RPM 101
Overview of Reliability Pricing Model
Agenda

• Introduction
• Resource Adequacy
• Demand in RPM
• Supply in RPM
• Auction Structure
• Auction Clearing

• Resource Clearing Prices
• CTRs & ICTRs/CTR & ICTR Credit Rates
• Zonal Capacity Prices
• RTO/Zonal/LSE Unforced Capacity Obligations
• Committed Resource Obligations in Delivery Year
• Changes for 2020/2021 Delivery Year
RPM 101 Objectives

• Describe the purpose of the Reliability Pricing Market (RPM)

• Explain demand and supply in RPM

• Explain the RPM auction process

• Explain the pricing structure within the PJM capacity market (RPM)

• Explain participant obligations within the PJM capacity market (RPM)

• Describe changes to RPM coming in the 2020/2021 Delivery Year
Disclaimer:

PJM has made all efforts possible to accurately document all information in this presentation. The information seen here does not supersede the PJM Operating Agreement or the PJM Tariff both of which can be found by accessing: http://www.pjm.com/documents/agreements/pjm-agreements.aspx

For additional detailed information on any of the topics discussed, please refer to the appropriate PJM manual which can be found by accessing: http://www.pjm.com/documents/manuals.aspx
Introduction
Capacity vs. Energy

**Capacity**

- A commitment of a resource to provide energy during PJM emergency under the capped energy price.
- Capacity revenues paid to committed resource whether or not energy is produced by resource.
- Daily product

**Energy**

- Generation of electrical power over a period of time
- Energy revenues paid to resource based on participation in PJM’s Day-Ahead & Real-Time Energy Markets
- Hourly product

Capacity, energy & ancillary services revenues are expected, in the long term, to meet the fixed and variable costs of generation resources to ensure that adequate generation is maintained for reliability of the electric grid.
How PJM Secures Capacity

Reliability Pricing Model (RPM)

PJM secures capacity on behalf of LSEs to satisfy load obligations not satisfied through self-supply.

Fixed Resource Requirement Alternative (FRR)
(opt-out of RPM)

LSE secures capacity to satisfy their load obligation.
What is the RPM?

- Reliability Pricing Model (RPM) is PJM’s resource adequacy construct
- RPM is part of an integrated approach to ensuring long-term resource adequacy and competitively priced delivered energy
- RPM aligns the price paid for capacity with overall system reliability requirements
- RPM includes pricing to recognize and quantify the locational value of capacity and the operational value of capacity
- RPM provides forward investment signals
Objectives of RPM

• Secure resource commitments to meet system peak loads three years in the future

• Provide three year forward pricing which is aligned with reliability requirements and which adequately values all capacity resources

• Provide transparent information to all participants far enough in advance for actionable response

Purpose of RPM is to enable PJM to obtain sufficient resources to reliably meet the needs of electric consumers within PJM
RPM Capacity Performance Product

• Capacity Performance Resources must be capable of sustained, predictable operation that allows resource to be available to provide energy and reserves throughout the Delivery Year

• Subject to Non-Performance Charge assessed during Performance Assessment Hours which are (triggered by an Emergency Action) throughout the entire Delivery Year

• Only product type in RPM beginning in 2020/2021 Delivery Year
RPM Capacity Performance

Increased Performance Expectations
- Performance expectations during emergencies
- Very limited excuses
- Parameter Limited Schedules

Increased Non-Performance Charges
- High non-performance charge rate
- Can result in having to pay back more than all capacity revenues received

Increased Revenue Opportunities
- High default offer cap
- Opportunity for bonus payments
FRR Entities Opt out of RPM for __________ years.

a) Three  
b) Five  
c) One  
d) Ten
Capacity Performance is the only product type in RPM beginning in which Delivery Year?

a) 2017/2018
b) 2018/2019
c) 2019/2020
d) 2020/2021
Resource Adequacy
Resource Adequacy Overview

The purpose of PJM RTO resource adequacy is to determine the amount of Capacity Resources that are required to serve the forecast load and satisfy the PJM reliability criterion.

The reliability criterion is based on Loss of Load Expectation (LOLE) not exceeding one occurrence in ten years.

The resource requirement to meet the reliability criterion is expressed as the Installed Reserve Margin (IRM) as a percentage of forecast peak load.
Common Terminology in RPM

- **Installed Capacity (ICAP)** value of a unit is based on the summer net dependable rating of a unit as determined in accordance with PJM’s Rules and Procedures.

- **Unforced Capacity (UCAP)** value of a unit is the installed capacity rated at summer conditions that is not on average experiencing a forced outage or forced derating.

\[
\text{UCAP} = \text{ICAP} \times (1 - \text{EFORd})
\]

- **Equivalent Demand Forced Outage Rate (EFORd)** is a measure of the probability of a generating unit will not be available due to forced outages or forced deratings when there is demand on the unit to operate.

UCAP Concept is extended to value demand resources, energy efficiency resources, qualifying transmission upgrades in RPM.
Installed Reserve Margin & Forecast Pool Requirement

**Installed Reserve Margin (IRM)**

Used to establish level of **installed** capacity resources that will provide acceptable level of reliability.

**Forecast Pool Requirement (FPR)**

- Used to establish level of **unforced** capacity resources that will provide acceptable level of reliability.

\[
FPR = (1 + IRM) \times (1 - \text{pool-wide avg. EFORd})
\]

**Example: 2020/2021 Base Residual Auction**

- IRM = 16.6%, Forecast Peak Load = 153,915.0 MW, Pool-wide avg. EFORd = 0.0659
- ICAP Requirement = Forecast Peak Load * (1 + IRM) = 179,464.9 MW
- FPR = (1 + 0.166) * (1 - 0.0659) = 1.0892
- UCAP Requirement = Forecast Peak Load * FPR = 167,644.2 MW
Locational Deliverability Areas (LDAs)

- PJM determines sub-regions (i.e., Locational Deliverability Areas (LDAs)) and respective LDA Reliability Requirements to be modeled in RPM Auctions to recognize and quantify the locational value of capacity within the PJM region.

- Modeled Locational Deliverability Areas (LDAs) are determined by comparing the import limit of a LDA (CETL) to the amount of capacity that needs to be imported into a LDA to meet the reliability criterion (CETO).

\[ \text{CETL} = \text{Capacity Emergency Transfer Limit} \]
\[ \text{CETO} = \text{Capacity Emergency Transfer Objective} \]
Criteria for Modeling LDA in RPM Auction

• An LDA is modeled if:
  – LDA has CETL < 1.15 CETO
  – LDA had locational price adder in any of three immediately preceding BRAs
  – LDA is likely to have a locational price adder based on a PJM analysis using historic offer price levels
  – LDA is EMAAC, SWMAAC, and MAAC

LDAs modeled in a Base Residual Auction are modeled in the Incremental Auctions for the Delivery Year.

An LDA that does not meet the criteria above may be modeled if PJM identifies reliability concerns with LDA.
Locational Deliverability Areas

RTEPP has currently identified 27 sub-regions as potential Locational Deliverability Areas (LDAs)

• Regions
  – Western PJM (ComEd, AEP, Dayton, DLCO, APS, ATSI, Duke)
  – Mid-Atlantic Area Council (MAAC) Region
  – Eastern MAAC (PSE&G, JCP&L, PECO, AE, DPL & RECO)
  – Southwestern MAAC (PEPCO & BGE)
  – Western MAAC (Penelec, MetEd, PPL)

• Zones
  – AE, AEP, APS, ATSI, BGE, ComEd, Dayton, DLCO, Dominion, DPL, Duke, EKPC, JCPL, MetEd, PECO, Penelec, PEPCO, PPL, PSEG

• Sub-Zones
  – PSEG Northern Region (north of Linden substation)
  – DPL Southern Region (south of Chesapeake and Delaware Channel)
  – Cleveland (within ATSI)

PJM required to file with FERC before adding a new LDA.
Capacity Import Limits (CILs) (2017/2018 - 2019/2020 DYs)

- Locational constraints that limit the delivery of external generation from areas outside of PJM region

- CILs determined for PJM Region and five external source zones:
  - **Northern Zone**: NYISO & ISONE
  - **Western Tier 1 Zone**: MISO East, MISO West & OVEC
  - **Western Tier 2 Zone**: MISO Central & MISO South
  - **Southern Tier 1 Zone**: TVA & LGEE
  - **Southern Tier 2 Zone**: VACAR (non-PJM)
### 2020/2021 BRA Planning Parameters

#### 2020-2021 RPM Base Residual Auction Planning Parameters

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<td>Installed Reserve Margin (IRM)</td>
<td>16.6% 2016 IRM Study</td>
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<td>Pool-Wide Average EFORd</td>
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<td>Forecast Pool Requirement (FPR)</td>
<td>1.6892 2016 IRM Study</td>
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<td>Preliminary Forecast Peak Load</td>
<td>153,915.0 Load data from 2017 Load Report with adjustments due to load served outside PJM.</td>
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#### Reliability Requirement

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#### Gross CONE, $/MW-Day (UCAP Price)

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#### Net CONE, $/MW-Day (UCAP Price)

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#### EE Addback (UCAP) (to be provided prior to the auction)

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#### Variable Resource Requirement Curve:

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#### Nominated PRO Value, MW

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#### VRR Curve adjusted for PRD:

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The product transacted in the RPM Market is called __________.

a) Installed Capacity  
b) Unforced Capacity  
c) Hard Drive Capacity  
d) Expensive
A LDA is modeled only when the CETL is less than 1.15 times CETO

a) True
b) False
Demand in the Reliability Pricing Model
Demand in RPM

• Demand curve(s) are defined in advance of a Base Residual Auction based on Variable Resource Requirement curve concept

• Demand curve(s) for 1st, 2nd, and 3rd Incremental Auctions are built based on locational buy bids that are submitted by participants and any buy bids that are submitted by PJM

• Demand curve(s) for Conditional Incremental Auction are built based on buy bid that is submitted by PJM

• PJM Buy Bids are defined in advance of a Scheduled or Conditional Incremental Auction
What is the VRR?

The Variable Resource Requirement (VRR) Curve is a downward sloping demand curve that relates the maximum price for a given level of capacity resource commitment relative to reliability requirements.

- The price is higher when the resources are less than the reliability requirement and lower when the resources are in excess.
- VRR Curves are defined for the PJM RTO and for each constrained Locational Deliverability Area (LDA) modeled within the PJM region.
VRR Parameters

The Variable Resource Requirement Curves for the PJM Region and each LDA are based on the following parameters defined prior to the RPM Auctions:

- Target Level of Reserve
- Cost of New Entry
- Net Energy & Ancillary Services (E&AS) Revenue Offset
A VRR Curve is defined for the PJM Region & each LDA
# 2020/2021 BRA Planning Parameters

## 2020-2021 RPM Base Residual Auction Planning Parameters

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### Variable Resource Requirement Curve:

- **Point (a) UCAP Price, $/MW-Day:** $439.43
- **Point (b) UCAP Price, $/MW-Day:** $219.71
- **Point (c) UCAP Price, $/MW-Day:** $0.00
- **Point (d) UCAP Level, MW:** 167,356.6
- **Point (e) UCAP Level, MW:** 171,813.7
- **Point (f) UCAP Level, MW:** 180,260.6

### Nominated PRD Value, MW

- **Point (a) UCAP Price, $/MW-Day:** $439.43
- **Point (b) UCAP Price, $/MW-Day:** $219.71

### VRR Curve adjusted for PRD:

- **Point (a) UCAP Price, $/MW-Day:** $439.43
- **Point (b) UCAP Price, $/MW-Day:** $219.71
PJM Buy Bids in Scheduled Incremental Auctions

- PJM Buy Bids in an Incremental Auction may be due to:
  - Increase in RTO/LDA Reliability Requirement (RR) beyond a threshold (500 MW or 1% of prior RR). Threshold does not apply for 3rd IA
    - If parent LDA meets threshold, an increase in the child LDA RR will be reflected even if the child LDA does not meet the threshold
  - Inclusion of entire uncleared portion of the updated VRR Curve (i.e., entire Updated VRR Curve Increment) if prior auction’s (RTO/LDA RR – STRPT) exceeds total capacity committed in all prior auction’s by the threshold

- The determination of the PJM Buy Bid quantity in scheduled IA also considers the uncleared PJM Buy Bids/Sell Offers from prior IA

- PJM Buy Bid prices based on Updated VRR Curve Increment

- PJM Buy Bids are defined in advance of the Incremental Auction
Updated VRR Curve Increment/Decrement

Updated VRR Curve

Updated Reliability Requirement

Updated VRR Curve Increment
portion of the updated VRR Curve to the right of the vertical line at the current UCAP commitment level

Updated VRR Curve Decrement
portion of the updated VRR Curve to the left of the vertical line at the current UCAP commitment level

Price

Quantity

$600

$500

$400

$300

$200

$100

$0

145,000

150,000

155,000

160,000

165,000

170,000

Updated VRR Curve

Current Commitment Level
VRR Curve Increment - MAAC

Updated VRR Curve
MAAC

2,000 MW

PJM Buy Bid Curve
MAAC

$210
$190
$170
$150
$130
$110
$90
$70
$50

$187
$71

0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000
MW

Updated VRR  Current Commitment Level  Reliability Requirement Shift
Demand Curve in Conditional Incremental Auction

- Conditional Incremental Auctions may be held if the in service date of a backbone transmission upgrade that was modeled in the Base Residual Auction is announced as delayed by Office of the Interconnection beyond July 1 of the Delivery Year for which it was modeled and the delay causes reliability criteria violation

- If conducted, the demand curve will be a single buy bid entered by PJM for the required MWs at 1.5 times the Net CONE in the LDA with the reliability criteria violation

- PJM will seek to procure any remaining capacity amount not procured in Conditional Incremental Auction in the next scheduled Incremental Auction
The VRR Curve is constructed using a quantity of MW defined by the Reliability Requirement at a cost defined by_________.

a) eBAY
b) NET CONE
c) Last Auction’s Clearing Price
d) CONE
If the load forecast for a Delivery Year increases, PJM may submit a(n) ______ into an Incremental Auction.

a) Increase in EFORd  
b) Sell Offer  
c) Panicked Tweet  
d) Buy Bid
Supply in the Reliability Pricing Model
Supply in RPM Auction

• Supply of unforced capacity is procured to meet the demand as a function of the clearing of RPM Auctions

• Supply curve is defined based on the resource-specific offers submitted by providers
  – Supply curve for Incremental Auctions may include locational non-unit specific sell offers submitted by PJM to release commitments

• Supply that is procured in the RPM multi-auction clearing ensures that sufficient resources are committed to meet the reliability requirement
Supply Resources in RPM

- **Generation**
  - Existing/Planned
  - Internal/External

- **Demand Resources**
  - Existing/Planned

- **Energy Efficiency Resource**
  - Existing/Planned

- **Aggregate Resource**
  - Existing/Planned

- **Qualifying Transmission Upgrade**
  - Existing/Planned
Participation by Resource Providers

- Participation is voluntary for resource providers with:
  - External generation;
  - Planned generation (includes new units and upgrades to existing unit not yet in service that have not cleared at an unmitigated price in a prior Delivery Year);
  - Existing demand resources;
  - Planned demand resources;
  - Energy Efficiency resources;
  - Qualifying Transmission Upgrades.
Aggregate Resource – Commercial Aggregation (Effective 2018/2019 Delivery Year)

• Capacity Resources which may not, alone, meet the requirements of a Capacity Performance product, may combine their capabilities and offer as a single Aggregate Resource
  – Applies to Intermittent Resources, Capacity Storage Resources, Demand Resources, Energy Efficiency Resources, and Environmentally-Limited Resources

• Resources being combined must reside in a single Capacity Market Seller account
Seasonal Capacity Performance Resources (Effective 2020/2021 Delivery Year)

**Summer-Period CP Resources**
- Summer Period DR
- Summer Period EE
- Capacity Storage Resource
- Intermittent Resource
- Environmentally-Limited Resource

**Winter-Period CP Resources**
- Capacity Storage Resource
- Intermittent Resource*
- Environmentally-Limited Resource*

* May request additional CIRs for winter-period for DY and offer additional ICAP value in winter-period

**Notes**
- Available June-October & May of DY (summer-period)
- If clear, Auction Credit & commitment for summer-period only
- Available November-April (winter-period)
- If clear, Auction Credit & commitment for winter-period only
## What is the Value of a Resource?

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Capacity Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generation Resource</strong></td>
<td>Summer Net Dependable Rating, converted to <strong>Unforced Capacity (UCAP)</strong></td>
</tr>
<tr>
<td><strong>DR, &amp; EE Resources</strong></td>
<td>UCAP Equivalent is calculated (based on load reduction amount, Forecast Pool Requirement (FPR))</td>
</tr>
<tr>
<td><strong>Transmission Upgrade</strong></td>
<td>Valued in terms of an increase in import capability into a constrained LDA</td>
</tr>
</tbody>
</table>
UCAP Calculation

Installed Capacity (ICAP) is converted to unforced capacity (UCAP) with the following formulas:

- Generation: $UCAP_{Generation} = (1 - EFORd) \times ICAP$
- Demand Response: $= ICAP \times ForecastPoolRequirement$
- Energy Efficiency: $CAP_{EE} = ICAP \times ForecastPoolRequirement$
## Demand Resource Product Type Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Limited DR (Prior to 18/19 DY)</th>
<th>Extended Summer DR (Prior to 18/19 DY)</th>
<th>Annual DR (Prior to 18/19 DY)</th>
<th>Base (18/19 &amp; 19/20 DY only)</th>
<th>Capacity Performance (Effective 18/19 DY)</th>
<th>Summer Period Seasonal DR (Effective 20/21 DY)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Availability</strong></td>
<td>Any weekday, other than NERC holidays, during June – Sept. period of DY</td>
<td>Any day during June-October period and following May of DY</td>
<td>Any day during DY (unless on an approved maintenance outage during Oct. - April)</td>
<td>Any day during June-September of DY</td>
<td>Any day during DY (unless on an approved maintenance outage during Oct.-April)</td>
<td>Any day during June-October period and following May of DY</td>
</tr>
<tr>
<td><strong>Maximum Number of Interruptions</strong></td>
<td>10 interruptions</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>Unlimited</td>
</tr>
<tr>
<td><strong>Hours of Day Required to Respond (Hours in EPT)</strong></td>
<td>12:00 PM – 8:00 PM</td>
<td>10:00 AM – 10:00 PM</td>
<td>Jun – Oct. and following May: 10 AM – 10 PM</td>
<td>10:00 AM – 10:00 PM</td>
<td>Jun – Oct. and following May: 10 AM – 10 PM</td>
<td>Jun – Oct. and following May: 10 AM – 10 PM</td>
</tr>
<tr>
<td><strong>Maximum Duration of Interruption</strong></td>
<td>6 Hours</td>
<td>10 Hours</td>
<td>10 Hours</td>
<td>10 Hours</td>
<td>No limit</td>
<td>No limit</td>
</tr>
</tbody>
</table>
PJM Sell Offers in Incremental Auctions

- PJM Sell Offers in an Incremental Auction to release commitments may be due to:
  - Decrease in RTO/LDA Reliability Requirement(s) beyond the threshold
  - Need to release commitments in the parent LDA of an LDA with a reliability violation in the Scheduled IA that occurs after a Conditional IA

- The determination of the PJM Sell Offer quantity in scheduled IA also considers uncleared PJM Buy Bid/Sell Offer from prior IA

- PJM Sell Offer prices based on Updated VRR Curve Decrement

- PJM Sell Offers are defined in advance of Incremental Auction
Updated VRR Curve Increment/Decrement

Updated VRR Curve

Updated Reliability Requirement

Updated VRR Curve Increment portion of the updated VRR Curve to the right of the vertical line at the current UCAP commitment level

Updated VRR Curve Decrement portion of the updated VRR Curve to the left of the vertical line at the current UCAP commitment level

Price

Quantity

Updated VRR Curve

Current Commitment Level
VRR Curve Decrement - MAAC

Updated VRR Curve
MAAC

PJM Sell Offer Curve
MAAC

PJMC © 2017
Energy Efficiency Resources are dispatched by PJM during emergencies.

a) True
b) False
Only generators located inside the PJM market footprint may participate in RPM_________.

a) True
b) False
Planned DR resources are not allowed to participate in an RPM auction

a) True
b) False
Auction Structure
RPM Auction Schedule

Base Residual Auction

First Incremental Auction

Second Incremental Auction

Third Incremental Auction

EFORd Fixed

Ongoing Bilateral Market

Delivery Year

May

Sept

July

Feb.

June

3 Years

20 months

10 months

3 months

04/18/2017

PJM©2017
## Overview of RPM Auctions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Purpose</th>
<th>Cost of Procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Residual Auction</td>
<td>Procurement of RTO Obligation less an amount reserved for short term resources (prior to 18/19 DY), less FRR Obligation</td>
<td>Allocated to LSEs through Locational Reliability Charge</td>
</tr>
</tbody>
</table>
| 1<sup>st</sup> Incremental Auction | Allows for:  
1. replacement resource procurement  
2. increases and decreases in resource commitments due to reliability requirement adjustments; and  
3. deferred short-term resource procurement (prior to 18/19 DY) | Allocated to resource providers that purchased replacement resources and LSEs through Locational Reliability Charge |
| 2<sup>nd</sup> Incremental Auction | Procurement of additional capacity in a LDA to address reliability problem that is caused by a significant transmission line delay       | Allocated to LSEs through Locational Reliability Charge                              |
| 3<sup>rd</sup> Incremental Auction | Procurement of additional capacity in a LDA to address reliability problem that is caused by a significant transmission line delay       | Allocated to LSEs through Locational Reliability Charge                              |
Sell Offers / Buy Bids

- Sell Offers and Buy Bids for the Base Residual and Incremental Auctions must be submitted in PJM’s eRPM system
  - Sell offers and buy bids are only accepted during a fixed bidding window which is open for at least five business days
  - The bidding window for an auction will be posted on the PJM website

- Sell offers and buy bids may not be changed or withdrawn after the bidding window for an auction is closed
RPM Schedule of Activities is posted on the RPM Auction User Information Web Page.
### Capacity Bids

**Company:** PJMTST  
**Planning Period:** 2018/2019  
**Product Type:** ALL

<table>
<thead>
<tr>
<th>LDA</th>
<th>Product Type</th>
<th>Bid Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATSI Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATSI Base DRIE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATSI Cap. Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATSI CLEVELAND Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATSI CLEVELAND Base DRIE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATSI CLEVELAND Cap. Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DGE Base</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bids Data:**

- **Price:** (null) (null) (null) (null) (null) (null) (null) (null) (null) (null)
- **BTU:** (null) (null) (null) (null) (null) (null) (null) (null) (null) (null)

**Status:** BASE: CLEARED  
**Auction Type:** FIRST  
**Auction Results Summary:** Second: Future  
**Participant Auction Results:** Third: Future

*PJM©2017*
Market Power Mitigation

• Existing generation capacity resources must offer into each RPM Auction (prevent physical withholding)

• Application of Market Seller Offer Caps to existing generation capacity resource sell offers (prevent economic withholding)

• Application of Minimum Offer Price Rule (MOPR) to planned generation capacity resource sell offers (prevent buyer-side market power)
RPM Auctions begin _____ years prior to the Delivery Year?

a) 1
b) 2
c) 3
d) 5
Buy bids or sell offers may be changed during the auction bidding window

a) True
b) False
Auction Clearing
Auction Clearing Mechanism

- RPM Auctions use an optimization-based market clearing algorithm
- This algorithm has the objective of minimizing capacity procurement costs given
  - Supply Offers
  - Demand Curves
  - Locational Constraints
  - Resource Constraints
- The clearing price for each LDA is determined by the optimization algorithm
Clearing Mechanism

Demand
- RTO/LDA Variable Resource Requirement (VRR)
- Curves for Base Residual Auction
- Locational Buy Bids by Auction Participants and/or PJM for Incremental Auctions

Supply
- Resource-specific Sell Offers
- May include PJM locational sell offer

Optimization Algorithm

Auction Results
- Resource Commitments
- Resource Clearing Prices
- UCAP Obligation values
- Capacity Transfer Rights

Constraints
- Locational Constraints
- Resource Constraints

Zonal Capacity Prices
CTR Rates
<table>
<thead>
<tr>
<th>Period</th>
<th>Resource Constraints</th>
</tr>
</thead>
</table>
| 2014/2015 - 2016/2017 | • **Minimum Annual Resource Requirement** - minimum amount of Annual Resources to be procured  
• **Minimum Extended Summer Resource Requirement** - minimum amount of Extended Summer Demand Resources and Annual Resources to be procured |
| 2017/2018              | • **Limited Resource Constraint** – maximum amount of Limited DR to be procured         
• **Sub-Annual Resource Constraint** – maximum amount of Limited DR & Extended Summer DR to be procured |
| 2018/2019 - 2019/2020 | • **Base Capacity DR Constraint** – maximum amount of Base Capacity DR and Base Capacity EE to be procured  
• **Base Capacity Resource Constraint** – maximum amount of Base Capacity DR, Base Capacity EE, and Base Capacity Generation to be procured |
| 2020/20201 & beyond    | • Cleared quantity of Summer-Period CP Resources = Cleared quantity of Winter-Period CP Resource |
Updated Auction Clearing Process
(Beginning 2020/2021 Delivery Year)

- Auction clearing algorithm will clear all annual CP sell offers, summer-period CP sell offers, and winter-period CP sell offers simultaneously to minimize bid-based cost of satisfying the reliability requirements of the RTO and each modeled LDA subject to all applicable requirements and constraints, including:
  - LDA CETL values
  - Total cleared summer-period sell offers must exactly equal total cleared winter-period sell offers across the entire RTO (new constraint to ensure that seasonal CP sell offers clear to form annual CP commitments)
The RPM auction clearing algorithm uses an objective function to maximize capacity costs

a) True
b) False
Resource Clearing Prices
• The **Resource Clearing Price** (RCP) for Generation Resources, Demand Resources, and EE Resources within each LDA is the sum of:

(1) the marginal value of system capacity; (2) Locational Price Adder(s), if any in such LDA; (3) Limited Resource Price Decrements, if any in such LDA; and Sub-Annual Resource Price Decrements, if any in such LDA; (4) Base and Base DR/EE Price Decrements, if any in such LDA.

Marginal value of system capacity is clearing price for Annual/Capacity Performance Resources within the Rest of the RTO.

**Resource Clearing Price in LDA**

- Marginal Value Of System Capacity
- Locational Price Adder(s)*
- Limited Resource Price and Sub-Annual Resource Price Decrement (2017/2018 only) Applicable for Limited DR only and Limited DR & Extended Summer DR respectively

*Adder with respect to immediate higher level LDA

RCP may not be equal to Final Zonal Capacity Price. RCP (price paid to resources) and Final Zonal Capacity Price (price paid by LSEs) are different terms in RPM.
# Auction Clearing Prices – 2019/2020 BRA

## 2019/2020 BRA Resource Clearing Results

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RTO</td>
<td>$100.00</td>
<td>$0.00</td>
<td>$100.00</td>
<td>($20.00)</td>
<td>$80.00</td>
<td>$0.00</td>
<td>$80.00</td>
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<tr>
<td>MAAC</td>
<td>$100.00</td>
<td>$0.00</td>
<td>$100.00</td>
<td>($20.00)</td>
<td>$80.00</td>
<td>$0.00</td>
<td>$80.00</td>
</tr>
<tr>
<td>WMAC</td>
<td>$100.00</td>
<td>$19.77</td>
<td>$119.77</td>
<td>($20.00)</td>
<td>$99.77</td>
<td>$0.00</td>
<td>$99.77</td>
</tr>
<tr>
<td>PS</td>
<td>$100.00</td>
<td>$0.00</td>
<td>$100.00</td>
<td>($20.00)</td>
<td>$80.00</td>
<td>$0.00</td>
<td>$80.00</td>
</tr>
<tr>
<td>PSNORTH</td>
<td>$100.00</td>
<td>$0.00</td>
<td>$119.77</td>
<td>($20.00)</td>
<td>$99.77</td>
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<tr>
<td>DPLSOUTH</td>
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<td>$0.00</td>
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<td>($20.00)</td>
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<td>($20.00)</td>
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<td>ATSI</td>
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<td>($20.00)</td>
<td>$80.00</td>
<td>$0.00</td>
<td>$80.00</td>
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<tr>
<td>ATSI-CLEVELAND</td>
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<td>$0.00</td>
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<td>($20.00)</td>
<td>$80.00</td>
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<td>$80.00</td>
</tr>
<tr>
<td>COMED</td>
<td>$100.00</td>
<td>$102.77</td>
<td>$202.77</td>
<td>($20.00)</td>
<td>$182.77</td>
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<tr>
<td>BGE</td>
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<td>$0.30</td>
<td>$100.30</td>
<td>($20.00)</td>
<td>$80.30</td>
<td>$0.00</td>
<td>$80.30</td>
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<tr>
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<td>$0.00</td>
<td>$100.00</td>
<td>($20.00)</td>
<td>$80.00</td>
<td>$0.00</td>
<td>$80.00</td>
</tr>
<tr>
<td>NORTH ***</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>WEST 1 ***</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>NA</td>
</tr>
<tr>
<td>WEST 2 ***</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>SOUTH 1 ***</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>SOUTH 2 ***</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

*System Marginal Price is the clearing price for Capacity Performance Resources in unconstrained area of RTO.

** Locational Price Adder (positive number) is with respect to the immediate higher level LDA. Locational Price Decrement (negative number) is with respect to the unconstrained area of RTO.
A resources clearing price is based on the marginal system value, any locational price adder if applicable and product specific price decrement, if applicable.

a) True
b) False
Regional differences in capacity auction clearing prices are typically caused by ______.

a) Weather
b) Generator Outages
c) Lunar Phase
d) Transmission Constraints
Capacity Transfer Rights
Why Capacity Transfer Rights

Resources in the unconstrained LDA (and capacity imported into constrained LDAs) are paid the Unconstrained (lower) Resource Clearing Price:

\[
\text{Unconstrained LDA RCP} = \$111.92/\text{MW-day}
\]

LSEs pay a Locational Reliability Charge for their entire UCAP obligation (including imports) at the higher zonal capacity price:

\[
\text{Constrained LDA FZCP} = \$150.53/\text{MW-day of UCAP obligation}
\]

Capacity Transfer Right (CTR) Credit reduces the LSE load charge by recognizing the economic value of less expensive resources imported from outside the constrained LDA.
# How are CTR Rates Determined?

<table>
<thead>
<tr>
<th>Rate</th>
<th>Equation</th>
<th>When posted?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Zonal CTR Credit Rate ($/MW-day of obligation)</td>
<td>= Base Economic Value of CTRs allocated to LSEs in a zone from BRA/Base Zonal UCAP Obligation</td>
<td>With BRA clearing results</td>
</tr>
<tr>
<td>Final Zonal CTR Credit ($/MW-day of obligation)</td>
<td>= Final Economic Value of CTRs allocated to LSEs in a zone as determined after the Final IA/Final Zonal UCAP Obligation</td>
<td>With Final IA clearing results</td>
</tr>
<tr>
<td>Final CTR Settlement Rate ($/MW-day of CTRs)</td>
<td>= Final Economic value of CTRs allocated to LSEs in a zone as determined after the Final IA/Final Zonal CTRs allocated to LSEs</td>
<td>With Final IA clearing results</td>
</tr>
</tbody>
</table>
| Final Sink LDA ICTR Settlement Rate ($/MW-day of ICTRs) | • Participant-Funded Project ICTRs  
• Regional Project ICTRs  
= Final Economic Value of ICTRs in Sink LDA/Final ICTRs MWs in Sink LDA | With Final IA clearing results                   |
CTR credits are used to recognize the value of less expensive resources imported from outside the constrained LDA.

a) True

b) False
Zonal Capacity Prices
When are Zonal Prices Determined?

- Base Residual Auction Results
  - Preliminary Zonal Capacity Prices
  - Base Zonal Capacity Transfer Right (CTR) Credit Rate

- Incremental Auction Results
  - Adjusted Zonal Capacity Prices
  - Adjusted Zonal CTR Credit Rates

- Final Incremental Auction Results
  - Final Zonal Capacity Prices
  - Final Zonal CTR Credit Rates

Locational Reliability Charge = Daily Zonal UCAP Obligation * Final Zonal Capacity Price
Final Zonal Capacity Prices are calculated such that the:

**Payments**
- Total Payments to:
  - Incremental CTR Holders
  - Resources cleared in all Auctions, except resources cleared as replacement capacity
  - Cleared QTUs
  - LSEs receiving CTRs

**Charges**
- Total amount of Locational Reliability Charges (assessed to loads)
### Example of Final Zonal Capacity Prices

<table>
<thead>
<tr>
<th>Final Zonal UCAP Obligation ($/MW-day)</th>
<th>Adjusted Zonal Capacity Price ($/MW-day)</th>
<th>Final CP Transition IA Cost Component ($/MW-day)</th>
<th>Final Zonal Capacity Price with CP Transition IA Cost Component ($/MW-day)</th>
<th>Final Zonal CTR Credit Rate ($/MW-UCAP Obligation-day)</th>
<th>Final Zonal Net Load Price ($/MW-day)</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,766.6</td>
<td>$123.42</td>
<td>$39.86</td>
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<td>$101.62</td>
<td>$0.00</td>
<td>$101.62</td>
<td>DAYTON</td>
</tr>
</tbody>
</table>
Committed Resource Obligations
Energy Market Offer Requirements

• All generation resources that have an RPM Resource Commitment must offer into PJM’s Day Ahead Energy Market

• Demand Resources that have an RPM Resource Commitment must be registered in the Full Program Option or Capacity Only Option of the Emergency or Pre-Emergency Load Response Program
  – and thus available for dispatch during PJM declared emergency events
## Resource Performance Measures

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPM Commitment Compliance</td>
<td>Determines if sufficient unforced capacity on resource during DY to meet its RPM commitments</td>
</tr>
<tr>
<td>Peak-Hour Period Availability</td>
<td>Measures if generation resource was available during critical peak-hour periods during DY</td>
</tr>
<tr>
<td>Summer/Winter Capability Testing</td>
<td>Determines if generation resource demonstrated its ICAP commitment amount through summer and winter testing</td>
</tr>
<tr>
<td>PSM Compliance</td>
<td>Determines if generation resource took an unapproved planned or maintenance outage during peak season period</td>
</tr>
<tr>
<td>Load Management Event Compliance</td>
<td>Determines if committed demand resource reduced load during a PJM-initiated LM event</td>
</tr>
<tr>
<td>Load Management Test Compliance</td>
<td>In the absence of a PJM-initiated LM event, this assessment determines if committed demand resource reduced load during a CSP-initiated test</td>
</tr>
<tr>
<td>EE M&amp;V Audit</td>
<td>Confirms the Nominated EE Value and CP value of an EE Resource through a post-installation M&amp;V audit</td>
</tr>
<tr>
<td>Non-Performance Assessment</td>
<td>Evaluate the performance of committed capacity resources during Emergency conditions</td>
</tr>
</tbody>
</table>
Assessments for Annual, Extended Summer DR, & Limited DR Commitments

**Generation Resource**
- Commitment Compliance
- Peak Hour Period Availability*
- Generation Rating Test*
- Peak Season Maintenance Compliance**

**Demand Resource (DR)**
- Commitment Compliance
- Load Management Event Compliance
- Load Management Test Compliance

**Energy Efficiency Resource (EE)**
- Commitment Compliance
- Measurement & Verification Audit

*Not applicable to wind and solar resources
**Not applicable to hydro and intermittent resources
Assessments for CP & Base Commitments

**Generation Resource**
- Commitment Compliance
- Non-Performance Assessment
- Generation Rating Test*

**Demand Resource (DR)**
- Commitment Compliance
- Non-Performance Assessment
- Load Management Test Compliance

**Energy Efficiency Resource (EE)**
- Commitment Compliance
- Measurement & Verification Audit
- Non-Performance Assessment

* Not applicable to wind and solar resources
LSE Obligations in RPM

- PJM procures capacity on behalf of LSEs through RPM Auctions to satisfy their daily UCAP obligations during the DY.

- LSEs will automatically be assessed a Locational Reliability Charge for load served during the DY.

- LSEs are not required to participate in RPM Auctions.
  - An LSE may choose to offer resources in RPM Auctions and use any Auction Credits received to offset the Locational Reliability Charges.
## How are **Final** UCAP Obligations Determined?

<table>
<thead>
<tr>
<th>When Determined?</th>
<th>Final RTO UCAP Obligation</th>
</tr>
</thead>
<tbody>
<tr>
<td>After clearing of the final IA for the DY</td>
<td>Total amount of MWs cleared in Buy Bids submitted by PJM across all RPM Auctions less the total amount of MWs cleared in Sell Offers submitted by PJM across all Incremental Auctions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When Determined?</th>
<th>Final Zonal UCAP Obligation</th>
</tr>
</thead>
<tbody>
<tr>
<td>After clearing of the final IA for the DY</td>
<td>Zonal allocation of the Final RTO UCAP Obligation</td>
</tr>
</tbody>
</table>
Obligation Peak Load – Annual Allocation

- Each PJM Electric Distribution Company (EDC) is responsible for allocating the previous summer’s weather normalized peak to end-use customers in the zone (both retail and wholesale) by Dec. 31 prior to the start of the Delivery Year.

Zonal WN Peak = 1000 MW

Obligation Peak Load allocation for a zone/area is constant and effective for the entire Delivery Year.

Often referred to as a “PLC” or “capacity ticketing” process.
Obligation Peak Load – Daily Allocation

• Areas with Retail Choice can modify LSE share on a daily basis by uploading XML files to eRPM.

• XML Uploads must be submitted by EDC at least 36 hours prior to the start of the operating day.
LSE UCAP Obligation

• LSE UCAP Obligations are assessed daily based on load served during Delivery Year
• Daily UCAP Obligation is locked 36 hours prior to the start of the operating day
• FPR used is the final value updated prior to the Third Incremental Auction
Locational Reliability Charges

Locational Reliability Charge =

- Each RPM LSE that serves load in a PJM Zone or load outside PJM using PJM resources (i.e., Non-Zone Network Load) during the Delivery Year must pay a Locational Reliability Charge.

- Charges calculated daily and billed weekly during Delivery Year.
The Electric Distribution Companies (EDCs) upload the load serving responsibility of suppliers in their zone to PJM each day.

a) True
b) False
Changes for 2020/2021 Delivery Year
Enhanced Aggregation Filing

- Enhance Capacity Performance aggregation rules
- Establish winter Capacity Interconnection Rights for eligible resources
- Modify Demand Resource Measurement & Verification Rules
Updated Aggregate Resource Business Rules

• Allow Intermittent, Capacity Storage Resources, DR, EE, and environmentally limited resources that are located in different LDAs to form an Aggregate Resource
  – Aggregate Resource will be modeled in smallest modeled LDA common to underlying resources

• Total committed quantity on Aggregate Resource allocated to underlying resources on monthly basis and updated no later than last day of month preceding delivery month
  – Quantity allocated to an individual resource cannot exceed the CIR value/UCAP value of the individual resource
  – If total committed quantity on Aggregate Resource increases/decreases due to replacement capacity transactions, must increase/decrease the allocation of commitment to the underlying resources by a commensurate amount
Updated Aggregate Resource Business Rules (Cont’d)

• Performance of an Aggregate Resource for a given PAH is based on the net of the performance of the individual underlying resources that were required to perform during the PAH (i.e. the resources located in the PAH area).

• The Non-Performance Charge Rate for an under-performing Aggregate Resource is based on the rate associated with the LDA in which the under-performing underlying resources are located weighted by the under-performance MW quantity of such resources.

• The stop-loss of the Aggregate Resource is based on the Non-Performance Charge Rate associated with the LDA in which the Aggregate Resource was modeled in the RPM Auction.
Seasonal Capacity Performance Resources
(Effective 2020/2021 Delivery Year)

Summer-Period CP Resources
- Summer Period DR
- Summer Period EE
- Capacity Storage Resource
- Intermittent Resource
- Environmentally-Limited Resource

Winter-Period CP Resources
- Capacity Storage Resource
- Intermittent Resource*
- Environmentally-Limited Resource*

* May request additional CIRs for winter-period for DY and offer additional ICAP value in winter-period

- Available June-October & May of DY (summer-period)
- If clear, Auction Credit & commitment for summer-period only

- Available November-April (winter-period)
- If clear, Auction Credit & commitment for winter-period only
Update Sell Offer Requirements

CP Offer Segment (Annual)
• Specify Min & Max MW offered & offer price
• Up to 10 segments
• Each segment clears independently
• MWs offered/cleared for entire DY

Seasonal CP Offer Segment (Summer or Winter)
• Specify Max MW offered & offer price (flexible offer)
• Up to 10 segments
• Each segment clears independently
• MWs offered/cleared for entire seasonal period

Total MWs offered across CP Offer segments <= Annual Max Available ICAP
Total MWs offered across all segments <= Seasonal Max Available ICAP
All sell offer segments are separate and independent of each other and all segments may potentially clear the auction. NOT COUPLED OFFERS
Update Auction Clearing Process

• Auction clearing algorithm will clear all annual CP sell offers, summer-period CP sell offers, and winter-period CP sell offers simultaneously to minimize bid-based cost of satisfying the reliability requirements of the RTO and each modeled LDA subject to all applicable requirements and constraints, including:

  – LDA CETL values (same as today)

  – Total cleared summer-period sell offers must exactly equal total cleared winter-period sell offers across the entire RTO (new constraint to ensure that seasonal CP sell offers clear to form annual CP commitments)
Update Nominated DR Value calculation for FSL/GLD customer on CP registration

**FSL Customer**

- Nominated DR Value = lesser of: (a) PLC – [Summer FSL * loss factor] or (b) [Winter Peak Load * Winter Weather Adjustment Factor – Winter FSL] * loss factor
- Nominated DR Value effective for entire DY

**FSL Customer**
(Effective 2020/2021 DY)

- Nominated DR Value for winter-period = PLC-[Summer FSL * loss factor]
- Nominated DR Value for non-winter period = lesser of: (a) PLC – [Summer FSL * loss factor] or (b) [Winter Peak Load * Winter Weather Adjustment Factor – Winter FSL] * loss factor
- If registration indicates Summer-Period DR Only, Nominated DR Value for non-winter period = 0

**GLD Customer**

- Nominated DR Value = lesser of: (a) summer GLD amount* loss factor or (b) winter GLD amount * loss factor
- Nominated DR Value effective for entire DY
- Nominated DR Value shall not exceed PLC

**GLD Customer**
(Effective 2020/2021 DY)

- Nominated DR Value for winter-period =summer GLD amount * loss factor
- Nominated DR Value for non-winter period = lesser of: (a) summer GLD amount * loss factor or (b) winter GLD amount * loss factor
- If registration indicates Summer-Period DR Only, Nominated DR Value for non-winter period = 0
- Nominated DR Value for both summer & non-winter period shall not exceed PLC

- CSP determines Winter Peak Load based on customer’s peak load between hours ending 7:00 EPT through 21:00 EPT on each of PJM defined 5CP days from December through February two Delivery Years prior to the DY for which registration is submitted
- PJM calculates and posts Zonal Winter Weather Adjustment Factor.
Contact Information:

PJM Client Management & Services
Telephone: (610) 666-8980
Toll Free Telephone: (866) 400-8980
Website: www.pjm.com

The Member Community is PJM’s self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services