Enabling Resources Program: Storage and Hybrid Integration Project

Settlements

Memo 1.1

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Engagement Topic: Settlements Design Element for Storage Resources

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Purpose

The purpose of this document is to provide information on the IESO's market design work with respect to the Market Settlements design element for the single resource storage participation model. It articulates how the IESO undertook the design and the decisions that are relevant to stakeholders for the enhanced storage participation model.

The IESO will utilize this document and materials from subsequent design phases to support the implementation of the design work for the Storage and Hybrid Integration Project. This will be captured in future changes to Market Rules, Market Manuals, software interfaces with the IESO and internal IESO systems and processes. These external changes will be reviewed for input with stakeholders. Any material changes to this design as a result of implementation discovery will be discussed with stakeholders.

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List of Abbreviations

Abbreviation	Definition
BESS	Battery Energy Storage Systems
CAISO	California ISO
DA	Day-Ahead
DAM	Day-Ahead Market
DAM BC	Day-Ahead Market Balancing Credit
DA LC	Day-Ahead Lost Cost
DAM MWP	Day-Ahead Market Make-Whole Payment
DMSR	Dual Model Storage Resource
DSO	Dispatch Scheduling and Optimization
ELT	Expedited Long-Term
EOP	Economic Operating Point
EMFC	Enhanced Mitigation for Conduct
GOG	Generator Offer Guarantee
IAM	IESO-Administered Market
ISO	Independent System Operator
ISoC	Initial State of Charge
LC	Lost Cost
LMP	Locational Marginal Prices
LOC	Lost Opportunity Cost
LT-1	Long-Term 1
MIM	Market Information Management
MP	Market Participant
MRP	Market Renewal Program
MISO	Midcontinent ISO
MWP	Make-Whole Payment
NYISO	New York ISO
OR	Operating Reserve
PD	Pre-Dispatch
RT	Real-Time
RT LC	Real-Time Lost Cost
RT LOC	Real-Time Lost Opportunity Cost
RT-MIO	Real-Time Multi Interval Optimization
RT MWP	Real-Time Make-Whole Payment
SEAL	Safety, Equipment, and Applicable Law
SoC	State of Charge
SMSR	Single Model Storage Resource
TAOR	Total Accessible Operating Reserve

Background

ERP's Storage and Hybrid Integration Project is focused on developing an enhanced participation model for storage resources and co-located hybrid facilities. During the design phase, the IESO proceeded with the core Optimization element within the Grid and Market Operations module, which is the main precursor to design decisions to support other design modules and elements. The Settlements design module describes the Market Settlement process requirements in the day-ahead market (DAM) and real-time (RT) market for a single model storage resource (SMSR).

Phased Approach

The Storage and Hybrid Integration Project is adopting a phased delivery approach to expedite and prioritize the implementation of essential functionality, including:

- SMSR (battery) with bi-directional offers;
- State of Charge (SoC) Management.

As seen in Figure 1 below, subsequent design phases will implement:

- Regulation service;
- Uplift exemptions;
- Any required enhancement resulting from Phase 1 implementation.

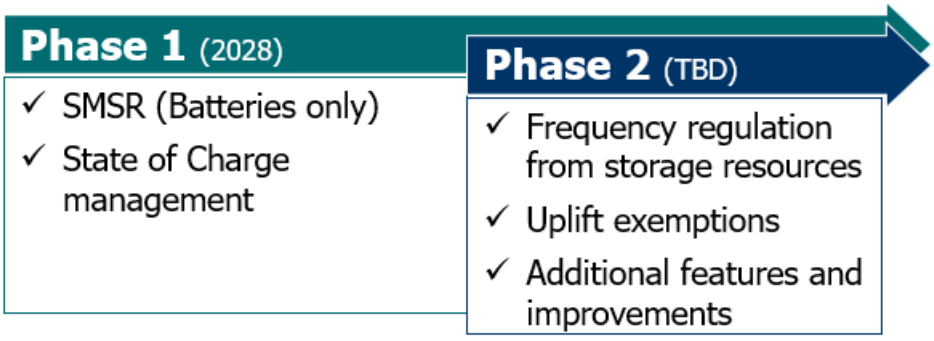


Figure 1: Project Scope

Scope of Settlements Phase 1 Design

For Phase 1 of the enhanced market design, the IESO will focus on Battery Energy Storage Systems (BESS). In subsequent phases, the IESO will consider the applicability of other types of storage technologies and potential nuances that may require additional/different parameters. The scope of design modules and elements for Phase 1 design is depicted in Figure 2 below with this document focusing on Settlements. During Batch 2 Design, the IESO worked on all the relevant design elements in parallel to expedite delivery.

Batch #	Design Module	Design Element
1	Grid and Market Operations	Optimization (Energy & Operating Reserves)
2	Grid and Market Operations	Dispatch data and other inputs
	Grid and Market Operations	Operations Integration
	Connection and Registration	Market Registration
		Connection Assessment and Approval
	Settlements	Market Settlement
	Contracts	Contract Impacts
	Market Power Mitigation (MPM)	Ex-ante, ex-post, settlements mitigation
3	Hybrid	All modules

Figure 2: Design Modules and Elements for Phase 1

The IESO's focus is on single-site dispatchable storage resources. This enhanced market design will support recent storage procurements via Long-Term 1 (LT1) and Expedited Long-Term (ELT) procurements. Some of these BESS facilities have/will have achieved their Commercial Operation Date before the enhanced participation model is live. The Enabling Resources Program (ERP) will require the transition of all dispatchable BESS resources into the SMSR participation model. The details of the transition of these facilities, and resources that currently participate in the IESO-Administered Markets (IAMs) as the dual model storage resource (DMSR) to the single model storage resource (SMSR) will be discussed with stakeholders at a later date.

Design Principles and Methods

Principles

The ERP market design principles guide design decision criteria to verify that the design meets the needs of the IESO and market participants (MPs). These principles were derived from the foundational Market Renewal Program (MRP) and were considered as part of the long-term vision for storage.

- **Efficiency** - Deliver efficient market outcomes to benefit consumers;
- **Competition** - Provide open, fair, non-discriminatory competitive opportunities to enable MPs to meet evolving system needs;
- **Implementation** - Collaborate with our stakeholders to evolve the market in a feasible and practical manner;
- **Certainty** - Maintain enduring market-based mechanisms that send clear, efficient price signals;
- **Transparency** - Accurate, timely and relevant information is available and accessible to MPs to enable their effective participation in the market;
- **Operability** – The new participation models will improve the IESO's ability to plan/forecast the operational needs of the grid and provide accurate signals to BESS resources.

Method

The design and integration of storage will be organized in a build-to-bill format called modules (representing larger functions) and elements (more specific functions within a module). The build-to-bill modules and elements are specific to the MP and IESO processes to bring new resources onto the grid and facilitate their participation in markets and services. Design modules and elements will be engaged based on project dependencies and priorities (i.e., not in a chronological format like a typical build-to-bill decision-making process).

Settlements Design Module

Settlement of DA and RT energy and operating reserve (OR) using as-submitted or mitigated dispatch data is accomplished through a two-settlement system for dispatchable facilities, including SMSRs. Any deviations between DA and RT schedules are settled through the RT market at RT prices, which may result in a financial buy-back or sell-back of the MP's DA position.

The DA and RT calculation engines will use dispatch data submitted by MPs to determine schedules and prices. New dispatch data will be provided daily to the Settlement process and used by the Make-Whole Payment (MWP) calculation.

Economic Operating Points (EOPs) are calculated through an optimization process that finds the best operation for a resource. EOPs and settlement rules interact to ensure MWPs that reflect the operating characteristics of a resource and incentivize the correct MP behaviour.

The following design elements under Settlements will undergo changes:

- Two-settlement for Energy and OR:
    - For energy, new DAM and RT charges for bi-directional offers of the SMSR;
    - No change for OR.
- Operating Reserve Non-Accessibility charge:
    - Updates to the Total Accessible Operating Reserve (TAOR) calculation.
- Day-Ahead Markets Make-Whole Payments (DAM MWP):
- Real-Time Make-Whole Payments (RT MWP):
    - Lost Cost (LC);
    - Lost Opportunity Cost (LOC).
- Economic Operating Point (EOP) tools:
    - Update required due to the introduction of SoC tracking, new storage constraints, bi-directional energy offers, OR branching capability and derates.
- Settlement impacts due to Enhanced Mitigation for Conduct (EMFC):
    - Changes to EMFC data are described in the Market Power Mitigation design memo.

New and Revised Inputs to Support Design Decisions

Collection of New Dispatch Data from Market Participants

The DA and RT calculation engines will use dispatch data submitted by MPs to determine schedules and prices. This new dispatch data will be provided daily to the Settlement process as settlement-ready data to support the settlement calculations.

Table 1: Dispatch Data used for Settlements

Variable	Parameter Name	Description
$ISOC_k^m$	Initial State of Charge	This represents the initial SoC that is submitted by MP at delivery point 'm' for MP 'k' Unit of measurement: MWh
$DAM_MinSOC_{k,h}^m$	Day-Ahead Market Minimum State of Charge	This represents the minimum SoC in the DAM at delivery point 'm' in settlement hour 'h' for MP 'k' Unit of measurement: MWh
$DAM_MaxSOC_{k,h}^m$	Day-Ahead Market Maximum State of Charge	This represents the maximum SoC in the DAM at delivery point 'm' in settlement hour 'h' for MP 'k' Unit of measurement: MWh
$RT_MinSOC_{k,h}^m$	Real-Time Minimum State of Charge	This represents the minimum SoC in the RT market at delivery point 'm' in settlement hour 'h' for MP 'k' Unit of measurement: MWh
$RT_MaxSOC_{k,h}^m$	Real-Time Maximum State of Charge	This represents the maximum SoC in the RT market at delivery point 'm' in settlement hour 'h' for MP 'k' Unit of measurement: MWh
$BES_{k,h}^{m,t}$	Real-Time Price Curve	This represents the energy bi-directional offer submitted in the RT market by a SMSR, represented as an N-by-2 matrix of price-quantity pairs at delivery point 'm' for MP 'k' for metering interval 't' of settlement hour 'h'
$DAM_BES_{k,h}^m$	Day-Ahead Market Price Curve	This represents the energy bi-directional offer submitted in DAM by a SMSR represented as an N-by-2

Variable	Parameter Name	Description
		matrix of price-quantity pairs for market participant 'k' at delivery point 'm' for settlement hour 'h'

Collection of New and Revised Data from Market Information Management (MIM)

Table 2: New and Revised Data from MIM

Variable	Name	Description
$DAM_SOC^{m}_{k,h}$	Day-Ahead Market State of Charge (New)	This represents the SoC that is determined by the DAM calculation engine at delivery point 'm' in settlement hour 'h' for MP 'k'
$RT_SOC^{m}_{k,h}$	Real-Time State of Charge (New)	This represents the SoC that is determined by the RT calculation engine at delivery point 'm' in settlement hour 'h' for MP 'k'
$DAM_QSW^{m}_{k,h}$	Day-Ahead Market Quantity of Energy scheduled for withdrawal at a delivery point (Revised)	This is the DAM quantity of energy scheduled for withdrawal by MP 'k' at delivery point 'm' in settlement hour 'h This will be represented as a negative value for SMSRs.
$RT_QSW^{m}_{k,h}$	Real-Time Quantity of Energy scheduled for withdrawal at a delivery point (Revised)	This is the RT quantity of energy scheduled for withdrawal by MP 'k' at delivery point 'm' in settlement hour 'h This will be represented as a negative value for SMSRs.

Operating Profit Function

The existing operating profit function currently handles only positive quantities when calculating profit and loss. SMSRs are expected to submit bi-directional offers which will include a quantity of zero, indicating a transition of the resource from charging to discharging.

The existing operating profit function used to calculate DAM MWP and RT MWP will be updated as follows to handle bi-directional offers for SMSRs:

Let OP(P,Q,B) be a profit function of Price (P), Quantity (Q), and an N-by-2 matrix (B) of price-quantity pairs.

$$OP(P,Q,B) = \mathrm{P.Q} - \sum_{n=1}^{s*} P_n.(Q_n - Q_{n-1}) - (Q - Q_{s*}).P_{s*+1}$$

Using matrix notation for parameter 'B':

$$OP(P,Q,B) = \mathrm{P}.\mathrm{Q} - \sum_{n=1}^{s*} \Big[B[n,1].(B[n,2] - B[n-1,2]) - \big[(Q - B[s^*,2]).B[s^*+1,1]\big]\Big]$$

Where

- For all injections, where Q > 0, s* is the highest indexed row of B such that
- $Q_{s*} >= Q >= Q_n$ and $Q_n = 0$
- For all withdrawals, where Q <0, s* is the lowest indexed row of B such that
- $Q_{s*} <= Q <= Q_n$ and $Q_n = 0$

Design Decisions

The sections below provide detailed explanation of the decisions made and the supporting rationale underlying the Settlements scope described above in the Scope of Settlements Phase 1 Design section.

Decisions Related to Settlements

Two-Settlement for Energy and Operating Reserves

In the IESO's renewed market, the two-settlement process for energy and OR is designed to settle the DAM, while the RT market functions as a balancing market. Day-ahead (DA) schedules are financially binding, and MPs are required to follow the DA energy and OR schedules in the RT market. Any deviations between DA and RT schedules are settled through the RT market at RT prices, which may result in a financial buy-back or sell-back of the MP's DA position.

This market design principle will be applied consistently to SMSRs, therefore no modifications to the two-settlement process are required for SMSRs. However, new settlement charge codes are required to support their participation in the market. These charge codes will be designed to accommodate potential future expansion to other non-conventional resources during future phases of the ERP program.

Decision

Two new settlement charge codes for energy will be introduced to settle DA and RT market energy for SMSRs. The two-settlement charges are categorized into resource types (e.g., dispatchable generation, dispatchable loads, imports, exports, etc.). This will create a new charge type associated with resource type for SMSRs in DA and RT.

The DA settlement amount will be calculated as:

$$HPTSA\{1\}_{k,h} = \sum^{M} \left[\left(DAM_QSI^{m}_{k,h} + DAM_QSW^{m}_{k,h} \right) x \, DAM_LMP^{m}_{h} \right]$$

The Real-Time Balancing settlement amount will be calculated as:

$$HPTSA\{2\}_{k,h} = \sum^{M,T} RT_LMP^{m,t}_{h} \, x \, \frac{\left(\left(AQEI^{m,t}_{k,h} - DAM_QSI^{m}_{k,h} \right) - \left(AQEW^{m,t}_{k,h} + DAM_QSW^{m}_{k,h} \right) \right)}{12}$$

Where:

DAM_QSW will be represented as a negative value for quantity of energy scheduled for withdrawal in DAM.

The two-settlement charge codes for SMSRs are listed below.

1. CT 1126: Day-Ahead Market Energy Settlement Amount for SMSRs.
2. CT 1127: Real-Time Energy Settlement Amount for SMSRs.

The two-settlement calculations and charge codes for OR remain unchanged.

Rationale

Consistent treatment of storage resources that aligns with other resources for two-settlement calculations and charge codes for energy and OR.

Day-Ahead Market Balancing Credit (DAM BC)

In the current market, Generator Offer Guarantee (GOG)-eligible resources and boundary entities are the only two types of resources that are eligible for the DAM BC settlement amount. These resources are not eligible for RT MWP when they are being dispatched below the DAM schedule to meet a reliability need, hence DAM BC is provided. The intent of DAM BC is to incentivize the resource to follow dispatch even if it results in operating at a loss when responding to dispatch instruction to meet a reliability need. All other resources within the IESO market with a DAM schedule are exposed to the financial risks of the two-settlement system and are expected to manage those risks with their offers or bids.

Similarly, an SMSR may incur buy-back or sell-back in RT. Situations may arise due to SoC limitations, which may be attributed to inadequate initial SoC in the DA market, depletion of SoC to meet a reliability need, or offer strategies that prevent charging or discharging earlier in the day, to force buy-back later when SoC is constrained.

Decision

In instances where buy-back occurs due to insufficient SoC resulting from MP offer strategies, the associated risk is within the MP's control and should be managed through their offers. In addition, MPs will be required to submit an initial SoC in the DAM to accurately reflect their capability, enabling the day-ahead calculation engine to produce a feasible schedule when optimizing over the entire day. This shift reallocates responsibility to MPs for managing financial risk in the market.

However, if a storage resource incurs a buy-back because it was uneconomically scheduled to meet a reliability need, it is expected that RT MWP will provide sufficient compensation to cover its as-offered cost and therefore, no further payments are warranted. RT MWP ensures the resource is not worse off for following dispatch instructions, by covering any loss or foregone profit incurred when operating above or below their economic operating point. Therefore, SMSR will not be eligible for DAM BC. This treatment aligns with the current DAM BC design.

Rationale

1. Consistent treatment of storage resources that aligns with other energy limited resources.
2. Consistent with other Independent System Operators (ISOs), such as New York ISO (NYISO), California ISO (CAISO) and Midcontinent ISO (MISO) where storage resources are exposed to RT prices when they are unable to deliver DA schedules.

Inaccessible Operating Reserve

Inaccessible OR ensures that the resource is available to provide the OR service procured when activated. If a resource is unable to deliver the MWhs, any market payment made for the unattainable OR will be clawed back.

While SMSRs have the unique characteristic of being able to both inject and withdraw energy to provide OR, there are certain situations where the resource may not be able to achieve potential OR activation, which can have significant impacts on the reliability of the grid.

Below are two scenarios under which storage resources may not be able to provide scheduled OR.

Scenario 1

A storage resource is scheduled in RT to generate at 90 MWs and it has a maximum capacity as per energy price curve of 100 MW. It is also scheduled to provide OR of 10 MWs. Based on its metered data, it is injecting 92 MWs, hence 2 MWs of the 10 MWs of OR is inaccessible if it is activated.

Scenario 2

A storage resource has a maximum OR offer quantity at 200 MW and is scheduled to provide 180 MWs of OR. The maximum capacity for energy is 100 MWs and the DA engine schedules it to charge at 80 MWs to meet demand in peak hours later in the day. The resource responds to dispatch, but metered data shows that its consumption is 78 MWs. For the resource to meet 180 MWs, it must reduce consumption by 78 MWs and inject 102 MWs. Since the maximum capacity for energy is 100 MW, 2 MWs of the OR is inaccessible. While this is expected to be a rare occurrence given the fast ramp rates of storage resources, it should still be considered in the design of inaccessible OR.

Decision

Consistent with other conventional resources, SMSRs will be subjected to inaccessible OR clawback, unless they are activated for OR.

Since an SMSR can discharge and charge when providing OR, the Total Accessible Operating Reserve (TAOR) must be modified to account for this unique characteristic.

When the resource is injecting or withdrawing energy in an interval, TAOR will be determined as follows:

$$TAOR_{k,h}^{m,t} = AQEW_{k,h}^{m,t} + \left(MAX_CAP_{k,h}^{m,t} - AQEI_{k,h}^{m,t}\right)$$

Where:

$AQEW_{k,h}^{m,t}$ is the actual quantity (in MWh and up to three decimal places) of energy withdrawn by MP 'k' at primary registered wholesale meter 'm' in metering interval 't' of settlement hour 'h', as defined in Market Rules Appendix 9.2, section 8.

$AQEI_{k,h}^{m,t}$ is the actual allocated quantity (in MWh and up to three decimal places) of energy injected by MP 'k' at primary registered wholesale meter 'm' in metering interval 't' of settlement hour 'h', as defined in Market Rules Appendix 9.2, section 8.

$MAX_CAP_{k,h}^{m,t}$ is the maximum limit for MP's 'k' for delivery point 'm' used in determining the RT schedule for generation in the dispatch scheduling and pricing process for metering interval 't' in settlement hour 'h'.

Rationale

1. Consistent treatment of storage resources that aligns with other dispatchable resources.
2. Any market payment made to provide OR and maintain grid reliability is uplifted to loads. If SMSRs are unable to deliver on their obligation, loads should not bear these costs in the market.

Impacted charge codes: CT 206, 208, 210.

Day-Ahead Market Make-Whole Payment (DAM MWP)

DAM MWP incentivizes MPs to offer efficiently and respond to dispatch instructions by providing LC compensation when the revenue earned is insufficient to cover their as-offered costs for energy and OR. All dispatchable resources that participate in DAM are eligible for DAM MWPs.

The DAM calculation engine will co-optimize the SMSR over the entire day. As a result, the resource may be uneconomically scheduled to charge over an hour, or the engine may preserve its charge to discharge during peak periods when it is most valuable to the market. As a result, the resource may incur a loss in hours when it is charging but will likely be profitable during the peak hours when prices are high. ~~Over the entire day,~~The DAM MWP ensures the resource is not worse off for following IESO dispatch instructions.

Decision

Storage resources will be eligible for DAM MWP. ~~and it will be calculated over the entire day.~~

The DAM MWP will be calculated for each settlement hour, or across a set of settlement hours within an assessment period.

The start of an assessment period is defined by, and includes, the settlement hour in which at hour-end, the DAM SoC differs from the DAM LC EOP SoC. The assessment period ends with, and includes, the earlier of the settlement hour in which, at hour-end, the DAM SoC equals the DAM LC EOP SoC, or the last settlement hour of the trade day.

The revised DAM MWP equation for SMSR is as follows:

~~$$DAM_MWP_{k}^{m} = Max\left(0, \sum_{}^{H} DAM_COMP1_{k,h}^{m} + DAM_COMP2_{k,h}^{m}\right)$$~~

$$DAM_MWP_{k,h}^{m} = Max\left(0, DAM_COMP1_{k,h}^{m} + DAM_COMP2_{k,\mathrm{h}}^{m}\right)$$

$$DAM_MWP_{k,a}^{m} = Max\left(0, DAM_COMP1_{k,a}^{m} + DAM_COMP2_{k,\mathrm{a}}^{m}\right)$$

Where:

~~H is the set of all hours in the trade day~~

'h' is a settlement hour within a trade day;

'a' is the set of hours that is within an assessment period in a trade day; and

$\mathrm{DAM_MWP}_{\mathrm{k,h}}^{\mathrm{m}}$ applies to each settlement hour 'h' not within an assessment period, and $\mathrm{DAM_MWP}_{\mathrm{k,a}}^{\mathrm{m}}$ to each assessment period, 'a'.

1. When SMSR is dispatched to generate energy, DAM_COMP1 will be calculated as:

~~$$DAM_COMP1_{k,\mathrm{h}}^{m} = (-1) \times \{[\textstyle\sum_{Hp} OP\left(DAM_LMP_{h}^{m}, DAM_QSI_{k,h}^{m}, DAM_BES_{k,h}^{m}\right)] + [\textstyle\sum_{Hn} OP\left(DAM_LMP_{h}^{m}, DAM_QSI_{k,h}^{m}, DAM_BES_{k,h}^{m}\right) OP\left(DAM_LMP_{h}^{m}, DAM_EOP_{k,h}^{m}, DAM_BES_{k,h}^{m}\right)]\}$$~~

a. For a settlement hour not within an assessment period:

$$DAM_COMP1^{m}_{k,h} = (-1) \times [OP(DAM_LMP^{m}_{h}, DAM_QSI^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})]$$

b. For an assessment period 'a':

$$DAM_COMP1^{m}_{k,a} = (-1) \times \left\{ \left(\sum_{Hp_a} [OP(DAM_LMP^{m}_{h}, DAM_QSI^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})] \right) + \left(\sum_{Hn_a} [OP(DAM_LMP^{m}_{h}, DAM_QSI^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})] \right) \right\}$$

Where:

- Hp_a is the set of hours in the ~~trade day~~assessment period 'a' where the operating profit at DAM_QSI is positive; and
- Hn_a is the set of hours in the ~~trade day~~ assessment period 'a' where the operating profit at DAM_QSI is negative and DAM_QSI is greater than DAM_EOP.

2. When SMSR is dispatched to withdraw energy, DAM_COMP1 will be calculated as:

$$DAM_COMP1^{m}_{k,h} = \{[\textstyle\sum_{Hp} OP(DAM_LMP^{m}_{h}, DAM_QSW^{m}_{k,h}, DAM_BES^{m}_{k,h})] + [\textstyle\sum_{Hn} OP(DAM_LMP^{m}_{h}, DAM_QSW^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})]\}$$

a. For a settlement hour not within an assessment period:

$$DAM_COMP1^{m}_{k,h} = (-1) \times [OP(DAM_LMP^{m}_{h}, DAM_QSW^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})]$$

b. For an assessment period 'a':

$$DAM_COMP1^{m}_{k,a} = (-1) \times \left\{ \left(\sum_{Hp_a} [OP(DAM_LMP^{m}_{h}, DAM_QSW^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})] \right) + \left(\sum_{Hn_a} [OP(DAM_LMP^{m}_{h}, DAM_QSW^{m}_{k,h}, DAM_BES^{m}_{k,h}) - OP(DAM_LMP^{m}_{h}, DAM_EOP^{m}_{k,h}, DAM_BES^{m}_{k,h})] \right) \right\}$$

Where:

- Hp_a is the set of hours in the assessment period 'a' ~~trade day~~ where the operating profit at DAM_QSW is positive; and
- Hn_a is the set of hours in the assessment period 'a' ~~trade day~~ where the operating profit at DAM_QSW is negative and DAM_EOP is greater than DAM_QSW.

3. When SMSR is scheduled to provide OR, DAM_COMP2 is calculated as:

$$DAM_COMP2^{m}_{k,h} = (-1) \times \left\{ \left(\sum_{Hp} \sum_{R} OP(DAM_PROR^{m}_{r,h}, DAM_QSOR^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h}) \right) + \left(\sum_{Hn} \sum_{R} [OP(DAM_PROR^{m}_{r,h}, DAM_QSOR^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h}) - OP(DAM_PROR^{m}_{r,h}, DAM_EOP^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h})] \right) \right\}$$

a. For a settlement hour not within an assessment period:

$$DAM_COMP2^{m}_{k,h} = (-1) \times \sum_{R} [OP(DAM_PROR^{m}_{r,h}, DAM_QSOR^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h}) - OP(DAM_PROR^{m}_{r,h}, DAM_OR_EOP^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h})]$$

b. For an assessment period 'a':

$$DAM_COMP2^{m}_{k,\text{~~h~~}a} = (-1) \times \left\{ \left(\sum_{Hp_a} \sum_{R} [OP(DAM_PROR^{m}_{r,h}, DAM_QSOR^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h}) - OP(DAM_PROR^{m}_{r,h}, DAM_OR_EOP^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h})] \right) + \left(\sum_{Hn_a} \sum_{R} [OP(DAM_PROR^{m}_{r,h}, DAM_QSOR^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h}) - OP(DAM_PROR^{m}_{r,h}, DAM_OR_EOP^{m}_{r,k,h}, DAM_BOR^{m}_{r,k,h})] \right) \right\}$$

Where:

- Hp_a is the set of hours in the ~~trade day~~ assessment period 'a' where the operating profit at DAM_QSOR is positive; and
- Hn_a is the set of hours in the ~~trade day~~ assessment period 'a' where the operating profit at DAM_QSOR is negative and DAM_QSOR is greater than DAM_OR EOP.

~~1.~~4. DAM MWP for SMSR will be settled with the existing charge types for DAM MWP~~under four new daily charge codes~~.

- The existing ~~A new~~ daily uplift charge will be used to recover the cost of DAM MWP to SMSRs.
- DAM MWP will be subjected to hourly settlement mitigation.

Rationale

Consistent treatment of storage resources that aligns with other energy-limited resources, with linked-hour ~~full-day~~ consideration for MWP to account for unique storage characteristics.

Eligibility

SMSR will not be eligible for DAM MWP in any hour that it is scheduled due to a Safety, Equipment, and Applicable Law (SEAL) event condition that endangers the safety of any person, results in equipment damage, or violates any applicable law.

Real-Time Make-Whole Payment (RT MWP)

Real-Time Make-Whole Payment incentivizes MPs to follow IESO dispatch instructions by providing compensation in the form of an LC or LOC payment for energy and ORs. A SMSR may incur an LC if it is dispatched above its economic operating point or an LOC if it is dispatched below its economic operating point.

RT MWP will be calculated as:

$$RT_MWP_{k,h}^{m} = \sum^{T} Max\left(0, RT_ELC_{k,h}^{m,t} + RT_OLC_{k,h}^{m,t}\right) + Max\left(0, RT_ELOC_{k,h}^{m,t} + RT_OLOC_{k,h}^{m,t}\right)$$

When SMSR is dispatched to generate, RT_ELC and RT_ELOC will be calculated as follows:

$$RT_ELC_{k,h}^{m,t} = -1 \text{ x } [[OP\left(RT_LMP_{h}^{m,t}, Max(DAM_QSI_{k,h}^{m}, Min(RT_QSI_{k,h}^{m,t}, AQEI_{k,h}^{m,t})), BES_{k,h}^{m,t}\right) - OP\left(RT_LMP_{h}^{m,t}, Max(RT_LC_EOP_{k,h}^{m,t}, DAM_QSI_{k,h}^{m}), BES_{k,h}^{m,t}\right)]]/12$$

$$RT_ELOC_{k,h}^{m,t} = \{Max[0, OP\left(RT_LMP_{h}^{m,t}, RT_LOC_EOP_{k,h}^{m,t}, BES_{k,h}^{m,t}\right)] - Max[0, OP\left(RT_LMP_{h}^{m,t}, (Max(RT_QSI_{k,h}^{m,t}, AQEI_{k,h}^{m,t})), BES_{k,h}^{m,t}\right)]\}/12$$

If the SMSR is dispatched to generate but is economic to withdraw (RT_QSI >=0), the RT_ELOC will be calculated as follows:

$$RT_ELOC_{k,h}^{m,t} = \{OP\left(RT_LMP_{h}^{m,t}, RT_LOC_EOP_{k,h}^{m,t}, BES_{k,h}^{m,t}\right) - OP\left(RT_LMP_{h}^{m,t}, Min\left(0, AQEW_{k,h}^{m,t} \text{ x } -1\right), BES_{k,h}^{m,t}\right)\}/12$$

When calculating RT_ELOC, if the offer price of the price curve $BES_{k,h}^{m,t}$ to inject energy is greater than RT_LMP, the IESO will adjust the offer price to RT_LMP.

When SMSR is dispatched to withdraw energy:

$$RT_ELC_{k,h}^{m,t} = -1 \text{ x}[OP\left(RT_LMP_{h}^{m,t}, Min(DAM_QSW_{k,h}^{m}, Max(RT_QSW_{k,h}^{m,t}, AQEW_{k,h}^{m,t} \text{x } -1)), BES_{k,h}^{m,t}\right) - OP\left(RT_LMP_{h}^{m,t}, Min(RT_LC_EOP_{k,h}^{m,t}, DAM_QSW_{k,h}^{m}), BES_{k,h}^{m,t}\right)]/12$$

$$RT_ELOC_{k,h}^{m,t} = \{OP\left(RT_LMP_{h}^{m,t}, RT_LOC_EOP_{k,h}^{m,t}, BES_{k,h}^{m,t}\right) - OP\left(RT_LMP_{h}^{m,t}, Min(RT_QSW_{k,h}^{m,t}, AQEW_{k,h}^{m,t}\ x - 1), BES_{k,h}^{m,t}\right)\}/12$$

If the SMSR is dispatched to withdraw energy but is economic to generate (RT_QSI < 0), the RT_ELOC will be calculated as follows:

$$RT_ELOC_{k,h}^{m,t} = \frac{\{OP\left(RT_LMP_{h}^{m,t}, RT_LOC_EOP_{k,h}^{m,t}, BES_{k,h}^{m,t}\right) - OP\left(RT_LMP_{h}^{m,t}, Max\left(0, AQEI_{k,h}^{m,t}\right), BES_{k,h}^{m,t}\right)\}}{12}$$

When calculating RT_ELOC, if the offer price of the price curve $BES_{k,h}^{m,t}$ to withdraw energy is less than RT_LMP, the IESO will adjust the offer price to RT_LMP.

The RT lost cost for operating reserve (RT_OLC) and RT lost opportunity cost for operating reserve (RT_OLOC) formulas remain unchanged.

RT MWP offer price adjustment will be applied to SMSR when calculating RT MWP, that is, negative energy offer prices submitted for withdrawals will be adjusted to the Min (RT LMP, -$15/MWh) and negative energy offer prices submitted for injection will be adjusted to Min (RT LMP, $0/MWh). This aligns with the treatment of conventional resource as per Market Manual 5.5, section 2.7.

Similar to the current market, RT MWP for SMSR will be subjected to settlement mitigation and SMSRs that are part of a compliance aggregation model will be assessed based on the revenue meter at the delivery point.

Eligibility

The following eligibility rules are consistent with the current market and will be applied to SMSRs:

1. A SMSR will be eligible for RT MWP in any hour that it was constrained for reliability. A SMSR will not be eligible for RT MWP in any hour in which the MP requests a specific dispatch to prevent endangering the safety of any person, equipment damage, or violation of any applicable law (SEAL).
2. SMSRs that received a schedule in DAM will not be eligible for RT MWP for MWs that were scheduled in the DAM.
3. When an SMSR is scheduled to generate energy, it will be ineligible for:
    - Positive energy lost cost (ELC) when RT_QSI < RT_LC_EOP or AQEI < RT_LC_EOP.
    - Positive energy lost opportunity cost (ELOC) when RT_QSI > RT_LOC_EOP or AQEI > RT_LOC_EOP.
4. When an SMSR is scheduled to withdraw energy, it will be ineligible for:
    - Positive energy lost cost (ELC) when RT_QSI > RT_LC_EOP or AQEW > RT_LC_EOP.
    - Positive energy lost opportunity cost (ELOC) when RT_QSI < RT_LOC_EOP or AQEW < RT_LOC_EOP.
    - AQEW is represented as a negative value when used in the evaluation of eligibility in the first two bullets above.

Changes to Min/MaxSoC by Market Participants

The IESO will manage SMSR SoC to ensure that these resources are dispatched feasible schedules to avoid violating their MinSoC and MaxSoC operational constraints. If an SMSR increases its MinSoC or decreases its MaxSoC such that the resulting SoC trajectory would violate its operational constraints in the subsequent hour, the RT calculation engine will attempt to resolve the violation by dispatching the SMSR to meet the new constraints. Specifically, the RT calculation engine will adjust the SMSR's dispatch to restore SoC feasibility in the current hour, which may result in the resource being dispatched uneconomically. Any RT MWP received during this period would be unwarranted as it was due to the MP's actions.

Decision

An SMSR will not be eligible for RT MWP in the current hour if there is a change in its MinSoC or MaxSoC between the previous hour and the current hour and the updated constraint is binding. Such RT MWP is considered inappropriate since it was due to the operating behaviour of the resource, not due to conditions on the IESO-controlled grid.

Rationale

These payments are not consistent with the intent of RT MWP and increase market costs to consumers.

Control Actions to Manage SoC

A resource that is scheduled in DAM and is manually constrained in RT to hold SoC may incur buy-back charges that are outside of its control and could not have been mitigated through changed operational behaviour.

The manual control action is implemented specifically to preserve SoC for peak hours when market prices are expected to be higher. As a result, the MP is reasonably expected to recover sufficient revenue during those peak periods. The MP's profit-earning ability is delayed, not diminished.

Accordingly, MWPs are not warranted if the MP is able to earn profit later under more favorable pricing conditions. Compensating foregone profit for megawatts (MWs) that are intentionally withheld by IESO, thereby creating an opportunity for the SMSR to earn profit later, would result in compensating the same MW twice. This will unnecessarily increase market costs to consumers, despite no incremental value to the market.

Therefore, RT MWP will be assessed to determine whether maintaining SoC enabled the resource to earn profit in subsequent intervals, and any payment received will be adjusted accordingly.

RT MWP Adjustment

The SoC determined by the EOP process and real-time calculation engine can diverge, for example, when the control room operator takes a manual action, or when differences arise between the scheduling and pricing passes. This creates an opportunity for the SMSR to earn profit in subsequent intervals/hours due to the inter temporal nature of the SMSR.

When this occurs, the RT MWP will be adjusted by assessing the resource profitability over a defined period. The defined period begins at the interval that the constraint was applied or divergence occurred and ends when the SoC between the EOP process and RT calculation engine converges or at the end of the trade day.

Decision

SMSRs will be ineligible for RT MWP when net market revenue is greater than or equal to RT MWP paid over the calculation period. The IESO will reverse the unwarranted RT MWP under a new RT MWP adjustment charge.

Rationale

This avoids overcompensating the SMSR and preserves incentive for efficient arbitrage.

Decisions related to Economic Operating Points (EOP)

Economic Operating Points (EOPs) and Settlement rules are the two inputs into the process of ensuring that appropriate Make-Whole Payments (MWPs) are made. Together, the two inputs interact to ensure MWPs that reflect operating characteristics of a resource and incentivize the correct MP behaviour.

EOPs are calculated through an optimization process that finds the best operation for a resource when viewed through the lens of the operating profit calculated based on the Locational Marginal Prices (LMPs) determined by the Dispatch Scheduling and Optimization (DSO) engine and the MP's offer curve and physical characteristics. This optimization process is distinct from that used in the DSO and is completed after the DSO produces its outputs. These EOPs may differ from what is produced by the DSO, as schedules may be affected by reliability concerns or differences between scheduling and pricing passes. EOPs can be thought of as 'should have been' schedules, namely how a resource would have operated within its physical and MP-provided limits based on the LMP.

Economic Operating Points must be calculated for three different types of MWP:

- Day-Ahead Lost Cost (DA LC);
- Real-Time Lost Cost (RT LC); and
- Real-Time Lost Opportunity Cost (RT LOC).

For each type of MWP, there are separate EOPs for energy and for each class of reserve.

Overview of the Economic Operating Point Design

The conceptual design decisions are provided in the following tables. Further details behind the decisions for RT LC, RT LOC and DA LC are available in the sections below.

Design elements related to the overall structure of the optimizations are provided below in Table 3.

Table 3: Economic Operating Point Calculation Engine Decisions

Item	DA LC	RT LC	RT LOC
Model SoC in Economic Operating Point Engine?	Y	Y	Y
Use Same Initial State of Charge as Corresponding DAM/RTM Engine?	Y	Y	Y
Employ Look-Ahead in Optimization?	N	N	N
Co-optimize Across Products	Y	Y	Y

The nature of SMSRs, including the calculation of SoC, makes the use of co-optimization necessary for LC EOP calculations.

Decisions on which constraints to include in the three EOP optimization engines are the main aspect of the design. Tables summarizing which constraints should be included are provided below. For clarity, excluded constraints are also included below in Table 9.

Constraints related to the physical characteristics of resources and for MP requirements are included below in Table 4.

Table 4: Physical and Market Participant Requirement Constraints

Item	DA LC	RT LC	RT LOC
Scheduling Bounds for Energy and Operating Reserves	Y	Y	Y
Available Maximum Capacity	Y	Y	Y
Available Minimum Capacity	Y	Y	Y
SEAL Minimum	Y	Y	Y
SEAL Maximum	Y	Y	Y
SEAL Fixed	Y	Y	Y
Grid-Connected	N	N	Y

The bi-directional nature of SMSR offer curves necessitates incorporation of available minimum capacity constraints.

Constraints related to the ramping of energy and ORs are included below in Table 5.

Table 5: Ramping Constraints

Item	DA LC	RT LC	RT LOC
10-minute Ramping for OR	N	N	Y
10-minute Ramping for OR with Change in Energy	N	N	Y
30-minute Ramping for OR	N	N	Y
30-minute Ramping for OR with Change in Energy	N	N	Y
5-minute Ramping for Energy	N	N	Y

Constraints related to the modeling of SoC are included below in Table 6.

Table 6: State of Charge Constraints

Item	DA LC	RT LC	RT LOC
State of Charge Continuity	Y	Y	Y
Minimum State of Charge	Y	Y	Y
Maximum State of Charge	Y	Y	Y

Item	DA LC	RT LC	RT LOC
State of Charge Feasibility for Minimum State of Charge with Operating Reserve Activation	Y	Y	Y

Feasibility for minimum SoC with activation of OR should respect the requirements below in Table 7: . Note that the two energy only cases (first two rows) are shown for completeness.

Table 7: SoC Feasibility for Activation of Operating Reserve

Case	Room Needed for RT LC and RT LOC	Room Needed for DA LC
Withdrawal Only	N/A: Moving away from MinSoC	N/A: Moving away from MinSoC
Injection Only	5 min of injections	60 min of injections
OR Only	60 min of OR	60 min of OR
Injection and OR	65 min of injection + 60 min of OR	60 min of injection + 60 min of OR
Withdrawal and OR: No Branching	N/A: Moving away from MinSoC	N/A: Moving away from MinSoC
Withdrawal and OR: Branching	60 min of withdrawal + 60 min of OR	60 minutes of withdrawals and 60 min of OR

Constraints related to restricting LC EOPs to the region where there are negative operating profits are included below in Table 8.

Table 8: Constraints Dividing LC and LOC Operating Profit Regions

Item	DA LC	RT LC	RT LOC
Energy Economic Operating Point Between Zero and DSO Schedule	Y	Y	N
OR Economic Operating Points Between Zero and DSO Schedule	Y	Y	N

The bi-directional nature of storage and consideration of SoC make these constraints necessary.

For additional clarity, the constraints below in Table 9 are, by design, not included in any of the EOP calculation engines.

Table 9: Excluded Constraints

Item	DA LC	RT LC	RT LOC
CycleDEL	N	N	N
Minimum Loading Point	N	N	N

Item	DA LC	RT LC	RT LOC
Reliability Constraints	N	N	N
Regulation Constraints	N	N	N
Absolute Minimum SoC	N	N	N
Absolute Maximum SoC	N	N	N
SoC Feasibility for Maximum SoC with OR Activation	N	N	N

Determination of how to Model State of Charge

A central design question for incorporating storage into the EOP engines is whether the SoC should be imported from the DSO or whether the SoC must be modeled within the EOP calculation engines. At first glance, importing SoC values from the DSO might appear attractive. Importing SoC values, however, would be incorrect for the calculation of EOPs.

Any imported SoCs would effectively bring constraints with them into the EOP calculations, which is not appropriate. The nature of the EOP calculations is to give a 'should have been' schedule reflecting operations that would occur based on economics. Any imported SoCs would bring Control Room actions and scheduling and pricing pass differences, which are the items that MWPs are designed to compensate.

Equally important, importing interval-level SoC from the DSO would fix the energy EOP for that interval/hour. The change in SoC between time periods is determined by the energy in the time step and some constant parameters. If the SoC is externally fixed at both the start and end of a time step, then the energy movement consistent with that SoC would be determined a priori, leaving no ability for the EOP engines to calculate the 'should have been' energy schedules. As such, an energy EOP would be equal to the corresponding schedule calculated by the DSO. This would effectively result in only having OR EOPs optimized and not co-optimized with energy.

For these reasons, the EOP calculation engines must model SoC internally, using the storage SoC evolution equation that ties intervals together and appropriate constraints on the SoC. This approach preserves the underlying integrity of LC and LOC calculations and will ensure that the EOP calculation engines have the full flexibility to determine their own counterfactual energy and OR profiles.

A result of this decision is that SoC can differ between the EOP calculation engines and the DSO.

Decision

The EOP calculation engines should internally calculate SoC for each resource and maintain it within appropriate limits.

Rationale

Avoids incorporating Control Room actions in the EOP engine, retains energy as a decision variable, tracks uneconomic actions in prior intervals for which MWP have been paid and provides the correct incentives.

Choice of Initializing State of Charge

With the decision to model SoC within the EOP calculation engines, starting points for the SoC will be required.

Real-Time Lost Cost and Real-Time Lost Opportunity Cost

RT LC and RT LOC must use the same initializing value for SoC. Both engines are performing the same function for different sets of assumptions for the same resources over the same horizon. Their purpose differs, but the system they model does not. They must begin from the same point.

When determining what the initializing SoC for the real-time EOP engines should be, there are several possible sources. One option is to use the end-of-day SoC from the previous day's DAM or the initializing SoC used for the DAM. This choice, however, would create an unjustified dependency between the RT and DAM MWPs.

Another potential source for the initial SoC could be the end-of-day result produced by the RT LC and RT LOC engines from the previous day. This approach, however, has several serious flaws. First, it would create inconsistent starting points between LC and LOC, which is enough to rule out this option. But it also introduces a deeper structural problem, namely it would chain days together. The LC/LOC outcomes for Day 0 would become the physical precondition for Day 1, which in turn would feed into Day 2, and so on. Any correction, resettlement, or rerun affecting a previous day would then propagate to subsequent days. This is directly at odds with the LC/LOC paradigm, which has always been that the calculation of EOPs for each operating day should begin fresh, unaffected by prior days.

Given these shortcomings, the most defensible starting point is to adopt the same SoC that Real-Time Multi Interval Optimization (RT-MIO) uses at the beginning of a day. This will ensure that the RT LC and RT LOC calculation engines begin from the same starting point and with the same amount of stored energy as the RT-MIO calculations.

Decision

The RT LC and RT LOC EOP calculation engines for a given day should be initialized on the same SoC as used by the RT-MIO for that day. The LC and LOC EOP calculation engines should directly reference the values used by RT-MIO rather than attempting to re-implement its logic.

Rationale

The use of a different starting point than in the DSO would allow MWP to be based on a different quantity of energy (SoC), which would not provide correct financial incentives.

Day-Ahead Lost Cost

A similar question arises when determining the appropriate initial SoC for DAM LC. As with the RT LC and RT LOC EOP calculation engines, DAM LC must begin from a starting point that is logically consistent with the DSO to compute valid EOPs.

The arguments against tying RT and DAM together apply here as well. Just as for RT, the most appropriate approach is to start the DAM LC calculations from the same point as the DAM. For these reasons, the most defensible approach is for the DAM LC calculation engine to use the Initializing State of Charge (ISoC) submitted by MPs.

Decision

The DAM LC EOP calculation engine should begin with the same ISoC assumptions as the DAM, which means starting with the MP-submitted ISoC.

Rationale

The use of a different starting point than in the DSO would allow MWP to be based on a different quantity of energy (SoC), which would not provide correct financial incentives.

Choice of Optimization Horizon

Real-Time Lost Cost and Real-Time Lost Opportunity Cost

The question of whether RT LC and RT LOC should extend their optimization horizon beyond a single five-minute interval arises naturally once storage resources are introduced. RT-MIO uses a 12-interval horizon because it must produce operationally feasible dispatch instructions that look ahead to future ramping, reserve requirements, system conditions, etc. RT LC and RT LOC, however, serve a fundamentally different purpose. They do not plan future operations, nor do they evaluate multi-interval economic trajectories. Instead, they compute interval-specific 'should have been' schedules. That intent remains for SMSRs.

Decision

RT LC and RT LOC EOPs should retain a single-interval optimization horizon. Optimization should proceed interval by interval until the end of a day.

Rationale

Maintains consistency with the current design.

Day-Ahead Lost Cost

While the DAM engine optimizes across 24 hours, extending the calculation of DAM LC to a 24-hour horizon would, in practice, require building a separate parallel DAM LC engine. The current DAM LC EOP calculations are performed one hour at a time. Keeping DAM LC EOP determination hour by hour preserves the current settlement paradigm and allows the current engine to be leveraged.

Decision

DAM LC should retain a one hour optimization horizon. Optimization should proceed hour by hour until the end of a day.

Rationale

Maintains consistency with the current design.

Impacted Current Settlement Amounts

Internal Congestion and Loss Residual

With the introduction of new calculations to support the settlement of SMSRs, the internal congestion and loss residuals settlement amount will be updated to include congestion and loss residuals attributed to SMSRs.

The Internal Congestion and Loss Residual equation will be modified as follows to handle the negative scheduled quantities in both DAM and RTM:

$$
\begin{aligned}
\mathrm{CRLR}_{\square} = \sum_{K,H}^{M} \Big[& \left(DAM_QSW_{k,h}^{m} - DAM_QSI_{k,h}^{m}\right) x\ DAM_LMP_{h}^{m} \\
& + \sum^{T} \left(\left(AQEW_{k,h}^{m,t} - AQEI_{k,h}^{m,t}\right) - \left(DAM_QSW_{k,h}^{m} - DAM_QSI_{k,h}^{m}\right) \right) x\ RT_LMP_{h}^{m,t} \\
& /12 \Big] \\
& + \sum_{K,H}^{M} \Big[\left(DAM_QSW_{k,h}^{m} + DAM_QSI_{k,h}^{m}\right) x\ DAM_LMP_{h}^{m} \\
& + \sum^{T} \left(\left(AQEW_{k,h}^{m,t} - AQEI_{k,h}^{m,t}\right) - \left(DAM_QSW_{k,h}^{m} + DAM_QSI_{k,h}^{m}\right) \right) x\ RT_LMP_{h}^{m,t} \\
& /12 \Big] + \sum_{K,H}^{V} \Big[\left(DAM_QVSW_{k,h}^{v} - DAM_QVSI_{k,h}^{v}\right) x \sum_{\square}^{T} \left(DAM_LMP_{h}^{v} - RT_LMP_{h}^{v,t}\right) \Big] \\
& + \sum_{K,H}^{M1} \Big[\left(DAM_LMP_{h}^{z} + LFDC_{h}\right) x \sum^{T} AQEW_{k,h}^{m,t} \Big] \\
& + \sum_{K,H}^{I} \Big[\left(DAM_QSW_{k,h}^{i} - DAM_QSI_{k,h}^{i}\right) x\ DAM_LMP_{h}^{i} \\
& + \sum^{T} \left(\left(SQEW_{k,h}^{i,t} - SQEI_{k,h}^{i,t}\right) - \left(DAM_QSW_{k,h}^{i} - DAM_QSI_{k,h}^{i}\right) \right) x\ RT_LMP_{h}^{i,t}/12 \Big] \\
& - \sum_{K,H}^{I} \left(DAM_QSW_{k,h}^{i} - DAM_QSI_{k,h}^{i}\right) x\ DAM_PEC_{h}^{i} \\
& - \sum_{K,H}^{I,T} \left(\left(SQEW_{k,h}^{i,t} - SQEI_{k,h}^{i,t}\right) - \left(DAM_QSW_{k,h}^{i} - DAM_QSI_{k,h}^{i}\right) \right) \times\ RT_PEC_{h}^{i,t}/12 \\
& - \sum_{K,H}^{I} \left(DAM_QSW_{k,h}^{i} - DAM_QSI_{k,h}^{i}\right) x\ DAM_PNISL_{h}^{i} \\
& - \sum_{K,H}^{I,T} \left(\left(SQEW_{k,h}^{i,t} - SQEI_{k,h}^{i,t}\right) - \left(DAM_QSW_{k,h}^{i} - DAM_QSI_{k,h}^{i}\right) \right) \times\ RT_PNISL_{h}^{i,t} \\
& /12
\end{aligned}
$$