Energy Storage Integration: Market Design Concept Proposal

A Report by the
New York Independent System Operator

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Executive Summary

Energy Storage Resources (ESRs) will provide significant system and market benefits to the New York Independent System Operator, Inc. (NYISO) administered wholesale markets over the coming decades. To realize those benefits the NYISO will need to reduce barriers to entry for those resources. As indicated in *The State of Storage: Energy Storage Resources in New York's Wholesale Electricity Markets,*[1] the NYISO has begun a multi-year effort to develop a new participation model specifically for ESRs that provide greater opportunity for ESRs to participate in the wholesale markets. The first phase of this multi-year effort, the *Energy Storage Integration* project, will establish participation rules for ESRs in the NYISO's Energy, Ancillary Service, and Capacity markets. It is anticipated that the market rule and software changes necessary to implement the *Energy Storage Integration* project will be completed in 2020.

This comprehensive Market Design Concept Proposal was developed with the help of stakeholders throughout 2017, and explains the NYISO's proposals related to: (i) minimum eligibility requirements, (ii) aggregation eligibility requirements, (iii) registration and offer parameters, (iv) scheduling logic, (v) settlements logic, and (vi) mitigation framework. Specifically, the NYISO proposes to:

(i) Require that ESRs be capable of providing a minimum power output of one tenth of one megawatt (0.1 MW), and a minimum energy output of one tenth of one megawatt-hour (0.1 MWh) in order to be eligible to provide Energy, Ancillary Services, and Capacity in the NYISO-administered wholesale markets;

(ii) Permit ESRs of any size that are located behind the same transmission node to participate as an aggregation with a single PTID; aggregations must meet the same participation requirements that apply to non-aggregated ESRs;

(iii) Establish new registration and offer parameters that recognize the unique attributes of ESRs, such as their ability to withdraw energy;

(iv) Modify the NYISO's optimization software to use the proposed registration and offer parameters;

(v) Establish settlements rules, including revised Day-Ahead Margin Assurance Payment (DAMAP) requirements and Bid-Production Cost Guarantee (BPCG) provisions; and

(vi) Provide energy market mitigation rules.

This report also identifies market design topics that will be discussed further in 2018, such as Energy market mitigation rules, Capacity market obligations, additional Ancillary Services provisions, and guidelines for the simultaneous participation in NYISO-administered wholesale markets and a retail-level program or market ("dual participation").

[1] New York Indep. Sys. Operator, Inc., The State of Storage: Energy Storage Resources in New York's Wholesale Electricity Markets. December, 2017. Recovered from http://www.nyiso.com/public/webdocs/markets_operations/documents/Studies_and_Reports/Studies/Market_Studies/State_of_Storage_Report_Final_1Dec2017.pdf on Dec. 12, 2017.

Project Description

Although certain types of ESRs can participate in the NYISO-administered wholesale markets today, existing market products offer limited opportunities to provide Energy and Ancillary Services, which is inconsistent with the NYISO's goal to integrate the full range of storage resources into the wholesale markets. Existing programs also do not account for operating constraints that have important performance implications for ESRs, such as Upper Storage Limit, Minimum Load level, and Transition Time.

To address these shortcomings, the NYISO, as part of its *Energy Storage Integration* project, is developing a participation model that will better enable the NYISO to economically schedule eligible ESRs for Energy, Capacity, and Ancillary Services in NYISO-administered wholesale markets.

Participation Model Criteria

Operating States

ESRs are capable of either supplying energy to the grid ("injecting") or removing energy from the grid ("withdrawing").[2] They may also remain online between charge and discharge cycles in a neutral state ("idle"). Consistent with previous stakeholder discussions,[3] these operating states will be defined within the participation model as injecting, withdrawing and idling, respectively.

Resource Eligibility

The NYISO proposes to decrease the established minimum energy supply offer threshold from 1 MW to 0.1 MW for ESRs and ESR Aggregations ("Assets"). This proposal is consistent with the Federal Energy Regulatory Commission's (FERC) November 2016 Notice of Proposed Rulemaking,[4] and the NYISO's DER Roadmap proposal. Assets will also be required to have a storage capacity of at least 0.1 MWh of energy.

As part of both the *Energy Storage Integration* and DER Roadmap efforts, the NYISO is evaluating the need for, and content of, rules to integrate single resources or ESR and DER aggregations with minimum offers of less than one megawatt (1 MW). As more Assets interconnect to the bulk electric system, the complexity of the market optimization will grow. This could increase the calculation time required by the

[2] International Energy Agency, iea. Energy Storage Technology Roadmap – Technology Annex. March 19, 2014. Recovered from https://www.iea.org/media/freepublications/technologyroadmaps/AnnexA_TechnologyAnnexforweb.pdf on Dec. 12, 2017.

[3] Noriega, Daniel F. "Energy Storage Integration – Settlements". PowerPoint for Market Issues Working Group, Rensselaer, New York, August 25, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-08-25/agenda%207%20Energy%20Storage%20I%200.pdf on Dec. 12, 2017.

[4] Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, Notice of Proposed Rulemaking, 81 Fed. Reg. 86522 (Nov. 30 2016).

market software, resulting in late or incorrect postings of Day-Ahead (DA) and Real-Time (RT) schedules. To mitigate this risk, the NYISO proposes that Assets offering less than 1 MW will not be eligible to provide ancillary services at this time. The NYISO will continue to test the market software and develop approaches to minimize software constraints with the goal of enhancing market participation opportunities in the future.

ESR Aggregations

The NYISO proposes to allow ESRs to aggregate.[5] To participate in NYISO-administered wholesale markets, ESR aggregations will be required to meet all of the eligibility criteria that apply to non-aggregated ESRs. For example, to qualify to participate, an ESR aggregation must have a minimum offer of 0.1 MW and a minimum energy storage size of 0.1 MWh.

Aggregations

Eligibility to enroll under this proposed participation model is limited to aggregations comprised solely of storage resources. The NYISO will continue to develop aggregation requirements that will apply to all aggregations, independent of their resource classification, as part of the NYISO's DER Roadmap effort.

Summary of Aggregation Requirements Currently Proposed as Part of the NYISO's DER Roadmap Project:

1) The minimum aggregation size eligible to participate in the NYISO wholesale energy and ancillary services markets is 0.1 MW. Individual resources in the aggregation must have an output capability no greater than 20 MW.
2) All individual resources in an aggregation must be mapped to the same electrically appropriate sub-zonal transmission node.
3) Aggregations with an output capability of at least 1 MW can offer energy, ancillary services and capacity products.
4) Aggregations below 1 MW of capability can only offer energy and capacity.
5) Aggregations will be required to meet the same metering, telemetry and bidding obligations as individual resources.

ESR aggregations will be considered as a single "resource" by the NYISO, and will be modeled as a single PTID for the exchange of telemetry and dispatch signals. Aggregators will be responsible for accurately representing their aggregate operating characteristics, responding to NYISO-provided dispatch instructions, and managing the performance of their aggregation. Failure to provide accurate operating parameters or respond to dispatch instructions could put the reliability of the bulk electric system at risk,

[5] Noriega, Daniel F. "Energy Storage Integration: Aggregations". PowerPoint for Market Issues Working Group, Rensselaer, New York, November 2, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-11-02/Energy%20Storage%20I%200%20MIWG%2017%2011%2002.pdf on Dec. 12, 2017.

and the NYISO intends to impose penalties under certain conditions if the Assets misrepresent their capabilities or fail to respond to NYISO-provided signals. Any penalties would be similar to those currently applicable to Generators for similar conduct.

Except for large-scale renewable facilities co-located with ESRs, aggregations of ESRs with other resource types (*e.g.,* Demand Side Resources, or residential solar panels) will be permitted and is being evaluated as part of the NYISO's DER Roadmap effort. Heterogeneous aggregations of ESRs with other resource types will be ineligible for the ESR participation model proposed in this report. The NYISO's aggregation concepts currently limit the maximum individual resource size to 20 MW of injection capability, therefore aggregating large renewable generators with storage may not fit in that participation model. The NYISO intends to address market rules for combinations of large-scale renewables and ESRs as part of the third phase of the NYISO's ESR effort called *Renewable and Storage Aggregation*.

Scheduling Parameters

Resources participating in the NYISO-administered wholesale markets are scheduled to provide services at the lowest cost to meet system needs. As part of the scheduling process, information supplied by Market Participants (MPs) that are managing ESR offers is necessary. The NYISO proposes that all existing scheduling parameters currently supplied by MPs be carried over into the ESR participation model. Generators are currently able to submit the following energy market commitment and bid data:

- Upper Operating Limit (UOL) for normal and emergency situations (MW)
- Minimum Generation rate
- Minimum Generation Cost (MW and $)
- Minimum Run Time (h)
- Minimum Down Time (h)
- Maximum Stops per Day
- Start-up Time (h) and Start-up Cost ($)
- Incremental Bid Curve ($/MW)
- Response Rates (MW/min)
- Market Choice: Day-Ahead Market (DAM), Real-Time Market (RTM), or both
- Fuel Type
- Burdened Fuel Price ($/mmBTU, optional)
- Operating Mode
- Bid date and number of hours offer pertains to
- Offer expiration date and time (DAM only)

Whereas scheduling parameters are submitted to the NYISO with each bid, registration parameters are operating characteristics that generators provide when registering to participate in NYISO-administered wholesale markets, and can only be changed thereafter by the NYISO upon request, pending verification.

In contrast, commitment parameters (non-time varying offer attributes), and Bid specifications (time varying offer attributes) may be changed by MPs as necessary. Changes must be validated within the time horizon established by NYISO market rules in order to be considered in the market solution process.[6] The time requirement for validation differs based on the type of parameter and into which market(s) the generator is offering (Day-Ahead Market ("DAM"), Real-Time Market ("RTM"), or both).

A brief explanation of how the NYISO proposes to apply existing offer parameters to Assets in the participation model is provided in Figure 1. Parameters that only the NYISO is authorized to update are marked with an "X" in the "NYISO" column, while commitment parameters and Bid specifications the MP can adjust are marked with an "X" in the "MP" column.

[6] *See,* New York Indep. Sys. Operator, Inc., Market Administration and Control Area Services Tariff §§ 2.18, 4.2 [hereinafter *Services Tariff*].

Figure 1: Existing Scheduling Parameters

Parameter	Unit	Description[7]	Authorized to Update	
			NYISO	MP
Upper Operating Limit (UOL)	MW	Maximum MWs the unit can supply		X
Minimum Generation	MW	Minimum MWs the unit can supply.		X
Minimum Run Time	Hours	Minimum time the unit can inject energy. Taken as a consecutive interval.		X
Minimum Down Time	Hours	The minimum amount of time that the unit, once stopped, must remain off before being committed again.		X
Maximum Stops per Day	Whole Number	The maximum number of times that a unit may be stopped and then started again in a single day. May be submitted either as a single value or as a time-varying curve dependent on how long the unit has been offline.		X
Start-up Notification Time	Hours	How far in advance the unit needs to be made aware of its schedule in order to be prepared to operate at its bid minimum generation or minimum load level, whichever is greater.		X
Start-up Cost	$	Amount of money needed to begin injecting energy from an offline state. Can be submitted as an incremental cost curve.		X
Minimum Generation Cost	$	How much it costs for the unit to remain at its bid minimum injection rate. Is an hourly rate.		X
Incremental Bid Curve	$/MWh	A series of monotonically increasing steps that indicate the quantities of Energy for a given price that an entity is willing to supply to the NYISO. The NYISO proposes that units utilize this mechanism to specify price points for both injecting and withdrawing energy.		X
Response Rates	MW/Min	How quickly the unit can respond to dispatch instructions from the NYISO under various operating conditions.	X	
Market Choice	-	Unit may select whether to offer into the DAM or RTM, or both.		X
Unit Operation	-	Generators may operate in one of four modes: ISO-Committed Flexible, ISO-Committed Fixed, Self-Committed Flexible and Self-Committed Fixed. Details regarding the various bid modes may be found in Section 4 of the NYISO Services Tariff. The NYISO anticipates that all four bid modes will be available in the storage participation model.		X
Fuel Type	-	Optional parameter. Typically used by traditional (fossil-fuel) generators. If no Fuel Type is provided, the NYISO evaluates the bid against the Reference Level for the generator based on its primary Fuel Type. The NYISO is evaluating how, if at all, this functionality will be leveraged for ESRs.		X
Burdened Fuel Price	$/mmBtu	Optional parameter. Typically used by traditional (fossil-fuel) generators. The generator's in-day per unit cost of fuel, including raw fuel price, taxes, and the adder as defined in the Reference Level Software User's Guide. [8] The NYISO is evaluating how, if at all, this functionality will be leveraged for ESRs.		X

[7] Additional detail about Generator Bid Parameters may be found on the NYISO's public website.. New York Indep. Sys. Operator, Inc., Market Participants User's Guide § 7.3 (Nov. 2016), *available at* http://www.nyiso.com/public/webdocs/markets_operations/documents/Manuals_and_Guides/Guides/User_Guides/mpug.pdf.

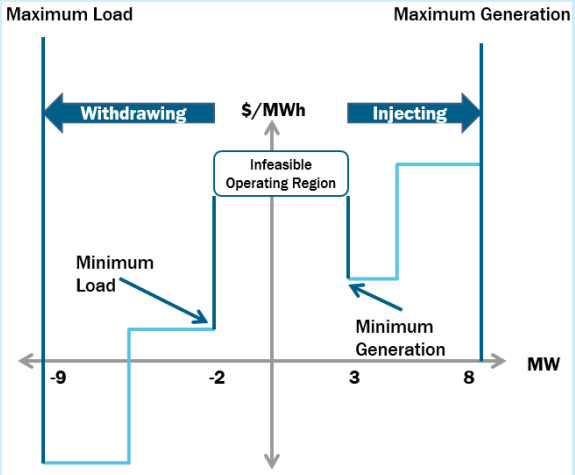
[8] New York Indep. Sys. Operator, Inc., Reference Level Software User's Guide. Recovered from http://www.nyiso.com/public/webdocs/markets_operations/documents/Manuals_and_Guides/Guides/User_Guides/RLS_UG.pdf on Dec. 12, 2017.

Because these generator scheduling parameters do not consider all of the operating characteristics necessary to optimize storage Asset performance, the NYISO proposes to add several new parameters (listed in Figure 2) for ESRs. These parameters are consistent with the FERC's recommendation[9] that the following inputs be required of ESRs (NYISO definitions provided in parentheses): upper charge limit (Upper Storage Limit), lower charge limit (Lower Storage Limit), maximum energy charge rate (Maximum Load), and maximum energy discharge rate (UOL). [10] FERC also proposed to include other optional parameters that the NYISO agrees are beneficial to Asset optimization[11], some of which are already used for traditional generators: minimum charge time (Minimum Withdrawing Time), maximum charge time (Maximum Withdrawing Time), minimum run time (Minimum Run Time), and maximum run time (Maximum Run Time).[12]

The NYISO intends to subject the market optimization software to testing prior to including any new parameters in the NYISO's production software environment in order to determine the cumulative effect of adding these data points on the software's solution time. The NYISO will consider the results of that testing before implementing the full set of offer parameters proposed in this document. The NYISO will further consider input from stakeholders regarding the value of particular parameters in order to ascertain that the complexity introduced provides benefits to those managing storage resources. A discussion of the prospective scheduling parameters follows.

Infeasible Operating Region

If an asset has non-zero Minimum Load and/or Minimum Generation parameters, it has an "Infeasible Operating Region" because its dispatchable range from its Maximum Load to its Upper Operating Limit is not continuous.



Upper and Lower Storage Limits

The daily output of a storage Asset is limited by the amount of potential energy that it can convert to electricity, which is equivalent to the amount of energy

[9] *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Notice of Proposed Rulemaking, 157 FERC ¶ 61,121, Nov. 17, 2016.

[10] *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Notice of Proposed Rulemaking, 157 FERC ¶ 61,121, Nov. 17, 2016.

[11] *Comments of the ISO-RTO Council on the Notice of Proposed Rulemaking Titled* "Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators" From FERC. Doc # RM16-23-000 and AD16-20-000 Feb. 13, 2017.

[12] *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, Notice of Proposed Rulemaking, 157 FERC ¶ 61,121, Nov. 17, 2016.

that it can store less conversion losses. The NYISO proposes to define the maximum energy that an Asset can store as its Upper Storage Limit, and the minimum energy that it can store as its Lower Storage Limit. Traditional generators do not require fuel storage limits to be defined because it is not typically a bidding constraint.

Minimum and Maximum Load

Because the participation model will permit Assets to withdraw energy, the boundaries of the withdrawing state must be specified. Minimum Load is defined as an Asset's lowest withdrawing rate, while Maximum Load is defined as its highest withdrawing rate. These parameters are analogous to UOL and Minimum Generation when injecting energy.

Figure 2: Proposed Scheduling Parameters

Parameter	Unit	Description[13,14]	Authorized to Update	
			NYISO	MP
Upper Storage Limit	MWh	Maximum energy the Asset is willing to store.		X
Lower Storage Limit	MWh	Minimum energy the Asset is willing to store.		X
Minimum Load	MW	Minimum MWs the unit can withdraw.		X
Maximum Load	MW	Maximum MWs the unit can withdraw.		X
Minimum Withdrawing Time	Hours	Minimum time the Asset can withdraw energy. Taken as a consecutive interval.		X
Maximum Withdrawing Time	Hours	Maximum time the Asset can withdraw energy. Taken over an entire operating day.		X
Maximum Run Time	Hours	Maximum time Asset can inject energy. Taken over an entire operating day.		X
Transition Time	Hours	Minimum time required to switch between injecting and withdrawing states.		X
Start Up Load Cost (Start Down Cost)	$	Amount of money needed to begin withdrawing energy from an offline state. Can be submitted as an incremental cost curve.		X
Minimum Load Cost	$	How much it costs to remain at minimum load rate. Is an hourly rate.		X
Additional Response Rate(s)	MW/min	How quickly the Asset can respond to NYISO-given signals under specific conditions. The need for new response rates is still being evaluated.	X	
Withdrawing Conversion Losses	%	Used to determine the round trip efficiency and monitor the Energy Level of the resource when it is withdrawing energy.	X	
Injecting Conversion Losses	%	Used to determine the round trip efficiency and monitor the Energy Level of the resource when it is injecting energy.	X	
Throughput	MWh/day	How much energy the Asset is willing to inject on a daily basis.		X
Energy Level/State of Charge Flag	Yes/No	Does the Asset want to exchange an energy level signal with the NYISO? If yes, the NYISO will honor its Upper and Lower Storage Limits. The FERC calls energy level "State of Charge" (SoC).	X	
Beginning Energy Level	MWh	Initial SoC expected for beginning of the day. Parameter for use in the DAM optimization only.		X

[13] Noriega, Daniel F. "Energy Storage Integration and Optimization". PowerPoint for Market Issues Working Group, Rensselaer, New York, May 5, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-05-05/2017%2004%2020%20Energy%20Storage%20I%200%20MIWG%202017%2005%2005.pdf on Dec. 12, 2017.

[14] Noriega, Daniel F. "Energy Storage Integration – Scheduling Logic". PowerPoint for Market Issues Working Group, Rensselaer, New York, July 19, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-07-19/Energy%20Storage%20I-0%20(MIWG%2017%2007%2019).pdf on Dec. 12, 2017.

Maximum Run Time, Minimum Withdrawing Time, and Maximum Withdrawing Time

Storage Assets require scheduling flexibility because their potential run times are dependent on other parameters like UOL and Upper Storage Limit. Minimum Run Time is used by traditional generators and will also be offered in the new participation model.[15] In recognition of these dependencies, the NYISO proposes to introduce three new parameters: Maximum Run Time, Minimum Withdrawing Time, and Maximum Withdrawing Time. Maximum Run Time is defined as the maximum duration for which an Asset can inject energy. This could be driven by physical constraints such as thermal limits or maximum number of cycles. Similarly, Assets would be able to specify both a Minimum Withdrawing Time and a Maximum Withdrawing Time.

Transition Time

The amount of time required to shift from withdrawing to injecting and from injecting to withdrawing must be defined to ensure that the NYISO can schedule Assets according to physical constraints. The NYISO recognizes that different technologies could have significantly different transition capabilities. In the event that an Asset requires a different amount of time to transition from withdrawing to injecting than it does to transition from injecting to withdrawing, the MP will submit whichever is greater.

Start-up Load Cost

Certain marginal costs incurred by traditional generators upon start-up cannot be included in its incremental energy Bid curve. The amount of money needed for a generator to move from an offline state to its Minimum Generation level is captured in the Start-up Cost parameter. ESRs will be permitted to bid Start-up Costs, but they may also have costs when moved from an offline state to Minimum Load. These "start-down" costs are not reflected in the incremental energy Bid curve. The Start-up Load Cost parameter will allow Assets to inform the NYISO of marginal withdrawing commitment costs.

Minimum Load Cost

The Minimum Load Cost represents the amount of money required for an Asset to maintain its Minimum Load rate, on an hourly basis. A Minimum Load Cost when withdrawing is analogous to a Minimum Generation Cost when injecting.

Additional Response Rate(s)

The NYISO requires generators to submit a series of response rates that correspond to various injecting scenarios. Some define how quickly the generator can respond to the NYISO's dispatch

[15] For the real-time market, the NYISO will continue to model Minimum Run Times of greater than 1 hour as 1 hour. *See Services Tariff* § 4.4.1.4.

instructions under normal operating conditions, while others define how quickly the generator can respond to signals for reserves or regulation. The NYISO proposes that the three normal response rates available to generators to describe their ability to respond to NYISO-given instructions while injecting be extended to storage Assets. Assets in the participation model would be permitted to provide three normal response rates across their full range of capabilities, including their withdrawing and injecting states.

The NYISO recognizes that additional parameters may be desired to define the response rate(s) of storage Assets while injecting or withdrawing energy and will consider revising response rate parameters to accommodate such needs in the future.

Conversion Losses

A fraction of energy is always lost when energy is converted from one state to another. For example, when a lithium ion battery is discharged, most of its chemical potential is converted to electricity, some is converted to heat, and some is dissipated irreversibly as entropy. To maintain reliability and accurately optimize the performance of the grid, the NYISO must account for conversion losses when estimating the amount of energy that Assets will exchange in the wholesale markets. Because the efficiency of withdrawing and injecting conversion processes can be significantly different, the NYISO proposes to employ two distinct parameters to describe conversion losses: Withdrawing Conversion Losses and Injecting Conversion Losses.

Throughput

The NYISO proposes to add a "Throughput" registration parameter to capture the maximum amount of energy that an Asset can inject, per day. This parameter would help MPs to manage the long-term degradation of their Assets by limiting total daily energy output. For example, if an Asset were to specify a Throughput value equal to its Upper Storage Limit, it would not be scheduled to discharge more than one full cycle per day.

Energy Level/State of Charge Flag

The NYISO proposes the introduction of a yes/no Energy Level or SoC "flag" that will allow Assets with a minimum capability of 1MW/1MWh to indicate whether they wish to exchange SoC telemetry with the NYISO in RT.[16] If "yes" is selected, the NYISO will use SoC data provided by the Asset to honor the Asset's Lower and Upper Storage limits. If "no" is selected, the NYISO will be unable to ensure that the Asset is

[16] Noriega, Daniel F. "Energy Storage Integration: Aggregations". PowerPoint for Market Issues Working Group, Rensselaer, New York, November 2, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-11-02/Energy%20Storage%20I%200%20MIWG%2017%2011%2002.pdf on Dec. 12, 2017.

dispatched within its SoC limits. MPs that elect to disable the SoC flag will need to monitor and modify their offers in the RTM to avoid exceeding operating limits.

Beginning Energy Level

Beginning Energy Level is proposed as an optional parameter to be used only in the DAM optimization. It represents the SoC that an Asset expects to achieve prior to the start of the following day. This parameter may improve convergence between DA and RT schedules, because it will enable Assets to select their anticipated initial SoC, which will better align DA Energy Level forecasts with RT conditions. [17]

When an Asset chooses not to provide a Beginning Energy Level value, the NYISO will assign one. The NYISO is currently evaluating several methods that could be used to select Beginning Energy Level values. For example, the market software could be used to set the Beginning Energy Level to a value that falls within an Asset's storage constraints (*i.e.,* Upper and Lower Storage Limits) and minimizes total production cost. Alternatively, the NYISO could default to the Asset's Lower or Upper Storage Limit, or assume an initial SoC of zero.

SoC Management

Storage Assets may wish to have their SoC optimized by the NYISO's market software. SoC management could be partially implemented in the DAM with the addition of an Ending Energy Level parameter. Ending Energy Level would specify an Asset's desired SoC for the end of the DAM optimization day.

Ending Energy Level will not initially be available as an offer parameter in the participation model of this Phase 1 *Energy Storage Integration* project because SoC optimization is expected to significantly increase the complexity of the market software's solution algorithm. The NYISO is considering ways to efficiently incorporate this and other ESR modeling enhancements into the market software. The framework of the participation model will continue to evolve in future years, and may eventually include the development of energy level-based scheduling logic. The NYISO will begin to develop this logic as part of phase 2 of the Energy Storage market design project: *Energy Storage Optimization.*

Incremental Bid Curve for Storage Resources

A single incremental Bid curve enables generators to submit a series of up to 11 monotonically increasing price points at which they would be willing to supply Energy or Ancillary Services. The NYISO

[17] Pacific Gas and Electric Company. Energy Storage For Market Operations. Electric Program Investment Charge (EPIC). Pacific Gas and Electric Company, 2016. Recovered from https://www.pge.com/pge_global/common/pdfs/about-pge/environment/what-we-are-doing/electric-program-investment-charge/PGE-EPIC-Project-1.01.pdf on Dec. 12, 2017.

proposes that a single incremental Bid curve consisting a series of up to 11 monotonically increasing price point spanning the entire operating range of an Asset (withdrawing and injecting) be used for each offer period in both the DAM and RTM. In 2018, participation model prototypes will be used to test the viability of this proposal. The NYISO will monitor the market and solution algorithm outcomes that result from simulations in which Assets offer price points for both withdrawing and injecting during the same Bid intervals.

Scheduling Logic

The NYISO does not intend to significantly modify the existing market optimization software to integrate the ESR participation model, and instead plans to craft the participation model to blend into existing scheduling framework of both the DAM and RTM.

Day-Ahead Scheduling Logic

The NYISO's DAM optimization produces schedules for resources on an hourly interval basis. The NYISO proposes that, like all other suppliers, Assets in this participation model receive a schedule for a single withdrawing, injecting, offline, or idling set point for each hour in the DAM. [18]

The NYISO further proposes that time-based offer parameters that were provided in sub-hourly increments be rounded to the nearest hour that would prevent physical constraints from being violated. As proposed, an Asset with a Transition Time of 0.7 hours will receive at least one full hour to transition in the DAM optimization. Similarly, an Asset with a Maximum Run Time of 2.5 hours will be scheduled to operate for a maximum of two hours. Energy offers will not be permitted to exceed the maximum hourly injecting capability. For example, an Asset with Injecting Conversion Losses of zero percent, an Upper Storage Limit of five MWh and a Lower Storage Limit of one MWh will never receive an hourly energy award of more than four MWh.

To avoid introducing unnecessary complexity to the market optimization algorithm, the DAM software will assume that Energy Levels remain constant between unscheduled intervals. This will not prohibit an Asset from offering capabilities in RT that the Asset was not scheduled to provide in the DAM. As an example, suppose that the DA market software has calculated that an Asset will have a storage capacity of twelve MWh at the end of Hour-Beginning (HB) five. Now, suppose that the same Asset has received no DA award for the hours between HB six and HB ten. As proposed, the NYISO's DAM software will assume that

[18] Noriega, Daniel F. "Energy Storage Integration: DA scheduling and Mitigation". PowerPoint for Market Issues Working Group, Rensselaer, New York, October 3, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-10-03/Energy%20Storage%20I-0.pdf on Dec. 12, 2017.

the Asset still has twelve MWh of energy available at HB eleven. The Asset would be eligible to offer additional services between HB six and HB ten in the RTM. However, the Asset could be penalized if it later failed to honor its original DA schedule as a result of being picked up for additional capabilities in RT.

Real-Time Scheduling Logic

In RT, Assets will be economically scheduled to withdraw or inject energy on a sub-hourly basis by the Real-Time Commitment (RTC) and Real-Time Dispatch (RTD) market optimization tools.[19, 20] Some additional scheduling logic is proposed for storage Assets in the RTM.

RTC evaluates constraints associated with unit commitment parameters such as Maximum Run Time, Transition Time, and Start-up Cost to determine whether a unit is economic and physically available to be committed (turned on). RTD adjusts Base Points on a five-minute basis in response to RT conditions, but cannot commit units or turn them off. If RTC commits an Asset to withdraw, RTD will be unable to change the state of that Asset to idling or injecting.

Assets offering Regulation Services would be scheduled by the Automatic Generation Control (AGC) control program, which sends dispatch signals in RT every six-seconds.

RT-evaluated Assets will be categorized as either "RTC-committed" or "fully dispatchable" resources.[21, 22] RTC-committed resources are Assets that have a transition time to change state from injecting to withdrawing energy, and therefore have commitment parameters associated with their operating characteristics (*i.e.,* time-related constraints, output discontinuities or non-incremental costs).[23] Fully dispatchable resources will represent Assets that can seamlessly transition between injection and withdrawal without any transition time and therefore do not have any commitment restrictions. If an Asset is RTC-committed, it will be assigned a state (injecting, withdrawing, or idle), which will be static for

[19] Noriega, Daniel F. "Energy Storage Integration – Scheduling Logic". PowerPoint for Market Issues Working Group, Rensselaer, New York, July 19, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-07-19/Energy%20Storage%20I-0%20(MIWG%2017%2007%2019).pdf on Dec. 12, 2017.

[20] See, New York Indep. Sys. Operator, Inc., The State of Storage: Energy Storage Resources in New York's Wholesale Electricity Markets at 33 (Dec. 2017), *available at* http://www.nyiso.com/public/webdocs/markets_operations/documents/Studies_and_Reports/Studies/Market_Studies/State_of_Storage_Report_Final_1Dec2017.pdf.

[21] Noriega, Daniel F. "Energy Storage Integration – Scheduling Logic". PowerPoint for Market Issues Working Group, Rensselaer, New York, July 19, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-07-19/Energy%20Storage%20I-0%20(MIWG%2017%2007%2019).pdf on Dec. 12, 2017.

[22] Noriega, Daniel F. "Energy Storage Integration – Settlements". PowerPoint for Market Issues Working Group, Rensselaer, New York, August 25, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-08-25/agenda%207%20Energy%20Storage%20I%200.pdf on Dec. 12, 2017.

[23] Commitment parameters include Transition Time, Minimum Load and/or Generation, Minimum and/or Maximum Run Time, Minimum and/or Maximum Withdrawing Time, Start-up or Start-up Load Costs, and Start-up Notification Time.

at least one RTC interval (15 minutes). On the other hand, if an Asset is fully dispatchable, the Real Time Dispatch software will schedule anywhere within the Asset's injecting or withdrawing operating range. Therefore, fully dispatchable resources could be transitioned from injecting to withdrawing energy on a five-minute basis.

Settlements

The NYISO intends to apply the existing settlements framework used for Generators to Assets, with certain modifications to address the unique characteristics of energy storage.[24] For example, the NYISO intends to settle Assets at nodal market clearing prices like those used to settle generator transactions in the Energy market.[25]

The existing framework, however, may not fully capture the operating characteristics of energy storage. Dispatchable Generators, for example, are eligible to receive "make-whole" payments for operating costs associated with injecting energy that exceed daily LBMP revenues to ensure that generators do not have to operate at a loss when following NYISO instructions. The NYISO proposes that the existing make-whole payment constructs be extended to Assets discharging onto the system. Storage Assets may also require separate make-whole payments while withdrawing, distinguishing them from generators, and therefore, require revision to accommodate ESRs. The new offer parameters proposed for the participation model will need to be reviewed carefully to determine how they may impact Assets' eligibility for make-whole payments.

In 2017, the NYISO discussed guidelines for the following settlements provisions with internal and external stakeholders: penalties for over- and under-generation, Day-Ahead Margin Assurance Payments (DAMAP) and Bid-Production Cost Guarantee (BPCG) payments. [26]

[24] Noriega, Daniel F. "Energy Storage Integration – Settlements". PowerPoint for Market Issues Working Group, Rensselaer, New York, August 25, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-08-25/agenda%207%20Energy%20Storage%20I%200.pdf on Dec. 12, 2017.

[25] The NYISO intends to settle ESR aggregations at prices for intra-zonal Load bus nodes developed in conjunction with the DER Roadmap and Granular Pricing initiatives. See, New York Indep. Sys. Operator, Inc., Distributed Energy Resources Market Design Concept Proposal at 30 (Dec. 14, 2017), *available at* http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-12-19/Distributed%20Energy%20Resources%202017%20Market%20Design%20Concept%20Proposal.pdf. ESRs participating in the market individually will be assigned a PTID and be settled like existing Generators.

[26] Noriega, Daniel F. "Energy Storage Integration – Settlements". PowerPoint for Market Issues Working Group, Rensselaer, New York, August 25, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-08-25/agenda%207%20Energy%20Storage%20I%200.pdf on Dec. 12, 2017.

Penalties for Over- and Under-Generation

Penalties for over- and under-generation are designed to incentivize generators to accurately follow Base Point Signals[27] sent by the NYISO in RT. Under the current NYISO rules, energy providers are expected not to deviate from their Base Point Signal by more than 3% of their UOL. If a generator's actual output deviates from its Base Point Signal by more than 3% of its UOL, the generator is subject to penalties as follows:[28]

> **Scenario 1:** Generator over-generates, exceeding its Base Point Signal by more than 3% of its UOL.
>
> **Penalty:** Generator is compensated for injections up to 3% of its UOL above its original Base Point Signal. Injections above 3% are not compensated.

> **Scenario 2:** Generator under-generates, failing to reach its Base Point Signal by more than 3% of its UOL.
>
> **Penalty:** Generator is compensated for its actual output. Generator incurs a penalty for the difference between its actual output and the lower bound of the 3% band created around the Base Point Signal that the generator received.

Penalties are associated with Base Point Signal deviations of more than 3% of a generator's UOL whether as a result of over- or under-generating. Over-generation penalties are implied because generators are only compensated for the portion of energy that they were scheduled to supply, and must absorb any costs associated with the production of additional energy. Under-generation penalties are tied to the RT cost of Regulation Service.[29]

In the proposed participation model, Assets will also be expected to follow Base Point Signals sent by the NYISO. The NYISO proposes to maintain the existing over- and under-generation penalty structure for injecting states and extend it to withdrawing states. Because the economics of withdrawing states are inverted with respect to injecting states, the sign conventions used in generator settlements logic will need to be reversed to accommodate storage Assets.

Generally, a Base Point Signal deviation of less than 3% of an Asset's UOL when injecting or less than 3% of an Asset's Maximum Load when withdrawing will not incur a penalty. If an Asset under-withdraws,

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[27] Electronic signals sent from the ISO and ultimately received by Generators or Demand Side Resources specifying the scheduled MW output for the Generator. (MST Section 2.2)

[28] The information presented is intended to summarize relevant features of the existing structure. For additional information refer to Section 15.3A. of the NYISO MST.

[29] For additional information on the Under-Generation penalty calculation refer to Appendix I of the NYISO Accounting and Billing Manual. New York Indep. Sys. Operator, Inc., Accounting and Billing Manual § I.7 (Dec. 2016), *available at* http://www.nyiso.com/public/webdocs/markets_operations/documents/Manuals_and_Guides/Manuals/Administrative/acctbillmnl.pdf.

deviating from its Base Point Signal by more than 3% of its Maximum Load, the Asset will be required purchase all of the energy that it was scheduled to withdraw at the settlement LBMP, less 3% of its Maximum Load. This is analogous to not being compensated for extra energy supplied when injecting. If an Asset over-withdraws, deviating from its Base Point by more than 3% of its Maximum Load, the Asset will incur a penalty analogous to that applied to a generator when it under-generates.

In summary, the NYISO envisions that Assets could incur financial penalties for over- or under-withdrawing as part of the participation model. Under-withdrawing will result in an implied penalty, while over-withdrawing will result in a calculated penalty similar to the penalty applied for under-performing generators today. The NYISO will perform a detailed analysis in 2018 to ensure the propriety of adding penalties for withdrawing states to its settlements logic.

Day-Ahead Margin Assurance Payments (DAMAP)

DAMAP are designed to protect generators from economic harm when required by NYISO dispatch to buy out of Day-Ahead schedules at a loss. The NYISO proposes to maintain this construct for injecting states in the participation model, and develop appropriate rules to permit DAMAP compensation for withdrawing states.[30] Eligibility provisions for generators to receive DAMAP payments include:[31]

1) Generators that are dispatched by RTD or available for commitment by RTD may be eligible to receive DAMAP.
2) Generators must not lag behind RTD Base Point Signals such that they would incur a penalty for under-generation.
3) Generators that make changes to their bids which make them less likely to be dispatched in RT as compared to their DA schedule are precluded from receiving DAMAP. Specific causes include, for example, increasing RT Incremental Energy Bids, or RT Start-up costs.

The rationale behind protecting generators' DA margins if dispatched to a lower level in RT stems from the idea that a resource awarded a DA schedule was economically selected to provide a certain product quantity in the NYISO markets and already obtained a margin as a result. Therefore, the resource's margin could be harmed if the resource schedule was decreased in RT inconsistently with its offer (*i.e.,* dispatched down). If the resource was dispatched in RT to a higher output value, then the margin of the resource would presumably be increased as a result, and these positive margins are used to offset losses for other products and for other intervals within the hour.

[30] Noriega, Daniel F. "Energy Storage Integration – Settlements". PowerPoint for Market Issues Working Group, Rensselaer, New York, August 25, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-08-25/agenda%207%20Energy%20Storage%20I%200.pdf on Dec. 12, 2017.

[31] The information presented is intended to summarize relevant features of the existing structures. For additional information refer to Attachment J of the Services Tariff. *Services Tariff* § 25 (Att. J).

The NYISO proposes that the ESR participation model utilize the existing DAMAP construct for injecting states. Additionally, the NYISO proposes that ESRs be eligible for DAMAP if dispatched to a lower withdrawing rate in RT than the withdrawing rate scheduled in the DAM. Permitting Assets to receive DAMAP when withdrawing would protect them from the economic harm that could be incurred if forced to sell out of a DA schedule at a loss due to NYISO dispatch instructions.

In order to remain eligible for DAMAP, Assets must follow RT dispatch signals. Under the NYISO's scheduling proposal, if Assets elect to provide their Energy Level to the NYISO in RT, it will be used to ensure that the Asset's storage limits are not exceeded. As a result, Assets will always receive feasible RT schedules, even in cases where they deviate from their DA schedules. Since the existing DAMAP construct aims to protect resources that could have honored their DA schedule in RT had the NYISO not provided different instructions, the NYISO plans to consider the RT Energy Level information of the Asset to determine if it is eligible for DAMAP in a given hour. If the ESR does not provide an Energy Level signal in RT, it is at risk of receiving a schedule that it would not be able to meet; and not following NYISO instructions in RT would make the resource ineligible for DAMAP.

Bid-Production Cost Guarantee (BPCG) Payments

If a generator is committed by the NYISO but the revenue it receives is insufficient to cover its marginal costs, it may be eligible for a BPCG payment. BPCG ensures that suppliers do not incur a net loss over a commitment day. For example, a generator may have a minimum run time of 12 hours and is the most economic resource for SCUC to commit to meet a reliability need that exists for 10 hours. The generator is marginal and recovers its costs for the ten hours that it is needed to meet the reliability needs but the generator costs are greater than the LBMPs set for the remaining two hours the resource must run to fulfill its minimum run time. The BPCG payment would cover the difference between costs and LBMPs for the two hours where the generator costs where higher than the LBMPs. If the generator was inframarginal during any of the other ten hours, then these revenues would be netting against any losses the generator may have incurred for the remaining two hours..

BPCG allows generators to recover Decremental, Start-up and Minimum Generation costs that are not recovered through the LBMP payment. Storage Assets could be exposed to the same net loss situations as conventional generators. The NYISO therefore proposes that storage Assets be eligible for BPCG if they are committed by the NYISO to inject or withdraw energy.

Mitigation

Under today's market rules, Electric Facilities are monitored to determine whether their conduct could substantially distort competitive market outcomes. If the NYISO determines that an Electric Facility has influenced prices or payment in an uncompetitive manner, that Electric Facility may be subject to mitigation. It is important for the NYISO to maintain robust market mitigation procedures so that all MPs can be monitored fairly, accurately, and efficiently and consumers can be confident that they are paying a fair price for the services purchased. In 2017, the NYISO discussed the conceptual framework for energy market mitigation as it would pertain to the ESR participation model.[32]

Because the participation model would permit Assets to set market clearing prices, the NYISO proposes to extend its energy market mitigation procedures to include storage Assets. As proposed, the NYISO will evaluate storage Assets for both conduct and impact. Conduct and impact evaluations of storage Assets should consider uncompetitive behavior across both injecting and withdrawing states. Mitigation criteria that are inapplicable to generators may be necessary for ESRs to evaluate pricing outcomes and conduct inconsistent with competitive behavior for withdrawing states.

As part of its market mitigation procedures, the NYISO calculates Reference Levels as a proxy for the offers that resources would submit in a competitive market, and compares calculated Reference Level with offers that were actually submitted. The NYISO is required to develop Reference Levels based on a Tariff prescribed hierarchy, which includes Bid, LBMP, and Cost-based Reference Levels. The NYISO processes Reference Levels through its Reference Level Software (RLS), which validates and adjusts proxy costs. The NYISO proposes to use the existing Bid-LBMP-Cost hierarchy in the participation model, and continue to process Reference Levels through the existing Reference Levels System (RLS).

Bid-LBMP-Cost hierarchy

The NYISO is required to develop Reference Levels based on a Tariff prescribed hierarchy. They are:

1. Bid-Based – A 90-day rolling average of accepted bids, with numerous qualifiers detailed in 23.3.1.4.1.1 of the MST Attachment H.
2. LBMP-Based – A 90-day rolling average of LBMP when the unit is operating, with numerous qualifiers detailed in 23.3.1.4.1.2 of the MST Attachment H.
3. Cost-based – A value that represents the operating cost of the Generator defined as defined as the combined cost of fuel, emissions, and operating and maintenance costs.

Mitigation procedures will be developed in detail beginning in 2018. Final mitigation provisions will

[32] Noriega, Daniel F. "Energy Storage Integration: DA scheduling and Mitigation". PowerPoint for Market Issues Working Group, Rensselaer, New York, October 3, 2017. Recovered from: http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-10-03/Energy%20Storage%20I-O.pdf on Dec. 12, 2017.

include stipulations for Assets which might be subject to the Automated Mitigation Procedure (AMP) for market participants located in the highly-constrained New York City area.

Conclusion and Next Steps

The NYISO intends to implement the ESR participation model described in this report in 2020. Over the next three years, market rules and software changes necessary for the participation model described above will be developed. In 2018, the NYISO will continue to develop scheduling, aggregation, mitigation, and settlements rules. The NYISO will also address concepts for supplying ancillary services, dual participation in wholesale and retail markets, and capacity market participation.

NYISO staff have also received a number of inquiries about whether ESRs and other resources will be permitted to participate simultaneously in NYISO-administered wholesale markets and in retail markets or distribution system programs. The highest priority of the NYISO is to maintain the reliability of the grid. To meet that objective, it is critical that the NYISO be able to accurately forecast the supply and demand of electricity over the next five minutes, the next hour, tomorrow, and into the future. If suppliers can meet the NYISO's performance expectations and help maintain system reliability at the wholesale level, while also participating in retail programs, they should be permitted to do so. As part of the DER Roadmap efforts, the NYISO is working with stakeholders to analyze the challenges associated with dual participation and develop the rules that may be necessary to ensure that system reliability is not compromised by any future dual participation models.

To the extent they are capable of reliably providing Capacity market services, storage Assets should not be excluded from participation in the Capacity market. As part of the DER Roadmap and ESR integration plans for 2018, the NYISO is beginning to consider how best to ensure that ESRs value to the bulk electric system is recognized in the Capacity market.

Finally, the NYISO does not plan to eliminate existing market products like ELRs and LESRs with the introduction of a storage participation model.

To conclude, with input from its stakeholders, the NYISO is developing a new participation model for ESRs that is expected to significantly improve the value that ESRs can provide in NYISO-administered wholesale markets. The participation model will more accurately represent Assets' capabilities to withdraw and inject energy, enable ESRs to set clearing prices and be scheduled economically, and maximize their benefits in the wholesale markets so that their full potential can be realized in New York state.