



Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2016

The tables presented below will be incorporated in the Electricity Market Module chapter of the AEO2016 Assumptions document. Table 8.2 represents EIA's 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" photovoltaics, will be described elsewhere in the Assumptions document. The costs shown in Table 8.2, except as noted below, represent 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 during technology research and development to underestimate the full engineering and development costs for new technologies.

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 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 correct for this, Table 8.2 shows a weighted average cost for wind based on the regional cost factors assumed for wind in the AEO2016 and the actual regional distribution of wind builds that occurred in 2014.

Table 8.2a presents a full listing of the overnight costs for each technology and electricity region (http://www.eia.gov/forecasts/aeo/pdf/nerc_map.pdf), if the resource or technology is available to be built in the given region. The regional costs reflect the impact of locational 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 impact the available capacity of a combustion turbine, and EIA's modeling addresses this 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. As sites near existing transmission, with access to a road network, or otherwise located on lower-development-cost lands are utilized, additional costs may be incurred to access sites with less favorable characteristics. EIA represents this through a multiplier applied to the wind plant capital costs that increases as the best sites in a given region are developed.

Table 8.2. Cost and performance characteristics of new central station electricity generating technologies

Technology	First Available Year ¹	Size (MW)	Lead time (years)	Contingency Factors			Total Overnight Cost in 2015 ^{4,10} (\$/kW)	Variable O&M ⁵ (2015 \$/MWh)	Fixed O&M (2015 \$/kW/yr.)	Heatrate ⁶ in 2015 (Btu/kWh)	nth-of-a-kind Heatrate (Btu/kWh)
				Base Overnight Cost in 2015 (2015 \$/kW)	Project Contingency Factor ²	Technological Optimism Factor ³					
Coal with 30% carbon sequestration (CCS)	2019	650	4	4,649	1.07	1.03	5,098	6.95	68.49	9,750	9,221
Conv Gas/Oil Comb Cycle	2018	702	3	911	1.05	1.00	956	3.42	10.76	6,600	6,350
Adv Gas/Oil Comb Cycle (CC)	2018	429	3	1,000	1.08	1.00	1,080	1.96	9.78	6,300	6,200
Adv CC with CCS	2018	340	3	1,898	1.08	1.04	2,132	6.97	32.69	7,525	7,493
Conv Comb Turbine ⁷	2017	100	2	1,026	1.05	1.00	1,077	3.42	17.12	9,960	9,600
Adv Comb Turbine	2017	237	2	632	1.05	1.00	664	10.47	6.65	9,800	8,550
Fuel Cells	2018	10	3	6,217	1.05	1.10	7,181	44.21	0.00	9,500	6,960
Adv Nuclear	2022	2,234	6	5,288	1.10	1.05	6,108	2.25	98.11	10,449	10,449
Distributed Generation-Base	2018	2	3	1,448	1.05	1.00	1,520	7.98	17.94	9,004	8,900
Distributed Generation - Peak	2017	1	2	1,739	1.05	1.00	1,826	7.98	17.94	10,002	9,880
Biomass	2019	50	4	3,498	1.07	1.01	3,765	5.41	108.63	13,500	13,500
Geothermal ^{8,9}	2019	50	4	2,559	1.05	1.00	2,687	0.00	116.12	9,541	9,541
MSW - Landfill	2018	50	3	7,954	1.07	1.00	8,511	9.00	403.97	14,360	18,000
Conventional Hydropower ⁹	2019	500	4	2,191	1.10	1.00	2,411	2.62	14.70	9,541	9,541
Wind ¹⁰	2018	100	3	1,536	1.07	1.00	1,644	0.00	45.98	9,541	9,541
Wind Offshore	2019	400	4	4,605	1.10	1.25	6,331	0.00	76.10	9,541	9,541
Solar Thermal ⁸	2018	100	3	3,895	1.07	1.00	4,168	0.00	69.17	9,541	9,541
Photovoltaic ^{8,11}	2017	150	2	2,362	1.05	1.00	2,480	0.00	21.33	9,541	9,541

¹Represents the first year that a new unit could become operational.

²A contingency allowance is defined by the American Association of Cost Engineers as the “specific provision for unforeseeable elements of costs within a defined project scope; particularly important where previous experience has shown that unforeseeable events which will increase costs are likely to occur.”

³The technological optimism factor is applied 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.

⁴Overnight capital cost including contingency factors, excluding regional multipliers and learning effects. Interest charges are also excluded. These represent costs of new projects initiated in 2015.

⁵O&M = Operations and maintenance.

⁶For hydro, wind, solar and geothermal technologies, the heat rate shown represents the average heat rate for conventional thermal generation as of 2014. This is used for purposes of calculating primary energy consumption displaced for these resources, and does not imply an estimate of their actual energy conversion efficiency.

⁷Combustion turbine units can be built by the model prior to 2017 if necessary to meet a given region's reserve margin.

⁸Capital costs are shown before investment tax credits are applied.

⁹Because geothermal and hydro cost and performance characteristics are specific for each site, the table entries represent the cost of the least expensive plant that could be built in the Northwest Power Pool region, where most of the proposed sites are located.

¹⁰Wind's total overnight cost of \$1644/kW represents the average input value across all 22 electricity market regions, as weighted by the wind capacity installed during 2014 in each region to account for the substantial regional variation in wind costs (as shown in Table 8.2a). The input value used for AEO 2016 was \$1837/kW, and represents the cost of building a 100 MW wind 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.

¹¹Costs and capacities are expressed in terms of net AC power available to the grid for the installed capacity.

Sources: For the AEO2016 cycle, EIA updated cost estimates for certain electric generating technologies, based on a draft report provided by external consultants. This report will be provided on the EIA website when finalized. Costs were updated for coal with CCS, the combined cycle (without CCS) technologies, the combustion turbine technologies, advanced nuclear, onshore wind and solar PV. Costs for other technologies are consistent with AEO2015 assumptions.

Table 8.2a. Total overnight capital costs of new electricity generating technologies by region

2015 \$/kW

Technology	1 (ERCT)	2 (FRCC)	3 (MROE)	4 (MROW)	5 (NEWWE)	6 (NYCW)	7 (NYLI)	8 (NYUP)	9 (RFCE)	10 (RFCM)	11 (RFCW)
Coal with 30% CCS	4,760	5,001	4,841	4,887	5,119	N/A	N/A	4,802	5,478	4,951	5,134
Conv Gas/Oil Comb Cycle	875	904	913	933	1,062	1,541	1,541	1,080	1,131	955	979
Adv Gas/Oil Comb Cycle (CC)	1,035	1,056	1,026	1,068	1,200	1,644	1,644	1,219	1,267	1,071	1,116
Adv CC with CCS	1,991	2,065	2,073	2,051	2,184	3,111	3,111	2,195	2,333	2,089	2,147
Conv Comb Turbine	1,035	1,075	1,024	1,066	1,119	1,517	1,517	1,104	1,185	1,067	1,092
Adv Comb Turbine	645	666	640	666	720	1,028	1,028	714	774	666	686
Fuel Cells	6,728	6,893	7,217	7,000	7,245	8,703	8,703	7,145	7,374	7,173	7,159
Adv Nuclear	5,857	5,943	6,150	6,020	6,364	N/A	N/A	6,462	6,529	6,102	6,224
Distributed Generation - Base	1,353	1,392	1,491	1,486	1,737	2,482	2,482	1,759	1,819	1,543	1,559
Distributed Generation - Peak	1,754	1,822	1,735	1,806	1,896	2,571	2,571	1,871	2,008	1,809	1,851
Biomass	3,471	3,569	3,837	3,644	3,878	4,620	4,620	3,893	4,010	3,746	3,803
Geothermal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MSW - Landfill Gas	7,830	8,077	8,579	8,241	8,587	10,724	10,724	8,502	8,792	8,485	8,460
Conventional Hydropower	N/A	N/A	N/A	3,047	3,292	N/A	N/A	2,604	N/A	N/A	2,597
Wind	1,617	N/A	2,204	1,819	2,465	N/A	2,241	2,241	2,241	2,204	2,204
Wind Offshore	5,780	8,357	6,369	6,400	6,496	8,110	8,110	6,274	6,496	6,300	6,369
Solar Thermal	3,551	3,776	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Photovoltaic ¹	2,135	2,269	2,376	2,437	2,559	N/A	3,469	2,433	2,574	2,453	2,443

Technology	12 (SRDA)	13 (SRGW)	14 (SRSE)	15 (SRCE)	16 (SRVC)	17 (SPNO)	18 (SPSO)	19 (AZNM)	20 (CAMX)	21 (NWPP)	22 (RMPA)
Coal with 30% CCS	4,798	5,206	4,816	4,744	4,627	5,027	4,886	5,653	5,782	5,247	5,739
Conv Gas/Oil Comb Cycle	873	991	898	877	851	947	913	1,043	1,204	994	1,119
Adv Gas/Oil Comb Cycle (CC)	1,033	1,129	1,060	1,053	1,013	1,095	1,072	1,280	1,378	1,175	1,320
Adv CC with CCS	2,007	2,207	2,021	1,977	1,935	2,122	2,059	2,413	2,490	2,206	2,395
Conv Comb Turbine	1,048	1,113	1,077	1,030	1,019	1,089	1,067	1,244	1,237	1,128	1,295
Adv Comb Turbine	654	696	683	643	640	680	668	788	799	710	954
Fuel Cells	6,793	7,303	6,764	6,807	6,692	7,030	6,908	7,080	7,504	7,102	6,879
Adv Nuclear	5,894	6,199	5,876	5,906	5,839	6,034	5,961	6,065	N/A	6,126	6,108
Distributed Generation - Base	1,359	1,570	1,386	1,377	1,327	1,480	1,427	1,520	1,889	1,534	1,600
Distributed Generation - Peak	1,777	1,886	1,826	1,745	1,727	1,845	1,808	2,108	2,097	1,912	2,195
Biomass	3,502	3,829	3,483	3,517	3,438	3,663	3,599	3,765	4,051	3,773	3,524
Geothermal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,982	2,742	2,687	N/A
MSW - Landfill Gas	7,941	8,672	7,872	7,941	7,753	8,298	8,102	8,358	8,979	8,358	8,060
Conventional Hydropower	3,138	2,217	3,138	1,330	1,940	N/A	2,637	N/A	2,432	2,411	2,801
Wind	2,388	2,204	2,388	2,388	2,388	1,516	1,378	1,980	1,984	1,980	1,516
Wind Offshore	6,331	N/A	5,818	N/A	5,717	N/A	N/A	N/A	6,604	6,433	N/A
Solar Thermal	N/A	N/A	N/A	N/A	N/A	N/A	3,822	4,093	4,660	4,118	3,839
Photovoltaic ¹	2,210	2,500	2,170	2,192	2,081	2,383	2,284	2,403	2,765	2,443	2,326

Table shows overnight capital costs for projects initiated in 2015. Costs include contingency factors and regional cost and ambient conditions multipliers. Interest charges are excluded. The costs are shown before investment tax credits are applied.

N/A: plant type cannot be built in the region due to lack of resources, sites or specific state legislation.

¹PV represents a ground-mounted utility-scale system. Roof-top or other distributed PV can be built in NYCW, but the ability to site larger, ground-mounted plants may be limited in the densely populated region.

Region map: http://www.eia.gov/forecasts/aeo/pdf/nerc_map.pdf.

