Capacity Market Reform: PJM Proposal

CIFP - Resource Adequacy

July 27, 2023

Outline

- Key elements of proposal
- Proposal updates:
  - Simplified seasonal market clearing *(slides 4-24)*
  - Market power mitigation updates - Must offer and MSOC / CPQR *(slides 25-31)*
  - Performance assessments and testing *(slides 32-44)*
  - Weatherization program / generation site visits *(slides 45-55)*
- Latest analysis:
  - Reliability risk modeling and accreditation *(slides 56-68)*

Prior Presentation on PJM Stage 3 Proposal

Proposal Summary

Key Elements of PJM's Proposal:	
1.	Enhance risk modeling in resource adequacy studies and move to EUE as the primary reliability metric
2.	Implement a seasonal capacity market design (two seasons – summer and winter)
3.	Improve capacity accreditation to reflect resources' contribution during periods of risk by season
4.	Maintain the capacity performance framework with enhancements to the rules and testing requirements
5.	Align FRR rules and improve other areas of the market construct, including market power mitigation rules

Focus of the market design reforms is on near-term achievable improvements to the market's ability to meet resource adequacy requirements in an efficient, least-cost manner.

Simplified Seasonal Market Clearing

Changes Since Initial Proposal

- **Removed:** Marginal EUE curves and tie-back to annual VRR curve
- **New Approach:**
  - Seasonal demand curves set in advance of auction
  - No adjustment to demand curves during auction clearing
  - Aligned seasonal demand curve to match status quo VRR curve shape
  - Introduced maximum limit on annual average price across seasons

High-Level Overview

- **Demand:** Fixed demand curves represent the seasonal willingness-to-pay for accredited capacity in each season, using the FERC approved VRR curve shape, in which it is possible to fully recover annual Net CONE in one season.
- **Supply:** Three-part offers allow flexibility to reflect going-forward avoidable costs of commitment in summer, winter, or both seasons
- **Market Clearing:** Least-cost selection among resources given offered (summer, winter, and annual) costs
- **Prices:** Reflect marginal system cost of incremental seasonal supply & demand
  - One summer price, one winter price, *no annual price*
  - Revenues will equal or exceed costs for all cleared resources

$$P_{summer} \times Q_{summer} + P_{winter} \times Q_{winter} \geq Cost_{summer} + Cost_{winter} + Cost_{annual}$$

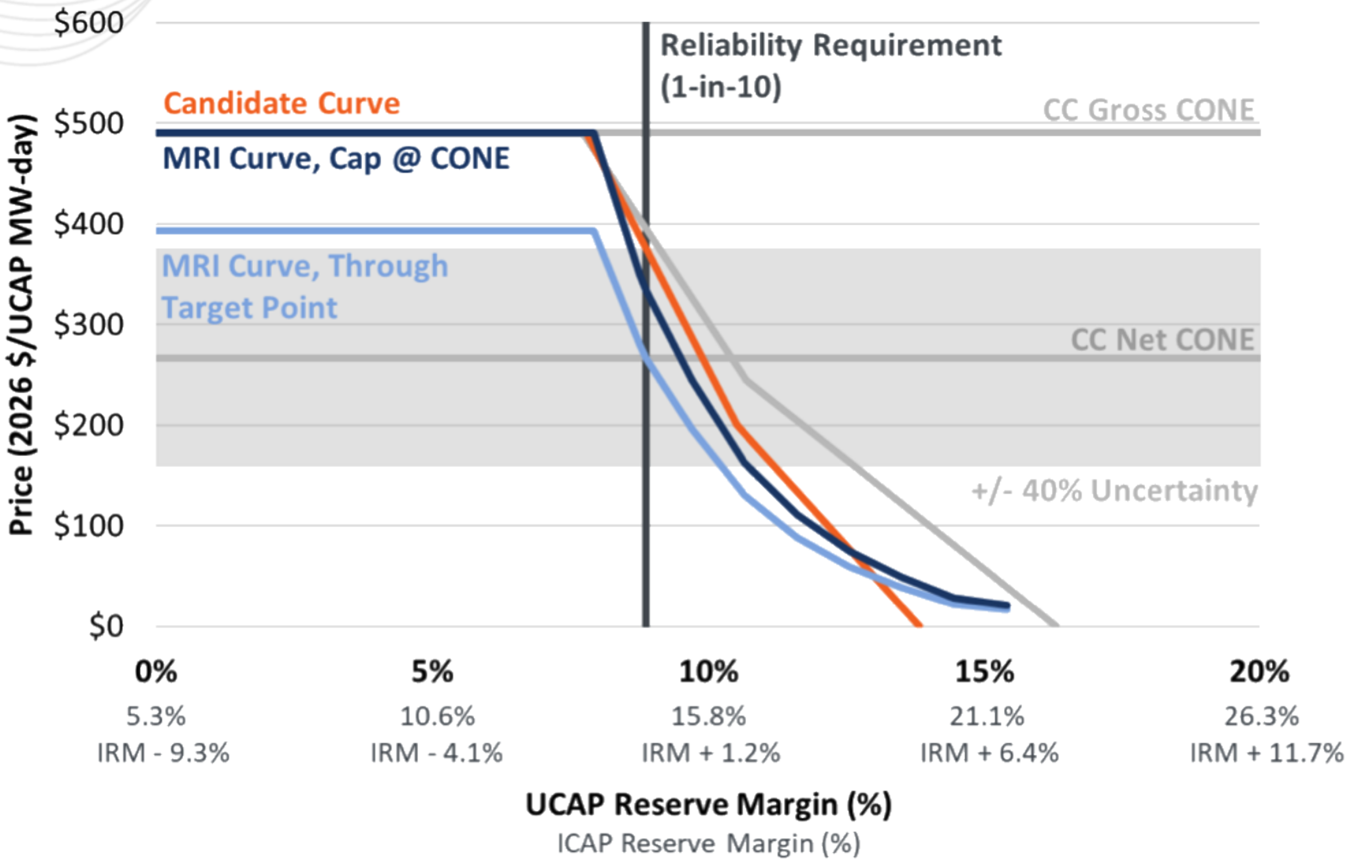
  - No uplift necessary to cover cleared costs

Detailed Walkthrough: Demand Curves

Context: VRR Curve & Marginal Reliability Impact

- The Marginal Reliability Impact (MRI) of capacity reflects the expected (EUE) improvement in reliability from adding 1 MW UCAP
- An MRI-based demand curve provides a consistent willingness-to-pay per avoided MWh of load shed across a range of reserve margins
- Quadrennial Review assessment of MRI-based annual curves vs. current:
  - <u>Shape</u> of 1-in-10 tuned MRI curve well aligned with current VRR
  - <u>Performance</u> similar but not identical; more frequently at price cap and below Reliability Requirement

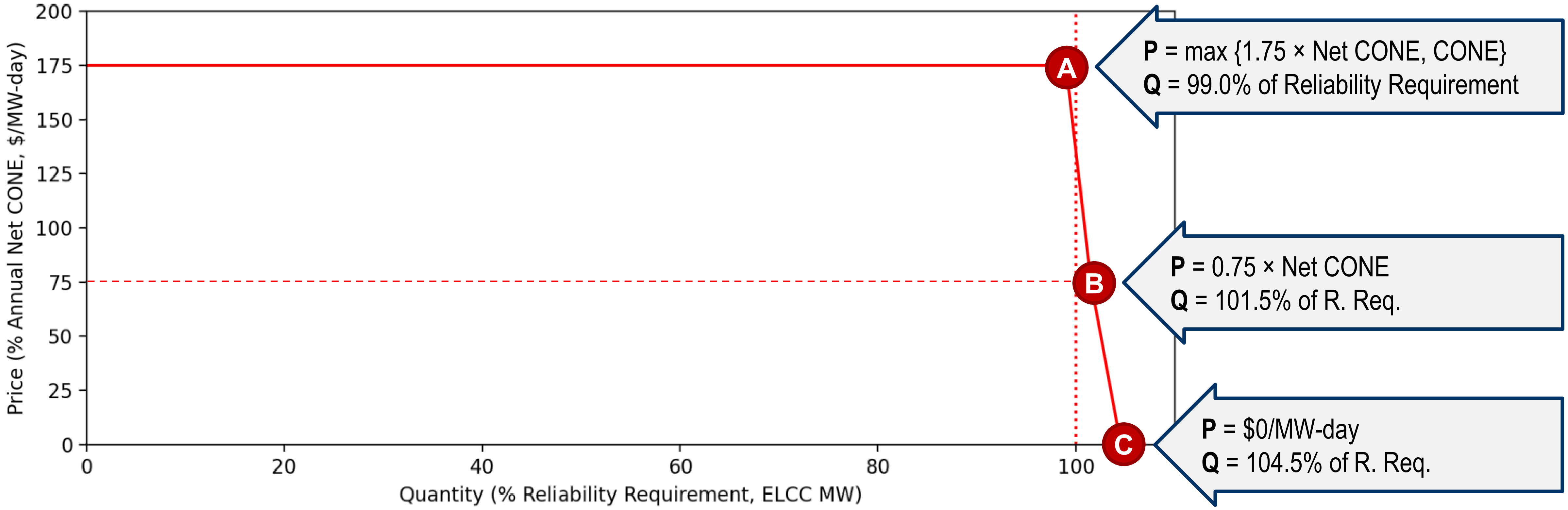
MRI-Based Demand Curves



Sources: Figure 9 and Table 7, "Fifth Review of PJM's Variable Resource Requirement Curve"

Context: Status Quo

- Annual VRR curve parameters were last adjusted in 2022:



Issue with Direct Translation of Status Quo VRR to Seasonal Design

- One potential approach would be to directly translate the annual VRR curve to a seasonal design, maintaining price levels in $/MW-Day in each season
- However, this approach risks inadequate funding for new entry in equilibrium:
  - Would not represent sufficiently high willingness to pay in either season, especially if supply is relatively unconstrained in the other season
  - *Example:* Clearing at 1.75 x annual Net CONE $/MW-Day in summer, and $0 in winter, only returns annual revenues of 0.875 x Net CONE.
- Clearing at the Reliability Requirement should allow recovery of annual Net CONE for the reference technology in equilibrium, even if most of the risk (and therefore value) occurs in only one season

Seasonal Demand Curves: Solution

- **Principle:** Seasonal demand curves should allow reference technology to earn Net CONE at equilibrium to meet the reliability criterion, without revenues from other seasons
- **Parallel:** This is consistent with LDA demand curves today that enable recovery of annual Net CONE at the LDA requirement, even without contribution from other (parent or child) LDAs
  - Any LDA can meet local requirement even if the price in RTO and any parent LDA is $0/MW-day
  - Likewise, RTO and LDAs can meet requirement without additional revenues from any child LDA
- **Application:** Define seasonal demand curves according to the same principle. Meet the (annual) reliability requirement at equilibrium price of (annual) Net CONE even without contribution from other season.
  - **Example:** If **winter** has negligible risk and clears excess capacity at $0/MW-day prices
  - Entire allowable EUE MWh risk can occur in **summer**
  - Seasonal prices in **summer** must allow recovery of annual net CONE in equilibrium

Parameters & Inputs

- **Seasonal UCAP Requirement:** Procurement target calculated to allow *all* annual risk to occur in one season, but demand curve slope & price cap prevent the annual EUE MWh at criterion from occurring in both seasons *simultaneously* (except if clearing at the annual price cap)
  - Summer Requirement at annual EUE MWh target: ~175 GW UCAP
  - Winter Requirement at annual EUE MWh target: ~145 GW UCAP

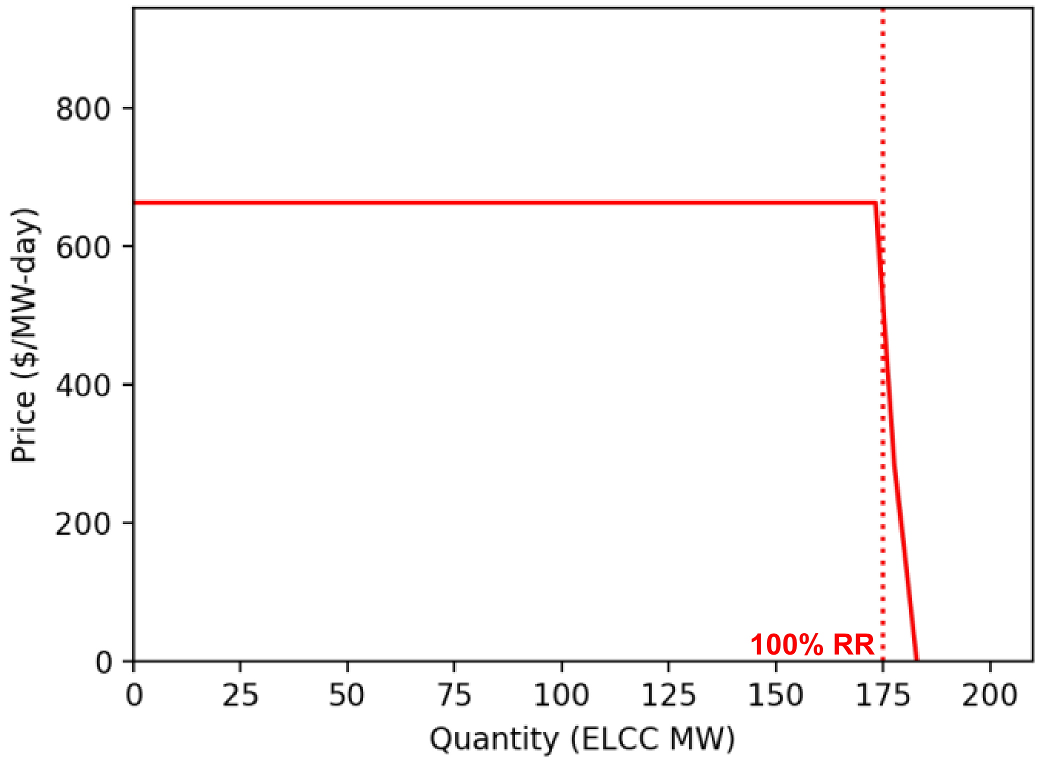
- **Annual Net CONE:** \$184/ICAP MW-day *(current 2026/27 default Net CONE)*
  - Summer Net CONE: \$379/UCAP MW-day = \$184 ÷ 0.97 ELCC × 2 seasons
  - Winter Net CONE: \$491/UCAP MW-day = \$184 ÷ 0.75 ELCC × 2 seasons

- When both seasons clear above \$0 and below the cap, both contribute to revenues of (most) resources, and both contribute some reliability risk
  - Simple average of seasonal prices can be interpreted as “annual average” price
  - Sum of reliability risk at cleared reserve margin in each season yields “annual average” reliability

Seasonal Demand Curves with Representative Parameters

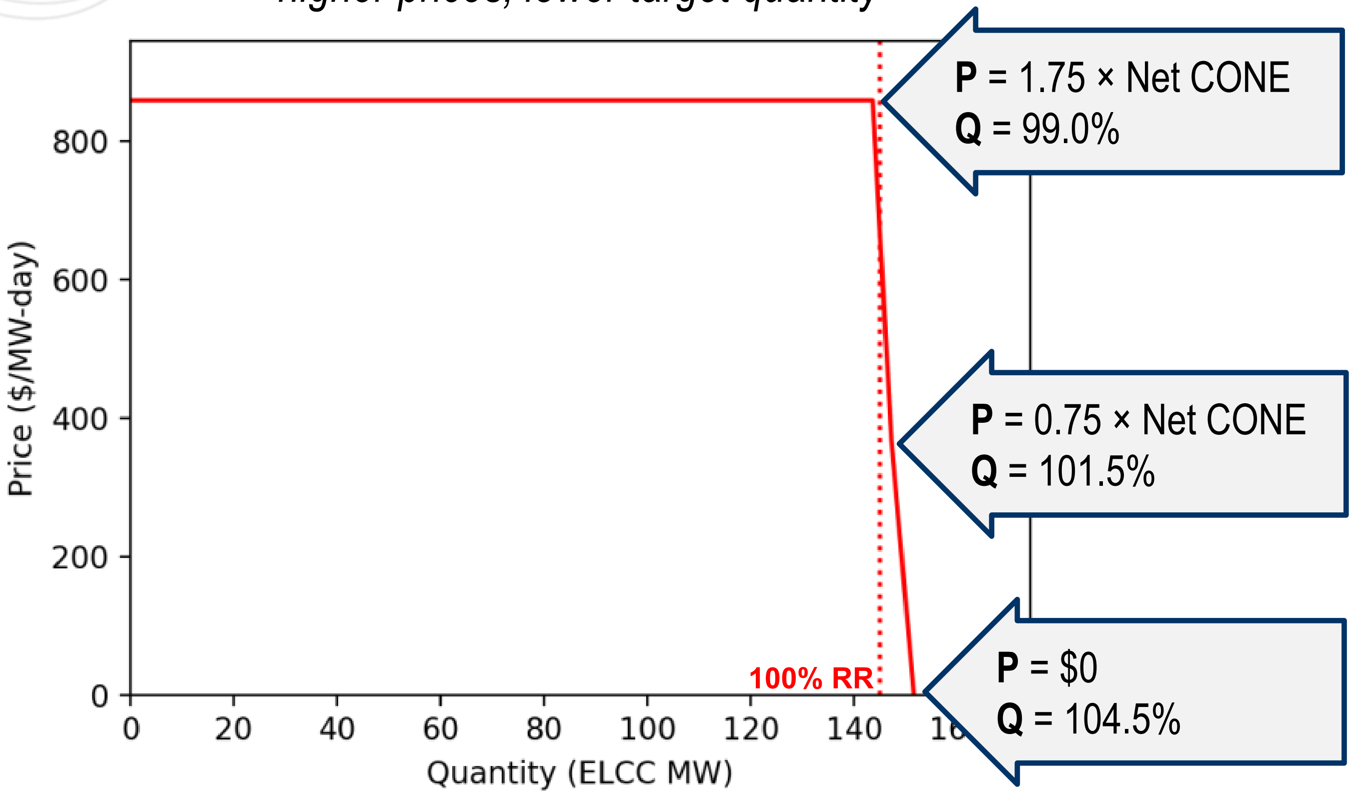
Summer

lower prices, higher target quantity



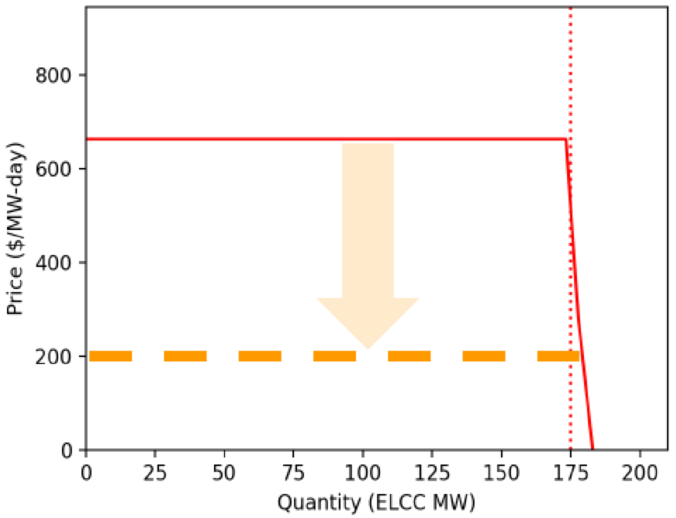
Winter

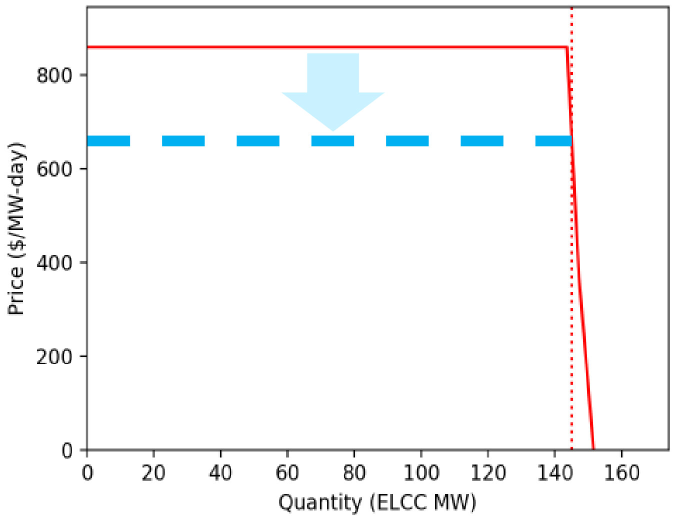
higher prices, lower target quantity



Annual Price Cap

- In the current annual design, the VRR curve provides a maximum annual willingness to pay for incremental capacity at point A of the curve: max{ Gross CONE, 1.75 x Net CONE }
  - This price defined in $/MW-day and is paid over 365 days of the delivery year
- The seasonal VRR curves presented thus far could allow a higher annual willingness to pay if supply is significantly constrained in both seasons. Therefore, to maintain the current maximum willingness to pay, we propose to apply an annual price cap in the clearing algorithm
  - The price in either season could exceed the cap if the price in the other season is below the cap
- **Implementation:** In auction clearing:
  1. If average seasonal price for the RTO or LDA is below the annual price cap, no cap is applied and the solution is final
  2. If the average seasonal price is above the annual price cap, the annual cap is applied
  3. When the annual price cap is applied, it reduces seasonal procurement by equal amounts in each season





Annual Price Cap (Example)

- **Annual Price Cap** is the annual average price if paying at point A in the season with the higher VRR curve and $0 in the other season.
- **Example:**
  - Point A on the **Summer** Demand Curve is $663/UCAP MW-day = $379 × 1.75
  - Point A on the **Winter** Demand Curve is $859/UCAP MW-day = $491 × 1.75
  - The average clearing price across seasons is constrained to no greater than $429.50.

$$\frac{Max(Summer_{Point\ A},\ Winter_{Point\ A})}{2\ Seasons} = \frac{Max(\$663, 859)}{2\ Seasons} = \$429.50$$

LDA Demand Curves

- **Status Quo**: No change to design principle that LDA demand curves enable recovery of annual Net CONE at the LDA requirement even without contribution from other LDAs
  - As mentioned, any LDA can meet local requirement even if price in RTO and any parents is $0/MW-day and any LDA child does not price separate
- **LDA Net CONE** translated to seasonal Net CONE values in the same manner as RTO
- **LDA Seasonal UCAP Requirement**
  - Procurement target calculated to allow *all* allowable annual LDA risk to occur in one season
  - Demand curve slope & price cap prevent local 1-in-25 equivalent risk from occurring in both seasons simultaneously (except at cap)
  - LDA seasonal requirement reflects amount of local seasonal capacity and annual CETO needed to meet local reliability needs

Detailed Walkthrough: Supply Offers

Seasonal Offer Structure

- **Context:** Under status quo, competitive resource offers reflect economic going-forward avoidable costs of selling capacity and taking on a capacity obligation:

- **Seasonal offer structure:** Each resource offers in the way that best reflects its economic going-forward avoidable costs of accepting a capacity obligation:
  - Annual offer component: reflects costs avoidable only if not committed in either season. *May be zero if resource plans continued operation and relevant costs of a capacity commitment are seasonal and included in seasonal offer components.*
  - Summer offer component: reflects costs avoidable only if not committed for summer
  - Winter offer component: parallel with summer

Note: offer components intended to be additive; examples on following slide

Seasonal Offer Structure, *Illustrative Examples*

Example Resource	Offer Structure
1. Resource has qualified & accredited capacity in summer only	Includes all costs in summer offer component
2A. Resource has qualified & accredited capacity in both seasons and with avoidable costs for continued operation, but is indifferent to receiving revenues in one or both seasons, AND is indifferent to receiving commitment in one or both seasons	Includes all costs in annual offer component; summer & winter offer components equal zero
2B. Annual resource plans to continue operation whose avoidable costs are entirely attributable to one season or the other; no annual net ACR	Separate all costs into summer and winter costs; annual offer component equals zero
2C. Annual resource incurs some costs it could avoid if uncommitted in both seasons, and other costs it could avoid if uncommitted in one season or the other	Provide non-zero offer summer, winter, and annual offer components reflecting costs

Application of market power mitigation and MSOC to seasonal offer components discussed in later slides

Detailed Walkthrough: Seasonal Market Clearing

Seasonal Auction Clearing – Overview

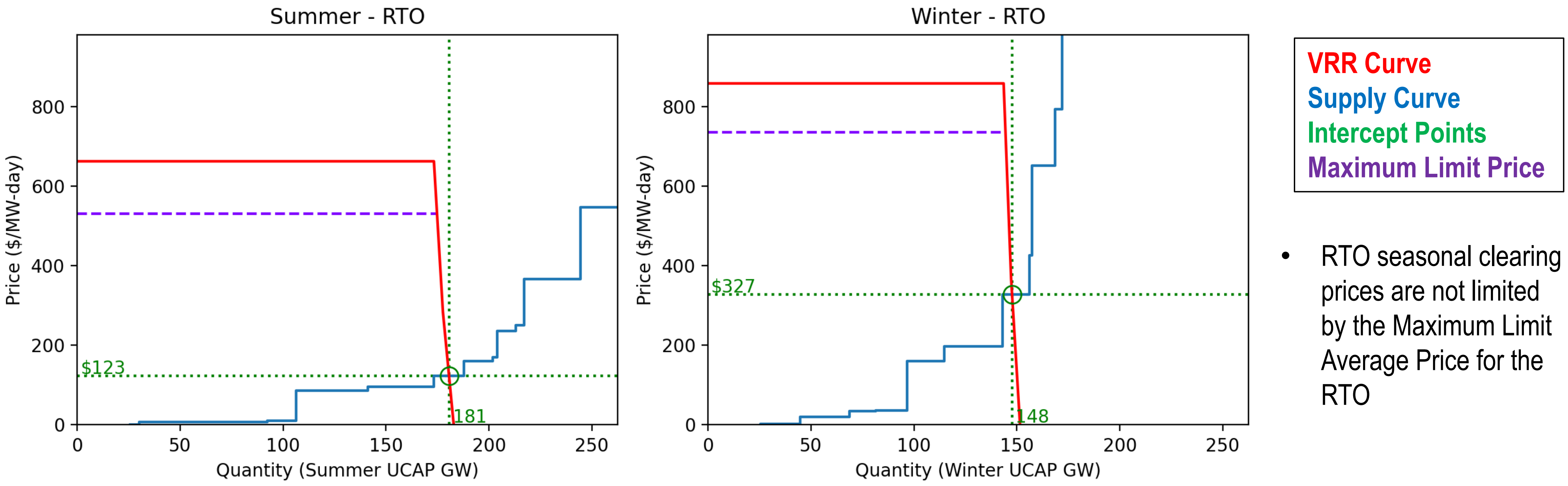
Auction clearing summary: Clear along seasonal VRR curves, choosing summer & winter capacity at least cost

- **Objective:** Implement existing clearing methodology in a seasonal framework as straightforwardly as possible, introducing no new design choices that conflict with status quo clearing approach
- **Approach:** Choose lowest-cost resources to clear market, minimizing clearing error (“deadweight loss”), while:
  - Recognizing differentiated capacity value of each resource and differentiated annual, summer, and winter costs
  - Enabling substitution of capacity in one season for capacity in another season when economic
- **Seasonal Prices:** Reflect marginal value of incremental capacity in each season at equilibrium supply/demand balance.
  - **Efficiently equalize marginal EUE per dollar across seasons**
  - **Ensure that the market clearing is market equilibrium** and no competitive participant prefers a different outcome than the clearing outcome given the seasonal clearing prices. Auction revenues cover costs of each cleared resource:

$$P_{summer} \times Q_{summer} + P_{winter} \times Q_{winter} \geq Cost_{summer} + Cost_{winter} + Cost_{annual}$$

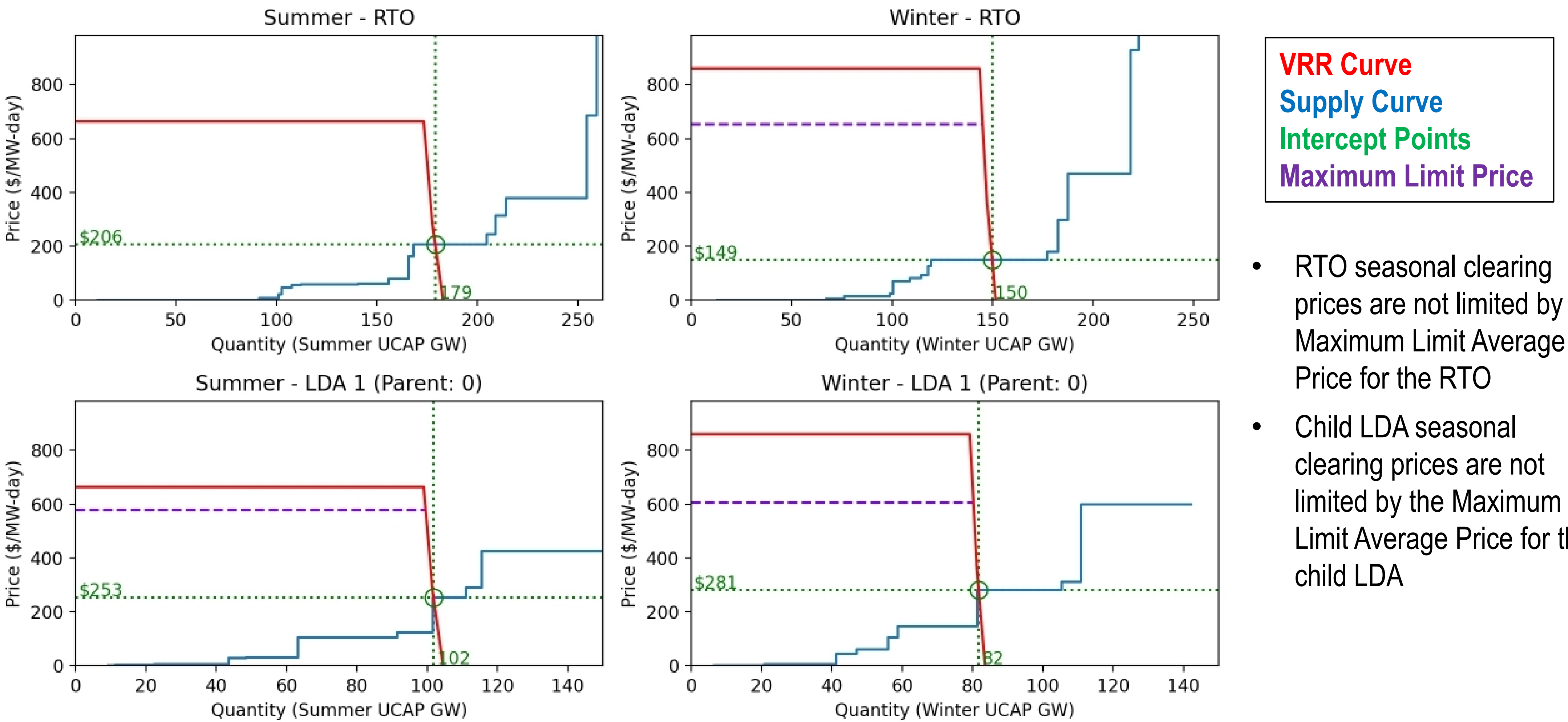
  - **Ensure “incentive compatibility” constraint is satisfied,** such that every participant achieves the best outcome by revealing their true costs. No participant can strategically bid to achieve a better outcome.
  - **Avoid any need for make whole payments** or uplift (excepting inflexible resource offers, as today)

Example 1: RTO Only



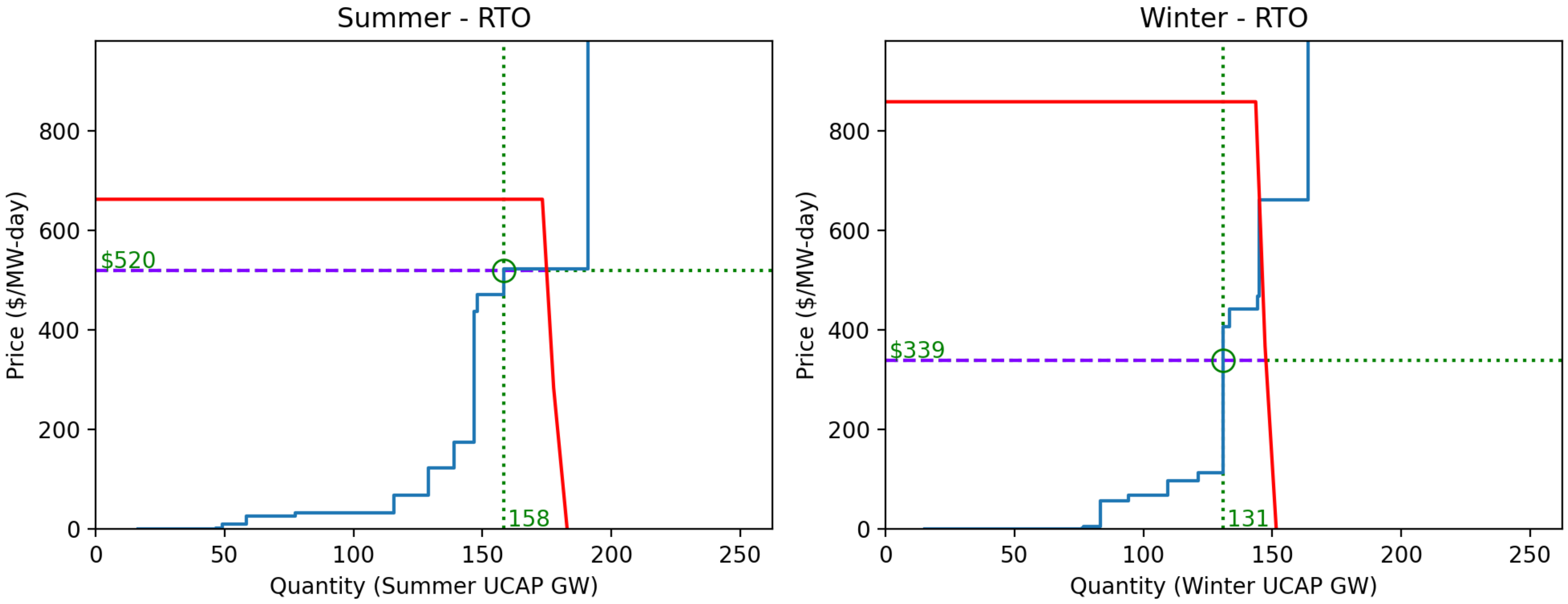
- RTO seasonal clearing prices are not limited by the Maximum Limit Average Price for the RTO

Example 2: RTO & LDA



- RTO seasonal clearing prices are not limited by the Maximum Limit Average Price for the RTO
- Child LDA seasonal clearing prices are not limited by the Maximum Limit Average Price for the child LDA

Example 3: RTO Only, Clearing at Price Cap



VRR Curve
Supply Curve
Intercept Points
Maximum Limit Price

- RTO seasonal clearing prices are limited by the Maximum Limit Average Price for the RTO.
- The clearing engine will equalize the distance between the cleared MW and VRR curve quantity at the relevant price level

Market Power Mitigation

Capacity Must Offer Obligation

Maintain status quo capacity must offer requirements, including the current categorical exemption from the must offer requirement for Intermittent and Storage Capacity Resources (and Hybrids) **Update to Proposal**

- Updated proposal with consideration of the concerns expressed by a number of stakeholders that removing the must offer exemption while continuing to subject units of these resource types to PAI penalties during time periods in which they have no ability to physically hedge the risk (e.g. solar at night) imposes inefficient risks for them

MSOC: Objectives & Principles

- Objective of capacity market power mitigation is to return the capacity market to outcomes that would prevail in a competitive market
- This requires mitigation of uncompetitive offers to competitive levels
- Competitive offer level includes all costs a competitive market seller would consider when making an offer
  - *Reflects the level below which costs of accepting capacity obligation exceed benefits and seller would prefer not to clear*
  - *Expressing a non-zero offer price does not constitute withholding*

MSOC for Seasonal Offer Components

- **Seasonal offer mitigation:** Each resource's offers mitigated to reflects the economic going-forward avoidable costs of accepting a capacity obligation that a competitive market seller would wish to recover, or else not clear:

- **Annual** offer component: reflects costs avoidable only if not committed in either season
  - Most closely reflects MSOC under annual status quo. Equal to current Net ACR definition with season-specific cost components removed
  - Will be zero if gross Avoidable Cost Rate, net of projected net E&AS revenues, is zero or negative.
  - Zero annual MSOC expected for many resources for which annual energy & other PJM revenues more than offset going-forward costs of operation & maintenance

- **Summer** and **winter** offer components: Resources already recovering annual & relevant seasonal costs in one season nevertheless bear additional costs when clearing for an additional season:
  - Summer and winter costs of mitigating CP risks (CPQR)
  - Other: costs of procuring firm fuel transportation for winter (if would not be incurred if not selling capacity); etc.

Standard Methodology for CPQR Calculation

- **CPQR Proposal:** Introduce a standard approach to estimate unit-specific CPQR based on assessment of unit-specific CP risk given historical performance
  - Provides "default" starting point for CPQR that PJM will accept as reflective of the expected costs of a competitive participant to mitigate and manage the risks associated with a CP obligation
  - Improves transparency regarding CPQR calculation
  - Lessens burden associated with unit-specific review process of seller CPQR assessment
  - Not intended to disallow sellers wishing to undertake unit-specific process

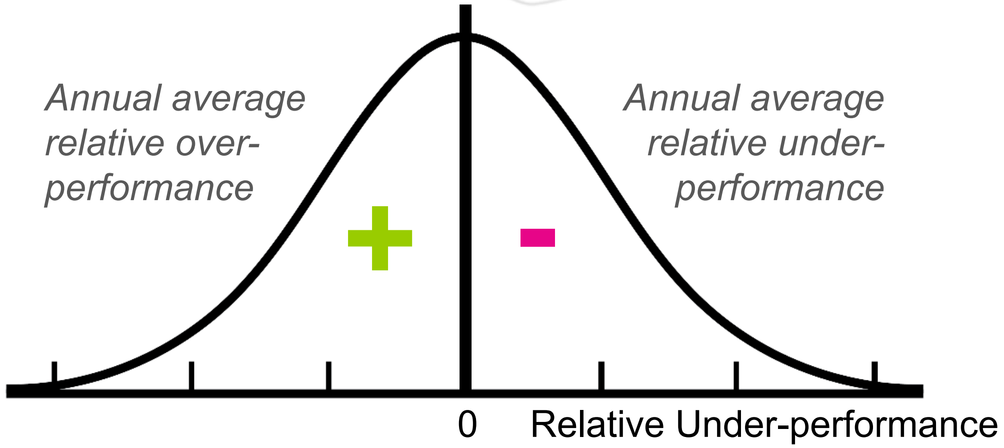
Standard CPQR Calculation: Approach

- **Approach Overview:** For each resource, PJM proposes to:
  1. Conduct probabilistic analysis of unit-specific performance under a range of system conditions
  2. Assess distribution of performance during simulated performance assessment intervals (PAIs)
  3. Assess distribution of potential net non-performance charges & bonuses
  4. Assess competitive cost of mitigating risk of net non-performance charges

- Broadly consistent with IMM framework describing simulated approach that relies on weather experienced during historical PAIs and condition probabilities (based on weather) for estimating number of PAIs and unit outage probability.

Standard CPQR Calculation: Approach, *Continued*

- **Assessment of Performance:** PJM to estimate unit-specific distribution of potential annual total *net* over- and under-performance (MW × intervals) during modeled PAIs
  - Because this assessment relies on the same risk & accreditation modeling used to determine UCAP, the mean of this distribution tends towards zero
- **Assessment of Risk:** PJM to estimate unit-specific distribution of potential annual total *net* PAI charges/bonuses
  - If penalty rate equals bonus rate on average, the mean of this distribution tends towards $0, but capacity resources still face risk across the distribution
  - Other CP design changes will tend to equalize penalty & bonus rate. PJM to assume equal for this analysis
- **Cost of Mitigating Risk:** Calculated as at right
  - Cost of risk & other assumptions periodically reviewed



$$CPQR_{Seasonal} = Risk\ Cost \times Extreme\ Value$$

Mean ($/MW-d)	Extreme Value (%ile)	Extreme Value ($/MW-d)	Cost of Risk (%)	CPQR ($/MW-d)
$0 *default*	95th *default*	$150 *unit-specific (example)*	10% *default*	$15 *unit-specific (example)*

Performance Assessments and Testing

Performance Assessments and Testing

Multi-tiered framework of performance assessments and testing to help ensure delivery of the capacity that has been committed through forward auctions

Does the physical capacity exist to meet its commitment?	• **Daily Commitment Compliance** – Assesses if a resource has sufficient accredited capacity to satisfy its capacity commitment. Daily penalty rate set at seasonal clearing price ($/MW-day) + higher of ($20, or 20% of clearing price). • **Generator Seasonal Capability Testing** – Assesses if a resource can demonstrate it's capable of operating at its committed ICAP in both summer and winter seasons. Same penalty rate as above, but retroactively assessed each day of season if short.
Is the unit prepared to run if needed?	• **Operational Testing** – PJM initiated testing of a generator's availability status to better ensure they are capable of operating if/when needed for reliability.
Does the unit perform during reliability events?	• **PAIs** – Assesses if a resource actually performs during "true" reliability events with a significant penalty for failure to meet expected performance levels.

Generator Seasonal Capability Testing

Status quo rules with the following proposed reforms: **Updated**

- Require a physical demonstration of capability in each season (no longer allow for summer test data to be adjusted for winter ambient conditions and submitted as verification of winter capability)
- Assess capability testing shortfalls by comparing the resource's seasonal capability test value to the committed ICAP of the resource for each day in the season; any day that the committed ICAP exceeds the seasonal test value results in a deficiency charge for the shortfall amount on that day.
  - Testing penalty rate for each season based on seasonal clearing price + higher of ($20/MW-day, or 20% of the seasonal clearing price)
  - Remove the current administrative rule that bases the decision to assess a penalty charge on if the owner submits the de-rate corresponding to the testing shortfall in GADS (no penalty charge), or if PJM has to submit it for them (penalty assessed)

Updated the shortfall assessment to be done against daily committed ICAP rather than average seasonal committed ICAP

Generator Operational Testing

Updated

- Allow for PJM to initiate up to two operational tests per season for each unit to better ensure resources are capable of operating if/when needed for reliability.
  - PJM initiated tests will respect parameter limits of the available schedule on which the unit is committed
  - Units will be made whole for their costs during PJM initiated tests, but not re-tests following a failed test
  - Considered passing if the unit successfully comes online within a certain threshold of expected time (i.e. greater of 10% TTS or 10 minutes) and operates for minimum run time

- **Impact of a failed test:**
  - Forced outage ticket in GADS and unit marked as unavailable until it successfully operates or addresses the issue that caused the unit to fail to start on time
  - PJM may issue re-tests (at owners cost) following any failed test (does not count against limit of 2)
  - If a re-test is issued by PJM and the unit fails to successfully come online, a capacity deficiency penalty shall be assessed until the unit is shown to be capable of operating again

PAI Reform

Proposal: Adopt PAI triggers consistent with recent filing: ER23-1996

(Focuses performance assessments on times of greatest reliability risk)

Triggers:

- Primary Reserve shortages coupled with certain Emergency Actions (e.g. Voltage Reduction Warnings, Manual Load Dump Warnings, Max Gen Emergency, etc.)

OR

- Deploy all resources action, voltage reduction action, manual load dump action, or load shed directive for an entire Reserve Zone or Reserve Sub-zone

Assessed Resources

Proposal: Limit pool of resources that get assessed during PAIs to only committed capacity

(Resources must meet the capacity qualification criteria and take on the obligations associated with a commitment to be eligible to receive any capacity revenues, including PAI bonus revenues)

- Actual Performance capped at committed ICAP of resources, including in the Balancing Ratio (BR)
- Non-committed capacity resources and “energy-only” units / imports not eligible for bonus
- Resources that perform above UCAP * BR eligible for bonus up to committed ICAP level
- DR/PRD not eligible for bonus (Expected Performance = Committed ICAP), although netting of performance across underlying customers / registrations / resources that are dispatched still allowed
- EE also not eligible for bonus (Expected Performance = Committed ICAP)

Proposal: Update Balancing Ratio formula to reflect the proposed change to assessed resources and adjust denominator for excused MW

(Better balances the penalty rate and bonus rate during PAIs)

- BR Numerator = Total Generation Actual Performance (capped at the committed ICAP of each resource). No Net Energy Imports or DR/PRD Bonus MW.
- BR Denominator = Total Generation Committed UCAP (reduced for committed MW that are excused from the assessment)

Proposal for Excused MW:

- Planned and maintenance outage MW approved by PJM (status quo, considering removing excusal)
- Manual dispatch instructions (status quo)
- Online units excused if LMP-desired MW (based on dispatched schedule) fall below committed UCAP
- No excusal for offline units absent manual dispatch instruction

Additional PAI Reforms

Updated

Proposal:

1. Remove the option for retroactive replacement transactions following a PAI (not allowed for FRR as well)
2. Remove the option for FRR Entities to elect a physical penalty assessment and apply the same financial assessment to all participants for PAIs
3. Clarify PAI calculations (e.g. Actual Performance) and excusal language in Tariff and/or Manuals
4. Enable more granular transactions of financial PAI obligation associated with committed UCAP:

Transfers of PAI Obligations

Update to Proposal

Proposal: Introduce new PAI obligation transfer for market sellers to exchange the financial PAI obligation associated with committed UCAP on a more granular basis (i.e. hourly)

(Enables market sellers to more effectively manage CP risk, thereby reducing CPQR, and provides for greater opportunity for the financial PAI obligation to be backed by a physical hedge)

Design Element	Proposal	Status Quo Transfers / Replacements
Product	Hourly PAI Committed UCAP	Daily Committed UCAP
Cap on Resource Obligation	Minimum of {Owned ICAP, CIRs}	Owned UCAP
Locational Constraints	Status quo rules on replacements	Recognizes LDA locational constraints
PAI Impact	Adjusts committed MW in PAI shortfall calculation for all intervals in hour	Adjusts committed MW in PAI shortfall calculation for all intervals in day
Impact on other Obligations	No impact beyond PAIs	Impacts other obligations (e.g. energy market must offer / testing)
Indemnification	Seller indemnifies PJM if buyer can't pay	Seller indemnifies PJM if buyer can't pay

PAI Summary

	Proposal
PAI Trigger(s) Keep the recently as-filed PAI triggers from ER23-1996	• Primary Reserve shortages coupled with certain Emergency Actions (e.g. Voltage Reduction Warnings, Manual Load Dump Warnings, Max Gen Emergency, etc.) • Deploy all resources action, voltage reduction action, manual load dump action, or load shed directive for an entire Reserve Zone or Reserve Sub-zone
Assessed Resources	Only committed capacity resources (up to committed ICAP)
Balancing Ratio	Actual Performance of committed generation capacity / committed UCAP of generation (adjusted for excused MW), not to exceed 1
Expected Performance	Status quo (i.e. Generation: Committed UCAP * Balancing Ratio; DR / EE / PRD: Committed ICAP)
Actual Performance	Status quo, but capped at committed ICAP of resources (or total portfolio committed ICAP of CSP)
Excusals	Limited to planned and maintenance outages approved by PJM, manual dispatch instructions, and transmission security limitations
Penalty Rate	Status quo (i.e. Net CONE * days in year / 30 hours / 12 intervals)
Stop-loss	Status quo (i.e. Net CONE * days in year * 1.5 * commitment)

FRR Insufficiency and Deficiency Charges

Updated

Proposal: Update the penalty rate for both insufficiency charges (*assessed on shortfalls of preliminary FRR plans*) and daily deficiency charges (*assessed on final plans during the Delivery Year*) to the greater of annual {CONE, or 1.75x Net CONE} (*i.e. annual price cap in RPM*).

(Improves the balance of potential charges between the two assessments; better aligns and improves the incentive for FRR entities to provide sufficient capacity to meet their fixed requirement going into the Delivery Year)

- Status quo penalty rates for FRR insufficiency and daily deficiency charges:
  - Insufficiency charges: 2x CONE penalty rate
  - Daily deficiency charges: 1.2x BRA clearing price

PJM Generation Weatherization Site Visit Proposal

Objective and Overview

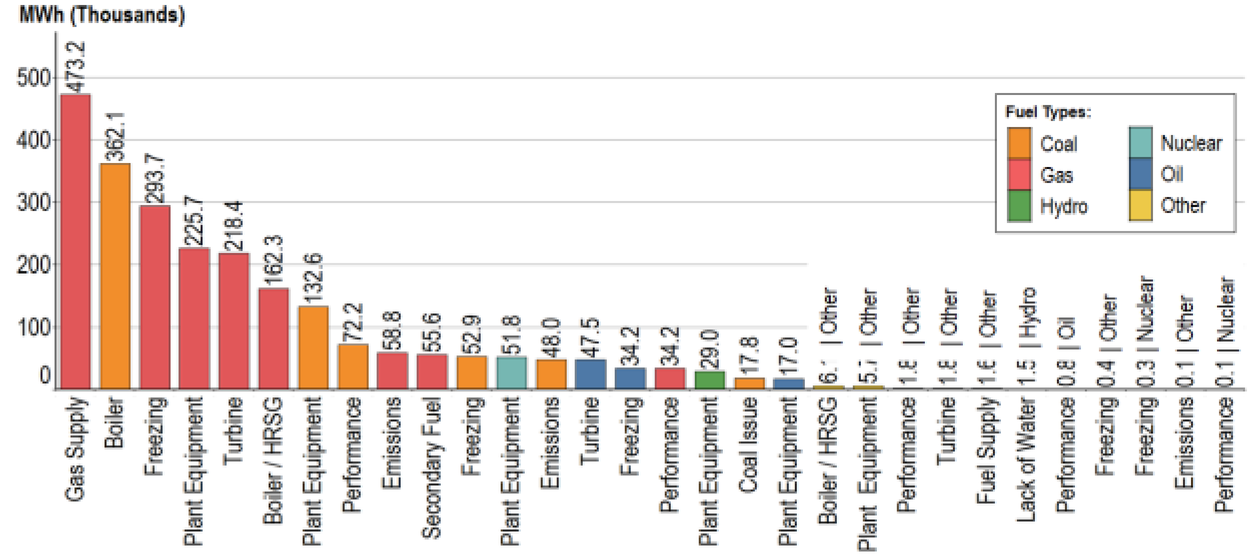
- Establish a more robust weatherization preparation and monitoring program to help ensure the reliability and dependability of capacity resources.
  - Building on NERC standards and existing PJM winterization efforts
  - Initial framework of an evolving program with metrics and reporting for transparency

- Create market mechanisms to incentivize taking proactive measures to maintain resource availability in a changing operating environment.

- Collaborative effort between PJM and resource owners.
  - Site visits to help identify potential gaps and promote best practices
  - Cure period to address issues year-round
  - Sharing lessons learned from analysis of common modes of failure

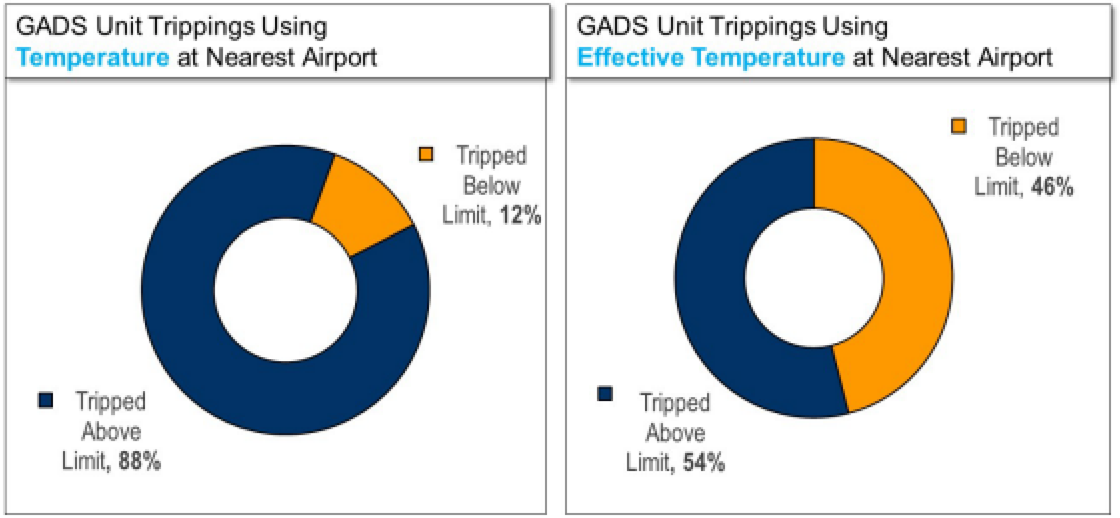
WSE Weather Related Outages

Figure 39. Dec 23, 24 and 25 Forced MWh by Fuel Type and Cause



Source: GADS as of March 1, 2023. Wind and solar unit outages are not included in the data.

Figure 40. Cold Weather Operating Limit Comparison Against GADS Reported Outage and Temperature



Existing Efforts

- ERCOT Summer/Winter preparations and readiness
  - Seasonal inspections of both generation and transmission facilities
  - Vast majority of generation fleet to be inspected over a several year period
  - Cure period to remedy issues without penalty
  - Dedicated staff to perform inspections, process results, and establish reports
- NYISO site visits to verify information from Capacity Market Participants
  - Ad-hoc visit, not meant to cover entire generation fleet
  - Verification of provided documentation around performance and operating data
  - Site-specific walkthroughs including reviews of various plant equipment and systems
- RF Winterization Outreach Program
  - Established in 2014 after FERC inquires stemming from the polar vortex
  - Yearly site visits to select generators based on established criteria
  - Outreach to provide education to generating facilities, not a compliance process

Site Visit Scope

- Ensure steps are taken in accordance with PJM's weatherization requirements.
  - Documentation for cold weather operating limits, fuel arrangements, etc.
  - Plant walkthrough to review weatherization actions and understand challenges
  - Not a standalone effort but rather one step in overall goal of operational readiness

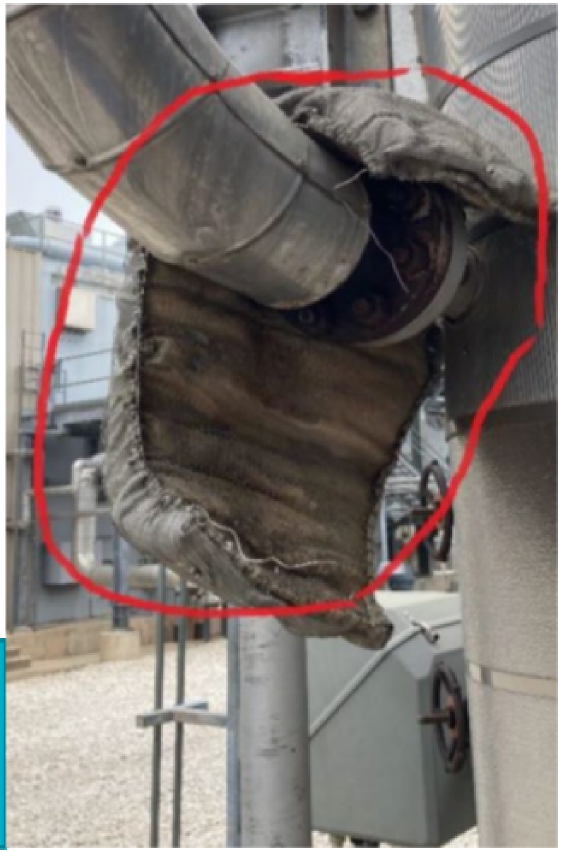
- Goal of visiting committed capacity resources roughly once every ***five*** years.
  - Focus is currently on winter preparations based on elevated risk
  - Guidelines to be provided around selection process, prioritization of newly commissioned resources
  - Ample notice to be provided to resources, not meant to be a surprise
  - Winter visits to be done in Q4 of calendar year when winterization efforts are near completion

- Standardized checklist of areas to review with adjustments for unit specific items.
  - Revise checklist based on updates to industry standards and operating experience
  - Not to be used as pass/fail or certification, more opportunity to do unit specific outreach

Examples

Heat Tracing Control Panel

Temporary Wind Break Structures



Incomplete Insulation Blanket above, "Clamshell" Instrument Enclosure below

Examples

De-Icing Mechanisms

Cable/Piping Placement

Cure Period

- Upon identification of an issue, PJM will work with the resource to establish a reasonable cure period to resolve the issue without capacity deficiency penalties.
  - Gaining an understanding of remedy scope and accommodating the outage
  - Weatherization failures outside of/beyond cure periods will incur penalties
  - High level metrics around identified issues and corrective actions
- Cure periods not restricted to site visit discovered issues, self-identified/reported issues are included as well.
  - Reporting to PJM shall include availability, operational restrictions, and parameter updates
  - Site visits are limited in frequency and scope
  - Encourage proactive collaboration between PJM and resources throughout the year

- PJM staff to manage and conduct site visits.
  - Mix of FTEs and trained contractors to schedule, perform, and report on plant walkthroughs
  - Potential partnerships with other entities (RF, SERC, IMM)
- Costs reflected in capacity offers and allocated to committed capacity resources through special schedule.
  - Includes training, procedure development, and logistics
  - Formula with proration to resources based on MWs
  - Allowable cost as part of ACR

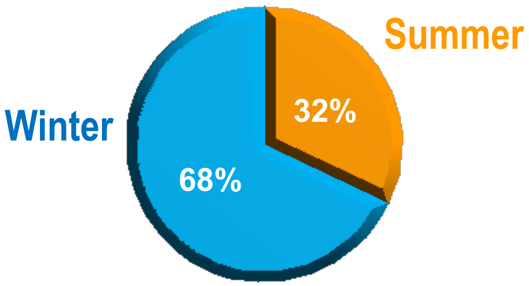
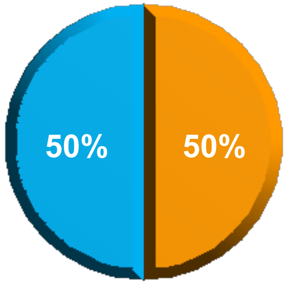
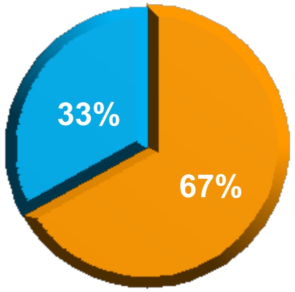
- Phased implementation of program over upcoming years.
  - 2023 Q4
    - Collaboration with other entities like RF, no PJM initiated site visits
    - Enhance existing winterization process and checklist
  - 2024/FERC acceptance of filling
    - Tariff/manual changes to outline details like penalties, cure periods, scope, and frequency
    - Develop site visit documentation and reporting
    - PJM initiated site visits

Summary

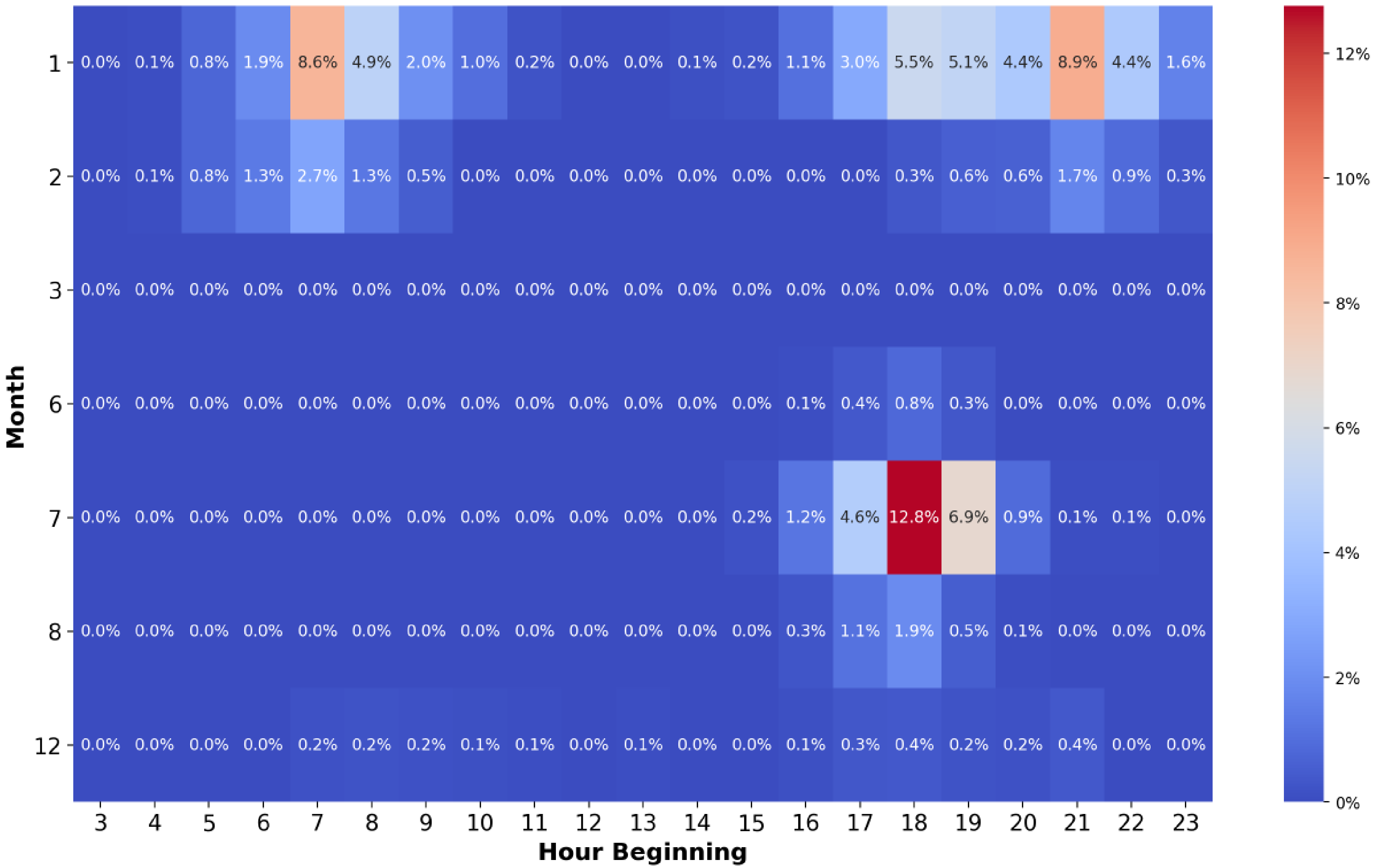
- Initial framework of weatherization process.
  - Participation in site visits included as part of PJM proposal
  - Implementation details to be worked out in governing document updates outside of CIFP
- Annual effort with a focus on winter readiness.
  - Performed for commercial units, not looking three years ahead
  - Potential for expansion beyond winter based on need
- Collaborative and transparent effort.
  - Reporting on progress, metrics, and lessons learned
  - Open communication with resource owners on site visit scheduling, checklist/areas of interest, and findings

Updated Analysis:
Reliability Risk Modeling and Accreditation

RTO Risk Modeling: Updated Base Case

Simulation	EUE	LOLH	LOLE
1 **Base Case** - Weather history back to **1993** - No climate change adjustment - Updated storage/DR dispatch and planned outage data	 EUE = 1,000 MWh	 LOLH = 0.3 hours	 LOLE = 0.10 days

Base Case Heatmap: Annual Share of EUE by Month-Hour



Sensitivity S1: Impact of Excluding 1994 Winter Event

Simulation		EUE	LOLH	LOLE
No climate change adjustments				
1	Base Case using weather back to 1993/94 (from slide 57)	W:68% S:32% 1,000 MWh	W:50% S:50% 0.3 hours	W:33% S:67% 0.10 days
S1	Weather back to 1994/95 (excludes 1994 winter)	W:44% S:56% 700 MWh	W:32% S:68% 0.27 hours	W:21% S:79% 0.10 days

If the system is planned using S1, but then a winter like winter 1993/94 were to occur with a probability of 1 in 30, then the metrics that describe the reliability of the system are:

LOLE: 0.11 days/year (+10% vs. 0.1 days/year)
LOLH: 0.34 hours/year (+26% vs 0.27 hours/year)
EUE: 1,100 MWh/year (+57% vs. 700 MWh/year)

Sensitivity S2B: Impact of Climate Change Adjustment to 1993

Simulation		EUE	LOLH	LOLE
Climate change adjustments (mean trend only)				
2B	Weather back to 1973	W:46% S:54% 1,400 MWh	W:30% S:70% 0.33 hours	W:21% S:79% 0.10 days
S2B	Weather back to 1993	W:17% S:83% 850 MWh	W:16% S:84% 0.27 hours	W:13% S:87% 0.10 days

Note: The results of this sensitivity (S2B) are not compared to the Base Case. Instead, they are compared to the results from the case that includes the climate change adjustment (mean trend only) with weather back to 1973.

Estimated 26/27 Class Average Accreditation Values *(based on "Model 1" to 1993)*

	Summer	Winter	Annual Equivalent
Onshore Wind	9%	36%	25%
Offshore Wind	17%	68%	47%
Solar Fixed Panel	18%	1%	8%
Solar Tracking Panel	31%	2%	13%
4-hr Storage	90%	38%	59%
6-hr Storage	97%	48%	67%
8-hr Storage	99%	58%	75%
10-hr Storage	100%	69%	81%
Solar Hybrid Open Loop	53%	11%	28%
Solar Hybrid Closed Loop	53%	11%	28%
Hydro Intermittent	40%	44%	42%
Landfill Gas Intermittent	60%	51%	55%
Hydro with Non-Pumped Storage	97%	82%	88%

	Summer	Winter	Annual Equivalent
Thermals (Overall)	**94%**	**78%**	**84%**
Nuclear	97%	95%	96%
Coal	89%	83%	86%
Gas CC	97%	75%	83%
Gas CT	98%	62%	76%

** Additional thermal class accreditations forthcoming*

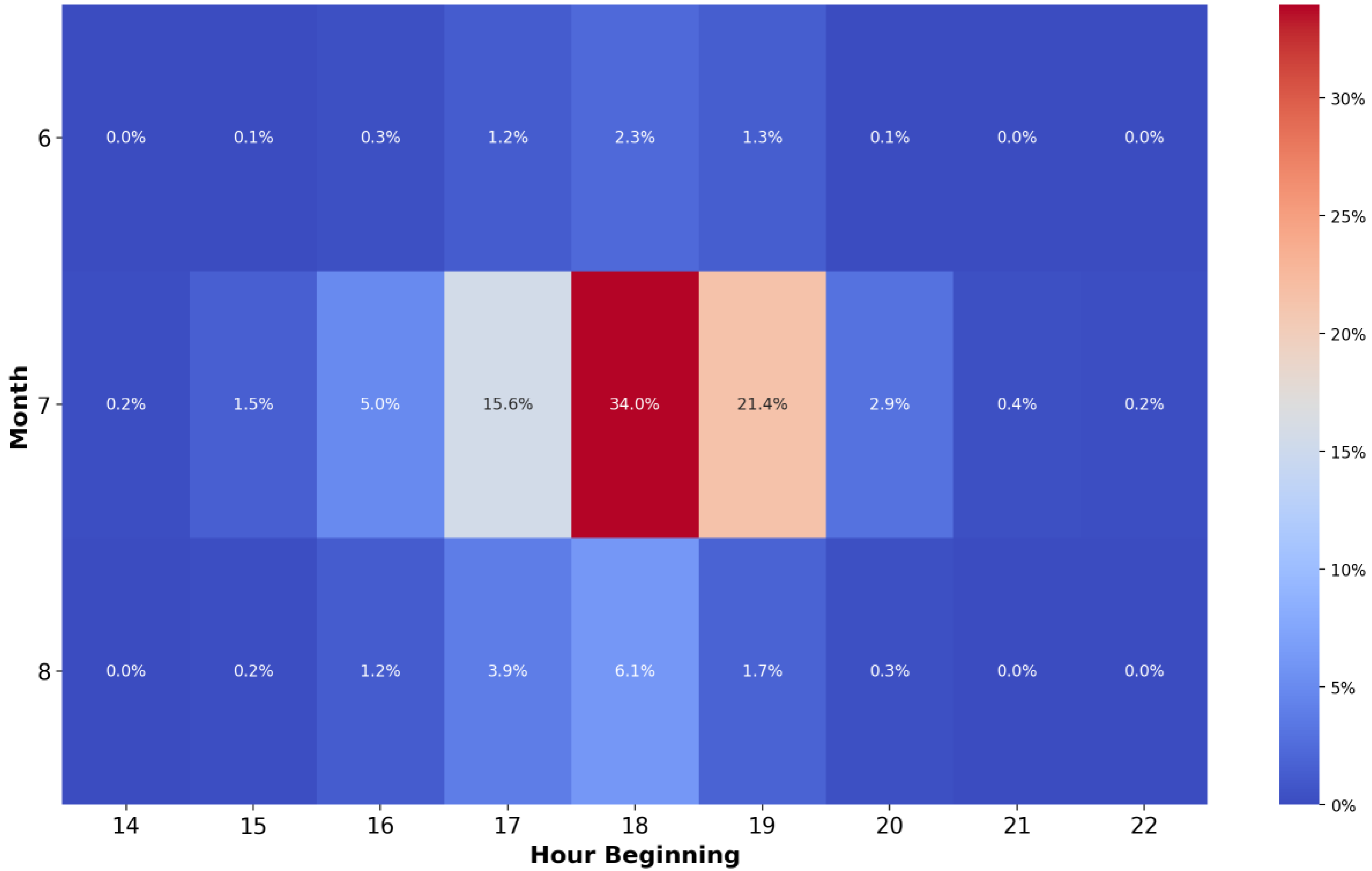
	Summer	Winter	Annual Equivalent
DR	109%	73%	87%

** DR values reflect status quo performance windows; assessment of 24-hour availability DR forthcoming*

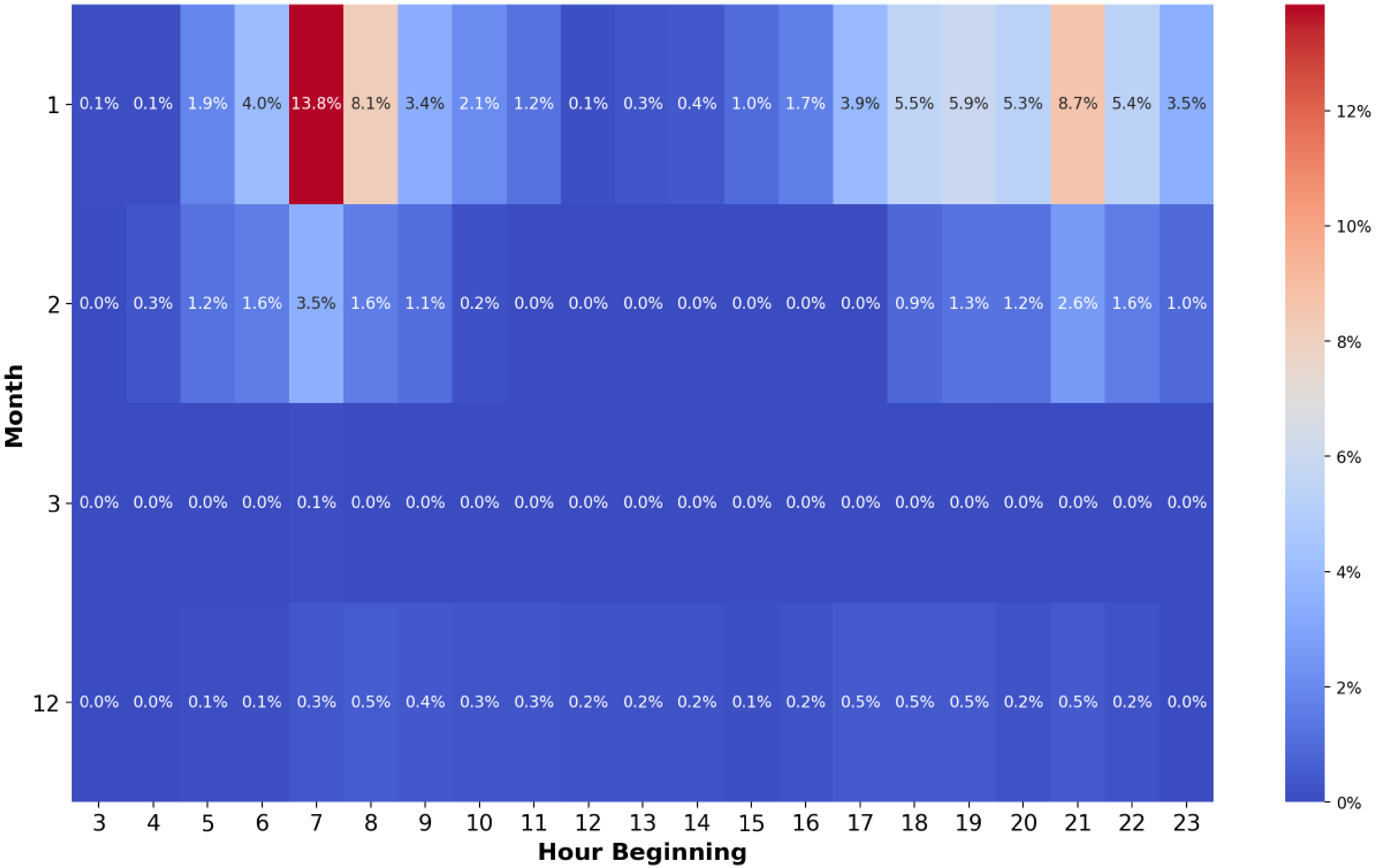
Understanding the Seasonal Accreditation Values

- The following slides provide seasonal LOLH heatmaps and various scatterplots to help visualize the patterns of reliability risk and results in accreditation values by season
- Seasonal LOLH heatmaps
  - Provide the key combinations of month-hour that drive the risk in the model. Therefore, these month-hour combinations play an important role in the determination of EUE improvement when an incremental quantity of each class is added to the system
- Scatterplots: Number of loss of load hours in day vs. average hourly performance as percent of nameplate during loss of load hours in day
  - Useful to understand accreditation results for limited-duration resources
  - As expected, the graphs show that the more hours with loss of load in a day, the lower the average performance in those hours of a limited duration resource

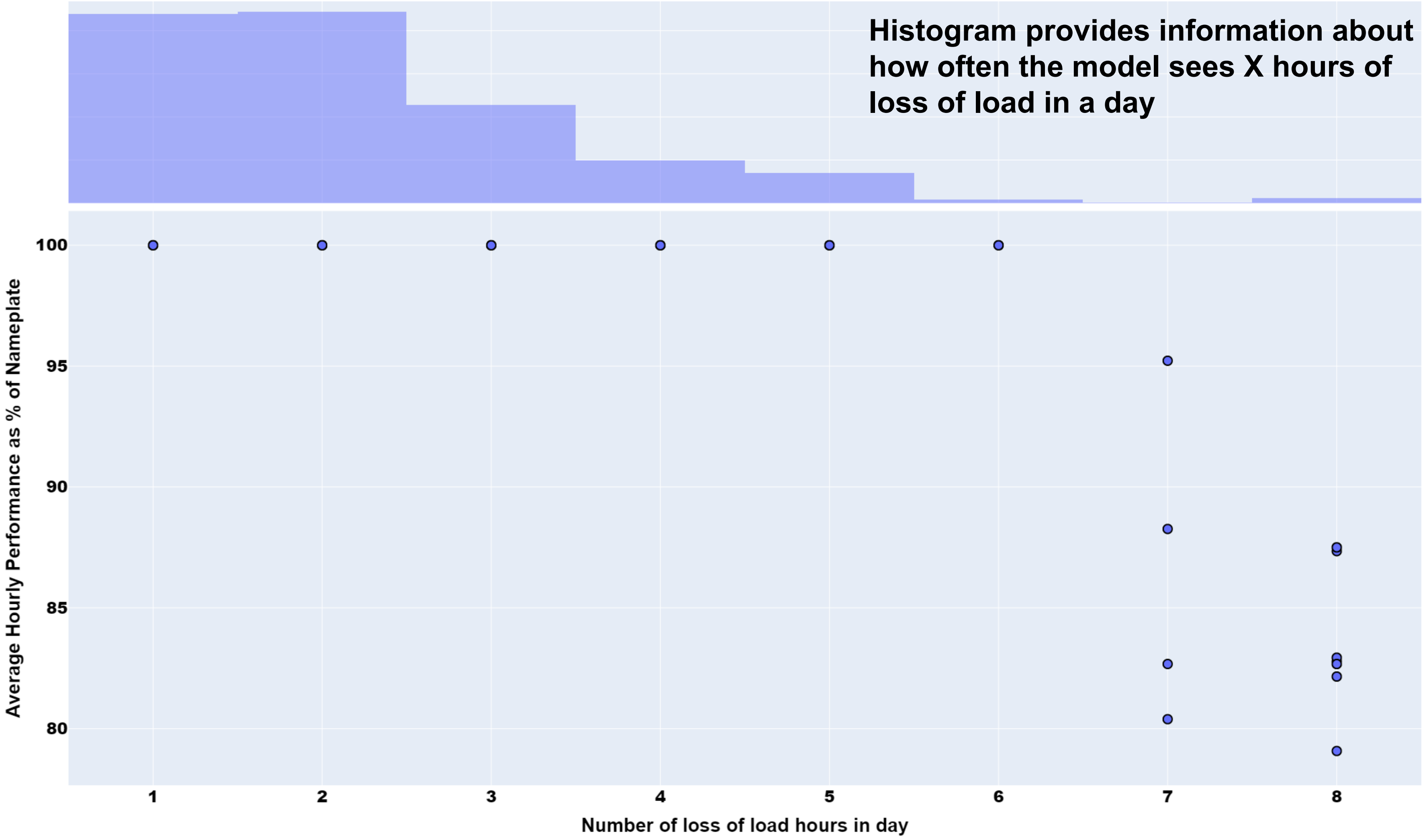
Heatmap: Summer Share of LOLH by Month-Hour



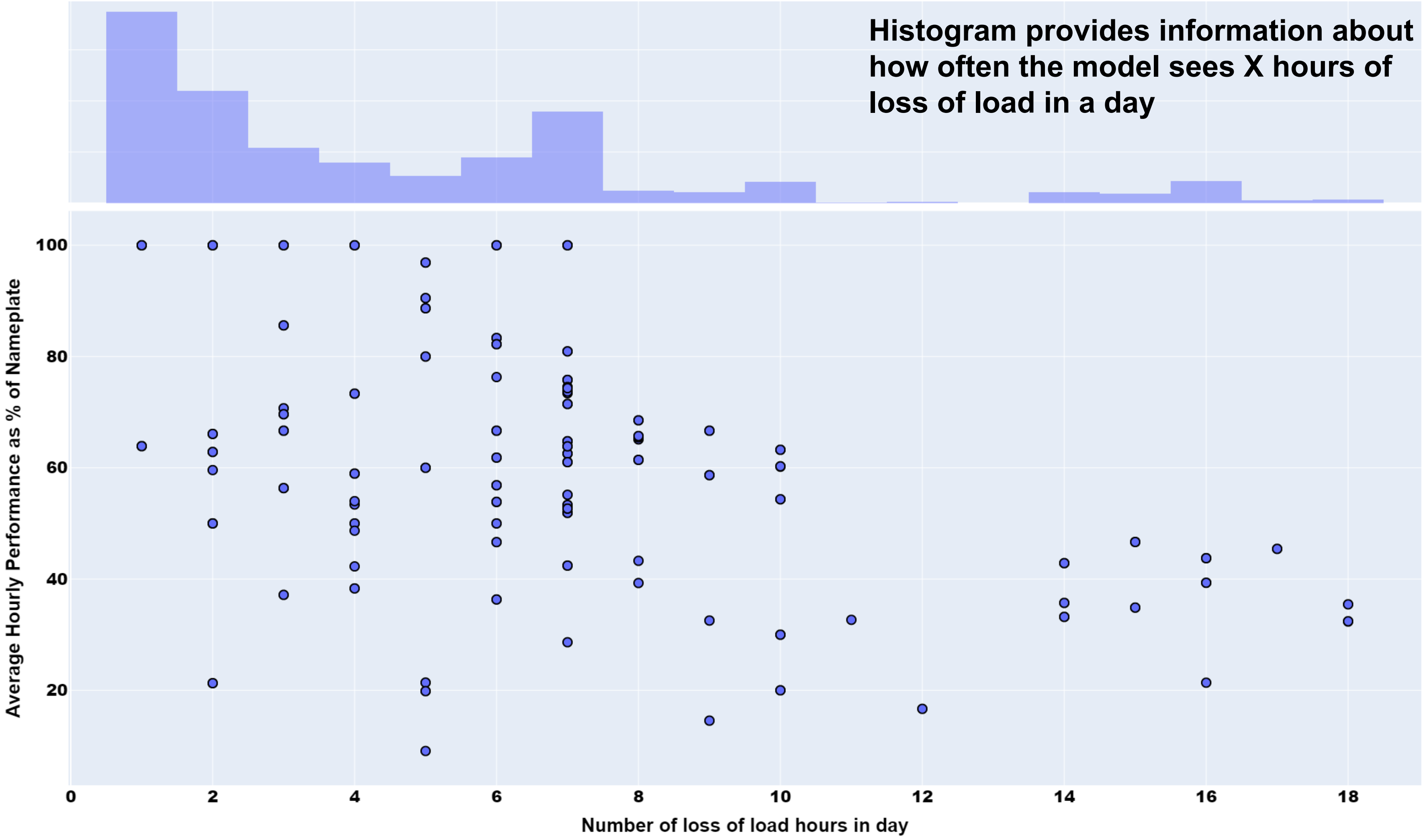
Heatmap: Winter Share of LOLH by Month-Hour



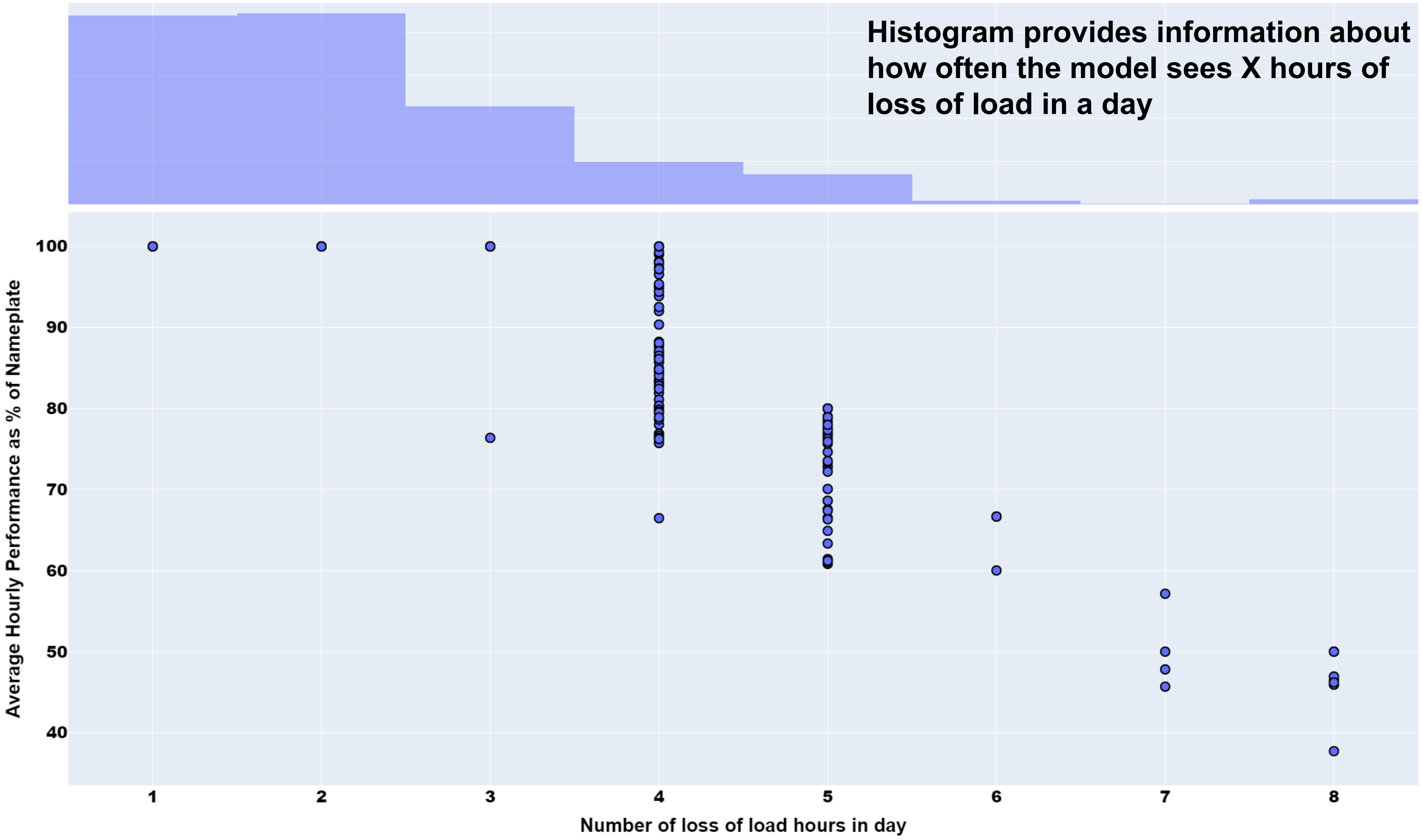
Scatterplot: Summer for 8-hour Storage



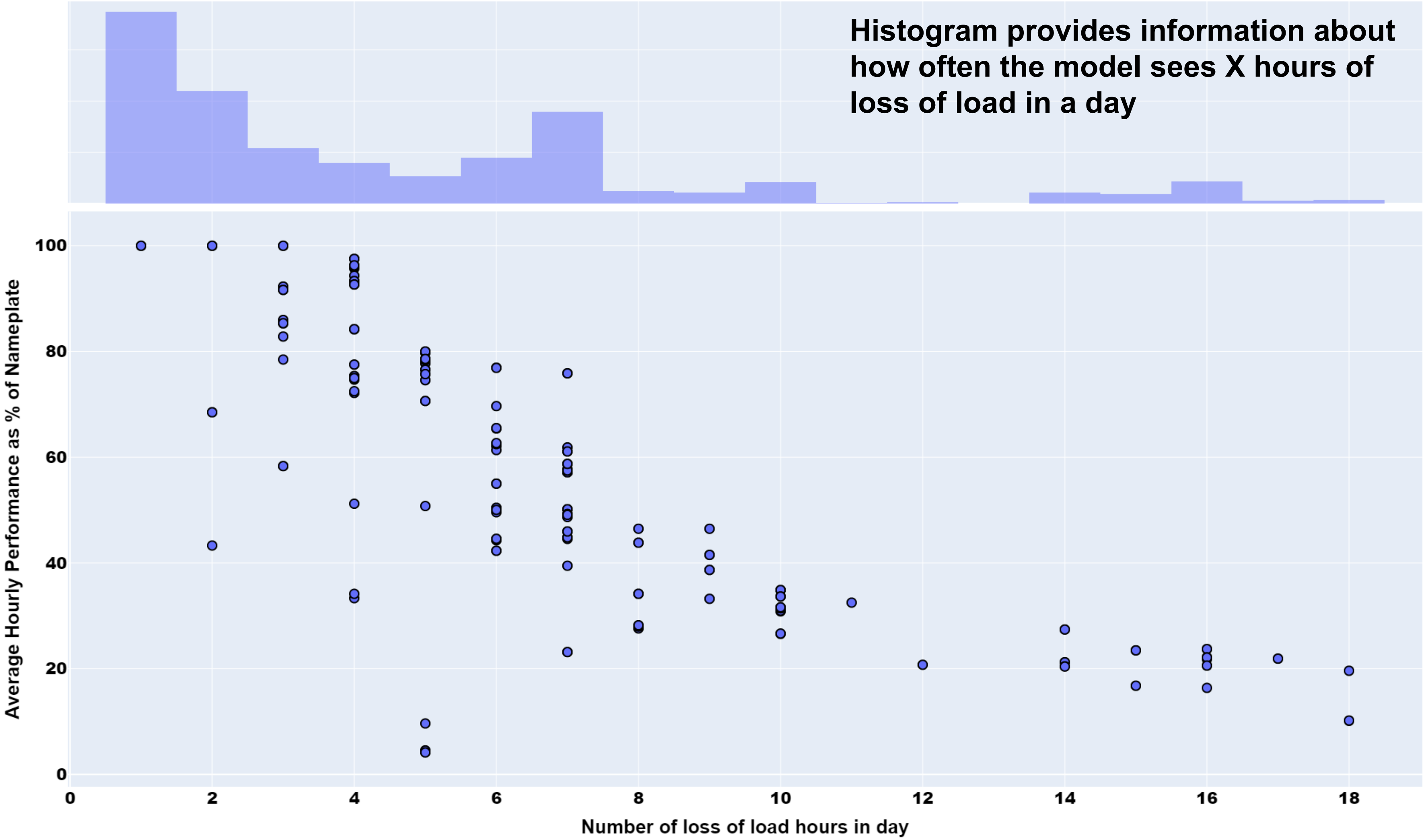
Scatterplot: Winter for 8-hour Storage



Scatterplot: Summer for 4-hour Storage



Scatterplot: Winter for 4-hour Storage



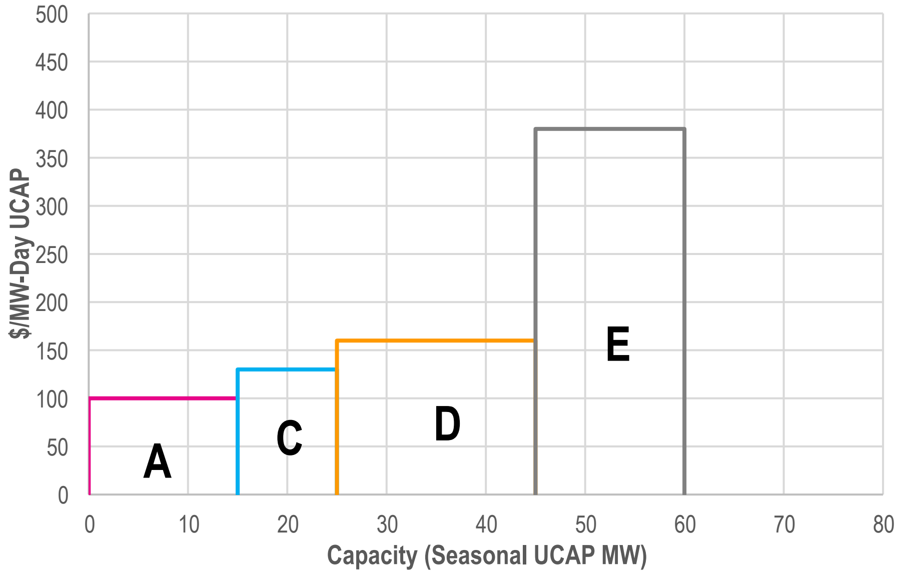
Appendix:
Seasonal Auction Clearing Examples

Example 1: Only Seasonal Offers

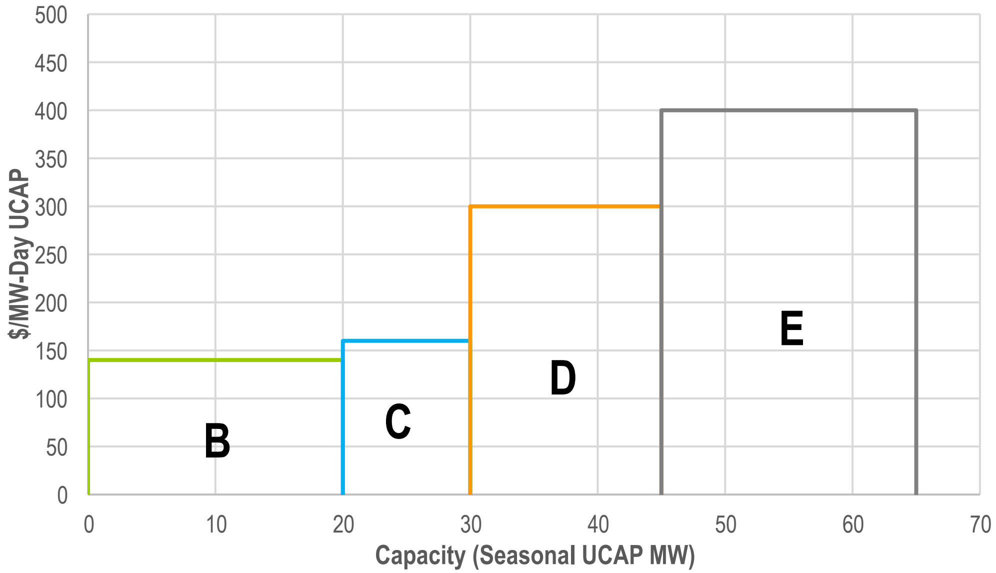
- Each resource only offers as a seasonal resource based on accredited UCAP MW and costs avoidable if not committed for that season.
- Resources can have different accredited UCAP MW depending on the season.

	Accredited UCAP MW		Offer $/MW-Day UCAP	
Resource	Summer	Winter	Summer	Winter
A	15		$100	
B		20		$140
C	10	10	$130	$160
D	20	15	$160	$300
E	15	20	$380	$400

Summer



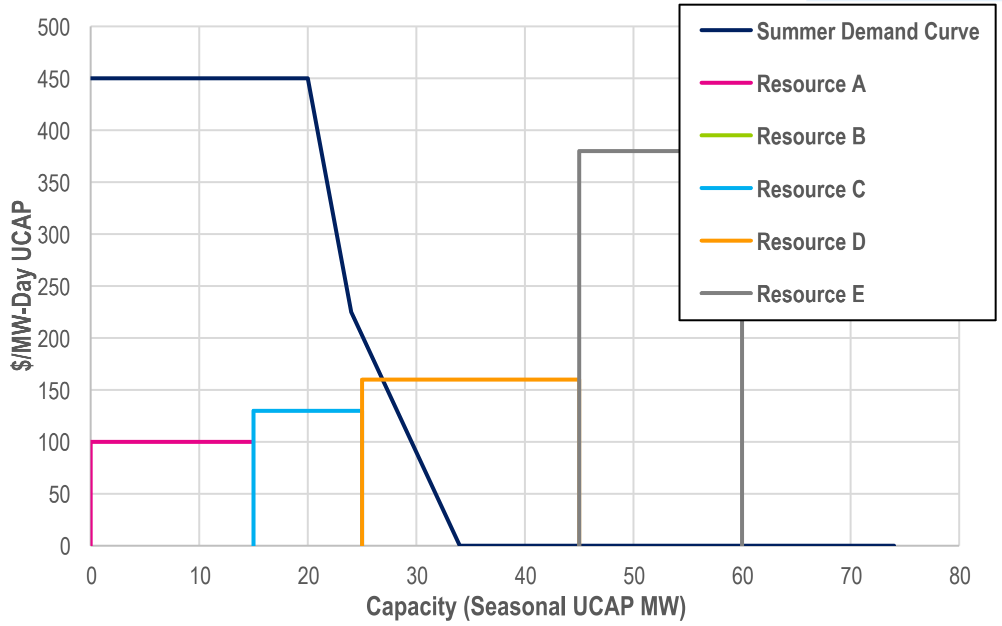
Winter

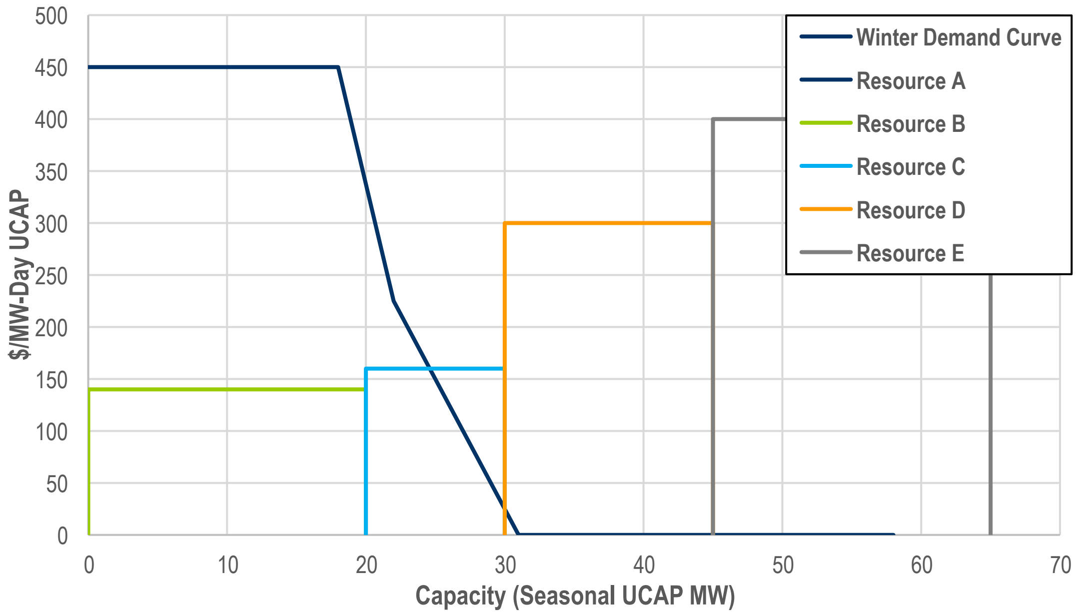


Example 1: Only Seasonal Offers + Demand

- All offers are flexible, meaning any amount of MW can clear.
- Example with only Seasonal offers is intuitive to understand.
- Resource D is marginal in Summer, and Resource C is marginal in Winter

	Accredited UCAP MW		Offer $/MW-Day UCAP	
Resource	Summer	Winter	Summer	Winter
A	15	0	$100	
B	0	20		$140
C	10	10	$130	$160
D	20	15	$160	$300
E	15	20	$380	$400





Example 1: Clearing Results

	Summer Auction Results		Winter Auction Results	
Clearing Price ($/MW-Day UCAP)	**$160**		**$160**	
	Cleared Summer MW (UCAP)	Summer Daily Revenue	Cleared Winter MW (UCAP)	Winter Daily Revenue
A	15 MW	$2,400 per day		
B			20 MW	$3,200 per day
C	10 MW	$1,600 per day	5 MW	$800 per day
D	3 MW	$480 per day		
E				
Total	**28 MW**	**$4,480 per day**	**25 MW**	**$4,000 per day**

Example 2: Seasonal and Annual Offers

	ICAP	Accredited UCAP		Offer $/MW-Day ICAP (Season)		Offer $/MW-day ICAP (Annual)	Offer $/MW-Day UCAP (Season)	
Resource		Summer	Winter	Summer	Winter		Summer +maximum annual	Winter +maximum annual
	[1]	[2]	[3]	[4]	[5]	[6]	$\frac{[4]\times[1]}{[2]}+\left(\frac{[6]\times[1]}{[2]}\times 2\right)$	$\frac{[5]\times[1]}{[3]}+\left(\frac{[6]\times[1]}{[3]}\times 2\right)$
A	16	13	0	$65.00			$80	
B	5	0	4		$80.00			$100
C	6	5	5			$50.00	$120	$120
D	12	5	10	$66.67	$108.33	$25.00	$160+$120	$130+$60
E	25	15	20	$120.00	$176.00		$200	$220

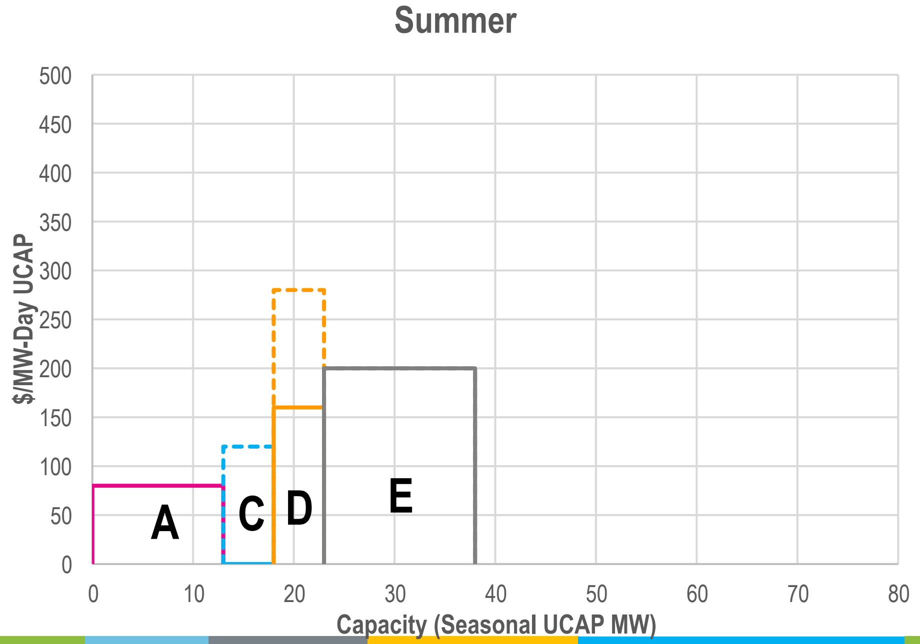
- Resources would input offers based on ICAP and $/MW-Day ICAP per season and annually.
- Maximum annual offer component reflects costs that would need to be recovered in a single season if the other season did not contribute to recovery of annual costs.
- Simplified $\frac{365}{X}$ to $\frac{365}{182.5}$ when calculating the maximum annual offer component (just for example).

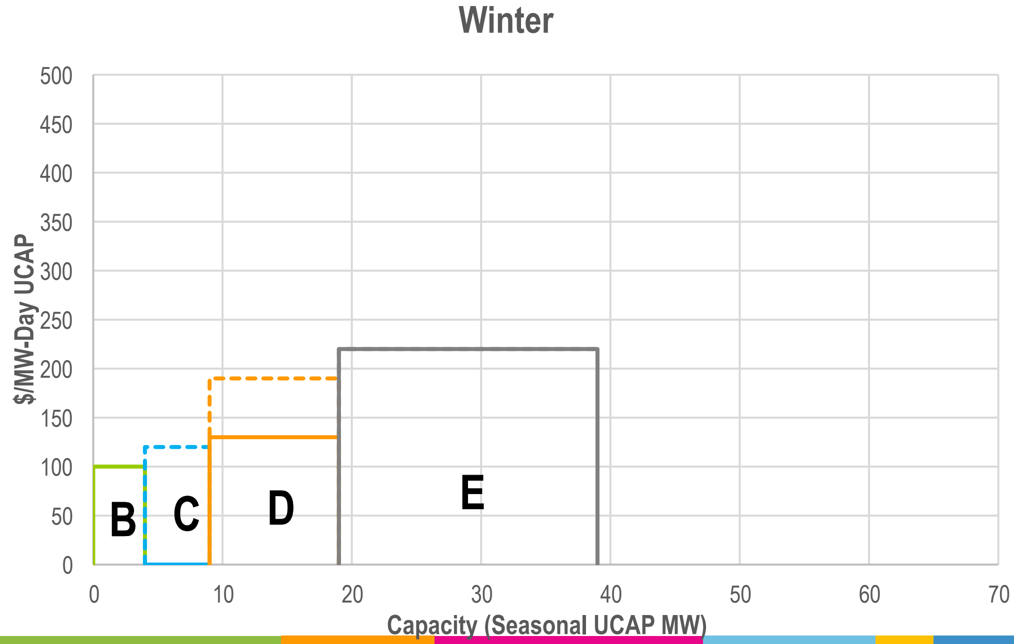
Example 2: Seasonal and Annual Offers, *Continued*

- Each resource offers as a seasonal, annual, or combination of seasonal and annual resource for costs avoidable if not committed for that season or annually.
- Annual offers represent the total cost required to operate for the entire Delivery Year. Dollars earned in one season reduce the dollars needed in the other season to meet the Annual offer.

	Accredited UCAP	
Resource	Summer	Winter
A	13	0
B	0	4
C	5	5
D	5	10
E	15	20

Offer $/MW-Day UCAP	
Summer +maximum annual	Winter +maximum annual
$80 (S)	
	$100 (W)
$120 (A)	$120 (A)
$160 (S) +$120 (A)	$130 (W) +$60 (A)
$200 (S)	$220 (W)

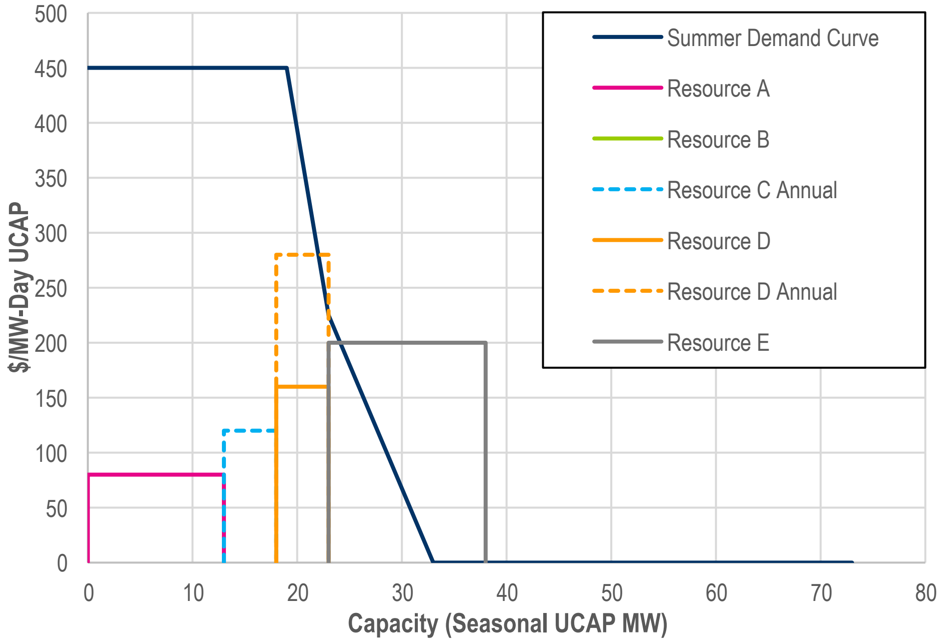


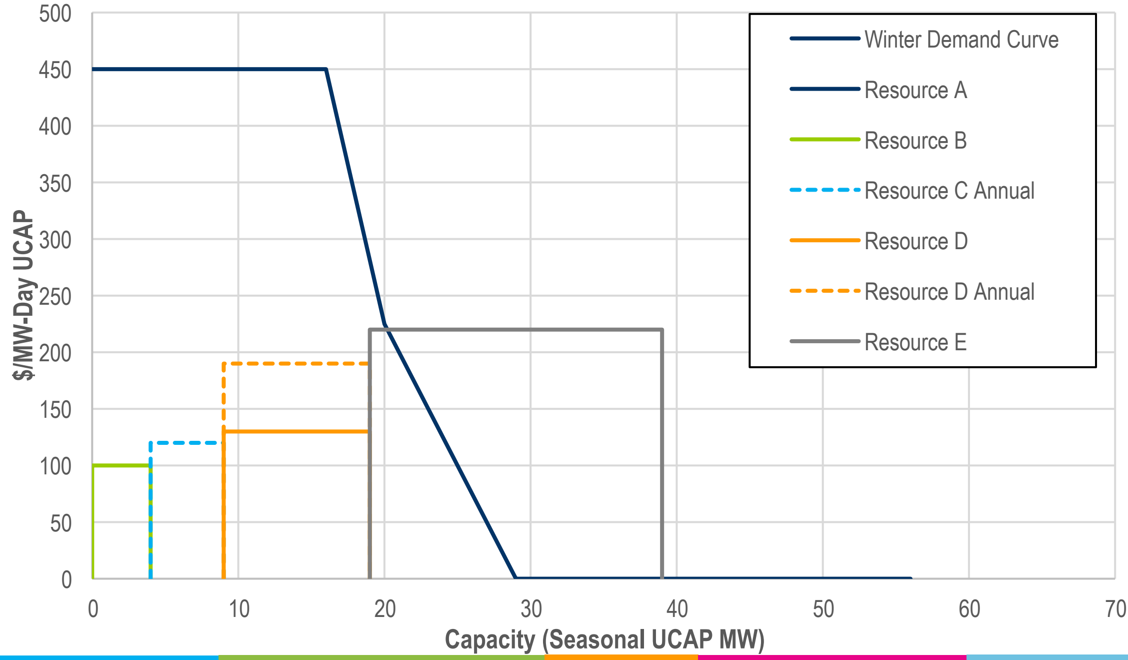


Example 2: Seasonal and Annual Offers + Demand

- All offers are flexible, meaning any amount of MW can clear.
- Resource D fully clears in Winter, allowing Resource D to also fully clear in Summer.
- Resource E is marginal in Summer and Winter

	Accredited UCAP		Offer $/MW-Day UCAP	
Resource	Summer	Winter	Summer +maximum annual	Winter +maximum annual
A	13	0	$80 (S)	
B	0	4		$100 (W)
C	5	5	$120 (A)	$120 (A)
D	5	10	$160 (S) +$120 (A)	$130 (W) +$60 (A)
E	15	20	$200 (S)	$220 (W)





Example 2: Clearing Results

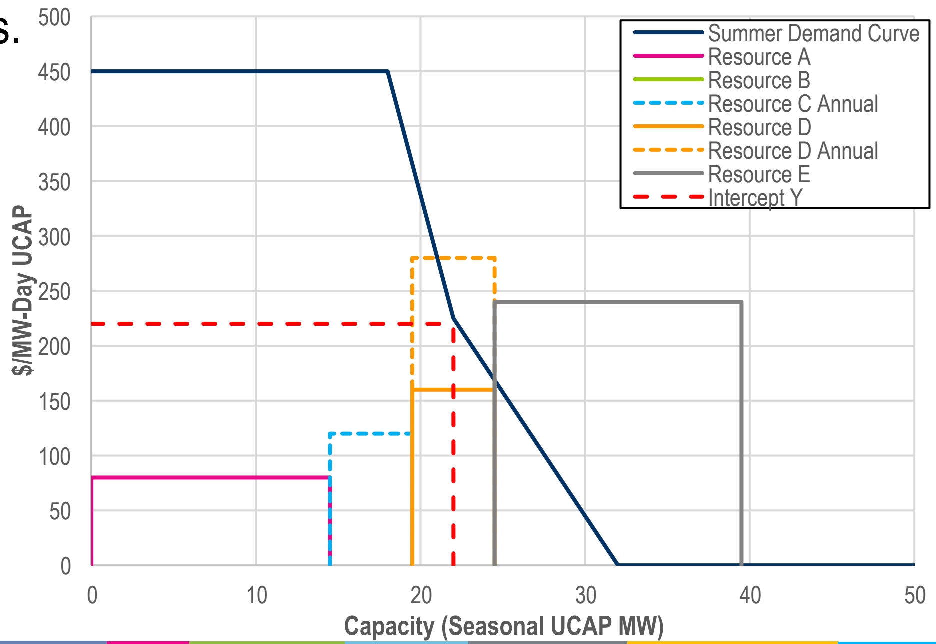
	Summer Auction Results		Winter Auction Results	
Clearing Price ($/MW-Day UCAP)	**$200**		**$220**	
	Cleared Summer MW (UCAP)	Summer Daily Revenue	Cleared Winter MW (UCAP)	Winter Daily Revenue
A	13 MW	$2,600 per day		
B			4 MW	$880 per day
C	5 MW	$1,000 per day	5 MW	$1,100 per day
D	5 MW	$1,000 per day	10 MW	$2,200 per day
E	1 MW	$200 per day	1 MW	$220 per day
Total	**24 MW**	**$4,800 per day**	**20 MW**	**$4,400 per day**

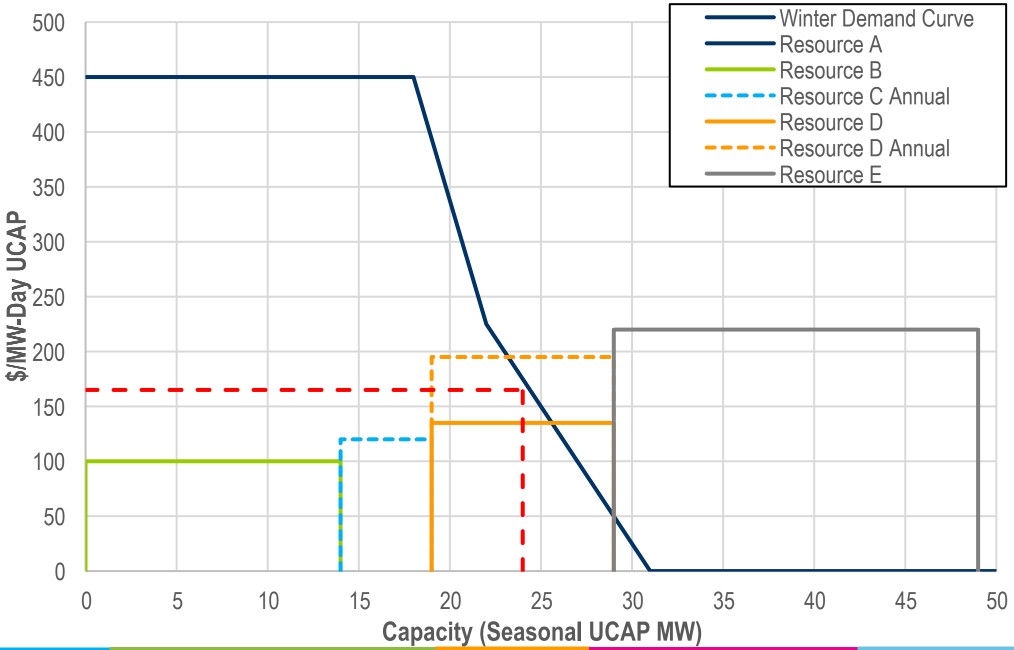
- Resource D's marginal value exceeded both its seasonal and annual costs.
- Resource D's annual costs are fully covered in winter, therefore it only required the summer offer component in order to clear.

Example 3: Seasonal and Annual Offers + Demand

- All offers are flexible, meaning any amount of MW can clear.
- In both seasons, seasonal revenue exceeds seasonal offer component for all cleared resources. Both seasons contribute to recovery of annual costs sufficiently so Resource D partially clears.
- Resource D is the marginal resource in both seasons.

	Accredited UCAP		Offer $/MW-Day UCAP	
Resource	Summer	Winter	Summer (+maximum annual)	Winter (+maximum annual)
A	14.5	0	$80 (S)	
B	0	14		$100 (W)
C	5	5	$120 (A)	$120 (A)
D	5	10	$160 (S) +$120 (A)	$135 (W) +$60 (A)
E	15	20	$240 (S)	$220 (W)





Example 3: Clearing Results

	Summer Auction Results		Winter Auction Results	
Clearing Price ($/MW-Day UCAP)	**$220**		**$165**	
	Cleared Summer MW (UCAP)	Summer Daily Revenue	Cleared Winter MW (UCAP)	Winter Daily Revenue
A	14.5 MW	$3,190 per day		
B			14 MW	$2,310 per day
C	5 MW	$1,100 per day	5 MW	$825 per day
D	2.5 MW	$550 per day	5 MW	$825 per day
E				
Total	**22 MW**	**$4,840 per day**	**24 MW**	**$3,960 per day**

- Resource D is partially clearing and recovering it's total costs required for the cleared amount.
- Total seasonal revenue is equal to the total cleared costs of Resource D.

Example 3: Resource D's Costs and Revenues, *Detail*

	ICAP	Summer UCAP	Winter UCAP
Total	12 MW	5 MW	10 MW
Cleared	6 MW	2.5 MW	5 MW

	Costs				Revenue			
	Cleared MW ICAP [1]	$/MW-Day ICAP [2]	Days [3]	$/Year [1] × [2] × [3] = [4]	Cleared MW UCAP [5]	$/MW-Day UCAP [6]	Days [7]	$/Year [5] × [6] × [7] = [8]
Summer	6 MW	$66.67	182.5	$73,000	2.5 MW	$220.00	182.5	$100,375
Winter	6 MW	$112.50	182.5	$123,187.50	5 MW	$165.00	182.5	$150,562.50
Annual	6 MW	$25.00	365	$54,750				
Total				**$250,937.50**				**$250,937.50**

- Total costs for 6 MW ICAP cleared of **$250,937.50** per year [4] is equal to the total revenue for 2.5 MW summer UCAP cleared and 5 MW Winter UCAP cleared of **$250,937.50** per year [8].