

# EDF Exhibit C.01



*Independent Statistics & Analysis*

U.S. Energy Information  
Administration

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## Cost and Performance Characteristics of New Generating Technologies, *Annual Energy Outlook 2022*

The tables presented below are also published in the Electricity Market Module chapter of the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2022* (AEO2022) Assumptions document. Table 1 represents our assessment of the cost to develop and install various generating technologies used in the electric power sector. Generating technologies typically found in end-use applications, such as combined heat and power or roof-top solar photovoltaics (PV), will be described elsewhere in the Assumptions document. The costs shown in Table 1, except as noted below, are the costs for a typical facility for each generating technology before adjusting for regional cost factors. Overnight costs exclude interest accrued during plant construction and development. Technologies with limited commercial experience may include a technological optimism factor to account for the tendency to underestimate the full engineering and development costs for new technologies during technology research and development.

All technologies demonstrate some degree of variability in cost, based on project size, location, and access to key infrastructure (such as grid interconnections, fuel supply, and transportation). For wind and solar PV, in particular, the cost favorability of the lowest-cost regions compound the underlying variability in regional cost and create a significant differential between the unadjusted costs and the capacity-weighted average national costs as observed from recent market experience. To reflect this difference, we report a weighted average cost for both wind and solar PV, based on the regional cost factors assumed for these technologies in AEO2022 and the actual regional distribution of the builds that occurred in 2020 (Table 1).

Table 2 shows a full listing of the overnight costs for each technology and [electricity region](#), if the resource or technology is available to be built in the given region. The regional costs reflect the impact of locality adjustments, including one to address ambient air conditions for technologies that include a combustion turbine and one to adjust for additional costs associated with accessing remote wind resources. Temperature, humidity, and air pressure can affect the available capacity of a combustion turbine, and our modeling addresses these possible effects through an additional cost multiplier by region. Unlike most other generation technologies where fuel can be transported to the plant, wind generators must be located in areas with the best wind resources. Sites that are located near existing transmission with access to a road network or are located on lower development-cost lands are generally built up first, after which additional costs may be incurred to access sites with less favorable characteristics. We represent this trend through a multiplier applied to the wind plant capital costs that increases as the best sites in a region are developed.

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Table 1. Cost and performance characteristics of new central station electricity generating technologies

Technology	First available year <sup>a</sup>	Size (MW)	Lead time (years)	Base overnight cost <sup>b</sup> (2021\$/kW)	Technological optimism factor <sup>c</sup>	Total overnight cost <sup>d,e</sup> (2021\$/kW)	Variable O&M <sup>f</sup> (2021 \$/MWh)	Fixed O&M (2021\$/kW-y)	Heat rate <sup>g</sup> (Btu/kWh)
Ultra-supercritical coal (USC)	2025	650	4	\$4,074	1.00	\$4,074	\$4.71	\$42.49	8,638
USC with 30% carbon capture and sequestration (CCS)	2025	650	4	\$5,045	1.01	\$5,096	\$7.41	\$56.84	9,751
USC with 90% CCS	2025	650	4	\$6,495	1.02	\$6,625	\$11.49	\$62.34	12,507
Combined-cycle—single-shaft	2024	418	3	\$1,201	1.00	\$1,201	\$2.67	\$14.76	6,431
Combined-cycle—multi-shaft	2024	1,083	3	\$1,062	1.00	\$1,062	\$1.96	\$12.77	6,370
Combined-cycle with 90% CCS	2024	377	3	\$2,736	1.04	\$2,845	\$6.11	\$28.89	7,124
Internal combustion engine	2023	21	2	\$2,018	1.00	\$2,018	\$5.96	\$36.81	8,295
Combustion turbine— aeroderivative <sup>h</sup>	2023	105	2	\$1,294	1.00	\$1,294	\$4.92	\$17.06	9,124
Combustion turbine—industrial frame	2023	237	2	\$785	1.00	\$785	\$4.71	\$7.33	9,905
Fuel cells	2024	10	3	\$6,639	1.09	\$7,224	\$0.62	\$32.23	6,469
Nuclear—light water reactor	2027	2,156	6	\$6,695	1.05	\$7,030	\$2.48	\$127.35	10,443
Nuclear—small modular reactor	2028	600	6	\$6,861	1.10	\$7,547	\$3.14	\$99.46	10,443
Distributed generation—base	2024	2	3	\$1,731	1.00	\$1,731	\$9.01	\$20.27	8,923
Distributed generation—peak	2023	1	2	\$2,079	1.00	\$2,079	\$9.01	\$20.27	9,907
Battery storage	2022	50	1	\$1,316	1.00	\$1,316	\$0.00	\$25.96	NA
Biomass	2025	50	4	\$4,524	1.00	\$4,525	\$5.06	\$131.62	13,500
Geothermal <sup>l,j</sup>	2025	50	4	\$3,076	1.00	\$3,076	\$1.21	\$143.22	8,813
Conventional hydropower <sup>j</sup>	2025	100	4	\$3,083	1.00	\$3,083	\$1.46	\$43.78	NA
Wind <sup>e</sup>	2024	200	3	\$1,718	1.00	\$1,718	\$0.00	\$27.57	NA
Wind offshore <sup>j</sup>	2025	400	4	\$4,833	1.25	\$6,041	\$0.00	\$115.16	NA
Solar thermal <sup>l</sup>	2024	115	3	\$7,895	1.00	\$7,895	\$0.00	\$89.39	NA
Solar photovoltaic (PV) with tracking <sup>e, i, k</sup>	2023	150	2	\$1,327	1.00	\$1,327	\$0.00	\$15.97	NA
Solar PV with storage <sup>l, k</sup>	2023	150	2	\$1,748	1.00	\$1,748	\$0.00	\$33.67	NA

Source: We primarily base input costs on a report provided by external consultants: Sargent & Lundy, December 2019. We most recently updated hydropower site costs for non-powered dams for AEO2018 using data from Oak Ridge National Lab

Note: MW=megawatt, kW=kilowatt, MWh=megawatthour, kW-y=kilowatt-year, kWh=kilowatthour; Btu=British thermal unit

<sup>a</sup> The first year that a new unit could become operational.

<sup>b</sup> Base cost includes project contingency costs.

<sup>c</sup> We apply the technological optimism factor to the first four units of a new, unproven design; it reflects the demonstrated tendency to underestimate actual costs for a first-of-a-kind unit.

<sup>d</sup> Overnight capital cost includes contingency factors and excludes regional multipliers (except as noted for wind and solar PV) and learning effects. Interest charges are also excluded. The capital costs represent current costs for plants that would come online in 2022.

<sup>e</sup> Total overnight cost for wind and solar PV technologies in the table are the average input value across all 25 electricity market regions, as weighted by the respective capacity of that type installed during 2020 in each region to account for the substantial regional variation in wind and solar costs (Table 4). The input value used for onshore wind in AEO2022 was \$1,411 per kilowatt (kW), and for solar PV with tracking, it was \$1,323/kW, which represents the cost of building a plant excluding regional factors. Region-specific factors contributing to the substantial regional variation in cost include differences in typical project size across regions, accessibility of resources, and variation in labor and other construction costs throughout the country.

<sup>f</sup> O&M = Operations and maintenance.

<sup>g</sup> The nuclear average heat rate is the weighted average tested heat rate for nuclear units as reported on the Form EIA-860, *Annual Electric Generator Report*. No heat rate is reported for battery storage because it is not a primary conversion technology; conversion losses are accounted for when the electricity is first generated; electricity-to-storage losses are accounted for through the additional demand for electricity required to meet load. For hydropower, wind, solar, and geothermal technologies, no heat rate is reported because the power is generated without fuel combustion, and no set British thermal unit conversion factors exist. The module calculates the [average heat rate for fossil-fuel generation](#) in each year to report primary energy consumption displaced for these resources.

<sup>h</sup> Combustion turbine aeroderivative units can be built by the module before 2023, if necessary, to meet a region's reserve margin.

<sup>i</sup> Capital costs are shown before investment tax credits are applied.

<sup>j</sup> Because geothermal and hydropower cost and performance characteristics are specific for each site, the table entries show the cost of the least expensive plant that could be built in the Northwest region for hydro and the Great Basin region for geothermal, where most of the proposed sites are located.

<sup>k</sup> Costs and capacities are expressed in terms of net AC (alternating current) power available to the grid for the installed capacity.

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**Table 2. Total overnight capital costs of new electricity generating technologies by region**

2021 dollars per kilowatt

Technology	1 TRE	2 FRCC	3 MISW	4 MISC	5 MISE	6 MISS	7 ISNE	8 NYCW	9 NYUP	10 PJME	11 PJMW	12 PJMC	13 PJMD
Ultra-supercritical coal (USC)	\$3,786	\$3,897	\$4,259	\$4,371	\$4,422	\$3,918	\$4,721	NA	\$4,614	\$4,763	\$4,064	\$5,120	\$4,385
USC with 30% CCS	\$4,777	\$4,903	\$5,294	\$5,437	\$5,480	\$4,935	\$5,846	NA	\$5,729	\$5,883	\$5,094	\$6,254	\$5,477
USC with 90% CCS	\$6,252	\$6,411	\$6,841	\$7,072	\$7,078	\$6,473	\$7,495	NA	\$7,303	\$7,508	\$6,601	\$7,994	\$7,015
CC—single-shaft	\$1,085	\$1,107	\$1,235	\$1,246	\$1,277	\$1,117	\$1,441	\$1,912	\$1,445	\$1,443	\$1,197	\$1,446	\$1,377
CC—multi-shaft	\$944	\$968	\$1,098	\$1,117	\$1,146	\$979	\$1,259	\$1,725	\$1,238	\$1,266	\$1,037	\$1,327	\$1,170
CC with 90% CCS	\$2,668	\$2,693	\$2,877	\$2,884	\$2,928	\$2,718	\$3,021	\$3,422	\$2,953	\$2,996	\$2,756	\$3,124	\$2,871
Internal combustion engine	\$1,898	\$1,940	\$2,073	\$2,155	\$2,131	\$1,966	\$2,209	\$2,769	\$2,125	\$2,209	\$1,980	\$2,408	\$2,056
CT—aeroderivative	\$1,145	\$1,168	\$1,354	\$1,357	\$1,398	\$1,193	\$1,456	\$1,864	\$1,405	\$1,448	\$1,242	\$1,591	\$1,317
CT—industrial frame	\$692	\$707	\$822	\$826	\$851	\$723	\$886	\$1,144	\$854	\$882	\$753	\$971	\$800
Fuel cells	\$6,933	\$7,041	\$7,362	\$7,680	\$7,534	\$7,159	\$7,815	\$9,201	\$7,498	\$7,748	\$7,138	\$8,261	\$7,358
Nuclear—light water reactor	\$6,636	\$6,779	\$7,157	\$7,807	\$7,530	\$7,000	\$7,964	NA	\$7,430	\$7,781	\$6,878	\$8,556	\$7,158
Nuclear—small modular reactor	\$7,032	\$7,197	\$7,841	\$8,176	\$8,173	\$7,287	\$8,441	NA	\$8,040	\$8,459	\$7,376	\$9,438	\$7,660
Distributed generation—base	\$1,563	\$1,595	\$1,779	\$1,795	\$1,840	\$1,609	\$2,076	\$2,754	\$2,081	\$2,079	\$1,724	\$2,083	\$1,984
Distributed generation—peak	\$1,839	\$1,877	\$2,174	\$2,180	\$2,246	\$1,916	\$2,339	\$2,994	\$2,257	\$2,326	\$1,995	\$2,555	\$2,116
Battery storage	\$1,316	\$1,320	\$1,301	\$1,364	\$1,319	\$1,347	\$1,357	\$1,351	\$1,321	\$1,325	\$1,313	\$1,329	\$1,325
Biomass	\$4,198	\$4,313	\$4,669	\$4,824	\$4,835	\$4,348	\$5,372	\$7,292	\$5,389	\$5,483	\$4,611	\$5,493	\$5,255
Geothermal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Conventional hydropower	\$4,498	\$5,495	\$2,186	\$1,453	\$2,959	\$4,378	\$2,025	NA	\$4,144	\$4,305	\$3,752	NA	\$3,808
Wind	\$2,757	NA	\$1,552	\$1,411	\$1,690	\$1,411	\$1,870	NA	\$2,281	\$1,870	\$1,411	\$2,055	\$1,948
Wind offshore	\$5,901	\$7,080	\$6,984	NA	\$7,234	NA	\$7,047	\$6,079	\$7,370	\$6,755	\$5,524	\$7,999	\$6,293
Solar thermal	\$7,616	\$7,731	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solar PV with tracking	\$1,304	\$1,279	\$1,323	\$1,372	\$1,357	\$1,290	\$1,370	\$1,612	\$1,357	\$1,397	\$1,320	\$1,440	\$1,317
Solar PV with storage	\$1,692	\$1,710	\$1,761	\$1,817	\$1,792	\$1,727	\$1,828	\$2,078	\$1,796	\$1,832	\$1,721	\$1,905	\$1,781

  

Technology	14 SRCA	15 SRSE	16 SRCE	17 SPPS	18 SPPC	19 SPPN	20 SRSG	21 CANO	22 CASO	23 NWPP	24 RMRG	25 BASN
Ultra-supercritical coal (USC)	\$3,920	\$3,979	\$4,032	\$3,947	\$4,193	\$3,991	\$4,159	NA	NA	\$4,406	\$4,119	\$4,297
USC with 30% CCS	\$4,939	\$4,985	\$5,059	\$4,952	\$5,226	\$4,999	\$5,215	NA	NA	\$5,480	\$5,159	\$5,353
USC with 90% CCS	\$6,485	\$6,542	\$6,620	\$6,451	\$6,778	\$6,497	\$6,758	NA	NA	\$7,090	\$6,658	\$6,967
CC—single-shaft	\$1,103	\$1,116	\$1,150	\$1,115	\$1,183	\$1,104	\$1,085	\$1,590	\$1,553	\$1,264	\$1,023	\$1,106
CC—multi-shaft	\$968	\$980	\$1,016	\$979	\$1,051	\$971	\$934	\$1,398	\$1,359	\$1,096	\$880	\$987
CC with 90% CCS	\$2,684	\$2,698	\$2,759	\$2,688	\$2,777	\$2,647	\$2,448	\$3,071	\$3,036	\$2,833	\$2,303	\$2,586
Internal combustion engine	\$1,977	\$1,982	\$2,017	\$1,962	\$2,068	\$1,982	\$2,001	\$2,398	\$2,355	\$2,133	\$1,975	\$2,114
CT—aeroderivative	\$1,186	\$1,196	\$1,241	\$1,194	\$1,279	\$1,203	\$1,086	\$1,529	\$1,491	\$1,341	\$1,051	\$1,198
CT—industrial frame	\$718	\$726	\$753	\$724	\$777	\$729	\$658	\$934	\$910	\$816	\$637	\$728
Fuel cells	\$7,211	\$7,205	\$7,304	\$7,080	\$7,376	\$7,143	\$7,243	\$8,299	\$8,203	\$7,585	\$7,104	\$7,567
Nuclear—light water reactor	\$7,090	\$7,035	\$7,263	\$6,807	\$7,198	\$6,805	\$7,058	NA	NA	\$7,640	\$6,837	\$7,648
Nuclear—small modular reactor	\$7,323	\$7,380	\$7,547	\$7,306	\$7,759	\$7,368	\$7,465	NA	NA	\$8,083	\$7,386	\$8,028
Distributed generation—base	\$1,589	\$1,608	\$1,657	\$1,606	\$1,705	\$1,591	\$1,563	\$2,290	\$2,238	\$1,821	\$1,474	\$1,593
Distributed generation—peak	\$1,905	\$1,922	\$1,994	\$1,919	\$2,055	\$1,932	\$1,744	\$2,456	\$2,394	\$2,154	\$1,688	\$1,924
Battery storage	\$1,359	\$1,340	\$1,357	\$1,310	\$1,318	\$1,302	\$1,333	\$1,371	\$1,373	\$1,348	\$1,305	\$1,357
Biomass	\$4,364	\$4,397	\$4,455	\$4,368	\$4,641	\$4,460	\$4,777	\$6,119	\$5,981	\$4,939	\$4,732	\$4,731
Geothermal	NA	NA	NA	NA	NA	NA	\$3,135	\$3,109	\$2,517	\$3,043	NA	\$3,076
Conventional hydropower	\$2,120	\$4,599	\$2,377	\$4,550	\$1,917	\$1,802	\$3,655	\$3,867	\$3,723	\$3,083	\$3,681	\$4,023
Wind	\$1,683	\$1,907	\$1,411	\$1,411	\$1,552	\$1,552	\$1,411	\$3,116	\$2,447	\$2,057	\$1,411	\$1,411
Wind offshore	\$5,437	NA	NA	NA	NA	NA	NA	\$9,112	\$9,560	\$6,836	NA	NA
Solar thermal	NA	NA	NA	\$7,693	\$7,991	\$7,614	\$7,980	\$9,400	\$9,282	\$8,493	\$7,668	\$8,510
Solar PV with tracking	\$1,343	\$1,276	\$1,318	\$1,278	\$1,328	\$1,287	\$1,300	\$1,447	\$1,440	\$1,332	\$1,315	\$1,327
Solar PV with storage	\$1,739	\$1,721	\$1,742	\$1,709	\$1,765	\$1,727	\$1,736	\$1,903	\$1,898	\$1,795	\$1,729	\$1,791

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Source: U.S. Energy Information Administration, Office of Electricity, Coal, Nuclear and Renewables Analysis

Notes: Costs include contingency factors, regional cost multipliers, and ambient condition multipliers. Interest charges are excluded. The costs are shown before investment tax credits are applied.

NA = not available; plant type cannot be built in the region because of a lack of resources, sites, or specific state legislation.

USC = ultra-supercritical, CCS = carbon capture and sequestration, CC = combined cycle, CT = combustion turbine, PV = photovoltaic

[Electricity Market Module region map](#)

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