ANALYSIS GROUP

Evaluation of Sub-Annual Designs for PJM's RPM

Final Assessment and Recommendations

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ANALYSIS GROUP

Today's Presentation

Provide overview of Analysis Group's assessment of sub-annual markets

- Today's presentation provides a high-level overview of our assessment and findings – full assessment and findings are provided in the report
  - Experience in other RTOs/ISOs
  - Potential benefits from sub-annual market
  - Design considerations and tradeoffs
- On balance, we recommend that PJM pursue the development of a sub-annual market
- We identify and discuss tradeoffs in the design of a sub-annual market and provide limited recommendations

Sub-Annual Markets in Other U.S. RTOs/ISOs

All other U.S. capacity markets have some form of sub-annual market

RTO Capacity Markets Comparison		Seasonal Capacity Market Construct	Auction Timing	Num. of Seasons	Auction Structure	Demand Curve	Resource Capacity Accreditation	Capacity Requirements
NYISO	Current	Yes	Prompt, Sequential: Spot Auctions Held Days Before Monthly Delivery Period	Monthly Auctions Two Capability Periods (Winter, Summer)	Independent	Sloped, Administratively-Set, by Locality and Capability Period	Annual, MRI-Based Accreditation	Annual IRMs/LCRs Set by NYSRC
MISO	Current	Yes	Prompt, Simultaneous: Single, Annual Auction in April Before Delivery Year	Four Seasons	Independent	Sloped, MRI-Based, by Local Resource Zone	Seasonal, MRI-Based, Accreditation, by Season (reflects Availability in Resource Adequacy Hours)	Relative Position of Capacity Requirements Reflect Seasonal Parameters
ISO-NE	Current	No	Forward, Annual: Annual Forward Auction 3 Years Before Delivery Period	One (Annual)	–	Sloped, Annual, MRI-Based, by Location	Qualified Capacity Based on Performance during Select Hours	Annual Capacity Targets
	Proposal	Yes	Prompt, Sequential	Two Seasons (Winter, Summer)	Independent	Sloped, Seasonal, MRI-Based, by Location	Seasonal, MRI-Based Accreditation	Targets reflecting Equal Seasonal Split of LOLE Risk

Assessment Reflects Potential Benefits and Costs of Sub-Annual Markets

Sub-annual markets can potentially provide many benefits to PJM

More accurate price signals for better short- and long-run efficiency

Better accounting for: sub-annual variation in value of capacity, resource contributions to resource adequacy; going-forward costs

Improved resource and system representation

- More accurate representation of resources with greater non-summer performance (esp. thermal generators)
- More accurate representation of transmission system performance (CETLs)
- More accurate ELCC values in LDAs

Increased supply through better alignment of resource obligation costs and risks

Better alignment of resource compensation with services provided

Reduced year-to-year variability in resource accreditation

RPM that more flexibly adapts to on-going changes in RA risks across sub-periods

The adoption of a sub-annual market would involve additional costs (to PJM and stakeholders) in the form of one-time implementation costs and on-going costs of managing a potentially more complex market

Achieving these benefits requires sound market design decisions

Market design decisions introduce tradeoffs – other RTOs/ISOs have taken different approaches given these tradeoffs

Design Options

We consider the many dimensions to sub-annual capacity market design

- Market structure
  - Auction structure
  - Resource offers and offer structure
  - Number of periods
- Demand curve
  - Reliability requirement
  - Curve slope/shape
  - Price caps
  - LDAs/ transmission constraints
- Supply
  - Resource accreditation
  - Offers (*see* market structure)
- Cost allocation

Market Structure

Multiple options for the structure of sub-annual auctions

	Sequential	Simultaneous
Independent	NYISO ISO-NE (proposed)	MISO
Co-optimized (Offer Selection)	**Not Feasible**	

Independent: Offers are cleared independently in each sub-annual auction

Sequential: Sub-annual auctions are cleared at different points in time, one after the other

Co-optimized: Offers for sub-annual products are cleared jointly within the same auction/optimization

Simultaneous: Multiple sub-annual products are cleared in auction(s) occurring at one point in time

Market Structure (2)

Multiple tradeoffs between alternative sub-annual auction approaches

	Co-Optimized (Simultaneous)	Independent, Sequential	Independent, Simultaneous
Sub-Annual Benefits and Efficiencies	Achieves primary sub-annual benefits and efficiencies	Achieves primary sub-annual benefits and efficiencies	Achieves primary sub-annual benefits and efficiencies
Market-clearing prices and resource awards	Greater productive efficiency (prices, resource awards) Can better account for and achieve efficiencies associated with fixed/variable avoidable costs	Less productive efficiency (prices, resource awards) Cannot account for differences in fixed/variable avoidable costs	Less productive efficiency (prices, resource awards) Cannot account for differences in fixed/variable avoidable costs
Price Caps	Can impose annual price cap within auction clearing	Cannot readily impose annual price cap	Can impose annual price cap after market-clearing
Implementation Ease, Cost, Simplicity, Transparency	Greater cost/complexity of implementation	Comparatively easy/lower cost to implement Simpler, more transparent	Comparatively easy/lower cost to implement Simpler, more transparent
Market Information (Most Relevant with Prompt Auction)	Less information and more uncertainty to suppliers (*e.g.*, delivery risk, operational decisions)	Better information and reduced uncertainty to suppliers (*e.g.*, delivery risk, operational decisions)	Less information and more uncertainty to suppliers (*e.g.*, delivery risk, operational decisions)

Offer Structure and Mitigation

Tradeoffs between co-optimized and independent auctions

	Co-optimized Auction	Independent Auction
Offer Structure	Can separately account for annual fixed costs and avoidable period costs Offer clearing ensures compensation for annual and period components	Cannot account for annual fixed costs separately from avoidable period costs Offer clearing may not lead to compensation that cover all annual and period costs
Offer Mitigation	Offer review and mitigation will need to distinguish annual costs from avoidable period costs	Offer review and mitigation issues: • Does owner have discretion in setting offer prices given periods when it expects to clear and/or when it expects to recover its costs? • Will offers be required to follow uniform offer price rules and assumptions?

Market Structure (3)

Tradeoffs between co-optimized and independent auctions

- Co-optimization offers greater opportunities for economic efficiency with respect to prices and resource mix
  - Offers flexibility to impose annual caps and mitigate under-recovery
  - Scope and magnitude of potential efficiency gains (relative to independent auction) are uncertain (*i.e.*, may affect relatively few awards at the margin)
  - Quantitative analysis
    - Does not measure impact on prices or resource awards
    - Shows under-recovery (with respect to costs) in Base Scenario but full (or near full) recovery under Current Market Scenario
    - Under-recovery in Base Scenario: 1.8% to 3.8% of resources (in ICAP); $4 million to $90 million in under-recovery (depends on assumptions regarding avoidable costs) (*see Table VII-15, Appendix)*

- Independent auctions less costly and time-consuming to implement, and may be simpler and more transparent to market participants
  - Simultaneous structure offers flexibility to impose annual caps and mitigate under-recovery
  - Advantages of independent auctions are greatest under a prompt market structure (especially, with prompt, sequential approach)

Market Structure (4)

Broader context for sub-annual market design decisions

- Market structure decision should be made within a broader framework of all potential RPM reforms and a targeted long-run design for the RPM (*e.g.*, MRI-based demand curves, prompt auction structure, etc.)
  - Tradeoffs between making reforms all at once versus sequentially
  - Potential sequencing of reforms toward a long-run design
  - Some interdependence in design decisions (*e.g.*, choice of auction structure given prompt v. forward market structure)
- If PJM initially develops an independent sub-annual auction (sequential or simultaneous), it retains the option to co-optimize at a later date

Number of Periods

Tradeoffs of greater temporal granularity

- Greater temporal granularity:
  - Accounts for relevant differences in the value of capacity in different periods and resources' ability to deliver resource adequacy contributions
  - Benefits materialize to the extent there is meaningful risk in sub-periods or there are meaningful differences in conditions across periods (seasonal risk, resource/system capabilities, etc.)
  - Complications (unintended consequences) arise with greater granularity
    - Periods of low risk:
      - May provide little value in improving market outcomes
      - May lead to low prices and associated complications: diminished incentives to supply (esp. given CP opportunity costs) and associated reliability impacts (given non-RA reliability values), price volatility, under-recovery of resource costs
    - Capacity market incentives for performance could conflict with energy market incentives
    - Complications with development of price caps

Number of Periods (2)

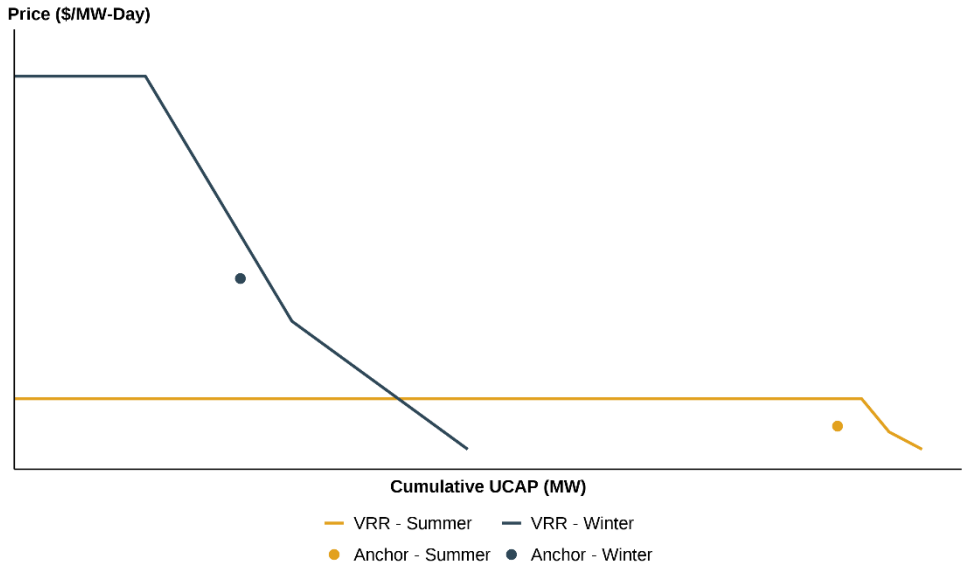
Alternatives

- Two-season market
  - Captures key seasonal differentiation
  - Change in delivery year calendar – Summer period: May 1 to October 31; Winter period: November 1 to April 30
- Market with shoulder seasons (3- or 4-season market)
  - Currently no shoulder season risk, but could emerge under particular future scenarios (*e.g.*, planned outages with expanded gas-fired generation)
  - Sub-annual market incentives are imprecise and not the best tool to manage planned maintenance outages, if they become a constraint
  - PJM retains option to add shoulder seasons in the future
- Intra-day periods
  - Intra-day period may better align capacity market awards and obligations for certain resource types (*e.g.*, solar)
  - With intra-day periods, market-clearing would be complex and potentially infeasible because accreditation of certain resource types (*e.g.*, storage) would reflect inter-dependent accreditation and market clearing across sub-periods
  - Potential conflicts with energy market incentives and complications for development of price caps
- Hourly
  - Many hours with low/non-existent risk
  - Practical challenges and complexity of setting hourly demand curves
  - Potential conflicts with energy market incentives and complications for development of price caps

Demand Curves

Regulatory requirements for resource requirement and Net CONE

Illustrative Seasonal Demand Curves, VRR Approach

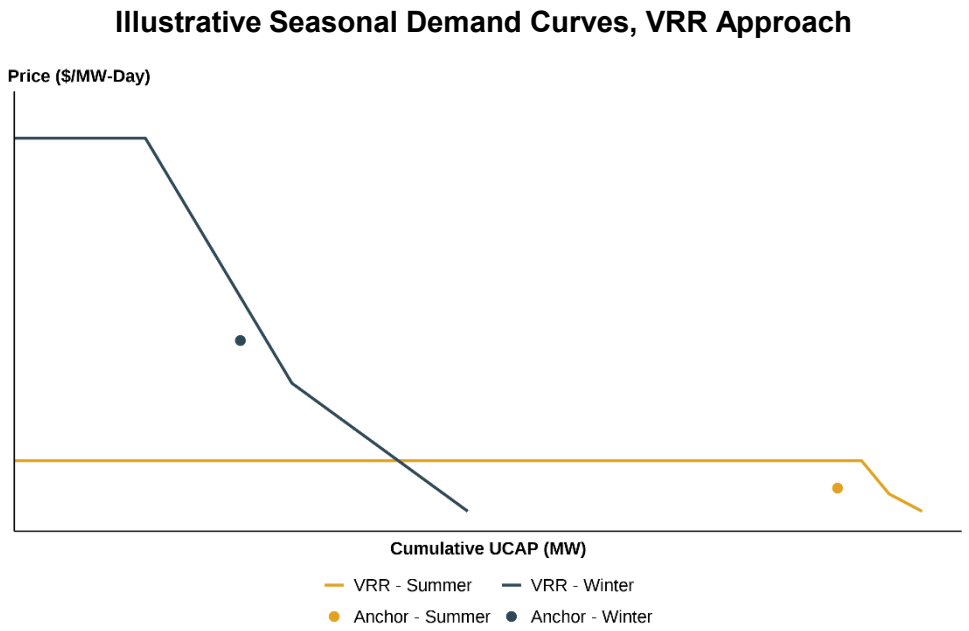


Sub-annual demand curves reflect regulatory requirement, including period-specific reliability requirement and "allocated" Net CONE

- Sub-annual reliability requirements
  - Ensure annual 1-in-10 requirement is met across all periods
- Net Cone "allocated" across periods
  - Ensure recovery of Net CONE across all periods
- Many alternatives for allocation of risk/requirements/net CONE across seasons
  - "Economic approach" (cost-effective) imposes uniform cost ($) per mEUE across periods
    - Economic approach is consistent with translation of MRI curve using fixed scalar (Net CONE $ per mEUE) necessary to meet regulatory requirement
    - Resource requirements based on annual 1-in-10 LOLE distribution of risk
    - Allocated Net CONE set at scalar times marginal risk in each period
  - Not the only alternative – multiple tradeoffs between alternatives (*e.g.*, ISO-NE proposing 50/50 summer/winter split of risk)

Demand Curves (2)

Period-specific slope/Shape and caps



- **Slope/shape of seasonal curves**
  - In principle, slope/shape reflects period-specific marginal risk (*e.g.*, marginal EUE)
  - Marginal Reliability Impact ("MRI") curves can inform slope/shape directly (MRI-based curves) or indirectly (VRR curves)
- **Price caps**
  - Economic approach implies price caps proportional to allocated Net CONE – implies max WTP per unit of risk (*e.g.*, EUE) not per MW of UCAP
  - Many considerations in setting *level* of price cap

Demand Curves (3)

MRI-based approach to demand curves

- Marginal Reliability Impact ("MRI") curves provide information on RA risks in each sub-period
- Two approaches to developing sub-period demand curves that account for sub-period variation in RA risk:

VRR Demand Curves (informed by MRI)

- Accurately accounting for sub-annual variation requires use of RA/MRI analysis
- Sub-annual requirement and allocated net CONE
  - With MRI data, requirements and net CONE allocation can reflect RA risk in each sub-period
- Slope/shape can be informed by MRI curves
  - VRRs can reflect relative sub-annual RA risks
  - Requires new administrative process

MRI Demand Curves

- Demand curves derived from MRI curves and economic principles (*e.g.*, equal cost per EUE across seasons)
- Demand curve directly derived from RA model outputs
  - More accurate
  - Can simplify administrative process of constructing demand curves and lower administrative (PJM and stakeholder) costs
- Well-developed methods (relied on by MISO and ISO-NE)

MRI-based demand curves as more accurate and less burdensome approach to developing sub-period demand curves

Price Caps

Sub-annual markets would require an assessment of the criteria and formulas for price caps

- Price caps establish a shortage price for capacity under shortage conditions
- Sub-annual price caps introduce new considerations to establishing the *level* of price caps
- Existing annual caps likely not the best guide for *level* of sub-annual caps – caps for individual periods can be set higher
  - If individual period caps are set based on annual caps, this will tend to reduce expected prices (*e.g.*, if market clears at cap in some but not all periods, average price is below the cap)
  - Many considerations in setting the level of caps for individual periods (see below)
- Annual cap mechanism limits prices across periods – mitigates need to set binding caps in individual periods
  - Co-optimized auction: annual cap can be internalized *within* market clearing
  - Simultaneous, independent auction: annual cap can be imposed *after* market clearing (*e.g.*, MISO)

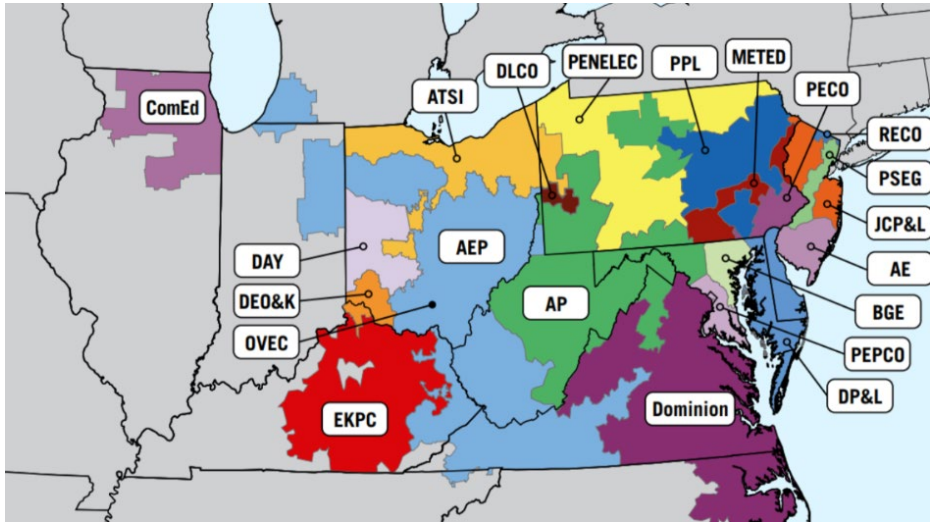
Price Cap Consideration	Issues
Risks of constraining price discovery	• A tighter price cap, all else equal, constrains price discovery • With a sub-annual market, greater risk that a cap constrains under otherwise normal market conditions • Price discovery in LDAs (smaller markets) may be particularly sensitive
Impact of cost recovery	• Stringent price caps may inadvertently limit cost recovery when resources clear in some but not all seasons
Excess recovery	• More relaxed price cap, all else equal, increases risk of “excess” recovery across seasons • “Excess” recovery across seasons may prompt desire for annual cap mechanism on pricing across periods

LDA Demand Curves and Transmission Constraints

CETOs, CETLs and demand curve basis

- A sub-annual market could raise new issues in establishing LDA parameters
- CETOs – *e.g.*, need to assess whether to estimate CETO on annual or sub-annual basis
- CETLs – *e.g.*, CETLs can be measured with respect to each period
- Demand curve
  - Sub-annual demand curves could reflect the same principles as the current approach (*e.g.*, annual target at 40% of RTO EUE at 1-in-10 requirement)
  - Approaches to sub-period capacity requirements, allocated Net CONE and slope/shape as discussed above
  - Modifying demand to reflect incremental basis (similar to ISO-NE) not total basis

PJM Zones



Source: PJM, available at https://www.pjm.com/-/media/DotCom/about-pjm/pjm-zones.pdf.

Offer Quantities

Resource offers can reflect capability in each sub-annual period

- Resource offer quantities can account for factors that affect sub-period capability:

Market rules in which sub-annual offer quantities most accurately reflect resources' actual performance will result in more reliable and cost-effective outcomes

Cost Allocation

Resource offers can reflect capability in each sub-annual period

- Sub-annual market would not change underlying principles for cost allocation (*e.g.*, cost causation)
- In principle, sub-annual market may affect:
  - Accuracy of alternative metrics (peak load, peak on high-risk days, etc.) in capturing cost causation across periods/seasons
  - Stability of cost allocators over time (which would, in turn, affect stability of retail costs)
  - Resulting allocation of costs across load-serving entities (*e.g.*, given differences in non-summer peak loads)
- Adoption of a sub-annual market could provide an opportunity to revisit past allocation decisions and/or revise allocation approaches given sub-annual considerations

Conclusion

- On balance, we recommend that PJM and its stakeholders pursue development of a sub-annual market
  - Conclusion reflects potential benefits from a sub-annual market (*e.g.*, seasonal price signals)
  - Reconciles RPM elements premised on summer design with actual risk spread across the year

- Sub-annual design and approach
  - Multiple reasonable designs/approaches for a sub-annual market
  - Sub-annual design/approach should reflect holistic RPM design decisions
  - Certain design choices offer net benefits (*e.g.*, seasonal design, use of MRI-based curves, supply offer quantities reflecting multiple seasonally varying factors)
  - Other design choices offer tradeoffs and/or require further assessment/analysis

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Thank You

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