Energy Storage Resources: Opportunity Costs and Mitigation Measures

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Agenda

- Reference Level Overview
- Opportunity Cost Overview for Energy Storage Resources (ESRs)
- Expected LBMPs
- Calculating an Opportunity Cost
- Opportunity Costs in Reference Levels
- Mitigation Measures

Reference Level Overview

Reference Levels for ESRs

- **The NYISO will be required to calculate a Reference Level for ESRs**
  - A Reference Level is a "proxy" intended to reflect the offers that a Market Participant would submit for a generator if it was in a competitive market and could not exercise Market Power
  - Opportunity cost is expected to be the largest component of an ESR's Reference Level for Incremental Energy
  - The NYISO has developed a standardized methodology for calculating the opportunity cost of these resources based on expected LBMPs that it plans to use as a baseline
  - Market Participants will be allowed to submit opportunity costs that were calculated using other methods, provided they are fully documented and accepted by the NYISO

Opportunity Cost Adjustments

- **NYISO will add a means for all Generators to reflect changes to their opportunity costs while injecting or withdrawing**
  - This will work similar to a thermal unit utilizing the Fuel Cost Adjustment functionality
  - Instead of submitting updated fuel costs, Generators will submit updated opportunity costs
  - Like a fuel cost update, allowed updated opportunity cost updates will revise the affected Generator's Reference Levels
  - There will be a penalty if inaccurate opportunity costs are submitted that result in the unit failing the conduct and impact tests

OCAs and FCAs

- Costs that are submitted or bid as fuel costs, shall not also be submitted or bid as opportunity costs
- Costs shall not be submitted or bid in two parts, as both a fuel cost and an opportunity costs, in order to evade applicable thresholds
- Fossil generators shall not submit or bid fuel costs, including balancing costs, as opportunity costs

Opportunity Cost Overview for Energy Storage Resources

Assumptions

- **The following assumptions are made when calculating the opportunity cost for an ESR and apply to both Day Ahead and Real Time**
  - At the beginning of the day, the energy storage level for an ESR will be its minimum level

Real-Time Risks

- **The calculations and algorithms do not account for additional risks that are found in the Real-Time Market**
  - In real-time the software won't be optimizing over a 24 hour period, which presents the risk that the unit could get a suboptimal schedule
  - Changes in revenue from buying out of a Day-Ahead schedule are not accounted for when Real-Time references are calculated, which could cause offers to deviate from references if OCAs are not utilized

Opportunity Cost Calculation

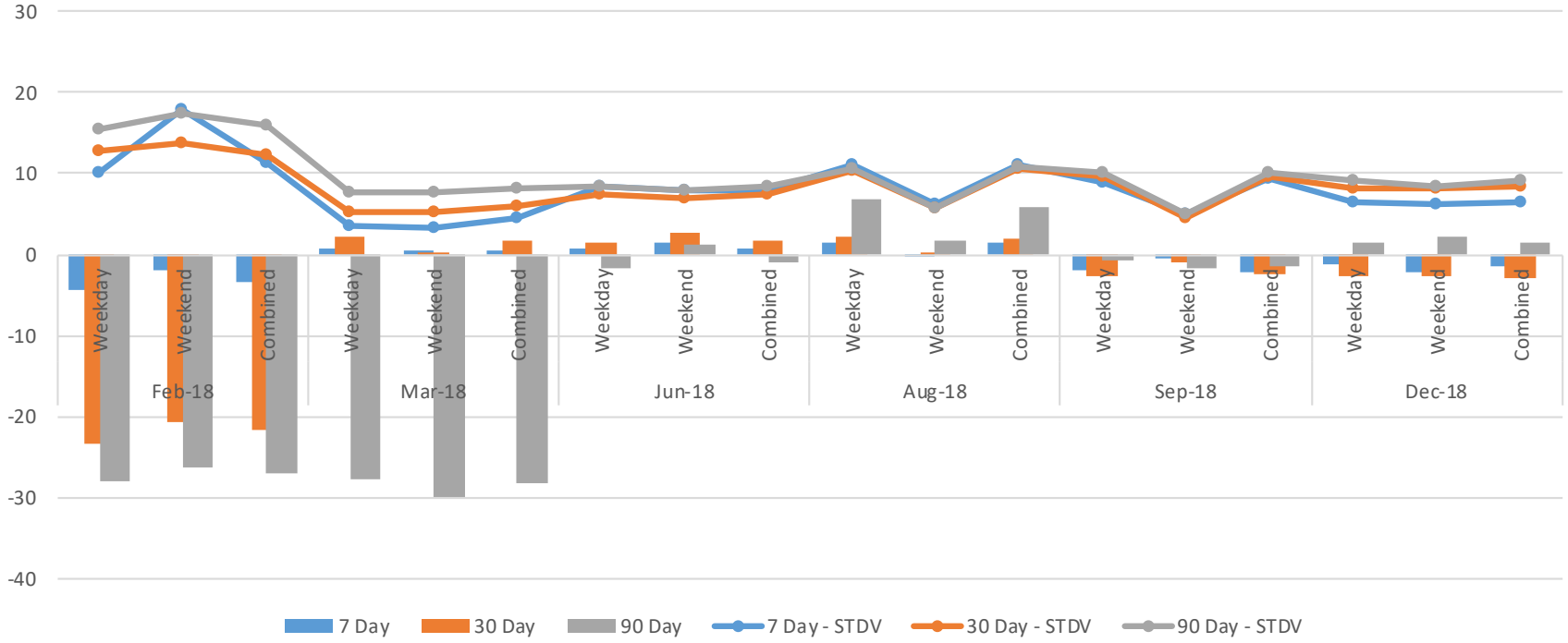
- **The main steps to calculate the opportunity cost for an ESR are**
  - Determine an expected LBMP Path (described below) for the day
  - Use the expected LBMP Path for the day to determine the ESRs' maximum revenue for each MW segment included in the units Reference Curve in RLS for each hour of the day
  - The difference in the maximum revenue between the MW segments is used to determine the opportunity cost for that MW range for each hour

Expected LBMPs

Expected LBMP Path – Day-Ahead

- Pull daily Day-Ahead Market LBMPs for the last 30 days
  - See the following slides for supporting data
- Calculate the average LBMP for each hour of the day using the historical sample
  - The average LBMPs will be adjusted to account for changes in fuel costs
- This will be the expected LBMP path used for the calculation of opportunity costs in the Day-Ahead Market

Average Hourly Deviation of Historical Sample Compared to Actual Day-Ahead LBMPs - Non Fuel Adjusted



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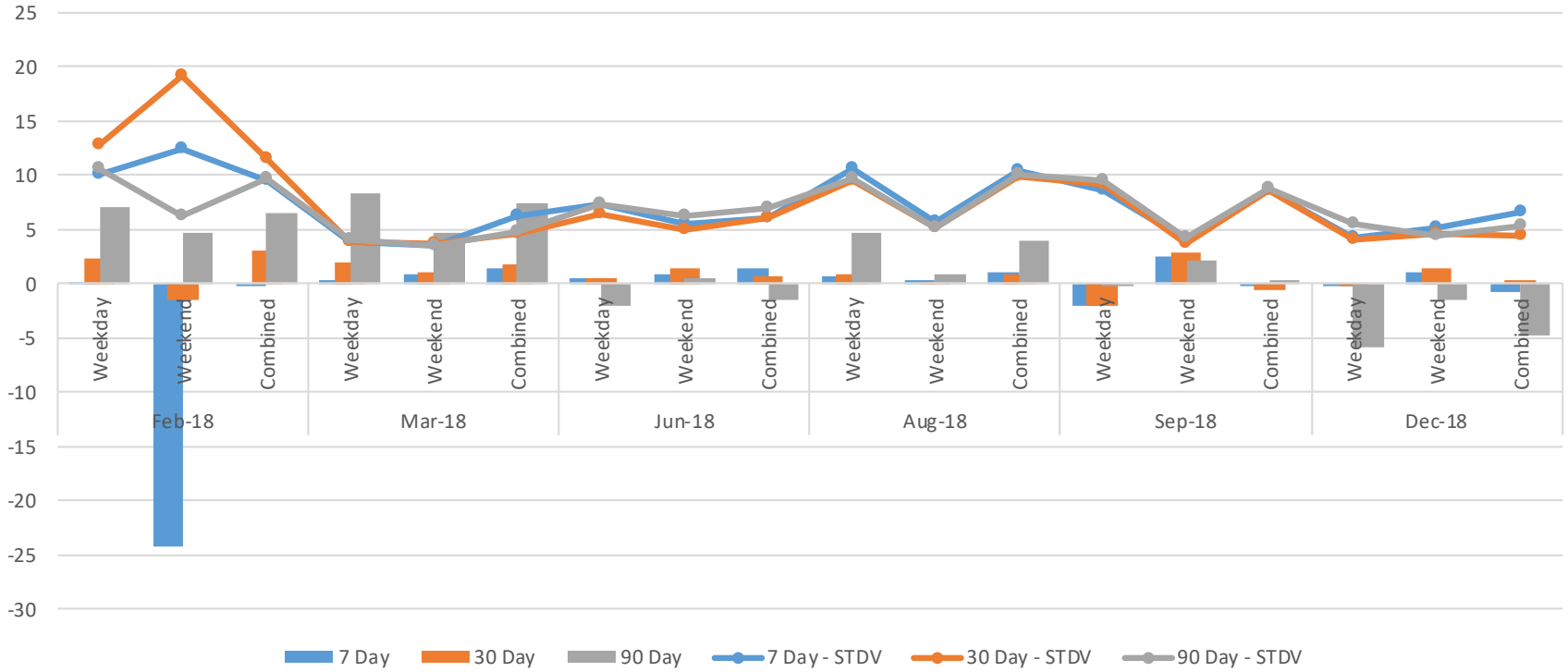
Average Hourly Deviation of Historical Sample Compared to Actual Day-Ahead LBMPs - Fuel Adjusted



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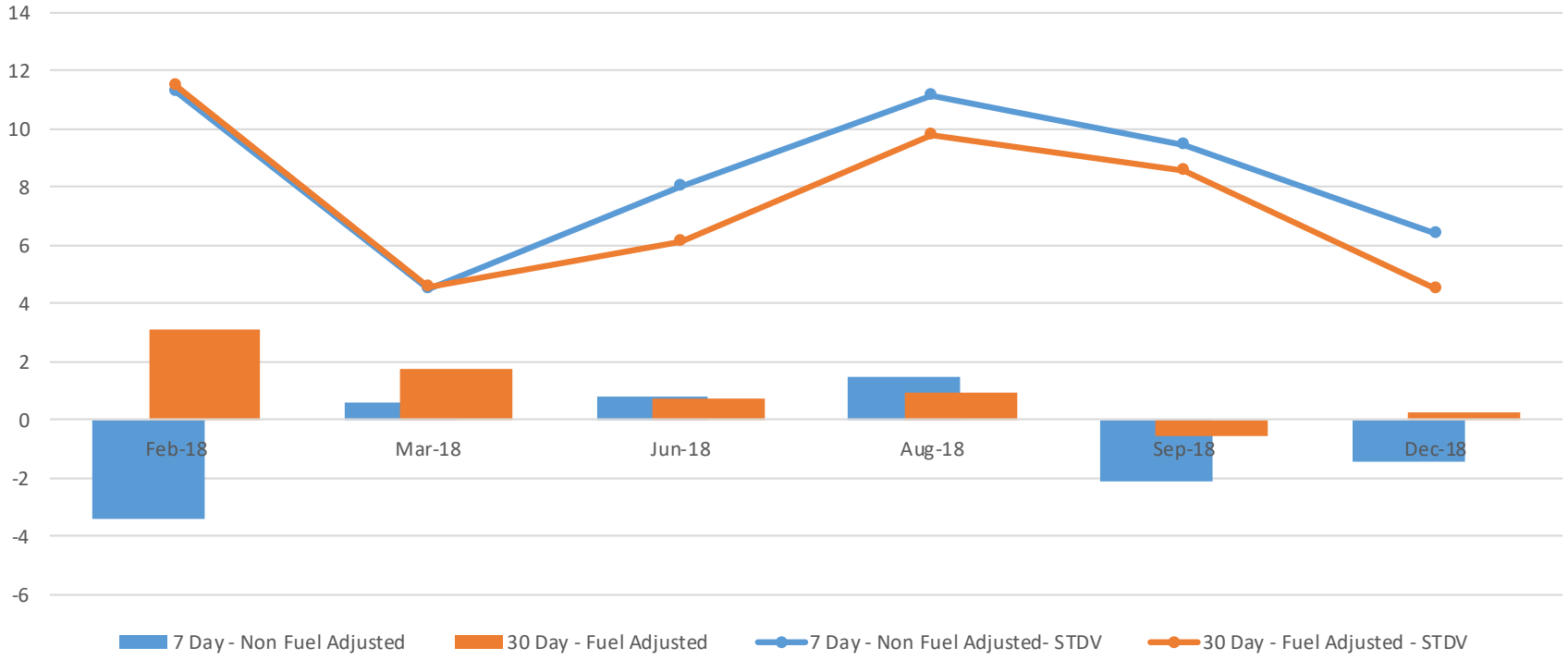
Average Hourly Deviation of Historical Sample Compared to Actual Day-Ahead LBMPs - Comparison of Top Performing Methodologies



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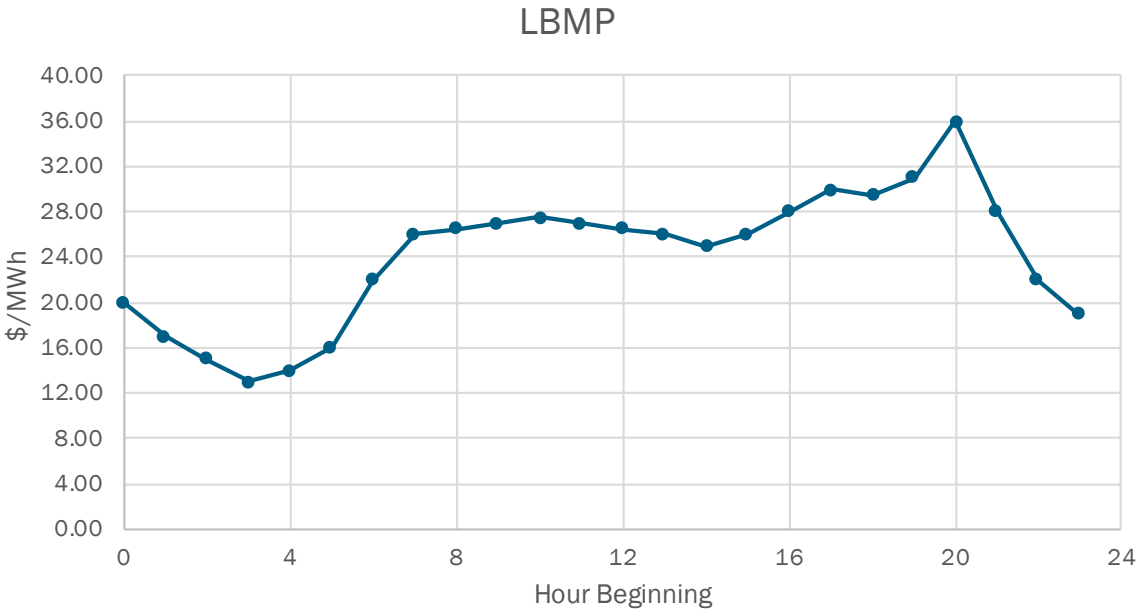
Expected LBMP Path – Real-Time

- For calculating Opportunity Costs in the Real-Time Market for a given market day, use the Day-Ahead Market LBMPs for that market day as the expected LBMP path

Example of an LBMP Path



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Calculating an Opportunity Cost

ESR Revenues

- **The revenue an ESR receives during the course of the day can be written as:**
  - $\Pi = \sum_{H=0}^{23} P_H(MW_H)$
  - Where:
    - Π is the expected revenue
    - P_H is the price in hour H
    - MW_H is the Energy generated or withdrawn in hour H

Optimizing ESR Revenues

- The maximum revenue an ESR can receive will be optimized using the following constraints:
  - $S_{H=0} = S_0 + IF(MW_H < 0,\ \eta MW_H, -MW_H)$
  - $S_{H>0} = S_{H-1} + IF(MW_H < 0,\ \eta MW_H, -MW_H)$
  - $LOL \leq MW_H \leq UOL$
  - $LSL \leq S_H \leq USL$
  - $0 \leq \eta \leq 1$
  - $\sum_{H=0}^{23} IF(MW_H < 0, 0, MWH) < (USL * R)$

Optimizing ESR Revenues

- **Definitions for the constraint variables:**
  - S_0 is the state of charge at the start of hour 0, assumed to be zero
  - S_H is the state of charge at the end of hour H
  - LOL is the lower operating limit
  - UOL is the upper operating limit
  - LSL is the lower storage limit
  - USL is the upper storage limit
  - η is the round trip efficiency
  - R is the maximum number of round trips allowed

Optimizing ESR Revenues

- The maximum revenue for the ESR will be calculated multiple times for each hour with one additional constraint
  - $MW_H = X$
  - Where X is the set of MW segments in the unit's RLS cost data

Example of Max Revenue Matrix

Hour	MW Seg. 1a: -4.1 MWs	MW Seg. 1: -4.0 MWs	MW Seg. 2: -2.0 MWs	MW Seg. 3: 0.0 MWs	MW Seg. 4: 2.5 MWs	MW Seg. 5: 5.0 MWs
0	$140.40	$141.00	$152.50	$162.50	-	-
1	$152.70	$153.00	$158.50	$162.50	$142.50	-
2	$160.90	$161.00	$162	$160.00	$144.38	$125.00
3	$160.70	$160.50	$156.00	$150.00	$131.88	$111.25
4	$161.60	$161.50	$159.00	$155.00	$139.38	$115.00

Inputs:

$UOL = 5$ MWs
$LOL = -5$ MWs
$LSL = 0$ MWs
$USL = 10$ MWs
$\eta = 0.8$
$R = 12$

Calculating Opportunity Cost

- The opportunity cost for each segment of the energy curve can be calculated as follows:
  - $OC = LBMP_H - \frac{(\Pi - \Pi^*)}{MW_{\Pi} - MW_{\Pi^*}}$
  - Where:
    - $LBMP_H$ is the expected LBMP in hour H
    - Π is the maximum revenue for a given MW segment for a given hour
    - Π^* is the maximum revenue for the prior MW segment for the same hour
    - MW_{Π} is the MW value for the given MW segment
    - $MW_{\Pi^*}$is the MW value for the prior MW segment

Example of Opportunity Cost

Max Revenue Matrix						
Hour	MW Seg. 1a: -4.1 MWs	MW Seg. 1: -4.0 MWs	MW Seg. 2: -2.0 MWs	MW Seg. 3: 0.0 MWs	MW Seg. 4: 2.5 MWs	MW Seg. 5: 5.0 MWs
0	$140.40	$141.00	$152.50	$162.50	-	-
1	$152.70	$153.00	$158.50	$162.50	$142.50	-
2	$160.90	$161.00	$162	$160.00	$144.38	$125.00
3	$160.70	$160.50	$156.00	$150.00	$131.88	$111.25
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Example for MW Segment 1 for Hour 0:

$$OC = 20 - \frac{(141.00 - 140.40)}{(-4.0 - -4.1)}$$

$$OC = 20 - \frac{(0.60)}{(.1)}$$

$$OC = 14$$

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Example of Opportunity Cost Matrix

Hour	MW Seg. 1: -4.0 MWs	MW Seg. 2: -2.0 MWs	MW Seg. 3: 0.0 MWs	MW Seg. 4: 2.5 MWs	MW Seg. 5: 5.0 MWs
0	$14.00	$14.25	$15.00	-	-
1	$14.00	$14.25	$15.00	$25.00	-
2	$14.00	$14.50	$16.00	$21.25	$22.75
3	$15.00	$15.25	$16.00	$20.25	$21.25
4	$15.00	$15.25	$16.00	$20.25	$23.75

Inputs:

$UOL = 5$ MWs
$LOL = -5$ MWs
$LSL = 0$ MWs
$USL = 10$ MWs
$\eta = 0.8$
$R = 12$

Example of Opportunity Cost Matrix

Hour	MW Seg. 3: 0.0 MWs	MW Seg. 4: 2.5 MWs	MW Seg. 5: 5.0 MWs
0	$15.00	$18.75	$18.75
1	$15.00	$25.00	$25.00
2	$16.00	$21.25	$22.75
3	$16.00	$20.25	$21.25
4	$16.00	$20.25	$23.75

Due to our assumption that the ESRs beginning energy level is zero, the optimizer cannot solve for a scenario that includes any injection in HB 0 or a max injection in HB 1

Opportunity costs at these points will be set to the maximum of the opportunity cost at the 0.0 MW segment divided by the round trip efficiency or the prior segments opportunity cost

Opportunity Costs in Reference Levels

Opportunity Costs in Reference Levels

- Reference Levels for ESRs will consist of opportunity costs plus any additional adders that the Market Participants can substantiate
  - Additional adders could include, but are not limited too, variable operating and maintenance adders or risk adders
- Reference Level = Opportunity Cost + VOM + Risk Adder

Energy Mitigation Measures for ESRs

Energy Mitigation Measures for ESRs

- **While ESRs are injecting, current mitigation measures should be sufficient in preventing the abuse of market power**
  - Except where the ISO economically evaluates the Bids as price spreads. The rules for mitigation of Incremental Energy Bids that are evaluated as price spreads are addressed in the next section

Energy Mitigation Measures for ESRs

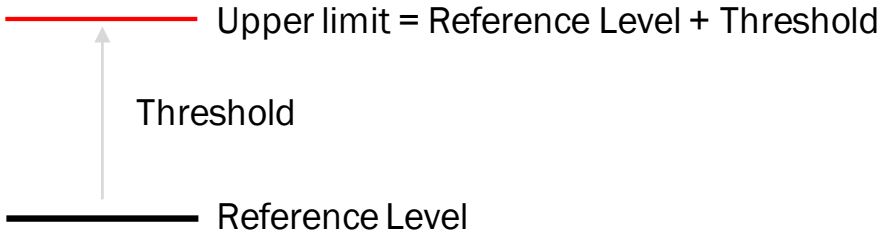
- **New mitigation measures for ESRs that are withdrawing energy or offering to withdraw energy have been created and filed with FERC**
  - An ESR with market power could submit a high offer to purchase energy in an attempt to set price and benefit the market party's generators in the same load pocket(s)

Example of High Withdrawal Offers to Benefit Other Generators

- Current Load of 1000 MW
- Generation Offers: 1050 MW at $50/MWh, 100 MW at $300/MWh
  - The Generation offers do not include the ESR, but could include Generators that are affiliated with the ESR
- 1000 MWs of Generation dispatched to meet Load and LBMP is $50/MWh
- ESR then offers to withdraw up to 100 MWs @ $200/MWh
- 1050 MWs dispatched to meet 1000 MWs of Load and 50 MWs withdrawn by ESR
- ESR offer is on the margin and sets LBMP at $200/MWh for all 1050 MWs

Conduct Test for ESR Offers to Withdraw Energy

- **Thresholds as follows:**
  - ROS: lower of 300% or $100/MWh, with a minimum of $75/MWh
  - Constrained Areas with active constraint: Load Pocket Thresholds
  - Reliability Schedules: greater of 10% or $10/MWh



Mitigation Measures for Bids Evaluated as a Price Spread

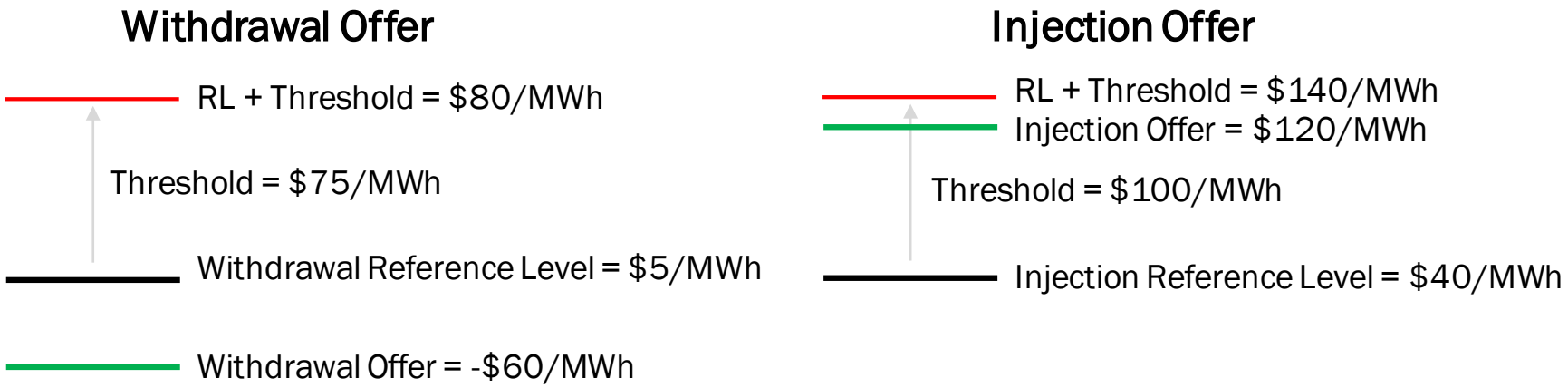
Price Spreads and Scheduling

- **Since the price spread between offers to withdraw and inject may influence the scheduling and dispatch of NYISO-managed ESRs, the price spread offered will need to be monitored**
  - An ESR might offer $5/MWh to withdraw energy and $40/MWh to inject energy, representing a $35/MWh price spread
  - Given certain Energy Level constraints, a NYISO-managed ESR could be scheduled to withdraw at $20/MWh and scheduled to inject at $55/MWh, because this still produces a $35/MWh price spread

Review of Price Spreads

- Thresholds used for review of bids evaluated as a price spread:
  - ROS: lower of 300% or $100/MWh
  - Constrained areas: Load Pocket Thresholds
- For constrained areas with an active constraint, price spreads represented by a single bid will be reviewed ex-ante (AMP)
- For ROS areas, price spreads will be reviewed ex-post
- Intertemporal prices spreads in the DAM will also be reviewed ex-post
  - Ex-post reviews could result in a financial sanction if there is LBMP impact

Example of Price Spread Evaluation



- Price spread represented by bids is $180/MWh, but price spread derived from Reference Levels is only $35/MWh
- This would fail the conduct test as $180/MWh exceeds $35/MWh by more than the $100 threshold

Uneconomic Withdrawals

Mitigation Measures for Uneconomic Withdrawals

- Addresses uneconomic withdrawals achieved by self-scheduling or by failure to follow dispatch instructions that causes or contributes to transmission congestion
- Applies to energy withdrawn at an LBMP that exceeds the applicable reference level by at least 300% or $75/MWh, whichever is less
- Because this measure targets self-scheduling and failure to follow dispatch, it does not apply when the unit was scheduled based on the economics of its offer
- The mitigation measure applies to withdrawals if the output differs from dispatch by more than 15 minutes times the Generator's Response rate per minute, or by 100 MW for a Generator, or 200 MW for a Market Party and its Affiliates

Example of Uneconomic Withdrawal

- **An ESR self-schedules to withdraw energy at an LBMP of $110/MWh, while its Reference Level is only $30/MWh**
  - LBMP is $80 greater than the Reference Level, exceeding the $75 threshold
  - If this withdrawal causes or contributes to congestion, mitigation will apply if impact is determined

Decreasing Real Time Energy Offers and Virtual Bidding

Decreasing Real Time Incremental Energy Offers and Virtual Bidding

- NYISO will monitor for submitted real-time Incremental Energy bids at a price lower than the Incremental Energy bids submitted day-ahead when the Generator has a day-ahead schedule to withdraw Energy and a Virtual Supply bid in the same hour
- The Market Party may be subject to a penalty and loss of ability to submit Virtual Bids in Load Zones where its ESRs are located if the real-time Incremental Energy bids is less than the Reference Level by more than the lower of $100/MWh or 300%, with a minimum of $75, for ROS units; or the Load Pocket Thresholds for Constrained Areas with an active constraint

Questions?

We are here to help. Let us know if we can add anything.

Appendix 1

LBMP Path Example Values

Hour	LBMP
0	20.00
1	17.00
2	15.00
3	13.00
4	14.00
5	16.00
6	22.00
7	26.00
8	26.50
9	27.00
10	27.50
11	27.00
12	26.50
13	26.00
14	25.00
15	26.00
16	28.00
17	30.00
18	29.50
19	31.00
20	36.00
21	28.00
22	22.00
23	19.00

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