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Market Renewal – Energy Project: Overview of Economic Operating Point Design

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Meeting Purpose and Agenda

Purpose: Completing a stakeholder request to inform participants of the methodology for determining economic operating point (EOP) for lost cost and lost opportunity make whole payments (MWP)

Agenda:

- Detailed Design Recap: MWPs, What is EOP and why is it required
- Resources eligible for an EOP and EOP process overview
- Methodology for determining Day-Ahead Market (DAM) and Real-Time Market (RTM) lost cost EOPs
- Methodology for determining RTM lost opportunity EOPs
- Session Summary and Next Steps

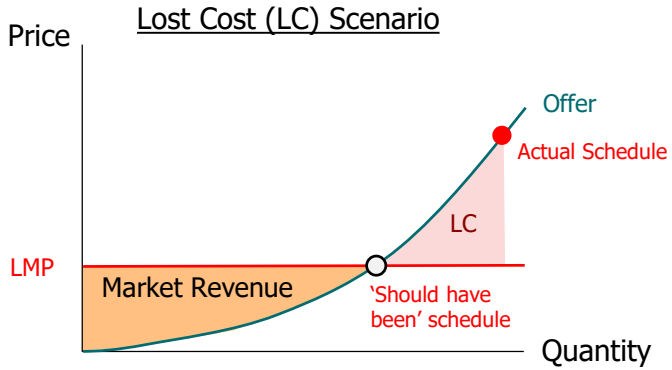
Detailed Design Recap: Why MWPs and What is EOP?

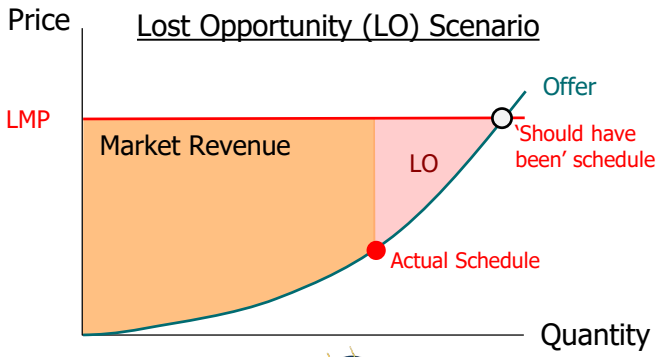
- Introducing a single schedule market where schedules and corresponding LMPs have greater alignment will substantially reduce the magnitude and frequency of make whole payment (MWPs) relative to today's two-schedule market
- Situations can still occur where schedules may not align with their corresponding LMPs, creating lost cost or lost opportunity scenarios
- MWPs are still required to maintain reliability, incentivizing a market participant to follow its schedule knowing they will not incur lost cost or lost opportunity
- EOP serves as the reference point from which MWPs for lost cost and lost opportunity scenarios are established – the 'should have been' schedule implied by a resource's locational market price (LMP)

Lost Cost and Lost Opportunity Scenarios

- Lost cost scenarios occur when the LMP implies the resource should have been scheduled lower

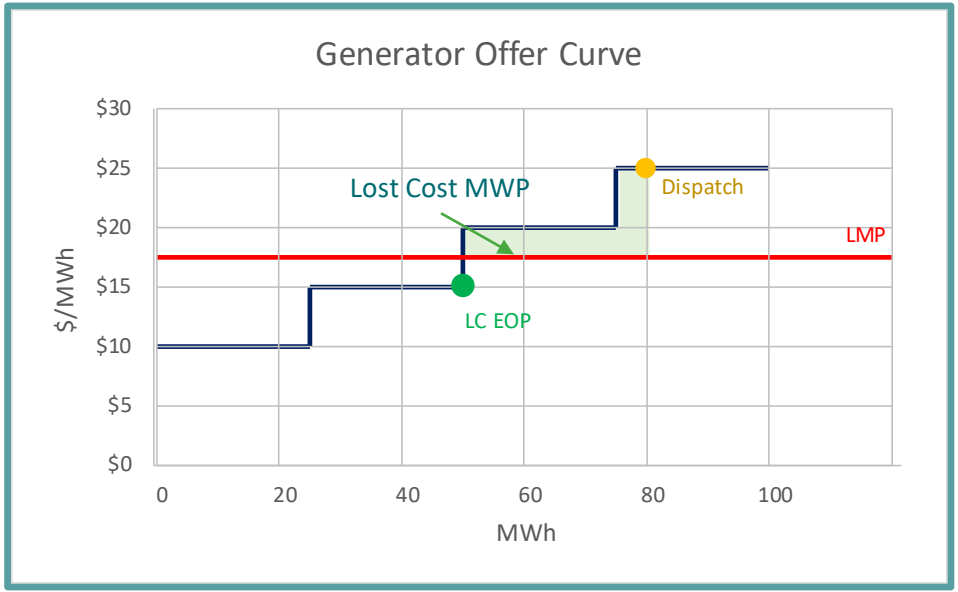
- Lost opportunity scenarios occur when the LMP implies the resource should have been scheduled higher





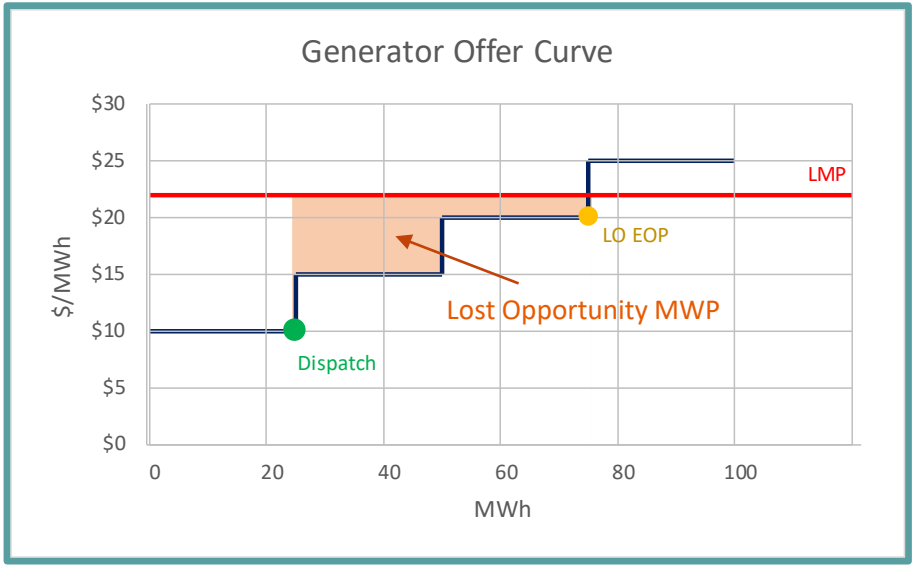
Lost Cost MWP and EOP Need

- A lost cost MWP is designed to compensate a resource when its market schedule results in unrecovered costs relative to its EOP
- Lost cost MWP is paid when market schedule > EOP
- Lost cost MWP incentivizes a resource to follow its market schedule knowing that it will not operate at a loss



Lost Opportunity MWP and EOP Need

- The lost opportunity MWP is designed to compensate a resource when its market schedule results in unrealized profits relative to its EOP
- Lost opportunity MWP is paid when market schedule < EOP
- Lost opportunity MWP incentivizes a resource to follow its market schedule knowing that it will not lose profits



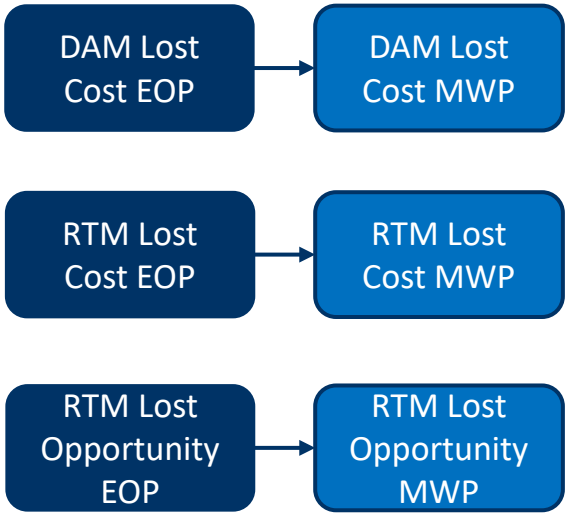
The Types of MWPs and EOPs

The Market Settlement Detailed Design includes three types of make whole payments (MWP):

- Lost Cost MWP for the Day-Ahead Market (DAM)
- Lost Cost MWP for the Real-Time Market (RTM) incremental to the DAM Lost Cost MWP
- Lost Opportunity MWP for the RTM

A separate EOP is required for each type of MWP

Lost opportunity MWPs are not required in DAM since opportunity costs are not fully realized until real-time



Resource Type Eligibility for MWP and EOP

Resource Type	DAM Lost Cost MWP & EOP	RTM Lost Cost MWP & EOP	RTM Lost Opportunity MWP & EOP
Dispatchable Generators	Yes	Yes	Yes
Non-Dispatchable Generators	No	No	No
Dispatchable Loads	Yes	Yes	Yes
Non-Dispatchable Loads	No	No	No
Imports	Yes	Yes	No
Exports	Yes	Yes	No
Price Responsive Loads and associated Hourly Demand Response Resources	Yes	No	No

Process for Determining EOP

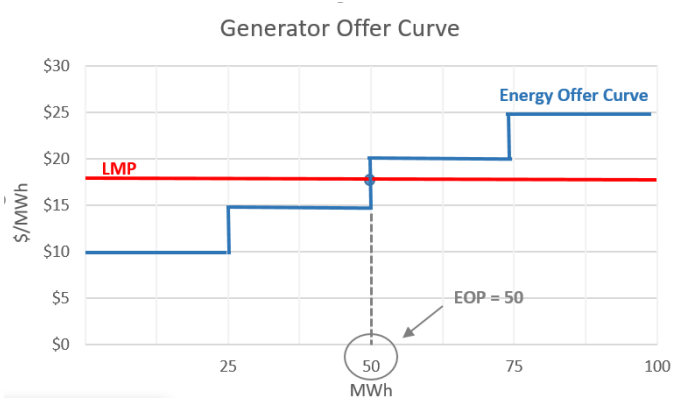
- Determining an EOP requires an evaluation of what schedule the resource could have achieved given its physical operating characteristics at its LMP, after initial market results are determined
- EOP inputs include a resource's dispatch data (offers/bids + operating constraints), outages/deratings, and LMPs
- EOPs are calculated for each interval scheduled for energy and each class of operating reserve (24 hourly intervals in DAM; 288 5-min intervals in the RTM)
- EOPs are re-calculated when administrative pricing is required

RTM Lost Cost EOP Methodology

RTM Lost Cost EOP Methodology

- RTM lost cost EOP will initially be determined where the resource's LMP intersects with the resource's offer curve

- Example: At an energy LMP of $17.50 in the RTM, this generator would have a RTM lost cost EOP of 50 MWh for energy



RTM Lost Cost EOP Adjustments

- RTM lost cost EOP may be adjusted when a resource's reserve loading point (RLP) is binding – meaning energy may have been scheduled above the intersection point to maximize operating profit from operating reserve
- RLP reflects the minimum amount of energy needed for a generator to provide the maximum quantity of operating reserve being offered. When RLP binds it implies the calculation engine may have scheduled energy at a loss to maximizing gains from trade from operating reserve
- If the operating profit realized from scheduling operating reserve more than offsets the lost cost incurred for energy, the EOP for energy will be set above the intersection point but no greater than the resource's RTM schedule

Example: EOP Adjustment When RLP Binds

- Assume the following offers and RTM results for Gen A

Product	Offer	RLP	LMP	Schedule	EOP Intersection
Energy	80 MW @ $10; 80 MW @ $50	N/A	$20	100 MW	80 MW (at $20 LMP)
10S OR	25 MW @ $5; 25 MW @ $15	100 MW	$80	50 MW	25 MW (at 80 MW of energy)

- A binding RLP results in an energy schedule > EOP intersection, implying a RTM lost cost MWP for energy as follows:
  = (Schedule – EOP Intersection) x (LMP – Offer Price)
  = (100 – 80) x (20 – 50)
  = $600

Example: EOP Adjustment When RLP Binds (cont'd)

- However, comparing the scheduled operating profit (OP) against the EOP intersection OP shows that operating reserve revenues more than offsets the lost cost in energy
- Scheduled OP = ($20 - $10) x 80 MW + ($20 - $50) x 20 MW + ($80 - $5) x 25 MW + ($80 - $15) x 25 MW = $3,700
- EOP Intersection OP = ($20 - $10) x 80 MW + ($80 - $5) x 25 MW = $2,675
- An OP of $1025 realized from Gen A's energy + operating reserve schedule more than offsets the $600 of lost cost in energy
- Therefore, the EOP for energy will be set to 100 MW to avoid make whole overpayment

DAM Lost Cost EOP Methodology

DAM Lost Cost EOP Methodology (General)

- Similar to RTM lost cost EOP, the DAM lost cost EOP will be determined where the resource's LMP intersects with the resource's offer curve and subject to the same adjustment when the RLP is binding
- An exception to this approach applies for dispatchable hydroelectric resources that were evaluated in the DAM as a cascade group
- A cascade group is defined as dispatchable hydroelectric resources that were linked with time lag and MWh ratio dispatch data dependencies in the DAM

DAM Lost Cost EOP for Cascade Resources

- A modified methodology for cascade resources only applies for the DAM lost cost EOP because cascade resources are effectively linked and evaluated as a single resource in the DAM
- The intent of the design is to set the DAM lost cost EOP equal to the DAM schedule and not trigger a MWP in situations where a cascade group of resources are in a lost cost scenario due to their own physical limitations
- Physical limitations imposed on a cascade resource include any operating constraints imposed by a market participant for safety, environmental, regulatory or legal reasons. These are typically submitted as dispatch data constraints or as manual constraints by the IESO on behalf of the market participant

DAM Lost Cost EOP for Cascade Resources (cont'd)

- Where a cascade group of resources are scheduled into a lost cost scenario for reasons that are not due to their own physical limitations, the EOP methodology will consider whether the operating profits for an upstream resource offset any losses incurred on a downstream resource or vice versa
- Physical limitations not imposed by the market participant include manual constraints imposed by the IESO for reliability reasons

DAM Lost Cost EOP for Cascade Resources (cont'd)

- DAM lost cost EOP for cascade resources will be equal to their DAM schedules when the following conditions are met:
  - (Any resource in the cascade group has a schedule equal to physical restriction on the resource imposed by the market participant; OR

    No resources in the cascade group have schedules that are equal to a manual restriction placed on the resource for IESO reliability reasons); AND
  - No constraint violations are identified by the DAM calculation engine
- If these conditions are not met, the DAM lost cost EOP will be determined by calculating the profit-maximizing energy and OR EOPs considering the submitted time lag and MWh ratio inputs

Example: Determining Profit Maximizing EOPs

- Assuming the following dispatch data and RTM results for the cascade group:

Resource	Energy Offer	Time Lag	MWh Ratio	LMP
G1	50 MW @ $10; 40 MW @ $20	N/A	N/A	$29
G2	50 MW @ $25; 40 MW @ $50	2 hours	0.9	$10

- The profit-maximizing EOPs will be calculated for each set of hours that the resources can be scheduled for in the DAM given the 2 hour time lag (e.g. hours 1 and 3, hours 2 and 4, hours 3 and 5 and so on)
- The operating profits for all schedule combinations between minimum and maximum capability of the cascade group will be calculated and compared
- The set of schedules that maximize the operating profit for the cascade group will be used to set the EOPs for cascade group resources.

Example: Determining Profit Maximizing EOPs (cont'd)

- For our example, the DAM lost cost EOPs for G1 and G2 would be 50 MW and 45 MW respectively (i.e. the profit maximizing combination)

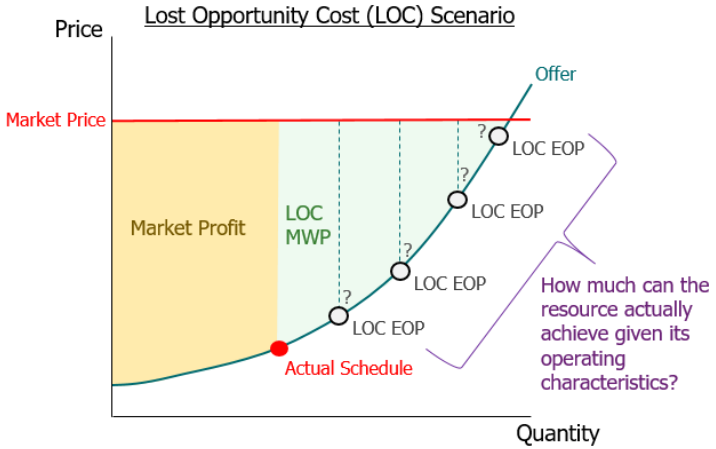
G1 EOP	G2 EOP (G1 EOP x MWh Ratio)	G1 OP [G1 EOP x (G1 LMP – G1 Offer $)]	G2 OP [G2 EOP x (G2 LMP – G2 Offer $)]	Total OP (G1 OP + G2 OP)
0 MW	0 MW	$0	$0	$0
⋮	⋮			
49 MW	44.1 MW	$931	-$661.5	$269.5
50 MW	**45 MW**	**$950**	**-$675**	**$275**
51 MW	45.9 MW	$959	-$688.5	$270.5
⋮	⋮			
90 MW	81 MW	$1,310	-$1,990	-$680

Represents the profit maximizing combination of EOPs

RTM Lost Opportunity EOP Methodology

RTM Lost Opportunity EOP Considerations

- Determining the RTM lost opportunity EOP cannot be as straightforward as determining where the LMP intersects with the offer curve because it may over compensate the market participant if the resource in question wasn't physically able to achieve the intersection quantity
- As shown in the lost opportunity scenario illustration, the resource is scheduled below the quantity implied by the LMP
- It is possible that the resource was not able to achieve the intersection quantity given its operating characteristics (i.e. ramp rates, deratings etc.)
- A simple EOP intersection would create make whole over-payment situations



RTM Lost Opportunity EOP Considerations (cont'd)

- The following example further illustrates the risk of make whole over-payment between energy and operating reserve, assuming an LMP-offer curve intersection methodology was used
- Assume the following dispatch data and RTM results for Gen A:

Product	Offer	LMP	Schedule	EOP Intersection
Energy	50 MW @ $30	$35	30 MW	50 MW (at $35 LMP)
10S OR	20 MW @ $5	$18	20 MW	20 MW (at $18 LMP)

- Although the maximum capability of Gen A is 50 MW, the 70 MW sum of the energy and operating reserve EOPs exceeds the maximum capability of the resource by 20 MW

RTM Lost Opportunity EOP Methodology

- The most accurate way to determine what the resource should have been scheduled to is to re-evaluate what the resource was physically able to achieve at its LMP given its operating characteristics
- The re-evaluation is similar to the optimization performed by the RTM calculation engine scheduling algorithm, with two main differences:
  - The resource's LMP is an input into the objective function; and
  - Each resource's energy offers/bids for energy and operating reserve are jointly optimized in isolation vs. other resources
- The lost opportunity EOP optimization avoids the potential for make whole over-payment by determining the most optimal energy and operating reserve schedules the resource could achieve at its LMPs while respecting the same operating constraints it had in the RTM.

Summary

- MWPs are required to ensure a resource is incentivized to follow its schedule to meet reliability needs of the system when LMPs place the resource in a lost cost or lost opportunity scenario
- EOPs establish the reference point from which MWPs are determined
- For lost cost MWPs, the intersection of a resource's LMP and its offer curve establishes the EOP, subject to specific constraints (when RLP is binding and cascade resource constraints are submitted)
- For lost opportunity MWPs, a joint optimization of resource offers/bids against its LMPs is required to determine EOPs to ensure MWPs for lost opportunity scenarios are not overpaid

Next Steps

- The EOP process and corresponding formulations will be provided for stakeholder review as part of the Market and System Operations batch of market rules and manuals

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