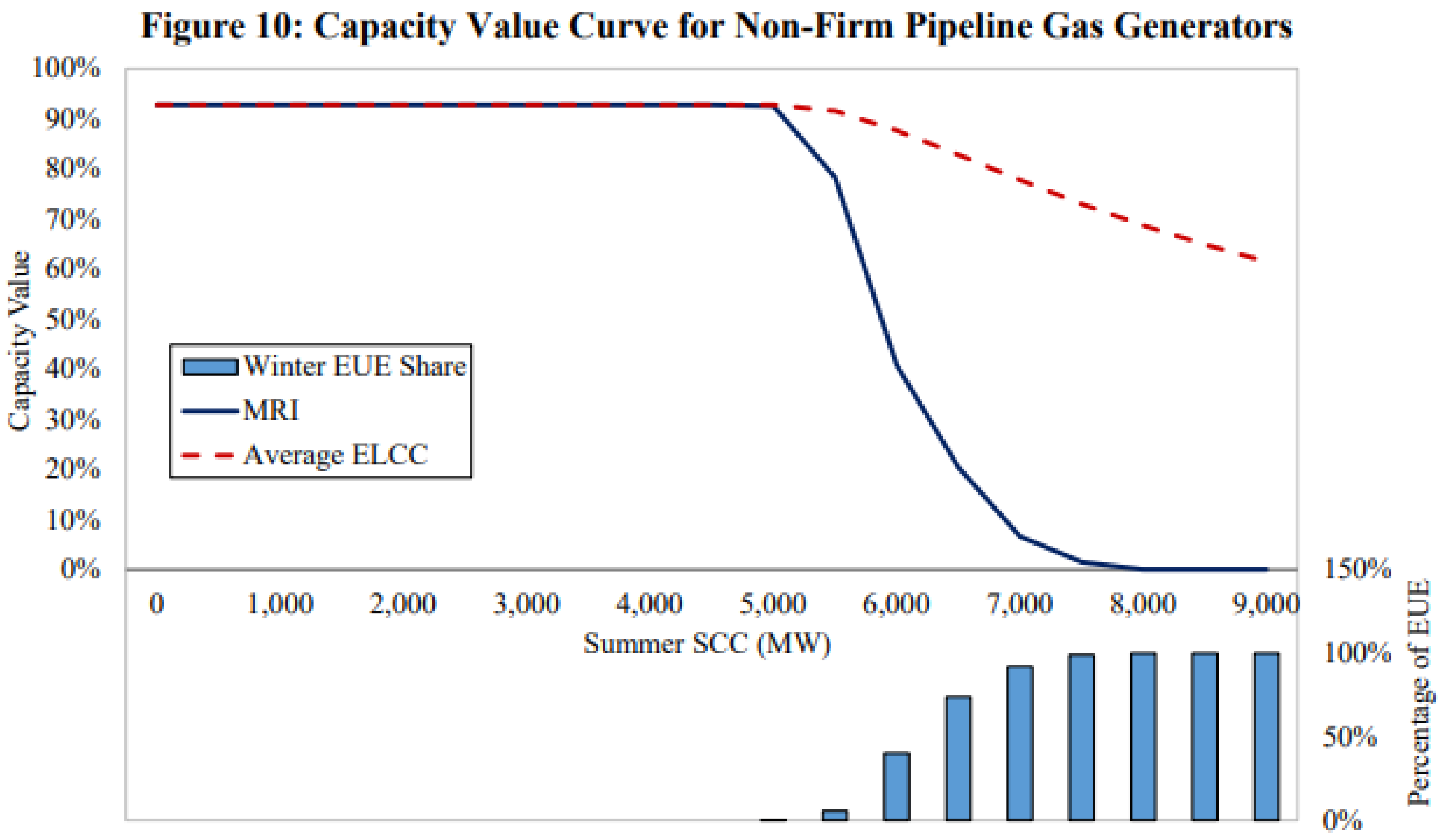
- The most holistic analysis found a winter ELCC of 69.3%, or **27.8% lower than the EFORd based CDR rating**
- The same values for summer were 90.8% ELCC, or **3.6% below than the EFORd based equivalent**
- This analysis is **based on an average/actual ELCC approach**

ISO-NE: material thermal performance risk beyond EFORd

Potomac Economics' [2021 State of the Market Report] released in June 2022 found rapidly declining marginal reliability value to non-firm pipeline gas generators beyond a certain point (5 GW).

In the most recent auction (FCA16, DY 25-26), around 8 GW of gas-only generation cleared. If this were accredited appropriately, Potomac estimates that it would have an MRI of 0% and an average ELCC of 69% during the winter season.

ISO-NE has identified this gap and is working to address it through its stakeholder process.



NYISO: material thermal performance risk beyond EFORd

Potomac Economics' November 2022 Quarterly Report identified unaccounted for risks under NYISO's current accreditation approach:

> We identified several categories of conventional generating capacity that may receive excessive accreditation under the current rules. (slides 22-23)
>
> ✓ On days when load surpassed 28 GW, an average of ~1,060 MW of ICAP from these resources was functionally unavailable to the market, including:
>   - 470 MW offered as emergency capacity with extremely limited availability;
>   - 210 MW derated related to ambient water temperature; and
>   - 370 MW derated related to humidity or mechanical issues reported as ambient.

Furthermore, recent analysis by Potomac Economics focused on gas availability risks found "On very cold days, gas will be available to generators only if: (i) Generator has firm transport contract, or (ii) Imported LNG creates a surplus above LDCs' needs."

Reliability metrics – an independent issue

Decisions around certain issues that are not interdependent on other KWAs—e.g., reliability metrics—can be made independently from decisions on other KWAs.

These can largely be assessed in isolation and need not further complicate what will already be a substantial undertaking in assessing the many other, interdependent KWAs.

Inter-related reforms – all other KWAs

There are numerous reforms that are intimately inter-related:

1. ~~Clean Procurement (KWA #1)~~ Moved into separate workstream
2. ~~Reliability Risks in the Capacity Market (KWA #2)~~ No-regrets undertaking
3. ~~Reliability Target and Metric (KWA #3)~~ Independent reform
4. Performance Assessments (KWA #4)
5. Qualification and Accreditation (KWA #5)
6. Energy Market Obligations (KWA #6)
7. Procurement process (KWA #7)
8. Seasonal Capacity Construct (KWA #8 + others)
9. Supply-side market power mitigation rules (KWA #9)
10. FRR Rules (KWA #10)

It is very hard to make progress in thinking through any of these inter-related KWAs without understanding the broader framework – e.g., when considering average/marginal, what are we assuming will be done for CP (KWA 4); etc.

Marginal accreditation – a good example of KWA interdependencies

PJM noted the benefits of marginal accreditation in their most recent presentation. We agree that there are some clear theoretical pros to marginal accreditation versus "average". However, marginal is largely untested in other jurisdictions, and PJM is unique – it is therefore important to consider the broader framework in which marginal would be implemented before assessing that it is superior to average.

There are predictable implementation challenges to marginal accreditation:

- Implementing **marginal accreditation for thermal resources will be particularly complicated and has the potential to create material regulatory uncertainty** that will in turn increase the risk premium associated with capacity market revenue forecasts for thermal assets
  - For instance, modelling and implementing distinctions in thermal accreditation for gas availability will be challenging. Evaluating which gas plant is most likely to get "cut off" first during an event in which gas supply became constrained will require taking a position on how different contractual terms translate into relative likelihood of gas delivery.
  - Example: imagine two gas contracts with equal terms, except that (i) one places slightly higher penalties for non-performance on the gas supplier, and (ii) the other has a slightly more expansive Force Majeure definition related to winter events, making it slightly more likely that the supplier will be able to effectively make their case that a future winter event falls under the FM definition – which one is more likely to deliver during an event?
- The **intersection of marginal accreditation and capacity performance is complicated** – marginal accreditation has clear drawbacks when coupled with the different CP constructs that have been discussed to-date (see next slide)

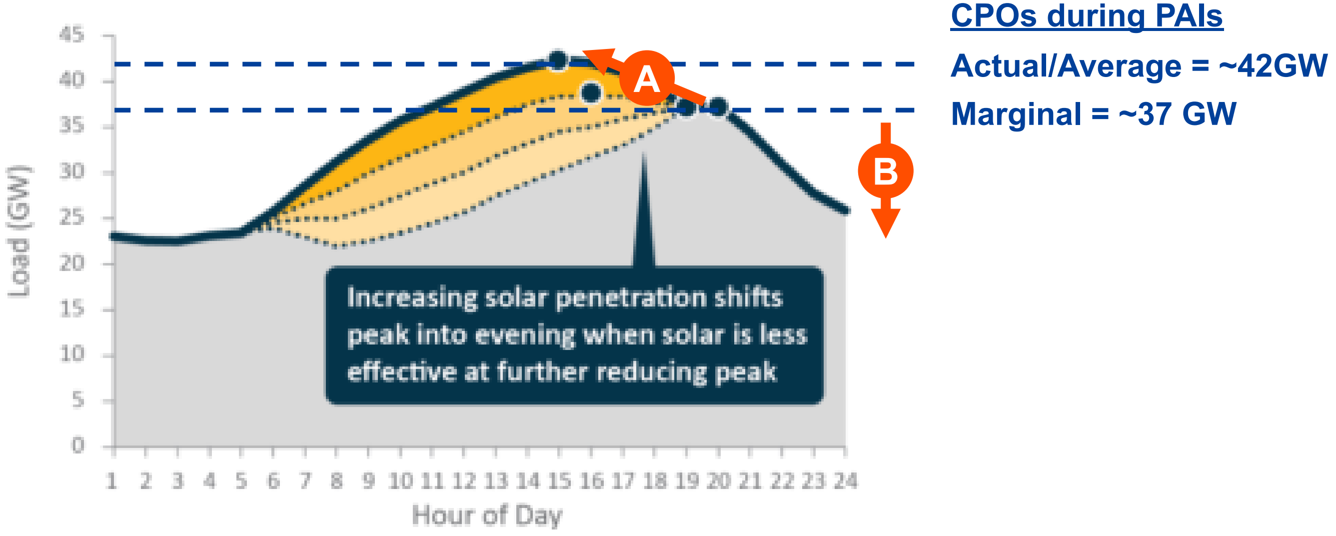
Marginal accreditation – (fixed) CP complications

Implementing a "fixed" CP obligation (CPO) in a marginal accreditation environment is risky:

- Marginal accreditation can create reliability risks if coupled with (i) a CPO that is set at each resource's cleared UCAP and (ii) a cap on Balancing Ratio at 1 (see RHS) by relying on UCAP that is not obligated to perform during PAIs. This also undermines incentives to perform during the marginal hours.
- Removing the Balancing Ratio cap would create a new issue, where resources could very well be obligated to perform during CP events above their accredited UCAP, and even possibly ICAP. This would create uncontrollable risk for capacity resources, increasing the risk premium to market participation, and thus, costs to end-users.

While a "dynamic" CPO might help to ameliorate this issue, it introduces another set of drawbacks (see next slide).

Illustrative Net Demand Dynamics



Source: E3 Whitepaper, "Capacity and Reliability Planning in the Era of Decarbonization"

A When PAIs occur during periods with higher demand than the "marginal" hours that are procured for, **the system is relying on capacity that is not obligated to perform.**

B **Issue "A" can be compounded by marginal accreditation dynamics vis-à-vis thermal and other resources**. For example: in the case of a modelled gas constraint, the marginal gas unit would have zero RA value in constrained hours, but the actual fleet contribution could be material (e.g., the ISO-NE example), driving UCAP procured below actual system needs during expected events, thereby increasing reliance on resources to perform in the absence of CPOs.

Marginal accreditation – (dynamic & variable) CP complications

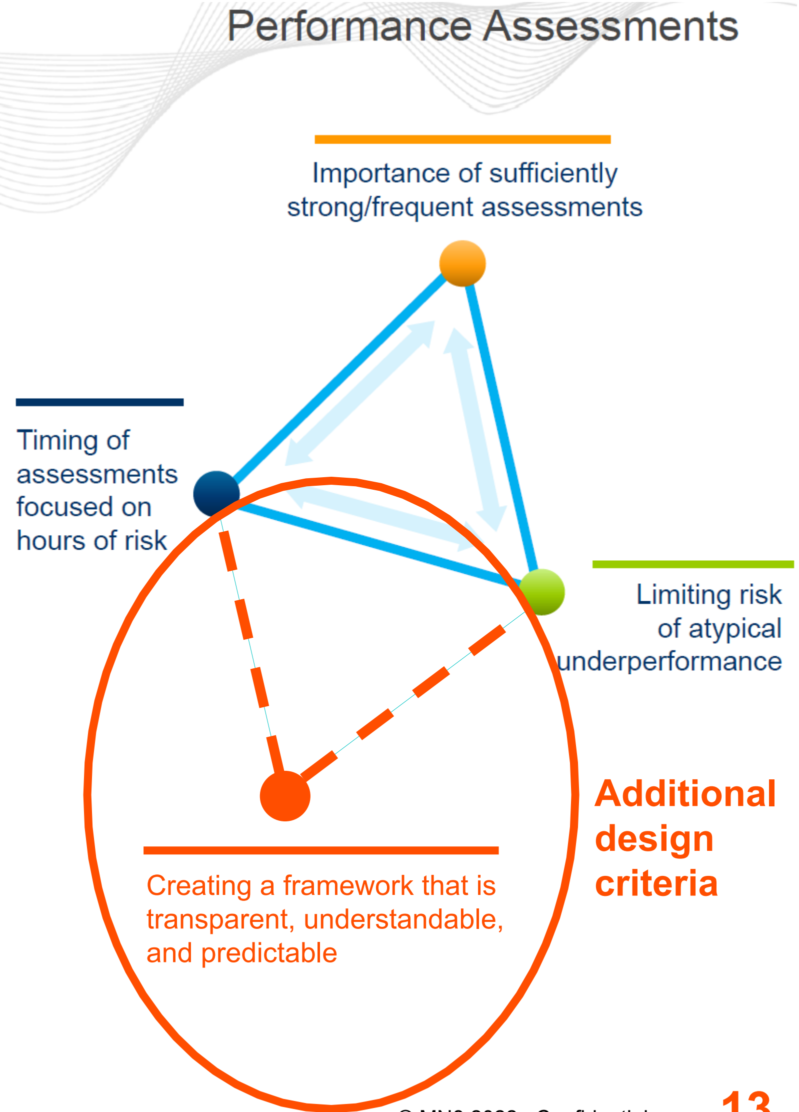
PJM highlighted a relevant tension between three design criteria (shown on RHS) in their last RASTF presentation that should be considered when coming up with CPO. We would **add one critical criteria: creating a framework that is transparent, understandable, and predictable**. This is critical to ensure that the RA construct sends price signals for efficient market entry/exit (that it's "financeable"). Opacity, complexity, and unpredictability will lead financing parties to require uncertainty risk premiums, increasing costs to end-users and possibly driving certain resource classes out of the capacity market altogether.

This design criteria detracts from the attractiveness of a "dynamic" performance baseline:

- Let's imagine a multi-day winter event where gas supplies became scarce and we experienced a PAI towards the end of the event, at which point substantial storage/hydro had run out of charge.
- How would PJM assess CP obligations (map actual conditions to modelled conditions) in this case for:
  - Storage (battery/hydro): performance drivers are not just local weather, but also include SOC, expected future system conditions (opportunity costs), and more - these would need to somehow be mapped to a modelled scenario
  - Thermals: performance drivers are not just local weather; they also include systemic issues such as regional weather (and related upstream supply issues) and pipeline infrastructure operational issues (e.g., operational flow orders)
- It's hard to see a straightforward framework here and, at a minimum, is clear that this would be extremely challenging to interpret and forecast for project owners and financing parties, which would lead to substantial risk premiums.

A "variable" baseline has some of the drawbacks of both "fixed" and "dynamic" baselines

Finally, both "dynamic" and "variable" baselines diverge from the widely shared goal of a homogenous capacity product



Marginal accreditation – summary of CP complications

There are positive features to the status quo accreditation-CP interface:

- It creates a robust set of equivalent, self-funded incentives for resources to perform during PAIs;
- It makes it highly likely that enough UCAP will be obligated to perform during any given PAI; and
- It ensures that all UCAP has the same obligations – in that sense, that UCAP is exchangeable.

The interaction of marginal accreditation and CP, on the other hand, presents drawbacks:

- In the case of a fixed CP obligation, it can introduce reliability risks and detract from valuable incentives to perform during PAIs (if BR = 1) or can impose costly, uncontrollable risk on capacity resources (if BR > 1)
- In the case of a profiled CP obligation (whether “dynamic” or “variable”), it creates UCAP that is no longer homogenous, insofar as it has different CP obligations and associated incentives, and hence, should be expected to perform differently during CP events
- It creates implementation challenges and regulatory uncertainty

A possible framework for assessing interdependent KWAs

To make progress in the face of many independent KWAs, it is important to be deliberate about the process and structured in the approach to tackling these issues.

A systematic approach could be used to help navigate the many interdependent issues and options. For example:

- **Take a scenario-based approach:** create several foundational packages that take critical design components as a given, and then attempt to build the most robust framework(s) possible around the foundations. We think that at the end of this process, we could then assess the resulting RA frameworks holistically.
- Select foundational reforms in a fashion that facilitates the most efficient and comprehensive process – criteria that might guide this selection include:
  - **Choose components with the greatest knock-on effects:** locking in components with the greatest impact on other KWAs is helpful – otherwise, consideration for other KWAs need to be heavily caveated each time vis-à-vis the component in question (ex: accreditation)
  - **Choose components that have the least consensus:** locking in components with the least consensus allows us to create a more manageable process while keeping all viable options on the table (ex: capacity performance obligations)
  - **Choose components with a manageable number of viable options:** this ensures a manageable number of scenarios (ex: accreditation)
  - **Choose components in a way that mitigates uncertainty:** locking in components with options that are less proven allows for important interdependencies to be thoughtfully explored (ex: marginal accreditation)

Illustrative framework – scoring components

	Most Uncertainty	Least Consensus	Greatest Knock-on Effects	Fewest Iterations	Total Score
Capacity qualification and accreditation (KWA5)	High	Medium	High	High	High–Medium
Performance assessments (KWA4)	Medium	Medium	Low	Medium	Medium–Low
Capacity performance obligations (KWA4)	High	High	Medium	Low	High–Medium
Market construct (KWAs 7&8)	Medium	Medium	High	Medium	High–Medium
Market power mitigation rules (KWA9)	Medium	Medium	Low	Medium	Medium–Low
Energy Market Obligations (KWA6)	Medium	High	Low	Medium	Medium

Legend: High | Medium | Low

This scoring could be informed by a survey or interviews done by PJM

Illustrative framework – selecting foundational elements

Select the highest scoring 2-3 components

Illustrative framework – scenario construction and analysis

Capacity Qualification and Accreditation	Market Construct	Performance Assessments	CP Obligation	Market Power Mitigation Rules	Energy Market Obligations
Average	1 Annual	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons
	2 Seasonal	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons
Marginal	3 Annual	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons
	4 Seasonal	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons	Option 1: pros, cons Option 2: pros, cons

Foundations / Scenarios

Build the best version(s) of each scenario possible – systematically work through options

Conclusion

- The goal of the RASTF should be to create an RA construct that efficiently achieves a reliable system
- Reliability risk modelling, particularly when it comes to the thermal resources that comprise a majority of today's UCAP, is a clear area where reform is needed to achieve these goals. This warrants urgent effort to construct better modelling of thermal risks which in turn will allow for more detailed consideration of how different reform options would translate into outcomes
- To make progress on the broader set of KWAs, a deliberate process is needed that allows for interdependent issues to be productively assessed in a holistic fashion
- A subset of issues can probably be assessed in isolation
- However, most issues have critical interdependencies; for these, a scenario-based approach such as the one we described could be one way to make progress in the RASTF
- Otherwise, there's a risk of making conclusions based on narrow and/or theoretical assessments of options that do not fully contemplate the practical limitations that often only emerge when considering the broader RA framework in which the interdependent options fit