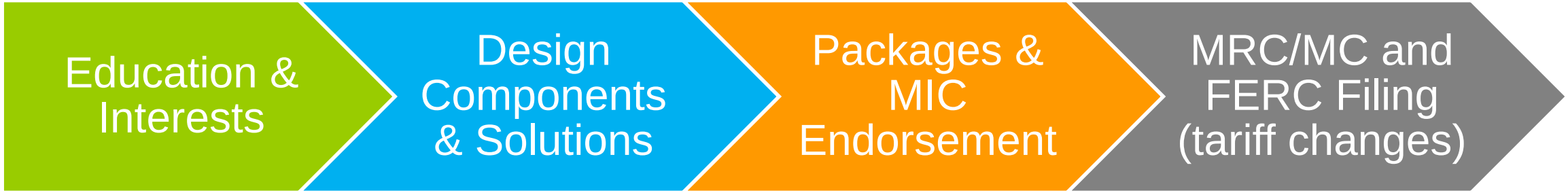
PJM's Balancing Ratio Proposals

Patrick Bruno
Sr. Engineer, Capacity Market Operations
Markets Implementation Committee
July 11, 2018

Background

- PJM raised the issue regarding the Balancing Ratio (*B*) used in the RPM default Market Seller Offer Cap (*MSOC*) in September, 2017
  - *Default MSOC = Net CONE$_{LDA}$ * B*
  - Existing methodology to calculate *B* does not work when no Performance Assessment Intervals (PAIs) occur during the 3 calendar years immediately preceding the BRA
- Review of the Non-Performance Charge Rate (*PPR*) and its assumed 30 hours of Emergency Actions included in Issue Charge
  - *PPR = (Net CONE$_{LDA}$ * 365 days) / 30 hours / 12 settlement intervals*
- Initially approved at MRC in October, 2017 and assigned to MIC
  - Revised Issue Charge approved at MRC in April, 2018
    - *Net CONE$_{LDA}$ * B* as the default MSOC equation brought back in scope

Expected Timeline



Feb-Mar MIC	Mar-May MIC	Jun-Aug MIC	Jul-Aug MRC (Sept MC)

★ File endorsed changes with FERC no later than October 2018

Package A Proposal

Proposal Description

To estimate the expected future Balancing Ratio (*B*) used in the default MSOC…

Take the average Balancing Ratios during the 3 Delivery Years that immediately precede the BRA using:

a) actual Balancing Ratios calculated during RTO PAIs of the Delivery Year, *and*

b) for any preceding Delivery Year with less than 360 intervals (30 hours) of RTO PAIs, estimated Balancing Ratios calculated during the intervals of the highest RTO peak loads that do not overlap a PAI

Proposal Rationale

- Straight-forward solution that augments the existing methodology by providing reasonable proxy hours and Balancing Ratios to use when no, or relatively few, actual PAIs occur
  - Peak load hours of the RTO provide reasonable proxies given correlation between hours of high demand and Emergency Actions
- Proposed Balancing Ratios appear on par with those calculated from actual data during historical RTO Emergency Actions
- Determinable in time to inform the unit-specific offer cap submission deadline for documentation
  - 120 days prior to the BRA (mid-January)

Example of a Preceding Delivery Year w/ less than 360 PAIs (30 hours)

Interval Count	Date	Time	PAI	Peak Hour	Balancing Ratio
1	Jul-18	14:15	Y	Y	93.4%
2	Jul-18	14:20	Y	Y	93.7%
3	Jul-18	14:25	Y	Y	93.7%
4	Jul-18	14:30	Y	Y	93.5%
5	Jul-18	14:35	Y	Y	93.3%
6	Jul-18	14:40	Y	Y	92.7%
7	Jul-18	14:45	Y	Y	92.4%
8	Jul-18	14:50	Y	Y	91.2%
9	Jul-18	14:55	Y	Y	90.8%
10	Aug-5	16:00	Y	Y	86.3%
11	Aug-5	16:05	Y	Y	85.7%
12	Aug-5	16:10	Y	Y	85.5%
⋮	⋮	⋮	⋮	⋮	⋮
216	Feb-2	07:10	Y	-	78.5%
217	Jul-18	14:00	-	Y	93.1%
218	Jul-18	14:05	-	Y	93.2%
219	Jul-18	14:10	-	Y	93.5%
⋮	⋮	⋮	⋮	⋮	⋮
360	Feb-2	07:05	-	Y	78.8%

a) 216 Balancing Ratios from actual PAIs (18 hours)

b) 144 estimated Balancing Ratios from highest RTO peak load hours not overlapping a PAI (12 hours)

Total of 360 intervals (30 hours) of Balancing Ratios to be averaged with the ratios of other 2 preceding DYs

Comparison of Existing and Proposed Balancing Ratios (*B*)

Delivery Year	Existing *B*	Proposed *B*	Prior 3 DYs
2018/2019	85.0%	88.3%	11/12, 12/13, 13/14
2019/2020	81.0%	85.3%	12/13, 13/14, 14/15
2020/2021	78.5%	83.8%	13/14, 14/15, 15/16
2021/2022	78.5% *	86.8%	14/15, 15/16, 16/17

Balancing Ratios during historical RTO Emergency Actions from 2011 - 2014

Summer (16 hours): **Avg = 93.5%** Min = 87.7% Max = 95.1%

Winter (26 hours): **Avg = 78.3%** Min = 71.5% Max = 84.9%

Package B Proposal

Proposal Summary

- Similar to Package A, determine an estimated Balancing Ratio for use in the default offer cap from the prior 3 Delivery Years using:
  a) Actual Balancing Ratios determined during RTO PAIs, and
  b) when needed, estimated Balancing Ratios during highest RTO peak loads

- Estimate the number of PAIs expected to occur in a Delivery Year using historical data from the prior 3 Delivery Years
  – "Projected Performance Assessment Intervals"

- Update the CP Non-Performance Charge Rate (*PPR*) and default MSOC formulas to include the "Projected Performance Assessment Intervals"

Projected Performance Assessment Intervals

- Calculated as the average number of RTO PAIs in the 3 Delivery Years immediately preceding the BRA for such Delivery Year
- Floored at 60 PAIs (5 hours) for the CP default MSOC
  - Reasonable for market sellers to still account for a few hours of opportunity costs from PAIs in their sell offer even when few, or no PAIs have occurred in recent Delivery Years
- Floored at 180 PAIs (15 hours) for the CP Non-Performance Charge Rate
  - Maintains a reasonable minimum number of days/hours before the stop-loss can be hit by a non-performing unit (≈23 hours w/ balancing ratios of 100%)
  - Prevents the penalty rate from becoming excessively high when few PAIs have occurred in recent Delivery Years

Non-Performance Charge Rate (*PPR*) and Default MSOC Formulas

- Update the *PPR* formula to *(Net $CONE_{LDA}$ * 365 days) / Projected $PAIs_{PPR}$*
  - Currently, set to *(Net $CONE_{LDA}$ * 365 days) / 30 hours / 12 intervals*
  - Equivalent to current when Projected $PAIs_{PPR}$ equals 360 intervals (30 hours)
  - Adjust the FRR physical CP penalty rate formula to keep consistent with change in assumed number of PAIs

- Update the default MSOC formula to *PPR * Projected $PAIs_{MSOC}$ * B / 365 days*
  - Currently, set to *Net $CONE_{LDA}$ * B*
  - Equivalent to current when *Projected $PAIs_{MSOC}$ = Projected $PAIs_{PPR}$*, meaning the same estimated number of Projected PAIs are used in both the Non-Performance Charge Rate and default MSOC

Examples

Given: *Net $CONE_{LDA}$ = $300/MW-day, B = 85%*

Existing *PPR = (Net $CONE_{LDA}$ * 365) / 30 / 12 intervals* ≈ ***$304/MW per PAI ($3,650 hourly)***

Existing *default MSOC = (Net $CONE_{LDA}$ * B)* = ***$255/MW-day***

Proposed *PPR_{PAI} = (Net $CONE_{LDA}$ * 365 days) / Projected $PAIs_{PPR}$*

Proposed *default $MSOC_{\$/MW\text{-}day}$ = (PPR * Projected $PAIs_{MSOC}$ * B) / 365 days*

Example	15/16 PAIs	16/17 PAIs	17/18 PAIs	22/23 BRA Projected PAIs	Projected $PAIs_{PPR}$	Projected $PAIs_{MSOC}$	Proposed PPR	Proposed $MSOC_{\$/MW\text{-}day}$
1	0	0	0	0 PAIs *(0 hours)*	180	60	$608 *($7,300 hourly)*	$85
2	0	120	240	120 PAIs *(10 hours)*	180	120	$608 *($7,300 hourly)*	$170
3	240	480	0	240 PAIs *(20 hours)*	240	240	$456 *($5,475 hourly)*	**$255**
4	360	0	720	360 PAIs *(30 hours)*	360	360	**$304** *($3,650 hourly)*	**$255**
5	460	320	480	420 PAIs *(35 hours)*	420	420	$261 *($3,129 hourly)*	**$255**

Proposed default MSOC Balancing Ratio (*B*)

To estimate the expected future Balancing Ratio (*B*) used in the default MSOC…

Take the average Balancing Ratios during the 3 Delivery Years that immediately precede the BRA using:

a) actual Balancing Ratios calculated during RTO PAIs of the Delivery Year, *and*

b) for any preceding Delivery Year with less actual RTO PAIs than the Projected $PAIs_{MSOC}$ (minimum of 60 intervals or 5 hours), estimated Balancing Ratios calculated during the intervals of the highest RTO peak loads that do not overlap a PAI

Comparison of Existing and Proposed Balancing Ratios (*B*)

Delivery Year	Existing *B*	Proposed *B*	Prior 3 DYs
2018/2019	85.0%	85.0%	11/12, 12/13, 13/14
2019/2020	81.0%	82.8%	12/13, 13/14, 14/15
2020/2021	78.5%	82.1%	13/14, 14/15, 15/16
2021/2022	78.5% *	88.9%	14/15, 15/16, 16/17

Balancing Ratios during historical RTO Emergency Actions from 2011 - 2014

Summer (16 hours): **Avg = 93.5%** Min = 87.7% Max = 95.1%

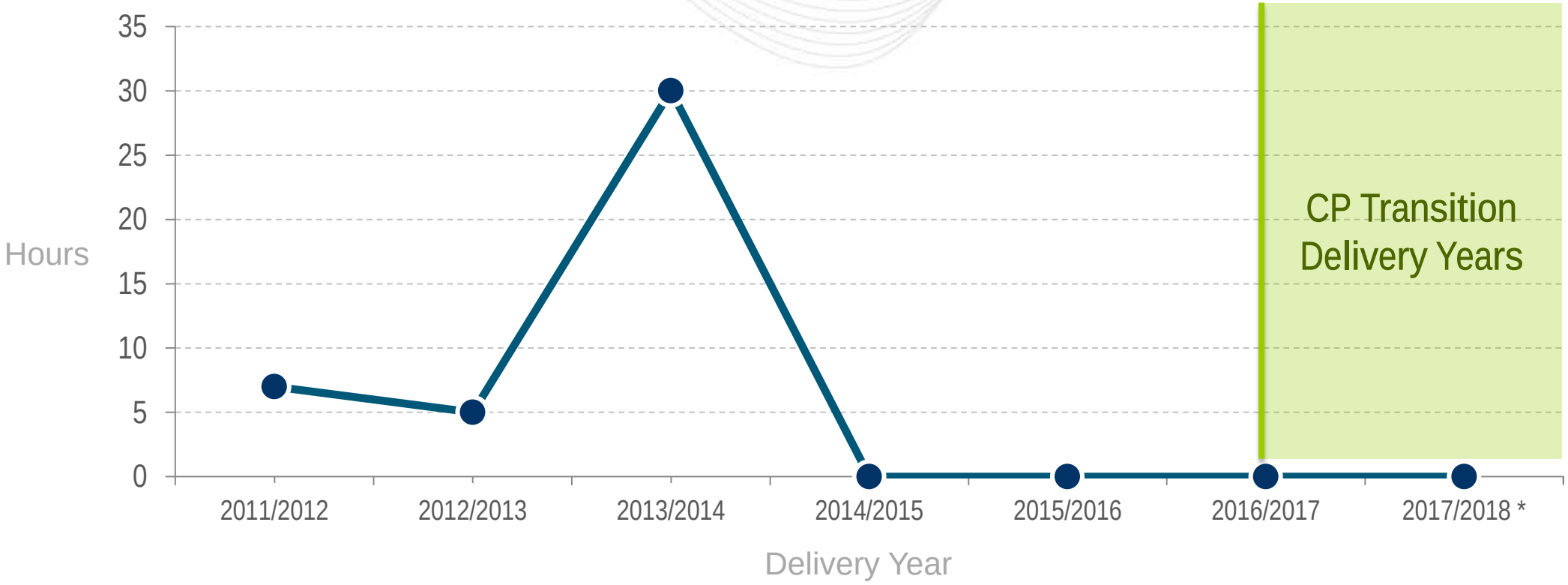
Winter (26 hours): **Avg = 78.3%** Min = 71.5% Max = 84.9%

Summary of RAA, OATT, and Manual 18 Revisions

- RAA (Package B only)
  - New definition for “Projected Performance Assessment Intervals” (also added to OATT)
  - Schedule 8.1G: FRR physical CP penalty rate formula update
- OATT Attachment DD
  - Section 6.4: New calculation of the Balancing Ratio in the default MSOC
  - Section 6.4 (Package B only): Default MSOC formula update
  - Section 10A (Package B only): CP Non-Performance Charge Rate formula update
- Manual 18
  - Glossary: New definition for “Projected Performance Assessment Intervals”
  - Section 5.4.1: CP default MSOC and Balancing Ratio updates
  - Section 8.4A (Package B only): CP Non-Performance Charge Rate formula update
  - Section 9.1.11 (Package B only): CP Non-Performance Charge Rate formula update
  - Section 11.8.9 (Package B only): FRR physical CP penalty rate formula update

Appendix: Prior Education

Historical RTO Performance Assessment Hours



Note: Hours shown prior to 2016/2017 reflect Emergency Actions that would have triggered a Performance Assessment Hour under the CP rules

Actual Balancing Ratios determined for Performance Assessment Intervals

- The calculated Balancing Ratio for a Performance Assessment Interval represents the percentage share of total generation capacity commitments needed to support the load and reserves on the system within the Emergency Action Area during the interval
  - i.e. (Load + Reserves) / Generation Capacity Commitments
- The Balancing Ratio is used to set the Expected Performance level of Generation Capacity Performance Resources within the Emergency Action Area during the Performance Assessment Interval
  - Expected Performance = Capacity Commitment (UCAP) x Balancing Ratio

$$\frac{\text{Total Actual Generation and Storage Performance + Net Energy Imports * + Demand Response Bonus Performance}}{\text{All Generation and Storage Committed UCAP}}$$

Annual Stop-Loss of Non-Performance Charges

Stop-Loss = **Net CONE x 365 days x 1.5 x Committed MW**

Where:

- Net CONE is the Net Cost of New Entry (stated in $/MW-Day, ICAP terms) for the relevant Delivery Year and modeled LDA in which the resource resides
- Committed MW is the resource's capacity commitment in UCAP

- Based on the maximum clearing price allowed by the VRR curve at Net CONE times 1.5
- At 30 assumed Performance Assessment Hours in the Non-Performance Charge Rate, a resource will hit the stop-loss after 45 hours of zero Actual Performance

GE MARS Study to Estimate “H”

GE MARS is a planning software tool capable of calculating standard reliability indices for a given power system (e.g. daily and hourly LOLE)

The tool also allows for review of emergency operating procedures, by calculating the expected number of days per year at a specified margin

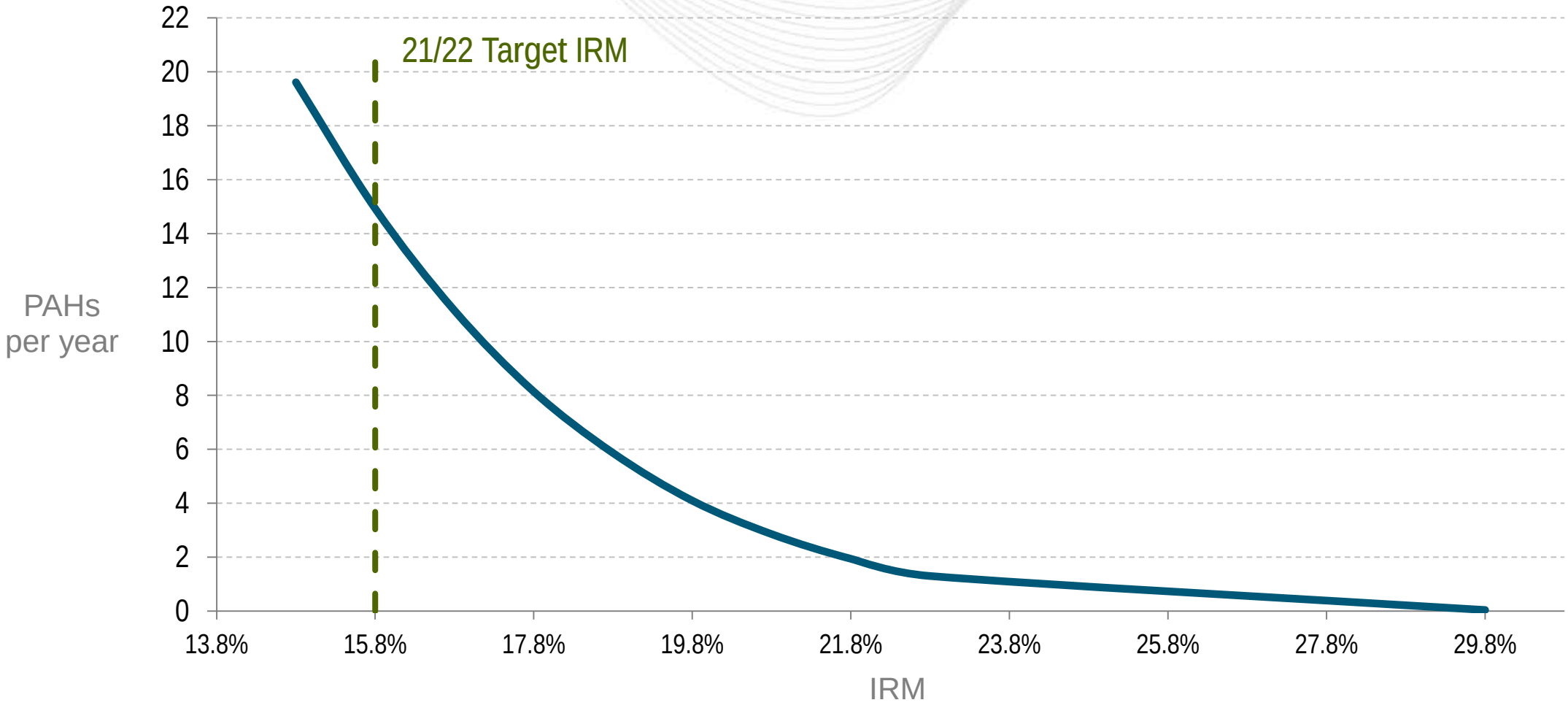
- e.g. A margin set at the typical Primary Reserve requirement might be used to estimate the number of Primary Reserve Warnings

The tool uses a sequential Monte Carlo simulation to calculate the probability of events, and requires a fair number of inputs and assumptions to run

GE MARS Study Assumptions

1. Same generator supply used in IRM Study
   - Operating histories randomly generated with each Monte Carlo replication for all units (reflects unit-specific forced outages rates)
   - Total Available Capacity determined for each hour
2. Solved peak load from IRM Study at reserve requirement
   - Monthly load shape using forecasted monthly peak loads; daily and hourly loads determined from an historical typical load shape
   - Hourly load levels varied in MARS simulations based on 7 load uncertainty levels, each with an associated probability
3. Specified Margin based on dispatch of Pre-Emergency DR
   - Estimated DR (8200 MW)
   - Operating Reserves/Regulation (3400 MW)

GE MARS Study Results
(1,000 replications run at each load level)



GE MARS Study Results / Observations

"H" significantly varies at different assumed reserve levels for the future DY

- IRM of 15.8%: ~ 15 Hours
- IRM of 21.8%: ~ 2 Hours

Virtually no Performance Assessment Hours occurred in winter months of the preliminary analysis; almost all risk and emergency hours in summer months

- Balancing Ratios calculated during the triggered Performance Assessment Hours of the program around 96 percent on average

Revised Issue Charge Scope Issue

- The default offer cap of $Net\ CONE_{LDA} * \overline{B}$ is derived from the equation of a competitive CP sell offer, and is a direct function of the Non-Performance Charge Rate

$$CP\ Competitive\ Offer = PPR * H * \overline{B} + max\{0, (ACR - PPR * H * \overline{A})\}$$

1. $Default\ MSOC_{\$/MW\text{-}year} = PPR * H * \overline{B} + max\{0, (ACR - PPR * H * \overline{A})\}$
2. $Default\ MSOC_{\$/MW\text{-}year} = [Net\ CONE * 365 / H] * H * \overline{B}$
3. $Default\ MSOC_{\$/MW\text{-}year} = Net\ CONE * 365 * \overline{B}$
4. $Default\ MSOC_{\$/MW\text{-}day} = Net\ CONE * \overline{B}$

Term	Description
PPR	Non-Performance Charge Rate
H	Expected number of PAHs
$\overline{B}$	Expected Balancing Ratio
$\overline{A}$	Expected unit availability
ACR	Net avoidable costs

- Therefore, proposed changes to the Non-Performance Charge Rate should also consider any impacts and corresponding changes needed to the default offer cap to keep the CP design logic intact

Revised Issue Charge (Redline)

Expected Deliverables

1. A more comprehensive methodology to determine the Balancing Ratio used in the calculation of the default MSOC
2. A recommendation to the MRC on the methodology used to determine the Non-Performance Charge Rate, and corresponding changes to the default MSOC

Out of Scope Items

1. The general ~~determination~~ underlying logic of the default Market Seller Offer Cap[1] ~~as Net $CONE_{LDA}$ * Balancing Ratio~~

[1] The calculation of the MSOC will remain the same as derived in equations 1-7 on page 5 of Appendix 1 of PJM's April 10, 2015 filed response in Docket No. ER15-623-000. The calculation shall reflect appropriate values as determined by the working group and as updated on a regular basis.

CP Competitive Offer

$$p = PPR \times H \times B' + \max\{0, (ACR - PPR \times H \times A')\}$$

Where:

- p: Offer price in RPM on a UCAP basis ($/MW-year)
- PPR: Non-Performance Charge Rate ($/MWh)
  - Assumed to be equivalent to the Bonus Performance Rate
- H: Expected number of Performance Assessment Hours in the year (hours/year)
- B': Expected value of balancing ratio across all Performance Assessment Hours in year
- ACR: Net ACR (net going forward costs) for a resource ($/MW-year)
- A': Expected value of availability across all Performance Assessment Hours in year

Note: The full overview and explanation of the Capacity Performance Offer Cap Logic can be found in Appendix 1 of PJM's April 10, 2015 response to FERC in Docket No. ER15-623-001

CP Competitive Offer for Low ACR Resource

Low ACR Resource is one whose net avoidable costs are less than its total expected Bonus Performance payments as an energy-only resource

- Second term of competitive offer drops to zero
- PPR substituted with Non-Performance Charge Rate

$p_{(\$/MW\text{-}year)}$ = PPR x H x B' ~~+ max{0, (ACR – PPR x H x A')}~~

$p_{(\$/MW\text{-}year)}$ = (Net CONE x 365 / H) x H x B'

$p_{(\$/MW\text{-}year)}$ = Net CONE x 365 x B'

$p_{(\$/MW\text{-}day)}$ = **Net CONE x B'** ⟶ CP default MSOC

CP Competitive Offer for High ACR Resource

High ACR Resource is one whose net avoidable costs are greater than its total expected Bonus Performance payments as an energy-only resource

- Second term of competitive offer remains greater than zero
- PPR substituted with Non-Performance Charge Rate
- Competitive offer dependent on unit-specific ACR and expected resource performance compared to B', requiring a unit-specific review of its MSOC
  - An appropriate unit-specific risk premium may also be included in the unit-specific review

$$p_{(\$/MW\text{-}year)} = PPR \times H \times B' + (ACR - PPR \times H \times A')$$

$$p_{(\$/MW\text{-}year)} = ACR + PPR \times H \times (B' - A')$$

$$p_{(\$/MW\text{-}year)} = ACR + (Net\ CONE \times 365 / H) \times H \times (B' - A')$$

$$p_{(\$/MW\text{-}day)} = ACR + Net\ CONE \times (B' - A')$$

CP Default MSOC – Example

	Capacity Resource	Energy-Only
Nameplate (MW)	100	100
Capacity Obligation (UCAP MW)	100	0
Net CONE ($/MW-day)	$250	$250
Balancing Ratio (B')	0.9	0.9
Actual Performance (A')	100	100
Expected Performance (MW)	90	-
Bonus Performance (MW)	10	100
Bonus Rate ($/MWh)	$3,042	$3,042
Bonus Performance Hours	30	30
Annual Bonus Performance ($/year)	$912,500	$9,125,000
Foregone Bonus Performance ($/year)	$8,212,500	-
Lost Opportunity Cost ($/MW-day)	**$225**	-
Default MSOC of Net CONE x B' ($/MW-day)	**$225**	-