Shortage Pricing Penalty Factors and the Offer Cap

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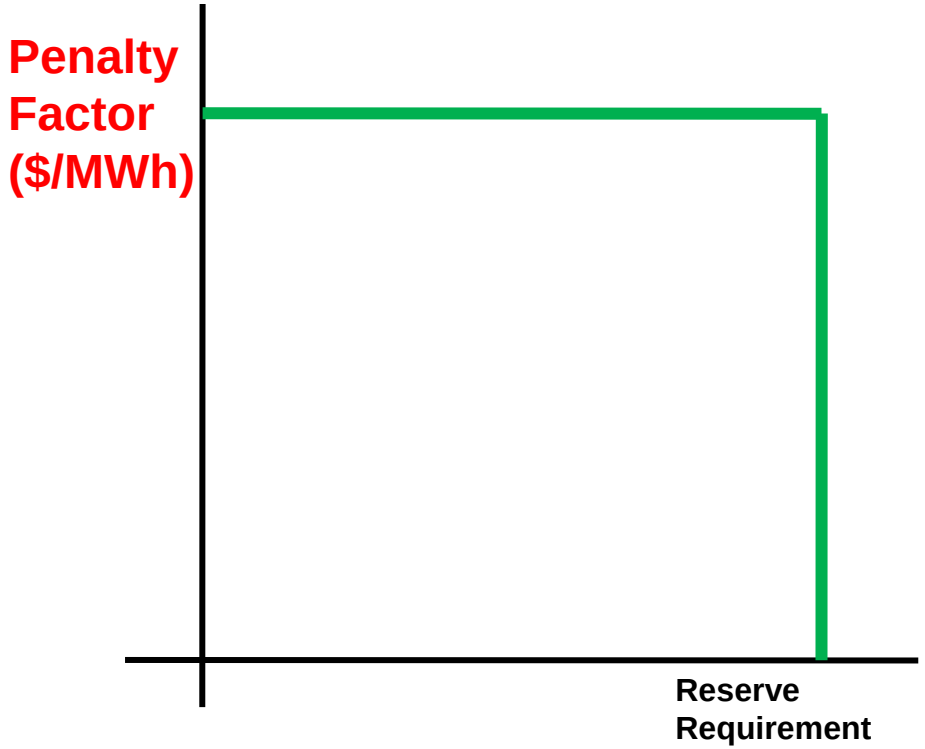
Background Information

- Operating Reserve Demand Curve (ORDC) and Reserve Constraint Penalty Factor Curve (RCPF) interchangeable terms
- The Penalty Factor (PF) is the y-coordinate on the ORDC
- For the curves we use today, the x-coordinate is the reserve requirement for the specific reserve product
  - Primary or Synchronized Reserves
  - RTO or Mid-Atlantic + Dominion
- Four total curves



The Penalty Factor

- The Penalty Factor level:
  - Puts a defined limit on the cost willing to be incurred to substitute reserves for energy
  - Acts as a cap on the market clearing price
- If the cost for a resource to provide reserves exceeds the willingness to pay for that reserve product, it will not be committed for reserves by the dispatch engine
  - The shortage created by not committing such resources will be consumed by the ORDC
  - PJM Operations would still assign reserves out-of-market if available and the cost of those reserves would be recovered through a make whole payment in the reserve market
- The penalty factor only explicitly impacts LMPs during shortage conditions.
  - We have had 10 hours of shortage pricing since it was implemented on October 1, 2012.
  - This is about .04% of all hours.

Conceptual Discussion: *Penalty Factors*

- Penalty factors must
  - Permit the full utilization and pricing of all assets necessary to meet energy and reserve needs given the offer cap
  - Not be set artificially low and result in “economic shortages”
    - Results in LMPs that are inconsistent with system conditions
    - Results in unutilized assets to meet system needs
    - Additional manual work by PJM Operators to manually allocate resources
    - May not be done in the most cost-effective manner
  - Not be set artificially high resulting in large and potentially unnecessary swings in LMPs and reserves prices

Why does the energy offer cap matter?

- A significant portion of the cost of the reserves during extreme system conditions is lost opportunity costs.
  - Lost opportunity costs depend on the offer of the unit providing reserves and the LMP.
  - The LMP depends on the offer price of the marginal unit.
  - As the LMP increases, the potential lost opportunity cost incurred by resources providing reserves will increase.
- The penalty factor must be increased to accommodate the increase in opportunity costs.
- Failure to do this will result in economic shortages.

Example Information

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)
A	$100	300	80
B	$500	400	100
C	$700 + $1/MW Output (up to $1,000)	400	80
Reserve Requirement: 200 MW		Penalty Factor for being short reserve: $850/MWh	Energy Offer Cap = $1,000/MWh

Generator C Cost Curve Example

- Generator C has an energy offer of $700 + $1/MW
  - Intended to simulate an incremental offer curve rather than a fixed offer like units A & B
  - For example:

Output (MW)	Calculation	Offer ($/MWh)
10	$700 + (10 MW * $1/MWh)	$710/MWh
100	$700 + (100 MW * $1/MWh)	$800/MWh
250	$700 + (250 MW * $1/MWh)	$950/MWh
300	$700 + (300 MW * $1/MWh)	$1,000/MWh
350	$700 + (300 MW * $1/MWh)	$1,000/MWh

Offer capped at $1,000/MWh

Adequate Supply— 200 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (LMP)	$100	300	80	**200**	**80**
B	$500	400	100	**0**	**100**
C	$700 + $1/MW	400	80	**0**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $100/MWh, Reserve price = $0/MWh
  - Gen A sets LMP

Adequate Supply— 400 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (MCP)	$100	300	80	**280**	**20**
B (LMP)	$500	400	100	**120**	**100**
C	$700 + $1/MW	400	80	**0**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $500/MWh, Reserve price = $400/MWh
  - Reserve price set by lost opportunity cost of Gen A, LMP set by Gen B

Adequate Supply— 700 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (MCP)	$100	300	80	**280**	**20**
B	$500	400	100	**300**	**100**
C (LMP)	$700 + $1/MW	400	80	**120**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $820/MWh, Reserve price = $720/MWh
  - Reserve price set by lost opportunity cost of Gen A, LMP set by Gen C

Close to Shortage — 829 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (MCP)	$100	300	80	**280**	**20**
B	$500	400	100	**300**	**100**
C (LMP)	$700 + $1/MW	400	80	**249**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $949/MWh, Reserve price = $849/MWh
  - Reserve price set by lost opportunity cost of Gen A, LMP set by Gen C

Economically Shortage — 840 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (LMP)	$100	300	80	**290**	**10**
B	$500	400	100	**300**	**100**
C	$700 + $1/MW	400	80	**250**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $950/MWh, Reserve price = $850/MWh
  - Reserve price set by the ORDC, LMP by Gen A + PF

What happened?

- The system went short of reserves even though enough capacity was available.
  - 1,100 MW of capacity available, only 1,030 MW used yet the system is “short”
  - Instead of dispatching Gen C for more energy and maintaining reserves, Gen A’s reserves are converted to energy causing a shortage because they would cost more than the PF if Gen C set LMP at $951/MWh
  - PJM operators will manually assign Gen A 20 MW of reserves

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (LMP)	$100	300	80	**290**	**10**
B	$500	400	100	**300**	**100**
C	$700 + $1/MW	400	80	**250**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

Economically Shortage — 855 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A	$100	300	80	**300**	**0**
B	$500	400	100	**300**	**100**
C (LMP)	$700 + $1/MW	400	80	**255**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $955/MWh, Reserve price = $850/MWh
  - Reserve price set by the ORDC, LMP by Gen C

What happened?

- The system is still short reserves.
  - 1,100 MW of capacity available, only 1,035 MW used yet the system is “short”
  - Reserves on Gen A are now fully converted to energy
  - PJM operators must counteract this by manually assigning Gen A 20 MW
  - The system prices indicate a shortage that does not exist
  - Gen A is made whole via reserve uplift

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (LMP)	$100	300	80	**300**	**0**
B	$500	400	100	**300**	**100**
C	$700 + $1/MW	400	80	**255**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $850/MWh		Energy Offer Cap = $1,000/MWh

Economically Shortage — 855 MW Energy Demand

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (MCP)	$100	300	80	**280**	**20**
B	$500	400	100	**300**	**100**
C (LMP)	$700 + $1/MW	400	80	**275**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $1,000/MWh		Energy Offer Cap = $1,000/MWh

- Energy price = $975/MWh, Reserve price = $875/MWh
  - Reserve price set by Unit A, LMP by Unit C

What happened?

- The system is no longer short reserves.
  - 1,055 MW of 1,100 MW of capacity are utilized
  - No economic shortage
  - Reserves on Gen A are restored
  - PJM operators do not need to intervene
  - The system prices do not indicate a shortage
  - No additional uplift is created

Generator	Energy Offer ($/MWh)	Total Capacity (MW)	Reserve Capability (MW)	Assigned Energy (MW)	Assigned Reserve (MW)
A (MCP)	$100	300	80	**280**	**20**
B	$500	400	100	**300**	**100**
C (LMP)	$700 + $1/MW	400	80	**275**	**80**
Reserve Requirement: 200 MW			Penalty Factor for being short reserves: $1,000/MWh		Energy Offer Cap = $1,000/MWh

Energy Offer Cap and Penalty Factor Level

- Allowing an increase in the offer cap will result in an increase in opportunity costs for reserve resources when high-priced resources are marginal
- If the offer cap is increased, the reserve penalty factors must follow
- Due to the temporary nature of the waivers, the penalty factors were not previously addressed.
- A permanent solution to the offer cap issue must include penalty factor changes.

Marginal Energy Offer ($/MWh)	Reserve Resource Offer ($/MWh)	Lost Opportunity Cost ($/MWh)
$500	$100	$400
$1,000	$100	$900
$1,500	$100	$1,400
$2,000	$100	$1,900