Energy Storage Integration – Scheduling Logic

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July 19, 2017. Krey Corporate Center, Rensselaer, NY.

Overview

- **Background**
  - Energy Storage Integration and Optimization, 2016 Market Design
  - Modeling enhancements
    - Feedback Received
- **Phase 1 Scheduling Logic**
- **Scheduling Examples**
- **Next Steps**

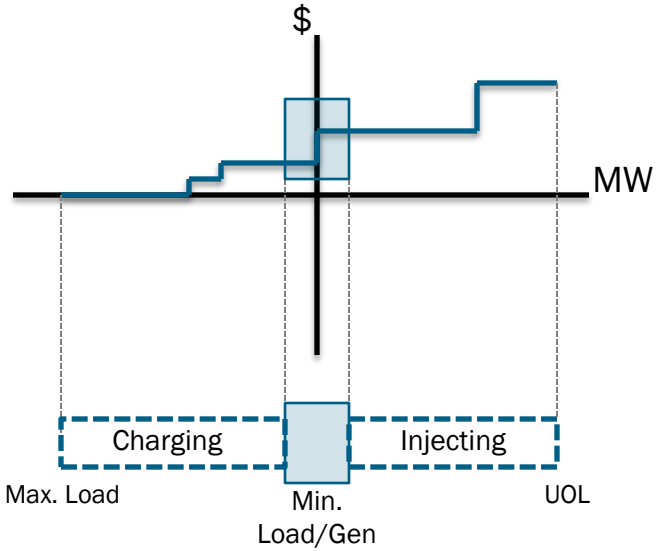
Background

Two-Track Market Design

- **Track 1: Energy Storage Integration**
  - Develop the participation model for Energy Storage Resources ("ESRs").
- **Track 2: Energy Storage Optimization**
  - Develop the optimization methodology for storage resources.
  - During this phase, the NYISO intends to make an enhanced Energy level (*i.e.,* State of Charge ("SoC")) management available to storage resources.

Energy Storage Resource Day-Ahead and Real-Time Offers

- **Single Incremental Hourly Offer**
  - Will allow energy storage resources to include intra-hour withdrawal or injection price points in its offer
  - Permitting intra-hour switching between withdrawals and injections provides RTC/RTD with flexibility to fully utilize the energy storage resources' capabilities
- **Additional offer parameters (see slides 6-10) will be available to reflect energy storage resource capabilities (*e.g.,* transition time and minimum load/injection)**



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Proposed Offer Parameters

Registration		*Registration / Biddable*		*Biddable*	
Transition Time	*[minutes]*	Min. Load	*[MW]*	Incremental Bid Curve	*[$/MW]*
Upper Charge Limit	*[MWh]*	Min. Generation	*[MW]*	Beginning State of Charge	*[MWh]*
Lower Charge Limit	*[MWh]*	Min. Load Cost	*[$]*	Ending State of Charge	*[MWh]*
Charge Rate (Max. Load)	*[MW]*	Min. Generation Cost	*[$]*		
Discharge Rate (UOL)	*[MW]*	Start-up Cost	*[$]*	Bid Modes	*[-]*
Energy level (SoC)	*[Yes/No]*	Start-up Load Cost *	*[$]*		
Min. Charge Time	*[minutes]*				
Max. Charge Time	*[minutes]*				
Min. Run Time	*[minutes]*				
Max. Run Time	*[minutes]*				
Min. Downtime	*[minutes]*				
Withdrawing conversion losses	*[%]*				
Injecting conversion losses	*[%]*				
Through-Put *	*[MWh]*				
Response Rate(s)	*[MW/min]*				
Start-up Notification Time	*[minutes]*				
Maximum Stops per Day	*[n]*				

(*) Parameters not included in 5/5/17 MIWG presentation.

Key

Existing Parameter

Additional Storage Parameter

New Parameters Definitions

- **Transition Time:** Minimum time that a resource requires to switch between injection/withdrawal states
- **Minimum Load:** Minimum withdrawal level at which the resource can operate
- **Upper Charge Limit:** Maximum quantity of energy that the resource can store
- **Lower Charge Limit:** Minimum quantity of energy that the resource must maintain

New Parameters Definitions (con't.)

- **Maximum energy charge rate (Max. Load):** How quickly the resource can withdraw electricity from the grid
- **Energy level (SoC):** [yes/no] If the resource will allow the NYISO to see its Energy Level (SoC)
- **Minimum charge time:** Minimum time that the resource can receive electricity from the grid
- **Maximum charge time:** Maximum time that the resource can receive electricity from the grid
- **Minimum load:** Minimum MW value that the resources may withdraw from the grid

New Parameters Definitions (con't.)

- **Maximum run time:** Maximum time that the resource can inject electricity onto the grid
- **Withdrawing conversion losses:** Conversion losses of the resource when charging
- **Injecting conversion losses:** Conversion losses of the resource when discharging
- **Start-up load cost:** The payment a resource requires to bring its unit to its minimum charging level from an offline or injecting state

New Parameters Definitions (con't.)

- **Track 2 of the Market Design (Energy Storage Optimization) will also consider the following parameters :**
  - Beginning State of Charge: Level of energy the resource desires at the beginning of the interval with an associated cost for deviations
  - Ending State of Charge: Level of energy the resource desires by the end of the interval with an associated cost for deviations
  - Through-put: How much energy the resource is able to inject into the grid on a 24-hour period

Feedback Received

- **Stakeholders have raised interest in the following items:**
  - Allow for a continuous bid from Max. Load to UOL
  - Roundtrip efficiency should be considered both when charging and discharging
  - Energy level (SoC) management should be optional
  - Allow resources to leverage price variations across 5-minute intervals
  - Consider a variable to capture total energy injected (Through-put)
- **Items that the NYISO proposes not to pursue as part of this effort:**
  - The number of cycles[ii] should be optional, or controlled by the resource owner
  - ESRs that are in front of a customer meter, and not serving Load at a facility will not be part of the NYISO's Pilot Project Program
    - Energy Storage Resources that are behind-the-meter may be part of a Pilot Project aggregation

ii. Number of cycles per interval: The maximum number of times that the Storage resource can go through full Upper-Lower charge limits cycles in an interval (Not part of this proposal)

Phase 1 Integration and Scheduling logic

Eligibility Criteria for Energy Storage Resources

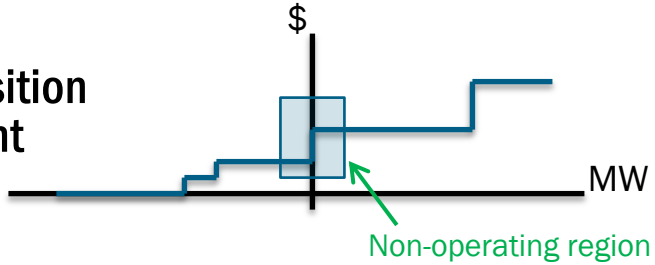
- **The initial phase of this program is targeted to enhance the integration of resources with a minimum output of 1 MW.**
  - The NYISO will allow bids in 0.1 MW increments above 1 MW, just as for other resources.
- **The NYISO proposes a minimum storage capability of 1 MWh (Upper Charge Limit – Lower Charge Limit).**
  - ESRs with a minimum energy storage capability of less than 1 MWh will be considered in the DER Roadmap effort.

Energy Storage Integration– Constrained Energy Level Scheduling

- The Energy Storage Integration project will develop a scheduling logic for ESRs in real-time based on their incremental energy bids, and additional operational characteristics.
  - This approach is consistent with the current optimization logic for generators, which minimizes total production cost, while honoring transmission system and resources' limitations.
- As part of this phase, ESRs Energy level will be considered as an additional constraint when scheduling the resource, rather than a variable. There will be no Energy Level optimization.

Proposed considerations for commitment decisions

- If the resource has a non-operating region and/or a transition time, then injecting, withdrawing, and idle will be different operating states.
  - Changes in operating state will be made in RTC.
  - The resource must be able to maintain each state for at least 15 minutes.
- If the resource does not have a non-operating region, or a transition time, RTD will have the capability to dispatch the resource through the full operating range (*i.e.* injecting/withdrawing).
- To the extent that commitment parameters are associated with scheduling the resource, the state of the resource will have to be assigned by RTC.



Proposed considerations for commitment decisions

- **Commitment parameters include:**
  - Transition Time
  - Min. Load – Min. Gen
  - Min. – Max. Run Time
  - Min. – Max. Charge Time
  - Start-up Costs
  - Start-up Notification Time

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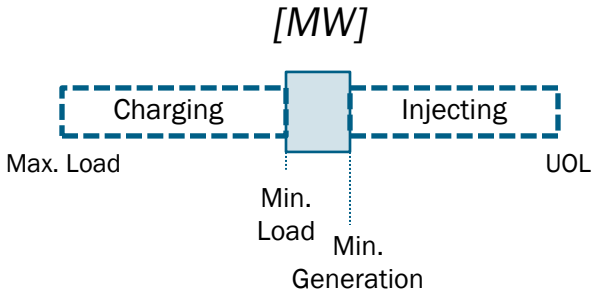
Energy level in RT

- **The NYISO proposes to allow resources to decide whether they want to provide Energy level telemetry.**
  - If the resource provides Energy level signal, then the NYISO will consider the energy level of the resource in real-time, and avoid scheduling it beyond the Upper and Lower Charge Limits.
  - If the resource decides not to provide Energy level signal, then it will be responsible for managing its energy level.

Charging and Discharging rates

- **The NYISO intends to apply existing parameters to energy storage resources where possible.**
  - The maximum discharging rate is equivalent to UOL.
  - The minimum discharging rate is equivalent to Minimum Generation.
- **Two additional bidding parameters will be created to capture the withdrawing capabilities of the resource: Minimum and Maximum Load.**

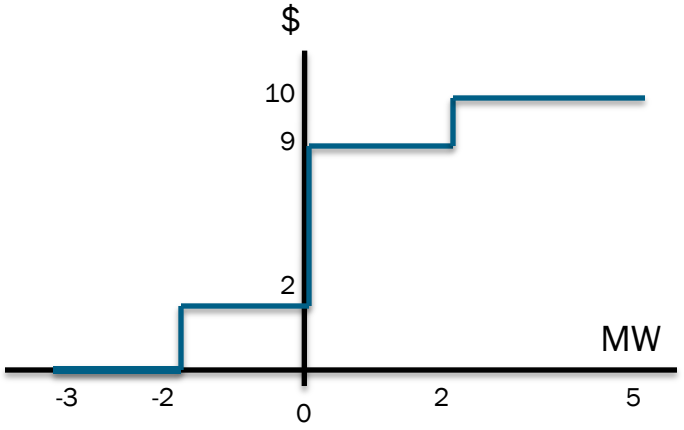


Other considerations

- The NYISO intends to implement a single ramp value for both charging and discharging.
  - *Feedback is requested on whether to allow different ramp values for charging and discharging states.*

Examples

- The examples will use the following format and bid curve
- Ramp constraints and start-up costs will not be considered (Lithium-ion battery, for example)
- Resources will be providing energy only



Bid Curve	
MW	Value
-2	0
0	2
2	9
5	10

Parameters	*Units*	*Value*
UOL	MW	5
Max. Load	MW	-3
Transition Time	Min	5
Min. Load	MW	-1
Min. Generation	MW	1
Withdrawing losses	%	4%
Injecting losses	%	4%
Energy Level (SoC)	-	Yes
Upper Charge Limit	MWh	5
Lower Charge Limit	MWh	0.5
Charge Rate	MW	-3
Discharge Rate	MW	5
Min. Charge Time	Min	0
Max. Charge Time	Min	300
Min. Run Time	Min	0
Max. Run Time	Min	500

Values will change through the examples.

Example 1

Parameters	*Units*	*Value*
UOL	MW	5
Max. Load	MW	-3
Transition Time	Min	5
Min. Load	MW	-1
Min. Generation	MW	1
Withdrawing losses	%	4%
Injecting losses	%	4%
Energy Level (SoC)	-	Yes
Upper Charge Limit	MWh	5
Lower Charge Limit	MWh	0.5
Charge Rate	MW	-3
Discharge Rate	MW	5
Min. Charge Time	Min	0
Max. Charge Time	Min	240
Min. Run Time	Min	0
Max. Run Time	Min	500

Bid Curve	
MW	Value
-2	0
0	2
2	9
5	10

- Since the resource has a non-operating region, it will be committed by RTC. Therefore, the minimum state duration will be 15 minutes (1 RTC interval). It will be committed by RTC.
- The resource is providing an Energy level signal.
- Assume Min. Load and Min. Generation costs are low enough for the resource to be scheduled.

Example 1

RTC	LBMP [USD]	Optimal Dispatch [MW]	Actual Dispatch [MW]	Total withdrawing [MWh]	Total injecting [MWh]	Energy level [MWh]
t-1	-	-	-	-	-	1.50
0:00	-1.00	-3.0	-3.0	-0.7	0.0	2.22
0:15	3.00	0.0	0.0	0.0	0.0	2.22
0:30	4.00	0.0	0.0	0.0	0.0	2.22
0:45	7.00	0.0	0.0	0.0	0.0	2.22
1:00	10.00	5.0	2.1	0.0	0.5	1.72
1:15	12.00	5.0	5.0	0.0	1.2	0.52
1:30	9.00	2.0	0.0	0.0	0.0	0.52
1:45	8.00	0.0	0.0	0.0	0.0	0.52
2:00	7.00	0.0	0.0	0.0	0.0	0.52
2:15	6.00	0.0	0.0	0.0	0.0	0.52

- Because the resource is providing an Energy level signal, RTC will honor the Upper and Lower charge limits.

Example 2

Parameters	*Units*	*Value*
UOL	MW	5
Max. Load	MW	-3
Transition Time	Min	0
Min. Load	MW	0
Min. Generation	MW	0
Withdrawing losses	%	4%
Injecting losses	%	4%
Energy Level (SoC)	-	No
Upper Charge Limit	MWh	5
Lower Charge Limit	MWh	0.5
Charge Rate	MW	-3
Discharge Rate	MW	5
Min. Charge Time	Min	0
Max. Charge Time	Min	-
Min. Run Time	Min	0
Max. Run Time	Min	-

Bid Curve	
MW	Value
-2	0
0	2
2	9
5	10

- Since the resource does not have a non-operating region, it can be fully dispatched by RTD (injecting/withdrawing).
- The resource does not provide an Energy level signal. Therefore, the Upper and Lower Charge Limits will not be honored by RTD.

Example 2

RTC	RTD	LBMP [USD]	Optimal Dispatch [MW]	Actual Dispatch [MW]	Total withdrawing [MWh]	Total injecting [MWh]	Energy level [MWh]
	t-1	-	-	-	-	-	1.50
1	0:00	-1.00	-3.0	-3.0	-0.2	0.0	1.74
	0:05	-1.00	-3.0	-3.0	-0.2	0.0	1.98
	0:10	2.00	0.0	0.0	0.0	0.0	1.98
2	0:15	3.00	0.0	0.0	0.0	0.0	1.98
	0:20	4.00	0.0	0.0	0.0	0.0	1.98
	0:25	7.00	0.0	0.0	0.0	0.0	1.98
3	0:30	10.00	5.0	5.0	0.0	0.4	1.58
	0:35	12.00	5.0	5.0	0.0	0.4	1.18
	0:45	11.00	5.0	5.0	0.0	0.4	0.78
4	0:50	9.00	2.0	2.0	0.0	0.2	0.62
	0:55	7.00	0.0	0.0	0.0	0.0	0.62
	1:00	5.00	0.0	0.0	0.0	0.0	0.62

- The resource is fully dispatchable and can leverage price variations across 5-minute intervals.

Example 3

Parameters	*Units*	*Value*
UOL	MW	5
Max. Load	MW	-3
Transition Time	Min	0
Min. Load	MW	0
Min. Generation	MW	0
Withdrawing losses	%	4%
Injecting losses	%	4%
Energy Level (SoC)	-	Yes
Upper Charge Limit	MWh	5
Lower Charge Limit	MWh	0.5
Charge Rate	MW	-3
Discharge Rate	MW	5
Min. Charge Time	Min	0
Max. Charge Time	Min	-
Min. Run Time	Min	0
Max. Run Time	Min	-

Bid Curve	
MW	Value
-2	0
0	2
2	9
5	10

- The resource is providing an Energy level signal, and it is RTD-dispatchable for injecting and withdrawing.

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Example 3

RTC	RTD	LBMP [USD]	Optimal Dispatch [MW]	Actual Dispatch [MW]	Total withdrawing [MWh]	Total injecting [MWh]	Energy level [MWh]
	t-1	-	-	-	-	-	0.50
	0:00	-1.00	-3.0	-3.0	-0.2	0.0	0.74
1	0:05	-1.00	-3.0	-3.0	-0.2	0.0	0.98
	0:10	2.00	0.0	0.0	0.0	0.0	0.98
	0:15	3.00	0.0	0.0	0.0	0.0	0.98
2	0:20	4.00	0.0	0.0	0.0	0.0	0.98
	0:25	7.00	0.0	0.0	0.0	0.0	0.98
	0:30	10.00	5.0	0.0	0.0	0.0	0.98
3	0:35	12.00	5.0	5.0	0.0	0.4	0.58
	0:45	11.00	5.0	1.0	0.0	0.1	0.50
	0:50	9.00	2.0	0.0	0.0	0.0	0.50
4	0:55	7.00	0.0	0.0	0.0	0.0	0.50
	1:00	5.00	0.0	0.0	0.0	0.0	0.50

- The resource is providing an Energy level signal, and it reaches the lower charge limit during the hour considered.

Example 4

Parameters	*Units*	*Value*
UOL	MW	5
Max. Load	MW	-3
Transition Time	Min	5
Min. Load	MW	-1
Min. Generation	MW	1
Withdrawing losses	%	4%
Injecting losses	%	4%
Energy Level (SoC)	-	Yes
Upper Charge Limit	MWh	5
Lower Charge Limit	MWh	0.5
Charge Rate	MW	-3
Discharge Rate	MW	5
Min. Charge Time	Min	30
Max. Charge Time	Min	240
Min. Run Time	Min	30
Max. Run Time	Min	500

Bid Curve	
MW	Value
-2	0
0	2
2	9
5	10

- The resource is RTC-committed and has Minimum and Maximum Charge Times.
- Assume Min. Load and Min. Generation costs are low enough for the resource to be scheduled if the incremental bid is selected.

Example 4

RTC	LBMP [USD]	Optimal Dispatch [MW]	Actual Dispatch [MW]	Total withdrawing [MWh]	Total injecting [MWh]	Energy level [MWh]
t-1	-	-	-	-	-	2.50
0:00	-1.00	-3.0	0.0	0.0	0.0	2.50
0:15	3.00	0.0	0.0	0.0	0.0	2.50
0:30	4.00	0.0	0.0	0.0	0.0	2.50
0:45	7.00	0.0	0.0	0.0	0.0	2.50
1:00	10.00	5.0	3.3	0.0	0.8	1.71
1:15	12.00	5.0	5.0	0.0	1.2	0.51
1:30	9.00	2.0	0.0	0.0	0.0	0.51
1:45	8.00	0.0	0.0	0.0	0.0	0.51
2:00	7.00	0.0	0.0	0.0	0.0	0.51
2:15	6.00	0.0	0.0	0.0	0.0	0.51

- Based on the projected LBMPs the resource is not economically selected for a period long enough to honor its minimum charge time. Therefore, the resource is not scheduled to withdraw energy from the grid.

Next Steps

- The NYISO intends to discuss the DA scheduling and Settlements logic with Stakeholders in August 24, 2017.
- The NYISO will continue to explore operational enhancements that may improve the integration of storage resources.

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Feedback

- The NYISO seeks feedback on the materials presented today
- Email additional feedback to: Daniel F. Noriega dnoriega@nyiso.com

Questions?

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

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