ESR Participation Model: Energy Market Design

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ENERGY MARKET DESIGN

Market Issues Working Group

September 21, 2018

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Agenda

- Background
- ESR operating characteristics
- Scheduling ESRs
- ESR Metering
- Settlements for ESRs
- Next steps
- Appendices
  - Appendix A : Bidding and Scheduling
  - Appendix B: Settlements

Background

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Previous Presentations

Date	Working Group	Discussion points
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 Management
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
07-31-18	MIWG	ESR Operating Characteristics
08-07-18	MIWG	Day-Ahead Margin Assurance Payments for ESRs
08-23-18	MIWG	Capacity Market Rules for Energy Storage Resources
08-30-18	MIWG	Scheduling ESRs
08-30-18	MIWG	ESR: Consumer Impact Analysis

Background

- In 2017, the NYISO developed a market design concept for a participation model that will enable ESRs to offer their full capabilities into the NYISO's wholesale Energy, Capacity, and Ancillary Services markets.[1]
  - The ESR participation model was prioritized as a key project with a deliverable of Market Design complete in Q3 of 2018.
- On February 15, 2018, FERC issued Order No. 841, directing "each RTO/ISO to revise its tariff to establish a participation model consisting of market rules that, recognizing the physical and operational characteristics of electric storage resources, facilitates their participation in the RTO/ISO markets."[2]
  - The compliance filing deadline for Order No. 841 is December 3, 2018, with an implementation deadline of December 3, 2019.

1. See NYISO, *Energy Storage Integration: Market Design Concept Proposal* (Dec. 20, 2017) at http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-12-20/2017%20ESR%20Market%20Design%20Concept%20Proposal.pdf
2. Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, Order No. 841, 162 FERC ¶ 61,127, at P3 (Feb. 15, 2018) ("Order No. 841") as amended by the Feb. 28, 2018 Errata Notice ("Order No. 841 Errata").

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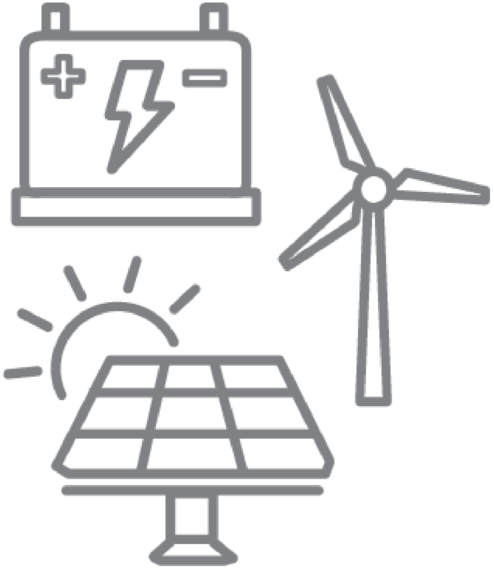
Expectations for Today's Meeting

- **NYISO staff will walk through the entire Market design for ESRs as it is planned for the FERC Order No. 841 Compliance filing.**
  - This presentation covers Energy Market Design topics.
  - Capacity Market Design and Mitigation for ESRs will be covered by other presenters during today's meeting.
- **We will accept questions at the end of each section.**
  - Examples and rationales for many of the NYISO's prospective market rules for ESRs are provided in the Appendices.
  - At the end of the presentation we can review specific examples as time permits.
- **Stakeholders are encouraged to submit additional questions by e-mail.**
  - All questions received will be posted with today's meeting materials.

Energy Market Design Overview

Energy Market Design Overview

- **Technology neutral participation model.**
  - Accommodates all storage types (e.g. flywheel, battery, pumped storage).
- **Minimum offer size for Energy, Capacity, and Ancillary Services: 100 kW.**
  - Energy and A/S will be scheduled following the same principles used for other suppliers.
  - ESRs will be eligible to provide Reserves and Regulation while withdrawing.
- **While withdrawing from the grid, Energy consumed by ESRs will be treated as negative generation rather than Load.**
  - Consistent with treatment of ELRs and LESRs today and directives in FERC Order No. 841.



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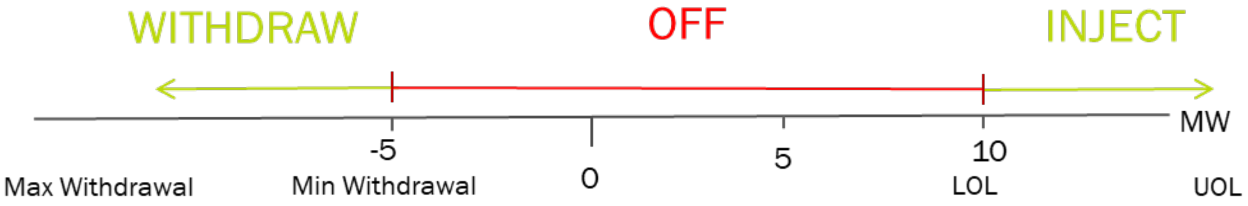
Energy Market Design Overview (cont.)

- No special treatment for metering or interconnection; will qualify as Generators under NYISO tariff.
  - Any ESR that is directly metered may participate in the NYISO’s wholesale markets, regardless of whether it is located at the bulk or distribution level.
- ESRs will be eligible to use most of the existing Generator offer parameters, as well as additional operating characteristics identified by NYISO and the FERC.
- ESRs will be settled comparably to traditional Generators.

Energy Market Design - Update

- **The NYISO has been working with software vendor ABB to develop a prototype of the ESR participation model to help identify impacts to market software solution times.**
  - The prototype enables ESRs to be scheduled for up to three possible operating states: Injecting, Withdrawing, and Off/Idle.
  - This functionality would allow ESRs with infeasible operating regions between their minimum withdrawal and minimum injection levels ("Non-Continuous ESRs") to offer both injection and withdrawal capabilities during the same market intervals.
  - Example of a non-continuous operating range:



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Energy Market Design - Update

- Prototype solution times are significantly slower than current market software solution times.
- As a result of performance and scalability concerns, the initial deployment of the ESR participation model will only recognize one operating state, “On” and will treat the ESRs as fully dispatchable within the operating range offered by the MP.
- The NYISO continues to work with ABB to prototype a simplified model that satisfies solution time and scalability requirements.
  - A report that details the prototyping work that has been completed in partnership with ABB will be published later this year.

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Energy Market Design –Update

- Certain existing offer parameters may also negatively impact solution time. As a result, the following parameters will not be available to ESRs during the initial participation model deployment:
  - Startup Cost, Min Gen Cost, Min Down Time, Max Stops per Day, Startup Notification Time
- Pending additional prototyping results, the following new parameters that have been previously proposed as part of the ESR participation model will be available to ESRs:
  - Max Run Time*, Min Withdrawing Time*, Max Withdrawing Time*, Roundtrip Efficiency, Upper Storage Limit*, Lower Storage Limit*, and Beginning Energy Level.
- Bidding and Scheduling will be discussed later in this presentation.
- An updated list of ESR parameters is posted with today's meeting materials.

*Denotes operating characteristic identified in FERC Order No. 841.

ESR Operating Characteristics

ESR Operating Characteristics

- The NYISO recognizes that ESRs have unique characteristics that should be accommodated in the Energy and Ancillary Services markets to reduce barriers to full participation.
- In addition, FERC Order No. 841 requires RTO/ISOs to “account for the physical and operational characteristics of electric storage resources through bidding parameters or other means”[1].
- This presentation details the manner in which the NYISO plans to account for those characteristics in the ESR participation model.

1. Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, Order No. 841, 162 FERC ¶ 61,127, at P5 (Feb. 15, 2018) (“Order No. 841”) as amended by the Feb. 28, 2018 Errata Notice (“Order No. 841 Errata”).

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Registration Parameters

Registration Parameters

- Upon Registration, Market Participant Administrators will be required to supply the following information about ESRs:

  - Max Physical Upper Operating Limit*
  - Lower Operating Limit*
  - Minimum Run Time
  - Maximum Run Time
  - Minimum Withdrawing Time
  - Maximum Withdrawing Time
  - Response Rates*
  - Upper Storage Limit*
  - Lower Storage Limit*
  - Roundtrip Efficiency*

*Indicates parameter may only be updated upon request and approval by the NYISO.

Where BLACK = Existing Generator parameter and BLUE = New parameter available only to ESRs

- Please see the "ESR Parameters" file uploaded with today's materials for more details on each parameter.

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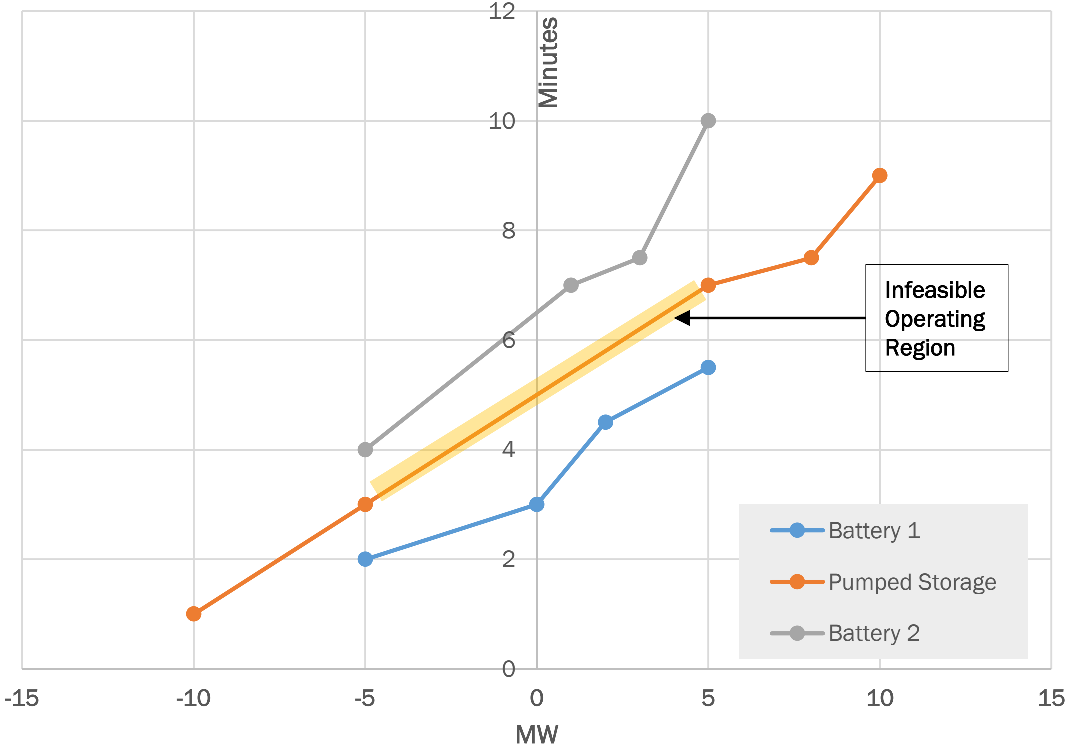
Response Rates

- Generators may submit the following Response Rates upon Registration:
  - Energy (MW/Min)
  - Operating Reserve (MW/Min)
  - Regulation Capacity (MW/Min)
  - Regulation Movement (MW/6 seconds)
  - Emergency Response Rate (MW/min)
  - Qualified Automatic Voltage Regulator (AVR) with supporting documentation.
- Response Rates may only be updated upon request and with approval from the NYISO.
- Energy, Operating Reserve, Regulation Capacity and Emergency Response Rates less than 0.1 MW/minute must be rounded to 0.1 MW/minute.
- No additional Response Rates are proposed for ESRs.

Examples of Acceptable Energy Response Rates



- Up to three Energy Response Rates may be specified.
- ESRs will submit both injecting and withdrawing Response Rates.
- Response Rates may span zero.
- Satisfies FERC Order No. 841 requirement to account for “Charge Ramp Rate” and “Discharge Ramp Rate”.
- Response Rates must span Non-continuous regions (see pumped storage example at left).

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Roundtrip Efficiency

- ESRs will be required to submit their Roundtrip Efficiency upon Registration.
- Roundtrip Efficiency is defined as the ratio of energy that can be injected to the grid (in MWh) to energy that must be withdrawn (in MWh):

$$\text{Roundtrip Efficiency} = \frac{Injection\ Energy\ (MWh)}{Withdrawal\ Energy\ (Mwh)}$$

- Example: A battery with 8 MWh of storage capacity has a Roundtrip Efficiency of 80%.

$$80\% = \frac{8\ MWh}{x\ Mwh}$$
$$x = 10\ Mwh$$

The battery must withdraw 10 MWh of energy in order to inject 8 MWh.

- The NYISO will use this parameter to help ensure that ESRs receive feasible injection schedules when operating as NYISO-Managed.

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Minimum and Maximum Run and Withdrawing Times

- FERC Order No. 841 requires the NYISO to account for the following operating characteristics of ESRs*:
  - Minimum Run Time
  - Maximum Run Time
  - Minimum Withdrawing Time (“Minimum Charge Time”)
  - Maximum Withdrawing Time (“Maximum Charge Time”)
- All ESRs must specify values for these parameters upon Registration.
- ESRs may specify a value of zero for any of these parameters, if that accurately reflects their physical capabilities.

*Names in parentheses are those used in FERC Order No. 841.

Minimum and Maximum Run and Withdrawing Times

- Treatment of the new Run and Withdrawing Time parameters will be identical to existing treatment of Minimum Run Time:
  - Honored for the look-ahead window of each optimization program (24 h in the DAM, 1 h in RT).
  - Values will be rounded to the next full hour in the DAM.
  - Values will be rounded to the next 0.25 hour in RTC.
    - For example, a value of 0.54 will be rounded up to 1 h in the DAM and 0.75 h in RT.
- ESRs will be responsible for managing operating limitations that cannot be accommodated by the NYISO's market software.
- Although Run Time parameters are submitted at Registration, Market Participant Administrators may update Run Time values prior to each market close, as needed.

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Upper and Lower Storage Limits

- ESRs will be required to provide their physical maximum and minimum storage limits upon Registration.
  - FERC Order No. 841 refers to these parameters as “Maximum State of Charge” and “Minimum State of Charge”.
- Updates may only be made upon request and approval by the NYISO.

Bid Parameters

Bid Parameters

- **All ESRs must submit values for the following parameters with their economic offers:**
  - Normal Upper Operating Limit
  - Emergency Upper Operating Limit
  - Lower Operating Limit
  - Incremental Bid Curve
  - Market Choice
  - Unit Operation
  - Beginning Energy Level (DAM Only)
  - Energy Level Mode (NYISO/Self)

Where BLACK = Existing Generator parameter and BLUE = New parameter available only to ESRs

- **Fuel Type, Burdened Fuel Price, and Opportunity Cost are optional bid parameters.**
- **Please see the "ESR Parameters" file uploaded with today's meeting materials for more details on each parameter.**

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Minimum and Maximum Withdrawal Limits

- FERC Order No. 841 requires the NYISO to account for the following operating characteristics of ESRs*:
  - Minimum Withdrawal Limit (“Minimum Charge Limit”)
  - Maximum Withdrawal Limit (“Maximum Charge Limit”)
- Market Participant Administrators will use the “Lower Operating Limit” and “Upper Operating Limit” bid parameters to specify which operating range they wish to make available during each market hour.
- Lower Operating Limit represents the minimum MW value at which an ESR is willing to operate within a given hour.
  - This can represent the Maximum Withdrawal Limit when withdrawing or the minimum output level while injecting.
- Upper Operating Limit represents the maximum MW value at which an ESR is willing to operate within a given hour.
  - This can represent the Minimum Withdrawal Limit when withdrawing or the maximum output level while injecting.

*Names in parentheses are those used in FERC Order No. 841.

Energy Level Modes for ESRs

- **ESRs will be allowed to participate in one of two Energy Level Modes:**
  - NYISO-Managed:
    - NYISO market optimization will use Beginning Energy Level, Roundtrip Efficiency, Lower and Upper Storage limits to ensure that ESRs receive physically feasible schedules in the DAM and RTM.
    - For example: once an ESR reaches its Upper Storage Limit, it will not be scheduled to withdraw more energy, regardless of its bid.
  - Self-Managed:
    - Beginning Energy Level, Roundtrip Efficiency, Lower and Upper Storage limits will not be considered in the market optimization.
      - Energy Level telemetry will be evaluated as a pre-optimization step to ensure that Reserve schedules meet reliability requirements and Energy schedules are feasible.
    - Self-Managed ESR’s will be responsible for managing their energy level constraints through their offers.

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Energy Level Modes for ESRs

- **ESRs will be required to select an Energy Level Mode when submitting their offers into the DAM and RTM.**
  - Bids that do not indicate whether the ESR wishes to operate as Self or NYISO-Managed will be rejected.
- **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 <u>will be</u> optimized over the entire 24 hour horizon.
    - If Self-Managed, Energy Level constraints <u>will not be</u> considered in the optimization.

Energy Level Modes for ESRs

- **ESRs will be able to toggle between Self and NYISO-Managed modes between markets, subject to existing rules regarding acceptable bid modes for unit operation.**
  - ESRs can offer as Self-Managed in the DAM and NYISO-Managed in the RTM.
  - ESRs can offer as NYISO-Managed in the DAM and Self-Managed in the RTM.
- **ESRs will be able to change Energy Level modes between hours in the RTM.**

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Unit Operation for ESRs

- NYISO-Managed ESRs must offer as ISO-Committed Flexible in both DAM and RTM.
- Self-Managed ESRs may offer as ISO-Committed Flexible, Self-Committed Flexible, Self-Committed Fixed or ISO-Committed Fixed in the DAM.
- Existing rules will apply for changing bid modes between markets.
  - These rules will limit the ability of ESRs to toggle between Self and NYISO-Managed states.

Energy Level and Unit Operation Modes for ESRs

DAM Offer		Permitted RTM Offers	
Energy Level Mode	Unit Operation Mode	Energy Level Mode	Unit Operation Mode
NYISO-Managed	ISO-Committed Flex	NYISO-Managed	ISO-Committed Flex
		Self-Managed	ISO-Committed Flex Self-Committed Flex Self-Committed Fixed*
Self-Managed	ISO-Committed Flex	NYISO-Managed	ISO-Committed Flex
		Self-Managed	ISO-Committed Flex Self-Committed Flex Self-Committed Fixed*
Self-Managed	Self-Committed Flex	Self-Managed	Self-Committed Flex Self-Committed Fixed*
Self-Managed	ISO-Committed Fixed**	Self-Managed	Self-Committed Fixed
Self-Managed	Self-Committed Fixed	Self-Managed	Self-Committed Fixed
No DAM Offer		NYISO-Managed	ISO-Committed Flex
		Self-Managed	ISO-Committed Flex Self-Committed Flex Self-Committed Fixed

- ESRs that bid using Self-committed Fixed or ISO-Committed Fixed will not be eligible to provide any Operating Reserves.
    - Consistent with treatment of generators[1].

* Only with approval from the NYISO.

** Units may only bid as ISO-Committed Fixed if qualified by the NYISO.

1. Section 15.4.1.2.4 of MST

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Unit Operation Modes for Self-Managed ESRs

- In RT, if a Self-Managed ESR bids as:
  - Self-Committed Fixed or Self-Committed Flexible, the optimization will only honor UOL, LOL and response rates.
  - ISO-Committed Fixed or ISO-Committed Flexible, the optimization will honor additional parameters minimum run time, maximum run time, minimum withdrawing time and maximum withdrawing time.

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Opportunity Cost

- **Market Participant Administrators will be able to submit Opportunity Costs with ESR offers.**
  - This feature will be deployed with the ESR participation model, and will be available to all Generators.
- **As previously discussed at MIWG, the NYISO is developing an Opportunity Cost calculation for ESRs[1].**
- **If a Market Participant Administrator elects not to enter an Opportunity cost with an ESR offer, the market software will default to the NYISO's calculated value.**
- **NYISO is soliciting feedback on whether Market Participant Administrators should also be permitted to submit a Fuel Type and Burdened Fuel Cost for ESRs.**
  - Burdened Fuel Cost may only be entered in units of $/mmBTU, therefore this field is limited to thermal fuel costs.
  - In this case, Fuel Type and Burdened Fuel Cost will be used for informational purposes only and will not affect ESRs' Reference Level calculations. Reference Levels will be determined by the NYISO's Opportunity Cost calculation and/or the Market Participant's submitted Opportunity Cost.

1. See NYISO, *Energy Market Mitigation Measures for ESRs*, July 10th 2018 (MIWG)

Scheduling ESRs

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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 are provided in Appendix A.

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Operating Reserve Awards

- The Northeast Power Coordinating Council (NPCC) requires that Operating Reserve awards be sustainable for at least one hour[1].
- To adhere to this requirement, the NYISO will use RT Energy Level telemetry to modify the Operating Reserve Availability of 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 in Appendix A.
- Energy Level constraints will also be used to modify the Operating Reserve Availability of NYISO-Managed ESRs as part of the RTM optimization.
- ESRs must have a minimum duration of one hour to participate as Operating Reserve suppliers if they meet the qualification requirements to provide Operating Reserves.

1. See NPCC directory 5, Requirement 5.13.

Scheduling Self-Managed ESRs

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:**
  - X Beginning Energy Level
  - X Roundtrip Efficiency
  - X Upper Storage Limit
  - X 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), Lower Operating Limit (LOL), Incremental Bid Curve, Response Rates, etc.

Real-Time Dispatch Envelope for Self-Managed ESRs

- **RT Energy Level telemetry will be used to modify the UOL and LOL whichever is applicable, of Self-Managed ESRs as part of the dispatch envelope calculation step that occurs <u>before</u> each RTM optimization period.**
  - If an ESR would not be physically capable of sustaining its offered UOL or LOL for the next RTM interval (5 minutes in RTD and 15 minutes in RTC) as a result of Energy Level constraints, the UOL or LOL will be derated automatically <u>before</u> the ESR is evaluated by RTD or RTC.
  - Examples of how this logic will be applied are provided in Appendix A.

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Scheduling Self-Managed ESRs

- **Currently, a Generator must notify the NYISO and Transmission Owner of all fuel outages[1].**
  - This results in a full or partial de-rate 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.
- **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.

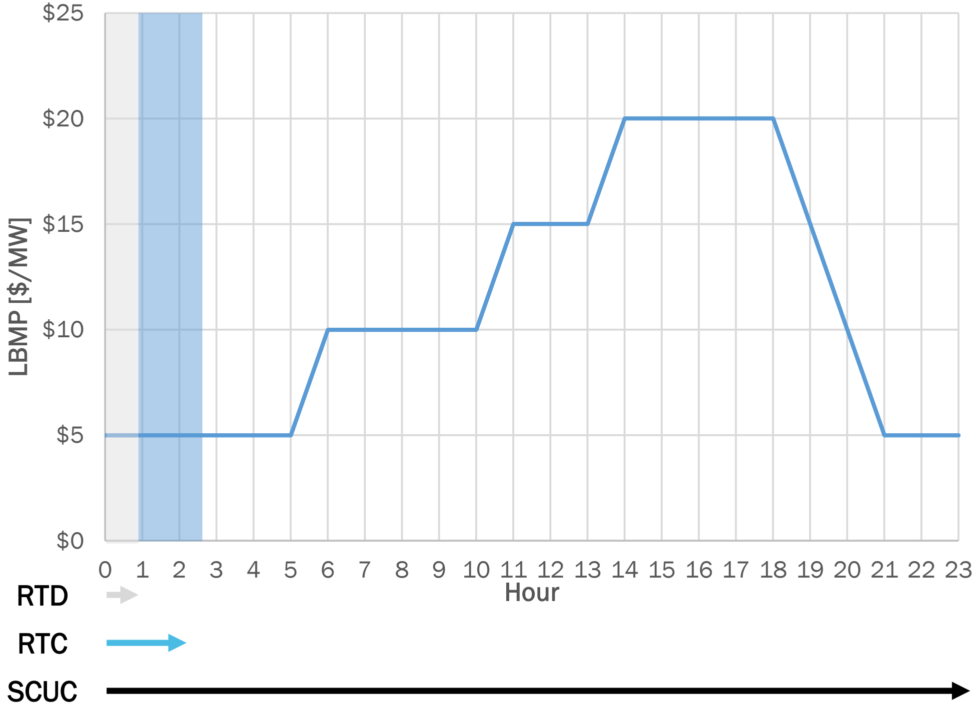
1. See the NYISO's Outage Scheduling Manual for more information on forced outages and derates.

Scheduling NYISO-Managed ESRs

Real-Time Dispatch Envelope for NYISO-Managed ESRs

- **The NYISO <u>will not</u> use RT Energy Level telemetry to modify UOL and LOL for NYISO-Managed ESRs as part of the dispatch envelope calculation step that occurs <u>before</u> each RTM optimization period.**
  - Dispatch envelopes for NYISO-Managed ESRs will be calculated like traditional Generators.
  - UOL and LOL will be modified based on Response Rates and last physical dispatch point, rather than Energy Level constraints.
- **Beginning Energy Level, Roundtrip Efficiency, Upper and Lower Storage limits will be honored within the RTM market optimization.**
  - Energy Level constraints will be respected for binding and advisory intervals.

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

- **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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ESR Metering and Station Power

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Metering Requirements

- **The NYISO proposes that ESR's be required to provide direct metering regardless of where they are physically located (transmission system, distribution system, or co-located with load).**
- **The NYISO does not anticipate that significant changes to existing tariff rules concerning metering will be necessary to comply with FERC Order No. 841.**
  - Language will need to be added to accommodate ESR's that are collocated with a load behind a retail net meter, that wish to participate in the NYISO's wholesale markets.
- **ESRs will be defined as a type of Generator in the NYISO's tariff.**
  - Therefore, the NYISO proposes to extend the existing Metering Requirements to ESRs.
- **Existing Metering Requirements[1] state that for the purposes of NYISO billing and settlements, Generator meters:**
  - Must be approved by a Metering Authority;
  - Must provide revenue-quality metering information;
  - Must provide 6-second telemetry; and
  - Must comply with minimum acceptable accuracy standards[2].
- **ESRs will be required to provide Energy Level telemetry in Real Time.**

1. Revenue Metering Requirements Manual, Section 2
2. Guide for Uniform Practices in Revenue Quality Metering

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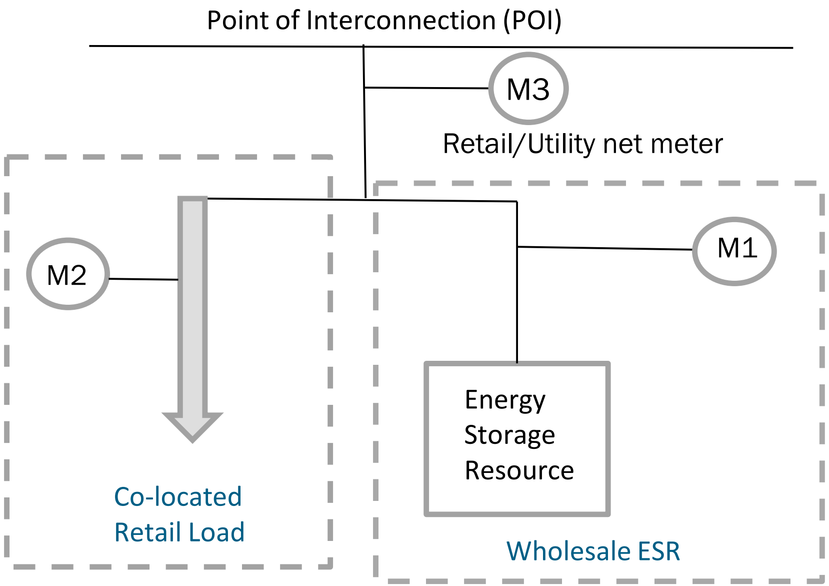
Metering Proposal for an ESR Collocated with a Load

- **Figure 1 is a simplified diagram of an ESR collocated with a Load.**
  - The ESR has a unique identifier (PTID) in the NYISO markets.
  - The NYISO receives telemetry and settlement data from the ESR (metered by M1) through the Transmission Owner's SCADA system.
    - This enables the NYISO to measure performance of the ESR independently of the Load.
    - The collocated Load (metered by M2) is accounted for as part of the LSE's retail load by the Meter Authority.
    - This configuration requires the Meter Authority to adjust LSE's retail load calculation to exclude the energy that the ESR exchanges with the grid.
    - Ensures that the ESR is not paying for the same charging energy twice.
- **The NYISO will require, as part of the interconnection process, the applicable utility to agree <u>not to</u> include energy withdrawals for the purpose of later injection back onto the grid in the facility's retail energy invoice.**

Figure 1. ESR Collocated with a Load



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Station Power

- ESRs will be required to account for Energy withdrawals that serve Station Power.
- Existing Station Power tariff provisions will be updated to include ESRs.
- Similar to existing Generators, additional meters may be required to differentiate Energy withdrawn for later injection to the grid from Energy used for Station Power.

Station Power

- The NYISO's existing Registration process includes a Station Power application for Generators that wish to use wholesale withdrawals to supply Station Power.[1]
    - The existing process requires schematics to be provided of the prospective metering configuration.
    - Process also requires the designation of a third-party Station Power provider, with authorization from the respective LSE or TO.
- No changes to the existing Station Power Registration process are anticipated to be needed to accommodate ESRs.

1. See the NYISO's Technical Bulletin 117

ESR Settlements

Balancing Market Settlements for ESRs

- Consistent with the treatment applied to traditional Generators, ESRs will be subject to balancing market settlements in both the injecting and withdrawing states.

- The existing calculation works for ESRs in both injecting and withdrawing states.
  - Calculation for ESR not providing Regulation Service:
    - Supplier payment = $[Lower\ of\,(Actual,(RT\ schedule\ + Tolerance) - DAM\ schedule\ )] * RT\ LBMP$

Where,

- If an ESR's RT schedule is to inject,
  - Tolerance is 3% of the supplier's UOL_N.
- If an ESR's RT schedule is to withdraw,
  - Tolerance is 3% of the supplier's LOL_N.
    - » Note: For withdrawing, tolerance is equal to 3% of the supplier's absolute value of LOL_N.
- Balancing market settlement calculation for ESR providing Regulation Service:
  - Supplier payment $= [Lower\ of\,(Actual, RTD\ Avg\ AGC\ basepoint) - DAM\ schedule\ ] * RT\ LBMP$

- Examples are provided in Appendix B.

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Regulation Revenue Adjustments

- Regulation Revenue Adjustments are designed to balance the Energy payments that Generators receive and the costs that Generators incur when providing Regulation Service.
  - For any interval in which a Generator that is providing Regulation Service receives an AGC Base Point Signal that is different from its RTD Base Point Signal, it may be eligible to receive a Regulation Revenue Adjustment Payment (RRAP) or be required to pay a Regulation Revenue Adjustment Charge (RRAC).
- RRAC and RRAP are designed to ensure that a unit is economically indifferent to following an AGC basepoint that differs from its RTD basepoint.
- Generators are eligible for RRAC/RRAP when:
  - Scheduled by RTD to provide Regulation service and;
  - Regulating up or down from their RTD basepoint.
- Existing formulas for RRAP/RRAC work for ESRs in both injecting and withdrawing states.
- Examples provided in Appendix B

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Persistent Over and Under-Generation Charges for ESRs

- ESRs will be subject to persistent over and under-generation charges in both injecting and withdrawing states.
  - ESRs will be expected to follow their Base Point Signal within a tolerance of 3% of their maximum capability (UOL/LOL - for injecting and withdrawing respectively).
- ESR injections will be subject to existing under and over generation settlement treatment for Generators.
- ESR withdrawals:
  - When an ESR is underwithdrawing, the conditions are equivalent to overgenerating.
  - Symmetrically, when an ESR is overwithdrawing, the conditions are equivalent to undergenerating.
- Examples are provided in Appendix B.

DAMAP Eligibility for ESRs

Day-Ahead Margin Assurance Payments

- **DAMAP protects Day-Ahead Margins that are lost as a result of Real-Time dispatch instructions provided by the NYISO.**
  - Protecting Generators' Day-Ahead Margins incentivizes them to respond to NYISO instructions in RT.
  - Generators that offer as ISO-Committed Flexible or Self-Committed Flexible for the same hours in the DAM and RTM are eligible for DAMAP (among certain other categories of Suppliers)
  - DAMAP is generally reduced or eliminated when Generators decrease their availability in RT.
- **At the August 14th MIWG, the NYISO detailed the rationale for why extending DAMAP to ESRs would be inappropriate in most cases and proposed that ESRs be eligible for DAMAP under limited circumstances.[1]**

1. See NYISO, DAMAP for ESRs (MIWG, August 14th, 2018)

ESRs: DAMAP Eligibility

- After additional consideration, the NYISO proposes to limit DAMAP eligibility further than previously proposed:

DAM Energy Level Mode	RTM Energy Level Mode	Eligible for DAMAP
NYISO-Managed	Self-Managed	No
	NYISO-Managed	No
Self-Managed	Self-Managed	~~Yes~~ No
	NYISO-Managed	No

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ESRs: DAMAP Eligibility

- **The NYISO proposes to further limit ESR eligibility for DAMAP for the following reasons:**
  - Few ESRs are likely to be eligible for DAMAP under the criteria previously proposed.
    - Clarification of this point is provided later in this presentation.
  - DAMAP was not designed to protect lost opportunity costs across multiple hours.
    - Designed as an hourly settlement to protect the DA margin of generation resources.
    - ESR Energy Level and fuel cost constraints are intertemporal. Decisions to withdraw or inject in one hour impact opportunity costs to withdraw or inject in future hours.
    - Extension of existing DAMAP construct to ESRs could dis-incentivize ESRs to respond flexibly to RT conditions.
    - Intertemporal constraints make it impossible to apply the existing settlement construct without significant modifications.
  - The NYISO expects ESR offers to reflect the opportunity costs associated with Energy arbitrage.
    - New bidding parameter will enable ESRs to update opportunity costs in RT to avoid uneconomic dispatch.

ESRs: DAMAP Eligibility

- **ESRs will be eligible for DAMAP when committed OOM for reliability.**
  - Consistent with the Order No. 841 requirement to “ensure that resources available for manual dispatch as a wholesale buyer and wholesale seller under the participation model for electric storage resources are held harmless for manual dispatch by being eligible for make-whole payments.”[1]
  - Consistent with existing treatment of Resources that are derated or decommitted by the ISO in response to an ISO or Transmission Owner system security need or to permit the ISO to procure additional Operating Reserves.

1. Paragraph 174 Order No. 841

BPCG Eligibility for ESRs

Day Ahead BPCG: Background and Eligibility

- Day-Ahead Bid Production Cost Guarantee (BPCG) payments are paid if a Supplier's total as-bid costs are greater than its revenues for the DA market.

- DA BPCG is a daily settlement that is calculated on an hourly basis.

- Eligibility Criteria[1]:
  - A supplier must be committed by the ISO and bid using ISO-Committed Fixed or ISO-Committed Flexible to be eligible for DA BPCG payments.
  - A supplier is not eligible to receive a DA BPCG payment if it is committed for any other hour as a result of a Self-Committed Fixed or Self-Committed Flexible bid.

1. MST Attachment C- Section 18.2.1.1

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Day-Ahead BPCG for ESRs: Eligibility

- **The NYISO proposes to allow both Self-Managed and NYISO-Managed ESRs to be eligible to receive Day-Ahead BPCG payments.**
- **Existing Eligibility criteria will also apply to ESRs.**
  - An ESR must be committed by the NYISO and operate in ISO-Committed Fixed or ISO- Committed Flexible modes to be eligible for a DA BPCG payment.
  - If a Self-Managed resource is committed for any hour of the day as a result of Self-Committed Fixed or Self-Committed Flexible mode, it <u>**will not**</u> be eligible to receive a DA BPCG payment.
- **Examples are provided in Appendix B.**

** Units may only bid as ISO-Committed Fixed if qualified by the NYISO

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Real Time BPCG: Background

- Real Time BPCG payments are paid if a qualifying Supplier's total as-bid costs are greater than its revenues for commitment in RT above its DA schedule.
- RT BPCG is a daily settlement that is calculated at the 5-minute level using RTD schedules.

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Real Time BPCG: Existing Eligibility Provisions

- **Suppliers are eligible for RT BPCG if they bids as follows[1] :**
  - ISO-Committed Flexible or ISO-Committed Fixed in RTM; or
  - Self-Committed Flexible – provided the RT Minimum Generation does not exceed its DA schedule at any point in the dispatch day; or
  - For hours where a generator is committed via SRE or OOM to ensure NYCA or local reliability.
- **Suppliers are ineligible for RT BPCG if they bid as follows:**
  - Switch from ISO-committed Fixed or Flexible to Self-committed Fixed/Flexible bid for any hour of the day.
    - However, the resource will not be precluded for other hours in which it was eligible if such a bid mode was used for
      - i) ISO-authorized start-up, shutdown or testing period (or)
      - ii) Generator committed via SRE or OOM for NYCA/local system reliability.

1. See MST Attachment C, section 18.4.1.1

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Real Time BPCG for ESRs- Eligibility

- The NYISO proposes that:
- ESRs that are NYISO-Managed in any hour of the RTM day, will not be eligible to receive RT BPCG. The reasons are the same as stated on Slide 56.
- ESRs that switch modes between NYISO and Self Managed between hours of RT market, will not be eligible to receive RT BPCG due to gaming concerns.
- ESRs that are Self-Managed for all hours of the RT market will be eligible to receive RT BPCG payments, subject to additional eligibility criteria.
  - The current eligibility rules for traditional generators switching unit operation modes from ISO to Self committed will apply to Self-Managed ESRs as well(discussed on Slide 62).
- Appendix B provides examples of different scenarios in which Self-Managed ESRs may receive a RT BPCG payment and the formulas that will apply.

Next Steps

- September - October 2018:
  - Finalize and publish prototyping results in partnership with ABB.
- December 3, 2018:
  - FERC Order No. 841 compliance filing.

Questions?

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

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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Appendix A : Bidding and Scheduling ESRs

Scheduling Self-Managed ESRs: Examples

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
Lower Operating 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 an Operating 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, for details concerning current Reserve eligibility and bidding requirements.

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
Lower Operating 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 Operating 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
Lower Operating 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
Lower Operating 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 LOL 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 LOL 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 LOL will be automatically derated before its operating characteristics are passed to RTD or RTC.**

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Scheduling Self-Managed ESRs

Example 2 (cont.):

- **LOL 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
  - LOL should be increased from -20 MW to 0 MW.
- **LOL derate calculation for RTC:**

  22 MWh [Upper Storage Limit] – 20 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
  - LOL 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, Lower Operating 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.
Lower Operating 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
Lower Operating 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]

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
Lower Operating 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 LOL 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 LOL 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
Lower Operating 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.
- 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.

Scheduling Self-Managed ESRs

Example 3 (cont.): The NYISO will adjust UOL, Lower Operating 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.
Lower Operating Limit	-20	-20	20	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	25			%	
Real-Time Energy Level	7			MWh	
Reserve Availability	20	5		MW	May be modified to ensure that potential Reserve awards meet NPCC sustainability requirement.

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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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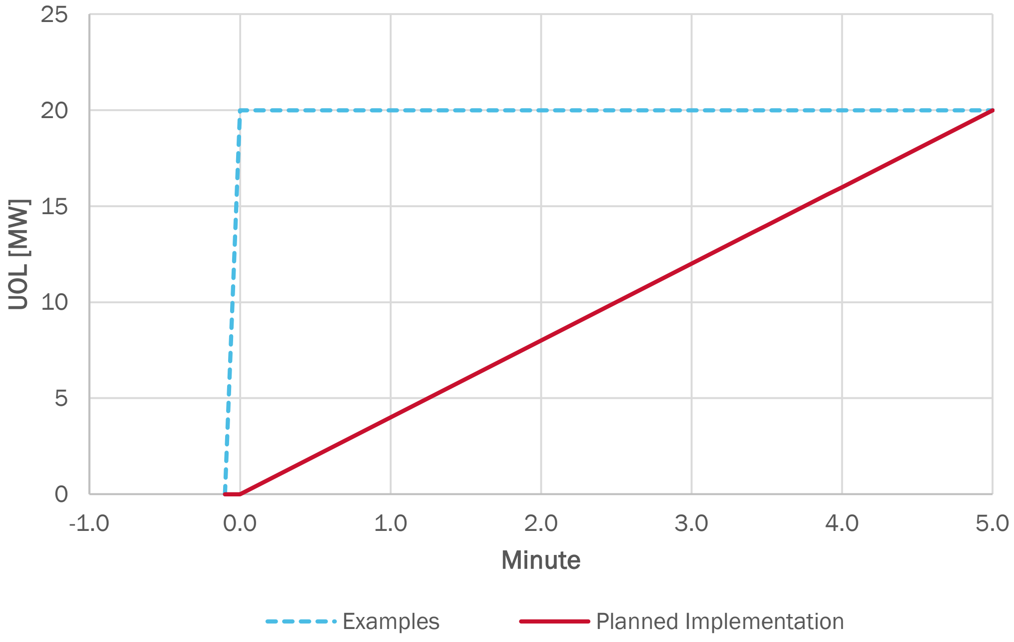
Scheduling Self-Managed ESRs

- **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.**

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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NYISO Energy Level Management

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.

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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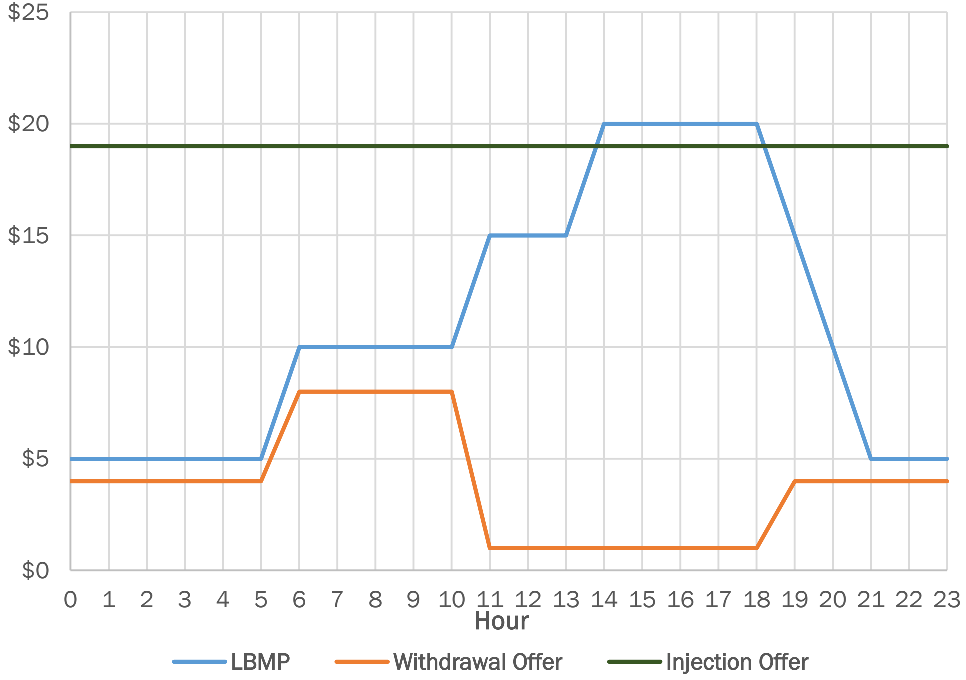
NYISO Energy Level Management

- 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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Scheduling NYISO-Managed ESRs: Examples

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

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.**

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.

Appendix B: Settlements

Charges for deviating from NYISO Basepoints

Existing Equations for Persistent Under and Over Generation Charges

$$Persistent\ undergeneration\ charge^{1} = Energy\ Difference\ x\ Max\ (MPRCDAM, MPRC_{RT})\ x\ Length\ of\ RT\ interval\ in\ seconds/3600$$
$$Overgeneration\ charge^{2} = Energy\ Difference\ x\ Max\ (MPRCDAM, MPRCRT)\ x\ Length\ of\ RT\ interval\ in\ seconds/3600$$

Where:

- $MPRC_{DAM}$: Regulation Capacity Market Price in the DAM ; ($/MW)
- $MPRC_{RT}$: Regulation Capacity Market Price in RT ; ($/MW)
- Energy Difference for Persistent Undergeneration: RT schedule– Actual Energy ; (MW)
- Energy Difference for Overgeneration : Actual Energy – RT Schedule; (MW)
  - Energy Difference calculation uses a 15 minute duration when determining persistent undergeneration charge
  - Energy Difference *will be set to zero* if:
    - Calculated value is negative (or)
    - Calculated value falls within a tolerance (i.e. 3% of UOL)

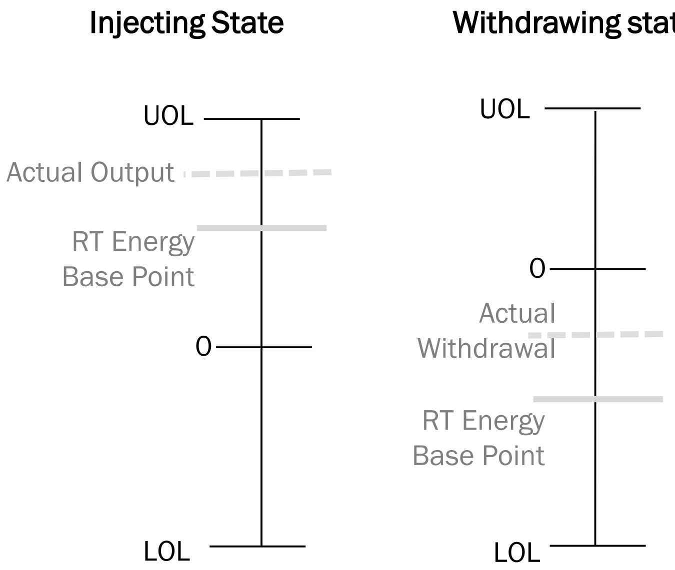
Notes:

- Under and Overgeneration charges are only applicable to suppliers not providing Regulation Service.
- Overgeneration charges are currently only applicable to wind resources.

1. Section 15.3.A.1 of MST
2. Section 15.3.A.2 of MST

See Accounting and Billing Manual- Section I.7 for additional details

Overgeneration charges for ESRs



- **ESRs will not incur explicit Overgeneration charges:**
  - When an ESR is scheduled to inject and operates above its basepoint (*i.e., overgenerating*) there is an implied penalty embedded in the operational costs.
  - When an ESR is scheduled to withdraw and operates above its basepoint (*i.e., underwithdrawing*) there is an implied penalty in the sense that the ESR will be settled at their scheduled RT Energy Base Point + tolerance.

Assume the ESR has no transition constraints for purpose of this illustration

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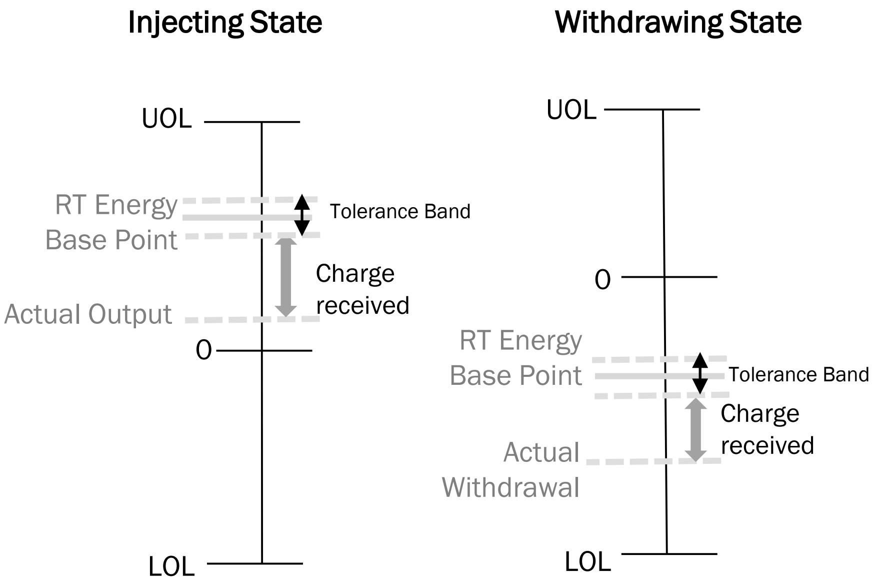
Persistent Undergeneration charges for ESRs



- **ESRs will incur explicit Undergeneration charges:**
  - When an ESR is scheduled to inject and operates below its basepoint (*i.e.*, undergenerating) there is an explicit undergeneration charge.
  - When an ESR is scheduled to withdraw and operates below its basepoint (*i.e.*, overwithdrawing) *there will be* an explicit overwithdrawing charge.
    - The equation will be the same as the Persistent undergeneration equation used in the tariff[1].
    - Note* : PLU function will need to be modified to reflect the withdrawing state.

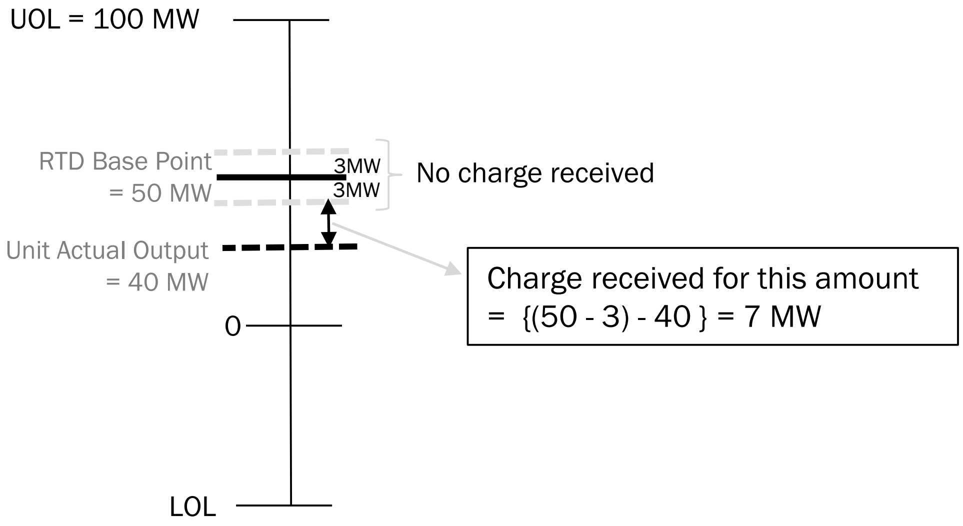
Assume the ESR has no transition constraints for purpose of this illustration

1. Section 15.3.A.1 of MST

Undergeneration Charge for ESRs: Example

- Assume an ESR with:

a) UOL = 100 MW
b) Max Load = -100 MW
c) RTD Base Point = 50 MW
d) Unit Actual Output = 40 MW
e) Length of RT interval = 5 min = 300 sec
f) 3 % of UOL = 3 MW
g) 3% of LOL= 3 MW



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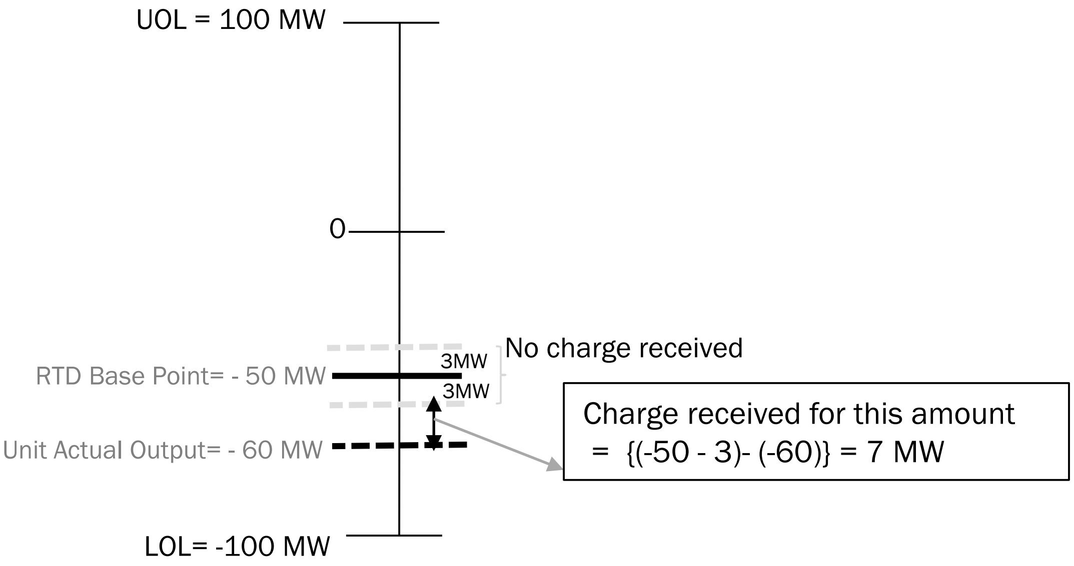
Overwithdrawal Charge for ESRs: Example

- Assume an ESR with:

a) UOL = 100 MW
b) Max Load = -100 MW
c) RTD Base Point = -50 MW
d) Unit Actual Output = -60 MW
e) Length of RT interval = 5 min = 300 sec
f) 3 % of UOL = 3 MW
g) 3 % of LOL= 3 MW

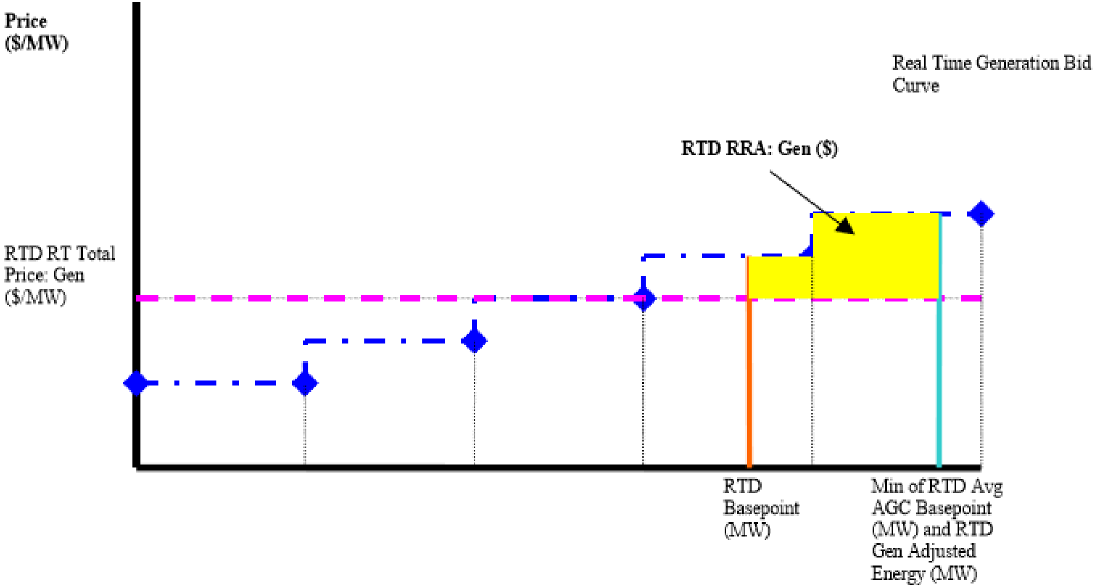


Regulation Revenue Adjustment Charge/Payment (RRAC/RRAP)

Regulation Revenue Adjustments

- **When the AGC Basepoint is greater than RTD Basepoint (i.e. Regulating Up)**
  - Calculation over a RTD interval:

$$[\{Bid\ Cost\ from\ RTD\ to\ lower\ of\ (Actual, AGC)\} - \{Gen\ LBMP * \ (lower\ of\ [Actual, AGC] - RTD)\}]$$



Results in:

RRAP: if Bid cost > Gen LBMP

RRAC: if Bid Cost < Gen LBMP

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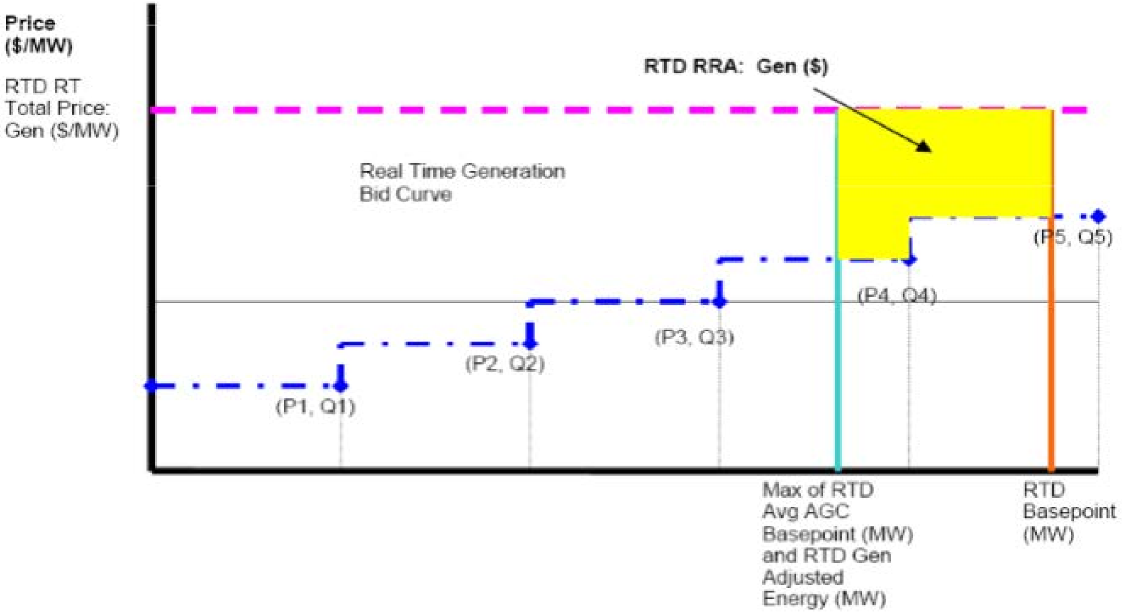
Regulation Revenue Adjustments

- **When the AGC Basepoint is less than RTD Basepoint (i.e. Regulating Down)**
  - Calculation over a RTD interval:

$$[\{Bid\ Cost\ from\ higher\ of\,(Actual, AGC)\ to\ RTD\} - \{Gen\ LBMP *\ (RTD - higher\ of\,[Actual, AGC])\} * -1]$$



Results in:

RRAP: if Bid cost < Gen LBMP

RRAC: if Bid Cost > Gen LBMP

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Day-Ahead Bid Production Cost Guarantee (DA BPCG)

Day Ahead BPCG for Generators: Formula

- $\mathrm{DA\ BPCG}^1 = \mathrm{Max}[\sum_{h=1}^{N}(\mathrm{Generator's\ costs\ } - \mathrm{Revenue}), 0]$

  Where,

  - Costs = Incremental energy, ancillary services, minimum generation and start-up costs
  - Revenue = Incremental energy and Ancillary services revenue

- **In order to receive a DA BPCG payment, the sum of all as-bid costs minus all revenue for each hour of a given day must result in a net loss.**

1. See MST Attachment C, section 18.2.2.1

Day Ahead BPCG: Formula

- Formula for DA BPCG for a generator g[1]:

$$Max\left[\sum_{h=1}^{N}\left(\underbrace{\int_{MGH_{gh}^{DA}}^{EH_{gh}^{DA}} C_{gh}^{DA} + MGC_{gh}^{DA}MGH_{gh}^{DA} + SUC_{gh}^{DA}NSUH_{gh}^{DA}}_{\text{Costs of the generator}} - \underbrace{LBMP_{gh}^{DA}EH_{gh}^{DA} - NASR_{gh}^{DA}}_{\text{Revenue earned by the generator}}\right), 0\right]$$

Where,

C_{gh}^{DA} = Bid cost submitted by generator g in hour h expressed in terms of \$/MWh

MGC_{gh}^{DA} = Minimum generation bid, \$/MWh

MGH_{gh}^{DA} = Energy scheduled to be produced by Min Gen segment of generator g in hour h, MWh

SUC_{gh}^{DA} = Start-up bid by generator g in hour h, \$/start

$NSUH_{gh}^{DA}$ = Number of times generator g is scheduled DA to start-up in hour h

$LBMP_{gh}^{DA}$ = DA LBMP at generator g's bus in hour h, \$/MWh

EH_{gh}^{DA} = Energy scheduled DA to be produced by generator g in hour h, MWh

$NASR_{gh}^{DA}$ = Net ancillary services revenue, \$

1. MST Attachment C, section 18.2.2

Day Ahead BPCG- Example

- Consider the following parameters for Hour 14

Parameters	Value	Unit
Min Gen	20	MW
Min Gen cost	50	$
Hr DAM schedule	100	MW
Hr DAM LBMP	40	$/MW
DAM Start-up cost	100	$
Incremental cost	20-50 MW = 30 50-120 MW = 60	$/MW

- The generator's receives a BPCG payment for hour 14 of **$50**

- $\text{DA BPCG} = \text{Max}[\sum_{h=1}^{N}(\text{Generator's costs} - \text{Revenue}), 0]$
- **Incremental energy bid cost = Area under bid curve from min gen(MW) to DAM schedule(MW)**

$$\int_{20}^{120} Incremental\ cost = \int_{20}^{50} 30 + \int_{50}^{100} 60$$

= 30*(50-20) + 60*(100-50) = $3900

- **Minimum generation cost = $50**
- **Start-up cost = $100**
- **Total cost = incremental energy bid cost + minimum generation cost+ start-up cost**

= $3900+$50+$100 = $4050

- **LBMP Revenue = Hr DAM LBMP* Hr DAM schedule = (40)*100 = $4000**
- **Net Ancillary services revenue = $0**
- **DA BPCG for hour 14 = Total Cost – LBMP Revenue – Net Ancillary Services revenue**

= $4050 - $4000 - 0 = $50

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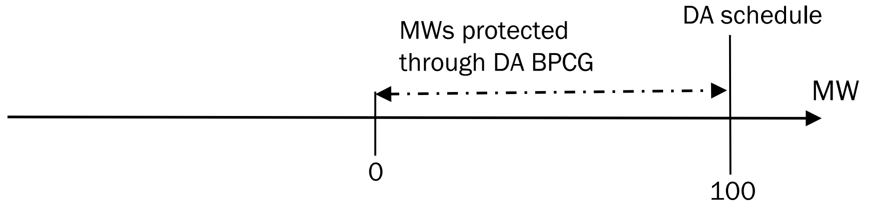
Day-Ahead BPCG for Continuous ESRs

- The current formula for DA BPCG works for continuous ESRs(shown on Slide 109).
- Continuous ESRs will not have Min gen ($/MW) pair or Start-up costs parameter available to them.
    - Therefore, these terms will not be considered in the calculation on DA BPCG.

1. See NYISO, ESR Operating characteristics presentation, MIWG(07/31/2018)

DA BPCG for Continuous ESRs- Example 1

- DA schedule is to inject.
- Consider the following parameters for an hour.
- Assume the resource has no ancillary services schedule.



Parameters	Value	Unit
Hr DAM schedule	100	MW
Hr DAM LBMP	40	$/MWh
Incremental cost	-120 to -50 = 10 -50 to 0 = 20 0-50 MW = 30 50-120 MW = 60	$/MWh

DA BPCG the hour =

$$\{\int_{\text{Min Gen}}^{\text{DA schedule}} Incremental\ cost\} - \{DA\ LBMP * DA\ schedule\}$$

$$= \{\int_{\text{Null}}^{50} 30 + \int_{50}^{100} 60\} - \{40 * 100\}$$

$$= \{30*(50\text{-Null}) + 60*(100\text{-}50)\} - 4000$$

$$= 4500 - 4000 = 500$$

- The units cost of $4500 exceeds the LBMP revenue $4000.
- The contribution the hour to the DA BPCG calculation is **$500**

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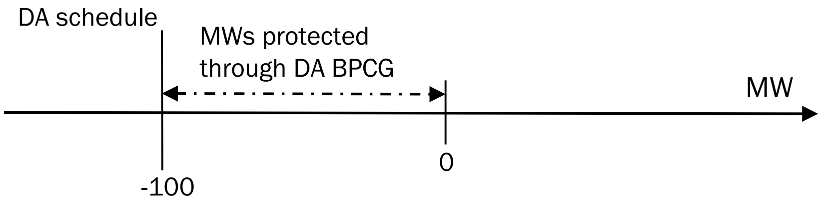
DA BPCG for Continuous ESRs- Example 2

- DA schedule is to withdraw.
- Consider the following parameters for an hour.
- Assume the resource has no ancillary services schedule.

Parameters	Value	Unit
Hr DAM schedule	-100	MW
Hr DAM LBMP	8	$/MWh
Incremental cost	-100 to 0 = 5 0-50 MW = 30 50-100 MW = 60	$/MWh



DA BPCG the hour =

$$\{\int_{\text{Min Gen}}^{\text{DA schedule}} Incremental\ cost\} - \{DA\ LBMP * DA\ schedule\}$$

$$= (\int_{Null}^{-100} 5\ - (8 * -100)$$

$$= (5*(-100\text{- Null}) – (-800)$$

$$= -500 – (-800) = -500 +800 = 300$$

- The unit offered to pay $500 to withdraw, unit had to pay $800 to withdraw.
- The contribution of the hour to the DA BPCG calculation is $300

Real Time Bid Production Cost Guarantee (RT BPCG)

Real Time BPCG for Generators: Formula

- $\text{RT BPCG}^{1} = \text{Max}[\sum_{i=1}^{N}(\text{Generator's costs(from DA to RT schedule)} \; -$

1. See MST Attachment C, section 18.4.2

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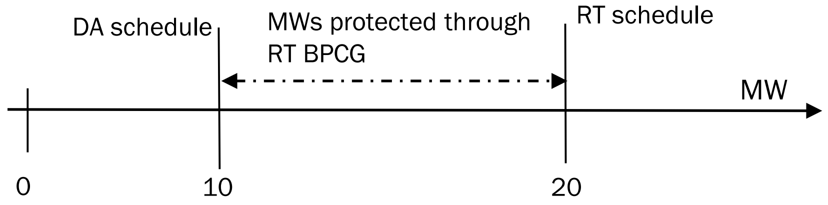
Real Time BPCG for Continuous ESRs- Scenarios

- Scenario 1: DA and RT schedule are to inject.
- Scenario 2: DA and RT schedule are to withdraw.
- Scenario 3: DA schedule is to inject and RT schedule is to withdraw.
- Scenario 4: DA schedule is to withdraw and RT schedule is to inject.

RT BPCG for Continuous ESRs- Scenario 1- Example

- DA schedule and RT schedule are to inject.
- Consider the following parameters for a RTD interval.
- Assume the resource has no ancillary services schedule.

Parameters	Value	Unit
Incremental cost in RT	-20 to 0 = 10 0 to 20 = 50	$/MWh
RT LBMP	40	$/MWh
DA energy schedule	10	MW
RT energy schedule	20	MW
Time	300	seconds



RT BPCG for RTD interval in hour 10 =

$$\{\int_{\max(DA\ schedule,0)}^{\max(RT\ schedule,0)} Incremental\ cost - RT\ LBMP * (RT\ schedule - DA\ schedule)\} * seconds/3600$$

$$= \{\int_{10}^{20} 50 - 40 * (20 - 10)\} * 300/3600$$

$$= \{50*(20\text{-}10) - 40*(20\text{-}10)\} *0.0833$$

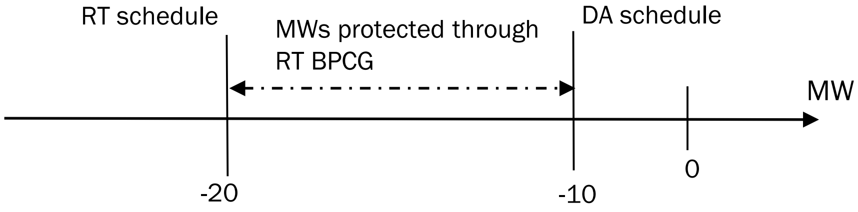
$$= \{500 - 400\}*0.0833 = 100*0.0833 = 8.33$$

- The units cost of $500 exceeds the LBMP revenue $400.
- The contribution of the RTD interval to the RT BPCG calculation is **$8.33**

RT BPCG for Continuous ESRs- Scenario 2- Example

- DA schedule and RT schedule are to withdraw.
- Consider the following parameters for a RTD interval .
- Assume the resource has no ancillary services schedule.

Parameters	Value	Unit
Incremental cost in RT	-20 to 0 = 5 0 to 20 = 50	$/MWh
RT LBMP	8	$/MWh
DA energy schedule	-10	MW
RT energy schedule	-20	MW
Time	300	seconds



RT BPCG for RTD interval =

$$\{\int_{\min(DA\ schedule,0)}^{\min(RT\ schedule,0)} Incremental\ cost - RT\ LBMP * (RT\ schedule - \min(DA\ schedule, 0))\} * seconds/3600$$

$$= \{\int_{-10}^{-20} 5 \ - 8 * (-20 - (-10)\} *300/3600$$

$$= \{5*(-20+10) - 8*(-20+10)\} *0.0833$$

$$=\{-50 -(-80)\} *0.0833 = 30 * 0.0833 = 2.49$$

- The unit offered to pay $50 to withdraw, unit had to pay $80 to withdraw.
- The contribution of the RTD interval to the RT BPCG calculation is **$2.49**

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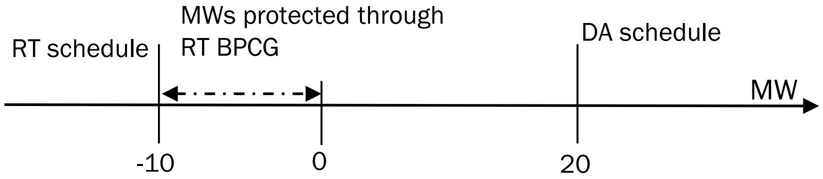
RT BPCG for Continuous ESRs- Scenario 3- Example

- DA schedule is to inject and RT schedule is to withdraw.
- Consider the following parameters for an RTD interval.
- Assume the resource has no ancillary services schedule.

Parameters	Value	Unit
Incremental cost in RT	-20 to 0 = 5 0 to 20 = 50	$/MWh
RT LBMP	10	$/MWh
DA energy schedule	20	MW
RT energy schedule	-10	MW
Time	300	seconds



RT BPCG for RTD interval =

$$\{\int_{\min(DA\ schedule,0)}^{\min(RT\ schedule,0)} Incremental\ cost - RT\ LBMP * (RT\ schedule - \min(DA\ schedule,0))\} * seconds/3600$$

$$= \{\int_0^{-10} 5 - 10 * (-10 - \min(20,0))\} * 300/3600$$

$$= \{5*(-10-0) - 10*(-10-0)\} * 0.0833$$

$$= \{-50 - (-100)\} * 0.0833 = 50 * 0.0833 = 4.16$$

- The unit offered to pay $50 to withdraw, unit had to pay $100 to withdraw.
- The contribution of the RTD interval to the RT BPCG calculation is **$4.16**

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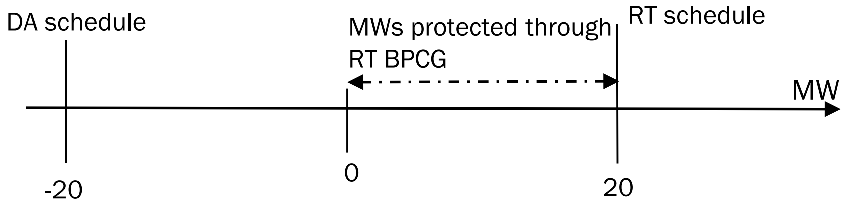
RT BPCG for Continuous ESRs- Scenario 4- Example

- DA schedule is to withdraw and RT schedule is to inject.
- Consider the following parameters for a RTD interval.
- Assume the resource has no ancillary services schedule

Parameters	Value	Unit
Incremental cost in RT	-20 to 0 = 10 0 to 20 = 50	\$/MWh
RT LBMP	40	\$/MWh
DA energy schedule	-20	MW
RT energy schedule	20	MW
Time	300	seconds



RT BPCG for RTD interval =

$$\{\int_{\max(DA\ schedule,0)}^{\max(RT\ schedule,0)} Incremental\ cost - RT\ LBMP * (RT\ schedule - \max(DA\ schedule, 0))\} * seconds/3600$$

$$= \{\int_{0}^{20} 50 \ - 40 * (20 - 0)\} * 300/3600$$

$$= \{50*(20\text{-}0) - 40*(20\text{-}0)\} *0.0833$$

$$=\{1000 - 800\} *0.0833 = 200 * 0.0833 = 16.66$$

- The units cost of \$1000 exceeds the LBMP revenue of \$800.
- The contribution of the RTD interval to the RT BPCG calculation is **\$16.66**

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Day Ahead Margin Assurance Payments for ESRs

ESRs: DAMAP Eligibility

- **According to the proposal discussed at the August 14th MIWG, ESRs would be eligible to receive DAMAP under very limited circumstances:[1]**
    1. When operating as Self-Managed in both DA and RT for that hour, two hours before, and two hours after,
    2. When offering as either ISO or Self-Committed Flexible for that hour, two hours before, and two hours after,
    3. When not decreasing availability between DA and RT, and
    4. When all other eligibility criteria set forth in MST 25.2, Attachment J have been met.
- **The NYISO anticipates that very few ESRs would be eligible for DAMAP under these criteria.**
- **See slides 54-57 of this presentation for the NYISO's current DAMAP for ESRs proposal.**

1. See NYISO, DAMAP for ESRs (MIWG, August 14th, 2018)

ESRs: DAMAP Eligibility

- **Under the eligibility criteria listed on the previous slide, an ESR that takes any of the following actions would be ineligible for DAMAP:**
  - Supplies ICAP – the NYISO requires ESRs that participate as ICAP providers to offer as NYISO-Managed into the DAM.
  - Offers as Self or ISO-committed Fixed in the DAM or RT
  - Increases economic offers to inject between DA and RT
  - Decreases economic offers to withdraw between DA and RT
  - Derates physical capabilities between DA and RT
- **ESRs are likely to take one or more of these actions to maintain ICAP eligibility and/or to effectively manage their schedules in RT.**
  - ESRs that offer as NYISO-Managed in the DAM may elect to change their offers in RT in order to manage the discrepancy in look-ahead periods between the DAM and RTM optimizations that was discussed at the August 14 and August 30th MIWG meetings.[1]

1. See NYISO, Scheduling ESRs (MIWG, August 30th, 2018)

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