Wind/Solar Dispatch Solution Options

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Current Status

- PJM supports and can implement these solution options.
- The following solution options do not represent a final proposal.
- PJM remains open to additional input and alternative options.
- Additional analysis is on-going and will be presented in support of a proposal in future meetings.

Challenges with Renewable Dispatch

- Currently there are three variables associated with renewable dispatch capability.
  - SE MW
  - Bid In Eco Max
  - Renewable Forecast
- The built in uncertainty associated with using Bid In Eco Max (not being updated) or Forecast (forecast error) has made it difficult to provide an accurate dispatch basepoint.
- SE MW is the best indicator of where the resource is currently operating and most likely be operating in the next 5 minutes.

Key Point: *Physical Characteristics of Renewable Resources Present Unique Challenges to PJM Dispatch*

Unlimited ramp capability

- Fast moving resources can lead to large MW swings from interval to interval
- Results in constraint volatility, potential ACE swings

Inconsistent bid-in parameters

- Resources operating outside their economic parameters creates discrepancies between SCED solution and reality
- Can lead to out-of-market actions

Solution Options - RTSCED

Design Component for RTSCED	Status Quo	Solution Option 1	Solution Option 2	Justification
Minimum dispatch MW signal	RTSCED is limited to dispatching resources based on submitted Economic minimum parameter	Bid-in Economic Minimum (Status Quo)		Continue to dispatch resource down to bid-in Economic minimum, eliminate any reliability concerns for resources not able to move down to 0 MW.
Maximum dispatch MW signal	RTSCED is limited to dispatching resources based on submitted Economic maximum parameter	1) If resource is not curtailed in the previous approved RTSCED case, then the effective EcoMax will be latest solved SE value. 2) If resource was curtailed in the previous approved RTSCED case, the an effective EcoMax will be the maximum of SE solution, Forecast for the target time or the bid-in Economic Maximum.	1) If resource is not curtailed in the previous approved RTSCED case, then the Effective EcoMax will be latest solved SE value. 2) If resource was curtailed in the previous approved RTSCED case, then Effective EcoMax will be either the minimum of PJM or participant forecast (Bid-in EcoMax).	Removes uncertainty of resource ability to achieve their forecast MW or SCED utilizing inconsistent bid-in parameters. Relies on utilizing forecast to determine optimal dispatchable range during transition periods.

Key Point: *There are limitations in RT SCED that prevent the optimal dispatch of Wind and Solar Resources*

IMW Solution

- Co-optimization of energy and reserves utilizing the latest SE solution, ramp, and load forecast values
- Assumes all resources reach basepoint at target time

IGD MW (Basepoint) Solution

- Economic basepoints are determined in a post process, based on the IMW solution LMPs
- Must respect bid-in economic parameters

Based on this current logic, SCED solutions and Basepoint signals diverge when resources are operating outside of their bid-in parameters.

Solution Options - RTSCED

Design Component for RTSCED	Status Quo	Solution Option	Justification
Dispatch basepoint calculation (IGD MW)	The dispatch basepoint, IGD MW, must be within the submitted bid-in parameters	Calculated basepoint to be within Economic Minimum and Effective Economic Maximum while accounting for ramp rate for target time. Internal MW and Basepoint to be same value.	Allow resources to be dispatchable to their effective capability and not limited by inconsistent bid-in parameters.
Curtailment Instructions	Curtailment Indicator currently set to be retired in March of 2025, resources expected to follow PJM dispatch signal	Provide curtailment flag to Wind and Solar resources. When the dispatch MW (and internal MW) is less than effective economic maximum, send the curtailment flag to resources.	Provide additional instruction to Wind and Solar resources to follow PJM basepoint when needed.
Solar Forecast MW utilization in RT SCED	Solar Forecast is not utilized in RT SCED	Will be utilized to determine the Effective Economic Maximum when resources are curtailed.	To be utilized within effective economic maximum calculation to determine where the resource can be dispatched when resource is no longer being curtailed.
Wind Forecast MW utilization in RT SCED	Wind Forecast is used in the ATM logic to determine the band for where a resource is dispatched within for internal MW (iMW) calculation.	Will be utilized to determine the Effective Economic Maximum when resources are curtailed.	To be utilized within effective economic maximum calculation to determine where resource can be dispatched when resource is no longer being curtailed.

High-Level Summary of Current Proposal

- The proposal utilizes a concept of an “Effective EcoMax”
- Effective EcoMax would change based on how the resources was dispatched in the previous approved RTSCED case.
- If resource was not previously curtailed, a non-curtailment period, the Effective EcoMax would be equal to the State Estimator solution value.
- If resource was previously curtailed, curtailment period, the Effective EcoMax would be equal to Option 1 or Option 2.

Terminology for Examples

Name	Type	Description
Interval		Each row represents one hypothetical RTSCED case solution.
SE MW	Input	Solved State Estimator solution value, which is treated as the initial MW for each RTSCED case.
Curtailment Flag	Input	Proposed resource specific flag, used to determine the Effective Economic Max that should be use for the current interval. This is based on previously approved RTSCED case solution.
Forecast MW	Input	PJM forecast MW data.
Bid-in EcoMax	Input	Resource Bid-In Economic Maximum MW
Effective EcoMax Option 1	Input	Proposed dispatchable range, up to effective EcoMax. In this option, the Effective EcoMax would be based on the formula: Effective EcoMax = Max (SE, Forecast, Bid in EcoMax)
Calculated Basepoint Option 1	Output	Based on RTSCED solution would be the proposed, calculated output based on the effective EcoMax from Option 1.
Effective EcoMax Option 2	Input	Proposed dispatchable range, up to effective EcoMax. In this option, the Effective EcoMax would be based on the formula: Effective EcoMax = Min (Forecast, Bid in EcoMax)
Calculated Basepoint Option 2	Output	Based on RTSCED solution would be the proposed, calculated output based on the effective EcoMax from option 2.
Curtailment Flag	Output	Calculated based on RTSCED case solution, based on the effective EcoMax and economics of the unit and case.
Description		Interpretation of the case solution.

Example 1 - Unit Operating Above Bid-In EcoMax

Interval	SE (MW)	Curtailed	Forecast MW	Bid-In EcoMax (MW)	Effective EcoMax (MW) Option 1	Calculated Base Point Option 1	Effective EcoMax (MW) Option 2	Calculated Base Point Option 2	Curtailed	Description
Type	Input	Input	Input	Input	Input	Output	Input	Output	Output	
1	0	0	0	100	0	0	0	0	0	Unit is offline
2	50	0	75	100	50	50	50	50	0	Unit is online, dispatchable up to Effective EcoMax, which is equal to the SE value because the unit was not curtailed in the previous interval.
3	110	0	75	100	110	110	110	110	0	Unit continues to produce more MWs, since it was not curtailed in the previous interval, continues to be dispatchable up to effective EcoMax, which is the SE value at this point.
4	95	0	95	100	95	95	95	95	0	Effective EcoMax continues to be based on the solved SE value since it was not curtailed in the previous interval.

When previously curtailed:

Option 1 - Effective EcoMax = Max (SE, Forecast, Bid in EcoMax)

Option 2 - Effective EcoMax = Min (Forecast, Bid in EcoMax)

*Since unit is not curtailed, there is no difference in option 1 or 2. Effective EcoMax = SE Value.

Example 2 – Curtailment

Interval	SE (MW)	Curtailed	Forecast MW	Bid-In EcoMax (MW)	Effective EcoMax (MW) Option 1	Calculated Base Point Option 1	Effective EcoMax (MW) Option 2	Calculated Base Point Option 2	Curtailed	Description
Type	Input	Input	Input	Input	Input	Output	Input	Output	Output	
1	110	0	75	100	110	85	110	85	1	1)Unit providing above bid-in EcoMax. 2)Assume constraint binds and SCED needs to move the unit down to 85MW. 3) Assume unit was not previously curtailed. Effective EcoMax would be up to 110MW.
2	105	1	95	100	105	85	95	85	1	1) Unit moves down slightly. 2) SCED continues to dispatch resource to 85MW. 3) Effective EcoMax continues to be based on the formulas since unit was previously curtailed.
3	80	1	95	100	100	85	95	85	1	1) Unit moves down more than needed. 2) Resources continues to be dispatched to 85 MW. 3) Unit continues to be curtailed since it is not dispatched up to Effective EcoMax (assuming economic would have allowed it to be).
4	80	1	95	100	100	100	95	95	0	1) Constraint no longer active. 2) Unit is dispatched up based on Effective EcoMax formulas

When previously curtailed:

Option 1 - Effective EcoMax = Max (SE, Forecast, Bid in EcoMax)

Option 2 - Effective EcoMax = Min (Forecast, Bid in EcoMax)

Example 3 – Transition Periods

Interval	SE (MW)	Curtailed	Forecast MW	Bid-In EcoMax (MW)	Effective EcoMax (MW) Option 1	Calculated Base Point Option 1	Effective EcoMax (MW) Option 2	Calculated Base Point Option 2	Curtailed	Description
Type	Input	Input	Input	Input	Input	Output	Input	Output	Output	
1	110	0	75	100	110	0	110	0	1	1)Unit providing above bid-in EcoMax. 2)Assume Constraint binds and SCED needs to move the unit down to 0MW. 3) Assume unit was not previously curtailed, Effective EcoMax would be up to 110MW.
2	0	1	75	100	100	0	75	0	1	1) Unit moves down to 0MW. 2) SCED continues to dispatch resource to 0MW. 3) Effective EcoMax based on the formulas since unit was previous curtailed.
3	0	1	75	100	100	100	75	75	0	1) Constraint no longer active. 2) Resources is dispatched to up to effective EcoMax. 3) **Transition period.**
4	80	0	75	100	80	80	80	80	0	1) Since unit was not previously curtailed, unit is dispatched to effective EcoMax of solved SE value.

When previously curtailed:

Option 1 - Effective EcoMax = Max (SE, Forecast, Bid in EcoMax)

Option 2 - Effective EcoMax = Min (Forecast, Bid in EcoMax)

Next Steps – Continue Development

- While current proposal improves dispatching of wind/solar resources, there are additional gaps and potentials for new challenges.
- With relying on SE solution to create a dispatchable range during unconstraint periods, proposal eliminates accounting for MWs that resources may not be able to achieve.
- However, challenges could arise during sunrise and sunset periods as SCED would not be account for additional MWs coming online or going offline, respectively.
- While constraint volatility may be minimized, it is not eliminated with this proposal.

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PJM Solution Option Details

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Appendix

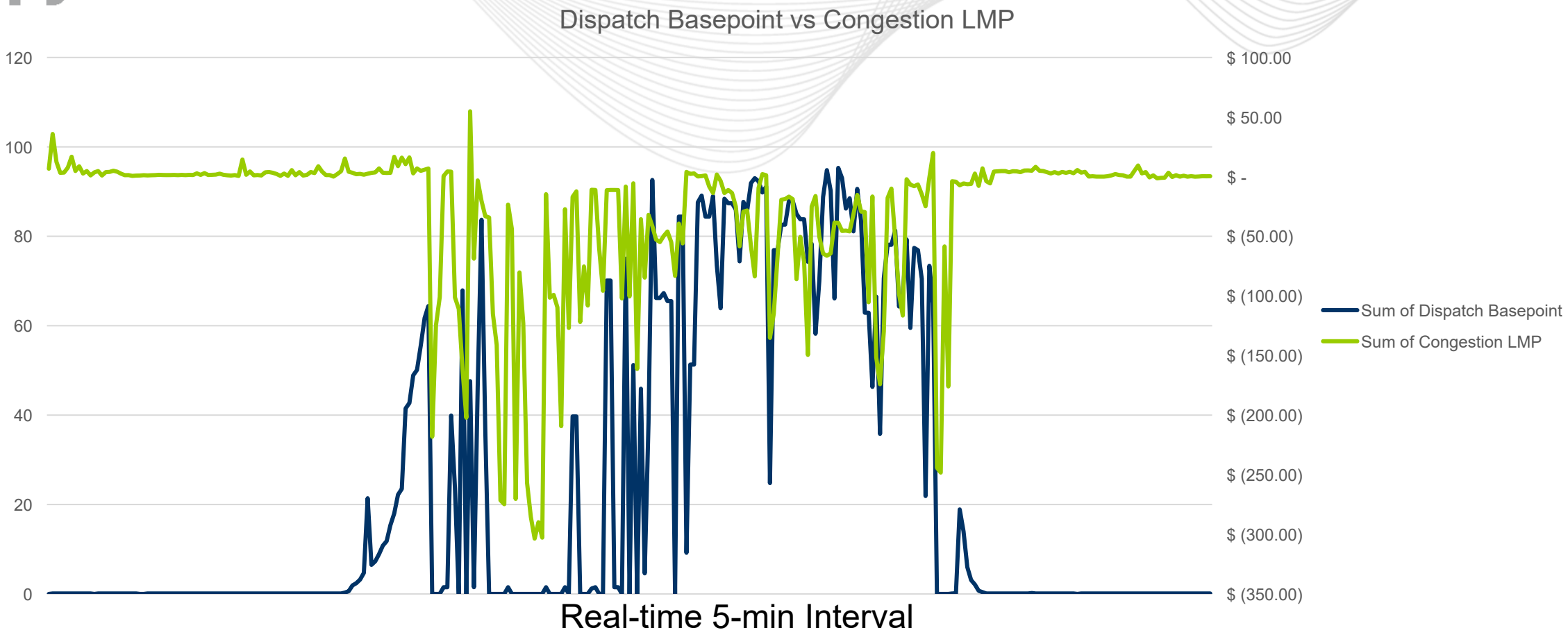
Misalignment of iMW and IGD MW Example

- Both resources operating above their bid-in EcoMax

Wind Unit	MARGINAL COST	LMP	SE MW	iMW	IGD MW	ECONOMIC MIN BID IN	ECONOMIC MAX BID IN
A	$0	$10	150	150	90	0	90
B	$0	$10	125	125	100	0	100

Key takeaway: SCED Basepoint is limited by economic parameters. Outdated values can lead to out of market, manual actions by PJM Dispatch.

Example: Dispatch Basepoint vs Congestion LMP



Key takeaway: Existing SCED dispatch logic and input parameters create volatile RT pricing and control issues for PJM Dispatch. This pattern on a larger scale can lead to ACE swings.

PROTECT THE POWER GRID

THINK BEFORE YOU CLICK!

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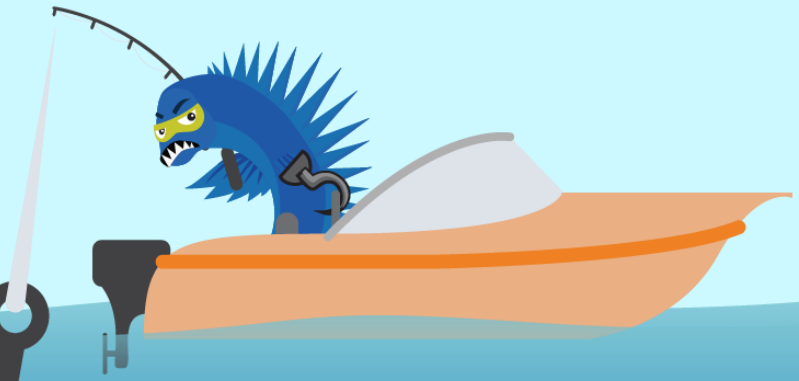

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