

Shortage Revenue Offset Example

20100322 SPWG – ITEM 2

- PJM proposal at the February 18, 2010 SPWG
 - RPM capacity resources are allowed to earn and retain shortage revenues
 - Continue the three-year historic offset used to determine Net CONE and Market Seller Offer Caps that includes shortage revenues
 - Moves opportunity to recover fixed costs including investments into the energy market from the capacity market
 - Implicitly assumes RPM capacity is a reliability product without any financial hedging properties

- Some stakeholders requested an analysis of the RPM price and cash flow impacts under the PJM proposal
 - Assume a certain amount of shortage revenues in a given year
 - Construct and example RPM auction using representative data for supply offers and VRR curve with and without shortage revenues
 - Determine RPM clearing prices under both scenario in subsequent year
 - Examine present discounted value of cash flow with hypothetical results of the next BRA following occurrence of reserve shortage.

- Over time the present value of cash flows resulting from any shortage revenues should be approximately offset by the change in cash flows in RPM due to the inclusion of shortage revenues in the E&AS Offset for Net CONE and in Market Seller Offer Caps
 - This works similarly as Net Energy Market Revenues, not related to shortage revenues, fluctuate over time due to variations in fuel prices and demand

- PJM provided an example at the March 4, 2010 SPWG
 - Shows example RPM auction results with and without inclusion of shortage revenues in Net CONE and RPM supply offers
 - One example showed the difference in cash flows from paying shortage revenues in current year versus reduced RPM expenditures three years later is small
 - Impacts on RPM auctions of including or not including shortage revenues on offsets depends on other assumption such as the shape of the supply curve, demand, level of shortage revenues being considered.
 - Stakeholders requested additional examples to examine impacts of changing demand, supply, or level of shortage revenues.

Example Base Assumptions: PJM Capacity Resources

Fuel Type Group	Fuel Type SubGroup	Installed Capacity	External Purchases	External Sales	Total Capacity
Coal	Bituminous Coal	57598.8	2547.6	-1965.5	58180.9
	Coal-based Synfuel	460.0			460.0
	Sub-Bituminous Coal	7089.5	1032.8		8122.3
	Waste Coal	1566.9			1566.9
Nuclear	Nuclear	31175.0		-443.5	30731.5
Natural Gas	Natural Gas	26656.3		-135.3	26521.0
	Natural Gas w/ Secondary	17653.5		-33.7	17619.8
	Other Gas	224.9			224.9
Petroleum	Distillate Fuel Oil	5459.4		-9.6	5449.8
	Jet Fuel	11.0			11.0
	Kerosene	1105.0			1105.0
	Residual Fuel Oil	8085.2	4.6	-119.0	7970.8
Solid Renewable	Municipal Solid Waste	572.0			572.0
	Wood Waste	107.0			107.0
Liquid Renewable	Black Liquor	42.0			42.0
Gaseous Renewable	Landfill Gas	394.7			394.7
Other Renewable	Water	7767.5			7767.5
	Wind	306.9			306.9
Demand Side	Demand Resource	993.2			993.2
	Interruptible Load for Reliability	3412.7			3412.7
External	R.E.C. Contract		172.4		172.4
Grand Total		170681.5	3757.4	-2706.6	171732.3

Source: RPM Capacity Effective 12/31/2009 23:59

Table 4 APIR statistics: 2012/2013 RPM Base Residual Auction¹⁷

	Weighted-Average (\$ per MW-day UCAP)						Total
	Combined Cycle	Combustion Turbine	Oil or Gas Steam	SubCritical/ SuperCritical Coal	Other	Opportunity Costs	
Non-APIR units							
ACR	\$41.84	\$32.61	\$75.47	\$207.54	\$57.18		\$110.84
Net revenues	\$91.67	\$35.29	\$7.51	\$396.82	\$257.96		\$208.65
Offer caps	\$5.28	\$14.40	\$67.96	\$11.31	\$15.63	\$136.48	\$21.55
APIR units							
ACR	\$218.10	\$49.83	\$177.52	\$715.10	N/A		\$464.65
Net revenues	\$98.97	\$15.62	\$3.62	\$508.00	N/A		\$302.04
Offer caps	\$119.12	\$34.96	\$173.89	\$215.38	N/A		\$167.62
APIR	\$218.10	\$26.59	\$89.08	\$559.97	N/A		\$351.74
Maximum APIR effect							\$1,155.57

- In 2011/2012 BRA about 55% of offers were price takers (\$0/MW-day)
- In 2012/2013 BRA about 45% of offers were price takers (\$0/MW-day)
- Assumed approximately half of offers are price takers

Example Base Assumptions: Price Taking Capacity

Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Nuclear, Renewable, DR and EE	Coal	Total
5,825	8,796	4,838	22,016	49,664	91,140

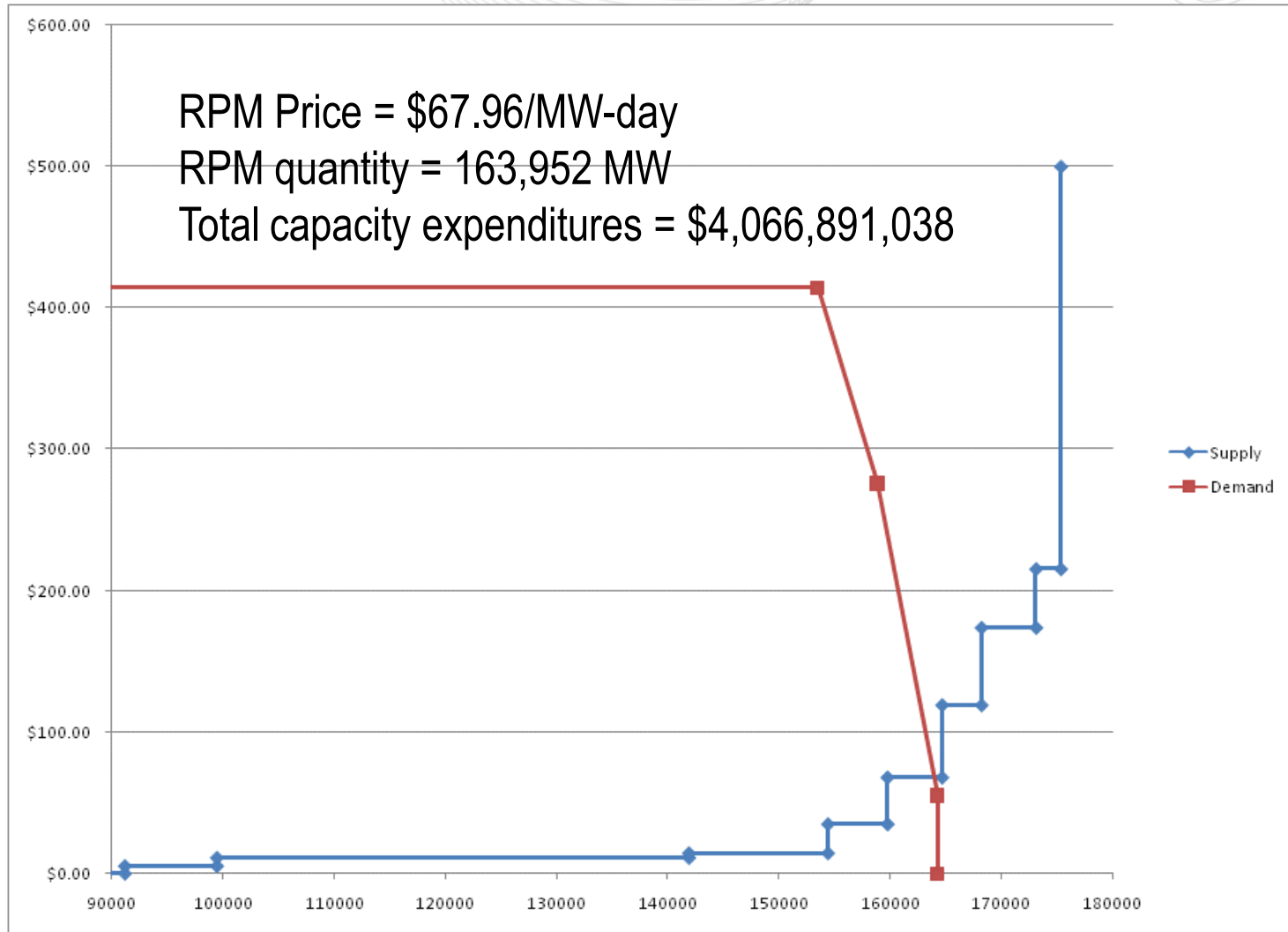
Example Base Assumptions: Offers with No Shortage Revenue

	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$14.40	\$67.96	\$11.13
MW offered	8,279	12,501	4,912	42,465
APIR				
Offer (\$/MW-day)	\$119.12	\$34.96	\$173.89	\$215.38
MW offered	3,548	5,358	4,912	2,235

Example Base Assumptions: VRR Curve with No Shortage Revenue

Pool EFORd	IRM	Forecast Pool Requirement	MW Requirement	Net CONE (ICAP)
0.0644	16.2%	1.087	157,488 MW	\$258.31

RPM Market Clearing in Base Case: No Shortage Revenue



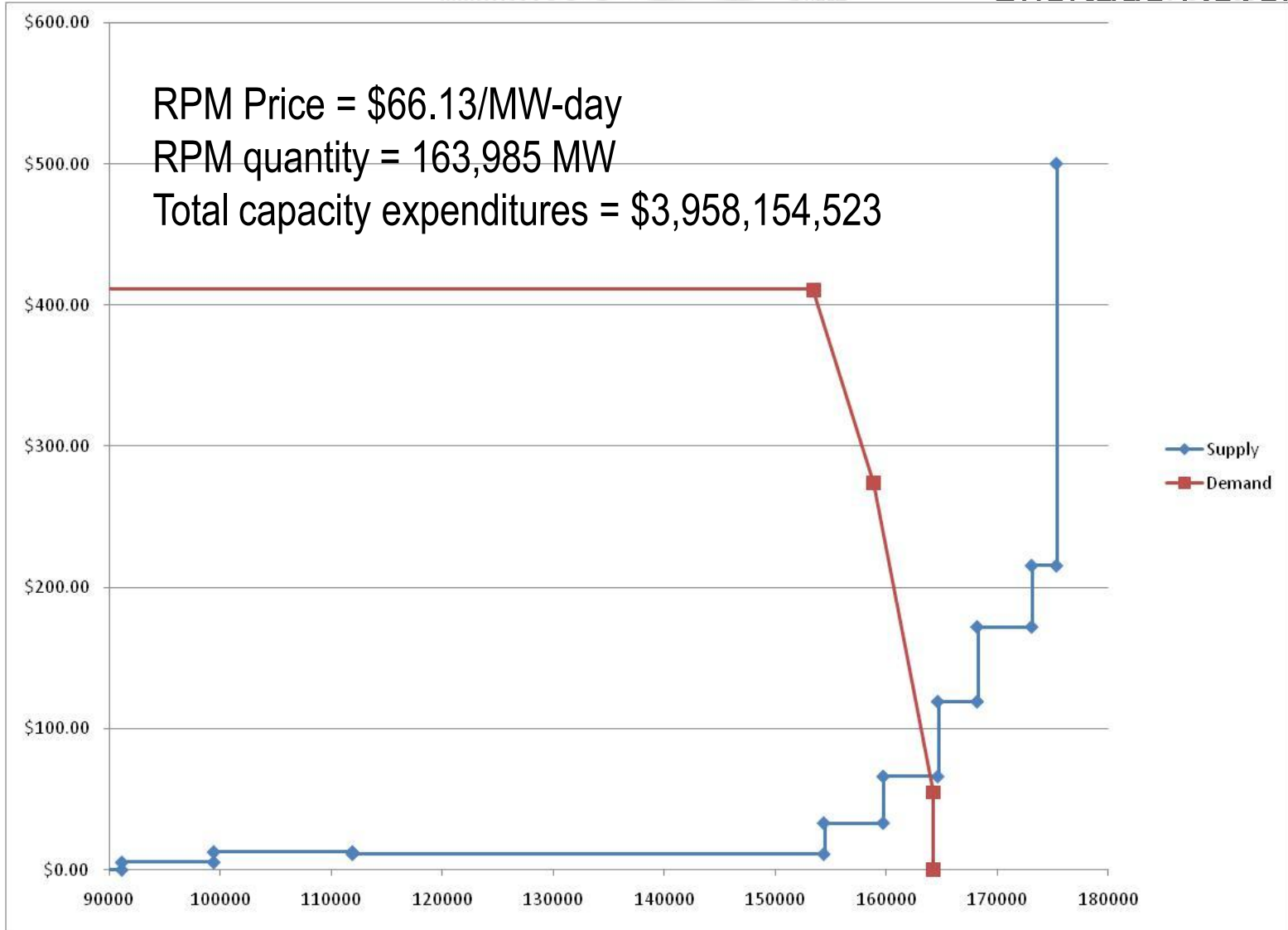
- Assume base load and intermediate resources are committed day-ahead and would not earn shortage revenue
- Only oil/gas steam or combustion turbines (peaking capacity) would earn shortage revenues.
 - Approximately 41,097 MW of this capacity
- Each peaking unit is assumed to earn \$2000/MW-year of shortage revenue
 - Akin to 4 hours of shortage in a year with shortage prices at \$1500/MWh and shortage revenues defined as prices over \$1000/MWh
 - Results in approximately \$82,194,000 is total shortage revenues
 - Assuming no shortage revenues in the other two years of historic energy market revenues translates to \$1.83/MW-day

Price taking MW are same as before

	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$12.57	\$66.13	\$11.13
Shortage (\$/MW-day)	\$0.00	\$1.83	\$1.83	\$0.00
MW offered	8,279	12,501	4,912	42,465
APIR				
Offer (\$/MW-day)	\$119.12	\$33.13	\$172.06	\$215.38
Shortage (\$/MW-day)	\$0.00	\$1.83	\$1.83	\$0.00
MW offered	3,548	5,358	4,912	2,235

Example Base Assumptions: VRR Curve with Shortage Revenue

Pool EFORd	IRM	Forecast Pool Requirement	MW Requirement	Net CONE (ICAP)
0.0644	16.2%	1.087	157,488 MW	\$256.48



- Shortage revenues included in the three year historic offset have an effect on the next BRA.
- However, the impacts of the next BRA will only be seen in settlements beginning three years following the occurrence of shortage revenues.
 - Must account for time value of money
- Analysis is holding all else equal
 - MW Requirement, EFORd, IRM, Supply Resources but for shortage revenue, etc.

Cash Flow Comparison in Base Case: RPM Expenditures vs. Shortage Revenue

	Include Shortage Revenue in Historic Offset, Not Rebated in Current Year
Year 1 (Shortage Revenue Collected)	\$82,194,000
Year 4 (Reduction in RPM Expenditures resulting from BRA in Year 2)	\$108,706,514
NPV of Reduced RPM Expenditures (7% discount rate)	\$88,736,897
Shortage Revenue Collected minus NPV of RPM Expenditures from BRA in Year 2	\$6,542,897 about 8% of shortage revenues

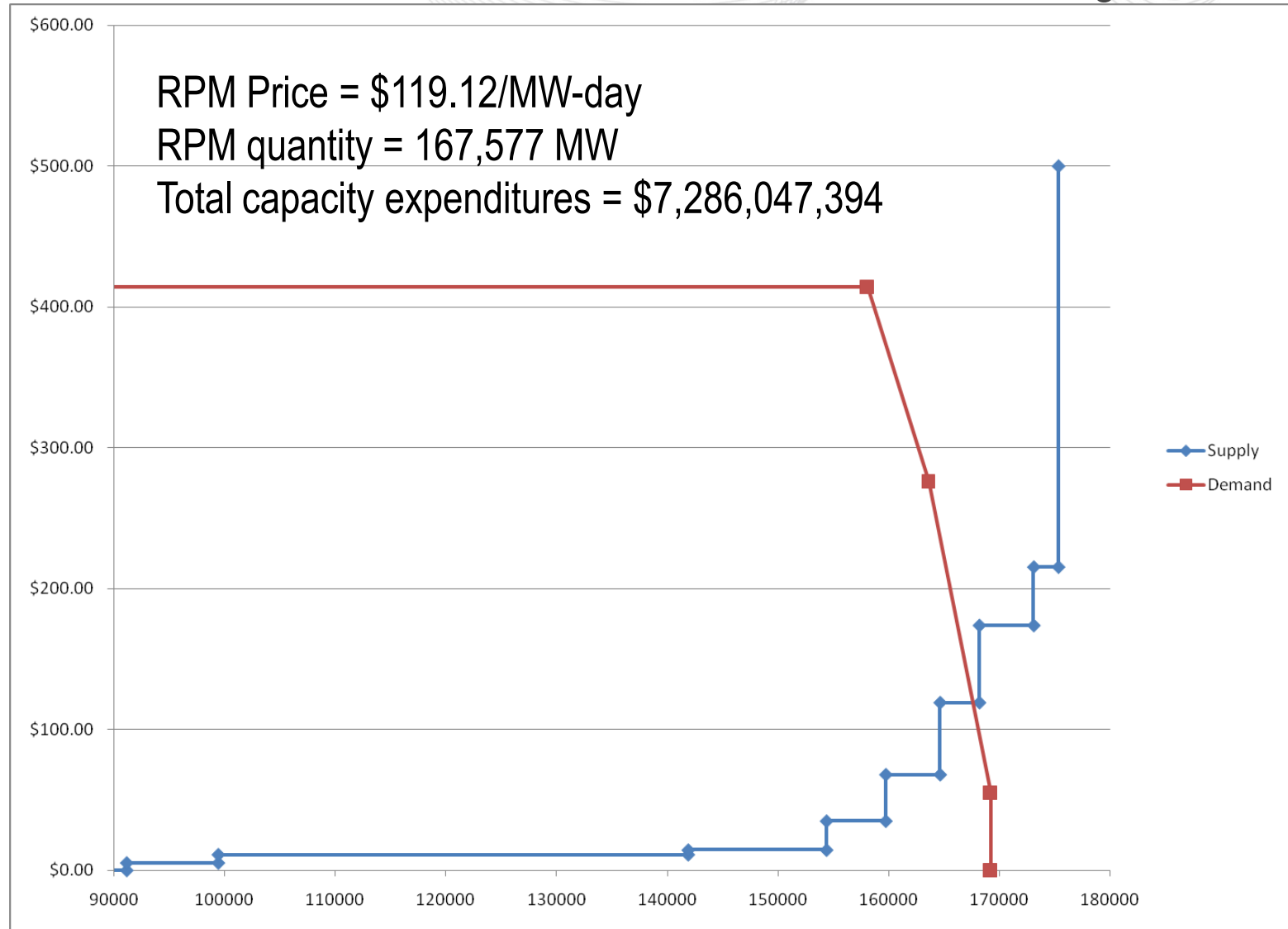
INCREASED RPM DEMAND OVER BASE CASE

Example High Demand Assumptions: VRR Curve with No Shortage Revenue

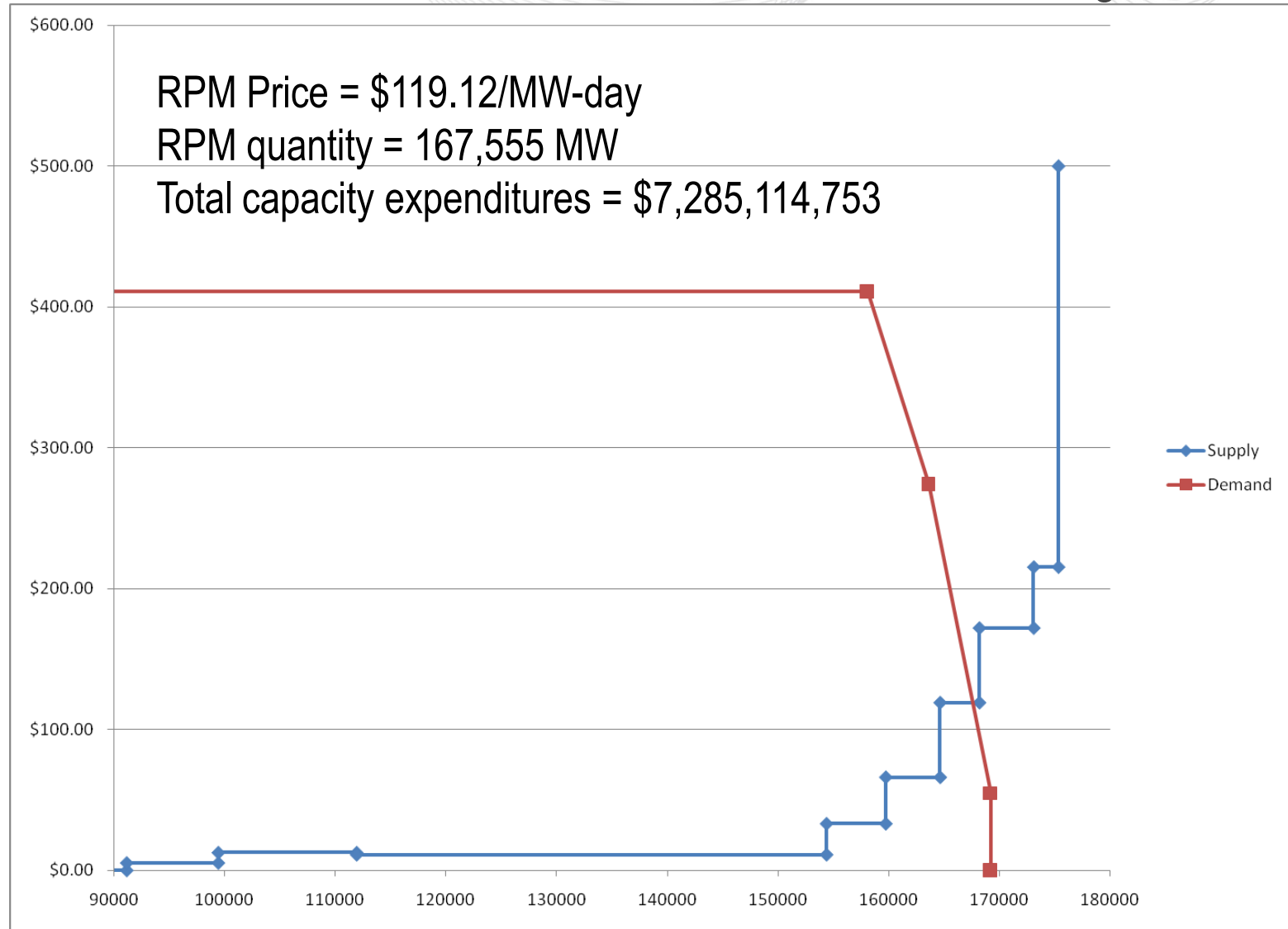
Pool EFORd	IRM	Forecast Pool Requirement	MW Requirement	Net CONE (ICAP)
0.0644	16.2%	1.087	162,213 MW	\$258.31

- Demand is 3% higher than the base case.
- All other assumptions are the same

RPM Market Clearing in High Demand Case: No Shortage Revenue



RPM Market Clearing in High Demand Case: Shortage Revenue



- RPM price is the same because the clearing price is set by a “new entry” combined cycle unit with or without the inclusion of shortage revenues
- Expenditures and total capacity are slightly lower including shortage revenues due to change in Net CONE.
- At least in this example BRA shortage revenues are not offset as in the base case by reduced RPM prices

Cash Flow Comparison in High Demand Case: RPM Expenditures vs. Shortage Revenue

	Include Shortage Revenue in Historic Offset, Not Rebated in Current Year
Year 1 (Shortage Revenue Collected)	\$82,194,000
Year 4 (Reduction in RPM Expenditures resulting from BRA in Year 2)	\$932,641
NPV of Reduced RPM Expenditures (7% discount rate)	\$761,313
Shortage Revenue Collected minus NPV of RPM Expenditures from BRA in Year 2	-\$81,432,687

INCREASED SHORTAGE REVENUES OVER BASE CASE

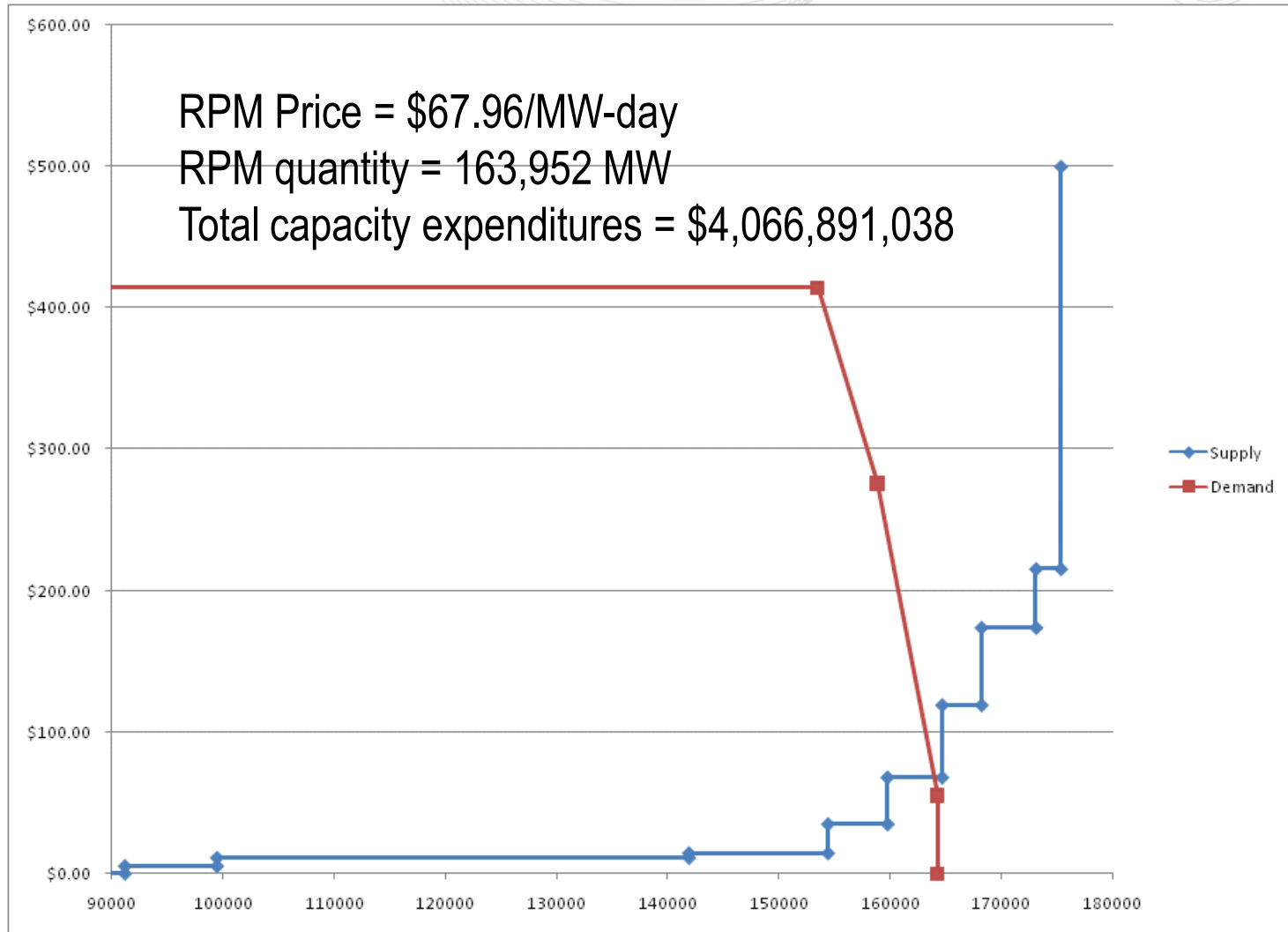
- Assume base load and intermediate resources are committed day-ahead and would not earn shortage revenue
- Only oil/gas steam or combustion turbines (peaking capacity) would earn shortage revenues.
 - Approximately 41,097 MW of this capacity
- Each peaking unit is assumed to earn **\$17,000/MW-year** of shortage revenue
 - Akin to **10** hours of shortage in a year with shortage prices at **\$2700/MWh** and shortage revenues defined as prices over \$1000/MWh
 - Results in approximately **\$698,649,000** is total shortage revenues
 - Assuming no shortage revenues in the other two years of historic energy market revenues translates to **\$15.53/MW-day**

Example Increased Shortage Revenue Assumptions: Offers with Shortage Revenue

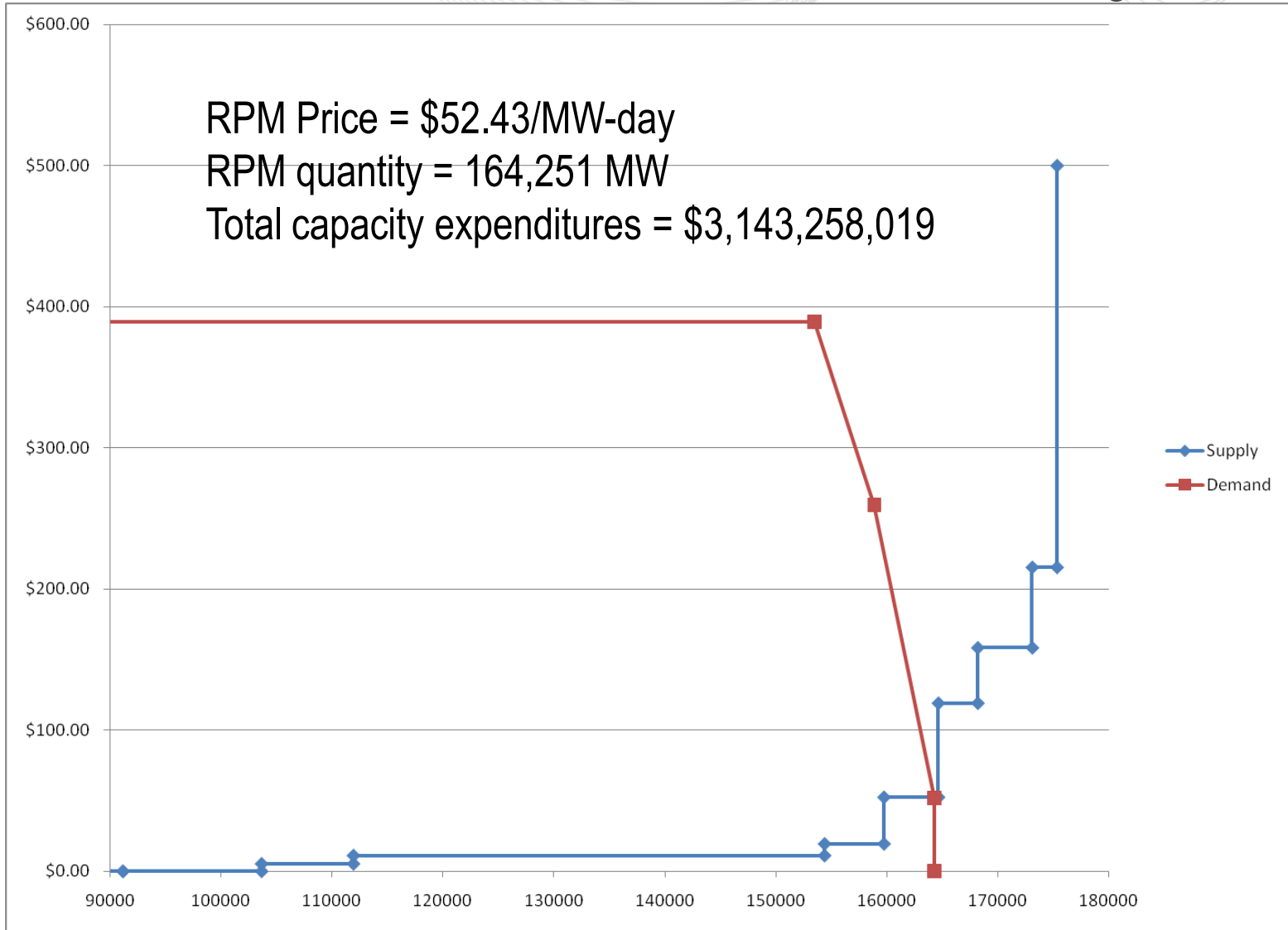
All other assumptions are the same as base case

	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$0.00	\$52.43	\$11.13
Shortage (\$/MW-day)	\$0.00	\$15.53	\$15.53	\$0.00
MW offered	8,279	12,501	4,912	42,465
APIR				
Offer (\$/MW-day)	\$119.12	\$19.43	\$158.36	\$215.38
Shortage (\$/MW-day)	\$0.00	\$15.53	\$15.53	\$0.00
MW offered	3,548	5,358	4,912	2,235

RPM Market Clearing in Increased Shortage Revenue Case: No Shortage Revenue



RPM Market Clearing in Increased Shortage Revenue Case: Shortage Revenue





Cash Flow Comparison in Increased Shortage Revenue Case: RPM Expenditures vs. Shortage Revenue

	Include Shortage Revenue in Historic Offset, Not Rebated in Current Year
Year 1 (Shortage Revenue Collected)	\$698,649,000
Year 4 (Reduction in RPM Expenditures resulting from BRA in Year 2)	\$923,633,018
NPV of Reduced RPM Expenditures (7% discount rate)	\$753,959,671
Shortage Revenue Collected minus NPV of RPM Expenditures from BRA in Year 2	\$55,310,671 8% of shortage revenue

ALTERNATE SUPPLY FROM BASE CASE

Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Nuclear, Renewable, DR and EE	Coal	Total
5,825	8,796	4,838	25,016	49,664	94,140

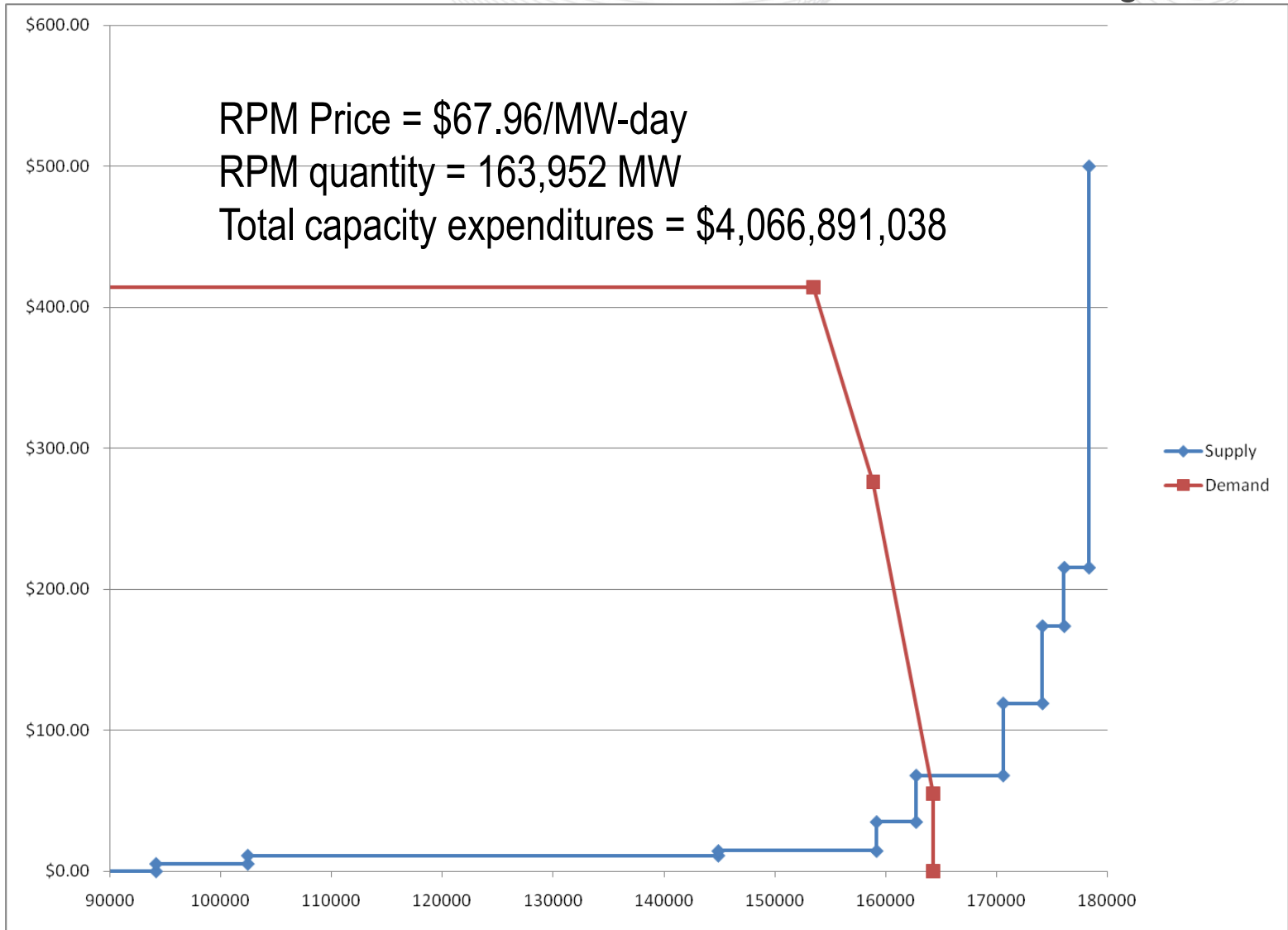
Additional 3000 MW of price taking DR capacity
 All other assumption under the base case are the same

Example Alternate Supply Assumptions: Offers with No Shortage Revenue

	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$14.40	\$67.96	\$11.13
MW offered	8,279	14,278	7,858	42,465
APIR				
Offer (\$/MW-day)	\$119.12	\$34.96	\$173.89	\$215.38
MW offered	3,548	3,572	1,965	2,235

More capacity is offering under ACR option than under APIR option

Example Alternate Supply Assumptions: No Shortage Revenue



Example Alternate Supply Assumptions: Offers with Shortage Revenue

	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$12.57	\$66.13	\$11.13
Shortage (\$/MW-day)	\$0.00	\$1.83	\$1.83	\$0.00
MW offered	8,279	14,278	7,858	42,465
APIR				
Offer (\$/MW-day)	\$119.12	\$33.13	\$172.06	\$215.38
Shortage (\$/MW-day)	\$0.00	\$1.83	\$1.83	\$0.00
MW offered	3,548	3,572	1,965	2,235

Cash Flow Comparison in Base Case: RPM Expenditures vs. Shortage Revenue

	Include Shortage Revenue in Historic Offset, Not Rebated in Current Year
Year 1 (Shortage Revenue Collected)	\$82,194,000
Year 4 (Reduction in RPM Expenditures resulting from BRA in Year 2)	\$108,706,514
NPV of Reduced RPM Expenditures (7% discount rate)	\$88,736,897
Shortage Revenue Collected minus NPV of RPM Expenditures from BRA in Year 2	\$6,542,897 about 8% of shortage revenues

The only thing that has changed in this case is that the supply curve has shifted but not enough to change outcomes from base case!

ALTERNATE SUPPLY 2 FROM BASE CASE

Example Alternate Supply 2 Assumptions: Offers with No Shortage Revenue

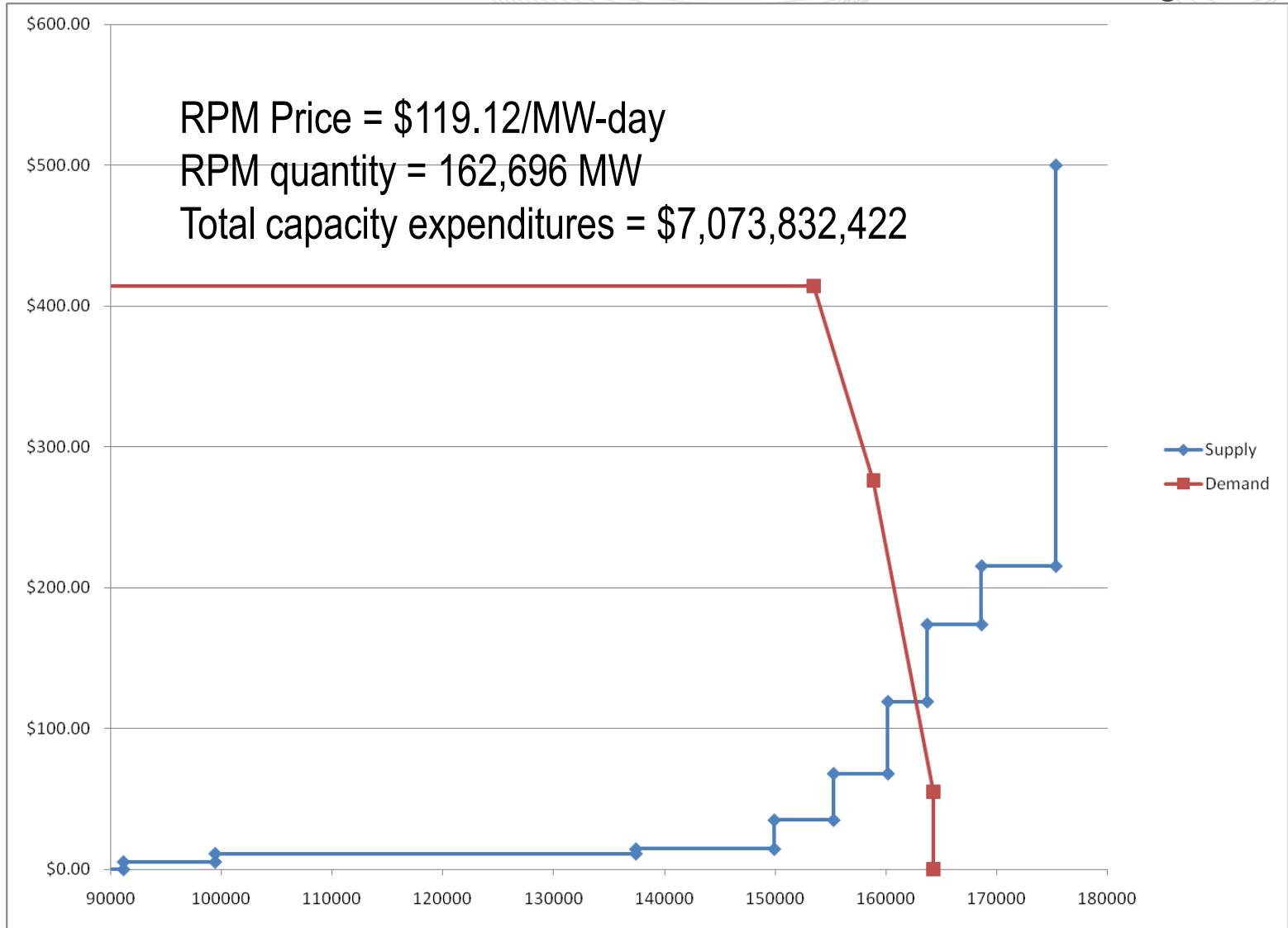
	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$14.40	\$67.96	\$11.13
MW offered	8,279	12,501	4,912	37,995
APIR				
Offer (\$/MW-day)	\$119.12	\$34.96	\$173.89	\$215.38
MW offered	3,548	5,358	4,912	6,705

Price taking MW are same as before

Changed how coal units offer ACR or APIR

All other assumptions from base case are the same

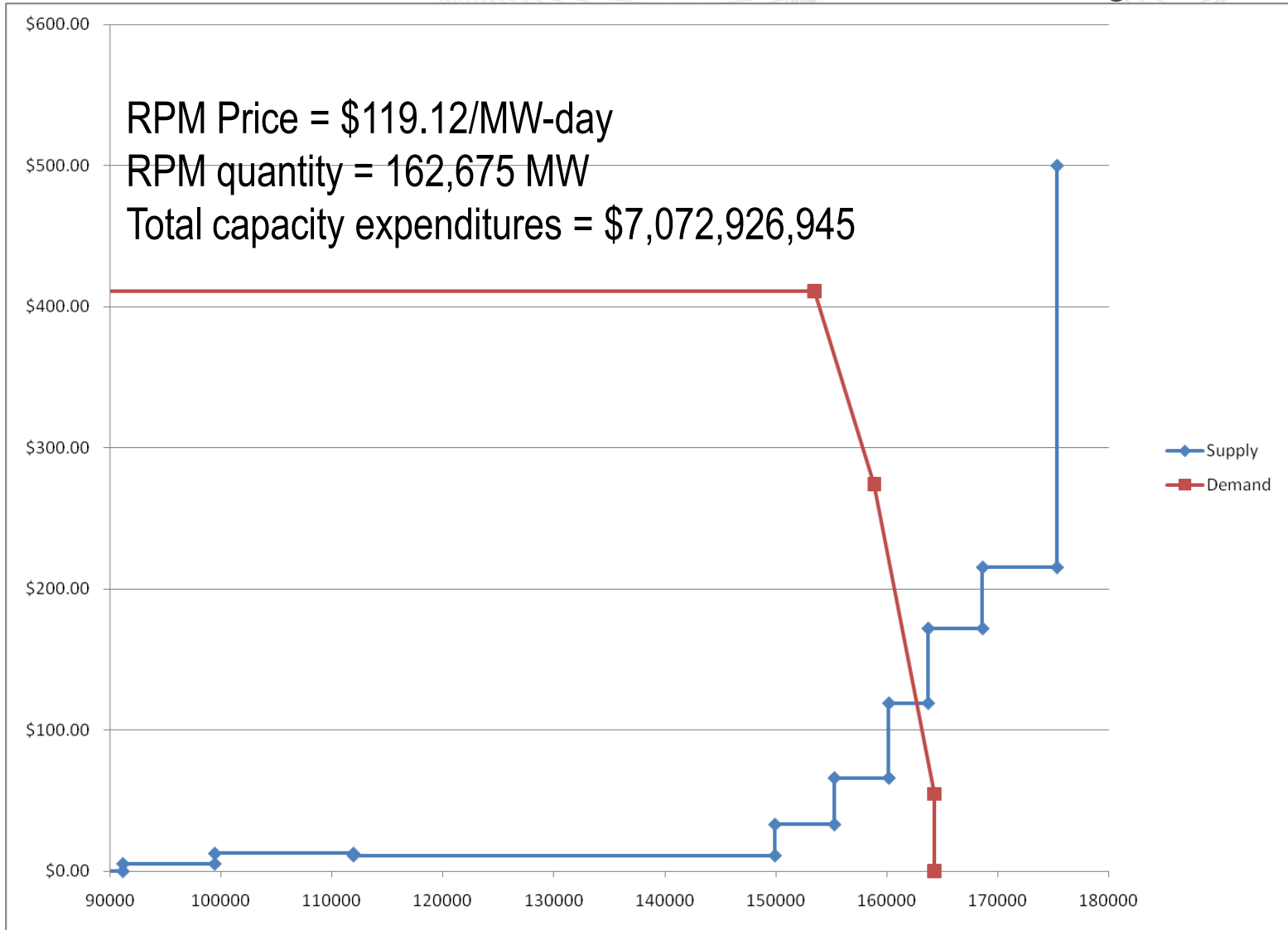
Example Alternate Supply 2 Assumptions: No Shortage Revenue



Example Alternate Supply 2 Assumptions: Offers with Shortage Revenue

	Gas Combined Cycle	Gas Combustion Turbine	Oil and Gas Steam	Coal
Default ACR				
Offer (\$/MW-day)	\$5.28	\$12.57	\$66.13	\$11.13
Shortage (\$/MW-day)	\$0.00	\$1.83	\$1.83	\$0.00
MW offered	8,279	12,501	4,912	37,995
APIR				
Offer (\$/MW-day)	\$119.12	\$33.13	\$172.06	\$215.38
Shortage (\$/MW-day)	\$0.00	\$1.83	\$1.83	\$0.00
MW offered	3,548	5,358	4,912	6,705

Example Alternate Supply 2 Assumptions: Shortage Revenue



Cash Flow Comparison in Alternative Supply 2 Case: RPM Expenditures vs. Shortage Revenue

	Include Shortage Revenue in Historic Offset, Not Rebated in Current Year
Year 1 (Shortage Revenue Collected)	\$82,194,000
Year 4 (Reduction in RPM Expenditures resulting from BRA in Year 2)	\$905,476
NPV of Reduced RPM Expenditures (7% discount rate)	\$735,139
Shortage Revenue Collected minus NPV of RPM Expenditures from BRA in Year 2	-\$81,454,861

- RPM price is the same because the clearing price is set by a “new entry” combined cycle unit with or without the inclusion of shortage revenues
 - Fewer coal units offering under ACR has shifted the supply curve around
- Expenditures and total capacity are slightly lower including shortage revenues due to change in Net CONE.
- At least in this example BRA shortage revenues are not offset as in the base case by reduced RPM prices

1. Shortage revenues paid to generation in one year can result in an approximate dollar-for-dollar offset in RPM expenditures in a single RPM BRA
 - The exact amount will depend on the shape of supply and VRR Curve
2. In subsequent BRAs with increasing demand for capacity and new entry and exit of supply resources, the future effects of the shortage revenue in the offset are expected to be influenced by other factors
 - Increased demand makes it more likely a new resource sets the RPM prices and the net energy market revenue has no influence on the offer
 - Changing mix of supply offered into the market makes it likely that in BRAs further away from the shortage event, shortage revenues would influence price
 - Exact effects depend on actual changes that occur