Calculation of Forced Outage Probability and the ORDC

EPFSTF

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Monitoring Analytics

PJM Forced Outage Distribution

- **PJM's approach to the inclusion of forced outages in the ORDC is not accurate.**
- **PJM's approach overstates the forced outage MW and the ORDC.**
- **PJM's approach assumes that all units are always online.**
- **PJM's approach misses the fact that there is a significant probability of zero outages for each 30 minute time horizon.**
- **The examples in this presentation illustrate the general problem with PJM's approach.**

PJM Forced Outage Distribution

- **PJM's ORDC includes an increase in demand for reserves based on an assumed distribution of generator forced outage rates.**
- **PJM's proposed probability distribution for the forced outage rate is based on all generators with capacity rights (excluding solar and wind).**
- **For each season/time block, PJM forms a probability distribution of forced outage MW by multiplying the forced outage rate distribution by the average load for the season/time block.**

Forced Outage Probability Distribution

- **Online Generators for June 18, 2018, Hours 15 -18**
  - **819 generators**
  - **150,980.3 MW capacity**
  - **Average MTTF 2,290.5 (MTTF: mean time to failure)**
  - **Probability of no forced outages is 0.14**
  - **Probability of forced outage MW ≤ 20 MW is 0.32**
  - **Mean 145.7 MW**
  - **Standard Deviation 200.2 MW**

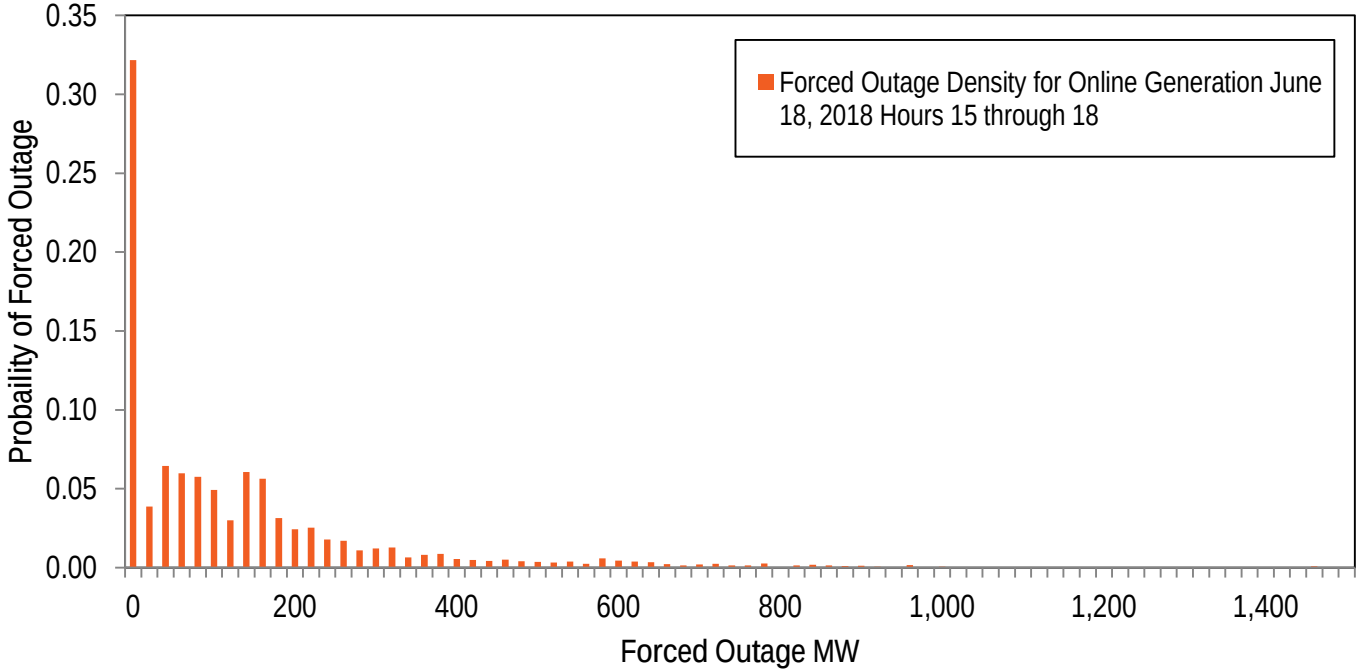
Forced Outage Probability Distribution

- **PJM – All generators with capacity rights**
  - **1,229 generators**
  - **184,731.3 MW capacity**
  - **Average MTTF 1,664.0 (MTTF: mean time to failure)**
  - **Probability of no forced outages is 0.0000319**
  - **Probability of forced outage MW ≤ 20 MW is 0.000389**
  - **Mean 447.9 MW**
  - **Standard Deviation 297.2 MW**

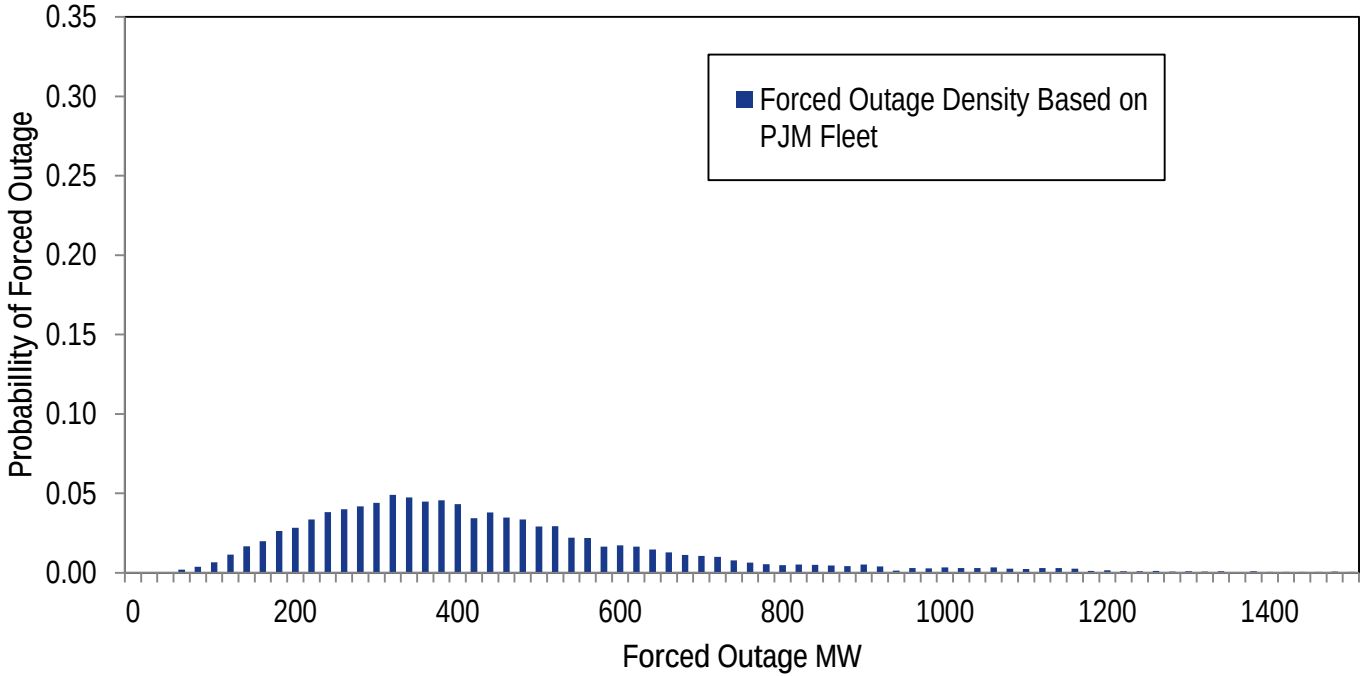
Forced Outage Probability Distribution

- **PJM – All generators with capacity rights with seasonal adjustment for summer, time block 5**
  - **Probability of no forced outages is 0.0000319**
  - **Probability of forced outage MW ≤ 20 MW is 0.001379**
  - **Mean 289.4MW**
  - **Standard Deviation 192.1MW**

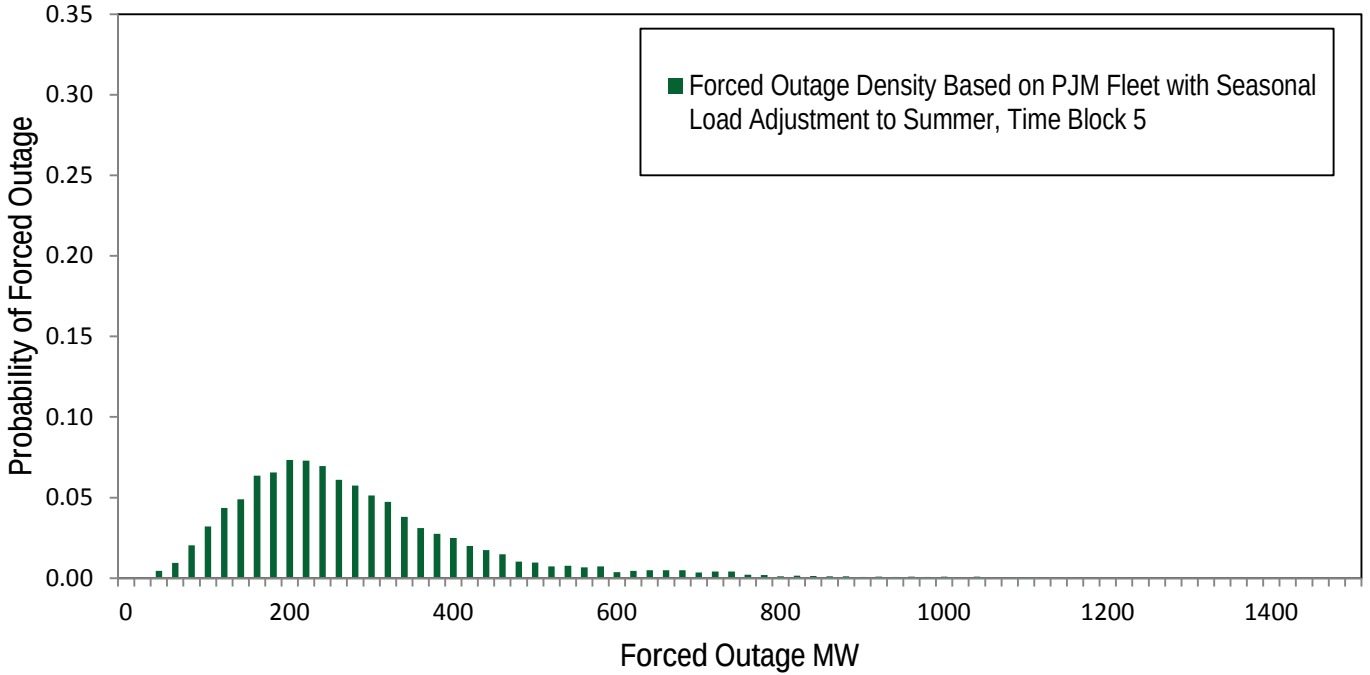
Probability Density – Online Generation



Probability Density – All Generators



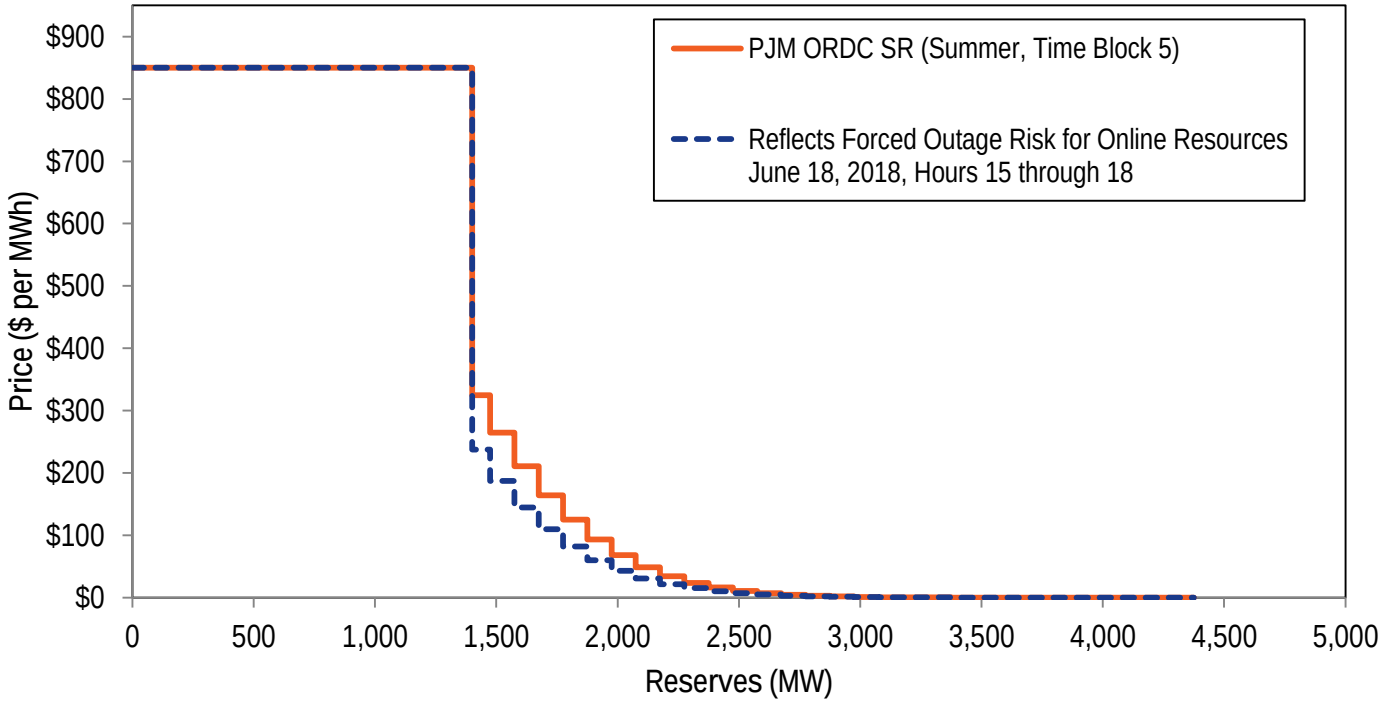
Probability Density – All Generators (Adjusted)



Impact on ORDCs

			PJM Method		Online Generation for June 18, 2018, Hours 15 - 18		
Reserves	Excess Above MRR (including RR Shift)	Forced Outage MW Level	Adjusted PBMRR	Price (Adjusted PBMRR x $850)	Adjusted PBMRR	Price (Adjusted PBMRR x $850)	Price Difference
0	-1400		1.000	$850.0	1.000	$850.0	$0
1400	0		1.000	$850.0	1.000	$850.0	$0
1475	75	600	0.382	$324.8	0.279	$237.4	$87
1575	175	700	0.311	$264.5	0.220	$187.2	$77
1675	275	800	0.248	$210.6	0.170	$144.9	$66
1775	375	900	0.193	$164.0	0.129	$109.7	$54
1875	475	1000	0.147	$125.0	0.097	$82.1	$43
1975	575	1100	0.110	$93.4	0.071	$60.1	$33
2075	675	1200	0.080	$68.3	0.051	$43.2	$25
2175	775	1300	0.058	$48.9	0.036	$30.8	$18
2275	875	1400	0.040	$34.3	0.026	$21.7	$13
2375	975	1500	0.028	$23.8	0.018	$15.1	$9
2475	1075	1600	0.019	$16.1	0.012	$10.4	$6
2575	1175	1700	0.013	$10.7	0.008	$7.1	$4
2675	1275	1800	0.008	$7.1	0.006	$4.9	$2
2775	1375	1900	0.005	$4.6	0.004	$3.2	$1
2875	1475	2000	0.003	$2.9	0.002	$2.1	$1
2975	1575	2100	0.002	$1.8	0.002	$1.3	$0

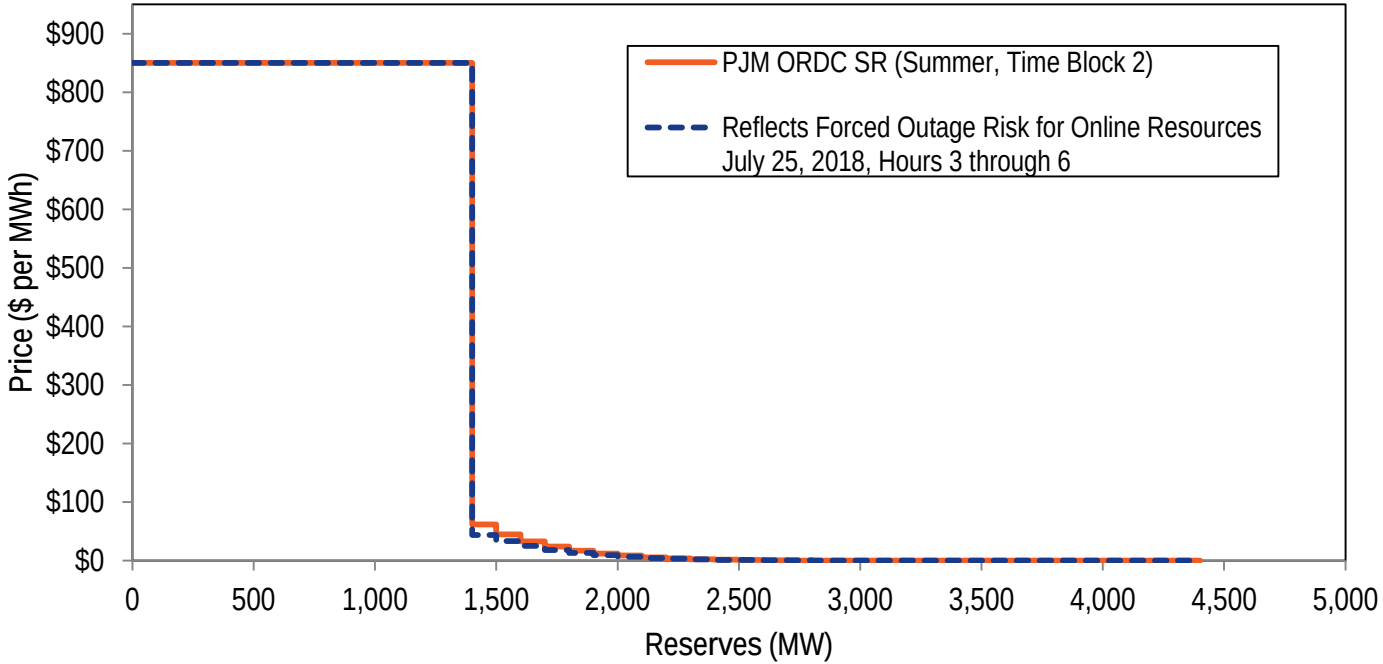
Impact on ORDC



Impact on ORDCs

			PJM Method		Online Generation for July 25, 2018, Hours 3 - 6		
Reserves	Excess Above MRR (including RR Shift)	Forced Outage MW Level	Adjusted PBMRR	Price (Adjusted PBMRR x $850)	Adjusted PBMRR	Price (Adjusted PBMRR x $850)	Price Difference
0	-1400		1.000	$850.0	1.000	$850.0	$0.0
1400	0		1.000	$850.0	1.000	$850.0	$0.0
1500	100	900	0.073	$61.7	0.052	$44.1	$17.6
1600	200	1000	0.053	$44.8	0.039	$33.3	$11.5
1700	300	1100	0.039	$32.8	0.030	$25.3	$7.5
1800	400	1200	0.028	$24.0	0.022	$18.4	$5.5
1900	500	1300	0.020	$17.3	0.016	$13.4	$3.9
2000	600	1400	0.015	$12.4	0.011	$9.6	$2.9
2100	700	1500	0.010	$8.7	0.008	$6.6	$2.1
2200	800	1600	0.007	$5.9	0.005	$4.7	$1.2
2300	900	1700	0.005	$3.9	0.004	$3.2	$0.7
2400	1000	1800	0.003	$2.6	0.003	$2.3	$0.3
2500	1100	1900	0.002	$1.7	0.002	$1.5	$0.2
2600	1200	2000	0.001	$1.1	0.001	$1.0	$0.1
2700	1300	2100	0.001	$0.7	0.001	$0.7	$0.0
2800	1400	2200	0.001	$0.5	0.001	$0.5	$0.0
2900	1500	2300	0.000	$0.3	0.000	$0.4	-$0.1
3000	1600	2400	0.000	$0.2	0.000	$0.2	$0.1

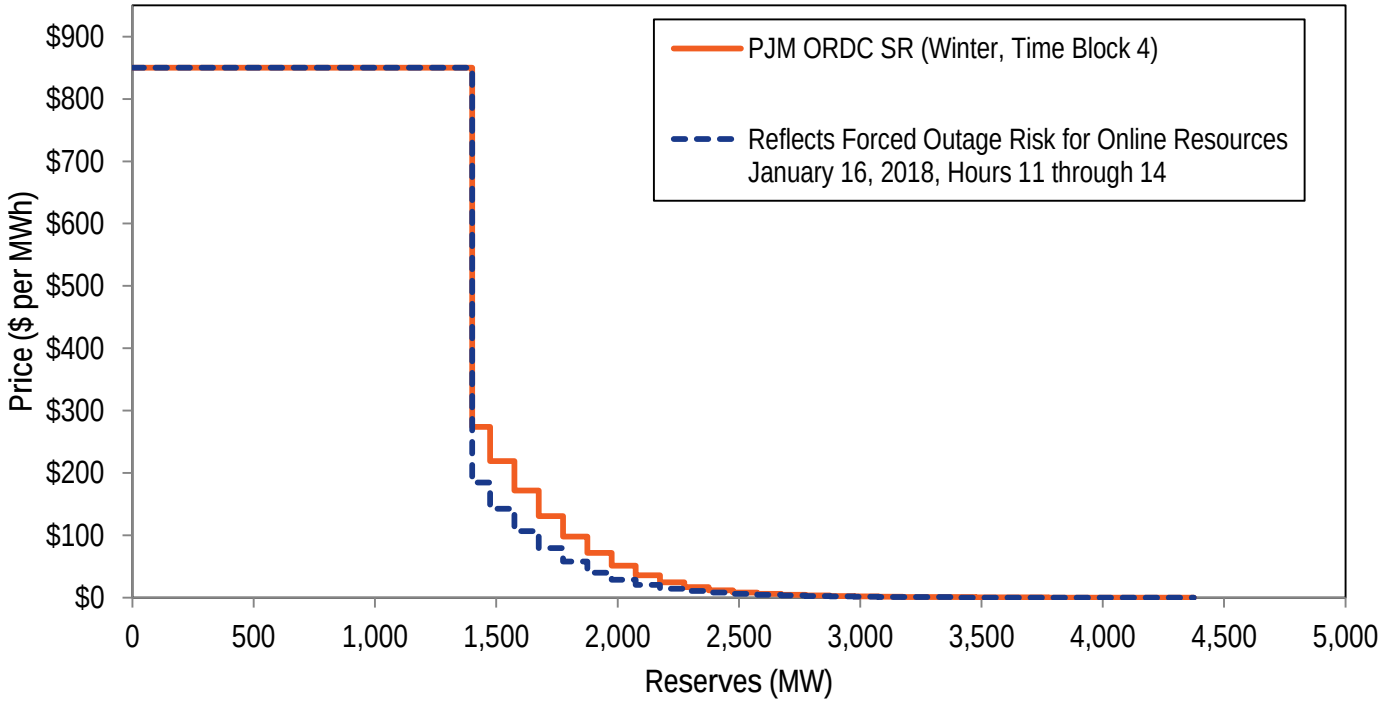
Impact on ORDC



Impact on ORDCs

			PJM Method		Online Generation for January 16, 2018, Hours 11 - 15		
Reserves	Excess Above MRR (including RR Shift)	Forced Outage MW Level	Adjusted PBMRR	Price (Adjusted PBMRR x $850)	Adjusted PBMRR	Price (Adjusted PBMRR x $850)	Price Difference
0	-1400		1.000	$850.0	1.000	$850.0	$0
1400	0		1.000	$850.0	1.000	$850.0	$0
1475	75	600	0.323	$274.1	0.217	$184.6	$90
1575	175	700	0.258	$219.0	0.168	$142.4	$77
1675	275	800	0.202	$171.6	0.125	$106.4	$65
1775	375	900	0.154	$130.8	0.094	$79.6	$51
1875	475	1000	0.115	$97.8	0.068	$57.9	$40
1975	575	1100	0.085	$71.9	0.047	$40.2	$32
2075	675	1200	0.060	$51.2	0.034	$28.7	$22
2175	775	1300	0.042	$35.7	0.024	$20.2	$15
2275	875	1400	0.029	$24.7	0.017	$14.2	$11
2375	975	1500	0.020	$16.9	0.012	$10.5	$6
2475	1075	1600	0.014	$11.6	0.009	$8.0	$4
2575	1175	1700	0.010	$8.3	0.007	$5.9	$2
2675	1275	1800	0.007	$6.1	0.005	$4.6	$2
2775	1375	1900	0.005	$4.5	0.004	$3.4	$1
2875	1475	2000	0.004	$3.4	0.003	$2.6	$1
2975	1575	2100	0.003	$2.6	0.002	$2.0	$1

Impact on ORDC



Terms

- **ORDC – Operating Reserve Demand Curve**
- **MRR – Minimum Reserve Requirement**
- **Excess Above MRR (including RR shift) – the excess above the minimum reserve requirement after an adjustment to account for the regulation requirement.**
- **PBMRR – Probability (of falling) below the minimum reserve requirement**

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