

Periodic Review of Default Gross CONE and Gross ACR Values

Skyler Marzewski Sr. Market Design Specialist Market Design Members Committee March 22, 2023

Application of Default CONE and ACR

Minimum Offer Price Rule (MOPR) – Attachment DD § 5.14 (h-2)

- New resources can elect a default Net Cost of New Entry (CONE) by using the default Gross CONE and subtracting the default Energy and Ancillary Service (E&AS) revenue.
- Existing resources can elect a default Net Avoidable Cost Rate (ACR) by using the default Gross ACR and subtracting the unit-specific E&AS revenue.

Market Seller Offer Cap (MSOC) – Attachment DD § 6.4

• Existing resources calculate a Net ACR by using the default Gross ACR and subtracting the unit-specific E&AS revenue.

Unit-specific request is an option to calculate MOPR or MSOC.



PJM Periodic Review of MOPR and MSOC Values

Beginning with the 2022/2023 Delivery Year, every four delivery years, PJM will update default Gross CONE and default Gross ACR values for MOPR purposes.

OATT Attachment DD § 5.14

Updated default Gross ACR values will also be used for MSOC purposes.



PJM updated the Gross CONE values using updated values from public sources and assumptions used in the Quadrennial Review.

PJM retained The Brattle Group (Brattle) and Sargent & Lundy (S&L) to analyze gross avoidable costs for existing generation. New Gross CONE values will start being used for the 2026/2027 Delivery Year.

New Gross ACR values will start being used for the 2026/2027 Delivery Year.





2026/2027 Updated Default CONE Values



Summary of Gross CONE Changes

PJM updated Gross CONE values similarly to the previous iteration. **Notable changes:**

- Changes in ITC and bonus depreciation due to planned sunset of the TCJA
- New reference resource for CC and onshore wind
- Quadrennial Review included BES data

All Gross CONE values increased except for batteries primarily due to ITC eligibility.



Final Default CONE Values

	Gross Cost of New Entry (2022/2023 \$/MW-Day)	Gross Cost of New Entry (2026/2027 \$/MW-Day)
Resource Types	(Nameplate)	(Nameplate)
1. Nuclear	\$2,000	\$2,568
2. Coal	\$1,068	\$1,480
3. Combined Cycle	\$320	\$540
4. Combustion Turbine	\$294	\$427
5. Fixed Solar PV	\$271	\$298
6. Tracking Solar PV	\$290	\$321
7. Onshore Wind	\$420	\$438
8. Offshore Wind	\$1,155	\$1,351
9. Battery Energy Storage	\$532	\$502

Gross CONE will continue to be escalated for each subsequent delivery year.



Resource Type	Fixed O&M Cost (\$/kW-Year)	Installed Capital Cost (\$/kW)	Investment Tax Credit %	Gross CONE (\$/MW-Day) (Nameplate)	Average Zonal Net Energy Revenue Offset (\$/MW-Day) (Nameplate)	Average Zonal Net Ancillary Services Revenue Offset (\$/MW-Day) (Nameplate)	Net CONE (\$/ICAP-MW- Day)	Capacity Value Percentages or Factors	Net CONE (\$/UCAP-MW- Day)
Nuclear	\$127	\$6,695	0%	\$2,568	\$786	\$9	\$1,773	99.1%	\$1,790
Coal	\$42	\$4,074	0%	\$1,480	\$186	\$9	\$1,285	87.2%	\$1,473
Combined Cycle			0%	\$540	\$347	\$9	\$184	96.4%	\$191
Combustion Turbine	\$40	\$927	0%	\$427	\$137	\$6	\$284	95.5%	\$297
Solar PV – Tracking	\$16	\$1,327	30%	\$321	\$264	\$9	\$48	45.0%	\$106
Solar PV – Fixed	\$16	\$1,234	30%	\$298	\$165	\$9	\$124	33.0%	\$375
Onshore Wind	\$28	\$1,718	30%	\$438	\$325	\$9	\$104	13.0%	\$799
Offshore Wind	\$115	\$4,833	30%	\$1,351	\$478	\$9	\$864	31.0%	\$2,787
Battery Energy Storage	\$37	\$1,681	30%	\$502	\$182	\$9	\$311	95.0%	\$818

NOTES:

 Fixed O&M and installed capital costs are from EIA report 2022. PV (fixed) costs are 93% of the costs for Solar PV (Tracking).

Joim

- Combined Cycle CONE value is the average of the CONE values from the as filed 2022 Quadrennial Review for 2026.
- Solar and Wind Investment Tax Credit depends on prevailing wage and apprenticeship requirements. An optimistic 30% value is assumed for solar and wind resources. The additional 10% ITC adder for domestic content, and additional 10% for building in an energy community, are not included.
- Class average ELCC values, estimated for the 2026/2027 Delivery Year, as percent of nameplate MW solar, wind and battery generation are used to calculate Net CONE in \$/UCAP-MW-day. Class average EFORd percentages are the values used in the 2024/2025 Delivery Year MOPR calculations.
- Battery energy storage costs are the average of the CONE values from the as-filed 2022 Quadrennial Review for 2026 for a four-hour plant with 15-year life. Gross CONE is calculated including an optimistic 30% Investment Tax Credit. The additional 10% ITC adder for domestic content, and additional 10% for building in an energy community, are not included. Net CONE (\$/UCAP-MW-day) is calculated by multiplying Net CONE (\$/ICAP-MW-day) by 2.5, and dividing by a 100% ELCC value and a 5% class average EFORd.
- Net Energy Revenue Offset is based on the posted 2025/2026 E&AS values, and Ancillary Service Revenue Offset is based on reactive services of \$3,350/MW-year or \$9/MW-day. The CT value is from the Tariff: \$2,199/MW-year or \$6/MW-day.



2026/2027 Updated Default ACR Values

PJM©2023



Summary of Gross ACR Changes

PJM contracted Brattle, along with S&L, to determine Gross ACRs. **Notable changes:**

- Added Steam Oil & Gas for a new default unit type
- Additional analysis into NEI data to reflect costs for the nuclear fleet
- Refined property tax and insurance estimates

All Gross ACR values increased except for Nuclear – Single resource type.

Jpjm

Gross Costs Estimates for Existing Generation

Resource Type	Representative Low-Cost Plant \$/MW-day	Representative Plant \$/MW-day	Representative High-Cost Plant \$/MW-day
Multi-unit nuclear	476	537	552
Single-unit nuclear	-	591	-
Coal	88	94	142
Natural gas CC	94	113	160
Simple-cycle CT	43	52	69
Steam oil & gas	53	64	102
Onshore wind	140	147	204
Large-scale solar PV	65	70	74



Final Default ACR Values

Resource Types	Default Gross ACR (2022/2023 \$/MW-Day) (Nameplate)	Default Gross ACR (2026/2027 \$/MW-Day) (Nameplate)
1. Nuclear – Single	\$697	\$591
2. Nuclear – Dual	\$445	\$537
3. Coal	\$80	\$94
4. Combined Cycle	\$56	\$113
5. Combustion Turbine	\$50	\$52
6. Steam Oil & Gas	NA	\$64
7. Solar PV (fixed and tracking)	\$40	\$70
8. Wind Onshore	\$83	\$147

Gross ACR will continue to be escalated for each subsequent delivery year.





SME/Presenter: Skyler Marzewski

Skyler.Marzewski@pjm.com

Chair:

David Scarpignato

Secretary:

Dave Anders

Dave.Anders@pjm.com

Periodic Review of Default CONE and ACR Values

Member Hotline (610) 666-8980 (866) 400-8980 custsvc@pjm.com



Appendix

Updated Gross CONE Data Sources

PJM selected installed capital costs (Capex) and fixed operating and maintenance costs (FOM) from public sources.

- National Renewable Energy Laboratory (NREL)
- U.S. Environmental Protection Agency (EPA)
- U.S. Energy Information Agency (EIA)
- Lazard



Sources of Technology Costs: 2026/2027

	Source	Link
1	NREL: 2022 Annual Technology Baseline	 <u>https://atb.nrel.gov/</u> <u>https://data.openei.org/submissions/5716</u>
2	Lazard: 2021 Levelized Cost of Energy & Storage	 <u>https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/</u> <u>https://www.lazard.com/media/451882/lazards-levelized-cost-of-storage-version-70-vf.pdf</u> <u>https://www.lazard.com/media/451905/lazards-levelized-cost-of-energy-version-150-vf.pdf</u>
3	EPA: IPM Platform 2021 Reference Case	https://www.epa.gov/power-sector-modeling/epas-power-sector-modeling-platform-v6-using- ipm-summer-2021-reference-case
4	EIA: 2022 Capital Cost Report	 <u>https://www.eia.gov/analysis/studies/powerplants/capitalcost/</u> <u>https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf</u>
5	PJM: Quadrennial Review	https://www.pjm.com/directory/etariff/FercDockets/6885/20220930-er22-2984-000.pdf
6	LBNL: Utility Scale Solar – 2022 Edition	https://emp.lbl.gov/utility-scale-solar/
7	IHS: US Solar PV Capital Cost and LCOE Outlook	https://ihsmarkit.com/research-analysis/index.html



Comparison of Installed Capital Costs (\$/kW)

Technology	NREL 2026	Lazard	EPA 2025	EIA 2022	Used by PJM
Nuclear	7,026	7,800–12,800	5,679	6,695	6,695
Coal	2,765	2,950–6,225	3,422	4,074	4,074
Combined Cycle	934	700–1,300	1,009	1,201	• 1,270
Combustion Turbine	809	700–925	613	785	• 927
Solar PV – Tracking	1 ,198	950	1,091	1,327	1,327
Solar PV – Fixed	▲ 1,114	800	▲ 1,041	▲ 1,234	1,234
Onshore Wind	1,155	1,025–1,350	1,456	1,718	1,718
Offshore Wind	2,823	2,500–3,600	1,987	4,833	4,833
Battery Energy Storage	1,285	NA	1,022	1,316	• 1,681

NREL installed capital cost is noted at \$936/kW DC, and PJM multiplied the value by an Inverter Load Ratio of 1.28 to calculate \$1,198/kW AC. ▲ Fixed cost is obtained from multiplying Solar PV - Tracking cost by 0.93.

• As-filed Quadrennial Review values



Financial Assumptions for Updated Gross CONE Values

- Financial assumptions for the 2026/2027 CONE values are the same values used in the as-filed 2022 Quadrennial Review.
- Bonus depreciation and Investment Tax Credit (ITC) were also used where applicable. Bonus depreciation drops to 20% for 2026, with the rest eligible for the MACRS depreciation.
- Combined cycle value is from the as-filed 2022 Quadrennial Review.
- PJM determined that the assumed applicable asset life for battery storage resources should be 15 years.

Financial Assumptions

Expected Life	20 Years
Debt Ratio	55%
Debt Rate	6.3%
Equity Rate	14.1%
Total Tax Rate	27.2%
ATWACC	8.85%
Inflation Rate	2.2%

Financial assumptions developed during 2022 Quadrennial Review were used to determine Gross CONE from the installed capital and fixed O&M costs.



Investment Tax Credit

Inflation Reduction Act signed into law Aug. 16, 2022, and included Investment Tax Credits (ITC) allowable to wind, solar and battery energy storage resources.

Eligibility requirements:

- 30% if prevailing wage and apprenticeship for five years after in service, or reduce the ITC to 6%
- Increased by 10% if domestic content requirements are satisfied; facility would need 100% of the steel or iron produced in the U.S. and 40% of the manufactured products produced in the U.S.
- Increased by 10% if built in an "energy community"

PJM is expecting market participants to maximize profits and therefore is using a 30% ITC value for determining Gross CONE values.



Description and Cost for Reference Resource

Resource Type	Technology Description	Source of Information	Fixed O&M (\$/kW-Year)	Installed Capital Costs (\$/kW)
Nuclear	2x Westinghouse AP1000 pressurized water reactor (2,156 MW)	EIA (Case 11)	127.35	6,695
Coal	Ultra-Supercritical coal (650 MW)	EIA (Case 1)	42.49	4,074
Combined Cycle	Double train 1x1 GE Frame 7HA.02 with evaporative cooling, SCR and CO catalyst (1,155 MW)	As-filed Quadrennial Review	38.5	1,270
Combustion Turbine	GE Frame 7HA.02 with evaporating cooling and SCR (357 MW)	As-filed Quadrennial Review	40	927
Solar PV – Tracking	Single-axis tracking (150 MW AC)	EIA (Case 24)	15.97	1,327
Solar PV – Fixed	Fixed tilt (100 MW AC)	EIA, LBNL	14.85	1,234
Onshore Wind	71 x 2.8 MW WTGs (200 MW)	EIA (Case 20)	27.57	1,718
Offshore Wind	40 x 10 MW WTGs, 100' deep (400 MW)	EIA (Case 22)	115.16	4,833
Battery Energy Storage	50 MW utility-scale, lithium-ion, 200 MWh rating	As-filed Quadrennial Review	36.85	1,681



- Brattle and S&L completed a bottom-up analysis of costs for representative plants, drawing on data and experience.
- Solicited and incorporated stakeholder input through three rounds of presentations at the MIC special session
- Selected a representative resource that balanced the risks of under-mitigation and over-mitigation
- Brattle and S&L provided a representative low-cost plant, representative plant, and representative high-cost plant for comparison for each unit type.

Analytical Approach

Analyzed the fleet of each technology type for defining characteristics of the median plant by capacity with the following cost drivers:

- Unit Size
- Plant age and technology vintage
- Location in PJM
- Configuration of the unit, including pollution controls

- Calculated gross costs that would be avoided if such plant retired, consistent with costs allowable per the Tariff
- Idiosyncratic plants, due to older, non-standard technology, limited default values for additional technology types.





- Thermal plants are based on S&L's regression analyses of FERC Form 1 filings with characteristics similar to the representative plant by technology type, benchmarked and adjusted using confidential cost estimates from S&L's project database.
- Nuclear plants are based on NEI's latest "Nuclear Costs in Context" study, with adjustments to reflect the representative plant.
- Intermittent plants used FERC Form 1 data and S&L's project database when FERC Form 1 data was insufficient.





- Brattle and S&L calculated each technologies' total costs and then allocated the allowable costs, as outlined in the PJM OA Schedule 2, into the default Gross ACRs.
- Default Gross ACRs include Fixed Capital Costs and Fixed Operation & Maintenance (FOM) costs, but not major maintenance costs for systems directly related to electric production.



PJM Fleet Capacity by Plant Type

Plant Type	Total MW (Summer ICAP)	% of Total PJM Capacity	Recommendation
NGCC	55,828	28%	Included
Coal	41,554	21%	Included
Nuclear	32,556	16%	Included
Simple Cycle CT	28,496	14%	Included
Wind	9,911	5%	Included
ST O&G	9,240	5%	Included
Solar	7,790	4%	Included
Pumped Storage	5,243	3%	Unit-specific review
Hydro	3,319	2%	Unit-specific review
Other	3,427	2%	Unit-specific review
PJM Total Installed Capacity	197,364	100%	

Notes and Sources: ABB, Energy Velocity Suite.

Jpjm[®]

Nuclear

			Μ	ulti-Unit Nuclear Pla	ant
		Single-Unit	Representative	Representative	Representative
	Units	Nuclear Plant	Low-Cost Plant	Plant	High-Cost Plant
Capacity	Nameplate MW	1,200	2,400	2,400	2,400
Gross Costs	\$/MW-day	\$591	\$476	\$537	\$552
Capital Costs	\$/MW-day	\$77	\$72	\$69	\$69
Fixed Operating Costs	\$/MW-day	\$491	\$381	\$445	\$460
Property Taxes	\$/MW-day	\$23	\$23	\$23	\$23
Non-Fuel Variable Costs	\$/MWh	\$2.44	\$2.22	\$2.19	\$2.20
Operating Costs	\$/MWh	\$0.33	\$0.25	\$0.30	\$0.31
Major Maintenance	\$/MWh	\$2.11	\$1.96	\$1.89	\$1.90



			Coal Plant	
		Representative	Representative	Representative
	Units	Low-Cost Plant	Plant	High-Cost Plant
Capacity	Nameplate MW	1,800	1,500	100
Gross Costs	\$/MW-day	\$88	\$94	\$142
Labor	\$/MW-day	\$38	\$41	\$60
Fixed Expenses	\$/MW-day	\$48	\$51	\$79
Property Taxes	\$/MW-day	\$0.5	\$0.5	\$0.5
Insurance	\$/MW-day	\$1.5	\$1.5	\$1.5
Non-Fuel Variable Costs	\$/MWh	\$10.47	\$10.92	\$9.61
Operating Costs	\$/MWh	\$5.00	\$5.45	\$5.62
Maintenance Adder	\$/MWh	\$5.47	\$5.47	\$3.99

Combined Cycle

	Natural Gas Combined Cycle Plant					
		Representative	Representative	Representative		
	Units	Low-Cost Plant	Plant	High-Cost Plant		
Capacity	Nameplate MW	1,100	750	400		
Gross Costs	\$/MW-day	\$94	\$113	\$160		
Labor	\$/MW-day	\$17	\$21	\$32		
Fixed Expenses	\$/MW-day	\$52	\$72	\$120		
Property Taxes	\$/MW-day	\$6	\$5	\$2		
Insurance	\$/MW-day	\$19	\$15	\$6		
Non-Fuel Variable Costs	\$/MWh	\$2.36	\$2.71	\$2.60		
Operating Costs	\$/MWh	\$0.75	\$0.52	\$0.94		
Maintenance Adder	\$/MWh	\$1.61	\$2.19	\$1.66		

Combustion Turbine

		Simple Cycle Combustion Turbine Plant		
		Representative	Representative	Representative
	Units	Low-Cost Plant	Plant	High-Cost Plant
Capacity	Nameplate MW	640	320	100
Gross Costs	\$/MW-day	\$43	\$52	\$69
Labor	\$/MW-day	\$6	\$10	\$23
Fixed Expenses	\$/MW-day	\$8	\$12	\$28
Property Taxes	\$/MW-day	\$16	\$16	\$3
Insurance	\$/MW-day	\$13	\$13	\$16
Non-Fuel Variable Costs	\$/MWh	\$4.29	\$4.29	\$5.39
Operating Costs	\$/MWh	\$0.42	\$0.42	\$0.97
Maintenance Adder	\$/MWh	\$3.88	\$3.88	\$4.43

Steam Oil and Gas

	Units	Oil and Gas-Fired Steam Turbine Plant		
		Representative Low-Cost Plant	Representative Plant	Representative High-Cost Plant
Capacity	Nameplate MW	1,300	900	350
Gross Costs	\$/MW-day	\$53	\$64	\$102
Labor	\$/MW-day	\$21	\$26	\$43
Fixed Expenses	\$/MW-day	\$26	\$32	\$53
Property Taxes	\$/MW-day	\$1.6	\$1.6	\$1.6
Insurance	\$/MW-day	\$4.8	\$4.8	\$4.8
Non-Fuel Variable Costs	\$/MWh	\$5.51	\$5.81	\$16.26
Operating Costs	\$/MWh	\$1.19	\$1.19	\$1.19
Maintenance Adder	\$/MWh	\$4.32	\$4.62	\$15.07

Onshore Wind

		Onshore Wind Plant		
		Representative	Representative	Representative
	Units	Low-Cost Plant	Plant	High-Cost Plant
Capacity	Nameplate MW	300	200	30
Gross Costs	\$/MW-day	\$140	\$147	\$204
Labor	\$/MW-day	\$26	\$27	\$50
Fixed Expenses	\$/MW-day	\$95	\$99	\$126
Property Taxes	\$/MW-day	\$12	\$13	\$17
Insurance	\$/MW-day	\$8	\$8	\$11
Non-Fuel Variable Costs	\$/MWh	\$0.00	\$0.00	\$0.00
Operating Costs	\$/MWh	\$0.00	\$0.00	\$0.00
Maintenance Adder	\$/MWh	\$0.00	\$0.00	\$0.00

Solar PV

		Large Scale Solar Photovoltaic Plant		
		Representative	Representative	Representative
	Units	Low-Cost Plant	Plant	High-Cost Plant
Capacity	Nameplate MW	80	10	2
Gross Costs	\$/MW-day	\$65	\$70	\$74
Labor	\$/MW-day	\$20	\$22	\$25
Fixed Expenses	\$/MW-day	\$30	\$33	\$36
Property Taxes	\$/MW-day	\$5	\$4	\$4
Insurance	\$/MW-day	\$10	\$10	\$10
Non-Fuel Variable Costs	\$/MWh	\$0.00	\$0.00	\$0.00
Operating Costs	\$/MWh	\$0.00	\$0.00	\$0.00
Maintenance Adder	\$/MWh	\$0.00	\$0.00	\$0.00



PJM Requirements on Updating MOPR

OATT Attachment DD § 5.14

- Beginning with the Delivery Year that commences June 1, 2022, and continuing no later than for every fourth Delivery Year thereafter, the Office of the Interconnection shall review the default gross cost of new entry values. Such review may include, without limitation, analyses of the fixed development, construction, operation, and maintenance costs for such resource types. Based on the results of such review, PJM shall propose either to modify or retain the default gross cost of new entry values stated in the table above. The Office of the Interconnection shall post publicly and solicit stakeholder comment regarding the proposal. If, as a result of this process, changes to the default gross cost of new entry values are proposed, the Office of the Interconnections with the FERC by October 1, prior to the conduct of the Base Residual Auction for the first Delivery Year in which the new values would be applied.
- Beginning with the Delivery Year that commences June 1, 2022, and continuing no later than for **every fourth Delivery Year** thereafter, the Office of the Interconnection shall review the **default Avoidable Cost Rates** for Capacity Resource that is subject to the provisions of the Minimum Offer Price Rule pursuant to Tariff, Attachment DD, section 5.14(h-2)(2) that have cleared in an RPM Auction for any Delivery Year. Such review may include, without limitation, analyses of the avoidable costs of such resource types. Based on the results of such review, PJM shall propose either to modify or retain the default Avoidable Cost Rate values stated in the table above. The Office of the Interconnection shall post publicly and solicit stakeholder comment regarding the proposal. If, as a result of this process, changes to the default Avoidable Cost Rate values are proposed, the Office of the Interconnection shall **file such proposed modifications with the FERC by October 1**, prior to the conduct of the Base Residual Auction for the first Delivery Year in which the new values would be applied.



PJM Requirements on Updating MSOC

OATT Attachment DD § 6.4 (a)

The Market Seller Offer Cap, stated in dollars per MW/day of unforced capacity, applicable to price-quantity offers within the Base Offer Segment for an Existing Generation Capacity Resource shall be the Avoidable Cost Rate for such resource, less the Projected PJM Market Revenues for such resource, stated in dollars per *MW/day of unforced capacity. A Capacity Market Seller offering above \$0/MW-day must support and obtain* approval of a unit-specific Market Seller Offer Cap pursuant to the procedures and standards of subsection (b) of this section 6.4 or may, at its election, if available, utilize a Market Seller Offer Cap determined using the applicable default gross Avoidable Cost Rate for the applicable resource type shown in the table below, as adjusted for Delivery Years subsequent to the 2022/2023 Delivery Year to reflect changes in avoidable costs, net of projected PJM market revenues equal to the resource's net energy and ancillary service revenues for the resource type, as determined in accordance with Tariff, Attachment DD, section 6.8(d-1).

