ORDC Supplemental Information – Part II

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Multiple Reserve Products - Product Substitution

Synch Reserves

Product Substitution

Primary Reserves

When MWs from a single product can be used to meet the requirements for multiple products

Synchronized Reserves

Requirement 1,450 MW

Available: 2,000 MW
Cleared: 1,450 MW
Remaining: 550 MW

Primary Reserves

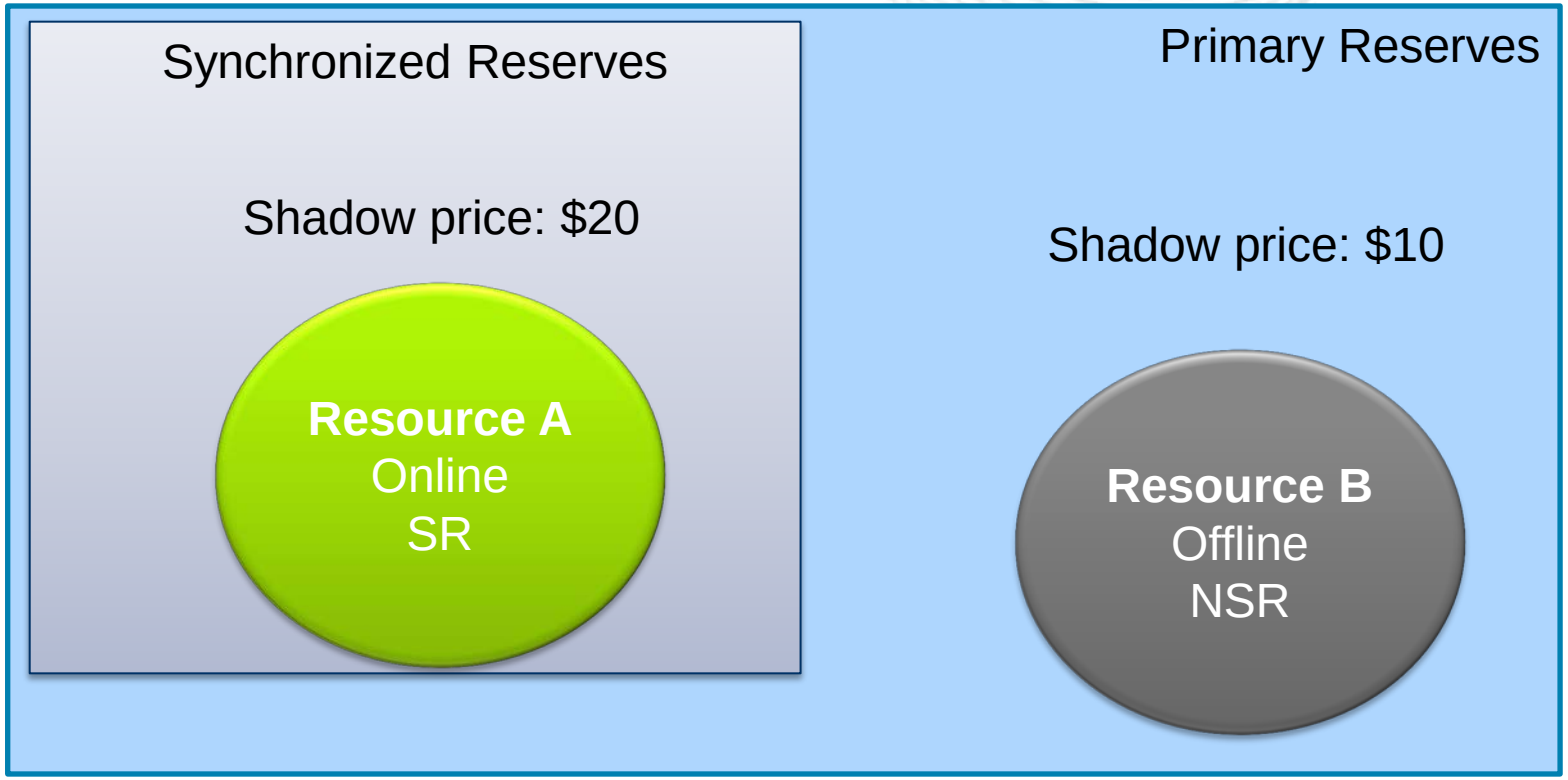
Requirement 2,175 MW
SR -1,450 MW
725 MW

Cleared based on most economic set

Note: Since Synchronized Reserves can be used to meet the Primary Reserve requirements, the SR clearing price must be at least as great as the NSR clearing price.

SR Price >= NSR Price

Multiple Reserve Products - Cascading Effect On Price



SRMCP = SR Shadow Price
+
PR Shadow Price

NSRMCP = PR Shadow Price

A is paid $30/MW

B is paid $10/MW

Multiple Reserve Products – Co-optimization of Energy and Reserves

- In previous presentations, we have stated that the objective function of the co-optimization of energy and reserves is

  Min (Energy Cost – Benefit of Reserves)

  – We have shown that the co-optimization reflects the trade off between energy and reserves
- If there are two reserve products, Synchronized Reserves (SR) and Primary Reserves (PR), then the objective function is

  Min (Energy Cost – Benefit of SR – Benefit of PR)

  – This objective function now reflects the trade-off between energy, SR and PR

ORDC for SR and PR

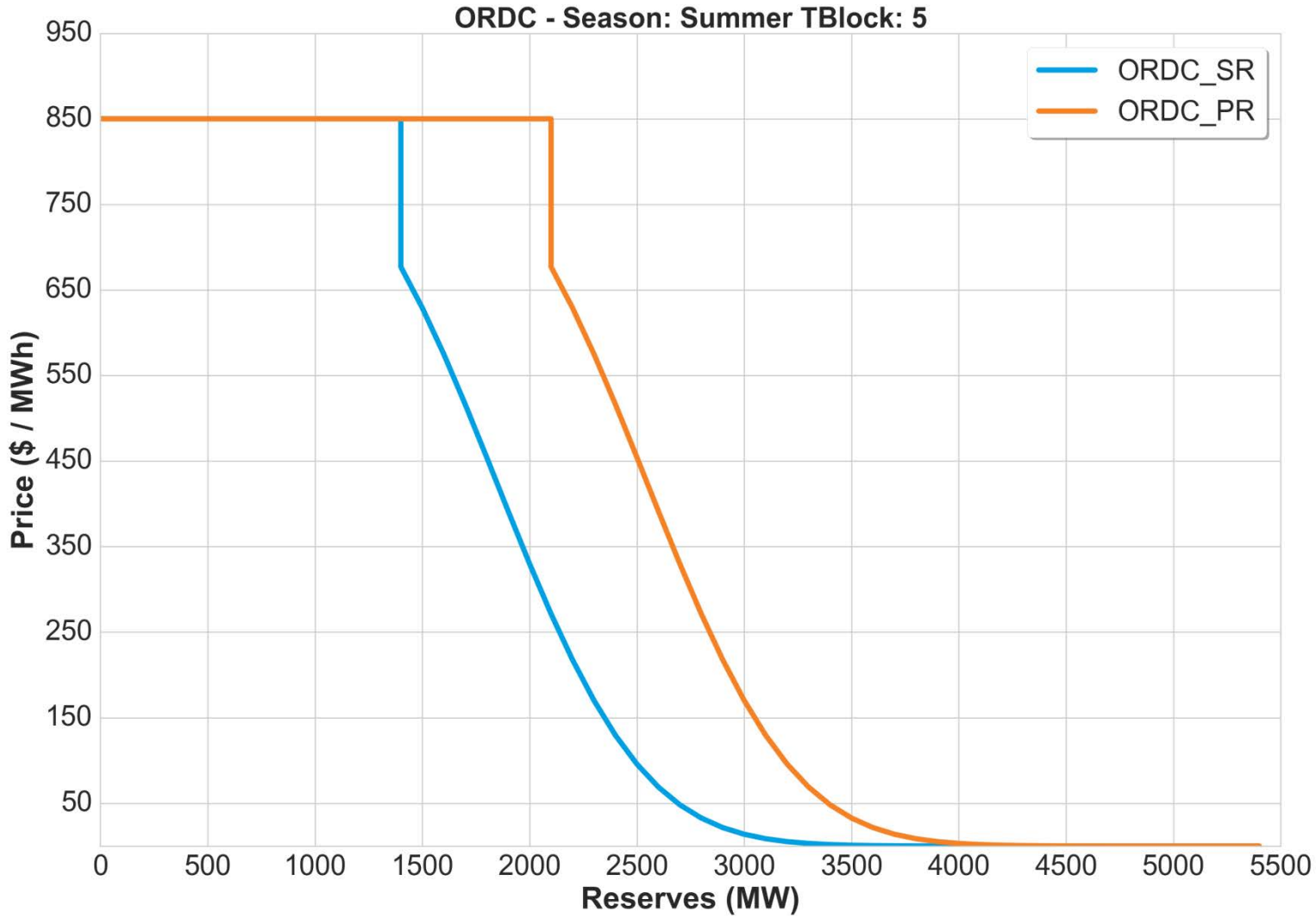
- SR and PR are both expected to respond within 10 minutes of the target time
  - Therefore, the same 30 minute look-ahead uncertainty interval can be used to derive the ORDC for each of the products. The Total Forecast Error distribution is thus identical for the PBMRR calculation of SR and PR
  - However, the MRR for PR is larger than the MRR for SR.
- Therefore, for a given combination Season - Time-of-Day Block, the ORDC for PR will have the same downward-sloping shape as the ORDC for SR but the entire curve will be shifted to the right by an amount equal to the difference in MRR between PR and SR
  - This is also the case because the maximum Penalty Factors for both SR and PR are set at $850 per MWh

ORDC for SR and PR

- For example, let's assume that the MRR for SR is 1,400 MW and the MRR for PR is 2,100
  - If we are interested in calculating the PBMRR for PR associated with a reserve level equal to 2,200 MW
  - The calculation boils down to

    PBMRR PR (2,200) = Probability Total Forecast Error is greater than 2,200 minus 2,100 (MRR For PR) = Probability (TFE > 100)
  - This is equivalent to the calculation of the PBMRR for SR associated with a reserve level equal to 1,500 MW
  - PBMRR SR (1500) = PBMRR PR (2,200)
  - Since the maximum penalty factors for SR and PR are both $850 per MWh, then the price associated with a SR reserve level equal to 1,500 MW is identical to the price associated with a PR reserve level equal to 2,200 MW

ORDC for SR and OR – Summer – Time-of-Day Block 5

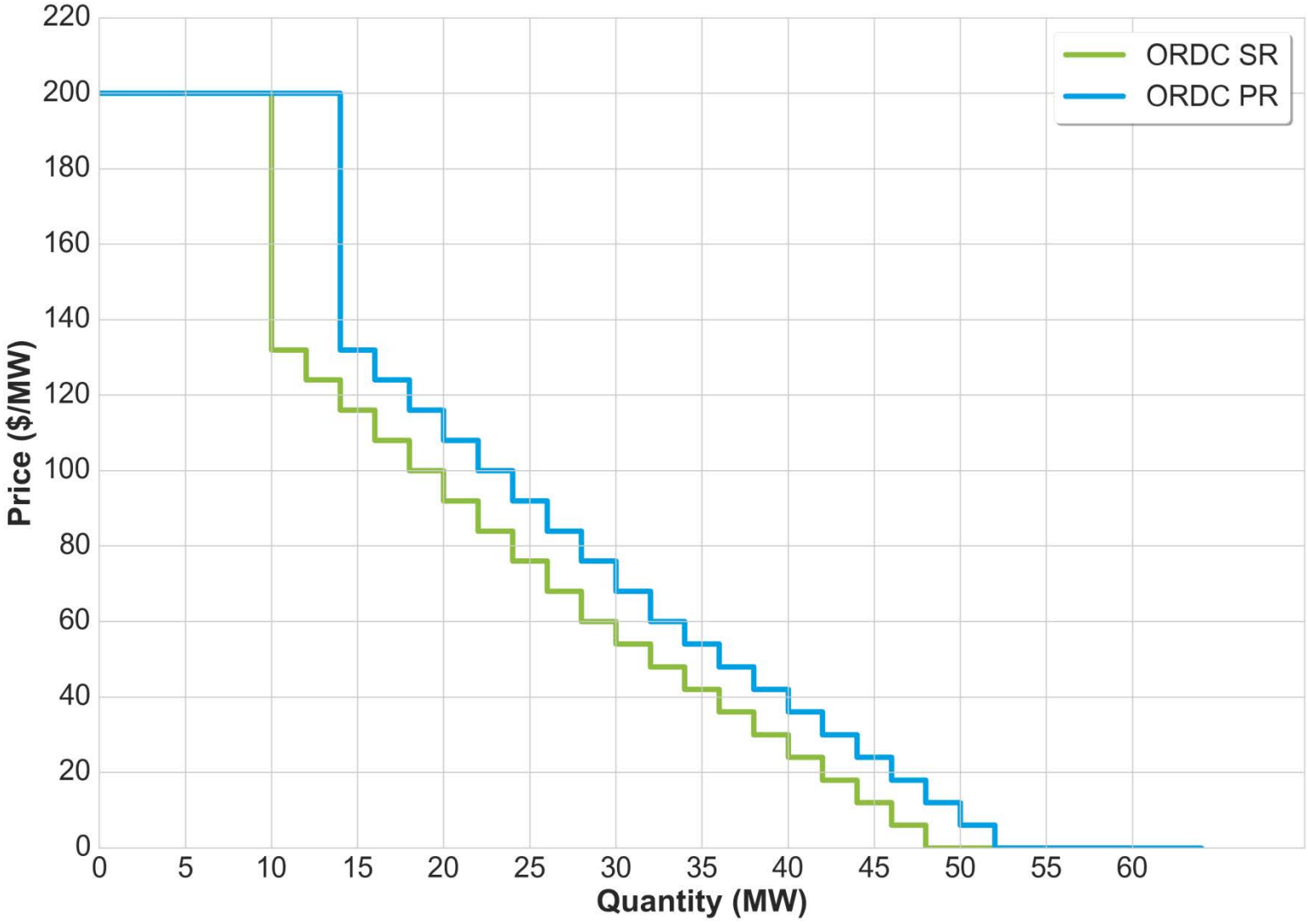


Assuming,

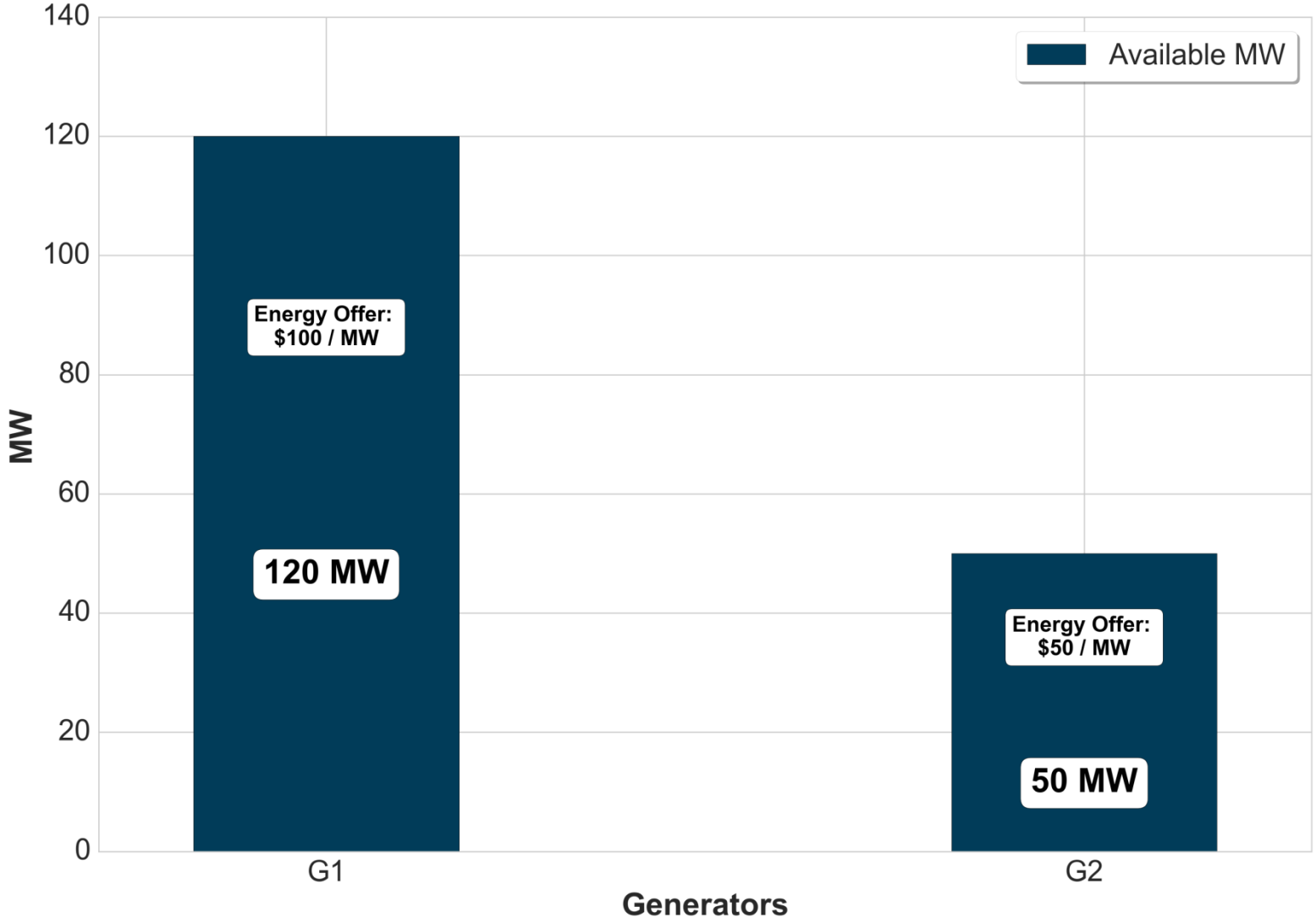
MRR SR	**1,400 MW**
MRR PR	**2,100 MW**

Energy, SR, and PR Co-Optimization Examples

SR and PR ORDCs

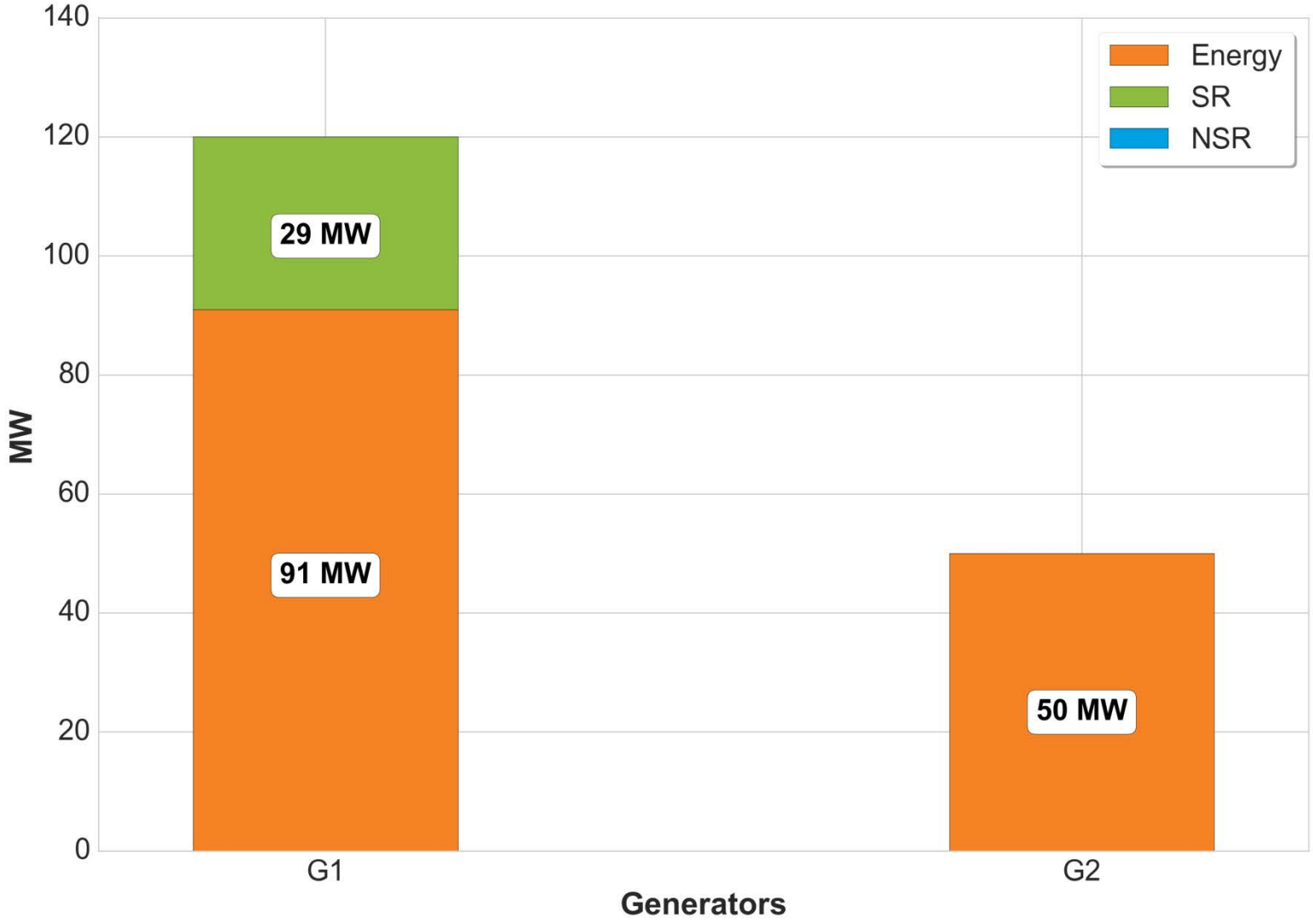


Example #1: Capacity Constrained / No NSR



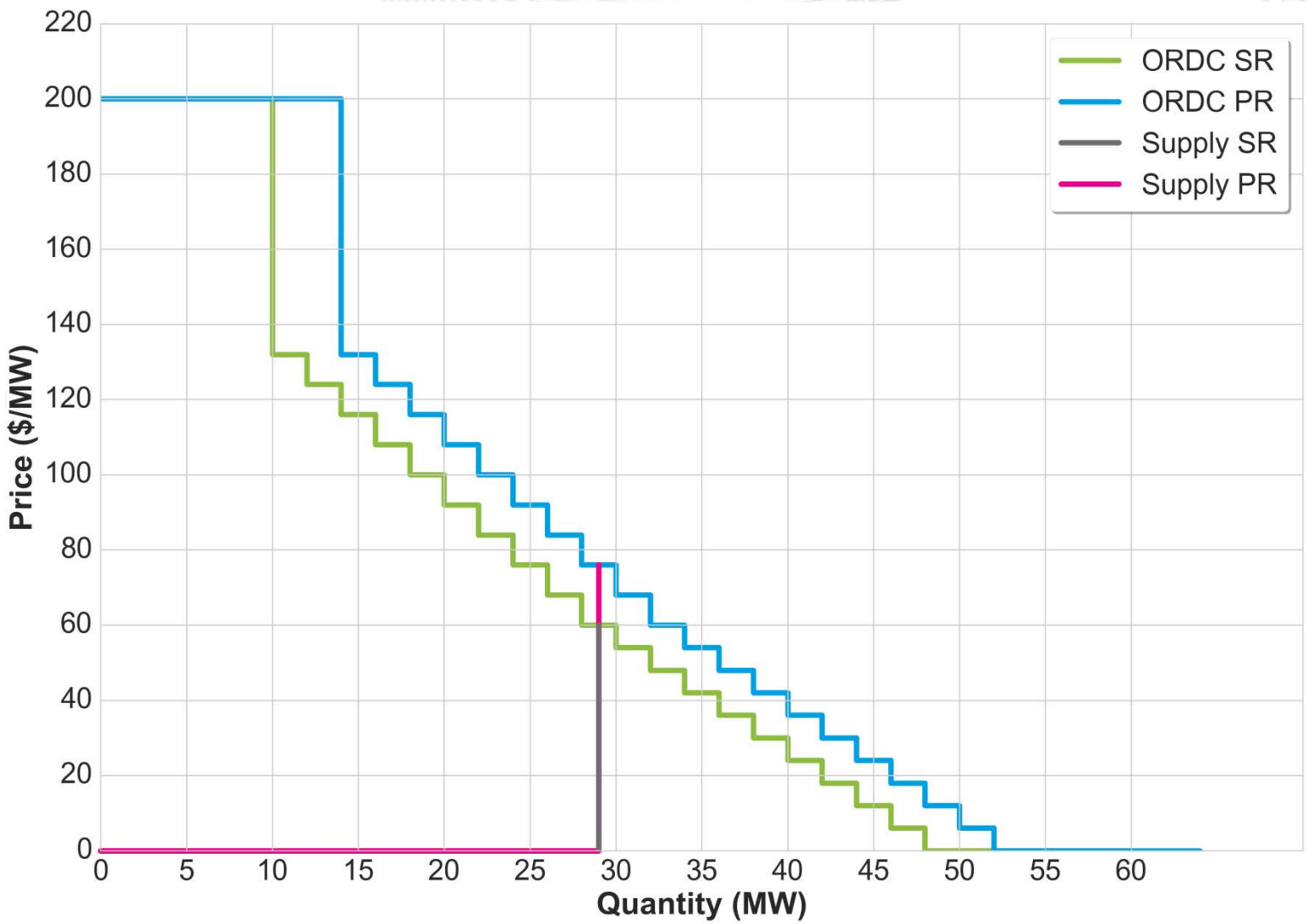
Demand **141 MW**

Example #1: Results

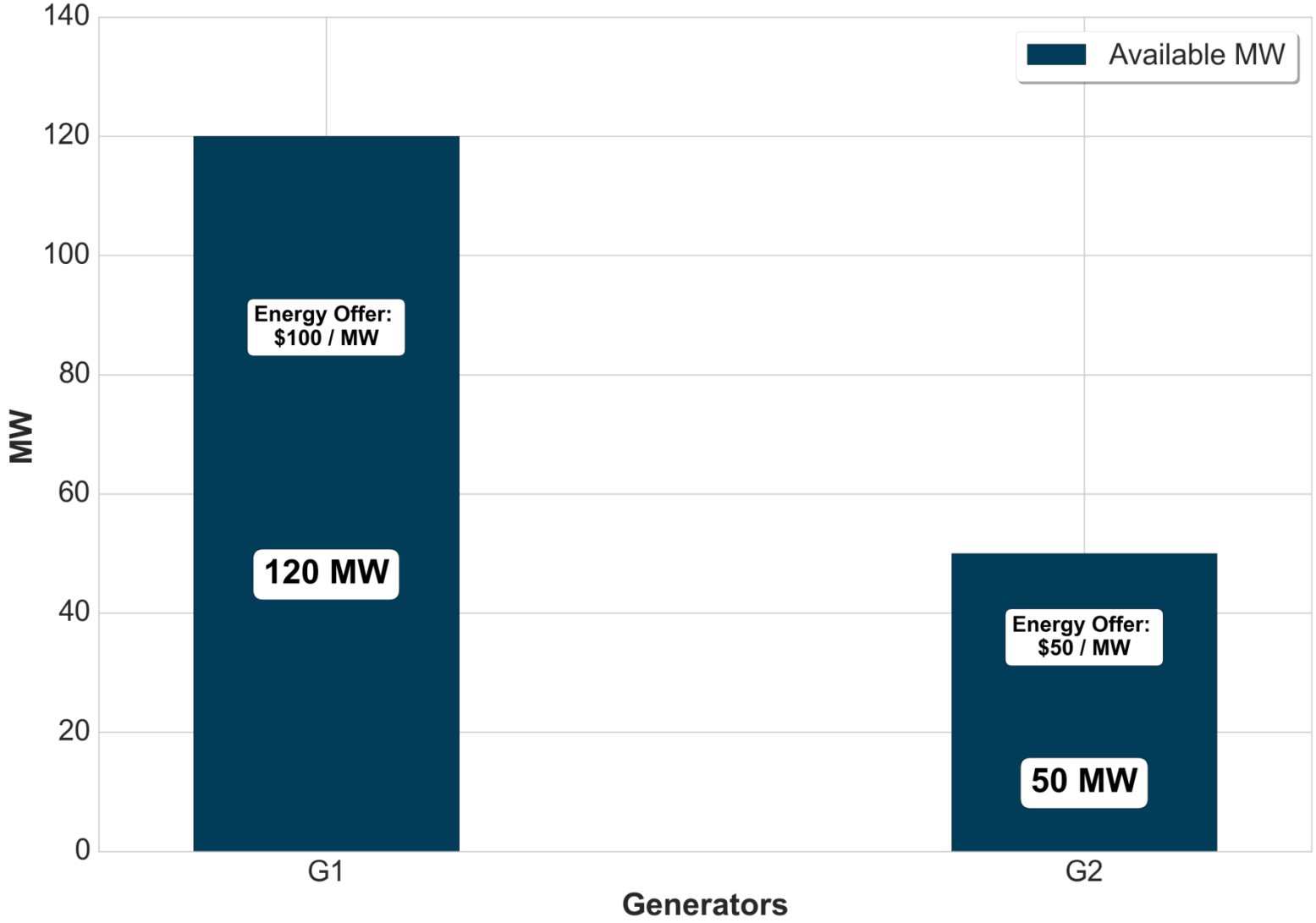


Energy Price	**$236/MWh**
SR Shadow Price	**$60/MWh**
PR Shadow Price	**$76/MWh**
SRMCP	**$136/MWh**
NSRMCP	**$76/MWh**

Example #1: Results - ORDC

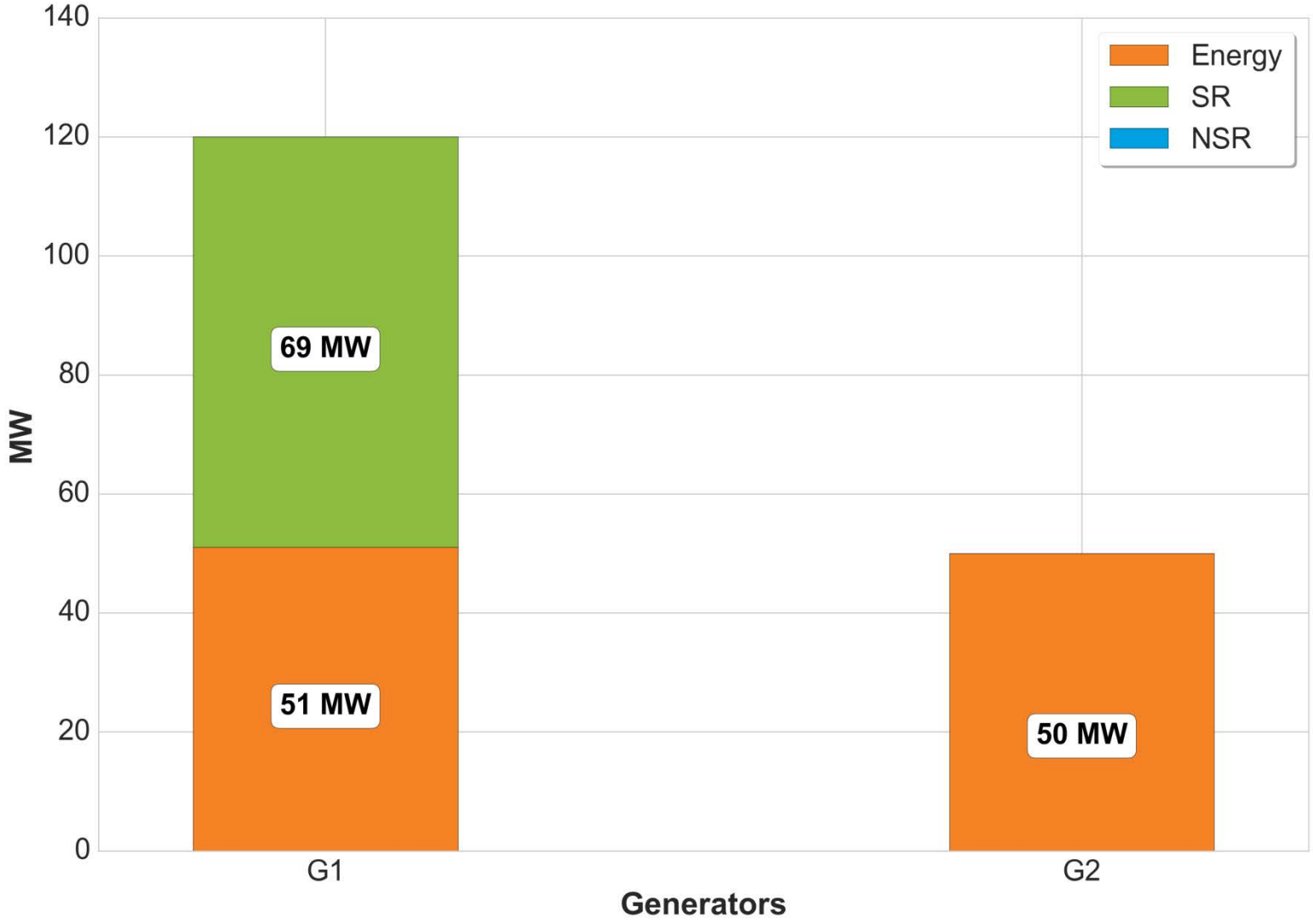


Example #2: Surplus / No NSR



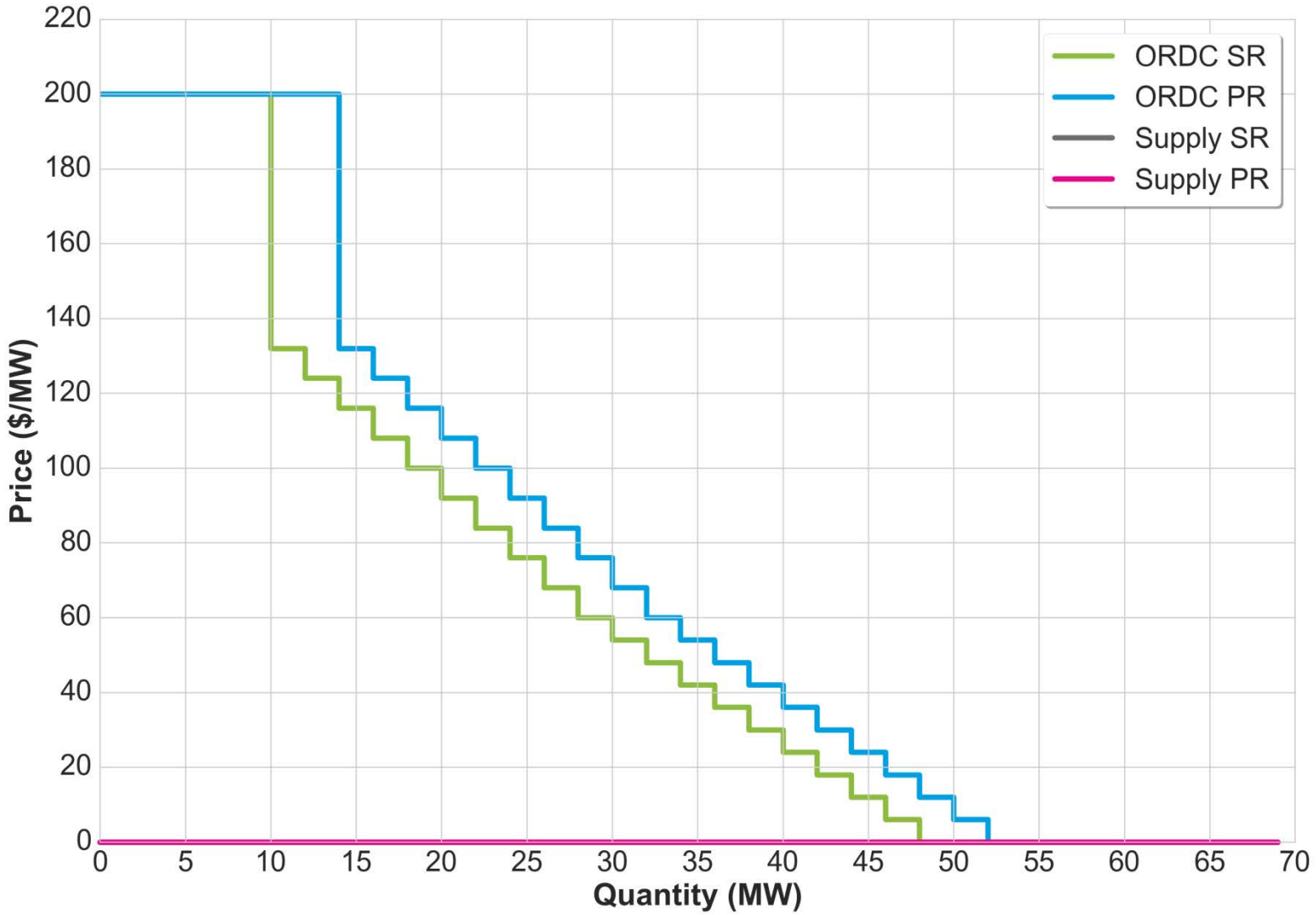
Demand **101 MW**

Example #2: Results

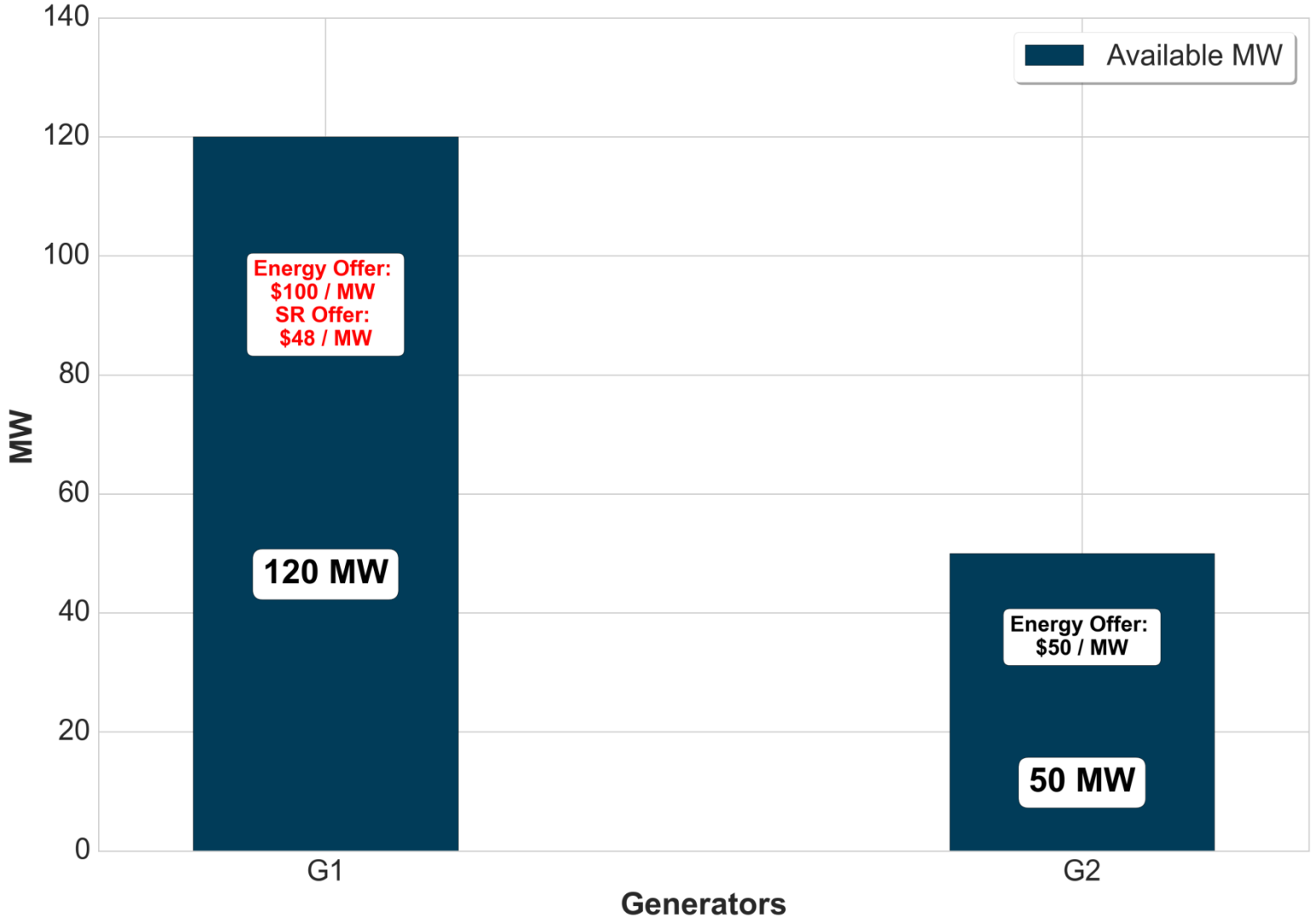


Energy Price	**$100/MWh**
SR Shadow Price	**$0/MWh**
PR Shadow Price	**$0/MWh**
SRMCP	**$0/MWh**
NSRMCP	**$0/MWh**

Example #2: Results - ORDC

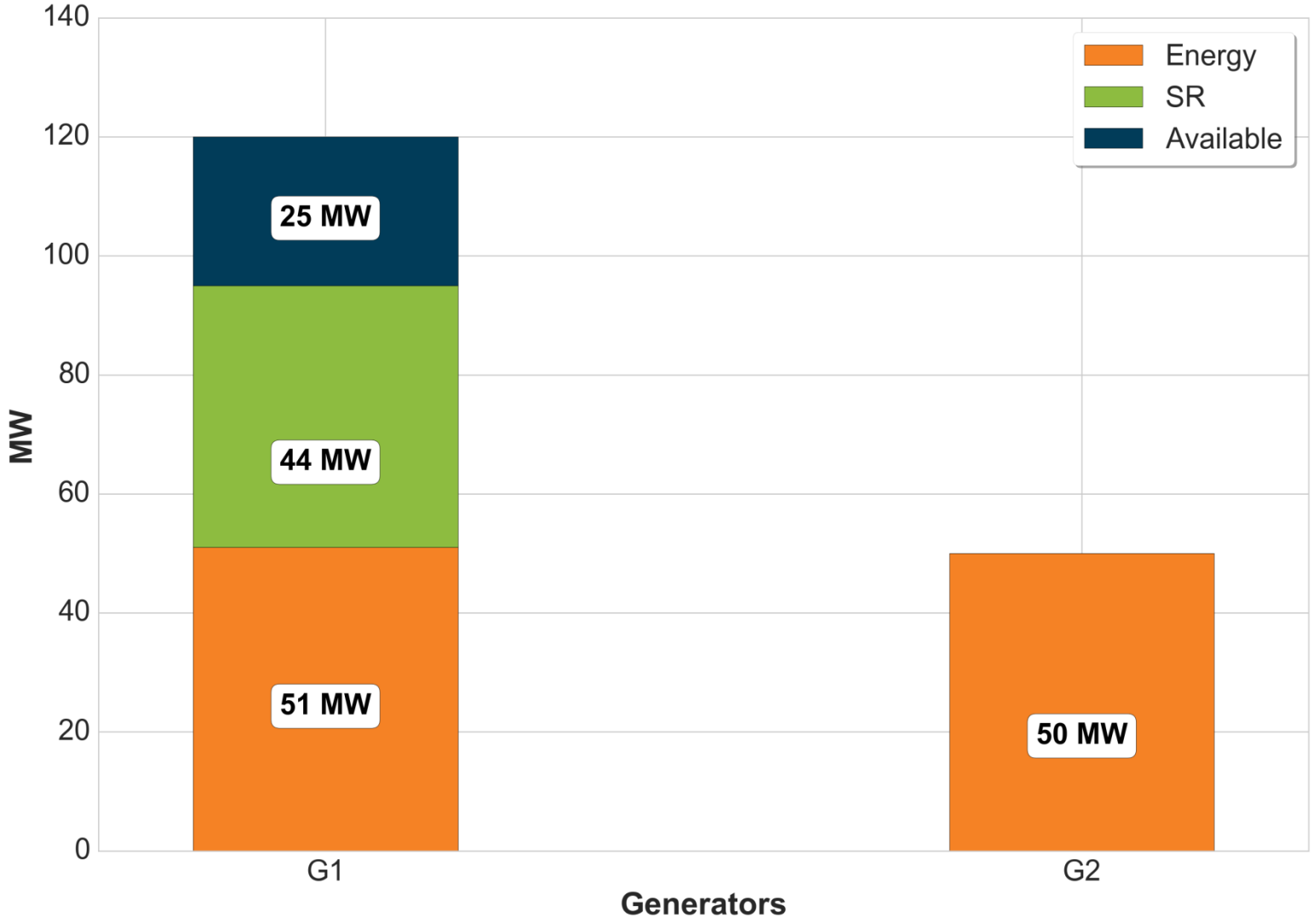


Example #3: Surplus with Reserve Offer / No NSR



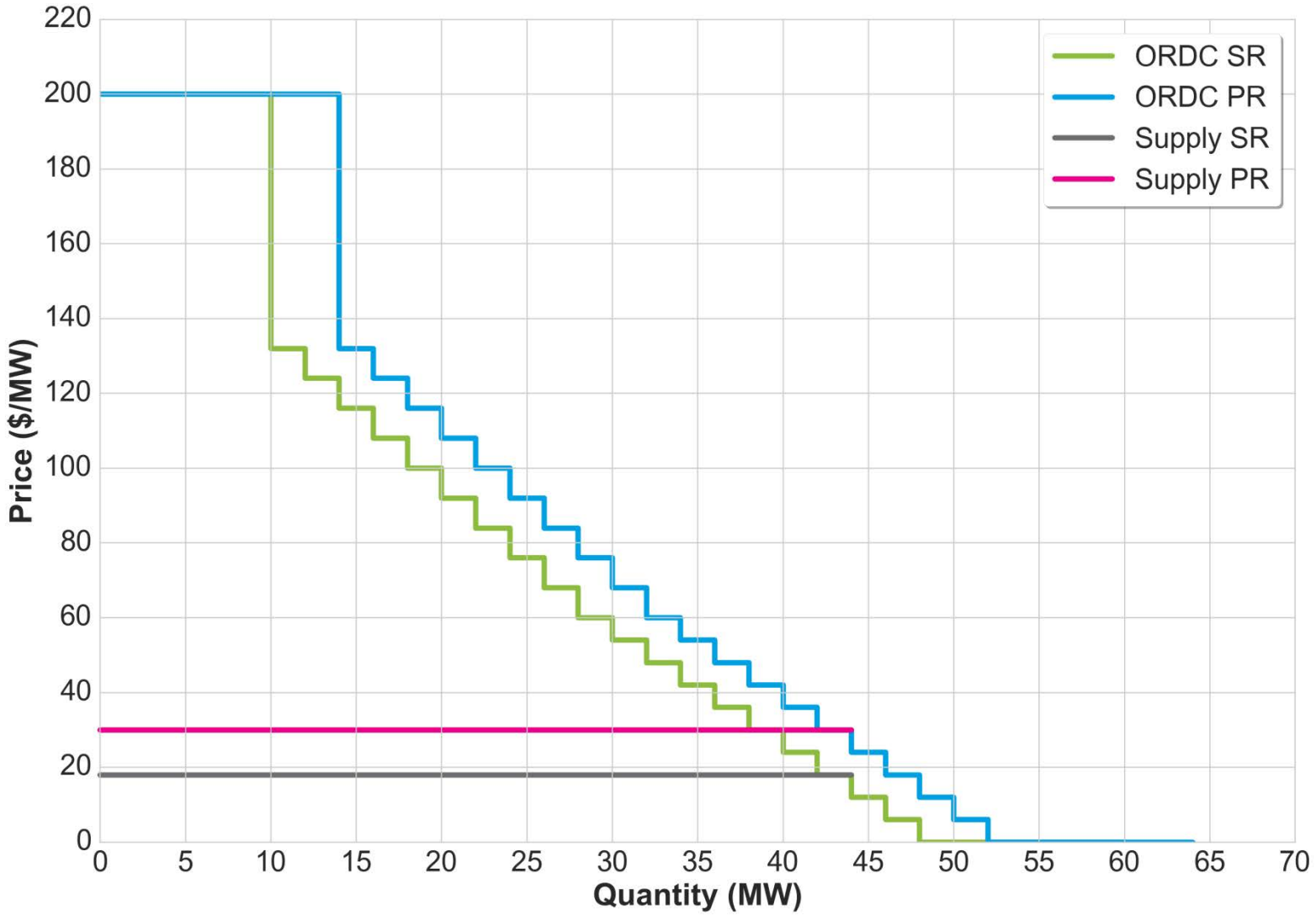
Demand **101 MW**

Example #3: Results

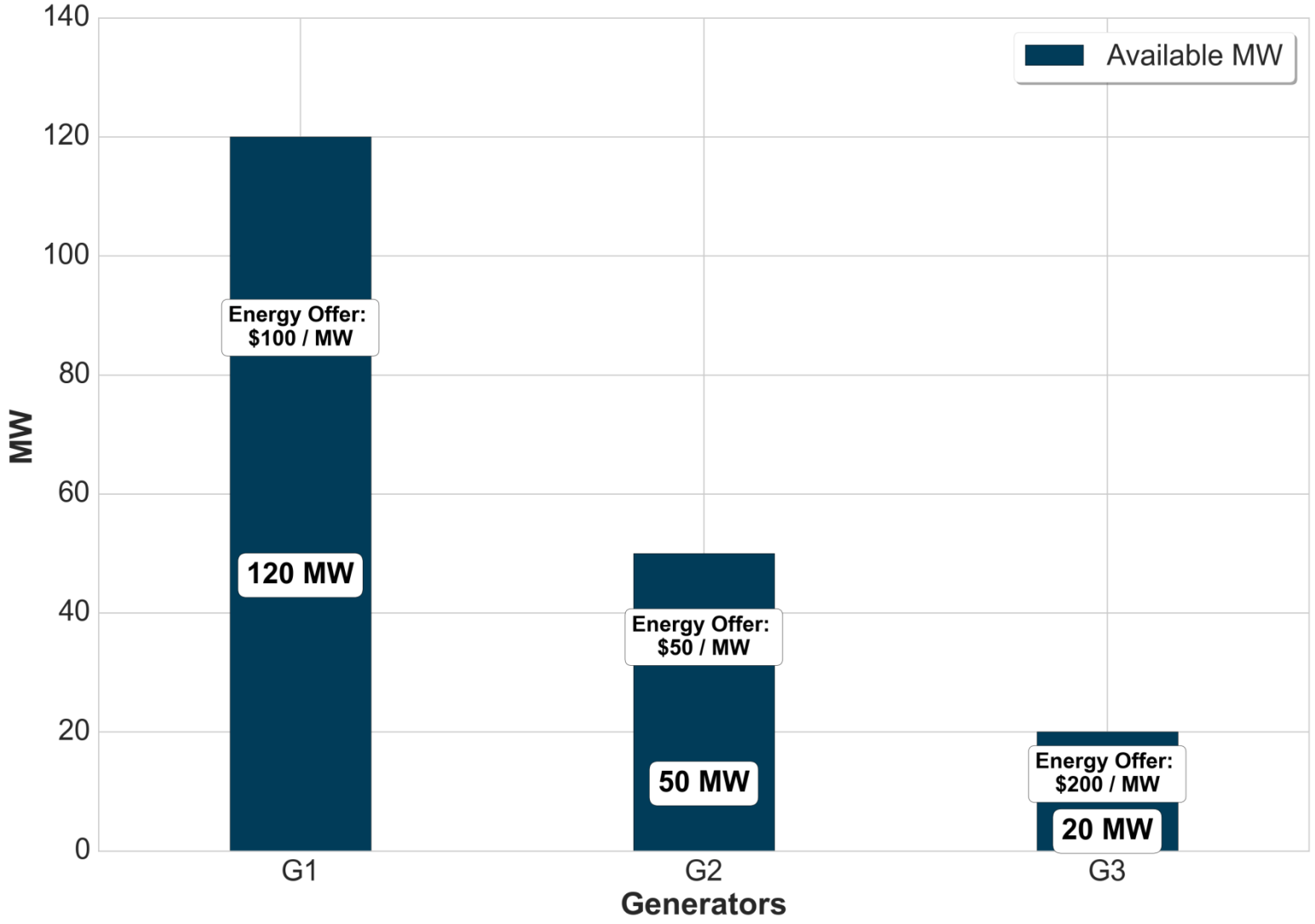


Energy Price	**$100/MWh**
SR Shadow Price	**$18/MWh**
PR Shadow Price	**$30/MWh**
SRMCP	**$48/MWh**
NSRMCP	**$30/MWh**

Example #3: Results - ORDC



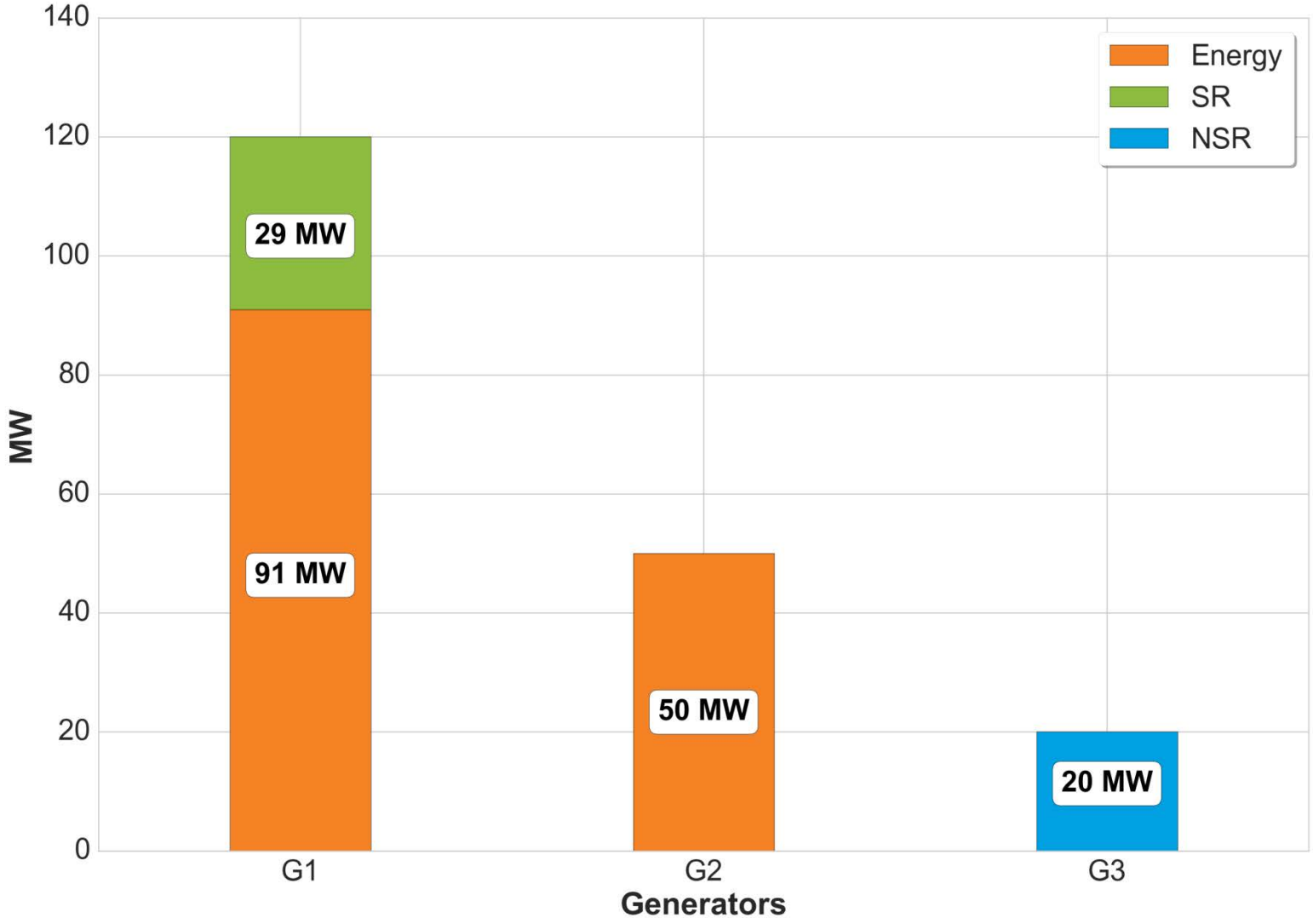
Example #4: Capacity Constrained with NSR



Demand **141 MW**

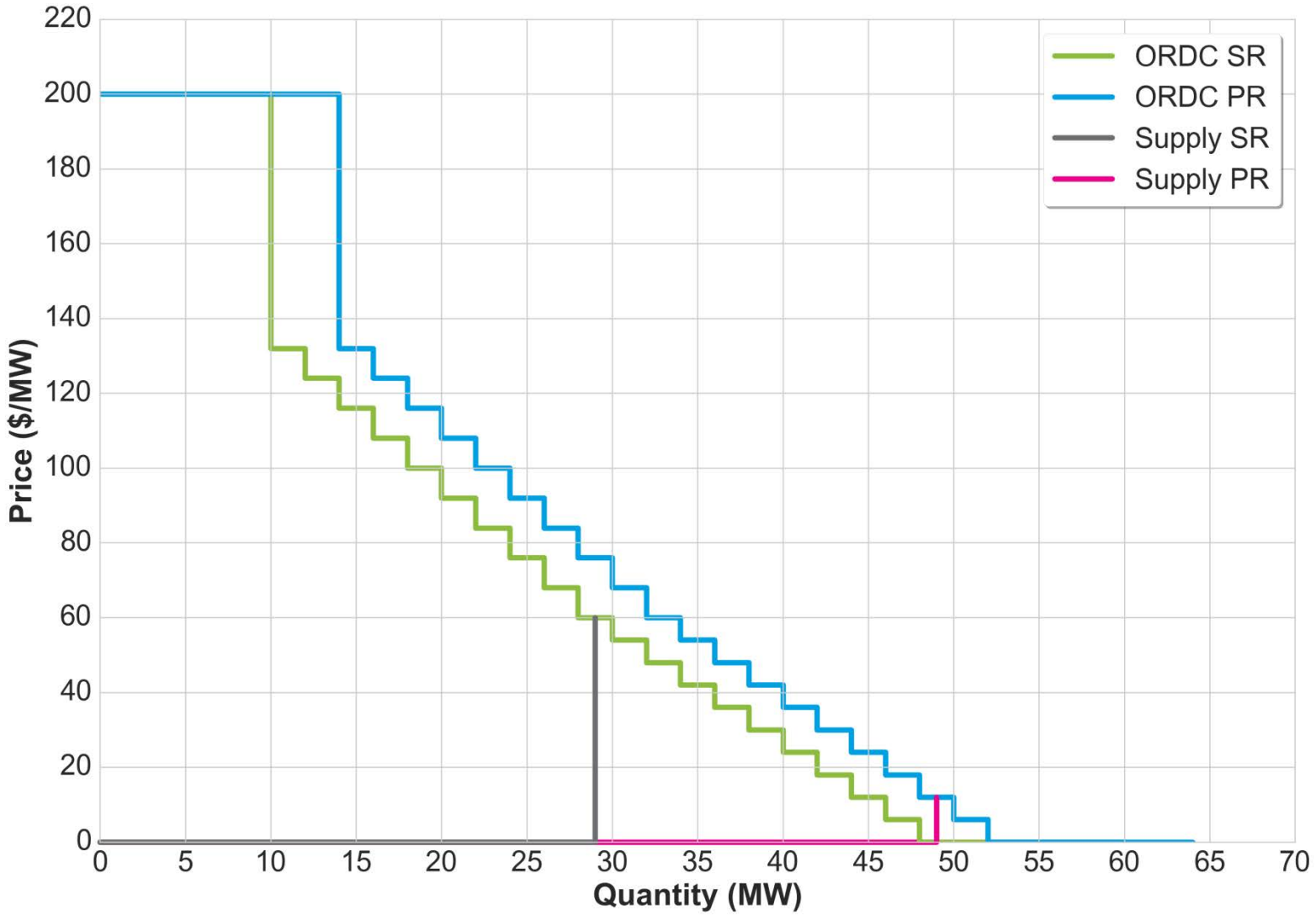
G3 is offline

Example #4: Results

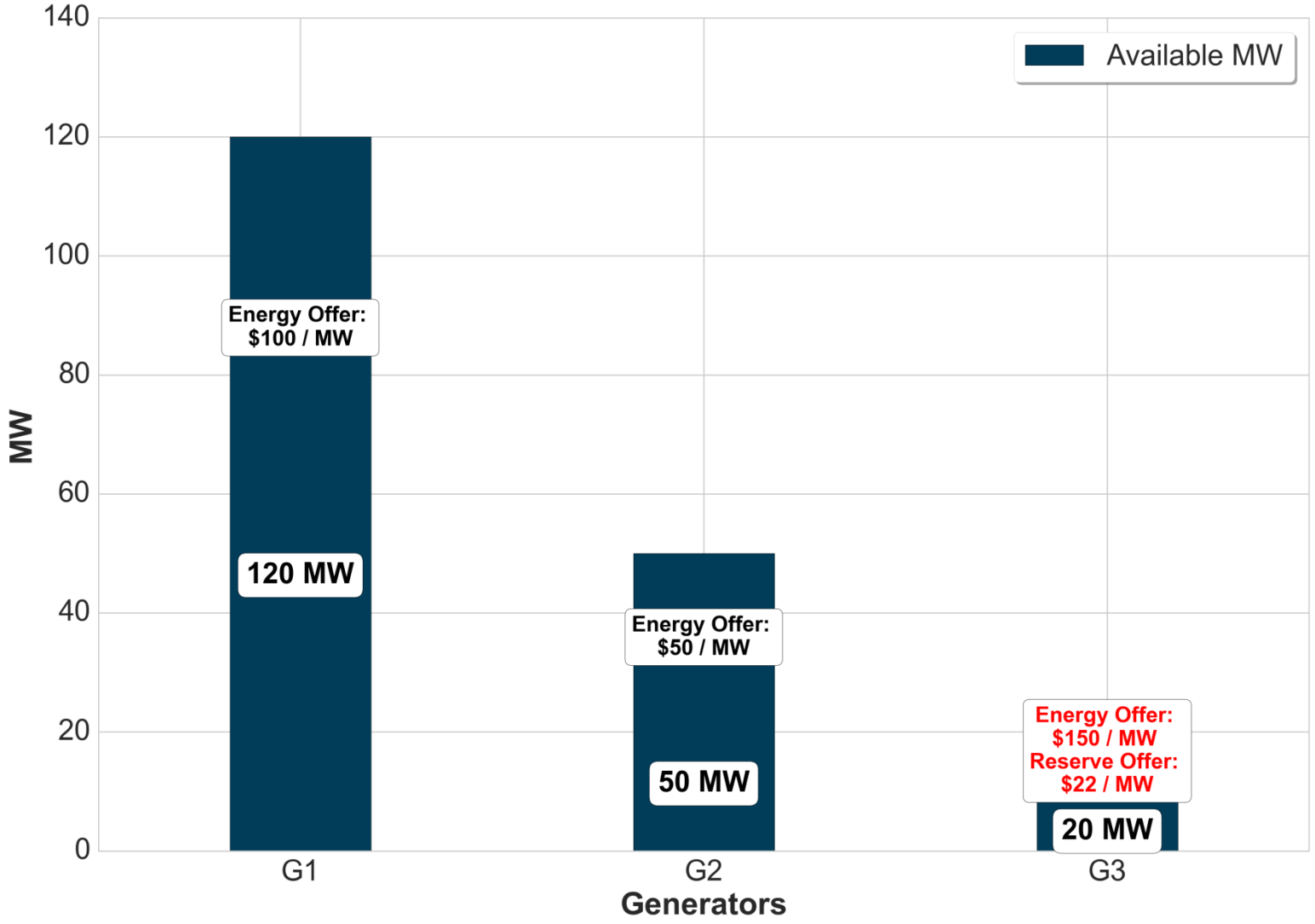


Energy Price	**$172/MWh**
SR Shadow Price	**$60/MWh**
PR Shadow Price	**$12/MWh**
SRMCP	**$72/MWh**
NSRMCP	**$12/MWh**

Example #4: Results - ORDC



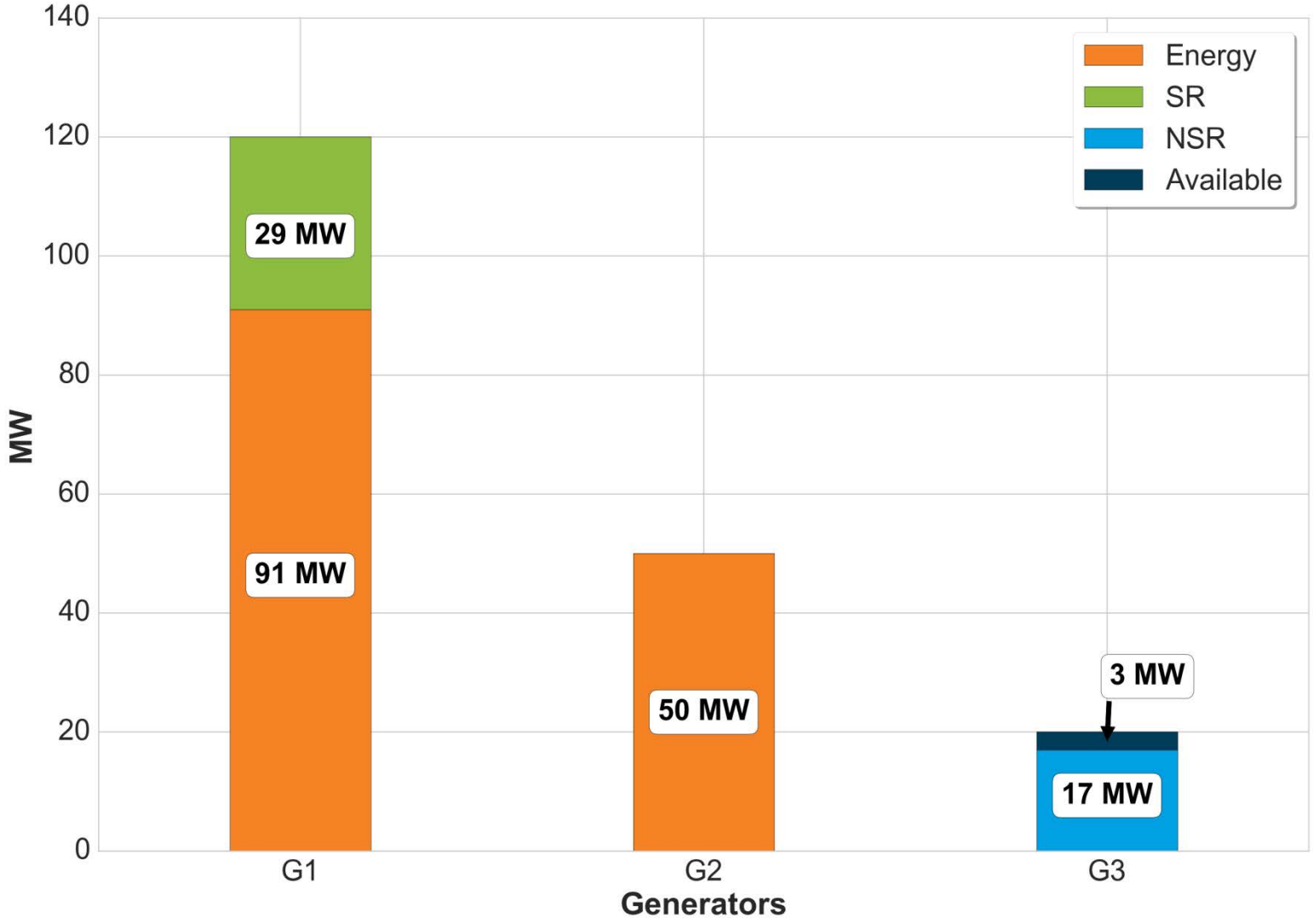
Example #5: Capacity Constrained with NSR and NSR LOC Reserve Offer



Demand **141 MW**

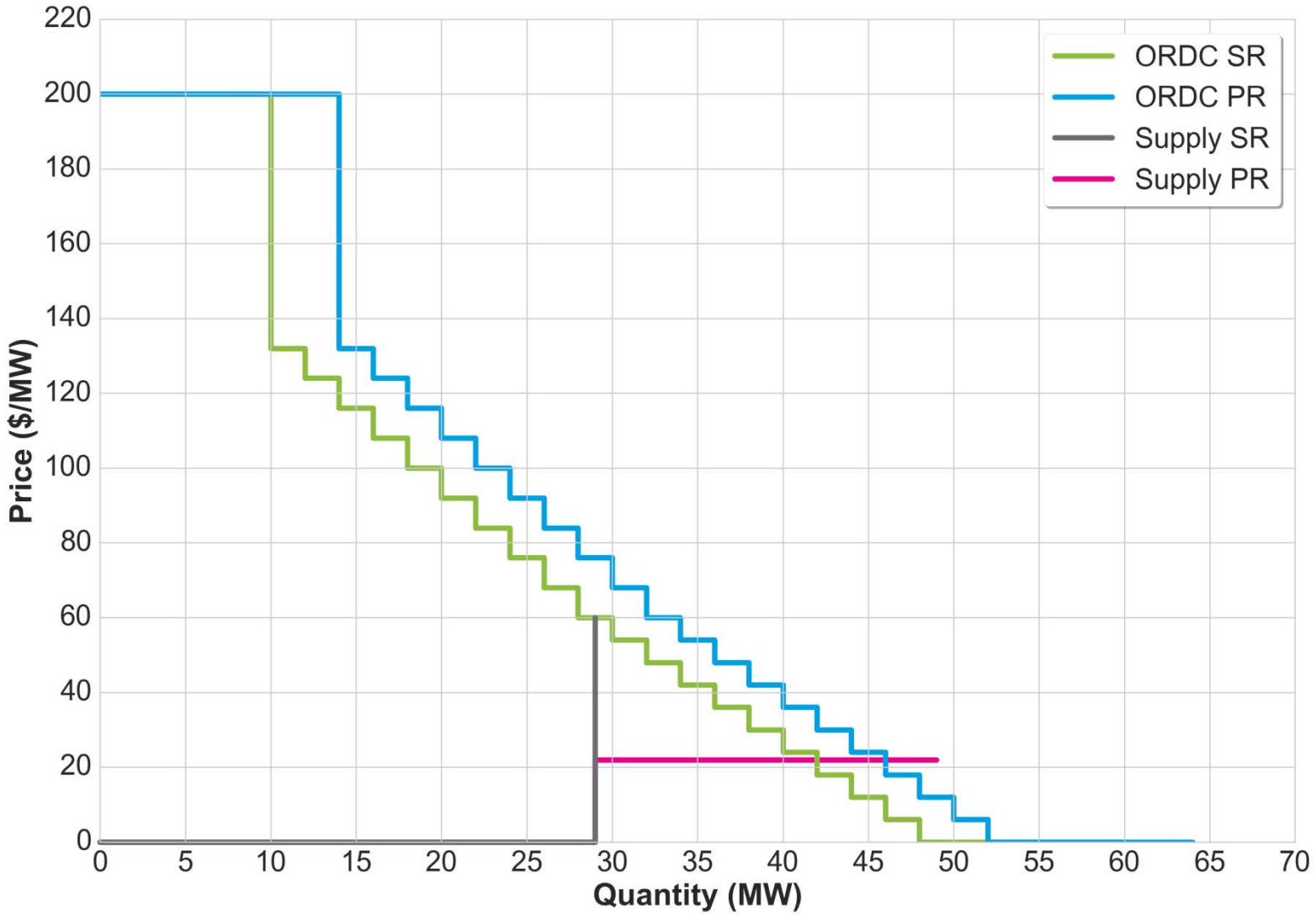
G3 is offline

Example #5: Results



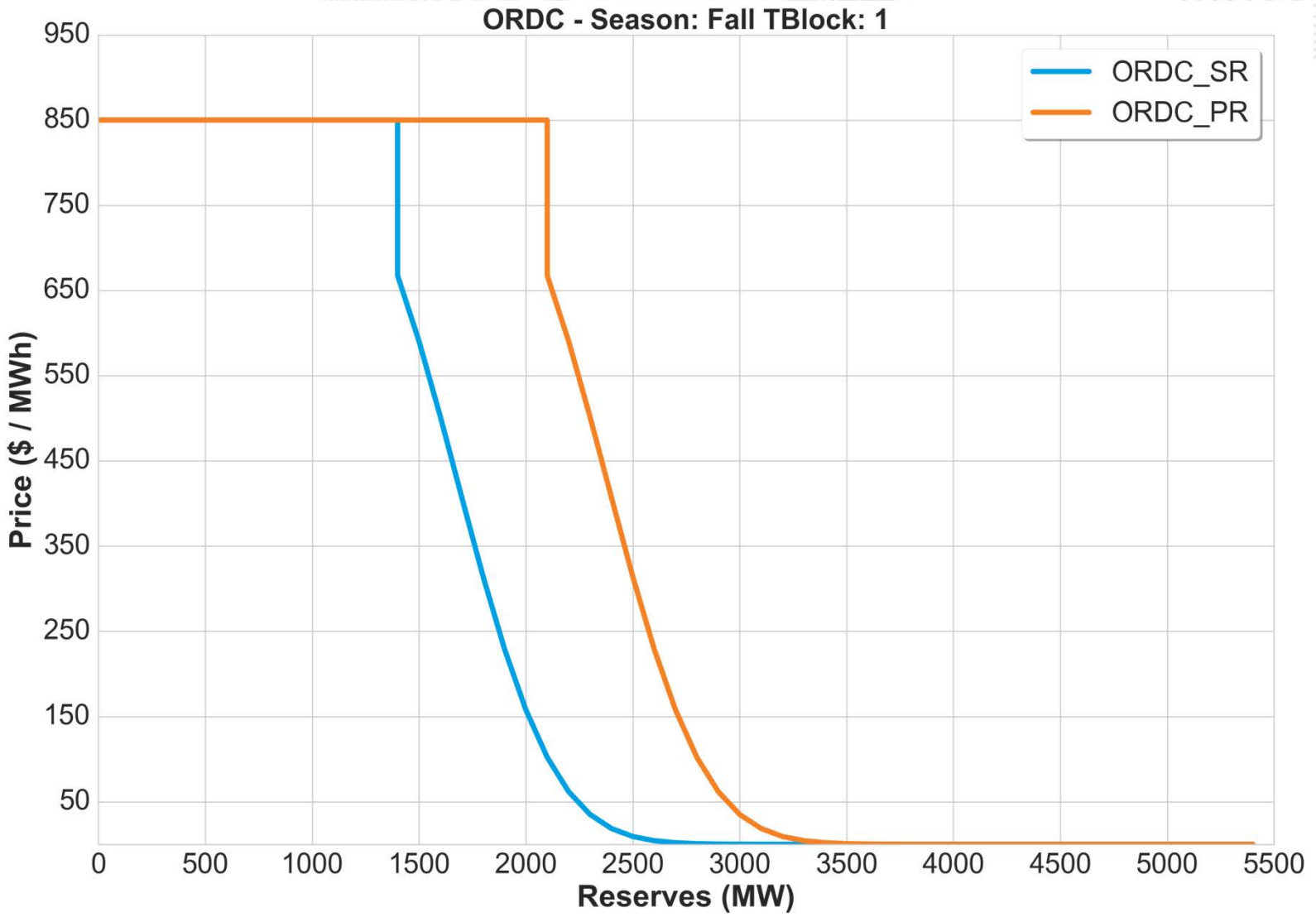
Energy Price	**$182/MWh**
SR Shadow Price	**$60/MWh**
PR Shadow Price	**$22/MWh**
SRMCP	**$82/MWh**
NSRMCP	**$22/MWh**

Example #5: Results - ORDC

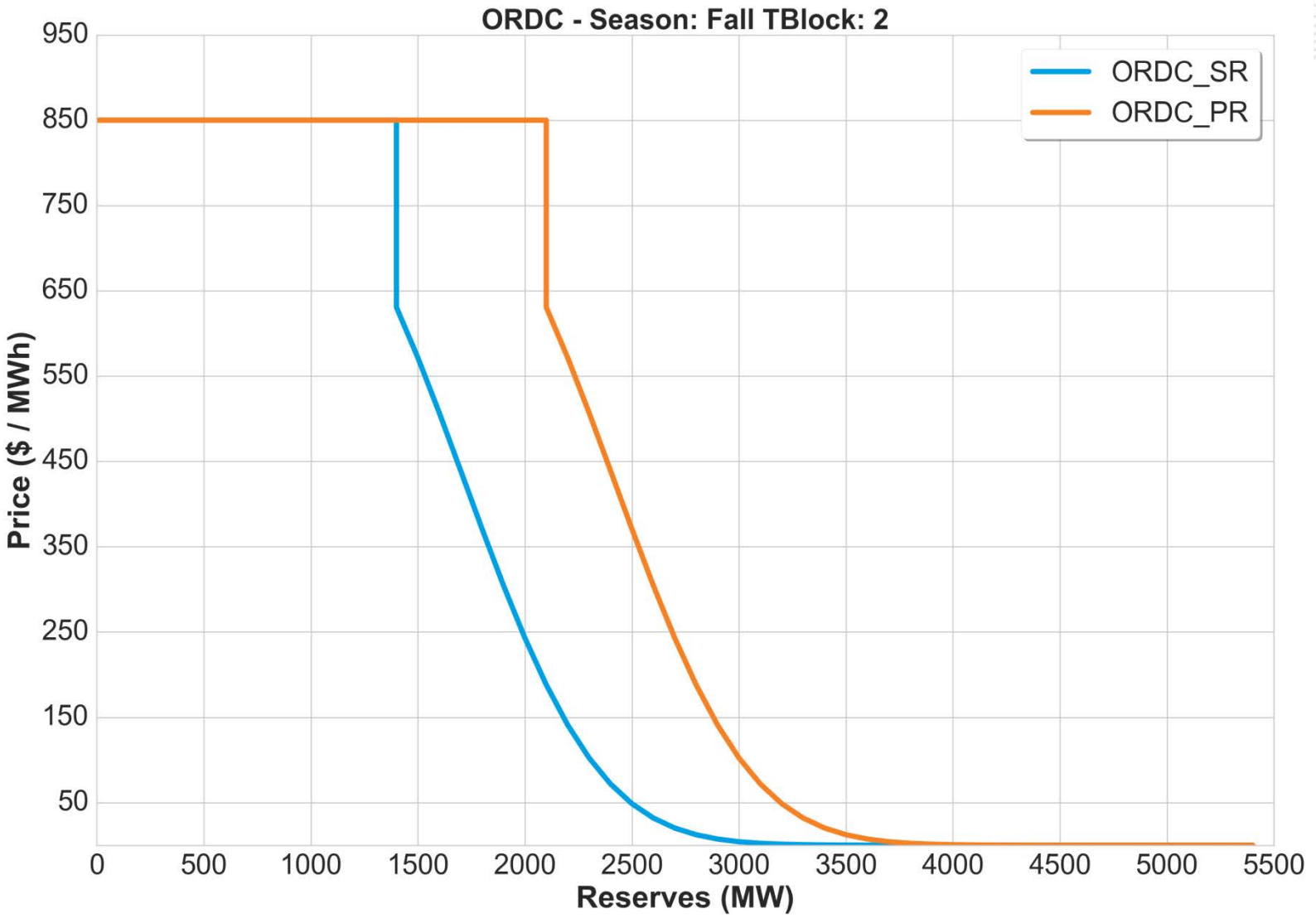


Appendix: SR and PR ORDCs for all Season – Time-of-Day Blocks combinations (including Forced Outages Uncertainty and assuming MRR SR = 1,400 MW and MRR PR = 2,100 MW)

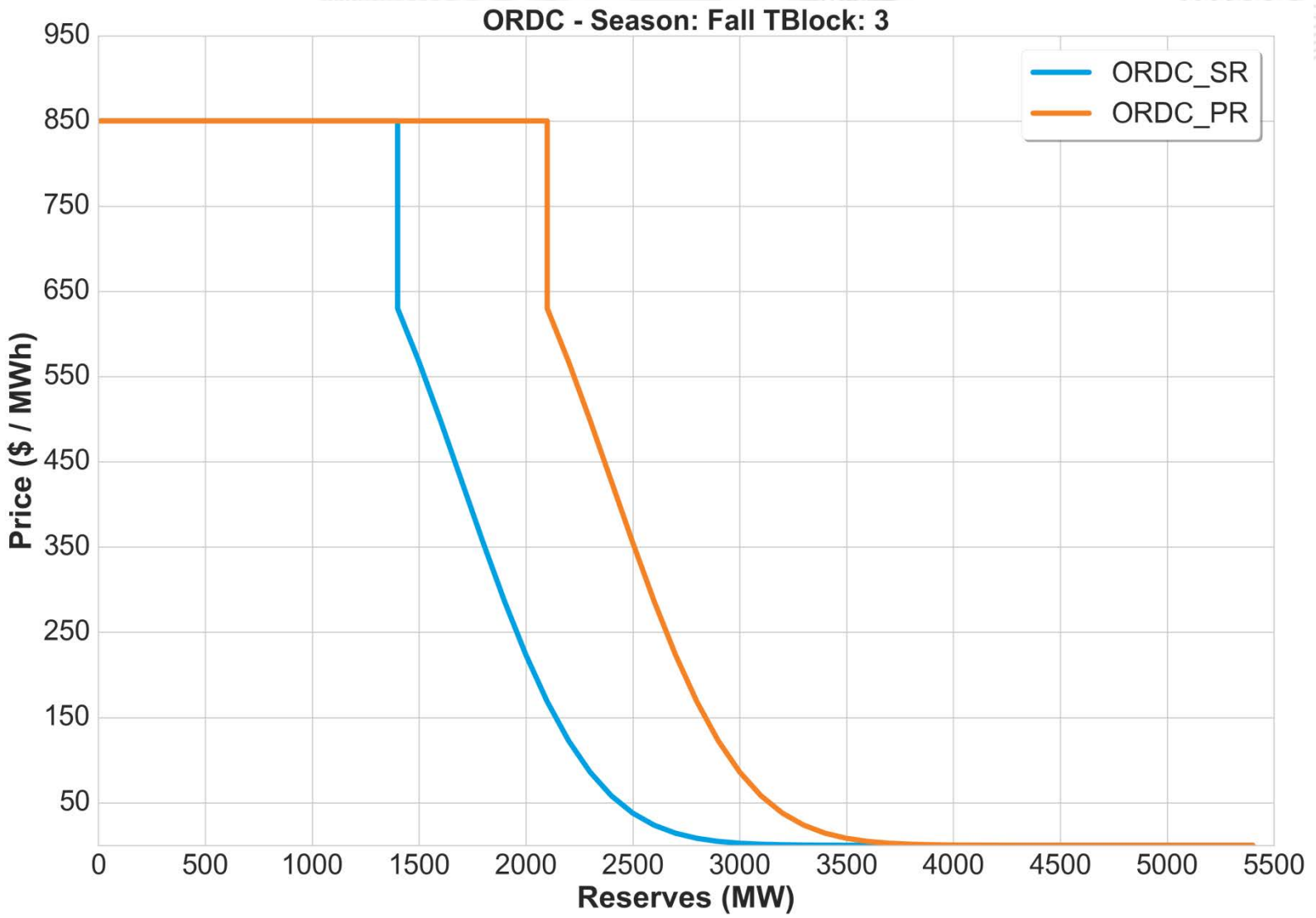
ORDC Fall TBlock 1 (2300-0200)



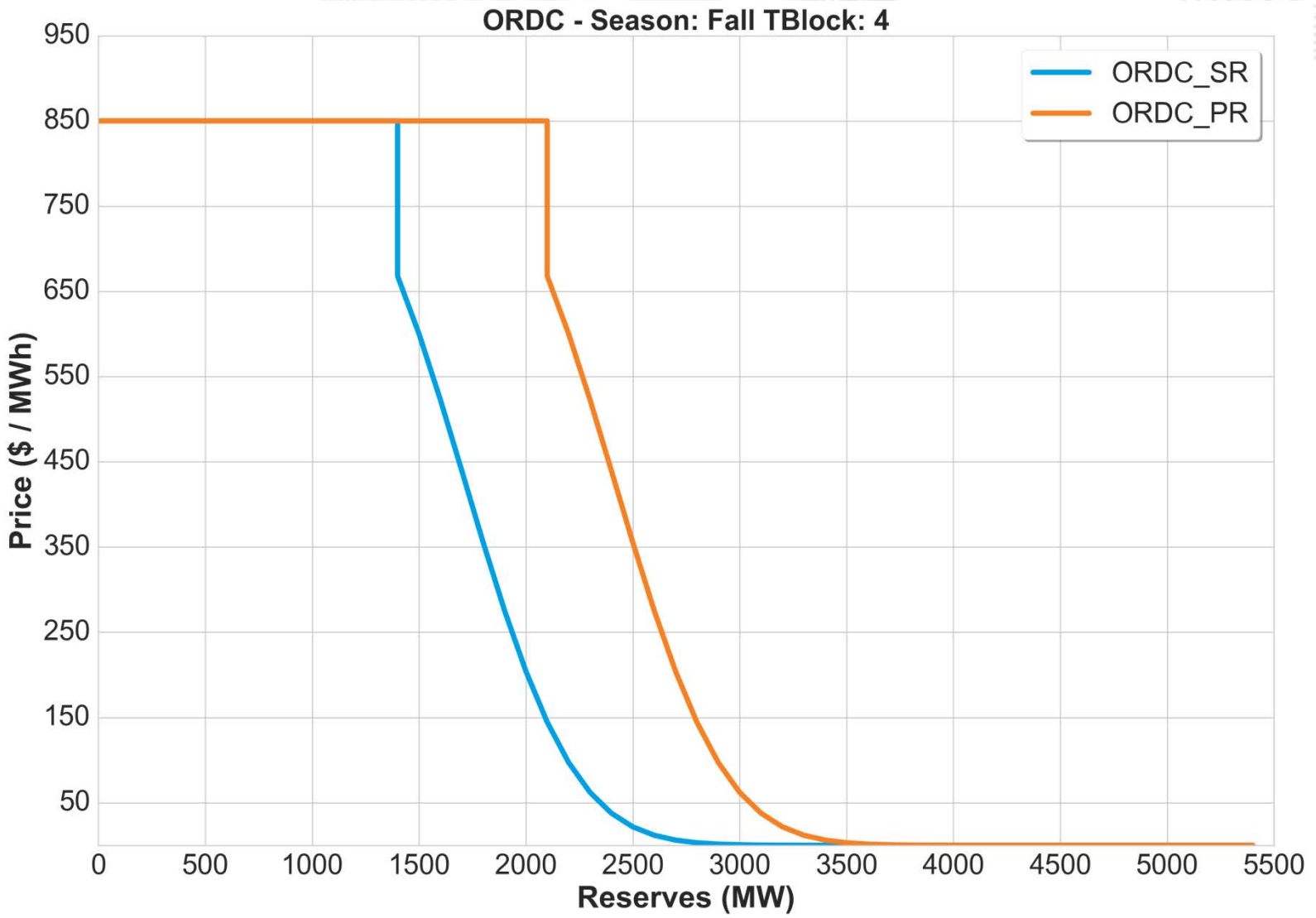
ORDC Fall TBlock 2 (0300-0600)



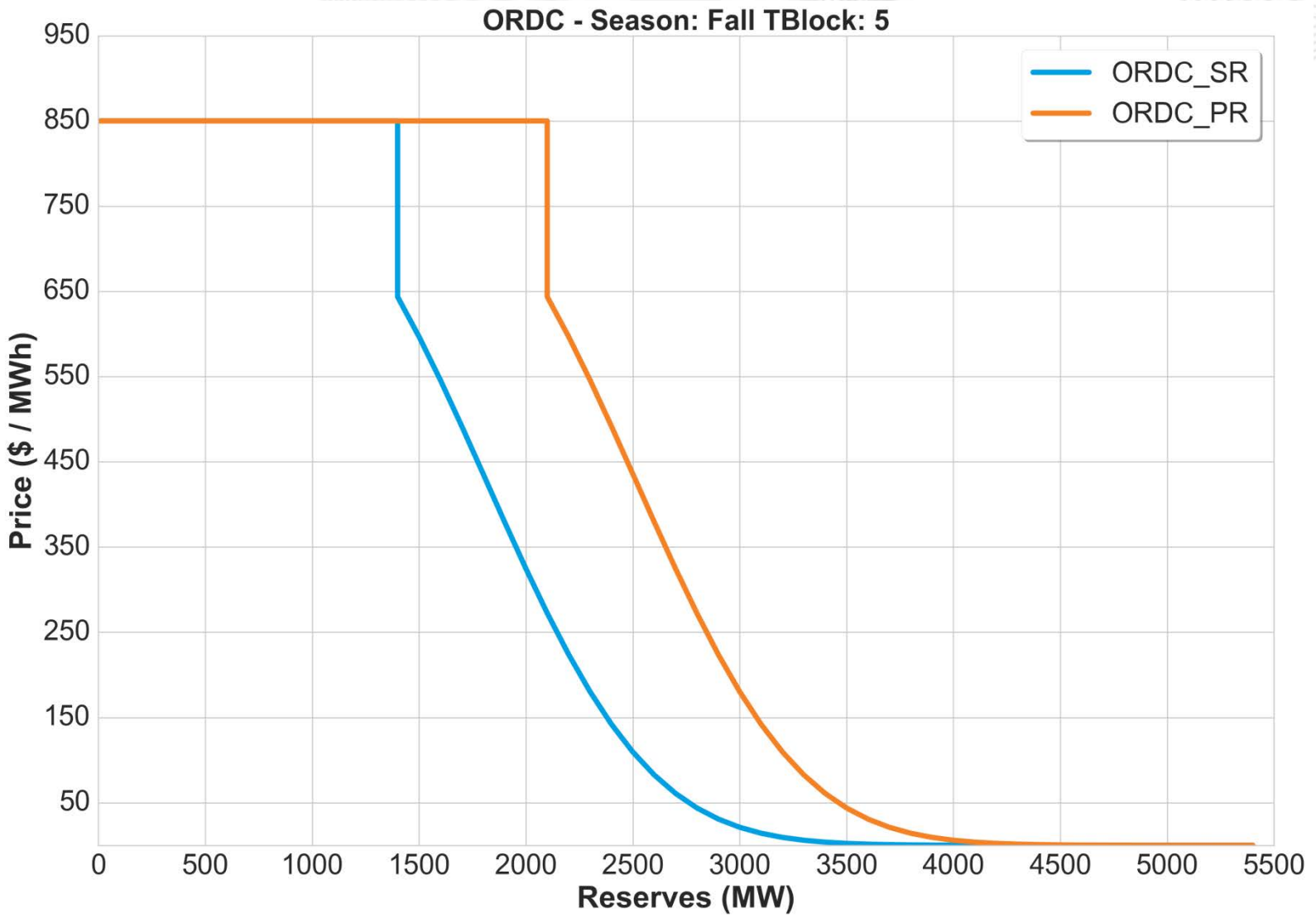
ORDC Fall TBlock 3 (0700-1000)



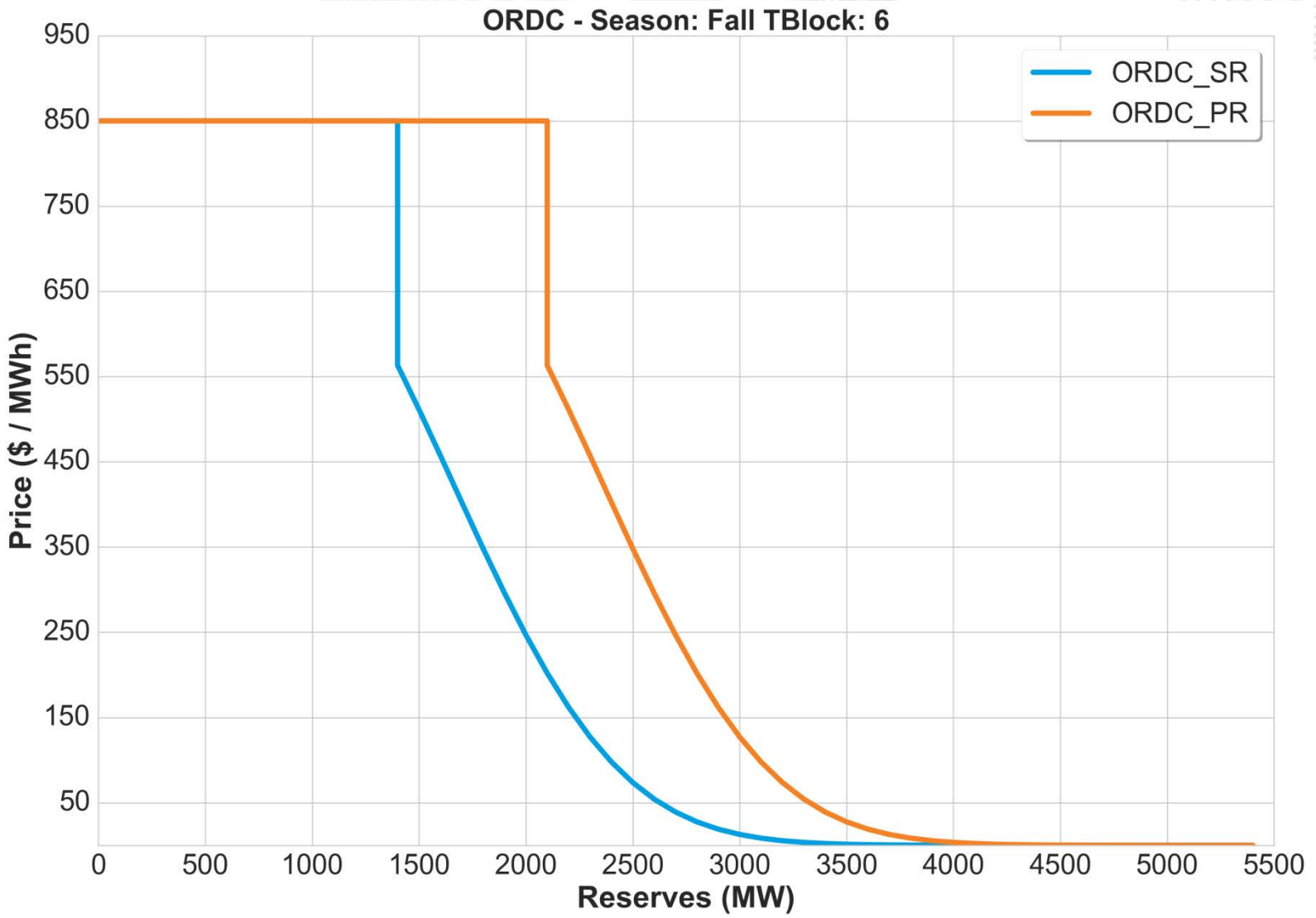
ORDC Fall TBlock 4 (1100-1400)



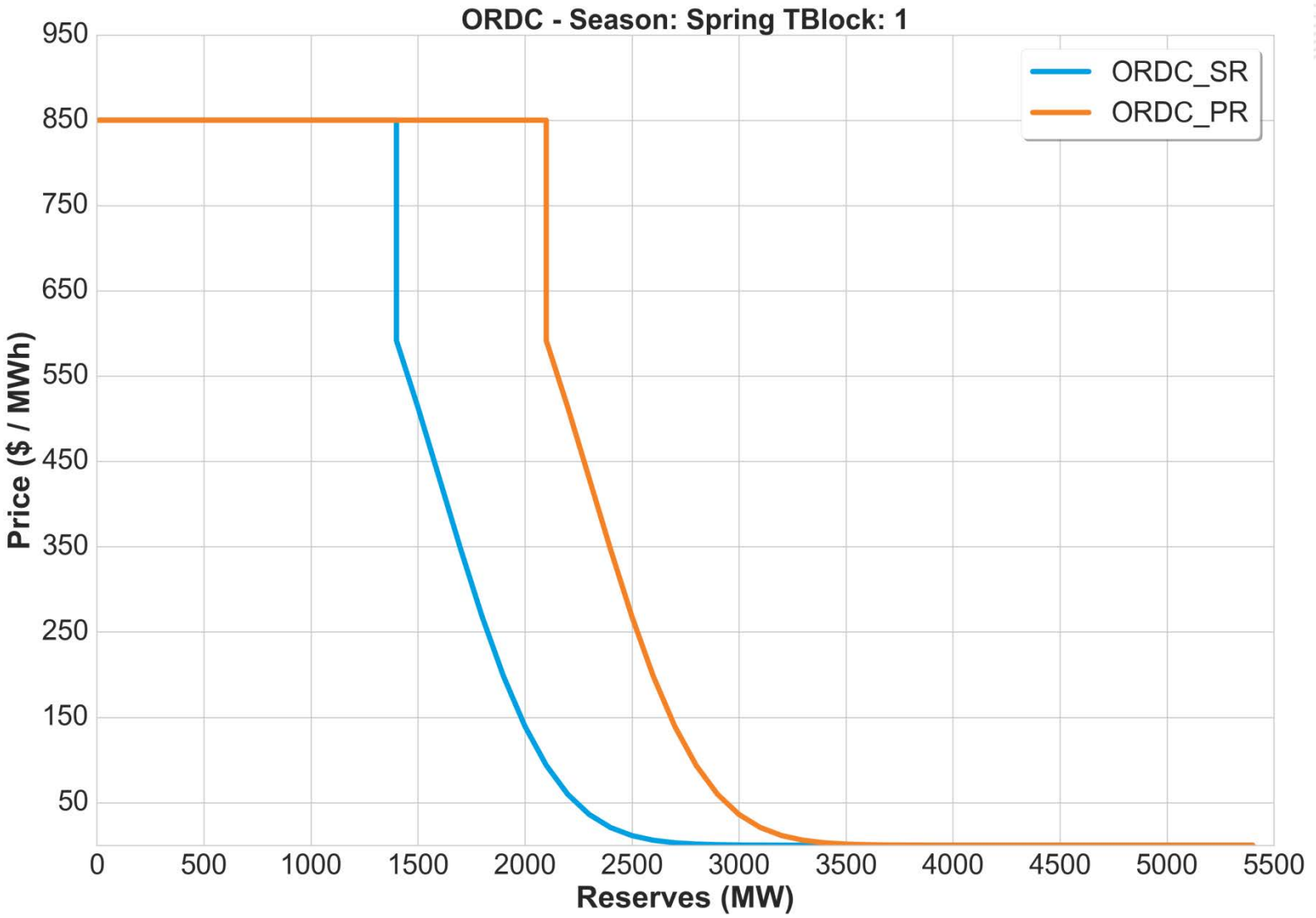
ORDC Fall TBlock 5 (1500-1800)



ORDC Fall TBlock 6 (1900-2200)



ORDC Spring TBlock 1 (2300-0200)



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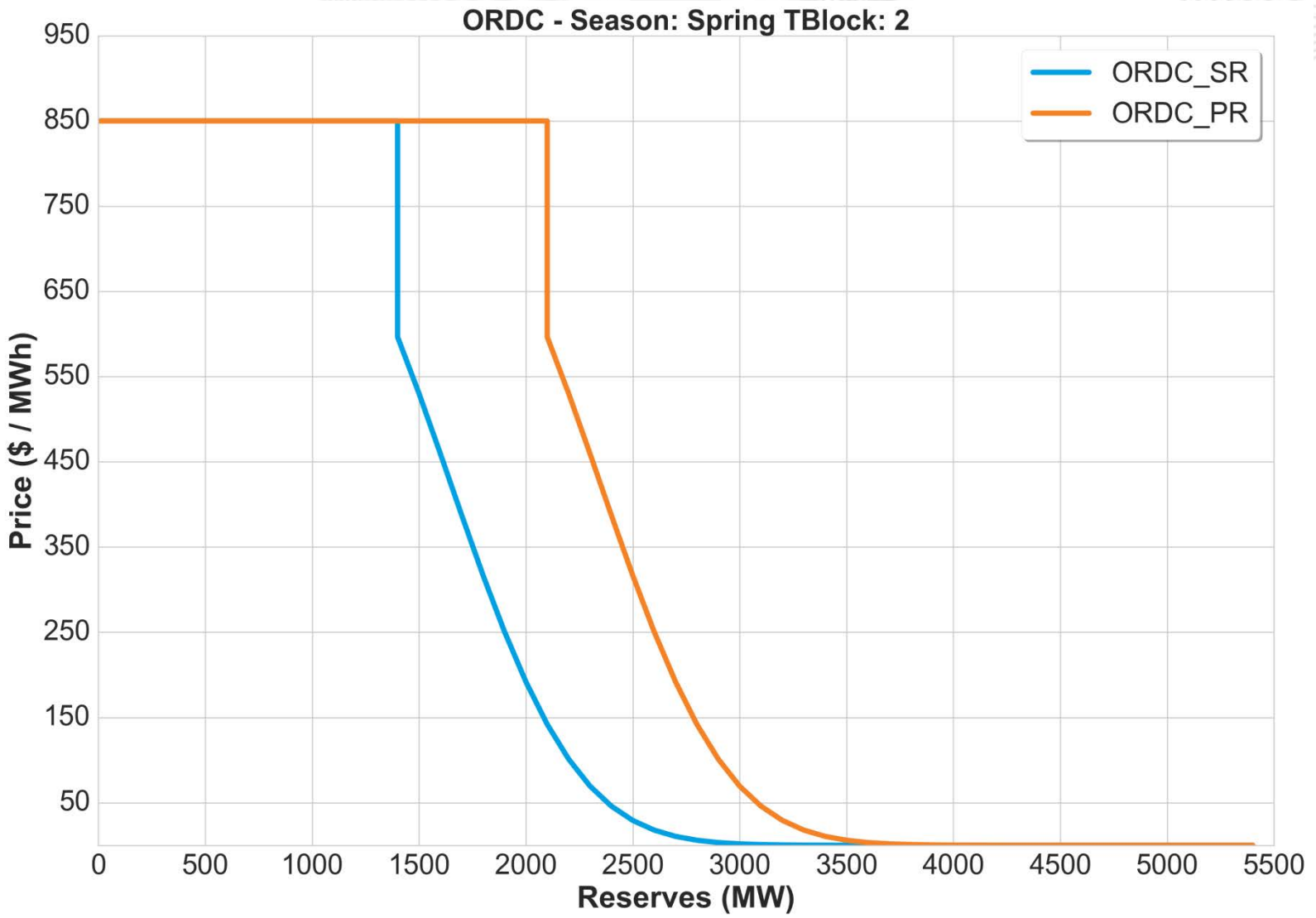
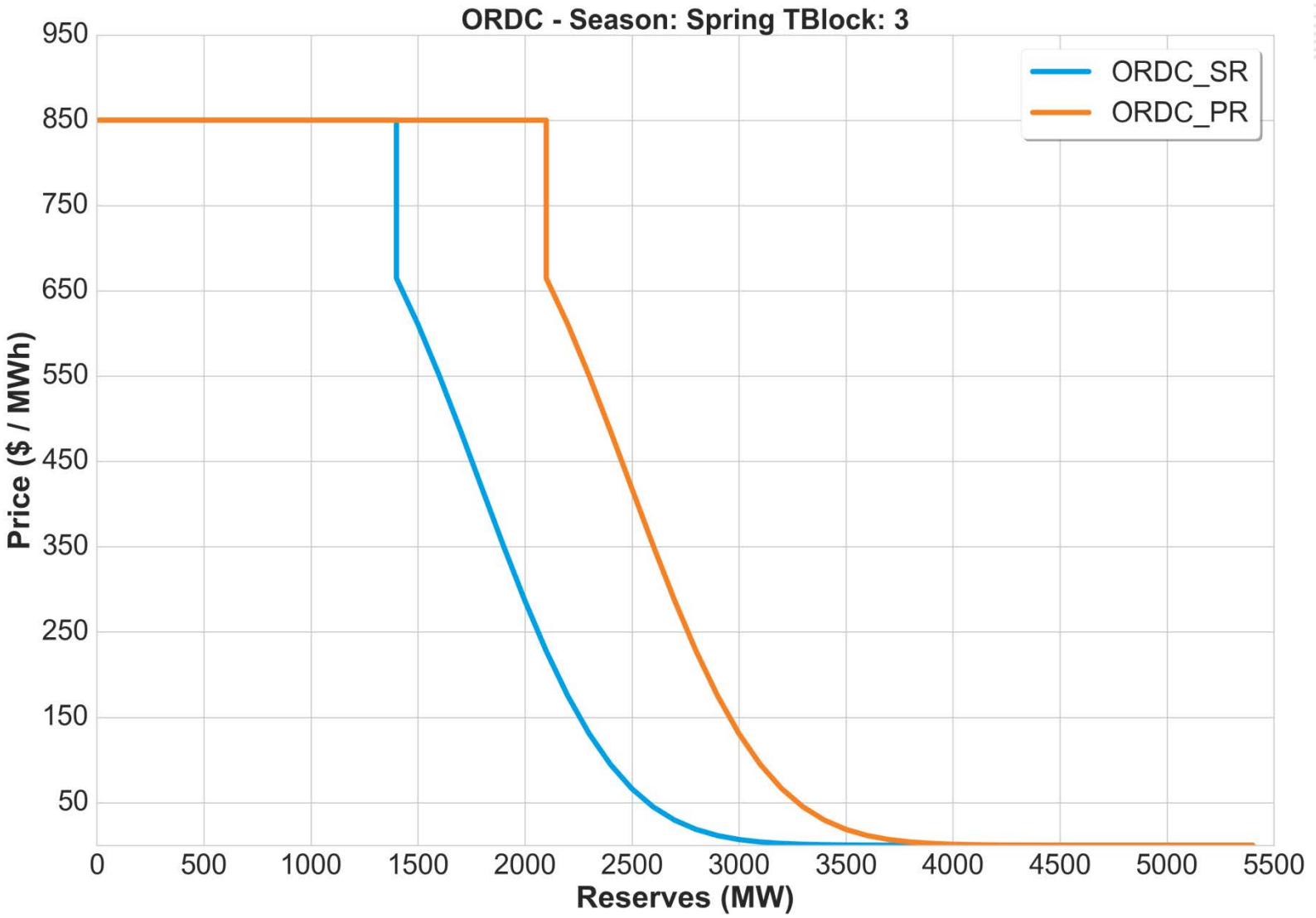
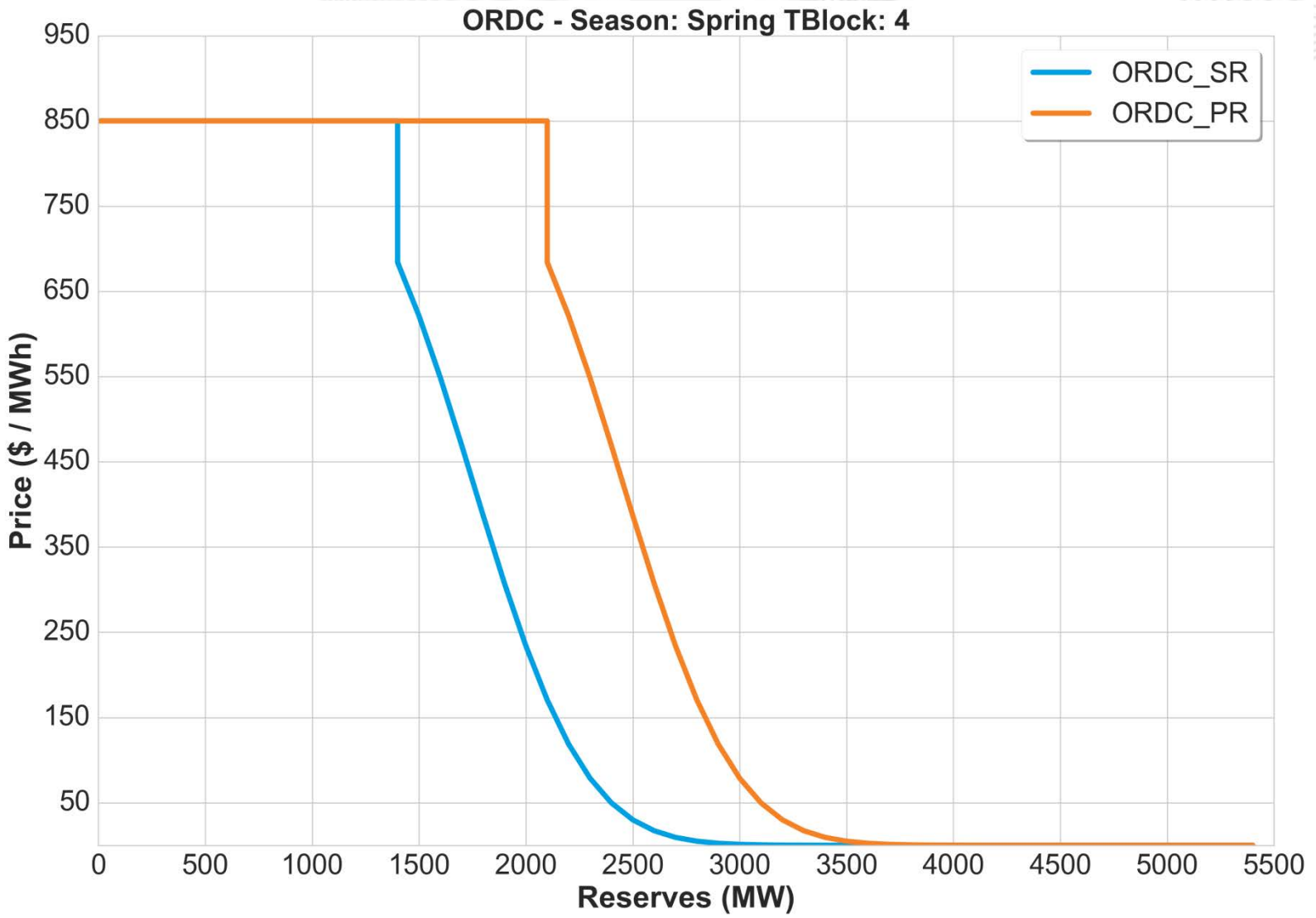


ORDC Spring TBlock 3 (0700-1000)



ORDC Spring TBlock 4 (1100-1400)



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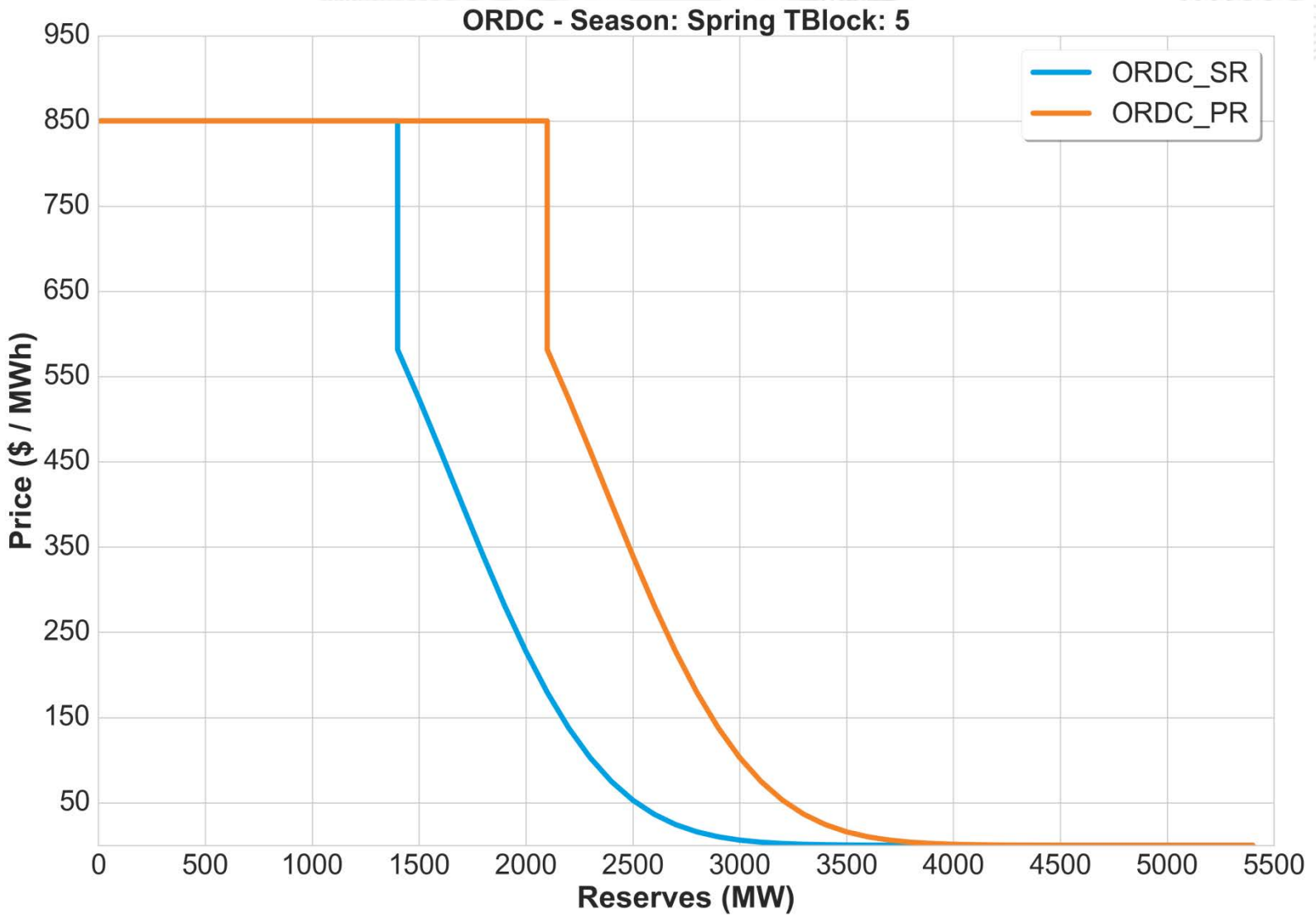
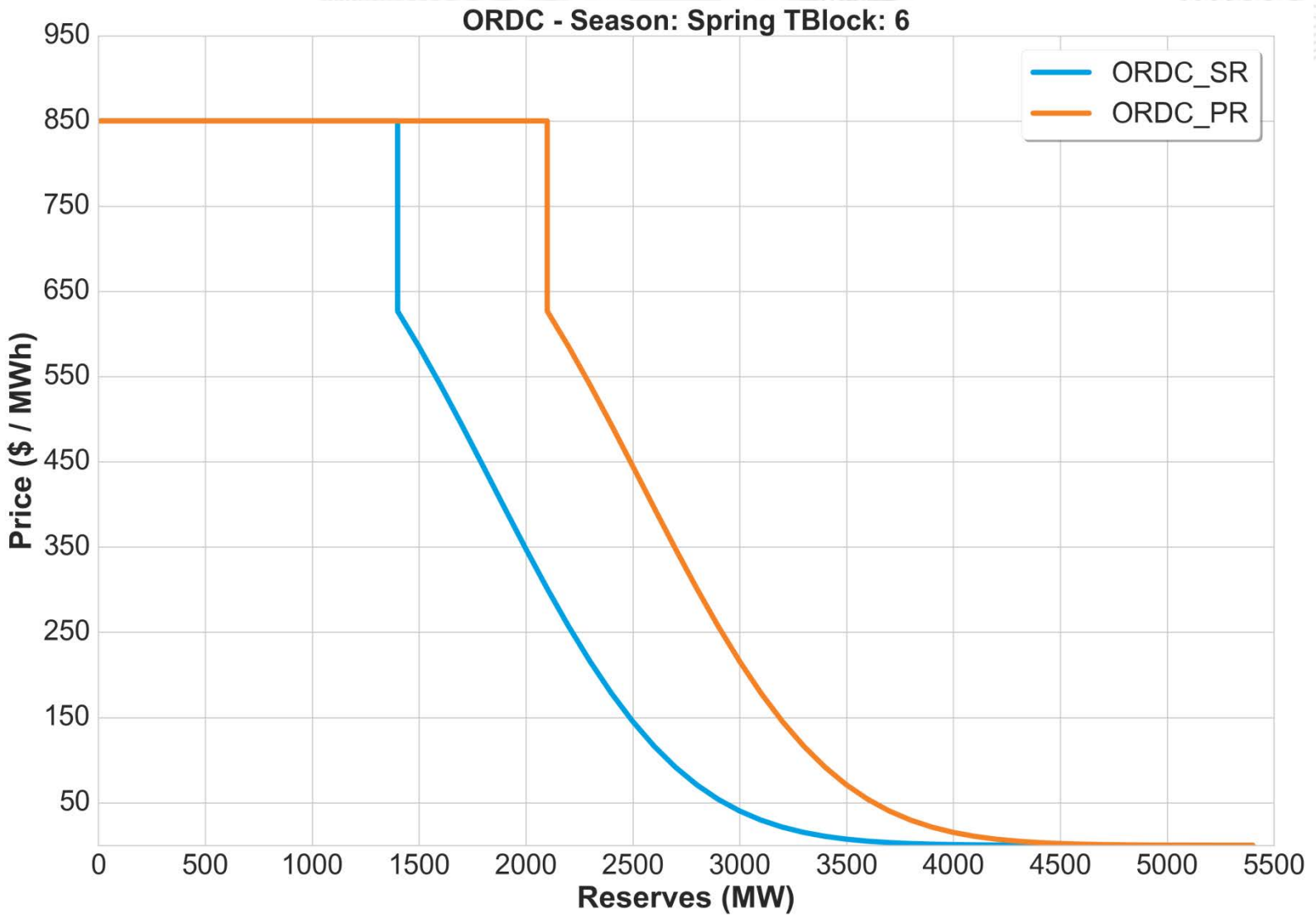


ORDC Spring TBlock 6 (1900-2200)



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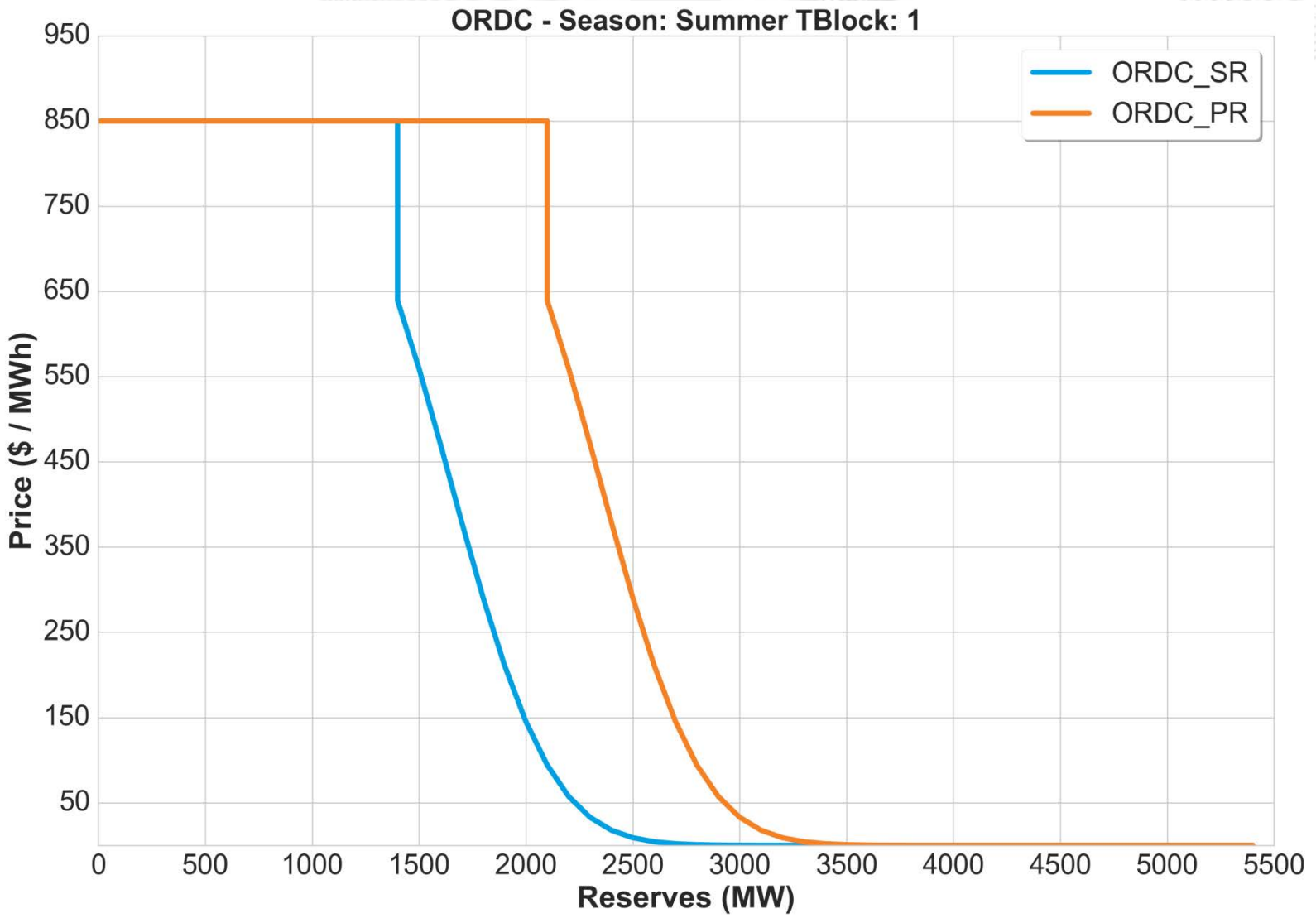

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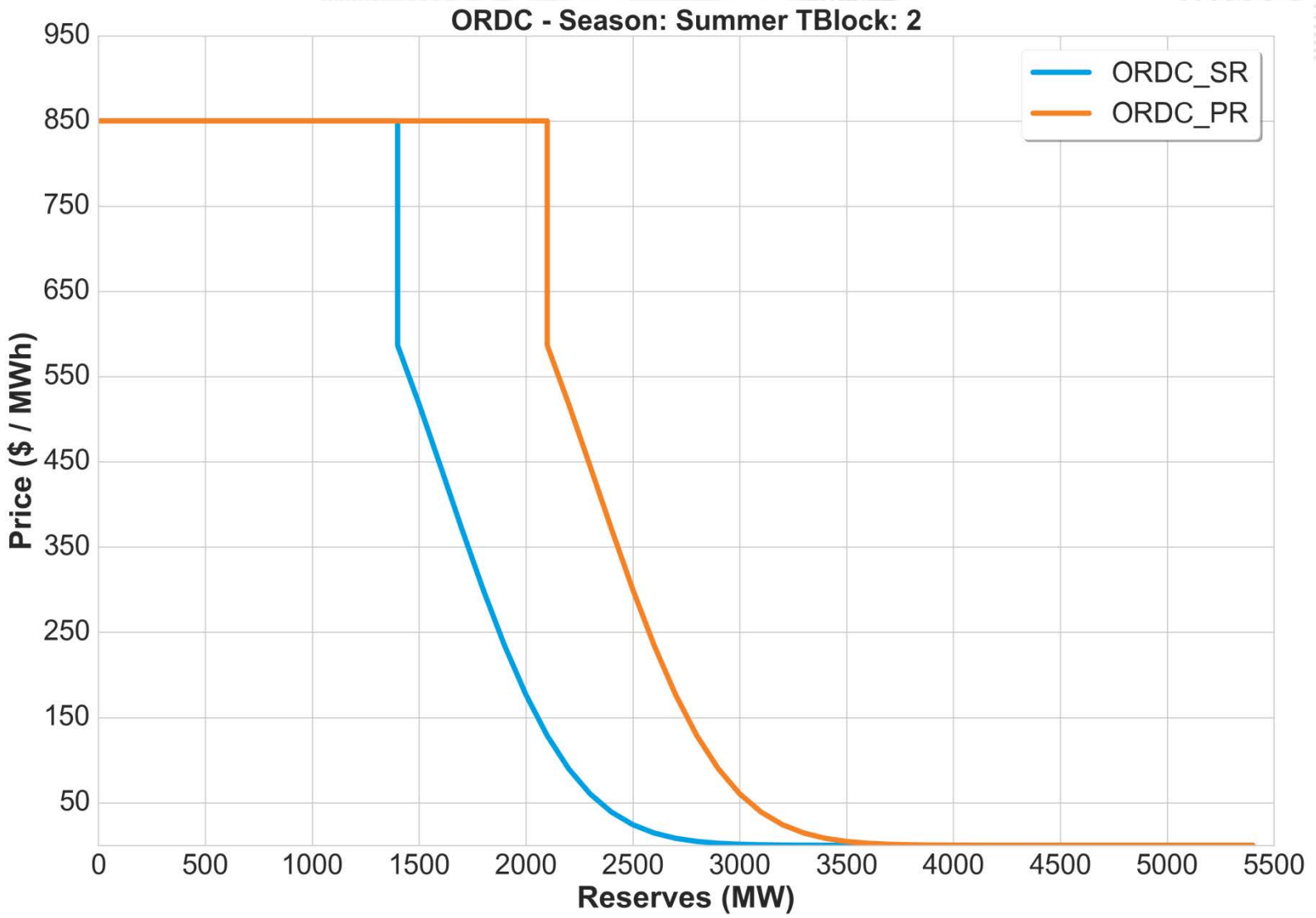
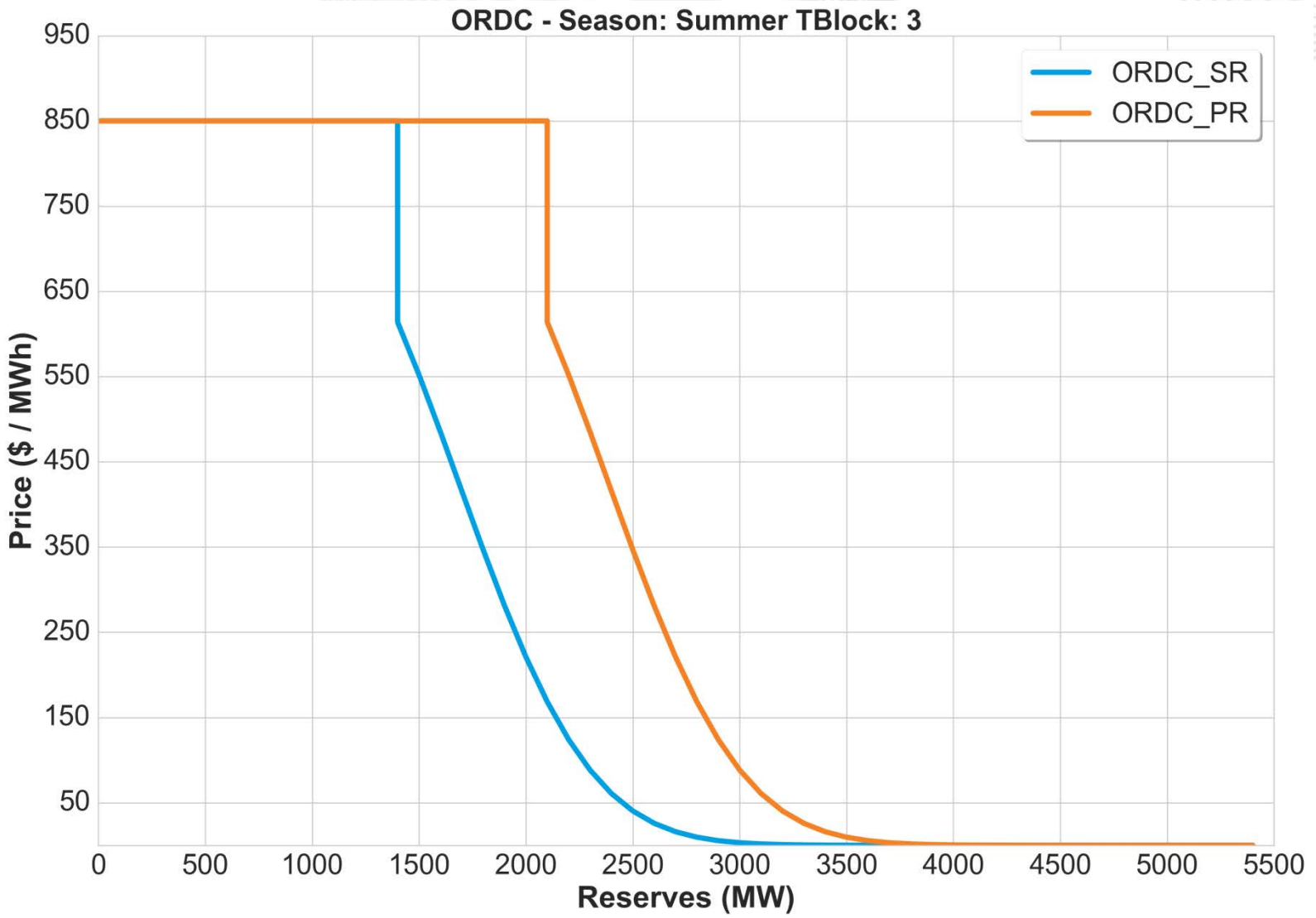


ORDC Summer TBlock 3 (0700-1000)



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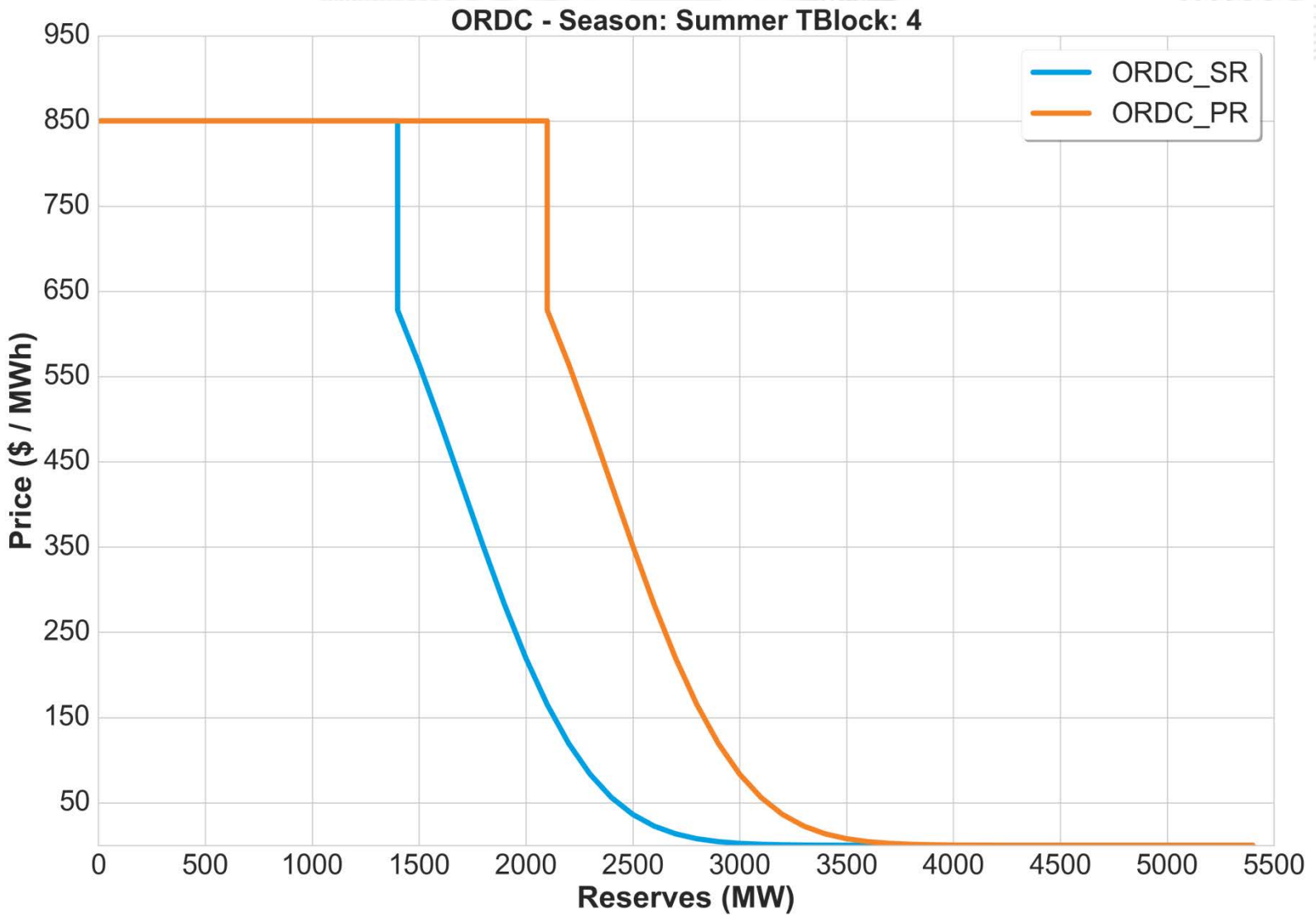
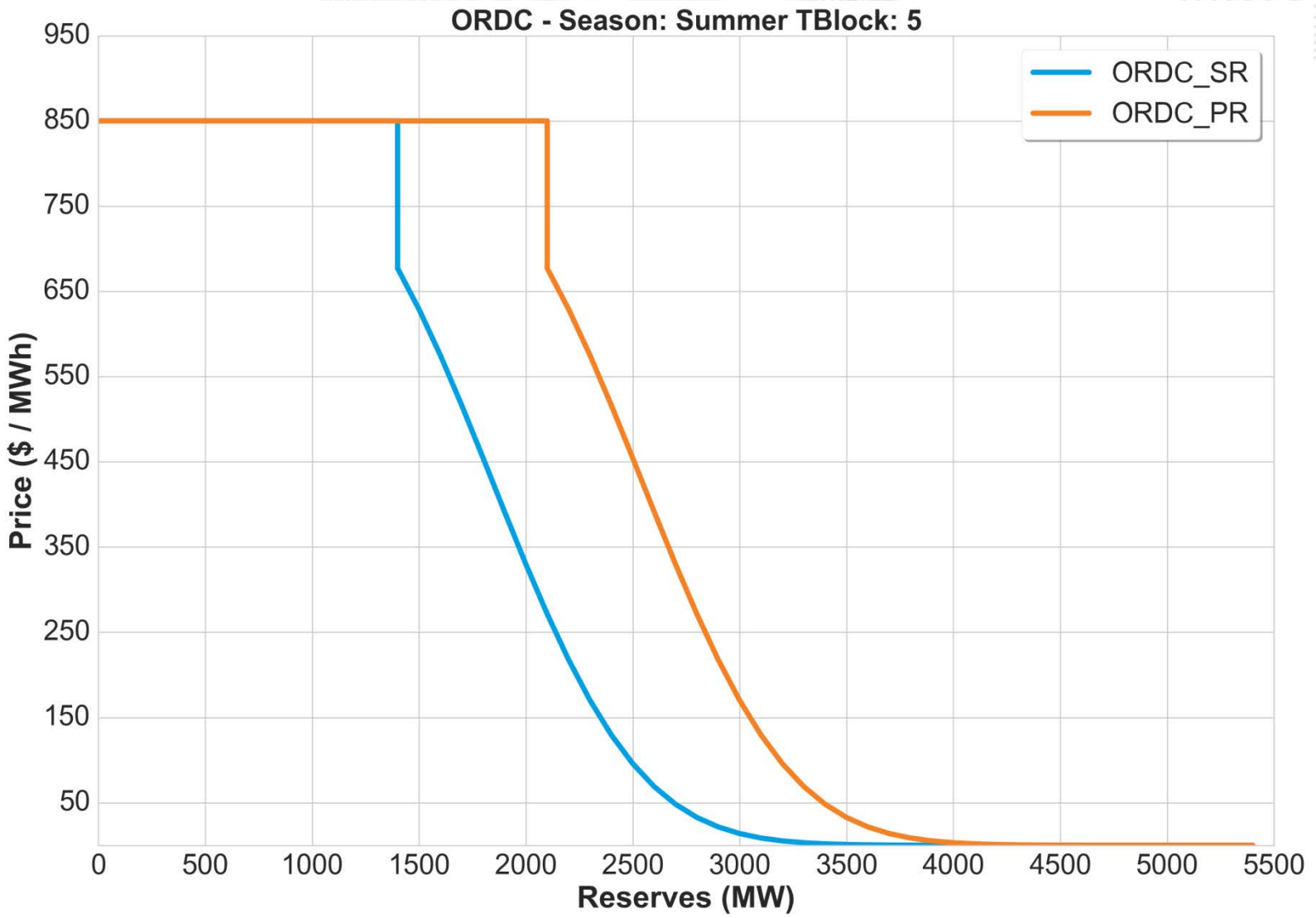
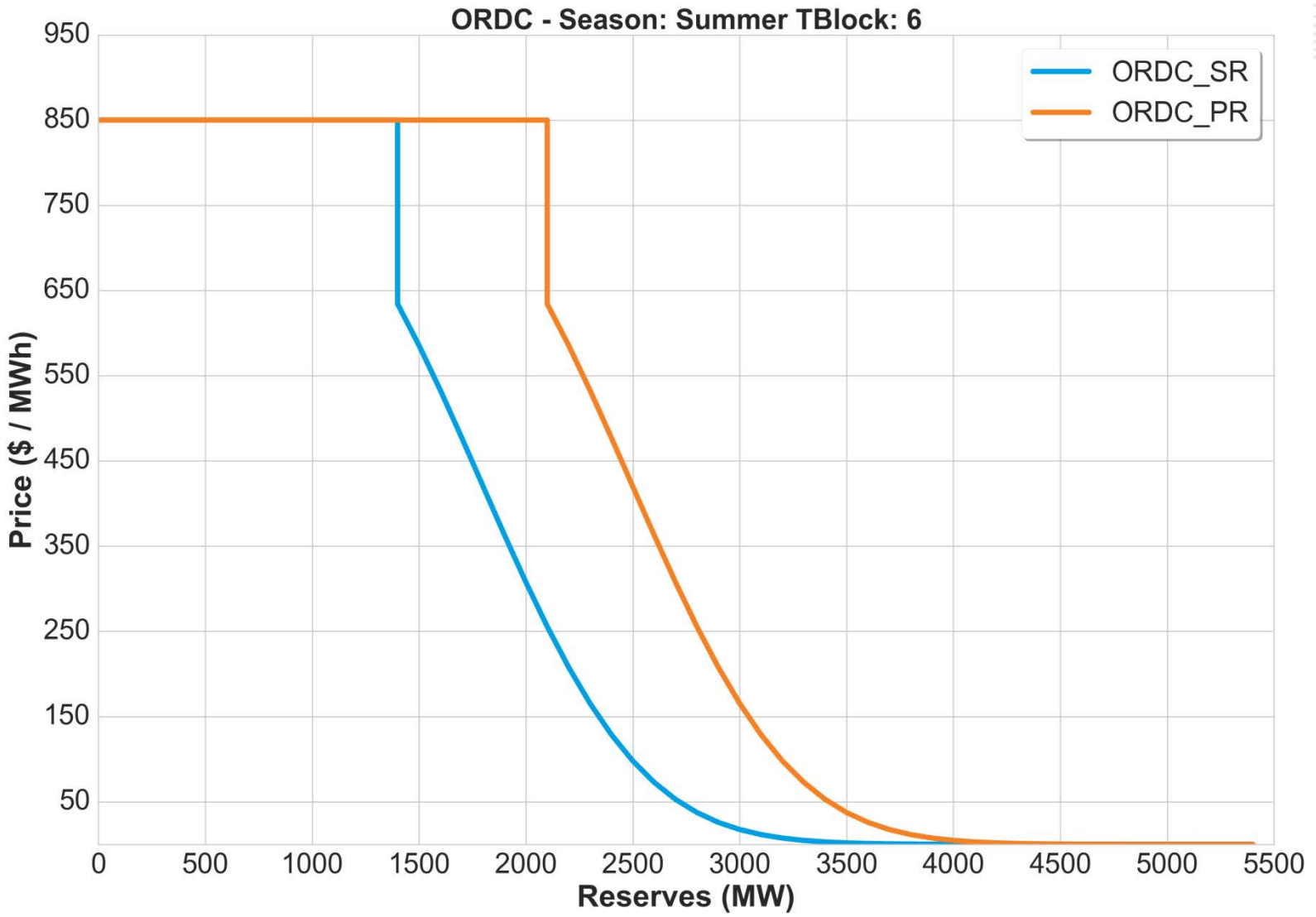


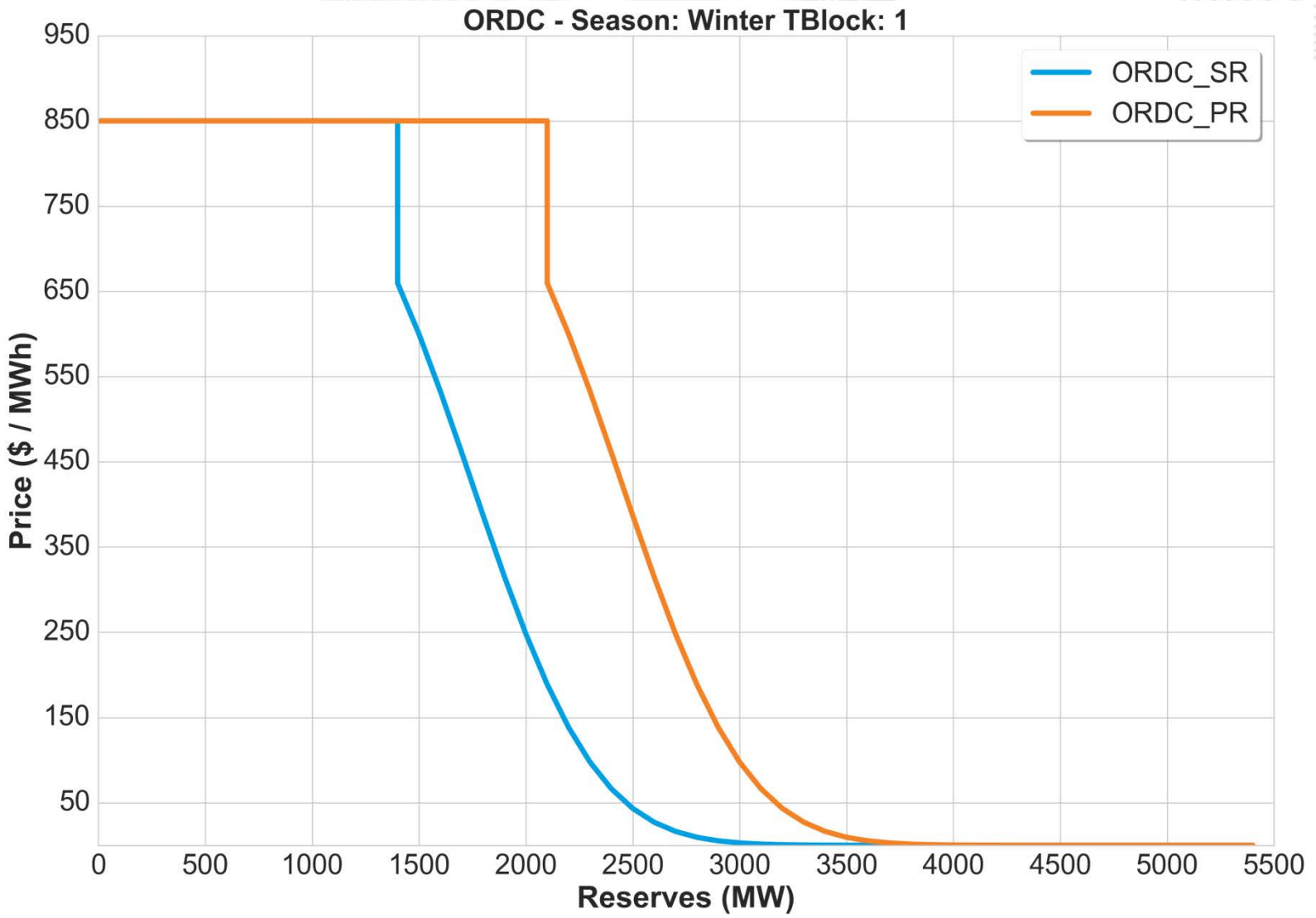
ORDC Summer TBlock 5 (1500-1800)



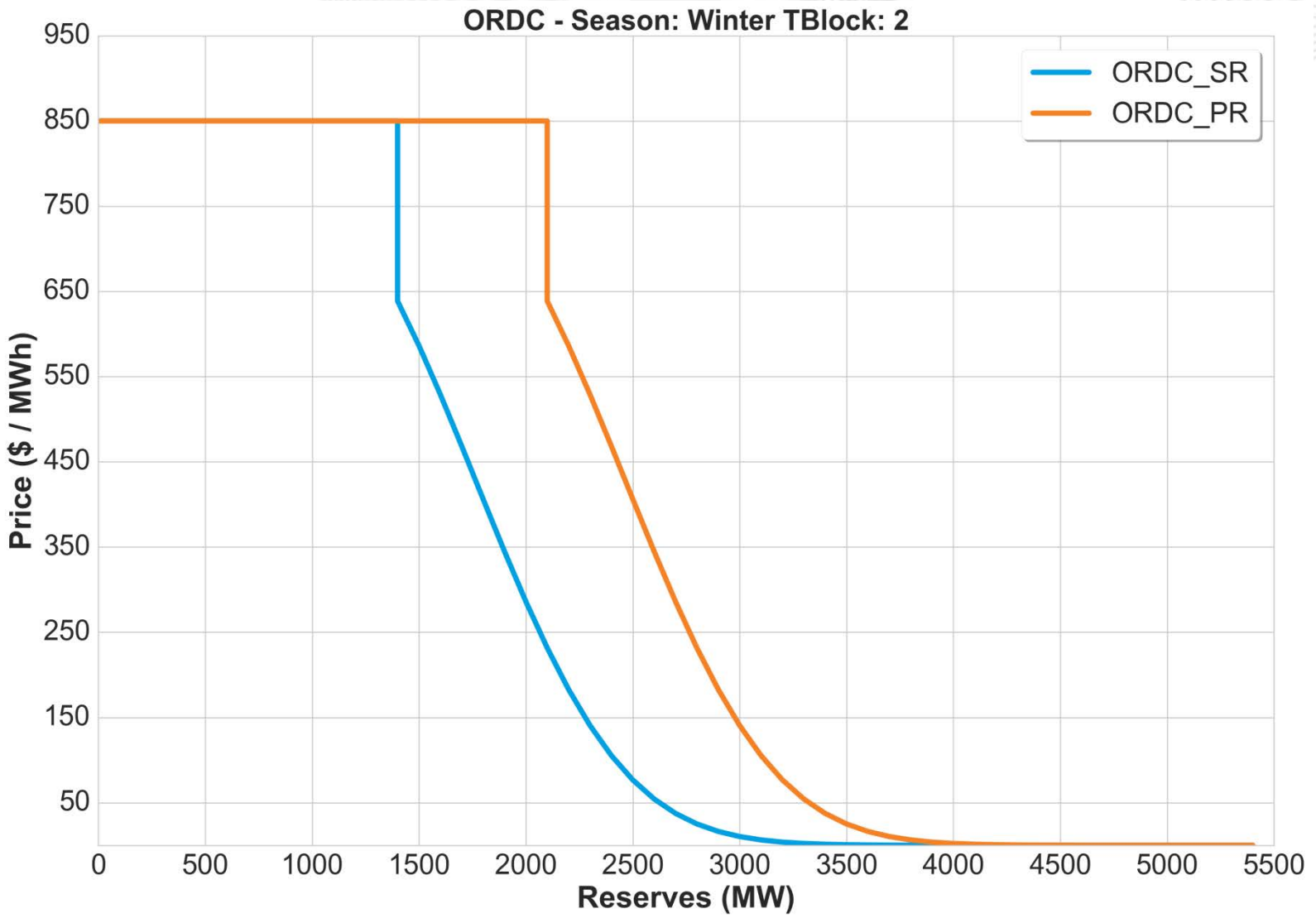
ORDC Summer TBlock 6 (1900-2200)



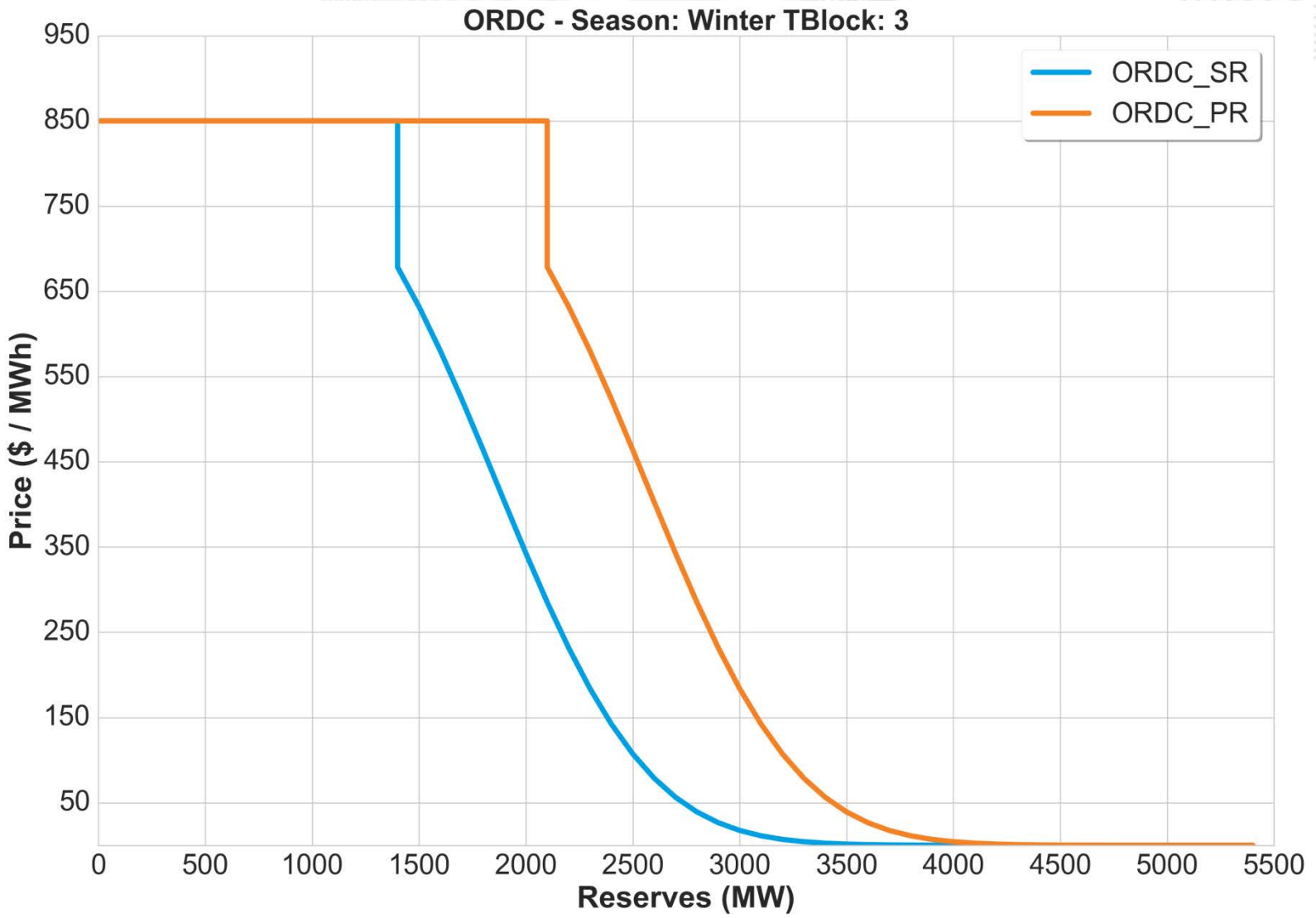
ORDC Winter TBlock 1 (2300-0200)



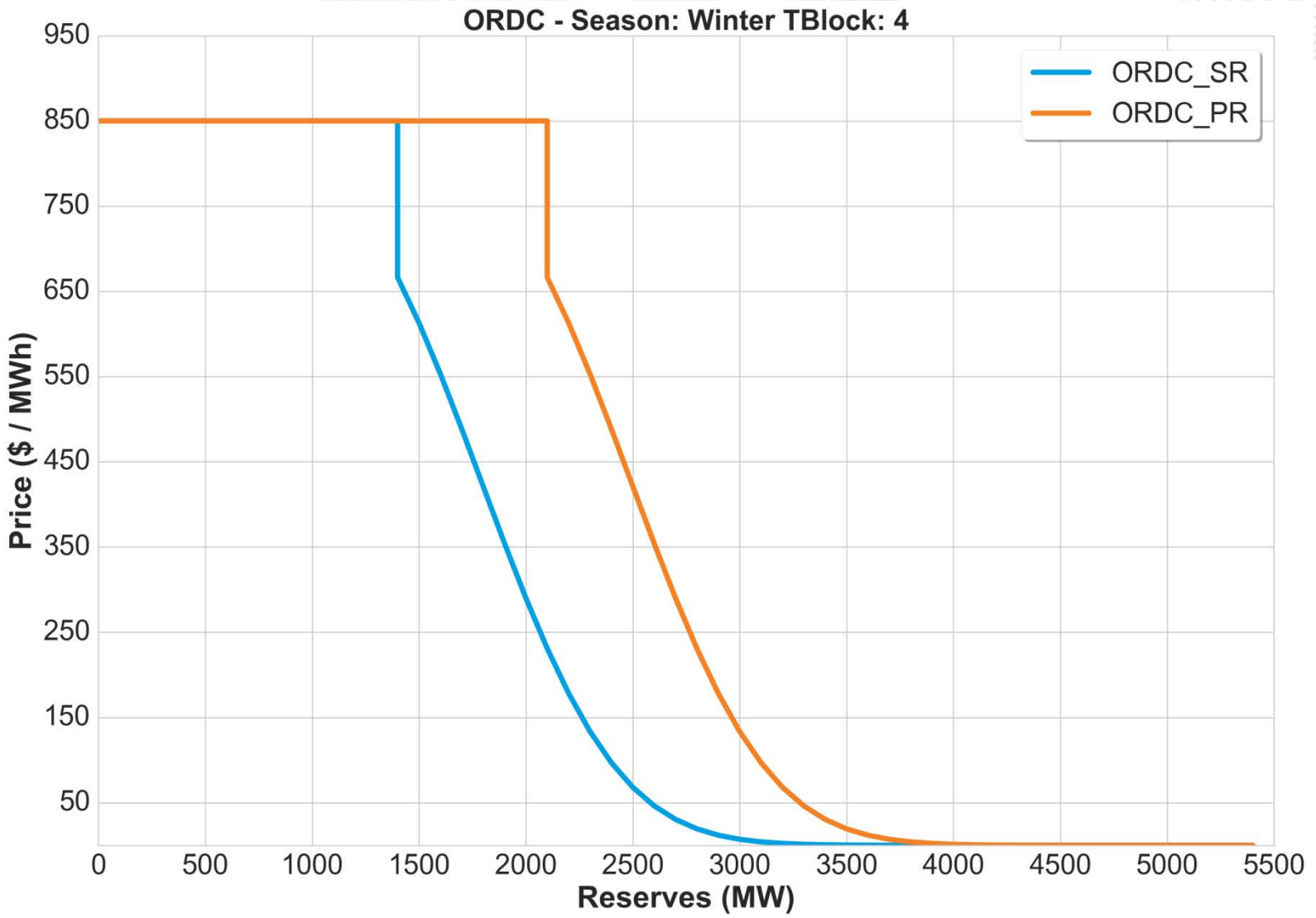
ORDC Winter TBlock 2 (0300-0600)



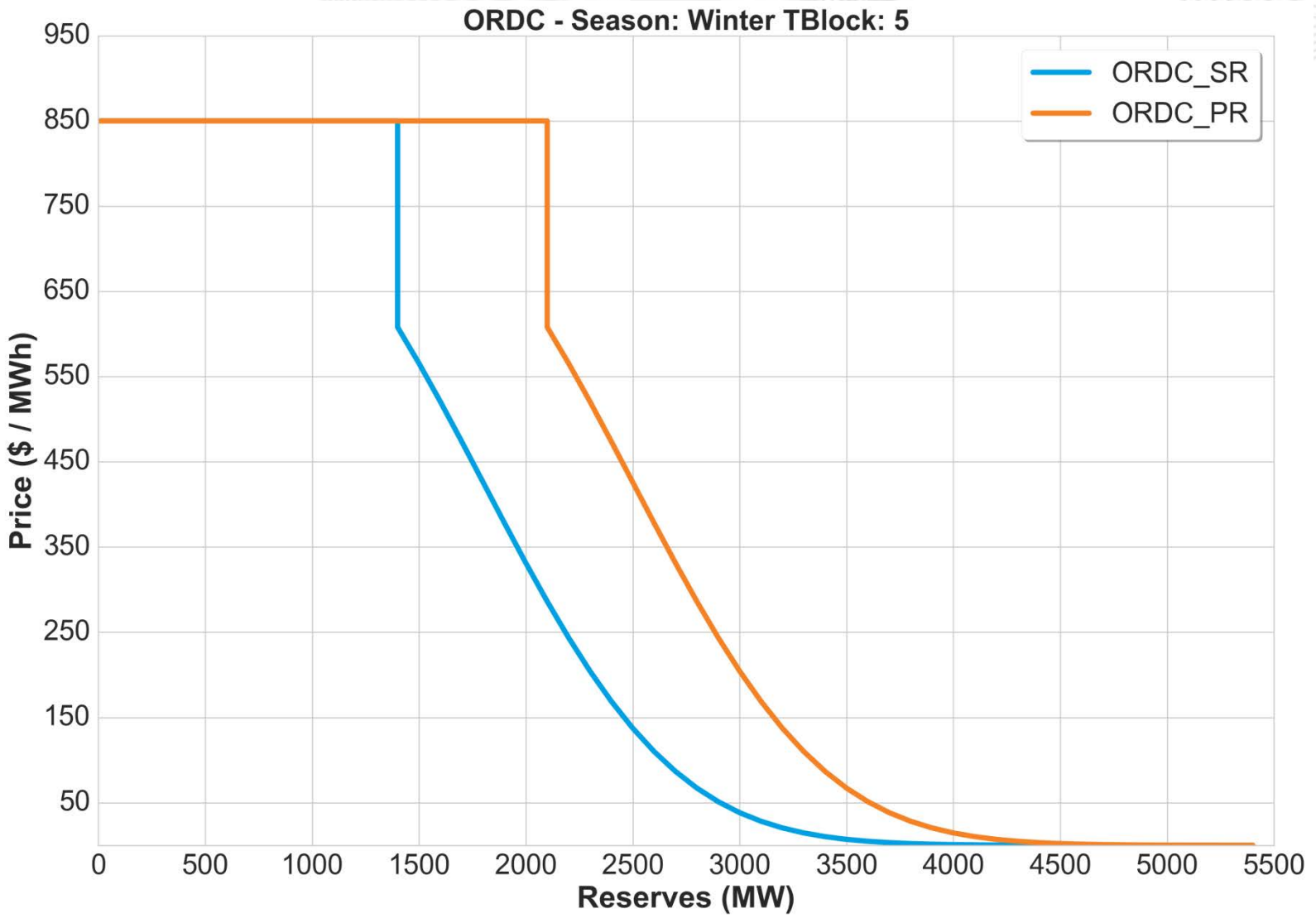
ORDC Winter TBlock 3 (0700-1000)



ORDC Winter TBlock 4 (1100-1400)



ORDC Winter TBlock 5 (1500-1800)



ORDC Winter TBlock 6 (1900-2200)