



Forward Net Energy & Ancillary Services Revenue Offset: Additional Data to Inform Matrix Discussions

MIC Special Session – Quadrennial Review
June 21, 2022



Combined Cycle Method Comparison

	2026/27 Historical EAS (Peak Hour Dispatch)	2026/27 Historical EAS (Optimized Dispatch)	2026/27 Forward EAS (Optimized Dispatch)
CONE Area 1			
AECO	\$118	\$151	\$223
DPL	\$162	\$206	\$343
JCPL	\$122	\$154	\$230
PECO	\$114	\$148	\$197
PSEG	\$122	\$154	\$227
RECO	\$142	\$177	\$262
CONE Area 2			
BGE	\$257	\$303	\$420
PEPCO	\$188	\$224	\$310
CONE Area 3			
AEP *	\$205	\$263	\$454
APS	\$226	\$269	\$466
ATSI *	\$183	\$236	\$390
COMED	\$126	\$181	\$293
DAY	\$209	\$266	\$429
DEOK	\$195	\$250	\$413
DUQ	\$193	\$229	\$246
DOM	\$180	\$216	\$291
EKPC	\$180	\$221	\$387
CONE Area 4			
METED	\$170	\$203	\$285
PENELEC	\$205	\$244	\$460
PPL	\$135	\$167	\$236
RTO	\$175	\$209	\$286

Optimized Dispatch

- Objective of committing and dispatching the resource for the purpose of maximizing its net energy and ancillary services revenues, subject to operating parameters and cost of the resource.
- Simulates whether the resource will run in any hour of the day

Peak Hour Dispatch

- Simulates whether the resource will be dispatched in the day-ahead and real-time energy market in a 16 hour “peak” block (between hour ending 8:00 and hour ending 23:00) each day. Unit will be committed if the average LMP is greater than or equal to the cost to generate for at least eight hours during each block.

* AEP & ATSI zonal values no longer include RGGI, following alignment with IMM assumptions



Combustion Turbine Method Comparison

	2026/27 Historical EAS (Peak Hour Dispatch)	2026/27 Historical EAS (Optimized Dispatch)	2026/27 Forward EAS (Optimized Dispatch)
CONE Area 1			
AECO	\$44	\$55	\$65
DPL	\$80	\$103	\$147
JCPL	\$43	\$55	\$65
PECO	\$43	\$55	\$55
PSEG	\$43	\$56	\$68
RECO	\$56	\$74	\$93
CONE Area 2			
BGE	\$145	\$180	\$204
PEPCO	\$79	\$99	\$110
CONE Area 3			
AEP *	\$97	\$147	\$276
APS	\$120	\$156	\$272
ATSI *	\$77	\$114	\$195
COMED	\$47	\$71	\$117
DAY	\$96	\$142	\$229
DEOK	\$89	\$128	\$215
DUQ	\$93	\$117	\$88
DOM	\$78	\$97	\$103
EKPC	\$67	\$99	\$196
CONE Area 4			
METED	\$78	\$98	\$105
PENELEC	\$101	\$133	\$266
PPL	\$55	\$70	\$73
RTO			
	\$72	\$93	\$89

Optimized Dispatch

- Objective of committing and dispatching the resource for the purpose of maximizing its net energy and ancillary services revenues, subject to operating parameters and cost of the resource.
- Simulates whether the resource will run in any hour of the day

Peak Hour Dispatch

- Simulates whether the resource may be dispatched in the day-ahead and real-time energy market in four independent, four-hour blocks (between hour ending 8:00 and hour ending 23:00) each day. Unit will be committed if the average LMP is greater than or equal to the cost to generate for at least two hours during each block.

* AEP & ATSI zonal values no longer include RGGI, following alignment with IMM assumptions

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Appendix – 5/20/2022 & 4/22/2022 Materials



Forward Net Energy & Ancillary Services Revenue Offset Methods & Comparisons

Natalie Tacka

Senior Engineer, Applied Innovation

MIC Special Session – Quadrennial Review

May 20, 2022

- PJM's most updated Net Energy & Ancillary Services Revenue Offset values with new historical years and forwards for 2026/27
- Reference resource parameters for E&AS
- Comparison of IMM and PJM forward-looking E&AS assumptions
- Comparison of PJM historical vs forward-looking E&AS methods and values



Indicative Values for 2026/27: Net CONE with Forward-Looking Net E&AS Revenue Offset (PJM Prelim Recommendations)

	2026/27 CONE (Brattle Report)	2023/24 Forward EAS (Brattle Report)	2026/27 Forward EAS (Updated)	2026/27 Net CONE (Updated)
CONE Area 1				
AECO	\$517	\$146	\$223	\$294
DPL	\$517	\$196	\$343	\$174
JCPL	\$517	\$143	\$230	\$287
PECO	\$517	\$174	\$197	\$320
PSEG	\$517	\$140	\$227	\$290
RECO	\$517	\$151	\$262	\$255
CONE Area 2				
BGE	\$506	\$239	\$420	\$86
PEPCO	\$506	\$185	\$310	\$196
CONE Area 3				
AEP	\$518	\$229	\$347	\$171
APS	\$518	\$267	\$466	\$52
ATSI	\$518	\$231	\$291	\$227
COMED	\$518	\$168	\$293	\$225
DAY	\$518	\$247	\$429	\$89
DEOK	\$518	\$237	\$413	\$105
DUQ	\$518	\$219	\$246	\$272
DOM	\$518	\$183	\$291	\$227
EKPC	\$518	\$239	\$387	\$131
CONE Area 4				
METED	\$522	\$205	\$285	\$237
PENELEC	\$522	\$310	\$460	\$62
PPL	\$522	\$182	\$236	\$286
RTO	\$516	\$177	\$286	\$230

Additional information based on
5/20/2022 Special Session discussion

Updated EAS since Brattle Report accounts for:

- Updated historical years (19/20/21 vs 18/19/20)
 - 21% increase in 3-year average historical LMP
 - 0% increase in 3-year average historical natural gas prices
- 2026/27 forward energy and natural gas prices
 - 58% increase in forward LMPs from 2023/24 values
 - 51% increase in forward gas prices from 2023/24 values
- Scaled reserve prices by forward energy prices
 - 33% increase in input reserve prices
- RGGI allowance cost added to zones in Pennsylvania
- EKPC mapped to MichCon

Included in both sets of values:

- Updated resource parameters
- No Regulation
- No natural gas transportation costs in variable costs



Reference Resource (Combined Cycle) Operating Parameters for Quad Review Net E&AS Revenue Offset

Parameter	Value	Notes
Configuration	GE 7HA.02(CT), ST F-A650(ST); Double Train 1x1 Single Shaft; Cooling towers to dry air-cooled condensers; Selective catalytic reduction	
Max Capacity	1,058 MW w/o Duct Burner; 1,182 MW w/ Duct Burner	Average capacity of CONE Area units at ISO conditions (59°F, 14.7 psia); Sargent & Lundy
Min Stable Level	176 MW	Min Stable Load for one 1x1x1 CC train = 33% single train MCR (assumes the 2nd train is not operating); Sargent & Lundy
Ramp Rate	30 MW/min	Existing unit offers (15 MW/min per turbine), two trains should ramp 2x faster than one; Sargent & Lundy
Heat Rate	7,866 Btu/kWh at Min Stable Level 6,293 Btu/kWh w/o Duct Firing; 6,537 Btu/kWh w/ Duct Firing	Min Stable (33% Load) Heat Rate ~125% Full Load Net Heat Rate. Other values are average of CONE Area full load heat rates at ISO conditions (59°F, 14.7 psia); Sargent & Lundy
Min Run	4 hr	Minimum Unit-Specific Operating Parameters for Generation Capacity Resources
Min Down	3.5 hr	
Time to Start	120 min	Time from ignition to base load, assumes appropriate steam cycle design. GE published startup time for these units is 60 min which assumes rapid response hot and optimal conditions. 120 min has been suggested as a more realistic time to be expected for a 1x1x1 single-shaft CC; Sargent & Lundy
VO&M	\$2.10/MWh	Brattle values from
Start Fuel	7,988 MMBtu/start	Average fuel use of CONE Area units adjusted for 120 min assumed Time to Start; Sargent & Lundy
Fuel Pricing Points	See Manual 18, Section 3.3.2; EKPC changed from Columbia-App to MichCon, Brattle	
NOx	0.0074 lb/MMBtu	Sargent & Lundy; historical allowance prices escalated for forward
	160 lb/start	
SO2	0.0006 lb/MMBtu	EPA; historical allowance prices escalated to delivery year
CO2	117 lb/MMBtu	EPA; Average of RGGI ECR & CCR trigger prices applied zones in RGGI states
Forced Outages (EFORd)	3.1%	PJM Weighted Average EFORd by Fuel Type, Class Average Values
Maintenance Outages	First two weeks in October	



Forward E&AS Assumptions Comparison: IMM vs PJM

Assumption Differences

	IMM	PJM
Major Maintenance in VOM	Excluded, MM in Gross CONE	Included
Ancillary Services	Reactive Service Only; No Reserves	Reserves & Reactive Service
Pipeline Mappings	PSEG (TETCO M3), AEP (Texas Gas Zn 1), EKPC (Tenn LA 500 Leg), PPL (Tenn Zn 4 300 Leg)	PSEG (Transco Z6 NY), AEP (Columbia-Appalachia TCO), EKPC (Mich Con; QR update), PPL (TETCO M3)
Zones with RGGI Allowance Cost	AEP and ATSI do not include RGGI	AEP, ATSI, and RTO include RGGI
Energy Forwards	4/25/2022	Past 30 trading days as of 4/25/2022

IMM & PJM both include:

- Optimized dispatch
- No Regulation
- Pipeline mappings for remaining zones corresponding to Manual 18
- SO₂ and NO_x allowance prices
- RGGI in zones: AECO, APS, BGE, DOM, DUQ, DPL, JCPL, METED, PECO, PENELEC, PEPCO, PPL, PSEG, RECO
- No 10% adder for CC



Indicative Values for 2026/27: PJM Historical vs Forward-Looking Net E&AS Revenue Offset

2026/27 Historical EAS 2026/27 Forward EAS

CONE Area 1		
AECO	\$118	\$223
DPL	\$162	\$343
JCPL	\$122	\$230
PECO	\$114	\$197
PSEG	\$122	\$227
RECO	\$142	\$262
CONE Area 2		
BGE	\$257	\$420
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RTO		
	\$175	\$286

	Historical	Forward
Dispatch Method	Peak-Hour	Optimized
Energy Prices	2019, 2020, 2021 <i>Average: \$28</i>	2019, 2020, 2021 scaled using delivery year forwards <i>Average: \$43, 54% increase</i>
Ancillary Services	Reactive Service Only	Reserves (optimized) & Reactive Service
Natural Gas Prices	2019, 2020, 2021 <i>Average: \$2.57</i>	2019, 2020, 2021 scaled using delivery year forwards <i>Average: \$3.71, 44% increase</i>
Emissions Allowance Costs	NO _x & SO ₂ only	NO _x & SO ₂ for all zones; CO ₂ for all zones in RGGI states, including RTO zone



Net Energy & Ancillary Services Revenue Offset Methodology Review

MIC Special Session – Quadrennial Review
April 22, 2022

For the purposes for the Quadrennial Review, PJM has calculated the Net Energy & Ancillary Services Review Offset using:

- The forward-looked “Projected EAS Dispatch” method, developed in 2020;
- Updates to the Projected EAS Dispatch model accounting for Brattle’s recommendations, in order to reflect the impacts of those recommendations on Net CONE.

This presentation provides a review of the Projected EAS Dispatch methodology

PJM will provide updates with regard to PJM’s position on the historical vs forward-looking approach at a future Quad Review MIC Special Session.

Optimal-based Dispatch at Forward LMPs

- CT
- CC
- Coal
- Storage

**Calculated Net EAS Offset
with updated
assumptions based on
Brattle Recommendations**

Assumed Output Model Applied to Forward LMPs

- Nuclear
- Solar (Fixed and Tracking)
- Wind (Onshore)
- Wind (Offshore)



Projected EAS Dispatch

Optimized dispatch with the objective of committing and dispatching a resource for the purpose of maximizing its net energy and ancillary services revenues, subject to operating parameters and cost of the resource.

Original Input Assumptions	Updates to Simulate Brattle Recommendations		
	Combined Cycle	Combustion Turbine	Battery Energy Storage
Resource parameters	Ramp Rate, Max Capacity, Min Stable Level, Heat Rates, Time to Start, VOM, Start Fuel	Ramp Rate, Heat Rate at Max Capacity, VOM, Start Fuel	
Energy Prices: Prior 3 calendar years of LMP scaled using forward LMPs for the Delivery Year.			
Prior 3 calendar years of Regulation Market Clearing Prices scaled using forward energy prices for the Delivery Year.	Removed Regulation		
Prior 3 calendar years of Reserve Market Clearing Prices	Scale using forward energy prices for the Delivery Year.*		
Natural Gas: Prior 3 calendar years of natural gas prices, scaled using forwards. Included variable transportation cost.	Variable transportation costs removed		N/A
Emissions Costs: Prior 3 calendar years of SO2 and NOx allowance prices scaled to delivery years. RGGI ECR prices for delivery year until historical			N/A
10% adder on VOM for CT	N/A	Include 10% adder on natural gas cost only	N/A

* Not included in preliminary simulations



Historical Approach Currently Uses Peak-Hour Dispatch

The Reference Resource is committed in the Day-ahead Energy Market in four distinct blocks of four hours of continuous output for each block from the peak-hour period beginning with the hour ending 0800 EPT through to the hour ending 2300 EPT for any day when the average day-ahead LMP for the area for which the Net Cost of New Entry is being determined is greater than, or equal to, the cost to generate (including the cost for a complete start and shutdown cycle), plus 10% of such costs only for the 2022/2023 Delivery Year, for at least two hours during each four-hour block, where such blocks shall be assumed to be committed independently; provided that, if there are not at least two economic hours in any given four-hour block, then the Reference Resource shall be assumed not to be committed for such block; and to the extent not committed in any such block in the Day-ahead Energy Market under the above conditions based on Day-Ahead LMPs, is dispatched in the Real-time Energy Market for such block if the Real-Time LMP is greater than or equal to the cost to generate, plus 10% of such costs only for the 2022/2023 Delivery Year, under the same conditions as described above for the Day-ahead Energy Market.