

## Updates in the EPA 2025 Reference Case

### Incremental to 2023 Reference Case

This document describes the updates in the EPA 2025 Reference Case that are incremental to the 2023 Reference Case - EPA's Power Sector Modeling Platform using IPM (full-fledged documentation is available at <https://www.epa.gov/power-sector-modeling/2023-reference-case>). Table 1-1 below lists updates included. There are five additional large tables that are uploaded separately; the list of those files are included at the end of this document.

**Table 1-1 Key Updates and Specifications in the EPA 2025 Reference Case**

Description	For More Information
<b>Modeling Framework</b>	
The model time horizon extends to 2059 with seven model run years: 2028, 2030, 2035, 2040, 2045, 2050, and 2055.	Table 2-1
<b>Power System Operation</b>	
Power system operations are updated based on recent data from EIA, NERC, and FERC.	Chapter 3
The electricity demand projection is based on the AEO 2025 Reference Case. The 2024 regional demand from AEO 2025 is scaled to match the NERC ES&D 2024 demand. The EV portion of the scaled AEO 2025 demand is replaced with the EV demand provided by the EPA's Office of Transportation and Air Quality (OTAQ), reflecting on the book rules. Similarly, the data center portion of the scaled AEO 2025 demand is replaced with the EPA's estimate of data center demand.	Section 3.2 and Attachment 3-1
The reserve margins are updated to NERC 2022 Long-Term Reliability Assessment levels.	Section 3.6
Inventory of state emission regulations is updated.	Section 3.10
One Big Beautiful Bill Act (OBBBA) Provisions (2025), RCU and CSAPR Update Rule, MATS (2011), and BART are reflected.	Section 3.10.4, Section 4.5
Inventory of RPS and CES standards are updated.	Table 3-18, Table 3-20
<b>Generating Resources</b>	
NEEDS planned units and retirements are updated based on April 2025 EIA Form 860M. Only retirements with a retirement year of 2030 or earlier in EIA Form 860M are included. Announced retirements from other public sources are not included. The emission control configurations are updated based on 2021 EIA Form 860 and AMPD 2019.	Table 4-1
Minimum capacity factor requirements of 10% are applied to existing coal steam units, and 2% are applied to existing oil/gas steam units and C2G retrofits, in regions without capacity markets	Section 3.5.2
Cost and performance characteristics for potential (new) units are updated based on AEO 2025 and NREL ATB 2023.	Table 4-12 and Table 4-15
Wind and solar technologies have revised cost and resource base estimates based on NREL ATB 2023. Onshore wind generation profiles are updated.	Section 4.4.5
Energy storage options of both 4-hour and 10-hour durations are based on NREL ATB 2023.	Section 4.4.5
Tax credit extensions from the OBBBA of 2025 are implemented for wind, solar, hydro, geothermal, landfill gas, energy storage, biomass, and 45Q.	Section 4.4.5
<b>Emission Control Technologies</b>	
Pipeline lateral costs for coal-to-gas-retrofits and natural gas co-firing retrofits are updated	Section 5.7.2
<b>Carbon Capture, Transport, and Storage</b>	
45Q is modeled in the 2030 and 2035 run years.	Section 3.12
Cost and performance assumptions for CCS controls are updated. Capital cost reductions are implemented over time for CCS retrofits	Section 6.1.2
Cost of geologic storage of carbon dioxide is updated using the GeoCAT 2.0 model. The update includes the quantity (in metric tons of capacity) and cost (in dollars per metric ton of CO <sub>2</sub> ) of potential geologic storage of carbon dioxide by location (generally defined as that portion of a geologic basin contained within one state) and by geologic storage type.	Section 6.2

Description	For More Information
CO <sub>2</sub> transportation cost adders reflect a transport cost algorithm that is based on a single, separate pipeline being used for each power plant all the way from the source to the sink.	Section 6.3
<b>Natural Gas</b>	
Natural gas assumptions as of the end of 2021 (with LNG export assumptions from AEO 2023) are modeled through annual gas supply curves and IPM region-level seasonal basis differentials.	Chapter 8
<b>Other Fuels</b>	
A hydrogen fuel price of 14.86 \$/MMBtu is assumed.	Chapter 9
<b>Financial assumptions</b>	
Cost adders for new non-peaking fossil units associated with future CO <sub>2</sub> emissions are no longer applied. The depreciation assumptions for solar, wind and energy storage are updated to 12-year straight line.	Chapter 10

EPA incorporated two major updates within the demand projections for this model release, namely repeal of the EPA vehicle rules (which reduced the demand for electricity from the transportation sector) and higher levels of data center demand (i.e. increasing levels of large load interconnections that increase the demand for electricity). In order to estimate transportation sector electricity demand consistent with the repeal of the vehicle rules, EPA relied on the “No Action Case” developed as part of the analysis for the impact of the vehicle rules. In order to estimate large load interconnections, EPA started with EPRI’s state level estimate<sup>1</sup> of historical data center demand, and grew this demand consistent with current market forecasts. EPA applied a publicly available load shape<sup>2</sup> to this demand to reflect high levels of utilization expected by these applications.

The load assumptions were aggregated using the following process: first, electricity demand was taken from the AEO 2025 Reference Case. The AEO estimate of demand in the run year 2024 was scaled regionally to align with the NERC ESND report. This 2024 value was then grown over the forecast horizon at the rate of growth projected under the AEO 2025 to derive values for all subsequent years over the analysis period. The embedded electric vehicle demand in the AEO 2025 was scaled up using the ratio used to adjust the 2024 projections of AEO demand, and this value was subtracted from the adjusted demand, and replaced with EPA projections of transportation demand consistent with the no action case under the vehicle rules. Using a similar approach, the amount of data center demand embedded in the AEO was removed and replaced by the Agency’s estimate of data center demand. The resulting demand forecast is presented in the tables below.

**Table 3-2 Electric Load Assumptions in the EPA 2025 Reference Case**

Year	Net Energy for Load (Billions-of kWh)
2028	4,845
2030	5,266
2035	6,181
2040	6,714
2045	7,031
2050	7,354
2055	7,815

**Table 3-3 Regional Electric Load Assumptions in the EPA 2025 Reference Case**

<sup>1</sup> Available at: <https://www.epri.com/research/products/3002028905>

<sup>2</sup> For details, please see page 24 of the PJM 2024 Load Forecast Supplement, January 2024

IPM Region	Net Energy for Load (Billions of kWh)						
	2028	2030	2035	2040	2045	2050	2055
ERC_FRNT	0	0	0	0	0	0	0
ERC_GWAY	0	0	0	0	0	0	0
ERC_PHDL	0	0	0	0	0	0	0
ERC_REST	460	498	579	625	647	670	708
ERC_WEST	91	98	113	121	125	129	137
FRCC	274	285	306	332	353	374	400
MIS_AMSO	36	37	39	43	45	48	51
MIS_AR	42	43	46	50	52	56	59
MIS_IA	25	29	37	40	41	41	44
MIS_IL	54	59	70	75	77	79	84
MIS_INKY	98	101	109	118	124	132	140
MIS_LA	55	56	60	65	69	73	77
MIS_LMI	105	109	120	130	139	147	157
MIS_MAPP	13	18	27	29	29	29	29
MIS_MIDA	34	43	59	63	63	62	65
MIS_MNWI	96	101	113	122	130	137	147
MIS_MO	41	43	48	52	55	58	61
MIS_MS	26	26	28	31	33	35	37
MIS_WOTA	39	42	48	52	54	56	59
MIS_WUMS	69	71	78	84	90	96	102
NENG_CT	35	37	41	44	47	50	53
NENG_ME	13	13	14	16	17	18	20
NENGREST	95	102	115	126	134	142	151
NY_Z_A	17	18	21	23	25	26	28
NY_Z_B	11	12	14	15	16	17	18
NY_Z_C&E	25	27	31	34	37	39	41
NY_Z_D	4	5	5	6	6	6	7
NY_Z_F	13	14	16	18	19	21	22
NY_Z_G-I	21	23	27	29	31	32	34
NY_Z_J	58	63	73	79	84	89	95
NY_Z_K	26	29	33	36	38	40	43
PJM_AP	55	61	72	77	80	83	87
PJM_ATSI	75	79	89	96	101	106	112
PJM_COMD	111	123	148	159	164	169	177
PJM_Dom	160	212	305	324	320	314	327
PJM_EMAC	167	185	223	244	256	267	282
PJM_PENE	20	21	24	26	27	29	31
PJM_SMAC	72	74	81	89	94	101	107
PJM_West	224	241	278	298	308	319	335
PJM_WMAC	62	65	72	77	81	85	91
S_C_KY	38	41	45	48	50	52	54
S_C_TVA	190	198	215	229	238	248	261
S_D_AECI	18	19	20	22	23	24	26
S_SOU	261	280	320	345	359	375	397
S_VACA	246	261	296	322	336	352	373
SPP_KIAM	0	0	0	0	0	0	0
SPP_N	86	89	96	104	112	119	128
SPP_NEBR	41	49	64	68	69	69	72
SPP_SPS	41	44	51	55	57	60	63
SPP_WAUE	31	34	40	43	44	45	48
SPP_WEST	121	127	142	155	164	173	184
WEC_BANC	17	19	23	26	28	30	32
WEC_CALN	130	143	175	197	211	224	240
WEC_LADW	37	42	51	56	60	63	68
WEC_SDGE	24	27	32	36	38	40	43
WECC_AZ	115	130	164	181	191	203	219
WECC_CO	81	88	107	122	133	144	157
WECC_ID	29	30	34	39	43	47	52
WECC_IID	5	5	6	7	8	9	9
WECC_MT	16	17	21	23	24	26	28
WECC_NM	26	28	35	40	44	47	52
WECC_NNV	17	20	26	29	31	32	35
WECC_PNW	220	250	318	350	368	384	411
WECC_SCE	120	134	166	186	199	211	225
WECC_SNV	34	40	53	58	61	64	69
WECC_UT	47	54	69	77	82	87	94
WECC_WY	29	34	44	48	50	53	57

**Table 3-4 National Non-Coincidental Net Internal Demand in the EPA 2025 Reference Case**

Year	Peak Demand (GW)			
	Winter	Spring	Summer	Fall
2028	789	672	885	727
2030	843	725	942	782
2035	970	848	1,075	908
2040	1,053	924	1,164	988
2045	1,106	972	1,223	1,038
2050	1,160	1,021	1,284	1,089
2055	1,237	1,089	1,371	1,161

Notes:

This data is an aggregation of the model-region-specific peak demand loads.

**Table 3-6 International Electricity Imports (billions kWh) in the EPA 2025 Reference Case**

	2028	2030	2035	2040	2045	2050	2055
Net Imports from Mexico	3.20	3.20	3.20	2.92	2.92	2.92	2.92

Note 1: Source: AEO 2025 Reference Case

Note 2: Imports & exports transactions from Canada are endogenously modeled in IPM.

**Table 3-18 Renewable Portfolio Standards in the EPA 2025 Reference Case**

State	2028	2030	2035	2040	2045	2050	2055
Arizona	8.6%	8.6%	8.6%	8.6%	8.6%	8.6%	8.6%
California	52.0%	57.3%	70.7%	84.0%	97.3%	100.0%	100.0%
Colorado	20.9%	20.9%	20.9%	20.9%	20.9%	20.9%	20.9%
Connecticut	40.0%	44.0%	44.0%	44.0%	44.0%	44.0%	44.0%
District of Columbia	73.0%	87.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Delaware	26.5%	28.0%	40.0%	40.0%	40.0%	40.0%	40.0%
Iowa	0.5%	0.5%	0.3%	0.3%	0.3%	0.3%	0.3%
Illinois	32.5%	40.0%	45.0%	50.0%	50.0%	50.0%	50.0%
Massachusetts	36.0%	40.0%	45.0%	50.0%	55.0%	60.0%	60.0%
Maryland	47.5%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Maine	71.0%	80.0%	85.0%	90.0%	95.0%	100.0%	100.0%
Michigan	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
Minnesota	34.0%	40.0%	55.0%	55.0%	55.0%	55.0%	55.0%
Missouri	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%
North Carolina	11.6%	11.6%	11.6%	11.6%	11.6%	11.6%	11.6%
New Hampshire	23.0%	23.0%	23.0%	23.0%	23.0%	23.0%	23.0%
New Jersey	46.5%	52.5%	52.5%	52.5%	52.5%	52.5%	52.5%
New Mexico	41.6%	45.2%	57.2%	69.2%	70.7%	72.3%	72.3%
Nevada	34.8%	41.4%	41.4%	41.4%	41.4%	41.4%	41.4%
New York	61.2%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
Ohio	7.6%	7.6%	7.6%	7.6%	7.6%	7.6%	7.6%
Oregon	18.6%	23.7%	31.1%	35.5%	39.9%	39.9%	39.9%
Pennsylvania	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Rhode Island	55.5%	72.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Texas	5.2%	4.8%	4.2%	3.9%	3.8%	3.7%	3.7%
Virginia	26.1%	30.8%	44.5%	60.2%	76.0%	78.4%	78.4%
Vermont	67.0%	71.0%	75.0%	75.0%	75.0%	75.0%	75.0%
Washington	12.2%	12.2%	12.2%	12.2%	12.2%	12.2%	12.2%
Wisconsin	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%	9.6%

Notes:

The Renewable Portfolio Standard percentages are applied to modeled electricity sale projections.

North Carolina standards are adjusted to account for swine waste and poultry waste set-asides.

**Table 3-21 Offshore Wind Mandates in the EPA 2025 Reference Case**

State	Bill/Act	Mandate Specifications	Implementation Year
Maryland	Senate Bill 516	400 MW, 800 MW, and 1,200 MW of offshore wind capacity by 2026, 2028 and 2030 respectively	2035
Connecticut	House Bill 7156	2,000 MW of offshore wind capacity by 2030	2035

Massachusetts	2016 Bill 4568	An Act to Promote Energy Diversity, legislation allows for the procurement of approximately 1,600MW of offshore wind	
		800MW Vineyard Wind	2024
		800MW South Coast Wind aka Mayflower Wind	2035
	Massachusetts Energy Diversity Act	4,000 MW of offshore wind capacity by 2027	2035
New York	Climate Leadership and Community Protection Act	9,000 MW of offshore wind capacity by 2035	2035
Virginia	Virginia Clean Economy Act	Development by Dominion Energy Virginia of qualified offshore wind projects having an aggregate rated capacity of not less than 5,200 megawatts by December 31, 2032 (Senate Bill 1441, legp604.exe (virginia.gov))	2035

**Table 3-22 Fossil Generation Limits (GWh) in the EPA 2025 Reference Case**

State	2028	2030	2035	2040	2045	2050	2055
California	152,259	151,890	136,468	97,013	44,954	35,336	37,704
Colorado	-	-	-	-	-	69,685	75,521
Illinois	-	-	-	123,742	127,323	14,707	15,479
New Mexico	-	-	17,873	15,315	15,718	8,095	8,707
Nevada	-	-	-	-	-	8,553	9,227
New York	72,503	63,508	73,404	16,192	17,120	18,107	19,278
Oregon	-	-	-	11,793	12,302	12,711	13,504
Virginia	-	-	-	150,946	97,598	87,917	90,852
Washington	-	14,168	18,317	20,042	20,908	21,602	22,950

**Table 3-24 Emission and Removal Rate Assumptions for Potential (New) Units in the EPA 2025 Reference Case**

	<b>Controls, Removal, and Emissions Rates</b>	<b>Ultra-Supercritical Pulverized Coal</b>	<b>Ultra-Supercritical Pulverized Coal with 36% CCS</b>	<b>Ultra-Supercritical Pulverized Coal with 95% CCS</b>	<b>Advanced Combined Cycle</b>	<b>Advanced Combined Cycle with CCS</b>	<b>Advanced Combustion Turbine</b>	<b>Biomass</b>	<b>Geothermal</b>	<b>Landfill Gas</b>
<b>SO<sub>2</sub></b>	<b>Removal / Emissions Rate</b>	98% with a floor of 0.06 lbs/MMBtu	98% with a floor of 0.06 lbs/MMBtu	98% with a floor of 0.06 lbs/MMBtu	None	None	None	0.08 lbs/MMBtu	None	None
<b>NO<sub>x</sub></b>	<b>Emission Rate</b>	0.05 lbs/MMBtu	0.05 lbs/MMBtu	0.05 lbs/MMBtu	0.011 lbs/MMBtu	0.011 lbs/MMBtu	0.011 lbs/MMBtu	0.02 lbs/MMBtu	None	0.09 lbs/MMBtu
<b>Hg</b>	<b>Removal / Emissions Rate</b>	90%	90%	90%	Natural Gas: 0.00014 lbs/MMBtu Oil: 0.48 lbs/MMBtu	Natural Gas: 0.00014 lbs/MMBtu Oil: 0.48 lbs/MMBtu	Natural Gas: 0.00014 lbs/MMBtu Oil: 0.48 lbs/MMBtu	0.57 lbs/MMBtu	3.7	None
<b>CO<sub>2</sub></b>	<b>Removal / Emissions Rate</b>	202.8 - 219.3 lbs/MMBtu	36%	95%	Natural Gas: 117.08 lbs/MMBtu Oil: 161.39 lbs/MMBtu	95%	Natural Gas: 117.08 lbs/MMBtu Oil: 161.39 lbs/MMBtu	195 lbs/MMBtu	None	115.2 lbs/MMBtu
<b>HCL</b>	<b>Removal / Emissions Rate</b>	99% with a floor of 0.001 lbs/MMBtu	99% with a floor of 0.001 lbs/MMBtu	99% with a floor of 0.001 lbs/MMBtu						

**Table 4-1 Data Sources for NEEDS for EPA 2025 Reference Case**

Data Source <sup>1</sup>	Data Source Documentation
EIA's Form EIA-860	<p>EIA's Form EIA-860 is both a monthly and annual survey of utility and non-utility power plants at the generator level. It contains data such as summer, winter and nameplate capacity, location (state and county), operating status, prime mover, energy sources and in-service date of existing and proposed generators. NEEDS uses EIA Form 860 (April 2025, January 2023, and August 2023 monthly versions, and 2021 annual release) data as primary generator data inputs.</p> <p>EIA's Form EIA-860 also collects data of steam boilers such as energy sources, boiler identification, location, operating status, and design information; and associated environmental equipment such as NO<sub>x</sub> combustion and post-combustion control, FGD scrubber, mercury control and particulate collector device information. Note that boilers in plants with less than 10 MW do not report all data elements. The association between boilers and generators is also provided. Note that boilers and generators are not necessarily in one-to-one correspondence. NEEDS uses EIA Form 860 (2021 annual release) data as one of the primary boiler data inputs.</p>
EIA's Annual Energy Outlook (AEO)	The Energy Information Administration (EIA) Annual Energy Outlook presents annually updated projections of energy supply, demand and prices covering a 20-25 year time horizon. The projections are based on results from EIA's National Energy Modeling System (NEMS). Information from AEO 2023 Reference Case such as capacity for nuclear units was used in NEEDS.
EPA's Emission Tracking System	The Emission Tracking System (ETS) database is updated quarterly. It contains boiler-level information such as primary fuel, heat input, SO <sub>2</sub> , NO <sub>x</sub> , Mercury, and HCL controls, and SO <sub>2</sub> and NO <sub>x</sub> emissions. NEEDS uses annual and seasonal ETS (2019) data as one of the primary data inputs for NO <sub>x</sub> rate development and ETS (2022) data for environmental equipment assignment.
Utility and Regional EPA Office Comments	Comments from utilities and regional EPA offices, and EPA research regarding the population in NEEDS as of Summer 2025 (e.g., new units) as well as unit characteristics were incorporated in NEEDS.

**Note:**

<sup>1</sup> Shown in Table 4-1 are the primary issue dates of the indicated data sources used. Other vintages of these data sources were also used in instances where data were not available for the indicated issued date, or where there were methodological reasons for using other vintages of the data.

**Table 4-2 Rules Used in Populating NEEDS for EPA 2025 Reference Case**

Scope	Rule
Capacity	Excluded units that had reported summer capacity, winter capacity, and nameplate capacity of zero or blank.
Status	Excluded units that were out of service for three consecutive years (i.e., generators or boilers with status codes "OS <sup>3</sup> " or "OA <sup>4</sup> " in the latest three reporting years) and units that were no longer in service and not expected to be returned to service (i.e., generators or boilers with status codes of "RE <sup>5</sup> "). Status of boiler(s) and associated generator(s) were considered for determining operation status.
Planned or Committed Units	<p>For non-renewable committed units, included those that had broken ground and were expected to be online by June 30, 2028.</p> <p>Renewable committed units are limited to TS, U, V, and a subset of T status flag units. The T status flag units are included based on the year cutoffs listed below, which are determined by OBBBA and technology-level lead times.</p> <p>Solar PV and Solar Thermal – December 31, 2027</p> <p>Onshore Wind and Offshore Wind – December 31, 2028</p> <p>Battery Storage – no year cutoff.</p>
Firm/Non-firm Electric Sales	Excluded non-utility onsite generators that did not produce electricity for sale to the grid on a net basis.

<sup>3</sup> OS - Out of service and was not used for some or all of the reporting period and is NOT expected to be returned to service in the next calendar year.

<sup>4</sup> OA - Out of service and was not used for some or all of the reporting period but is expected to be returned to service in the next calendar year.

<sup>5</sup> RE - Retired and no longer in service and not expected to be returned to service.

**Table 4-3 Summary Population (through 2024) of Existing Units in NEEDS for the EPA 2025 Reference Case**

Plant Type	Number of Units	Capacity (MW)
Biomass	132	2,913
Coal Steam	357	154,004
Combined Cycle	1,868	287,211
Combustion Turbine	6,348	150,422
Energy Storage	802	30,368
Fossil Waste	47	889
Fuel Cell	187	347.8
Geothermal	148	2,608
Hydro	3,750	79,361
IGCC	4	756
Landfill Gas	1,255	1,504
Municipal Solid Waste	134	1,748
Non-Fossil Waste	186	1,969
Nuclear	94	96,578
O/G Steam	372	61,096
Offshore Wind	4	971.3
Onshore Wind	1,526	153,693
Pumped Storage	149	22,865
Solar PV	7,061	131,283
Solar Thermal	11	1,392
Tires	1	26
<b>US Total</b>	<b>24,436</b>	<b>1,182,002</b>

**Table 4-4 Hierarchy of Data Sources for Capacity in NEEDS for EPA 2025 Reference Case**

Sources Presented in Hierarchy
Net Summer Capacity from Comments / ICF Research
AEO 2023 Nuclear Capacity in 2028
April 2025 EIA Form 860 monthly Net Summer Capacity
2021 EIA Form 860 Annual Net Summer Capacity

Notes:

Presented in a hierarchical order that applies.

If the capacity of a unit is zero MW, the unit is excluded from the NEEDS population.

**Table 4-7 Aggregation Profile of Model Plants as Provided at Set up of the EPA 2025 Reference Case**

Existing and Planned/Committed Units		
Plant Type	Number of Units	Number of IPM Model Plants
Biomass	283	102
Coal Steam	373	286
Combined Cycle	1,988	848
Combustion Turbine	6,389	1,159
Distributed Solar PV	130	130
Energy Storage	593	65
Fossil Waste	53	23
Fuel Cell	187	23
Geothermal	138	13
Hydro	5,434	213
IGCC	4	2
IMPORT	1	1
Landfill Gas	1,270	91
Municipal Solid Waste	135	49
Non-Fossil Waste	215	82
Nuclear	107	106
O/G Steam	455	276
Offshore Wind	7	5
Onshore Wind	1,902	86
Pumped Storage	159	27
Solar PV	6,503	107

Solar Thermal	12	6
Tires	1	1
<b>Total</b>	<b>26,339</b>	<b>3,701</b>
<b>New Units</b>		
<b>Plant Type</b>	<b>Number of Units</b>	<b>Number of IPM Model Plants</b>
New Battery Storage	--	518
New Biomass	--	134
New Combined Cycle	--	81
New Combined Cycle with CCS	--	203
New Combined Cycle with CCS Retrofit	--	140
New Combined Cycle with CF Limit	--	70
New Combined Cycle with HRI Retrofit	--	70
New Combined Cycle with Hydrogen Retrofit	--	70
New Combined Cycle with Hydrogen Retrofit Undone	--	70
New Combustion Turbine	--	117
New Combustion Turbine with HRI Retrofit	--	106
New Combustion Turbine with Hydrogen Retrofit	--	212
New Combustion Turbine with Hydrogen Retrofit Undone	--	212
New Fuel Cell	--	75
New Geothermal	--	61
New Hydro	--	153
New Landfill Gas	--	379
New Nuclear	--	66
New Offshore Wind	--	388
New Onshore Wind	--	2,058
New Small Modular Reactor	--	66
New Solar PV	--	2,110
New Solar Thermal	--	248
New Ultrasupercritical Coal with 30% CCS	--	192
New Ultrasupercritical Coal with 90% CCS	--	197
New Ultrasupercritical Coal without CCS	--	69
<b>Total</b>	--	<b>8,065</b>
<b>Retrofits</b>		
<b>Plant Type</b>	<b>Number of Units</b>	<b>Number of IPM Model Plants</b>
Retrofit Coal with ACI	--	97
Retrofit Coal with ACI + C2G	--	69
Retrofit Coal with ACI + C2G + SCR	--	16
Retrofit Coal with ACI + CCS	--	72
Retrofit Coal with ACI + DRET	--	97
Retrofit Coal with ACI + DSI	--	2
Retrofit Coal with ACI + DSI + C2G	--	2
Retrofit Coal with ACI + DSI + C2G + SCR	--	2
Retrofit Coal with ACI + DSI + DRET	--	2
Retrofit Coal with ACI + DSI + GPM	--	2
Retrofit Coal with ACI + DSI + GPM + C2G	--	2
Retrofit Coal with ACI + DSI + GPM + C2G + SCR	--	2
Retrofit Coal with ACI + DSI + GPM + DRET	--	2
Retrofit Coal with ACI + DSI + GPM + NGC	--	2
Retrofit Coal with ACI + DSI + GPM + SCR	--	2
Retrofit Coal with ACI + DSI + GPM + SCR + DRET	--	2
Retrofit Coal with ACI + DSI + GPM + SCR + NGC	--	2
Retrofit Coal with ACI + DSI + GPM + Scrubber + SCR + CCS	--	4
Retrofit Coal with ACI + DSI + GPM + SNCR	--	2
Retrofit Coal with ACI + DSI + GPM + SNCR + DRET	--	2
Retrofit Coal with ACI + DSI + GPM + SNCR + NGC	--	2
Retrofit Coal with ACI + DSI + NGC	--	2
Retrofit Coal with ACI + DSI + SCR	--	2
Retrofit Coal with ACI + DSI + SCR + DRET	--	2
Retrofit Coal with ACI + DSI + SCR + NGC	--	2
Retrofit Coal with ACI + DSI + Scrubber + SCR + CCS	--	4
Retrofit Coal with ACI + DSI + SNCR	--	2
Retrofit Coal with ACI + DSI + SNCR + DRET	--	2
Retrofit Coal with ACI + DSI + SNCR + NGC	--	2
Retrofit Coal with ACI + GPM	--	80
Retrofit Coal with ACI + GPM + C2G	--	54
Retrofit Coal with ACI + GPM + C2G + SCR	--	14
Retrofit Coal with ACI + GPM + CCS	--	59

Retrofit Coal with ACI + GPM + DRET	--	80
Retrofit Coal with ACI + GPM + NGC	--	80
Retrofit Coal with ACI + GPM + SCR	--	14
Retrofit Coal with ACI + GPM + SCR + CCS	--	6
Retrofit Coal with ACI + GPM + SCR + DRET	--	14
Retrofit Coal with ACI + GPM + SCR + NGC	--	14
Retrofit Coal with ACI + GPM + Scrubber + SCR + CCS	--	4
Retrofit Coal with ACI + GPM + SNCR	--	21
Retrofit Coal with ACI + GPM + SNCR + DRET	--	21
Retrofit Coal with ACI + GPM + SNCR + NGC	--	21
Retrofit Coal with ACI + NGC	--	97
Retrofit Coal with ACI + SCR	--	16
Retrofit Coal with ACI + SCR + CCS	--	8
Retrofit Coal with ACI + SCR + DRET	--	16
Retrofit Coal with ACI + SCR + NGC	--	16
Retrofit Coal with ACI + Scrubber + SCR + CCS	--	4
Retrofit Coal with ACI + SNCR	--	22
Retrofit Coal with ACI + SNCR + DRET	--	22
Retrofit Coal with ACI + SNCR + NGC	--	22
Retrofit Coal with C2G	--	239
Retrofit Coal with C2G + SCR	--	100
Retrofit Coal with CCS	--	188
Retrofit Coal with DCCS	--	163
Retrofit Coal with DCCS + CCS	--	94
Retrofit Coal with DCCS + SCR + CCS	--	40
Retrofit Coal with DCCS + Scrubber + CCS	--	7
Retrofit Coal with DCCS + Scrubber + SCR + CCS	--	22
Retrofit Coal with DCCS + SNCR + CCS	--	2
Retrofit Coal with DRET	--	277
Retrofit Coal with DSI	--	34
Retrofit Coal with DSI + C2G	--	33
Retrofit Coal with DSI + C2G + SCR	--	24
Retrofit Coal with DSI + DRET	--	33
Retrofit Coal with DSI + GPM	--	9
Retrofit Coal with DSI + GPM + C2G	--	9
Retrofit Coal with DSI + GPM + C2G + SCR	--	6
Retrofit Coal with DSI + GPM + DRET	--	9
Retrofit Coal with DSI + GPM + NGC	--	9
Retrofit Coal with DSI + GPM + SCR	--	6
Retrofit Coal with DSI + GPM + SCR + DRET	--	6
Retrofit Coal with DSI + GPM + SCR + NGC	--	6
Retrofit Coal with DSI + GPM + Scrubber + CCS	--	6
Retrofit Coal with DSI + GPM + Scrubber + SCR + CCS	--	11
Retrofit Coal with DSI + GPM + SNCR	--	6
Retrofit Coal with DSI + GPM + SNCR + DRET	--	6
Retrofit Coal with DSI + GPM + SNCR + NGC	--	6
Retrofit Coal with DSI + NGC	--	33
Retrofit Coal with DSI + SCR	--	24
Retrofit Coal with DSI + SCR + DRET	--	24
Retrofit Coal with DSI + SCR + NGC	--	24
Retrofit Coal with DSI + Scrubber + CCS	--	12
Retrofit Coal with DSI + Scrubber + SCR + CCS	--	40
Retrofit Coal with DSI + SNCR	--	26
Retrofit Coal with DSI + SNCR + DRET	--	26
Retrofit Coal with DSI + SNCR + NGC	--	26
Retrofit Coal with GPM	--	277
Retrofit Coal with GPM + C2G	--	238
Retrofit Coal with GPM + C2G + SCR	--	99
Retrofit Coal with GPM + CCS	--	184
Retrofit Coal with GPM + DRET	--	276
Retrofit Coal with GPM + NGC	--	276
Retrofit Coal with GPM + SCR	--	99
Retrofit Coal with GPM + SCR + CCS	--	78
Retrofit Coal with GPM + SCR + DRET	--	99
Retrofit Coal with GPM + SCR + NGC	--	99
Retrofit Coal with GPM + Scrubber + CCS	--	14
Retrofit Coal with GPM + Scrubber + SCR + CCS	--	58
Retrofit Coal with GPM + SNCR	--	92
Retrofit Coal with GPM + SNCR + CCS	--	6
Retrofit Coal with GPM + SNCR + DRET	--	92

Retrofit Coal with GPM + SNCR + NGC	--	92
Retrofit Coal with NGC	--	277
Retrofit Coal with SCR	--	100
Retrofit Coal with SCR + C2G	--	100
Retrofit Coal with SCR + CCS	--	78
Retrofit Coal with SCR + DRET	--	100
Retrofit Coal with SCR + NGC	--	100
Retrofit Coal with SCR + Scrubber + CCS	--	58
Retrofit Coal with Scrubber + CCS	--	14
Retrofit Coal with SNCR	--	93
Retrofit Coal with SNCR + C2G	--	79
Retrofit Coal with SNCR + CCS	--	6
Retrofit Coal with SNCR + DRET	--	93
Retrofit Coal with SNCR + NGC	--	93
Retrofit Combined Cycle with CCS	--	1452
Retrofit Combined Cycle with CF Limit	--	729
Retrofit Combined Cycle with HRI	--	662
Retrofit Combined Cycle with Hydrogen	--	729
Retrofit Combined Cycle with Hydrogen Retrofit Undone	--	729
Retrofit Combustion Turbine with HRI	--	746
<b>Total</b>	--	<b>11,011</b>
<b>Retirements</b>		
<b>Plant Type</b>	<b>Number of Units</b>	<b>Number of IPM Model Plants</b>
Biomass Retirement	--	102
Coal Steam Retirement	--	4,999
Existing Combined Cycle Retirement	--	5,149
Existing Combustion Turbine Retirement	--	1,905
Fossil Other Retirement	--	23
Fuel Cell Retirement	--	23
Geothermal Retirement	--	13
Hydro Retirement	--	105
IGCC Retirement	--	2
Landfill Gas Retirement	--	91
New Combined Cycle Retirement	--	420
New Combustion Turbine Retirement	--	424
Non-Fossil Other Retirement	--	132
Nuclear Retirement	--	106
Oil/Gas Steam Retirement	--	1,364
<b>Total</b>	--	<b>14,858</b>
<b>Grand Total (Existing and Planned/Committed + New + Retrofits + Early Retirements): 37,635</b>		

**Table 4-11 Summary of Planned-Committed Units in NEEDS in the EPA 2025 Reference Case**

Type	Capacity (MW)	Year Range Described
<b>Renewables/Non-conventional</b>		
Biomass	6	2025 - 2027
Energy Storage	22,064	2025 - 2028
Hydro	7.5	2025 - 2025
Geothermal	1.8	2028 - 2028
Non-Fossil Waste	2	2025 - 2025
Offshore Wind	3,714	2025 - 2027
Onshore Wind	14,234	2025 - 2028
Solar PV	41,967	2025 - 2027
Subtotal	81,995	
<b>Fossil/Conventional</b>		
Combined Cycle	4,307	2025 - 2027
Combustion Turbine	3,475	2025 - 2026
Subtotal	7,782	
<b>Grand Total</b>	<b>89,777</b>	

**Note:**

Any unit in NEEDS that has an online year of 2025 or later was considered a Planned/Committed Unit.

**Table 4-12 Performance and Unit Cost Assumptions for Potential (New) Capacity from Conventional Technologies in the EPA 2023 Reference Case**

	Combined Cycle - Single Shaft	Combined Cycle - Multi Shaft	Combined Cycle with 95% CCS	Combustion Turbine - Industrial Frame	Combustion Turbine - Aeroderivative	Advanced Nuclear	Small Modular Reactor	Ultra-supercritical Coal without CCS
<b>Size (MW)</b>	627	1227	543	419	211	2156	480	650
<b>First Year Available</b>	2030	2030	2030	2028	2028	2035	2035	2030
<b>Lead Time (Years)</b>	3	3	4	2	2	6	6	4
<b>Availability</b>	87%	87%	87%	92%	92%	90%	95%	85%
<b>Vintage #1 (2028)</b>								
<b>Heat Rate (Btu/kWh)</b>	6,226	6,226	7,239	9,142	9,447	10,452	10,452	8,638
<b>Capital (2022\$/kW)</b>	777	732	2,186	694	1,334	6,856	8,209	3,789
<b>Fixed O&amp;M (2022\$/kW/yr)</b>	14.85	11.60	23.72	6.57	9.14	149.50	116.77	45.68
<b>Variable O&amp;M (2022\$/MWh)</b>	3.20	3.26	4.84	3.82	5.46	2.39	3.04	5.06
<b>Vintage #2 (2030)</b>								
<b>Heat Rate (Btu/kWh)</b>	6,226	6,226	7,239	9,142	9,447	10,452	10,452	8,638
<b>Capital (2022\$/kW)</b>	758	714	2,130	670	1,289	6,667	7,983	3,717
<b>Fixed O&amp;M (2022\$/kW/yr)</b>	14.85	11.60	23.72	6.57	9.14	149.50	116.77	45.68
<b>Variable O&amp;M (2022\$/MWh)</b>	3.20	3.26	4.84	3.82	5.46	2.39	3.04	5.06
<b>Vintage #3 (2035)</b>								
<b>Heat Rate (Btu/kWh)</b>	6,226	6,226	7,239	9,142	9,447	10,452	10,452	8,638
<b>Capital (2022\$/kW)</b>	723	681	1,857	622	1,197	6,299	7,544	3,538
<b>Fixed O&amp;M (2022\$/kW/yr)</b>	14.85	11.60	23.72	6.57	9.14	149.50	116.77	45.68
<b>Variable O&amp;M (2022\$/MWh)</b>	3.20	3.26	4.84	3.82	5.46	2.39	3.04	5.06
<b>Vintage #4 (2040)</b>								
<b>Heat Rate (Btu/kWh)</b>	6,226	6,226	7,239	9,142	9,447	10,452	10,452	8,638
<b>Capital (2022\$/kW)</b>	702	661	1,464	600	1,155	5,950	7,127	3,353
<b>Fixed O&amp;M (2022\$/kW/yr)</b>	14.85	11.60	23.72	6.57	9.14	149.50	116.77	45.68
<b>Variable O&amp;M (2022\$/MWh)</b>	3.20	3.26	4.84	3.82	5.46	2.39	3.04	5.06
<b>Vintage #5 (2045)</b>								
<b>Heat Rate (Btu/kWh)</b>	6,226	6,226	7,239	9,142	9,447	10,452	10,452	8,638
<b>Capital (2022\$/kW)</b>	681	642	1,396	579	1,114	5,601	6,711	3,160
<b>Fixed O&amp;M (2022\$/kW/yr)</b>	14.85	11.60	23.72	6.57	9.14	149.50	116.77	45.68
<b>Variable O&amp;M (2022\$/MWh)</b>	3.20	3.26	4.84	3.82	5.46	2.39	3.04	5.06
<b>Vintage #6 (2050 - 2055)</b>								
<b>Heat Rate (Btu/kWh)</b>	6,226	6,226	7,239	9,142	9,447	10,452	10,452	8,638
<b>Capital (2022\$/kW)</b>	662	624	1,332	561	1,079	5,262	6,307	2,966
<b>Fixed O&amp;M (2022\$/kW/yr)</b>	14.85	11.60	23.72	6.57	9.14	149.50	116.77	45.68
<b>Variable O&amp;M (2022\$/MWh)</b>	3.20	3.26	4.84	3.82	5.46	2.39	3.04	5.06

**Notes:**

- <sup>a</sup> Capital cost represents overnight capital cost.
- <sup>b</sup> IPM regions in urban areas (NENGRST, NY\_Z\_J, NY\_Z\_K, PJM\_SMAC, PJM\_COMD, WEC\_LADW, WEC\_SDGE, and WEC\_BANC) are assigned "Combined Cycle - Single Shaft" and "Combustion Turbine - Aeroderivative" technologies. All other regions are assigned "Combined Cycle - Multi Shaft" and "Combustion Turbine - Industrial Frame" technologies.
- <sup>c</sup> The ultra-supercritical coal plant without CCS is not compliant with 80 FR 64510.

**Table 4-13 Short-Term Capital Cost Adders for New Power Plants in the EPA 2025 Reference Case (2022\$)**

Plant Type		2028			2030			2035		
		Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Biomass	Upper Bound (MW)	2,322	4,022	No limit	1,150	2,000	No limit	2,875	5,000	No limit
	Adder (\$/kW)	-	1,905	6,051	-	1,868	5,933	-	1,803	5,728
Coal Steam - UPC + UPC30 + UPC90	Upper Bound (MW)	2,990	5,200	No limit	1,495	2,600	No limit	3,738	6,500	No limit
	Adder (\$/kW)	-	3,069	9,748	-	3,004	9,542	-	2,767	8,789
Combined Cycle + Combustion Turbine	Upper Bound (MW)	91,596	157,013	No limit	44,253	76,962	No limit	110,632	192,404	No limit
	Adder (\$/kW)	-	308	979	-	294	933	-	273	867
Fuel Cell	Upper Bound (MW)	2,300	4,000	No limit	1,150	2,000	No limit	2,875	5,000	No limit
	Adder (\$/kW)	-	2,171	6,897	-	2,089	6,635	-	1,973	6,268
Geothermal	Upper Bound (MW)	698	1,120	No limit	295	514	No limit	605	1,053	No limit
	Adder (\$/kW)	-	3,343	10,619	-	3,308	10,506	-	3,308	10,506
Landfill Gas	Upper Bound (MW)	470	796	No limit	220	383	No limit	550	957	No limit
	Adder (\$/kW)	-	772	2,452	-	745	2,367	-	694	2,204
Nuclear	Upper Bound (MW)	6,077	10,569	No limit	3,148	5,475	No limit	6,452	11,220	No limit
	Adder (\$/kW)	-	2,256	7,166	-	2,194	6,969	-	2,073	6,585
Solar Thermal	Upper Bound (MW)	2,708	4,710	No limit	1,403	2,440	No limit	2,875	5,000	No limit
	Adder (\$/kW)	-	2,550	8,099	-	2,236	7,104	-	2,156	6,850
Solar PV	Upper Bound (MW)	184,882	308,122	No limit	86,378	150,222	No limit	177,003	307,832	No limit
	Adder (\$/kW)	-	507	1,611	-	465	1,477	-	385	1,224
Onshore Wind	Upper Bound (MW)	68,555	118,448	No limit	33,089	57,547	No limit	82,724	143,867	No limit
	Adder (\$/kW)	-	582	1,848	-	540	1,714	-	505	1,603
Hydro	Upper Bound (MW)	2,220	3,747	No limit	1,070	1,862	No limit	2,194	3,815	No limit
	Adder (\$/kW)	-	793	2,519	-	793	2,519	-	793	2,519

**Table 4-15 Performance and Unit Cost Assumptions for Potential (New) Renewable and Non-Conventional Technologies in the EPA 2025 Reference Case**

	Geothermal	Biomass	Landfill Gas LGHI	Fuel Cells	Solar Photovoltaic	Solar Thermal	Onshore Wind	Offshore Wind	Battery Storage (4 Hours)	Battery Storage (10 hours)
Size (MW)	0	50	36	10	100	115	200	1000	60	60
First Year Available	2030	2030	2030	2030	2028	2030	2030	2030	2028	2028
Lead Time (Years)	4	5	3	3	1	3	3	3	1	1
Availability	80% - 90%	83%	90%	87%	90%	90%	95%	95%	96.4%	96.4%
Generation Capability	Economic Dispatch	Economic Dispatch	Economic Dispatch	Economic Dispatch	Generation Profile	Economic Dispatch	Generation Profile	Generation Profile	Economic Dispatch	Economic Dispatch
<b>Vintage #1 (2028-2055)</b>					<b>Vintage #1 (2028)</b>					
Heat Rate (Btu/kWh)	30,000	13,300	8,513	6,469	0	0	0	0	0	0
Capital (2022\$/kW)	3,662 - 48,811	4,076	1,707	6,903	1,065	5,594	1,206	1,979	960	2,077
Fixed O&M (2022\$/kW/yr)	114 - 1,208	141.14	22.57	34.56	19.08	59.54	29.66	96.04	34.59	74.82
Variable O&M (2022\$/MWh)	0.00	5.42	6.96	0.66	0.00	3.37	0.00	0.00	0.00	0.00
					<b>Vintage #2 (2030)</b>					
Heat Rate (Btu/kWh)		13,300	8,513	6,469	0	0	0	0	0	0
Capital (2022\$/kW)		3,997	1,659	6,641	1,005	5,107	1,159	1,923	891	1,902
Fixed O&M (2022\$/kW/yr)		141.14	22.57	34.56	18.37	55.43	28.88	92.95	32.11	68.52
Variable O&M (2022\$/MWh)		5.42	6.96	0.66	0.00	3.21	0.00	0.00	0.00	0.00
					<b>Vintage #3 (2035)</b>					
Heat Rate (Btu/kWh)		13,300	8,513	6,469	0	0	0	0	0	0
Capital (2022\$/kW)		3,858	1,544	6,274	856	4,925	1,102	1,818	823	1,741
Fixed O&M (2022\$/kW/yr)		141.14	22.57	34.56	16.60	55.43	27.89	86.93	29.64	62.74
Variable O&M (2022\$/MWh)		5.42	6.96	0.66	0.00	3.21	0.00	0.00	0.00	0.00
					<b>Vintage #4 (2040)</b>					
Heat Rate (Btu/kWh)		13,300	8,513	6,469	0	0	0	0	0	0
Capital (2022\$/kW)		3,728	1,449	5,924	788	4,743	1,044	1,742	754	1,581
Fixed O&M (2022\$/kW/yr)		141.14	22.57	34.56	15.88	55.43	26.90	82.40	27.16	56.97
Variable O&M (2022\$/MWh)		5.42	6.96	0.66	0.00	3.21	0.00	0.00	0.00	0.00
					<b>Vintage #5 (2045)</b>					
Heat Rate (Btu/kWh)		13,300	8,513	6,469	0	0	0	0	0	0
Capital (2022\$/kW)		3,596	1,361	5,576	721	4,560	987	1,683	685	1,422
Fixed O&M (2022\$/kW/yr)		141.14	22.57	34.56	15.16	55.43	25.91	78.76	24.68	51.23
Variable O&M (2022\$/MWh)		5.42	6.96	0.66	0.00	3.21	0.00	0.00	0.00	0.00
					<b>Vintage #6 (2050-2055)</b>					
Heat Rate (Btu/kWh)		13,300	8,513	6,469	0	0	0	0	0	0
Capital (2022\$/kW)		3,468	1,268	5,238	653	4,378	930	1,634	617	1,263
Fixed O&M (2022\$/kW/yr)		141.14	22.57	34.56	14.44	55.43	24.92	75.72	22.21	45.51
Variable O&M (2022\$/MWh)		5.42	6.96	0.66	0.00	3.21	0.00	0.00	0.00	0.00

Note: The capital costs for the landfill gas units at low, and very low methane producing sites are assumed to be 26% and 94% higher than the capital costs for the landfill gas units at high methane producing sites. The capital costs for solar PV units in 2028 are from the ATB 2023 advanced case, and the capital costs starting in 2035 are from the ATB 2023 moderate case. The capital costs in 2030 are linearly interpolated. The capital costs and FOM of energy storage units are based on the AEO 2023 estimate for 2023 and are adjusted in future years based on the trend underlying the ATB 2023 moderate case assumptions

**Table 4-20 Onshore Reserve Margin Contribution by Wind Class in the EPA 2025 Reference Case**

Wind Class	Vintage #1 (2028)	Vintage #2 (2030-2059)
Class 1	0% - 51%	0% - 55%
Class 2	4%	4%
Class 3	0% - 62%	0% - 67%
Class 4	0% - 54%	0% - 58%
Class 5	0% - 73%	0% - 79%
Class 6	0% - 68%	0% - 73%
Class 7	0% - 76%	0% - 82%
Class 8	0% - 69%	0% - 74%
Class 9	0% - 74%	0% - 80%

**Table 4-21 Offshore Fixed Reserve Margin Contribution by Wind Class in the EPA 2025 Reference Case**

Wind Class	Vintage #1 (2028-2059)
Class 1	0.3% - 89%
Class 2	0.1% - 94%
Class 3	0% - 30%
Class 4	7.4% - 21%
Class 5	1.5% - 16%
Class 6	0% - 20%

**Table 4-22 Offshore Floating Reserve Margin Contribution by Wind Class in the EPA 2025 Reference Case**

Wind Class	Vintage #1 (2028-2059)
Class 8	0% - 93.8%
Class 9	0.8% - 97.2%
Class 10	1.6% - 3.1%
Class 11	0% - 34.4%
Class 12	0% - 36.1%

**Table 4-25 Example Calculations of Wind Generation, Reserve Margin Contribution, and Capital Cost for Onshore Wind in WECC\_CO for Wind Class 7, Resource Class 5, and Cost Class 1**

<u>Required Data</u>		
Table 4-36	Potential wind capacity (C) =	1,876 MW
Table 4-37	Winter average generation ( $G_W$ ) per available MW =	297 kWh/MW
Table 4-37	Spring average generation ( $G_{SP}$ ) per available MW =	426 kWh/MW
Table 4-37	Summer average generation ( $G_{SM}$ ) per available MW =	389 kWh/MW
Table 4-37	Fall average generation ( $G_F$ ) per available MW =	281 kWh/MW
	Hours in Winter ( $H_W$ ) season (December - February) =	2,160 hours
	Hours in Spring ( $H_{SP}$ ) season (March - April) =	1,464 hours
	Hours in Summer ( $H_{SM}$ ) season (May - September) =	3,672 hours
	Hours in Summer ( $H_F$ ) season (October - November) =	1,464 hours
Table 4-20	Reserve Margin Contribution (RM) WECC_CO, Wind Class 7, Resource Class 5 =	3.91 percent
Table 4-15	Capital Cost ( $Cap_{2030}$ in vintage range for year 2030 =	\$1,159/kW
Table 4-38	Capital Cost Adder ( $CCA_{ON,C1}$ ) for onshore cost class 1 =	\$37/kW
Table 4-14	Regional Factor (RF)	1.027
<u>Calculations</u>		
$\begin{aligned} \text{Generation Potential} &= C \times G_W \times H_W + C \times G_{SP} \times H_{SP} + C \times G_{SM} \times H_{SM} + C \times G_F \times H_F \\ &= 1,876 \text{ MW} \times 297 \text{ kWh/MW} \times 2,160 \text{ hours} + \\ &\quad 1,876 \text{ MW} \times 426 \text{ kWh/MW} \times 1,464 \text{ hours} + \\ &\quad 1,876 \text{ MW} \times 389 \text{ kWh/MW} \times 3,672 \text{ hours} + \\ &\quad 1,876 \text{ MW} \times 281 \text{ kWh/MW} \times 1,464 \text{ hours} \\ &= 5,830 \text{ GWh} \end{aligned}$		
$\begin{aligned} \text{Reserve Margin Contribution} &= RM \times C \\ &= 3.91\% \times 1,876 \text{ MW} \\ &= 73 \text{ MW} \end{aligned}$		
$\begin{aligned} \text{Capital Cost} &= (Cap_{2030} \times RF + CCA_{ON,C1}) \times C \\ &= (\$1,159/\text{kW} \times 1.027 + \$37/\text{kW}) \times 1,876 \text{ MW} \\ &= \$2,302,278 \end{aligned}$		

**Table 4-26 Solar Photovoltaic Reserve Margin Contribution by PV Class in the EPA 2025 Reference Case**

PV Class	Vintage #1 (2028-2059)
Class 1	0%
Class 2	0% - 100%
Class 3	0% - 23%
Class 4	0% - 100%
Class 5	0% - 67%
Class 6	0% - 70%
Class 7	0% - 45%
Class 8	0% - 91%
Class 9	0% - 3%
Class 10	0% - 31%

**Table 4-31 Bounds and Reserve Margin Contribution for Potential (New) Battery Storage in the EPA 2025 Reference Case**

IPM Region	Bound (MW)				Reserve Margin Contribution (%)			
	Step 1	Step 2	Step 3	Step 4	Step 1	Step 2	Step 3	Step 4
ERC_PHDL	1,498	2,014	1,563	NA	100%	100%	0%	0%
ERC_REST	5,226	17,036	4,285	NA	100%	100%	0%	0%
ERC_WEST	1,498	2,014	1,563	NA	100%	100%	0%	0%
FRCC	9,199	13,252	1,287	NA	100%	100%	0%	0%
MIS_AMSO	368	767	751	NA	100%	100%	0%	0%
MIS_AR	406	949	1,401	NA	100%	100%	5%	0%
MIS_IA	435	995	303	NA	100%	100%	0%	0%
MIS_IL	1,041	2,417	917	NA	100%	100%	0%	0%
MIS_INKY	1,876	3,815	232	NA	100%	100%	0%	0%
MIS_LA	1,007	801	1,553	NA	100%	100%	0%	0%
MIS_LMI	2,282	4,103	2,962	NA	100%	100%	0%	0%
MIS_MAPP	272	129	59	NA	100%	100%	0%	0%
MIS_MIDA	843	413	529	NA	100%	100%	0%	0%
MIS_MNWI	3,740	3,412	809	NA	100%	100%	0%	0%
MIS_MO	779	1,655	414	NA	100%	100%	0%	0%
MIS_MS	484	717	583	NA	100%	100%	0%	0%
MIS_WOTA	575	539	601	NA	100%	100%	0%	0%
MIS_WUMS	1,262	2,141	2,429	NA	100%	100%	5%	0%
NENG_CT	2,034	1,796	139	NA	100%	100%	0%	0%
NENG_ME	365	641	86	NA	100%	100%	0%	0%
NENGRST	6,714	2,955	648	NA	100%	100%	0%	0%
NY_Z_A	669	539	261	NA	100%	100%	0%	0%
NY_Z_B	583	460	6	NA	100%	100%	0%	0%
NY_Z_C&E	1,077	728	285	NA	100%	100%	0%	0%
NY_Z_D	97	101	38	NA	100%	100%	7%	0%
NY_Z_F	627	485	159	NA	100%	100%	0%	0%
NY_Z_G-I	647	783	475	NA	100%	100%	0%	0%
NY_Z_J	1,406	2,155	978	NA	100%	100%	0%	0%
NY_Z_K	1,083	1,146	675	NA	100%	100%	0%	0%
PJM_AP	892	1,293	440	NA	100%	100%	0%	0%
PJM_ATSI	1,704	2,459	1,668	NA	100%	100%	0%	0%
PJM_COMD	1,994	5,029	2,977	NA	100%	100%	0%	0%
PJM_Dom	783	2,968	3,174	NA	100%	100%	0%	0%
PJM_EMAC	5,166	7,937	4,931	NA	100%	100%	0%	0%
PJM_PENE	461	610	335	NA	100%	100%	0%	0%
PJM_SMAC	1,935	2,409	1,588	NA	100%	100%	0%	0%
PJM_West	4,541	1,099	6,214	NA	100%	100%	0%	0%
PJM_WMAC	993	1,539	252	NA	100%	100%	0%	0%
S_C_KY	640	631	128	NA	100%	100%	0%	0%
S_C_TVA	2,179	2,050	3,546	NA	100%	100%	9%	0%
S_D_AECI	921	665	286	NA	100%	100%	0%	0%
S_SOU	5,271	5,271	7,907	NA	100%	100%	0%	0%
S_VACA	6,064	3,589	5,198	NA	100%	100%	0%	0%
SPP_N	745	4,690	1,530	NA	100%	100%	0%	0%
SPP_NEBR	455	1,464	208	NA	100%	100%	0%	0%
SPP_SPS	768	1,418	490	NA	100%	100%	0%	0%
SPP_WAUE	289	330	678	NA	100%	100%	0%	0%
SPP_WEST	654	6,486	4,239	NA	100%	100%	0%	0%
WEC_BANC	1,684	842	907	NA	100%	100%	0%	0%
WEC_CALN	11,456	4,227	13,977	NA	100%	100%	0%	0%
WEC_LADW	4,001	2,639	793	NA	100%	100%	0%	0%
WEC_SDGE	1,685	981	135	NA	100%	100%	0%	0%
WECC_AZ	6,172	3,772	2,092	NA	100%	100%	0%	0%
WECC_CO	2,479	5,138	1,072	NA	100%	100%	0%	0%
WECC_ID	1,489	1,332	372	NA	100%	100%	0%	0%
WECC_IID	595	391	0	NA	100%	100%	0%	0%
WECC_MT	410	338	371	NA	100%	100%	0%	0%
WECC_NM	1,264	1,417	383	NA	100%	100%	0%	0%
WECC_NNV	498	667	219	NA	100%	100%	0%	0%
WECC_PNW	5,886	4,305	2,997	NA	100%	100%	0%	0%
WECC_SCE	12,843	6,239	438	NA	100%	100%	0%	0%
WECC_SNV	1,060	2,749	582	NA	100%	100%	0%	0%
WECC_UT	2,056	1,273	392	NA	100%	100%	0%	0%
WECC_WY	1,037	350	172	NA	100%	100%	0%	0%

IPM Region	Bound (MW)				Reserve Margin Contribution (%)			
	Step 1	Step 2	Step 3	Step 4	Step 1	Step 2	Step 3	Step 4
CN_AB	967	981	2,193	NA	100%	100%	0%	0%
CN_BC	810	978	2,096	NA	100%	100%	0%	0%
CN_MB	405	183	898	NA	100%	100%	0%	0%
CN_NB	221	78	171	NA	100%	100%	0%	0%
CN_NF	84	90	99	NA	100%	100%	0%	0%
CN_NL	161	172	350	NA	100%	100%	0%	0%
CN_NS	246	363	42	NA	100%	100%	0%	0%
CN_ON	967	3,468	2,501	NA	100%	100%	0%	0%
CN_PE	60	72	26	NA	100%	100%	0%	0%
CN_PQ	5,844	808	3,183	NA	100%	100%	0%	0%
CN_SK	254	192	646	NA	100%	100%	0%	0%

**Table 6-1 Cost and Performance Assumptions for Potential USC and NGCC with and without Carbon Capture in the EPA 2025 Reference Case**

	Combined Cycle - Single Shaft	Combined Cycle - Multi Shaft	Combined Cycle with 95% CCS	Ultra-supercritical Coal without CCS	Ultra-supercritical Coal with 36% CCS	Ultra-supercritical Coal with 95% CCS
Size (MW)	627	1227	543	650	650	650
First Year Available	2030	2030	2030	2030	2030	2030
Lead Time (Years)	3	3	4	4	5	5
Availability	87%	87%	87%	85%	85%	85%
<b>Vintage #1 (2028)</b>						
Heat Rate (Btu/kWh)						
Capital (2022\$/kW)						
Fixed O&M (2022\$/kW/yr)						
Variable O&M (2022\$/MWh)						
<b>Vintage #2 (2030)</b>						
Heat Rate (Btu/kWh)	6,226	6,226	7,239	8,638	9,751	12,293
Capital (2022\$/kW)	758	714	2,130	3,717	4,548	6,392
Fixed O&M (2022\$/kW/yr)	14.85	11.60	23.72	45.68	45.56	82.99
Variable O&M (2022\$/MWh)	3.20	3.26	4.84	5.06	7.95	13.14
<b>Vintage #3 (2035)</b>						
Heat Rate (Btu/kWh)	6,226	6,226	7,239	8,638	9,751	12,293
Capital (2022\$/kW)	723	681	1,857	3,538	4,289	5,888
Fixed O&M (2022\$/kW/yr)	14.85	11.60	23.72	45.68	45.56	82.99
Variable O&M (2022\$/MWh)	3.20	3.26	4.84	5.06	7.95	13.14
<b>Vintage #4 (2040)</b>						
Heat Rate (Btu/kWh)	6,226	6,226	7,239	8,638	9,751	12,293
Capital (2022\$/kW)	702	661	1,464	3,353	3,950	5,159
Fixed O&M (2022\$/kW/yr)	14.85	11.60	23.72	45.68	45.56	82.99
Variable O&M (2022\$/MWh)	3.20	3.26	4.84	5.06	7.95	13.14
<b>Vintage #5 (2045)</b>						
Heat Rate (Btu/kWh)	6,226	6,226	7,239	8,638	9,751	12,293
Capital (2022\$/kW)	681	642	1,396	3,160	3,798	4,942
Fixed O&M (2022\$/kW/yr)	14.85	11.60	23.72	45.68	45.56	82.99
Variable O&M (2022\$/MWh)	3.20	3.26	4.84	5.06	7.95	13.14
<b>Vintage #6 (2050-2055)</b>						
Heat Rate (Btu/kWh)	6,226	6,226	7,239	8,638	9,751	12,293
Capital (2022\$/kW)	662	624	1,332	2,966	3,651	4,732
Fixed O&M (2022\$/kW/yr)	14.85	11.60	23.72	45.68	45.56	82.99
Variable O&M (2022\$/MWh)	3.20	3.26	4.84	5.06	7.95	13.14

**Table 9-2 Waste Fuels in the EPA 2025 Reference Case**

Modeled Fuel in NEEDS	Number of Units in NEEDS	Total Capacity in NEEDS	Description	Supply and Cost	
				Modeled By	Assumed Price
Waste Coal	18	1,364 MW	"Waste coal is a usable material that is a byproduct of previous coal processing operations. It is usually composed of mixed coal, soil, and rock (mine waste). Most waste coal is burned as-is in unconventional fluidized-bed combustors. Waste coal may be partially cleaned by removing some extraneous noncombustible constituents. Waste coal includes fine coal, coal obtained from a refuse bank or slurry dam, anthracite culm, bituminous gob, and lignite waste." <a href="https://www.eia.gov/tools/glossary/index.php?id=W">https://www.eia.gov/tools/glossary/index.php?id=W</a>	Supply Curve Based on AEO 2023	AEO 2023
Petroleum Coke	11	1,114 MW	A residual product, high in carbon content and low in hydrogen, from the cracking process used in crude oil refining.	Price Point	\$56.44/Ton
Fossil Waste	47	889 MW	Waste products of petroleum or natural gas including blast furnace and coke oven gas. They do not include petroleum coke or waste coal which are specified separately among the modeled fuels.	Price Point	0
Non-Fossil Waste	188	1971 MW	Non-fossil waste products that do not qualify as biomass. These include waste products of liquid and gaseous renewable fuels (e.g., red, and black liquor from pulping processes and digester gases from wastewater treatment). They do not include urban wood waste which is included in biomass.	Price Point	0
Tires	1	26 MW	Discarded vehicle tires.	Price Point	0
Municipal Solid Waste	134	1748 MW	Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes. <a href="https://www.eia.gov/tools/glossary/index.php?id=M">https://www.eia.gov/tools/glossary/index.php?id=M</a>	Price Point	0

**Table 10-9 Real Capital Charge Rate – Blended (%)<sup>1</sup> in the EPA 2025 Reference Case**

New Investment Technology Capital Hybrid (60/40 Utility/Merchant)	2028 and Beyond
Environmental Retrofits - Utility Owned	10.58%
Environmental Retrofits - Merchant Owned	12.99%
Advanced Combined Cycle	8.39%
Advanced Combustion Turbine	8.69%
Ultra-Supercritical Pulverized Coal	8.01%
Nuclear without Production Tax Credit	7.91%
Biomass	7.65%
Wind, Solar	8.17%
Wind, Solar without Property Tax and Insurance	7.02%
Geothermal	8.15%
Geothermal without Property Tax and Insurance	7.00%
Landfill Gas	8.18%
Hydro	7.65%
Energy Storage	11.12%
Energy Storage without Property Tax and Insurance	9.97%

<sup>1</sup> Capital charge rates were adjusted for expected inflation and represent real rates. The expected inflation rate used to convert future nominal to constant real dollars is 1.76%. The future inflation rate of 1.76% is based on an assessment of implied inflation from an analysis of yields on 10-year U.S. Treasury securities and U.S. Treasury Inflation Protected Securities (TIPS) over a period of 5 years (2016-2020).

**Table 10-10 Real Capital Charge Rate – IPP (%) in the EPA 2025 Reference Case**

<b>New Investment Technology Capital (IPP)</b>	<b>2028 and Beyond</b>
Environmental Retrofits - IPP Owned	12.99%
Advanced Combined Cycle	9.70%
Advanced Combustion Turbine	10.19%
Ultra-Supercritical Pulverized Coal	9.64%
Nuclear without Production Tax Credit	9.35%
Biomass	8.71%
Wind, Solar	9.23%
Wind, Solar without Property Tax and Insurance	8.08%
Geothermal	9.12%
Geothermal without Property Tax and Insurance	7.97%
Landfill Gas	9.28%
Hydro	8.72%
Energy Storage	12.13%
Energy Storage without Property Tax and Insurance	10.98%

**Table 10-11 Real Capital Charge Rate – Utility (%) in the EPA 2025 Reference Case**

<b>New Investment Technology Capital Hybrid Utility</b>	<b>2028 and Beyond</b>
Environmental Retrofits - Utility Owned	10.58%
Advanced Combined Cycle	7.52%
Advanced Combustion Turbine	7.69%
Ultra-Supercritical Pulverized Coal	6.93%
Nuclear without Production Tax Credit	6.94%
Biomass	6.94%
Wind, Solar	7.47%
Wind, Solar without Property Tax and Insurance	6.32%
Geothermal	7.50%
Geothermal without Property Tax and Insurance	6.35%
Landfill Gas	7.46%
Hydro	6.95%
Energy Storage	10.46%
Energy Storage without Property Tax and Insurance	9.31%

**Table 10-12 Book Life, Debt Life, and Depreciation Schedules in the EPA 2025 Reference Case**

<b>Technology</b>	<b>Book Life (Years)</b>	<b>Debt Life (Years)</b>	<b>U.S. MACRS Depreciation Schedule (Years)</b>
Combined Cycle	30	20	20
Combustion Turbine	30	15	15
Coal Steam and IGCC	40	20	20
Nuclear	40	20	5
Geothermal	30	20	5
Solar and Wind	30	20	12-year Straight Line (ADS)
Landfill Gas	30	20	15
Biomass	40	20	5
Hydro	40	20	5
Energy Storage	15	15	12-year Straight Line (ADS)
Retrofits	15	15	15

**List of tables and attachments that are uploaded directly to the web:**

Table 2-2 Load Curves used in the EPA 2025 Reference Case

Table 3-26 Regional Net Internal Demand in the EPA 2025 Reference Case

Table 4-34 Planned-Committed Units by Model Region in NEEDS for the EPA 2025 Reference Case

Table 4-35 Onshore Average Capacity Factor by Wind Class, Resource Class, and Vintage in the EPA 2025 Reference Case

Table 4-37 Wind Generation Profiles in the EPA 2025 Reference Case (kWh of Generation per MW of Capacity)