MAY 22, 2026

ERP Storage and Co-located Hybrid Integration Project

Batch 2 Market Design – Settlements and Economic Operating Point

Independent Electricity System Operator (IESO)

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Territory Acknowledgement

The IESO acknowledges the land from where we are delivering today’s webinar is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Haudenosaunee and the Wendat peoples, and is now home to many diverse First Nations, Inuit and Métis peoples. We also acknowledge that Toronto is covered by Treaty 13 with the Mississaugas of the Credit First Nation.

As we have attendees from across Ontario, the IESO would also like to acknowledge all the traditional territories across the province, which include those of the Algonquin, Anishnabeg, Ojibwe, Cree, Oji-Cree, Huron-Wendat, Haudenosaunee, Métis, and Inuit peoples.

Engagement Principles

This engagement is conducted in accordance with the IESO's External Engagement Framework, which includes the following principles:

- **Purposeful** – Initiate meaningful conversations that move the sector forward
- **Inclusive** – Invite many voices and diverse perspectives to the table
- **Timely** – Seek input and insight when it can have the most impact
- **Accessible** – Ensure we meet people where they are on their energy journey
- **Traceable** – Allow everyone to follow the path that is being taken
- **Transparent** – Show how engagement helped shape the final outcome

Shared Commitment to Respectful Participation

To support a focused and constructive discussion:

- We will take questions one at a time; please use the raise-hand feature to enter the speaking queue
- We encourage concise and focused comments to allow time for multiple perspectives
- Participants are encouraged to raise relevant points during the discussion and provide more detailed feedback through the written submission process
- We ask that all participants maintain a respectful and professional tone throughout the session
- Facilitators will guide the discussion and manage participation to stay aligned with today's focus and agenda
- Where necessary, we may disable a participant's microphone to manage participation

Information Session Recording and Webpage

- Today's session will be **recorded** and available for viewing online
- **Meeting materials** are posted on the Public Information Session webpage created for this topic
- Please visit the Public Information Session's webpage here

Agenda

- Overview ERP Storage Integration Project
- Settlements Design:
  - Economic Operating Point
  - Make-Whole Payments Settlements
- Next Steps and Feedback

Enabling Resources Program Scope

The Enabling Resources Program is a set of projects that will further enable key emerging resources, specifically electricity storage ("storage"), hybrid generation-storage pairings ("hybrids") and aggregations of Distributed Energy Resources ("DERs") into the IESO-administered markets, tools, and processes to provide required system services and contribute to the safe and reliable operation of the bulk power system in Ontario.

Enabling Resources Program Scope

- The IESO will be implementing storage design through a phased approach.
- The intention of Phase 1 is to implement a fundamental design enabling storage participation in **Energy** and **OR** from both the injection and withdrawal ranges.
- The IESO will look to enhance the Phase 1 design in subsequent phases.

Outcomes of Optimization Phase 1 Design

1. Single resource model
2. State of Charge (SoC) modelling

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ERP Phase 2

- The IESO is in early stages of planning and design for Phase 2.
- Phase 2 scope includes enabling the IESO to access regulation service from battery storage resources, implementing uplift exemptions for storage resources, and other enhancements to the single resource model.
- Future engagements will provide further details on Phase 2 work.

Economic Operating Point (EOP) Design

Recap: Why Make-Whole Payments (MWP)?

- Situations can occur in which schedules determined by the Dispatching and Scheduling Optimization engines (DSO) may not align with their corresponding Locational Marginal Prices (LMPs), creating lost costs (LC) or lost opportunity costs (LOC).
  - A LC is created by a schedule resulting in a negative operating profit.
  - A LOC is a reduction in positive operating profit resulting from following a schedule.
- MWPs compensate market participants for LC and LOC and are required to maintain reliability by incentivizing market participants to follow schedules.
- There are three types of MWP: Day-Ahead LC, Real-Time LC, and Real-Time LOC.

Recap: What are Economic Operating Points (EOP)?

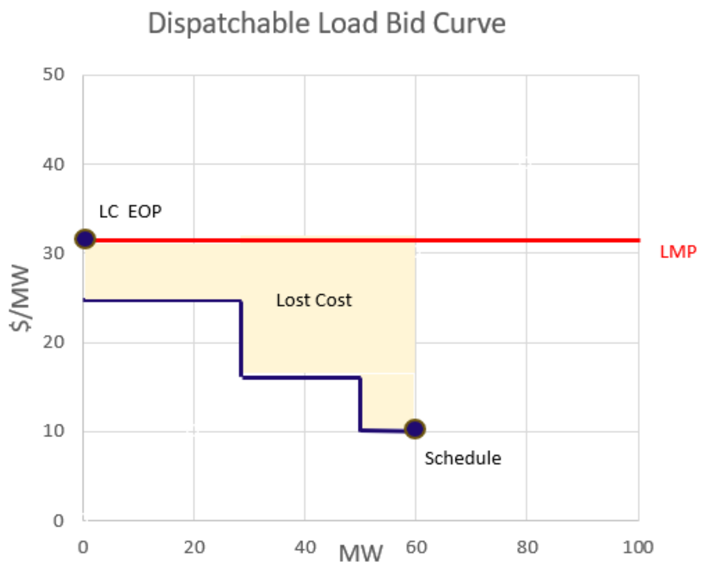
- EOPs serve as the reference points from which LC and LOC MWPs are determined and are calculated for each hour/interval.
- EOPs are calculated separately for DA LC, RT LC, and RT LOC.
- For each type of MWP, a resource has a separate EOP for energy and each class of operating reserve.
- EOPs can be thought of us as "should have been" schedules implied by a resource's locational marginal price (LMP).
- An EOP can be equal to a schedule, and a RT LC EOP can be equal to a RT LOC EOP.

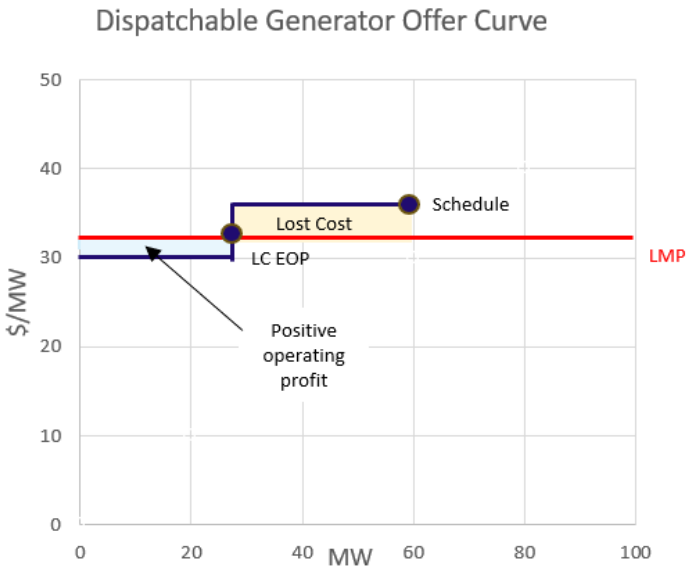
EOPs and Settlement Rules

- The EOP "should have been" schedules are one component contributing to the calculation of MWPs.
- Settlement eligibility rules are also integral to MWP calculations.
- Together, EOPs and Settlement rules ensure that MWP are appropriate and provide the correct financial incentives.

Lost Costs and Lost Opportunity Costs

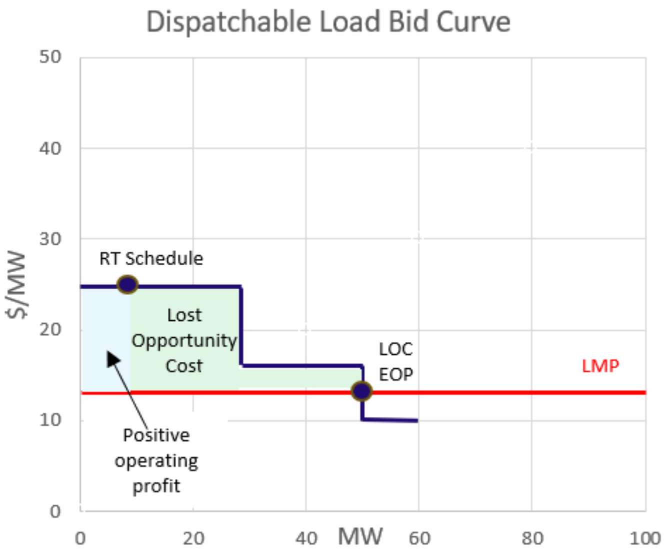
Recap: LC for Dispatchable Generation and Dispatchable Load

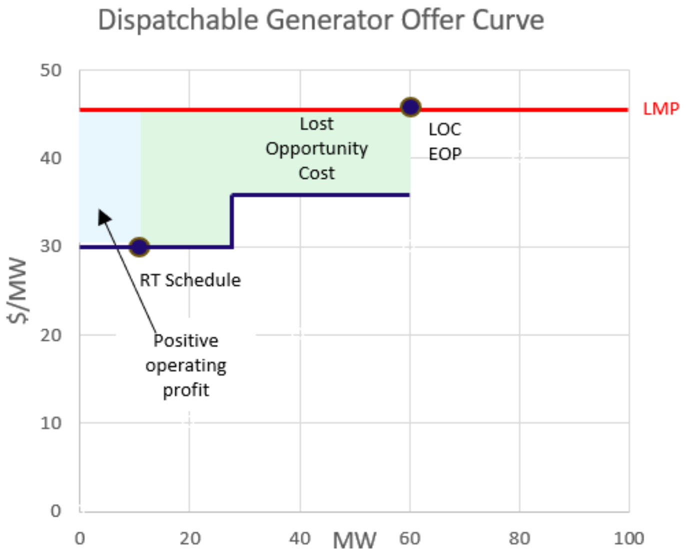




- Resource is scheduled such that is has a negative operating profit relative to its bid or offer curve. Lost cost MWP incentivizes a resource to follow its market schedule knowing that it will not operate at a loss.
- LC EOP is associated with "doing less" of something – i.e., moving towards zero MW and is bounded by 0 MW.

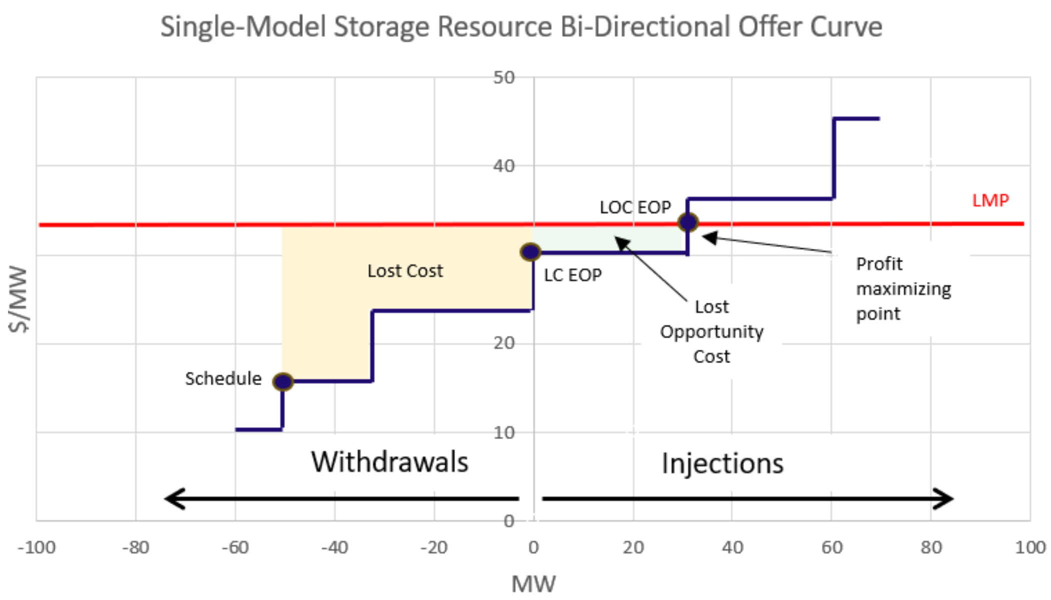
Recap: RT LOC for Dispatchable Generation and Dispatchable Load





- Resource is scheduled such that it foregoes positive operating profit relative to its bid or offer curve. Lost opportunity cost MWP incentivizes a resource to follow its market schedule knowing that it will not lose profits.
- LOC EOP is associated with “doing more” of something – i.e., moving away from zero MW.

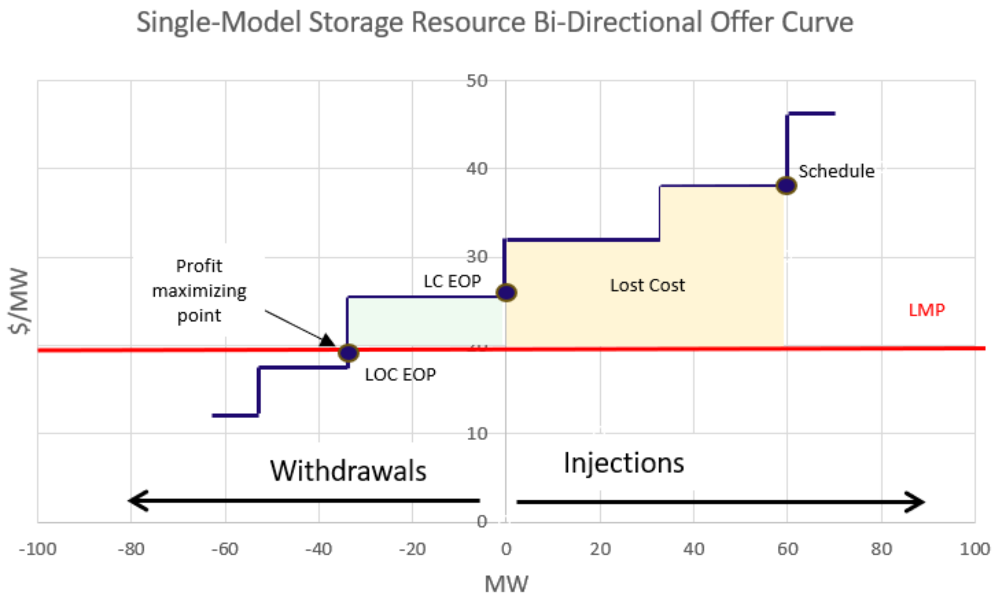
Uneconomic Withdrawal: Single-Model Storage Resource



Being able to both inject and withdraw creates additional considerations for the calculation of SMSR energy EOPs.

- **The SMSR is scheduled to withdraw when the LMP indicates it should be injecting.**
- With the bi-directional offer curve, the operating profit is maximized at an injection of 30 MW.
- Backing off the withdrawal to zero eliminates negative offering profit, so the LC EOP is 0 MW.
- Continuing through zero to an injection of 30 MW produces a positive operating profit, and the LOC EOP is 30 MW.

Uneconomic Injection: Single-Model Storage Resource



Being able to both inject and withdraw creates additional considerations for the calculation of SMSR energy EOPs.

- **The SMSR is scheduled to inject when the LMP indicates it should be withdrawing.**
- With the bi-directional offer curve, the operating profit is maximized at a withdrawal of -35 MW.
- Backing off the injection to 0 MW eliminates negative offering profit, so the LC EOP is 0 MW.
- Continuing through zero to a withdrawal of -35 MW produces a positive operating profit, and the LOC EOP is -35 MW.

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Economic Operating Point Calculations

Process for Determining EOP

- Determining an EOP requires an evaluation of what schedule the resource could have achieved at its LMP considering its physical operating characteristics.
- EOPs are calculated by tools that solve an optimization problem.
- Inputs include a resource's bi-directional offer curve, operating constraints, outages/deratings, and LMPs.
- Constraints can differ for DAM LC, RT LC, and RT LOC.
- EOPs are re-calculated when administrative pricing (which changes the LMPs) is required.

EOP Calculations

- The overall framework remains the same:
  - Three separate EOP calculation tools (DA LC, RT LC, and RT LOC);
  - Objective function unchanged; and
  - Calculated one time step at a time for each calendar day (no multi-period optimization).
- Changes to accommodate SMSR-specific characteristics include:
  - State of charge; and
  - Bi-directional offer curve.

EOP Calculations (cont.)

- For current resource types:
  - "Doing less" simplifies EOP LC calculations, which can rely more on Settlement rules to ensure appropriate MWP outcomes.
  - "Doing more" introduces dependencies between intervals for LOC.
- Because of SoC, SMSR inherently has dependencies between time steps which need to be considered.
- As a result, there will be fewer differences between LC and LOC EOP calculations for SMSR than there are for other resource types.

State of Charge Considerations

How to Model SoC for EOP Calculations?

- The SoC associated with the DSO schedules cannot be imported to EOP calculations because:
  - Doing so would introduce control room actions into the EOP outcomes; and
  - Knowing the SoC at the beginning and end of a time step would mean energy EOPs would equal the actual energy schedules.
- SoC will be modelled in all three (DA LC, RT LC, and RT LOC) EOP calculation engines.
- As a result, SoC can evolve differently in each EOP calculation engine compared to the DAM and RT schedules.

Real-Time Example of SoC Divergence

Item	Value
Start of Interval SoC	150 MWh
MaxSoC	500 MWh
MinSoC	0 MWh
Cycle Efficiency	95%
LMP	$70/MWh
Schedule	-30 MW

Price ($/MW)	Quantity (MW)	Price to Schedule ($/MW)	MP's Intended Action
10	-60	10 or less	Charge if price is $10/MW or below
50	0	10.01 to 49.99	Idle
50	60	50 or above	Inject if price is $50/MW or above

Source	Energy Quantity	Starting SoC	Ending SoC
DSO	Schedule = - 30 MW	150 MWh	150 MWh – (-30 MW · 0.95) x (1/12) h = **152.4 MWh**
RT LC	RT LC EOP = 0 MW	150 MWh	150 MWh – (0 MW · 0.95) x (1/12) h = **150.0 MWh**
RT LOC	RT LOC EOP = 60 MW	150 MWh	150 MWh – (60 MW) x (1/12) h = **145.0 MWh**

The SoC at the end of the interval diverges. This difference has the potential to affect operations in future intervals.

State of Charge Initialization

- SMSR EOPs should be calculated based upon the same amount of stored energy as are the DSO schedules.
- The EOP calculation engines will begin a day with:
  - The MP-submitted Initial State of Charge for DAM LC; and
  - The same initial SoC as used when calculating schedules for interval one of Hour Ending 1 for RT LC and RT LOC.

EOP Constraints

State of Charge Constraints

- State of charge continuity equation
  - Defines how SoC changes based upon energy injection/withdrawal, duration, and efficiency.
- Minimum SoC (MinSoC) and Maximum SoC (MaxSoC)
  - SoC must be within these bounds.
- Space above MinSoC with OR activation
  - Sufficient SoC must be available above MinSoC to allow for injections and OR activation.

SoC Feasibility above Minimum SoC

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 + 60 min of OR

The amount of space above SoC depends upon:

- DA vs. RT;
- Energy only vs. OR only vs. injection and OR; and
- Provision of OR via no branching or branching.

Additional Constraints

- Available minimum capacity
  - Analogue to existing available maximum capacity
  - Required to address bi-directional offer curve
- Division between LC and LOC
  - Ensure that calculated LC EOPs are "doing less" of something and don't switch from injection to withdrawal or vice versa

Modification of Constraints in SMSR EOP Calculations

- The details of how some existing constraints are applied to SMSR will be changed to accommodate bi-directional offer curves:
  - Scheduling bounds; and
  - Safety, Environment, and Applicable Law (SEAL) minimum and maximum constraints.

Constraints Not Included in SMSR EOP Calculations

- Minimum reliability constraints
  - Included in RT LOC for dispatchable generation and dispatchable load.
  - Not included in any EOP calculation engine for SMSR based on the dependence between intervals created by SoC.
- Regulation constraints
  - Included for dispatchable generation and dispatchable load.
  - To be addressed for SMSR in Phase 2

Constraints Not Included in SMSR EOP Calculations (cont.)

- Minimum loading point (MLP)
  - SMSR will have an MLP of zero, hence no constraints are necessary.
- Cycle Daily Energy Limit (CycleDEL)
  - Exclusion mirrors that for maximum daily energy limit (MaxDEL) DG resources.

Day-Ahead and Real-Time Make-Whole Payments

New Inputs to MWP Calculations

- New inputs will be added to the settlement process in DAM and RT to support MWP calculation, these include:
    - Minimum and Maximum State of Charge
    - State of Charge determined in DSO and EOP
    - New defined variable for bi-directional offers
- In addition, energy schedule for withdrawal will be represented as a negative value in the settlement process

Operating Profit

Key Changes:

- New condition added to the operating profit function to allow for branching between injection and withdrawal
- The Operating Profit function will use negative values for scheduled consumption (DAM_QSW, RT_QSW) and AQEW will be converted to a negative value before being used in the calculation

QSW = Quantity of energy scheduled for withdrawal (MW)
AQEW = Actual Quantity of Energy Withdrawn (MW)

Day-Ahead Make-Whole Payment

Day-Ahead Market Make-Whole Payment

- Day-Ahead Market Make-Whole Payment (DAM MWP) incentivizes Market Participants (MPs) to bid or offer efficiently by providing lost cost compensation when it is scheduled above its economic operating point in DAM for energy and OR
- An SMSR will be eligible for DAM MWP, which will be calculated over the entire day to offset profits against any loss incurred in individual hours of the day.
- An SMSR will not be eligible for DAM MWP in any hour that it is scheduled uneconomically due to a SEAL event.

Day-Ahead Market Make-Whole Payment

Rationale:

- Day-ahead calculation engine co-optimizes energy and Operating Reserve over the entire day and respects SMSR constraints
- Avoid potential gaming opportunities that may be associated with MP-submitted Initial State-of-Charge (ISOC)
- Reduces uplift to the market

Day-Ahead Market Make-Whole Payment (cont.)

DAM MWP will be calculated as follows:

$$DAM\_MWP_k^m = Max\left(0, \sum^{H} DAM\_COMP1_{k,h}^m + DAM\_COMP2_{k,h}^m\right)$$

When scheduled to generate, DAM_COMP1 will be calculated as:

$$DAM\_COMP1_{k,h}^m = (-1) \times \{[\textstyle\sum_{Hp} OP(DAM\_LMP_h^m, DAM\_QSI_{k,h}^m, DAM\_BES_{k,h}^m)] + [\textstyle\sum_{Hn} OP(DAM\_LMP_h^m, DAM\_QSI_{k,h}^m, DAM\_BES_{k,h}^m) - OP(DAM\_LMP_h^m, DAM\_EOP_{k,h}^m, DAM\_BES_{k,h}^m)]\}$$

Where:

Hp is the set of all hours in the trade day where the operating profit at DAM_QSI is positive, and

Hn is the set of all hours in the trade day where the operating profit at DAM_QSI is negative and DAM_QSI is greater than DAM EOP.

Day-Ahead Market Make-Whole Payment (cont.)

When scheduled to consume, DAM_COMP1 will be calculated as:

$$DAM\_COMP1_{k,h}^{m} = \{[\textstyle\sum_{Hp} OP(DAM\_LMP_{h}^{m}, DAM\_QSW_{k,h}^{m}, DAM\_BES_{k,h}^{m})] + [\textstyle\sum_{Hn} OP(DAM\_LMP_{h}^{m}, DAM\_QSW_{k,h}^{m}, DAM\_BES_{k,h}^{m}) - OP(DAM\_LMP_{h}^{m}, DAM\_EOP_{k,h}^{m}, DAM\_BES_{k,h}^{m})]\}$$

Where:

- Hp is the set of hours in the trade day where the operating profit at DAM_QSW is positive
- Hn is the set of hours in the trade day where the operating profit at DAM_QSW is negative and DAM_EOP is greater than DAM_QSW.

Day-Ahead Market Make-Whole Payment (cont.)

DAM_COMP2 will be calculated as:

$$DAM\_COMP2^{m}_{k,h} = (-1) \times \left\{ \left(\sum_{Hp} \sum_{R} OP\left(DAM\_PROR^{m}_{r,h}, DAM\_QSOR^{m}_{r,k,h}, DAM\_BOR^{m}_{r,k,h}\right) \right) + \left(\sum_{Hn} \sum_{R} \left[OP\left(DAM\_PROR^{m}_{r,h}, DAM\_QSOR^{m}_{r,k,h}, DAM\_BOR^{m}_{r,k,h}\right) - OP\left(DAM\_PROR^{m}_{r,h}, DAM\_EOP^{m}_{r,k,h}, DAM\_BOR^{m}_{r,k,h}\right) \right] \right) \right\}$$

Where:

Hp is the set of all hours in the trade day where the operating profit at DAM_QSOR is positive, and

Hn is the set of all hours in the trade day where the operating profit at DAM_QSOR is negative and DAM_QSOR is greater than DAM EOP.

Day-Ahead Market Make-Whole Payment (cont.)

Scenario 1: SMSR is scheduled for energy and OR over the trade day and it received DAM scheduled above EOP in 2 hours; ISOC = MinSOC

Energy Price Curve

P/Q Pair	Price($/MW)	Quantity (MW)	Price to Schedule ($/MW)
1	-200	-200	-200 or less
2	-100	-90	-199.99 to -100
3	0	-80	-99.99 to 0
4	25	-50	0.01 to 25
5	100	0	25.01 to 99.99
6	100	50	100 to 499.99
7	500	100	500 to 599.99
8	600	150	600 to 699.99
9	700	200	700 or more

OR Price Curve (10S)

P/Q Pair	Price($/MW)	Quantity (MW)
1	0.1	0
2	0.1	50
3	5	80
4	10	200
5	10.01	400

Day-Ahead Market Make-Whole Payment (cont.)

Hour ending	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24
DAM LMP	-$10.00	$0.06	-$200.00	-$200.00	-$200.00	$10.00	$15.00	$15.00	$30.00	$500.00	$500.00	$250.00	$550.00	$550.00	$600.00	$100.00	$710.00	-$100.00	-$250.00	$500.00	-$10.00	-$15.00	-$200.00	-$200.00
DAM OR LMP	$0.10	$15.00	$0.10	$0.10	$15.00	$15.00	$1.00	$1.00	$1.00	$10.00	$10.00	$15.00	$15.00	$4.00	$15.00	$1.00	$10.00	$4.00	$4.00	$4.00	$0.10	$0.10	$0.10	$0.10
DAM Energy Schedule (MW)	-80.0	-50.0	-200.0	-200.0	-200.0	-50.0	-50.0	30.0	0.0	0.0	0.0	120.0	100.0	100.0	150.0	100.0	0.0	-90.0	-200.0	0.0	0.0	-100.0	0.0	0.0
DAM OR Schedule (MW)	50.0	126.0	50.0	50.0	400.0	250.0	50.0	50.0	50.0	200.0	200.0	80.0	100.0	50.0	50.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0
State of Charge(SOC)	100	176	223.5	413.5	603.5	793.5	841	888.5	858.5	858.5	858.5	858.5	738.5	638.5	538.5	388.5	288.5	288.5	374	564	564	564	659	659
Available SOC	0	76	123.5	313.5	503.5	693.5	741	788.5	758.5	758.5	758.5	758.5	638.5	538.5	438.5	288.5	188.5	188.5	274	464	464	464	559	559
Daily Injection	0	0	0	0	0	0	0	30	30	30	30	150	250	350	500	600	600	600	600	600	600	600	600	600
CycleDEL Tracker (End of hour)	800	800	800	800	800	800	800	770	770	770	770	650	550	450	300	200	200	200	200	200	200	200	200	200
Energy Lost Cost(LC) EOP (MW)	-80.0	-50.0	-200.0	-200.0	-200.0	-50.0	-50.0	0.0	0.0	0.0	0.0	50.0	100.0	100.0	150.0	50.0	0.0	-90.0	-200.0	0.0	0.0	-80.0	0.0	0.0
OR Lost Cost (LC) EOP (MW)	50.0	126.0	50.0	50.0	400.0	250.0	50.0	50.0	50.0	200.0	200.0	80.0	100.0	50.0	50.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0
Energy Hp	**OP(DAM schedule) > 0**																							
Revenue	$800.00	-$3.00	$40,000.00	$40,000.00	$40,000.00	-$500.00	-$750.00	$450.00	$0.00	$0.00	$0.00	$30,000.00	$55,000.00	$55,000.00	$90,000.00	$10,000.00	$0.00	$9,000.00	$50,000.00	$0.00	$0.00	$1,500.00	$0.00	$0.00
Cost	-$1,250.00	-$1,250.00	$21,750.00	$21,750.00	$21,750.00	-$1,250.00	-$1,250.00	$3,000.00	$0.00	$0.00	$0.00	$42,000.00	$30,000.00	$30,000.00	$60,000.00	$30,000.00	$0.00	-$250.00	$21,750.00	$0.00	$0.00	$1,750.00	$0.00	$0.00
OP(DAM Schedule)	$2,050.00	$1,247.00	$18,250.00	$18,250.00	$18,250.00	$750.00	$500.00	-$2,550.00	$0.00	$0.00	$0.00	-$12,000.00	$25,000.00	$25,000.00	$30,000.00	-$20,000.00	$0.00	$9,250.00	$28,250.00	$0.00	$0.00	-$250.00	$0.00	$0.00
Energy Hn	**OP(DAM schedule) < 0 and DAM schedule > EOP**																							
Revenue (EOP)								$0.00				$12,500.00				$5,000.00						$1,200.00		
Cost (EOP								$0.00				$5,000.00				$5,000.00						-$1,250.00		
OP(EOP)								$0.00				$7,500.00				$0.00						$2,450.00		
DAM _COMP1	-$2,050.00	-$1,247.00	-$18,250.00	-$18,250.00	-$18,250.00	-$750.00	-$500.00	$2,550.00	$0.00	$0.00	$0.00	$19,500.00	-$25,000.00	-$25,000.00	-$30,000.00	$20,000.00	$0.00	-$9,250.00	-$28,250.00	$0.00	$0.00	$2,700.00	$0.00	$0.00
Operating Reserve Hp	**OP(DAM schedule) > 0**																							
Revenue	$5.00	$1,890.00	$5.00	$5.00	$6,000.00	$3,750.00	$50.00	$50.00	$50.00	$2,000.00	$2,000.00	$1,200.00	$1,500.00	$200.00	$750.00	$50.00	$0.00	$0.00	$200.00	$0.00	$0.00	$0.00	$0.00	$0.00
Cost	$0.50	$610.50	$0.50	$0.50	$3,352.50	$1,851.00	$0.50	$0.50	$0.50	$1,350.50	$1,350.50	$150.50	$350.50	$0.50	$0.50	$0.50	$0.00	$0.00	$0.50	$0.00	$0.00	$0.00	$0.00	$0.00
OP(DAM Schedule)	$4.50	$1,279.50	$4.50	$4.50	$2,647.50	$1,899.00	$49.50	$49.50	$49.50	$649.50	$649.50	$1,049.50	$1,149.50	$199.50	$749.50	$49.50	$0.00	$0.00	$199.50	$0.00	$0.00	$0.00	$0.00	$0.00
DAM_COMP2	-$4.50	-$1,279.50	-$4.50	-$4.50	-$2,647.50	-$1,899.00	-$49.50	-$49.50	-$49.50	-$649.50	-$649.50	-$1,049.50	-$1,149.50	-$199.50	-$749.50	-$49.50	$0.00	$0.00	-$199.50	$0.00	$0.00	$0.00	$0.00	$0.00

Total Profit (OR)	-$10,684.00
Total Profit (Energy)	-$174,097.00
Total Lost Cost	$44,750.00
Net DAM MWP	-$140,031.00

← **Resource earned sufficient profit to cover it's cost over the day therefore no DAM MWP is provided.**

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Day-Ahead Market Make-Whole Payment (cont.)

- DAM MWP for SMSR will be settled under four new daily charge codes.
- A new daily uplift charge will be used to recover the cost of DAM MWP to SMSRs.
- New DAM MWP charge codes for SMSR will be provided during implementation phase.

Day-Ahead Balancing Credit

Day-Ahead Market Balancing Credit

- Most resources within the IESO market are exposed to the financial risks of the two-settlement system and are expected to manage those risks with their bids or offers.
- Similarly, SMSRs will not be eligible for the Day-Ahead Market Balancing Credit (DAM BC) or any other compensation from financial risk of buy-backs.

Real-Time Make-Whole Payment

Real-Time Make-Whole Payment (RT MWP)

- RT MWP incentivizes MPs to follow IESO dispatch instructions by providing compensation in the form of a lost cost or lost opportunity cost payment for energy and OR when it is scheduled uneconomically above or below its EOP.

Eligibility

The following existing eligibility rules for loads and generators will be applied to SMSRs:

- RT MWP for SMSR will be subjected to hourly settlement mitigation.

Real-Time Make-Whole Payment - Eligibility

- An SMSR will not be eligible for RT MWP in any interval that it is scheduled uneconomically due to a SEAL event.
- SMSR will only be eligible for lost cost MWP for RT quantities above DAM schedule.
- SMSR bi-directional negative price offers will be adjusted as follows before they are used in the calculation of MWP:
  - For MWs submitted for withdrawal, offer price will be adjusted to Min(RT LMP, -$15/MWh) when offer price < -$15/MWh
  - For MWs submitted for generation, offer price will be adjusted to Min($0/MWh,RT LMP) when offer price < $0/MWh

Real-Time Make-Whole Payment - Eligibility

- SMSRs will be ineligible for the following RT MWP:

Scheduled to:	Type of RT MWP	Ineligibility Condition
Generate	Positive ELC	RT Schedule < RT lost cost EOP; or Actual MWs generated < RT lost cost EOP
Generate	Positive ELOC	RT Schedule > RT lost opportunity cost EOP; or Actual MWs generated > RT lost opportunity cost EOP
Withdraw	Positive ELC	RT Schedule > RT lost cost EOP; or Actual MWs withdrawn > RT lost cost EOP
Withdraw	Positive ELOC	RT Schedule < RT lost opportunity cost EOP; or Actual MWs withdrawn < RT lost opportunity cost EOP

- Similar to other resources, the ineligibility condition for positive OLC and OLOC as defined in Ch 9, section 3.5.4.7 & 3.5.4.8 are applicable to SMSR.

Real-Time Make-Whole Payment – Eligibility (New)

- If an SMSR is dispatched uneconomically in the current hour due to the MP increasing MinSoC or decreasing MaxSoc in the previous hour and the RT schedule is binding, it will not be eligible for MWP in the current hour. This will be considered self-induced MWP.

Rationale :

- RT MWP was due to MP action and not in response to IESO dispatch instructions.
- Consumers should not bear these costs.

Real-Time Make-Whole Payment - Eligibility (New)

- When an SMSR is dispatched uneconomically in an interval and it earns profit in subsequent intervals due to the divergence between DSO and EOP SoC, RT MWP will be adjusted.
- The adjustment will be settled under a new RT MWP adjustment charge

Rationale:

- Avoid over-compensating the resource
- Reduce the cost to the market

Real-Time Make-Whole Payment

Real-Time MWP will be calculated as follows:

$$RT\_MWP_{k,h}^{m} = \sum^{T} Max\left(0, RT\_ELC_{k,h}^{m,t} + RT\_OLC_{k,h}^{m,t}\right) + Max(0, RT\_ELOC_{k,h}^{m,t} + RT\_OLOC_{k,h}^{m,t})$$

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:

$$RT\_ELOC_{k,h}^{m,t} = \{OP\left(RT\_LMP_{h}^{m,t}, RT\_LOC\_EOP_{k,h}^{m,t}, BES_{k,h}^{m,t}\right) - OP\left(RT_{LMP}{}_{h}^{m,t}, Min(0, AQEW_{k,h}^{m,t} \text{ x} -1)\right)\}/12$$

Real-Time Make-Whole Payment

When SMSR is dispatched to withdraw energy:

$$RT\_ELC^{m,t}_{k,h} = -1 \text{ x}\left[OP\left(RT\_LMP^{m,t}_{h}, Min(DAM\_QSW^{m}_{k,h}, Max(RT\_QSW^{m,t}_{k,h}, AQEW^{m,t}_{k,h} \text{ x} - 1)), BES^{m,t}_{k,h}\right) - OP\left(RT\_LMP^{m,t}_{h}, Min(RT\_LC\_EOP^{m,t}_{k,h}, DAM\_QSW^{m}_{k,h}), BES^{m,t}_{k,h}\right)\right]/12$$

$$\boldsymbol{RT\_ELOC^{m,t}_{k,h} = \left\{OP\left(RT\_LMP^{m,t}_{h}, RT\_LOC\_EOP^{m,t}_{k,h}, BES^{m,t}_{k,h}\right) - OP\left(RT\_LMP^{m,t}_{h}, Min(RT\_QSW^{m,t}_{k,h}, AQEW^{m,t}_{k,h} \text{ x} - 1), BES^{m,t}_{k,h}\right)\right\}}$$

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

$$\boldsymbol{RT\_ELOC^{m,t}_{k,h} = \left\{OP\left(RT\_LMP^{m,t}_{h}, RT\_LOC\_EOP^{m,t}_{k,h}, BES^{m,t}_{k,h}\right) - OP\left(RT\_LMP^{m,t}_{h}, Max(0, AQEI^{m,t}_{k,h})\right\}/12}$$

Real-Time Market Make-Whole Payment (cont.)

Scenario 1: SMSR is scheduled uneconomically to withdraw but it was economic to generate

RT Energy Price Curve

Price($)	Quantity (MW	Price to Schedule ($/MW)
-200	-200	-200 or less
-100	-90	-199.99 to -100
0	-80	-99.99 to 0
25	-50	0.01 to 25
100	0	25.01 to 99.99
100	50	100 to 199.99
200	60	200 to 239.99
240	80	240 to 349.99
350	200	350 or more

RT Scehdule (RT_QSW)	-100MW
AQEW	-100MW
LC EOP	0
LOC EOP	60MW
RT LMP	$200

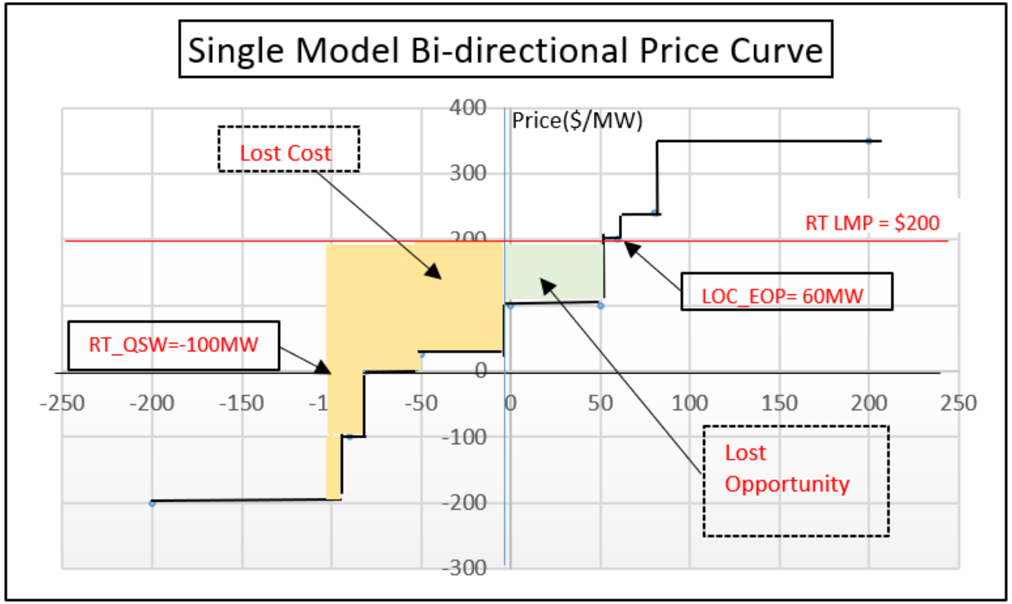
Offer price are below replacement bid - $15/MWh therefore it will be replaced with **Min($200, -$15/MWh) = -$15/MWh** when calculating MWP

Real-Time Market Make-Whole Payment (cont.)

Lost Cost Calculation	OP(RT_QSW)	OP(EOP)
Revenue	-$20,000.00	$0.00
Cost	-$950.00	$0.00
Total	-$19,050.00	$0.00
Lost Cost (LC)	$19,050.00	

Lost Opportunity Calculation	OP(EOP)	OP(RT_QSW)
Revenue	$12,000.00	$0.00
Cost	$7,000.00	$0.00
	$5,000.00	$0.00
Lost Opportunity Cost (LOC)	$5,000.00	

Net MWP =	$24,050.00



Real-Time Market Make-Whole Payment (cont.)

Scenario 2: SMSR is manually constrained for 1 hour to hold SOC to meet peak demand

RT Energy Price Curve

Price($)	Quantity (MW	Price to Schedule ($/MW)
-200	-200	-200 or less
-100	-90	-199.99 to -100
0	-80	-99.99 to 0
25	-50	0.01 to 25
100	0	25.01 to 99.99
100	50	100 to 199.99
200	60	200 to 239.99
240	80	240 to 349.99
350	200	350 or more

MinSOC	100
MaxSoc	800
Cycle Efficiency	0.95

Real-Time Market Make-Whole Payment (cont.)

Hour Ending	HE16	HE17	HE18	HE19	HE20
RT LMP		$200	$500	$500	$350
RT Energy Schedule		0	200	200	100
CRO Hold SOC		Y	N	N	N
RT LC		0	200	200	100
RT LOC		60	200	200	40
RT MWP		-$5,000.00	$0.00	$0.00	$6,200.00

LOC MWP of $5000 would be reversed because the resource was able to earn profit in HE20

SOC Divergence

	HE 17	HE 18	HE 19	HE 20
DSO	600	400	200	100
RT LC SOC	600	400	200	100
RT LOC SOC	540	340	140	100

EOP and DSO SOC diverge

EOP and DSO SOC converge

Next Steps and Feedback

Next Steps and Feedback

- Feedback is an important IESO engagement principal to ensure that sector input and perspectives are considered
- The IESO is requesting written feedback via the **IESO's Feedback Form** (available on the ERP Storage engagement webpage)
    - Feedback is being requested by **June 5, 2026**
- The next engagement session on the ERP Settlement design is targeted for the July Engagement Days
- Please submit feedback to IESO Engagement engagement@ieso.ca

Thank You

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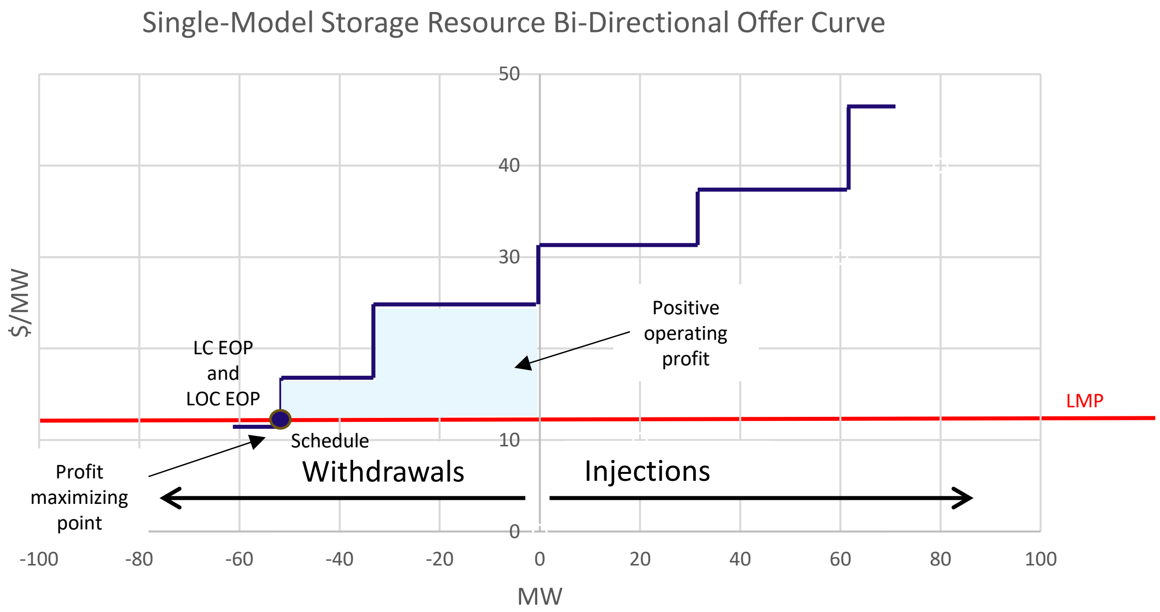
Appendix A – Additional Scenarios:

Real-Time Lost Cost and Lost Opportunity Cost

Withdrawal (1): Single-Model Storage Resource



Note: This and subsequent examples assume that ramping, SoC, and other constraints are not binding for the EOP calculations.

- With the bi-directional offer curve, the operating profit is maximized at a withdrawal of -55 MW.
- **The SMSR is scheduled to withdraw at the point that maximizes operating profit.**
- A withdrawal of more than -55 MW would create negative operating profit and withdrawing less than this would reduce positive operating profit.
- The LC EOP and LOC EOP are both equal to the schedule of -55 MW.

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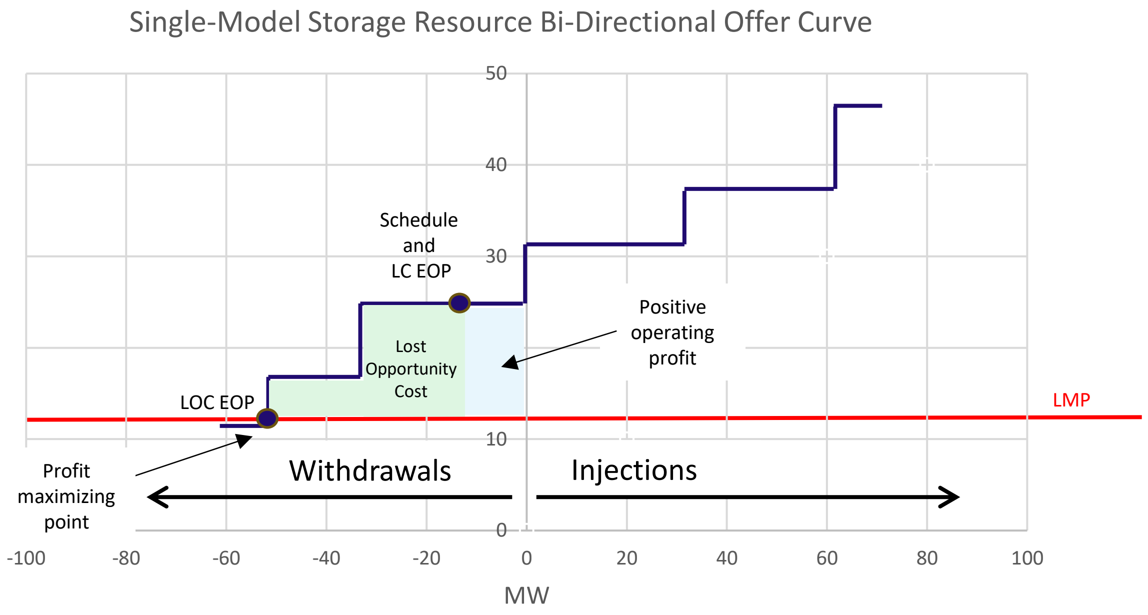
Withdrawal (2): Single-Model Storage Resource



- **The SMSR is scheduled to withdraw and the LMP indicates it should be withdrawing more.**
- With the bi-directional offer curve, the operating profit is maximized at a withdrawal of -55 MW.
- A withdrawal of less than -15 MW would reduce positive operating profit. The LC EOP is equal to the schedule of -15 MW.
- Increasing the withdrawal to -55 MW increases the operating profit and sets the LOC EOP.

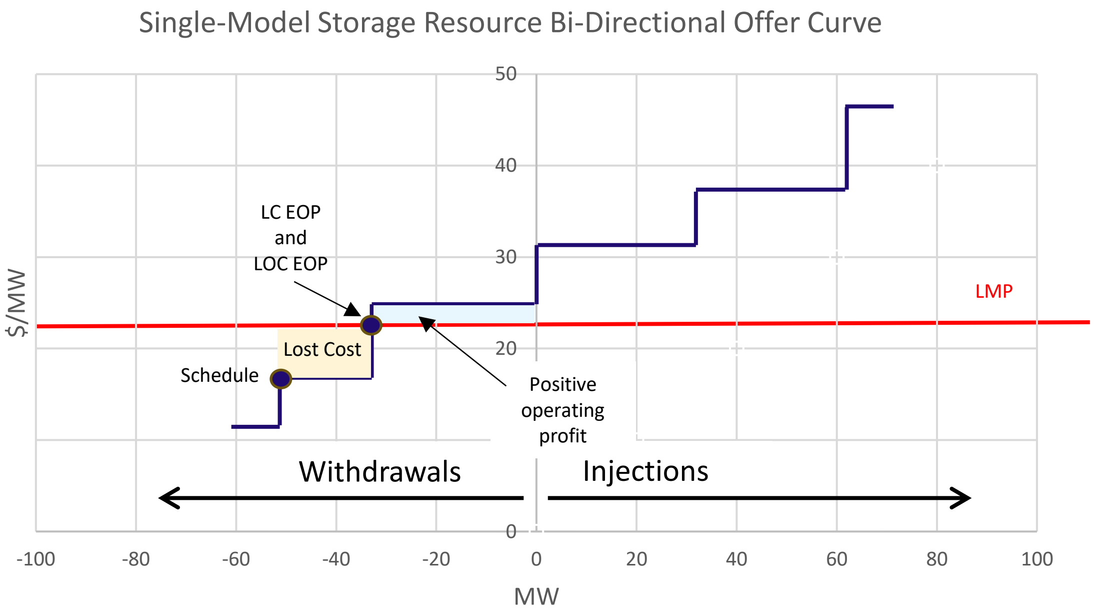
Scenario 1: SMSR is scheduled uneconomically to withdraw below its EOP

Price($)	Quantity (	Price to Schedule ($/MW)
12	-60	12 or less
15	-50	12.01 to 15
25	-30	15.01 to 25
30	0	25.01 to 30
30	30	30.01 to 34.99
35	60	35 to 44.99
45	80	45 or more

RT Schedule (RT_QSW)	-10MW
LC EOP	-10MW
LOC EOP	-50MW
RT LMP	$12

	OP(LOC EOP)		OP(RT_QSW)	
Revenue	-50MW x $12 =	-$600	-10MW x $12 =	-$120
Cost				
	-30MW x $25+		-10MW x $25=	
	-20MW x $25 =			
		-$1,050		-$250
Net	-$600+$1050=	$450		$130
RT_ELOC	$450 - $130 =	$320		

Withdrawal (3): Single-Model Storage Resource



- **The SMSR is scheduled to withdraw when the LMP indicates it should be withdrawing less.**
- With the bi-directional offer curve, the operating profit is maximized at a withdrawal of -35 MW.
- Backing off the withdrawal to -35 MW eliminates negative offering profit, so the LC EOP is -35 MW.
- At this LMP, additional positive operating profit can't be achieved and the LOC EOP is also -35 MW.

Scenario 2: SMSR is scheduled uneconomically to withdraw above its EOP

Price($)	Quantity (	Price to Schedule ($/MW)
10	-60	10 or less
15	-50	10.01 to 15
25	-35	15.01 to 25
30	0	25.01 to 30
30	35	30.01 to 34.99
35	60	35 to 44.99
45	80	45 or more

RT Schedule (RT_QSW)	-50MW
LC EOP	-35MW
LOC EOP	-35MW
RT LMP	$22

	OP(RT_QSW)		OP(LC EOP)	
Revenue	-50MW x $22 =	-$1,100	-35MW x $22 =	-$770
Cost				
	-35MW x $25+		-35MW x $25	
	-15MW x $15 =			
		-$1,100		-$875
Net	-$1100+$1100=	$0		$105
RT_ELC	($0 - $105) *-1=	$105		

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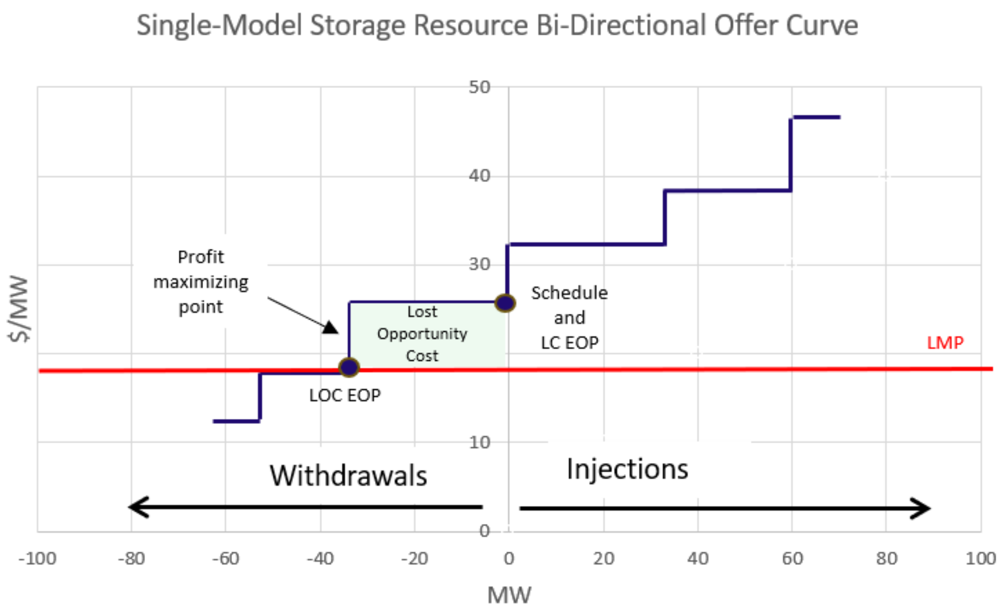
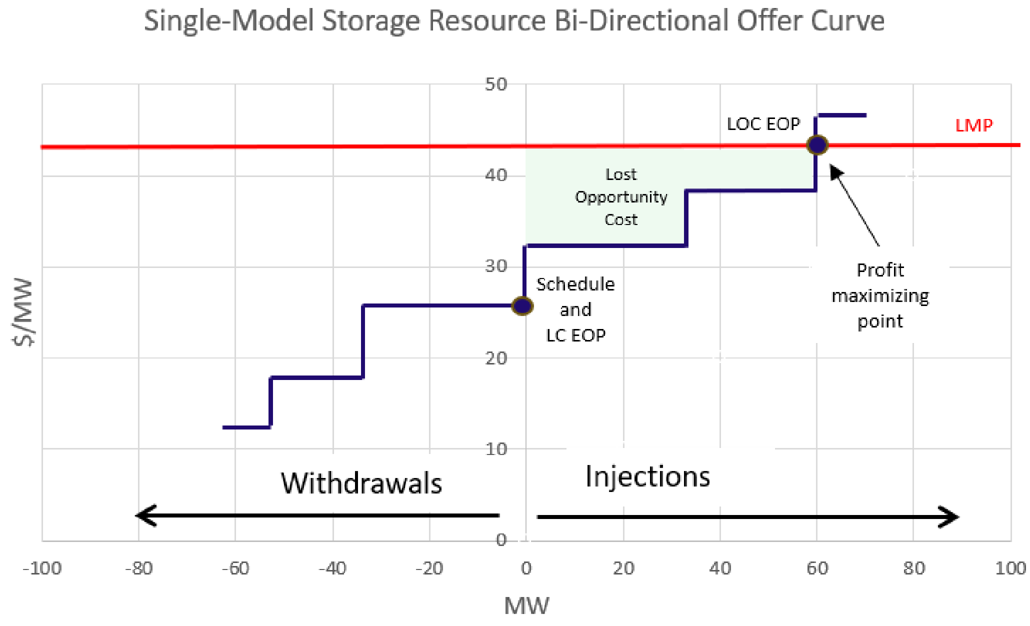
Zero Schedule (1): Single-Model Storage Resource



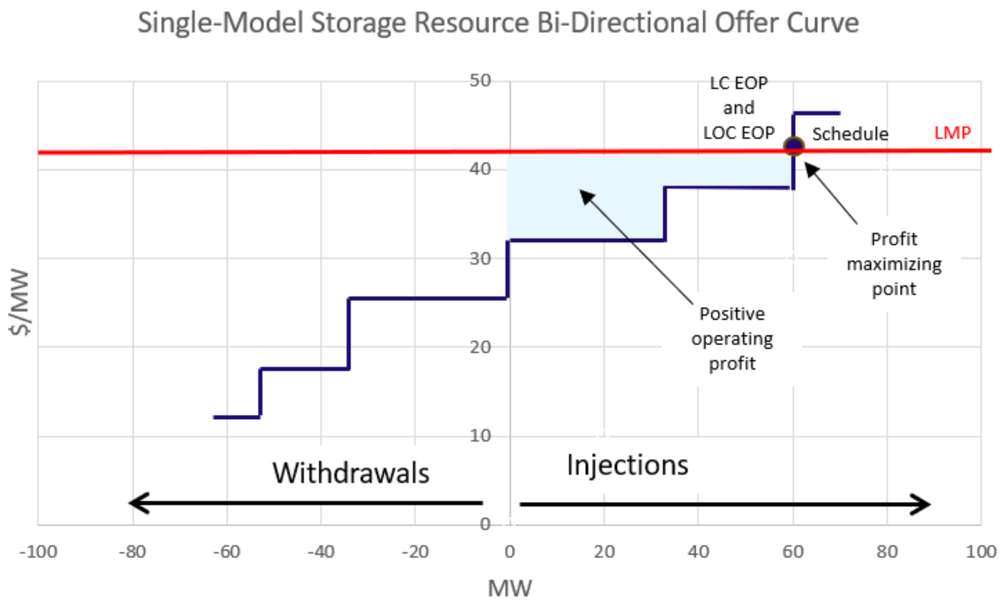
- **The SMSR is scheduled to do nothing when the LMP indicates it should be withdrawing.**
- With the bi-directional offer curve, the operating profit is maximized at a withdrawal of -35 MW.
- With a schedule of zero, there cannot be a negative operating profit. The LC EOP is zero.
- A withdrawal of -35 MW obtains the maximum the operating profit and sets the LOC EOP.

Zero Schedule (2): Single-Model Storage Resource



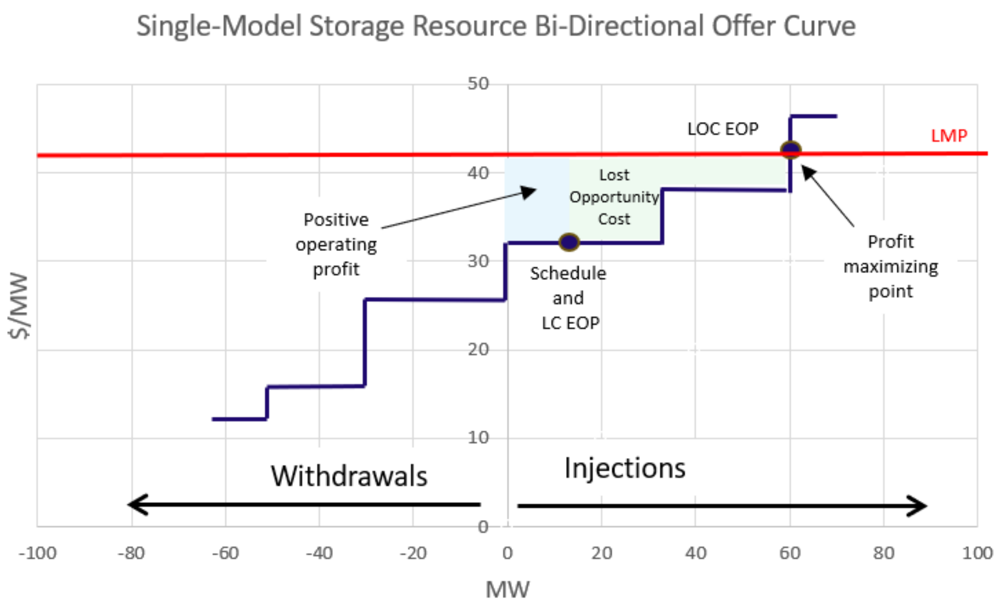
- **The SMSR is scheduled to do nothing when the LMP indicates it should be injecting.**
- With the bi-directional offer curve, the operating profit is maximized at an injection of 60 MW.
- With a schedule of zero, there cannot be a negative operating profit. The LC EOP is zero.
- An injection of 60 MW obtains the maximum the operating profit and sets the LOC EOP.

Injection (1): Single-Model Storage Resource



- With the bi-directional offer curve, the operating profit is maximized at an injection of 60 MW.
- **The SMSR is scheduled to inject at the point that maximizes operating profit.**
- An injection of more than 60 MW would create negative operating profit and withdrawing less than this would reduce positive operating profit.
- The LC EOP and LOC EOP are both equal to the schedule of 60 MW.

Injection (2): Single-Model Storage Resource



- **The SMSR is scheduled to inject and the LMP indicates it should be injecting more.**
- With the bi-directional offer curve, the operating profit is maximized at a withdrawal of 60 MW.
- An injection of less than 15 MW would reduce positive operating profit. The LC EOP is equal to the schedule of 15 MW.
- Increasing the injection to 60 MW increases the operating profit and sets the LOC EOP.

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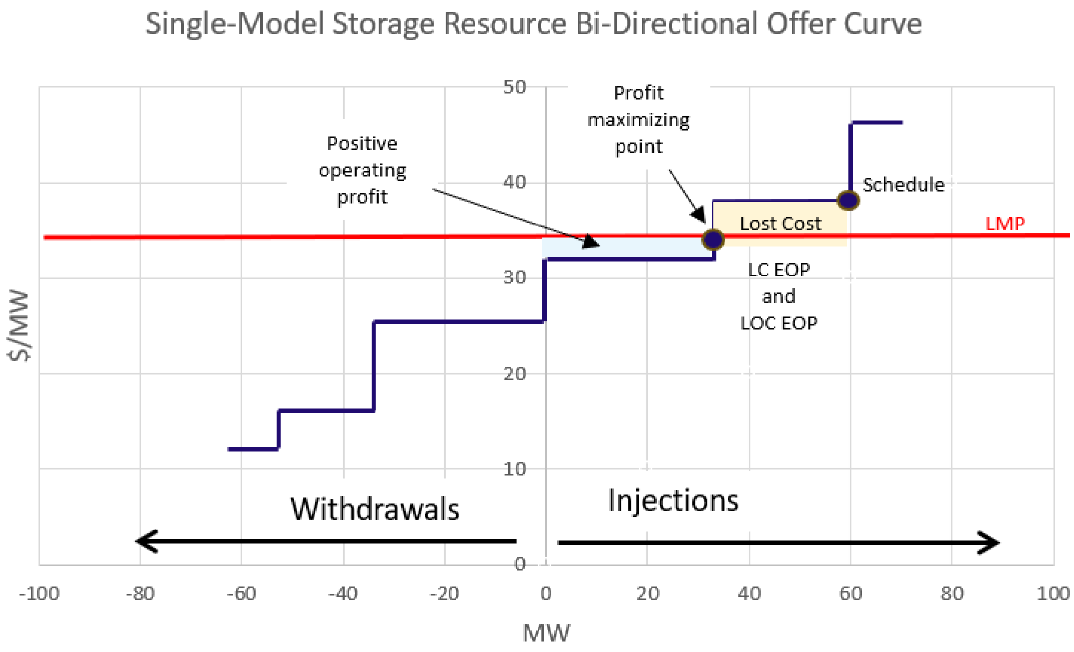
Scenario 3: SMSR is scheduled uneconomically to inject below its EOP

Price($)	Quantity (	Price to Schedule ($/MW)
12	-60	12 or less
15	-50	12.01 to 15
25	-30	15.01 to 25
32	0	25.01 to 32
32	30	32.01 to 37.99
38	60	38 to 44.99
45	80	45 or more

RT Schedule (RT_QSI)	15MW
LC EOP	15MW
LOC EOP	60MW
RT LMP	$42

	OP(LOC EOP)		OP(RT_QSI)	
Revenue	60MW x $42 =	$2,520	15MW x $42	$630
Cost				
	30MW x $32+		15MW x $30=	
	30MW x $38 =			
		$2,100		$450
Net	$2520-$2100=	$420		$180
RT_ELOC	$420 - $180 =	$240		

Injection (3): Single-Model Storage Resource



- **The SMSR is scheduled to inject when the LMP indicates it should be injecting less.**
- With the bi-directional offer curve, the operating profit is maximized at an injection of 35 MW.
- Backing off the injection to 35 MW eliminates negative offering profit, so the LC EOP is 35 MW.
- At this LMP, additional positive operating profit can't be achieved and the LOC EOP is also 35 MW.

Scenario 4: SMSR is scheduled uneconomically to inject above its EOP

Price($)	Quantity (	Price to Schedule ($/MW)
12	-60	12 or less
15	-50	12.01 to 15
25	-30	15.01 to 25
32	0	25.01 to 32
32	30	32.01 to 37.99
38	60	38 to 44.99
45	80	45 or more

RT Schedule (RT_QSI)	60MW
LC EOP	35MW
LOC EOP	35MW
RT LMP	$35

	OP(RT_QSI)		OP(LC EOP)	
Revenue	60MW x $35 =	$2,100	35MW x $35 =	$1,225
Cost				
	30MW x $32+		30MW x $32	
	30MW x $38 =		5MW x $38	
		$2,100		$1,150
Net	$2100-$2100=	$0		$75
RT_ELC	($0 - $75) *-1=	$75		