Circuit Breaker Simulation

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Disclaimer

- This presentation is meant to illustrate hypothetical scenarios to generate stakeholder discussion.
- The conditions and outcomes of the scenarios should not be interpreted to represent future market outcomes.

Scenario 1: Real-Time Load Risk Analysis Assumptions

Load Assumptions	• RT Hourly Metered Load levels from Jan. 7, 2014 • 97% of RT Hourly Load purchased at DA LMP in Day-Ahead Market • Remaining 3% of Load purchases at RT LMP in Balancing Market
Pricing Assumptions	• Shortage conditions assumed for 14 hours in Real-Time, starting at HE 7 • Simulated shortage with three pricing levels ($3,750 | $6,300 | $12,000) • Non-shortage hours use actual DA and RT Hourly LMPs from 1/7/2014
Circuit Breaker Design Assumptions	• Triggered after 10 hours of continuous shortage conditions (in effect for 4 hours of simulation) • Circuit breaker price set to $2,000/MWh

Analysis Findings – Scenario 1: Real-Time Load Risk

3% of Real-Time Load Exposed to Shortage Pricing for 14 Hours

Assumed Max Energy Price	RT Load Billing without Circuit Breaker	RT Load Billing with Circuit Breaker	Total Daily Billing*	Benefit to Exposed RT Load	%Total Daily Billing
$3,750	$224 Million	$195 Million	$972 Million	13%	3%
$6,300	$368 Million	$297 Million	$1.11 Billion	19%	6%
$12,000	$691 Million	$526 Million	$1.44 Billion	24%	11%

*Total Daily Billing = DA Energy Charges (97% Hourly Metered Load * Actual DA LMP) + RT Load Billing without Circuit Breaker

Takeaway: When shortage conditions only exist in real-time, the circuit breaker has a smaller benefit to load because of the small portion of load that is exposed to RT LMP.

Scenario 2: Generator Risk Analysis Assumptions

Generation Assumptions	• RT Hourly Metered Load levels from Jan. 7, 2014 • 97% of RT Hourly Load supplied by generation at DA LMP in Day-Ahead • 14% of DA cleared Generation forced out in Real-Time required to buy back at difference between DA and RT LMPs
Pricing Assumptions	• Shortage conditions assumed for 14 hours in Real-Time; Starting at HE7 • Simulated with three pricing levels ($3,750 | $6,300 | $12,000) • Non-shortage hours use actual DA and RT Hourly LMPs from 1/7/2014
Circuit Breaker Design Assumptions	• Triggered after 10 hours of continuous shortage conditions (in effect for 4 hours of simulation) • Circuit breaker price set to $2,000/MWh

Analysis Findings – Scenario 2: Generator Risk

14% of Day-Ahead Generation Buy Back During 14 Hour Shortage Event

Assumed Max Energy Price	RT Energy Buy Back without Circuit Breaker	RT Energy Buy Back with Circuit Breaker	Benefit to Supply
$3,750	$937 Million	$804 Million	14%
$6,300	$1.6 Billion	$1.3 Billion	21%
$12,000	$3.1 Billion	$2.3 Billion	25%

Takeaways: When shortage conditions only exist in real-time:

- The circuit breaker provides benefit to supply that is unavailable in real-time at the expense of incentivizing performance.
- Additive Capacity Performance penalties provide additional exposure.
- Capacity Performance penalties have an existing stoploss provision.

Scenario 3: Day-Ahead Shortage Analysis Assumptions

Load Assumptions	• RT Hourly Metered Load levels from Jan. 7, 2014 • 97% of load exposed to Day-Ahead prices
Pricing Assumptions	• Single day reserve shortage event; multi-day would be additive • Shortage conditions assumed for all 24 hours in Day-Ahead • Simulated with three pricing levels ($3,750 | $6,300 | $12,000)
Circuit Breaker Design Assumptions	• Simulation applies circuit breaker to all 24 hours • Circuit breaker price set to $2,000/MWh

Analysis Findings – Scenario 3: Day-Ahead Shortage

Shortage Event Triggered in Day-Ahead Market for all 24 Hours and Circuit Breaker Applied all 24

Assumed Max Energy Price	Estimated Cost without Circuit Breaker	Estimated Cost with Circuit Breaker	Reduction in Day-Ahead Billing
$3,750	$11.4 Billion	$5.1 Billion	55%
$6,300	$16.0 Billion	$5.1 Billion	68%
$12,000	$30.5 Billion	$5.1 Billion	83%

Takeaways: If there is a shortage in day-ahead:

- DA circuit breaker has a significant impact, even at existing price caps.
- Likelihood of DA shortage is low, as load not likely to bid into DA Market at the maximum price.

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Appendix
Historical Frequency of Shortage Conditions

Frequency of Shortage Conditions (2012-2017)

Date	Shortage Locations	Shortage Products	Total Number of Intervals / Max. Consecutive Intervals	Reason for Shortage
January 6, 2014	MAD & RTO	Primary and Synchronized Reserves	12 / 12	Voltage Reduction Action for RTO
January 7, 2014	MAD & RTO	Primary and Synchronized Reserves	59 / 54	Reserve shortage
September 21, 2017*	RTO	Synchronized Reserves	2	Reserve shortage
	MAD & RTO	Primary Reserves	19 / 12	Reserve shortage
October 31, 2017*	MAD & RTO	Synchronized Reserves	1 / 1	Reserve shortage

*Only short the Extended Reserve Requirement (Step 2 of ORDC)

Frequency of Shortage Conditions (2018-Present)

Year	Shortage Locations	Shortage Products	Total Number of Intervals / Max. Consecutive Intervals	Reason for Shortage
2018	MAD & RTO	Primary and Synchronized Reserves	5 / 2	Reserve shortage
2019	MAD & RTO	Primary and Synchronized Reserves	35 / 4	Reserve shortage
2020	MAD & RTO	Primary and Synchronized Reserves	8 / 2	Reserve shortage
2021	MAD & RTO	Synchronized Reserves	9 / 2	Reserve shortage