Scheduling ESRs

Whitney Lesnicki
Energy Market Design

MIWG

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Agenda

- Energy Level Modes
- Real-Time Dispatch Envelopes
- Scheduling Self-managed ESRs
  - Examples
- Scheduling NYISO-managed ESRs
  - Examples

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Previous Presentations

Date	Working Group	Discussion points
12-20-17	MIWG	Market Design Concept Proposal Summary
02-21-18	MIWG	Ancillary Services Treatment in the ESR Participation Model
04-24-18	MIWG	Capacity Market Rules for Energy Storage Resources
04-26-18	MIWG	ESR Participation Model: Energy Level Monitoring
05-23-18	MIWG	ESR Settlements
06-19-18	MIWG	ESR Metering
06-25-18	MIWG	ESR Settlements: Charges when deviating from NYISO Base Points
07-10-18	MIWG	Energy Market Mitigation Measures for ESRs
7-24-18	MIWG	ESR Market Design Update
7-24-18	MIWG	ESR Settlements - DAMAP, RRAC, RRAP, and Balancing Energy
7-24-18	MIWG	Methodology for Consumer Impact Analysis: Energy Storage Integration
07-31-18	MIWG	ESR Operating Characteristics
08-07-18	MIWG	Capacity Market Rules for Energy Storage Resources
08-07-18	MIWG	Day-Ahead Margin Assurance Payments for ESRs
08-14-18	MIWG	Capacity Market Rules for Energy Storage Resources
08-23-18	MIWG	Capacity Market Rules for Energy Storage Resources

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Energy Level Modes

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Energy Level Modes for ESRs

- **ESRs will be allowed to participate in one of two Energy Level Modes:**
  - NYISO-managed:
    - NYISO will use the Initial State of Charge (SoC), Roundtrip Efficiency, Lower and Upper Storage limits provided by Market Administrators to ensure that ESRs receive feasible DA and RT schedules.
  - Self-managed:
    - The NYISO will not consider SoC, Roundtrip Efficiency, Lower or Upper Storage limits as part of the market optimization when evaluating self-managed ESRs for commitment and dispatch.
      - Energy Level constraints will not be part of the market optimization.

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Energy Level Management - Review

- **ESRs will be able to toggle between Self and NYISO-Managed modes between markets.**
  - ESRs will be able to offer as Self-Managed in the DAM and NYISO-Managed in RTM.
  - ESRs will be able to offer as NYISO-Managed in the DAM and Self-Managed in RTM.
- **ESRs will not be able to change Energy Level Modes for different hours of the DAM optimization.**
  - DAM optimization produces a schedule that is financially binding for a full 24-hour period.
    - If NYISO-Managed, Energy Level constraints will be optimized over the entire 24 hour horizon.
    - If Self-Managed, Energy Level constraints will not be considered in the optimization.
- **ESRs will be able to change Energy Level modes between hours in the RTM.**

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Real-Time Dispatch Envelopes

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Real-Time Dispatch Envelopes

- **The NYISO uses Real-Time telemetry to calculate "dispatch envelopes", or feasible operating ranges, for the next binding market interval in Real-Time.**
  - This occurs as a pre-processing step before Generator operating characteristics are provided to both RTC and RTD for evaluation in the market optimization.
    - EMS limits UOL and Min Gen to feasible levels for the next binding market interval (5 minutes in RTD, 15 minutes in RTC) based on the last physical base point, Response Rate, physical UOL and Min Gen.
    - Prevents Generators from receiving dispatch instructions that they cannot meet.
    - Although base points are provided by RTD, this calculation must also be completed in RTC in order to better align RTD and RTC.
  - The NYISO plans to calculate dispatch envelopes for Self and NYISO-Managed ESRs.
  - Examples of current implementation are provided on the next slide.
  - Modifications to accommodate ESRs are discussed later in this presentation.

1. See NYISO, *Ancillary Services Manual,* section 6 at this link for details concerning current Reserve eligibility and bidding requirements.

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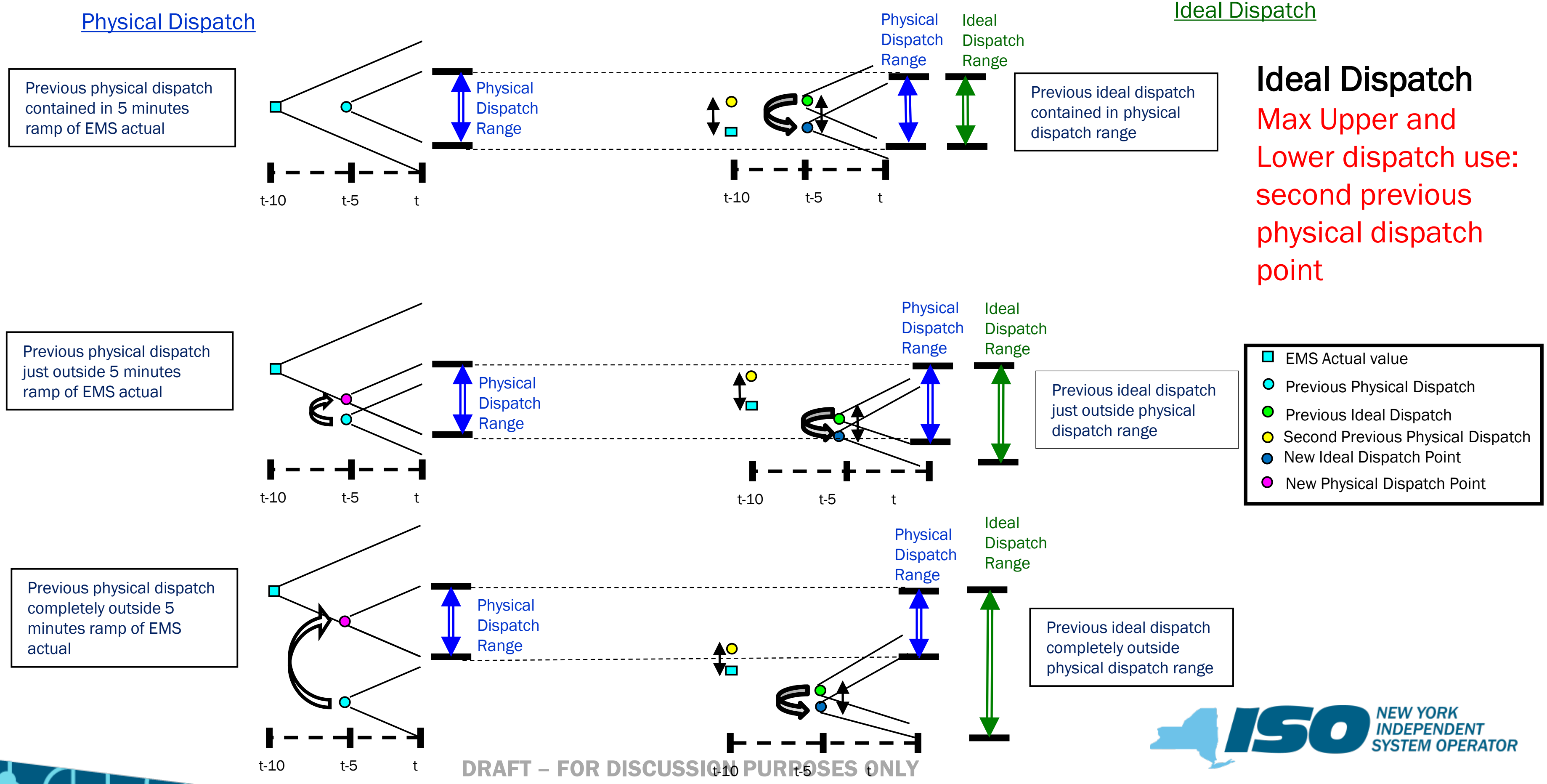
Current RTD Dispatch Ramping Range for Various Scenarios when Dispatchable unit is Undergenerating



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Real-Time Dispatch Envelopes

- **The NYISO will use Energy Level constraints to adjust UOL, Min Gen, and Maximum Withdrawal Limits for Self-managed ESRs as part of the Dispatch Envelope calculation.**
  - Based on Real-Time Energy Level telemetry and the Energy Level constraints provided as Registration parameters (Upper Storage Limit, Lower Storage Limit, and Roundtrip Efficiency).
  - Conservative assumptions will be used to ensure that Self-Managed ESRs do not receive Energy schedules they cannot meet in the next binding interval.
  - Necessary to meet Reliability requirements.
  - Examples are provided later in this slide deck.
- **The NYISO will NOT use Energy Level constraints to adjust UOL, Min Gen, and Maximum Withdrawal Limits for NYISO-managed ESRs.**
  - Less conservative assumptions are necessary for NYISO-managed ESRs because Energy Level constraints will be considered as constraints in the RTM optimization for binding and advisory intervals.
  - Dispatch envelopes for NYISO-managed ESRs will be calculated like traditional Generators.

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Reserve Awards

- The Northeast Power Coordinating Council (NPCC) requires that Reserve awards be sustainable for at least one hour:

  "Synchronized reserve, ten-minute reserve, and thirty-minute reserve available to a Balancing Authority, if activated, shall be sustainable for at least one hour from the time of activation. Balancing Authorities shall determine their sustainability requirement for reserve on Automatic Generation Control (AGC) based on their ability to achieve compliance with relevant standards, with due consideration of their operating characteristics." [1]

- In order to adhere to this requirement, the NYISO will use RT Energy Level telemetry to modify the Reserve Availability Self-Managed ESRs as part of the dispatch envelope evaluation that occurs before each RTM optimization period (5 minutes in RTD and 15 minutes in RTC).
  - Examples are provided later in this slide deck.
- Energy Level constraints will also be used to modify the Reserve Availability of NYISO-Managed ESRs as part of the RTM optimization.
  - Sustainability evaluation will occur for the binding and advisory intervals as part of the optimization.

1. See NPCC directory 5, Requirement 5.13 at this link.

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Scheduling Self-Managed ESRs

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Scheduling Self-Managed ESRs

- The SCUC, RTC, and RTD optimizations will not evaluate or consider the following Energy Level constraints for ESRs operating in Self-Managed mode:
  - χ State of Charge
  - χ Roundtrip Efficiency
  - χ Upper Storage Limit
  - χ Lower Storage Limit
- The market software will use all of the other physical and economic characteristics provided to make commitment and dispatch decisions for self-managed ESRs, e.g.:
  - Upper Operating Limit (UOL), Minimum Generation, Incremental Bid Curve, Minimum and Maximum Withdrawal Limit (if applicable), Response Rates, etc.
- The spread between injecting and withdrawing offers will not be considered by SCUC, RTC, or RTD.
  - Spread only becomes important when Energy Level constraints are introduced.

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Scheduling Self-Managed ESRs

- **The NYISO plans to use RT Energy Level telemetry to modify the UOL, Min Gen and Maximum Withdrawal Limit, whichever are applicable, of Self-Managed ESRs as part of the dispatch envelope calculation step that occurs before each RTM optimization period.**
  - If an ESR would not be physically capable of sustaining its offered UOL, Min Gen, or Maximum Withdrawal Limit for the next RTM interval (5 minutes in RTD and 15 minutes in RTC) as a result of Energy Level constraints, the UOL, Min Gen, or Maximum Withdrawal Limit will be derated automatically **before** the ESR is evaluated by RTD or RTC.
- **The NYISO has previously stated that Initial State of Charge, Roundtrip Efficiency, Upper and Lower Storage limits will not be considered as part of the market optimization for Self-Managed ESRs.[1]**
  - Although SoC telemetry will be used to impose limits on total Energy and Reserve availability for the next binding market interval in RTD and RTC, the statement above is still accurate because Energy Level constraints will not be included in the market optimization and will not be considered for advisory intervals.

1. See NYISO, *ESR Operating Characteristics*, (MIWG, 7/31/18) at this link

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Scheduling Self-Managed ESRs

- **When a Generator cannot meet its schedule due to lack of fuel, it is obligated to inform the NYISO and Transmission Owner.[1]**
  - This results in a full or partial derate of RT capabilities and is considered a forced outage.
  - Forced outages and derates may impact ICAP payments and Energy market settlements.
- **Reductions in the availability of Self-managed ESRs due to Energy Level constraints will be classified as forced outages.**
  - Self-Managed ESRs are expected to adjust their operating characteristics to reflect their availability. Failure to do so will result in derates.
- **Self-Managed ESRs may need to report forced outages more frequently than traditional Generators.**
  - Because their fuel constraints will not be considered by the market software, Self-Managed ESRs are more likely to receive physically infeasible schedules than traditional Generators that have continuous fuel supplies.

1. See the NYISO's *Outage Scheduling Manual* for more information on forced outages and derates, available at this link.

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Scheduling Self-Managed ESRs

- **Automatic derates for Self-managed ESRs will:**
  - Reduce the risk that operators will be overwhelmed by multiple simultaneous derate requests.
  - Contribute to securing system reliability by more accurately reflecting RT system capability in the market software.
- **Today, forced outages require manual Operator intervention.**
  - NYISO and TO Operators must respond to phone calls from Market Participants and/or manually take non-responsive Generators Out of Merit.
- **NYISO Operations is not staffed to accommodate a high volume of simultaneous forced outage reports using existing protocols.**

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Scheduling Self-Managed ESRs - Examples

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Scheduling Self-Managed ESRs

Example 1: Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD Base Point	0	MW
Real-Time SoC	Unknown	%
Real-Time Energy Level	**Unknown**	**MWh**
Reserve Availability	20	MW

- Without RT Energy Level data, the NYISO could not ensure that this ESR is capable of sustaining a Reserve award of 20 MW for one full hour.
- Similarly, the NYISO would not know whether this ESR is capable of sustaining an Energy award for the next 5 or 15 minutes, respectively.
- The NYISO will require all ESRs to provide RT Energy Level telemetry to ensure that the condition considered for this example never arises.

1. See NYISO, *Ancillary Services Manual,* section 6 at this link for details concerning current Reserve eligibility and bidding requirements.

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Scheduling Self-Managed ESRs

Example 2: Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD Base Point	0	MW
Real-Time SoC	100%	%
Real-Time Energy Level	22	MWh
Reserve Availability	20	MW

- **The ESR is capable of sustaining a 20 MW Reserve award for one hour:**
  20 MW x 1 hour = 20 MWh Energy depleted over one hour.
  22 MWh [RT Energy Level] – 20 MWh = 2 MWh [= Lower Storage Limit]

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Scheduling Self-Managed ESRs

Example 2 (cont.): Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD Base Point	0	MW
Real-Time SoC	100%	%
Real-Time Energy Level	22	MWh
Reserve Availability	20	MW

- **The ESR is capable of sustaining its 20 MW UOL for 5 minutes:**
  20 MW x (1/12 h)= 1.67 MWh Energy depleted over 5 minutes
  22 MWh [RT Energy Level] – 1.67 MWh = 20.33 MWh [< Lower Storage Limit]
- **The ESR is also capable of sustaining its 20 MW UOL for 15 minutes:**
  20 MW x (1/4 h)= 5 MWh Energy depleted over 15 minutes
  22 MWh [RT Energy Level] – 5 MWh = 17 MWh [< Lower Storage Limit]

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Scheduling Self-Managed ESRs

Example 2 (cont.): Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD base point	0	MW
Real-Time SoC	100	%
Real-Time Energy Level	22	MWh
Reserve Availability	20	MW

- The ESR is not capable of sustaining its -20 MW Min Gen level for 5 minutes:
  - 20 MW x (1/12 h)= 1.67 MWh Energy added to storage reservoir
  - 22 MWh [RT Energy Level] + 1.67 MWh =23.67 MWh [> Upper Storage Limit]
- Likewise, the ESR is not capable of sustaining its -20 MW Min Gen level for 15 minutes:
  - 20 MW x (1/4 h)= 5 MWh Energy added to storage reservoir
  - 22 MWh [RT Energy Level] + 5 MWh = 27 MWh [> Upper Storage Limit]
- The ESR's Min Gen will be automatically derated before its operating characteristics are passed to RTD or RTC.

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Example 2 (cont.):

- **Min Gen derate calculation for RTD:**

  22 MWh [Upper Storage Limit] – 22 MWh [RT Energy Level] = 0 MWh
  - Maximum Energy that can be added to storage reservoir over the next 15 minutes.

  0 MWh x (1/12 h) = 0 MW
  - Highest physically feasible withdrawal rate
  - Min Gen should be increased from -20 MW to 0 MW.

- **Min Gen derate calculation for RTC:**

  22 MWh [Upper Storage Limit] – 22 MWh [RT Energy Level] = 0 MWh
  - Maximum Energy that can be added to storage reservoir over the next 15 minutes.

  0 MWh x (1/4 h) = 0 MW
  - Highest physically feasible withdrawal rate
  - Min Gen should be increased from -20 MW to 0 MW.

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Scheduling Self-Managed ESRs

Example 2 (cont.): The NYISO will adjust UOL, Min Gen, Maximum Withdrawal Limit, and Reserve Availability as a pre-processing step before allowing Self-Managed ESRs to be evaluated by the RTM optimization software:

Parameter	Offered	Modified Capability		Units	Comment
		RTD	RTC		
Upper Storage Limit	22	N/A		MWh	• Used as inputs to data pre-processing. • RTC and RTD will not consider these parameters in the optimization when evaluating Self-Managed ESRs.
Lower Storage Limit	2			MWh	
Upper Operating Limit	20	20	20	MW	• May be modified to ensure that potential Energy awards do not result in infeasible dispatch.
Min Gen (Max Withdrawal Limit)	-20	0	0	MW	
Last RTD base point	0	N/A		MW	• Used as inputs to data pre-processing. • RTC and RTD will not consider these parameters in the optimization when evaluating Self-Managed ESRs.
Real-Time SoC	100			%	
Real-Time Energy Level	22			MWh	
Reserve Availability	20	20		MW	• May be modified to ensure that potential Reserve awards meet NPCC sustainability requirement.

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Scheduling Self-Managed ESRs

Example 3: Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD base point	0	MW
Real-Time SoC	25	%
Real-Time Energy Level	7	MWh
Reserve Availability	20	MW

- **The ESR is capable of sustaining its 20 MW UOL for 5 minutes:**

  20 MW x (1/12 h)= 1.67 MWh Energy depleted over 5 minutes

  7 MWh [RT Energy Level] – 1.67 MWh = 5.33 MWh [> Lower Storage Limit]

- **The ESR is also capable of sustaining its 20 MW UOL for 15 minutes:**

  20 MW x (1/4 h)= 5 MWh Energy depleted over 15 minutes

  7 MWh [RT Energy Level] – 5 MWh = 2 MWh [= Lower Storage Limit]

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Scheduling Self-Managed ESRs

Example 3 (cont.): Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD base point	0	MW
Real-Time SoC	25	%
Real-Time Energy Level	7	MWh
Reserve Availability	20	MW

- **The ESR is capable of sustaining its -20 MW Min Gen level for 5 minutes:**
  - 20 MW x (1/12 h)= 1.67 MWh Energy added to storage reservoir
  - 7 MWh [RT Energy Level] + 1.67 MWh = 8.66 MWh [< Upper Storage Limit]
- **The ESR is also capable of sustaining its -20 MW Min Gen level for 15 minutes:**
  - 20 MW x (1/4 h)= 5 MWh Energy added to storage reservoir
  - 7 MWh [RT Energy Level] + 5 MWh = 12 MWh [< Upper Storage Limit]

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Scheduling Self-Managed ESRs

Example 3 (cont.): Consider a Continuous, Self-Managed ESR that offers the following physical parameters:

Upper Storage Limit	22	MWh
Lower Storage Limit	2	MWh
Upper Operating Limit	20	MW
Min Gen (Max Withdrawal Limit)	-20	MW
Last RTD base point	0	MW
Real-Time SoC	25	%
Real-Time Energy Level	7	MWh
Reserve Availability	20	MW

- With an Initial State of Charge of 25%, the ESR is not capable of sustaining a 20 MW Reserve award for one hour:

  20 MW x 1 hour = 20 MWh Energy depleted over one hour

  7 MWh [RT Energy Level] – 20 MWh = -13 MWh [< Lower Storage Limit]
- The ESR's Reserve Availability will be automatically derated before being passed to RTC or RTD.
- NYISO-Managed ESRs will be evaluated for Reserve Availability in the same way.

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Scheduling Self-Managed ESRs

Example 3 (cont):

- Reserve Availability Derate Calculation:

  7 MWh [RT Energy Level] – 2 MWh [Lower Storage Limit] = 5 MWh Energy available

  5 MWh / 1 h = 5 MW Maximum injection rate that the ESR could sustain over one hour.

- The ESR's Reserve Availability would be automatically derated to 5 MW before being passed to RTC or RTD.
- This evaluation will re-occur for every binding market interval.
- The same evaluation will occur for Non-Continuous ESRs.
- A similar evaluation will occur for NYISO-Managed ESRs, but it will take place within the RTM optimization rather than as a pre-processing step.

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Scheduling Self-Managed ESRs

Example 3 (cont.): The NYISO will adjust UOL, Min Gen, Maximum Withdrawal Limit, and Reserve Availability as a pre-processing step before allowing Self-managed ESRs to be evaluated by the RTM optimization software:

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Offered</th><th colspan="2">Modified Capability</th><th rowspan="2">Units</th><th rowspan="2">Comment</th></tr>
<tr><th>RTD</th><th>RTC</th></tr>
<tr><td>Upper Storage Limit</td><td>22</td><td colspan="2" rowspan="2">N/A</td><td>MWh</td><td rowspan="2">Used as inputs to data pre-processing. RTC and RTD will not consider these parameters in the optimization when evaluating Self-Managed ESRs.</td></tr>
<tr><td>Lower Storage Limit</td><td>2</td><td>MWh</td></tr>
<tr><td>Upper Operating Limit</td><td>20</td><td>20</td><td>20</td><td>MW</td><td rowspan="2">May be modified to ensure that potential Energy awards do not result in infeasible dispatch.</td></tr>
<tr><td>Min Gen (Max Withdrawal Limit)</td><td>-20</td><td>-20</td><td>-20</td><td>MW</td></tr>
<tr><td>Last RTD base point</td><td>0</td><td colspan="2" rowspan="3">N/A</td><td>MW</td><td rowspan="3">Used as inputs to data pre-processing. RTC and RTD will not consider these parameters in the optimization when evaluating Self-Managed ESRs.</td></tr>
<tr><td>Real-Time SoC</td><td>25</td><td>%</td></tr>
<tr><td>Real-Time Energy Level</td><td>7</td><td>MWh</td></tr>
<tr><td>Reserve Availability</td><td>20</td><td colspan="2">5</td><td>MW</td><td>May be modified to ensure that potential Reserve awards meet NPCC sustainability requirement.</td></tr>
</table>

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Scheduling Self-Managed ESRs

Example 3 (cont.):

- **Assume the same ESR receives a base point of 5 MW at the beginning of RTD interval t=0.**
  - Over the next five minutes, if the ESR's base point remains 5 MW, the storage reservoir will be depleted as follows:

    7 MWh [RT Energy Level] – 5 MW x (1/12 hour) = 6.58 MWh remaining
  - Reserve Availability must be recalculated for the RTD interval beginning at t = 5 min.

    6.58 MWh [Forecast RT Energy Level at t=5] - 2 MWh [Lower Storage Limit] = 4.58 MWh

    4.58 MWh / 1 h = 4.58 MW max injection rate that could be sustained for one hour.
- **For the t=5 min binding RTD interval, the ESR's Reserve Availability would be automatically derated to 4.58 MW before being passed to RTC and RTD optimization.**

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Scheduling Self-Managed ESRs

- **The examples provided in this slide deck are simplified and more conservative than the calculation that the NYISO is developing for implementation.**
  - These examples forecast energy availability by assuming that ESRs will dispatched immediately to their UOLs in RT.
  - In reality, Generators are ramped gradually over the market interval according to their Response Rates.
  - The NYISO plans to account for ramp rates when forecasting Energy levels for ESRs.
- **See example on next slide.**

1. See NYISO, *Ancillary Services Manual,* section 6 at this link for details concerning current Reserve eligibility and bidding requirements.

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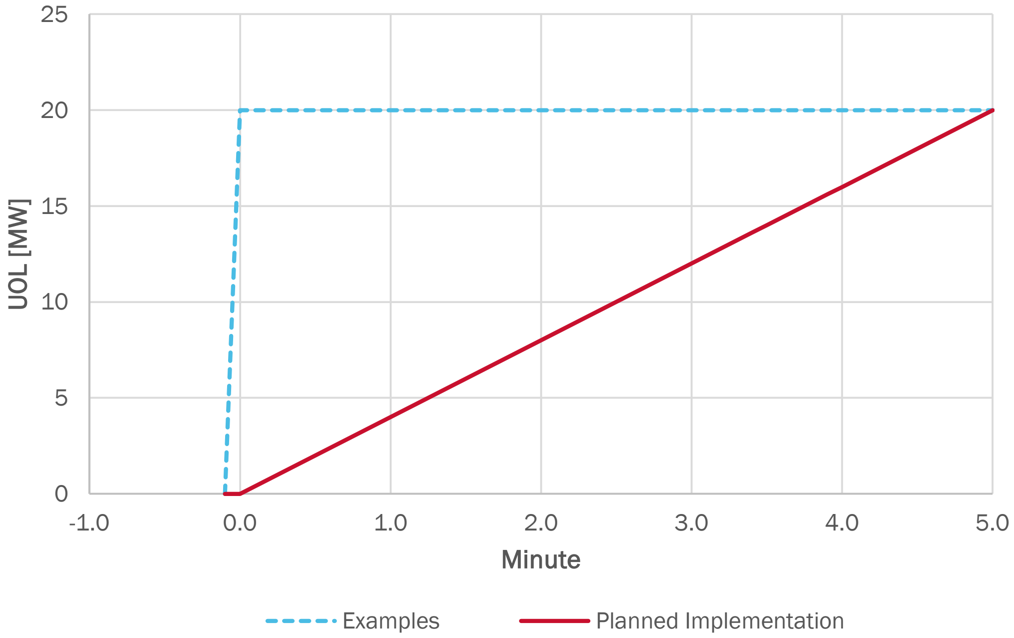
Scheduling Self-Managed ESRs

Ramping Assumptions: Examples 1-3 vs. Planned Implementation



- **The area under each line represents the max Energy (MWh) that could be consumed over an RTD interval if the ESR were fully deployed.**

Examples in this Slide Deck:

- ESR is dispatched instantly to UOL (20 MW)
- Storage reservoir is forecast to be depleted 1.67 MWh over 5 min.

Planned Implementation:

- ESR is ramped up steadily from its last physical base point (0 MW) to its UOL (20 MW).
- Storage Reservoir is forecast to be depleted 0.83 MWh over 5 min.

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Scheduling NYISO-Managed ESRs

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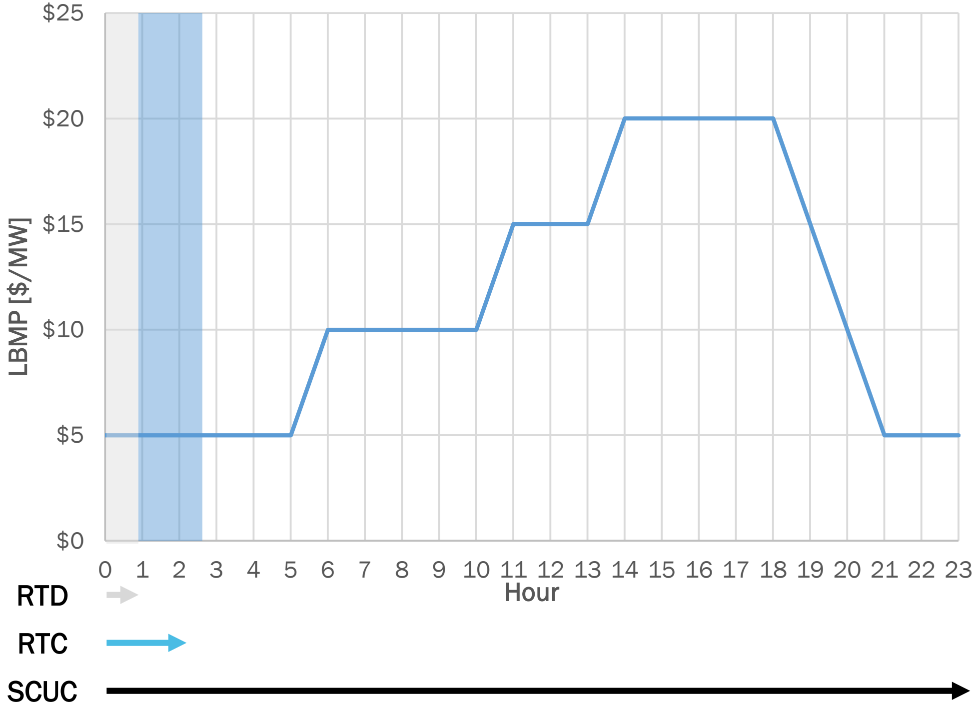
NYISO Energy Level Management



- **The objective function of the market optimization software is to serve Load reliably at the lowest total production cost.**
  - The lowest total production cost corresponds to the highest social welfare and greatest net benefit (profit) for suppliers.
- **SCUC optimizes withdrawals and injections over a 24 hour period.**
  - SCUC will anticipate high prices in future hours and optimize Energy usage accordingly.
  - Will schedule NYISO-Managed ESRs to inject when prices are high and withdraw when prices are low.
- **RTD and RTC optimize fuel use over shorter time horizons and cannot anticipate future price swings outside their respective study horizons.**
  - Depending on offer parameters, RTC and RTD are likely to schedule NYISO-Managed ESRs differently than they were scheduled Day-Ahead.

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NYISO Energy Level Management

- **Existing resources submit offers to sell Energy to, and where applicable withdraw Energy from, the NYISO's wholesale markets.**
  - The NYISO's market software economically evaluates all ISO-Committed and Self-Committed Flexible offers.
  - Each offer is considered independently.
- **ESRs' Energy Level constraints bind offers to sell and purchase Energy together.**
  - ESRs will purchase wholesale Energy from the NYISO as their fuel source.
  - The NYISO's market software will evaluate whether it is economic to schedule NYISO-Managed ESRs to withdraw for later injection.
  - The difference between ESRs' offers to buy and sell Energy ("bid spread") must be considered in order to successfully complete such an evaluation.
  - Beginning Energy Level and the values selected for the Incremental Bid Curve are also important factors in this evaluation.

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NYISO Energy Level Management

- **NYISO-Managed ESRs could be scheduled to withdraw or inject differently than their hourly offers would have predicted for individual market intervals.**
- **Example: An ESR offers into the DAM to withdraw for four hours at less than or equal to $5/MW, and inject for four hours at $25/MW or greater. Some possible outcomes:**
    1. The ESR is scheduled to withdraw below its offer price of $5/MW and inject above its offer price of $25/MW.
    2. The ESR is scheduled to withdraw above its offer price at $10/MW and inject above its offer price at $30/MW.
    3. The ESR is scheduled to withdraw below its offer price at $0/MW and inject below its offer price at $20/MW.
    4. The ESR is scheduled to inject above its offer price of $25/MW and never scheduled to withdraw.
    5. The ESR is scheduled to withdraw below its offer price of $5/MW and never scheduled to inject.
    6. The ESR is scheduled neither to inject nor withdraw.
  - No matter how it is scheduled for individual hours, the ESR's DA schedule will be economic over the entire day.
- **The same principles apply in Real-Time, but over a shorter time horizon.**

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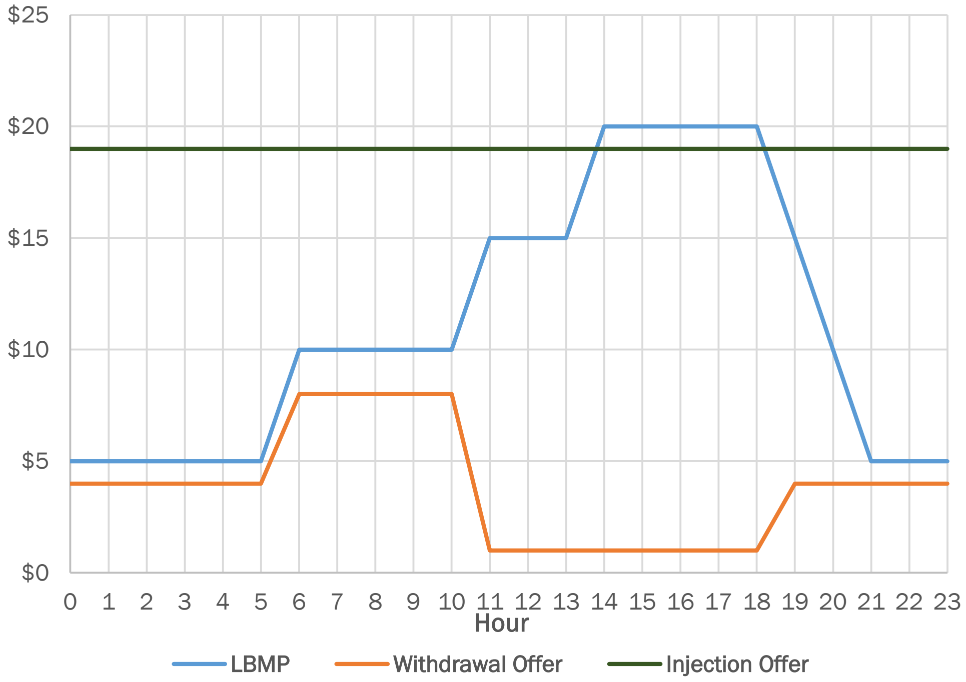
NYISO Energy Level Management

- Example: Two identical ESRs offer into the DAM. One offers as NYISO-Managed and the other as Self-Managed. Both have an Initial State of Charge of 0 MWh.



- In the example at left, the NYISO-Managed ESR would be scheduled to withdraw above its offered price of $4/MW during hours 0-4, and inject above its offered price of $19/MW during hours 14-17.
- The Self-Managed ESR would never be scheduled to withdraw because its offer of $4/MW is below the LBMP for the entire day.
- The Self-Managed ESR would be scheduled to inject above its offered price of $19/MW during hours 14-17.
- The Self-Managed ESR will not be able to meet its DA schedule without changing its offers in RT.

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NYISO Energy Level Management

- **Offering as NYISO-Managed in the DAM will result in optimal and feasible DA schedules for ESRs.**
  - Because Energy Level constraints will tie injection and withdrawal offers together, NYISO-Managed ESRs are more likely to be scheduled than Self-Managed ESRs when offering to inject and withdraw at the same price levels.
  - Bid spread can override discrete price levels if ESRs guess “wrong” when submitting their Incremental Bid Curves.
- **The NYISO will be limited in its ability to optimize Energy Level constraints in Real-Time because RTC and RTD have shorter look-ahead periods than SCUC.**
  - Changing the look-ahead periods of RTC and RTD to better align them with the DAM would require a significant market and software redesign.
  - NYISO staff have considered alternatives such as including an Ending State of Charge constraint, but have not found a solution that could be implemented in the near term without adverse effects.

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NYISO Energy Level Management

- **In recognition of the limitations of the NYISO's market software to optimize Energy Level constraints in Real-Time, the NYISO is offering several options to ESRs:**
  - Self-Manage Energy Level constraints in RT
  - Change economic offers in RT
  - Use Opportunity Costs to indicate willingness to be deployed while offering either as NYISO or Self-Managed
  - Automatic derates via dispatch envelope modifications
- **ESRs will be required to report all full or partial outages in accordance with ISO Procedures.**

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Scheduling NYISO-Managed ESRs: Examples

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Scheduling NYISO-Managed ESRs

Assumptions for Examples 1-4:

- 2-hour day.
- Single bus system- no transmission needed.
- 3 generator model.
- ESR is 100% efficient.
- Load in hour 1 = 500 MW
- Load in hour 2 = 1500 MW
- Generator 1 offer for hour 1 and 2 = $15/MWh
- Generator 2 offer for hour 1 and 2 = $50/MWh

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Scheduling NYISO-Managed ESRs: Example 1

- ESR is scheduled to withdraw and inject

- ESR offers to inject if the prices are $30/MWh or above and withdraw if prices are $10/MWh or below.

					Hour 1			Hour 2			
	Injection Offer ($/MWh)	Withdrawal Offer ($/MWh)	Initial State of Charge (MWh)	Max State of Charge (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Bid Production Cost ($)
Gen 1	15	N/A	N/A	N/A	1,000	N/A	600	1,000	N/A	1,000	24,000
ESR	30	10	0	100	-	(100)	(100)	100	0	100	2,000
Gen 2	50	N/A	N/A	N/A	1,000	N/A	-	1,000	N/A	400	20,000
Load							(500)			(1,500)	
Total							-			-	46,000

- In hour 1, LBMP is set by Generator 1 and is $15
- In hour 2, LBMP is set by Generator 2 and is $50

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Scheduling NYISO-Managed ESRs: Example 1

- **ESR's Revenue:**
  - ESR is scheduled to withdraw 100 MW in hour 1 above its offered price.
    - ESR's bid = (-100*10) = -$1,000
    - ESR pays = (-100*15) = -$1,500
  - ESR is scheduled to inject 100 MW in hour 2 above its offered price.
    - ESR's bid = (-100*30) = $3,000
    - ESR gets paid = (100*50) = $5,000
- **ESR pays an additional $500 in hour 1 and makes a profit of $2,000 in hour 2.**
- **ESR's net revenue is $1,500.**

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Scheduling NYISO-Managed ESRs: Example 2

- ESR scheduled only to withdraw

- ESR offers to inject if the prices are $60/MWh or above and withdraw if prices are $40/MWh or below

					Hour 1			Hour 2			
	Injection Offer ($/MWh)	Withdrawal Offer ($/MWh)	Initial State of Charge (MWh)	Max State of Charge (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Bid Production Cost ($)
Gen 1	15	N/A	N/A	N/A	1,000	N/A	600	1,000	N/A	1,000	24,000
ESR	60	40	0	100	-	(100)	(100)	100	0	0	-4000
Gen 2	50	N/A	N/A	N/A	1,000	N/A	-	1,000	N/A	500	25,000
Load							(500)			(1,500)	
Total							-			-	45,000

- In hour 1, LBMP is set by Generator 1 and is $15
- In hour 2, LBMP is set by Generator 2 and is $50

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Scheduling NYISO-Managed ESRs: Example 2

- **ESR's Revenue:**
  - The ESR is scheduled to withdraw 100 MW below its offered price in hour 1
    - ESR's bid = (-100*40) = -$4,000
    - ESR pays = (-100*15) = -$1,500
- **ESR saves $2,500 in hour 1 compared to its willingness to pay for Energy.**
- **ESR is not scheduled to inject in hour 2, because Gen 2's offer of $50/MWh is cheaper than the ESR's offer of $60/MWh.**

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Scheduling NYISO-Managed ESRs: Example 3

▪ ESR scheduled only to inject

- ESR offers to inject if the prices are $46/MWh or above and withdraw if prices are $10/MWh or below

					Hour 1			Hour 2			
	Injection Offer ($/MWh)	Withdrawal Offer ($/MWh)	Initial State of Charge (MWh)	Max State of Charge (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Bid Production Cost ($)
Gen 1	15	N/A	N/A	N/A	1,000	N/A	500	1,000	N/A	1,000	22,500
ESR	46	10	100	100	100	0	-	100	0	100	4600
Gen 2	50	N/A	N/A	N/A	1,000	N/A	-	1,000	N/A	400	20,000
Load							(500)			(1,500)	
Total							-			-	47,100

- In hour 1, LBMP is set by Generator 1 and is $15
- In hour 2, LBMP is set by Generator 2 and is $50

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Scheduling NYISO-Managed ESRs: Example 3

- **ESR's Revenue:**
  - ESR is scheduled to inject 100 MW above its offered price in hour 2
    - ESR's bid = (100*46) = $4,600
    - ESR pays = (100*50) = $5,000
- **ESR makes $400 more than it offered in hour 2.**

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Scheduling NYISO-Managed ESRs: Example 4

- ESR is scheduled neither to withdraw nor inject

- ESR offers to inject if the prices are $46/MWh or above and withdraw if prices are $10/MWh or below

					Hour 1			Hour 2			
	Injection Offer ($/MWh)	Withdrawal Offer ($/MWh)	Initial State of Charge (MWh)	Max State of Charge (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Max Hourly Injection (MWh)	Max Hourly Withdrawal (MWh)	Dispatch Signal (MWh)	Bid Production Cost ($)
Gen 1	15	N/A	N/A	N/A	1,000	N/A	500	1,000	N/A	1,000	24,000
ESR	46	10	0	100	-	(100)	-	-	0	-	-
Gen 2	50	N/A	N/A	N/A	1,000	N/A	-	1,000	N/A	500	25,000
Load							(500)			(1,500)	
Total							-			-	47,500

- In hour 1, LBMP is set by Generator 1 and is $15
- In hour 2, LBMP is set by Generator 2 and is $50

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Scheduling NYISO-Managed ESRs: Example 4

- ESR is not scheduled to withdraw or inject because it is uneconomic in both hour 1 and hour 2
- If the ESR were scheduled to withdraw 100 MW in hour 1, it would have to pay:
  - ESR's bid = (-100*10) = -$1,000
  - ESR pays = (-100*15) = -$1,500
- If the ESR were scheduled to inject 100 MW in hour 2, it would get paid:
  - ESR's bid = (100*46) = $4,600
  - ESR gets paid = (100*50) = $5,000
- The ESR would incur a loss of $500 in hour 1 and a profit of only $400 in hour 2.
- The net revenue of the ESR would be -$100. Therefore the ESR is scheduled neither to withdraw nor inject.

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Next Steps

- July – September 2018:
  - Continue Discussions at MIWG on key topics:
    - Settlements: BPCG
    - DA and RT market prototyping efforts
    - Mitigation examples
    - Credit implications
    - Consumer impact analysis

- July - September 2018:
  - Draft Tariff language and discuss with stakeholders.

- December 3, 2018:
  - FERC Order No. 841 compliance filing deadline.

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Questions?

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

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The Mission of the New York Independent System Operator, in collaboration with its stakeholders, is to serve the public interest and provide benefits to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policy makers, stakeholders and investors in the power system

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