4 Generating Resources

"Existing", "planned-committed", and "potential" are the three general types of generating units modeled in EPA Base Case v.4.10. Units that are currently operational in the electric industry are termed as "existing" units. Units that are not currently operating but are firmly anticipated to be operational in the future, and have either broken ground (initiated construction) or secured financing are termed "planned-committed". "Potential" units refer to new generating options used in IPM for capacity expansion projections of the electric industry. Existing and planned-committed units are entered as exogenous inputs to the model, whereas potential units are endogenous to the model in the sense that the model determines the location and size of all the potential units that end up in the final solution for a specific model run.

This chapter is organized into the following five sections:

(1) Section 4.1 provides background information on the National Electric Energy Data System (NEEDS), the database which serves as the repository for information on existing and planned-committed units which are modeled in the EPA Base Case v.4.10,
(2) Section 4.2 provides detailed information on existing non-nuclear generating units modeled in EPA Base Case v.4.10,
(3) Section 4.3 provides detailed information pertaining to planned-committed units which are assumed in EPA Base Case v.4.10,
(4) Section 4.4 provides detailed information pertaining to the IPM assumptions for potential plants, and
(5) Section 4.5 describes the handling of existing and potential nuclear units in EPA Base Case v.4.10

4.1 National Electric Energy Data System (NEEDS)

EPA Base Case v.4.10 uses the NEEDS database as its source for data on all existing and planned-committed units. Table 4-1 below summarizes the resources used in developing data on existing units in NEEDS v.4.10. The data sources for planned-committed units in NEEDS are discussed below in Section 4.3. The population of existing units in NEEDS v4.10 represents generating units that were in operation through the end of 2006. The population of planned-committed includes any units online or scheduled to come online from 2007 to the end of 2011 (with two exceptions listed in the note under Table 4-2 below).

4.2 Existing Units

EPA Base Case v.4.10 models existing units based on information contained in NEEDS. The sections below describe the procedures followed in determining the population of units in NEEDS, as well as each unit's capacity, location, and configuration. Details are also given on the model plant aggregation scheme and the cost and performance characteristics associated with the existing non-nuclear units represented in EPA Base Case v.4.10.

4.2.1 Population of Existing Units

The population of existing units was taken primarily from EIA 860 (2006) and EIA 767 (2005). A number of rules were used to screen the various data sources. These rules helped to ensure data consistency, but also made the population data adaptable for use in IPM. Table 4-2 below summarizes the rules used in populating the NEEDS v.4.10 database.

Table 4-1 Data Sources for NEEDS v.4.10 for EPA Base Case v.4.10

Data Source[1]	Data Source Documentation
DOE's Form EIA-860	DOE's Form EIA-860 is an annual survey of utility power plants at the generator level. It contains data such as summer, winter and nameplate capacity, location (state and county), status, prime mover, primary energy source and in-service year. NEEDS v.4.10 uses EIA Form 860 (2006) data as one of the primary data inputs.
DOE's Form EIA-767	DOE's Form EIA-767 is an annual survey, "Steam-Electric Plant Operation and Design Report", that contains data for utility nuclear and fossil fuel steam boilers such as fuel quantity and quality; boiler identification, location, status, and design information; and post-combustion NO_X control, FGD scrubber and particulate collector device information. Note that boilers in plants with less than 10 MW do not report all data elements. The relationship between boilers and generators is also provided, along with generator-level generation and nameplate capacity. Note that boilers and generators are not necessarily in a one-to-one correspondence. NEEDS v.4.10 uses EIA Form 767 (2005) data as one of the primary data inputs.
NERC Electricity Supply and Demand (ES&D) database	The NERC ES&D is released annually. It contains generator-level information such as summer, winter and nameplate capacity, state, NERC region and sub-region, status, primary fuel and on-line year. NEEDS v.4.10 uses NERC ES&D (2006) data as one of the primary data inputs.
DOE's Annual Energy Outlook (AEO)	The Energy Information Administration (EIA) Annual Energy Outlook presents annually updated forecasts 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 such as heat rates, planned committed units, nuclear unit capacities and uprates were used in NEEDS v.4.10.
Global Energy Decisions New Entrants database	Global Energy's New Entrants database has information on new power plant builds, rerates and retirements. Information on committed units is based on November 2009 dataset.
EPA's Emission Tracking System (ETS 2007)	The Emission Tracking System (ETS) database is updated quarterly. It contains boiler-level information such as primary fuel, heat input, SO_2 and NO_X controls, and SO_2 and NO_X emissions.
Utility and RPO (Regional Planning Organizations) Comments	Comments from selected U.S. utilities and RPOs regarding the population in NEEDS as well as unit characteristics were used in NEEDS v.4.10.

Note:
[1] Shown in Table 4-1 are the primary issue dates of the indicated data sources that were used. Other vintages of these data sources were also used in instances where date 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 v.4.10 for EPA Base Case v.4.10

Scope	Rule
Capacity	Excluded units with reported nameplate, summer and winter capacity of zero
Status	Excluded units that were out of service for two or three consecutive years (i.e., generators with status codes “OS” in the latest three reporting years and boilers with status codes “OS” in the latest two 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"). Status of boiler(s) and associated generator(s) were taken into account for determining operation status
Planned or Committed Units	Included planned units that had broken ground or secured financing and were expected to be online by the end of 2011; one biomass and one nuclear unit that are scheduled to come online after 2011 were also included
Firm/Non-firm Electric Sales	Excluded non-utility onsite generators that do not produce electricity for sale to the grid. Excluded all mobile and distributed generators

Note:
[1]The biomass unit is Mitchell, unit 3, and the nuclear unit is Watts Bar Nuclear Plant, unit 2.

As with previous versions of the database, NEEDS v.4.10 includes steam units at the boiler level and non-steam units at the generator level. A unit in NEEDS v.4.10, therefore, refers to a boiler in the case of a steam unit and a generator in the case of a non-steam unit. Table 4-3 provides a summary of the population and capacity of the existing units included in NEEDS v.4.10 through 2006. EIA Form 860 (2006) and Form 767 (2005) is the starting point and largest component of the existing unit population in NEEDS v.4.10 but the final population of existing units is supplemented based on information from other sources, including comments from utilities, submissions to EPA's Emission Tracking System, Annual Energy Outlook, and reported capacity in Global Energy’s New Entrants database.

Table 4-3 Summary Population (through 2006) of Existing Units in NEEDSv.4.10 for EPA Base Case v.4.10

Plant Type	Number of Units	Capacity (MW)
Biomass	134	2,286
Coal Steam	1,235	305,451
Combined Cycle	1,532	179,557
Combustion Turbine	5,386	132,293
Fossil Waste	20	610
Geothermal	196	2,264
Hydro	3,754	77,713
IGCC	4	529
Landfill Gas	698	1,068
Municipal Solid Waste	176	2,098
Non-Fossil Waste	45	516
Nuclear	104	101,099
O/G Steam	682	112,371
Pumped Storage	150	20,940
Solar	19	412
Tires	3	44
Wind	330	11,637
Grand Total	**14,468**	**950,889**

4.2.2 Capacity

The NEEDS unit capacity values implemented in EPA Base Case v.4.10 reflect net summer dependable capacity[16], to the extent possible. Table 4-4 summarizes the hierarchy of primary data sources used in compiling capacity data for NEEDS v.4.10.

Table 4-4 Hierarchy of Data Sources for Capacity in NEEDS v.4.10

Sources Presented in Hierarchy
Capacity from Utility Comments
2006 EIA 860 Summer Capacity
NERC ES&D 2006 Summer Capacity
2006 EIA 860 Winter Capacity
NERC ES&D 2006 Winter Capacity
2006 EIA 860 Nameplate Capacity

Notes:
Presented in hierarchical order that applies.
If capacity is zero, unit is not included.

As noted earlier, for steam units NEEDS v.4.10 includes boiler level data, while for non-steam units NEEDS v.4.10 contains generator level data. Capacity data in EIA and NERC data sources are generator specific and not boiler specific. Therefore, it was necessary to develop an algorithm for parsing generator level capacity to the boiler level for steam producing units.

The capacity-parsing algorithm used for steam units in NEEDS v.4.10 took into account boiler-generator mapping. Fossil steam and nuclear steam electric units have boilers attached to generators that produce electricity. There are generally four types of links between boilers and generators: one boiler to one generator, one boiler to many generators, many boilers to one generator and many boilers to many generators.

The capacity-parsing algorithm used for steam units in NEEDS utilized steam flow data with the boiler-generator mapping. Under EIA 767, steam units report the maximum steam flow from the boiler to the generator. There is, however, no further data on the steam flow of each boiler-generator link. Instead, EIA 767 contains only the maximum steam flow for each boiler. Table 4-5 summarizes the algorithm used for parsing capacity with data on maximum steam flow and boiler-generator mapping. In Table 4-5 MFB_i refers to the maximum steam flow of boiler *i* and MW_{Gj} refers to the capacity of generator *j*. The algorithm uses the available data to derive the capacity of a boiler, referred to as MW_{Bj} in Table 4-5.

Table 4-5 Capacity-Parsing Algorithm for Steam Units in NEEDS v.4.10

	Type of Boiler-Generator Links			
	One-to-One	One-to-Many	Many-to-One	Many-to-Many
For Boiler B_1 to B_N linked to Generators G_1 to G_N	$MW_{Bi} = MW_{Gj}$	$MW_{Bi} = \Sigma_j MW_{Gj}$	$MW_{Bi} = (MF_{Bi} / \Sigma_i MF_{Bi}) * MW_{Gj}$	$MW_{Bi} = (MF_{Bi} / \Sigma_i MF_{Bi}) * \Sigma_j MW_{Gj}$

Notes:
MF_{Bi} = maximum steam flow of boiler *i*
MW_{Gj} = electric generation capacity of generator *j*

[16] As used here, net summer dependable capacity is the net capability of a generating unit in megawatts (MW) for daily planning and operation purposes during the summer peak season, after accounting for station or auxiliary services.

Since EPA Base Case v.4.10 uses net energy for load as demand, NEEDS v.4.10 only includes generators that sell the majority of their power to the electric grid in order to be consistent with demand. The generators that should be in NEEDS v.4.10. by this qualification are determined from the 2005 EIA Form 906 non-utility source and disposition data set.

4.2.3 Plant Location

NEEDS v.4.10 uses state, county and model region data to represent the physical location of each plant.

State and County
NEEDS v.4.10 used the state and county data in EIA 860 (2006)

Model Region
For each unit the associated model region was derived based on NERC regions and sub-regions reported in NERC ES&D 2006 for that unit. For units with no NERC sub-region data, NERC region and state were used to derive associated model regions. For units with no NERC region data, state and county were used to derive associated model regions. Table 3-1 in Chapter 3 provides a summary of the mapping between NERC regions and EPA Base Case v.4.10 model regions.

4.2.4 Online Year

The EPA Base Case v.4.10 uses online year to capture when the unit entered service. NEEDS includes online years for all units in the database. In NEEDS v.4.10, online years for boilers, utility and non-utility generators were primarily derived from reported in-service dates in EIA 767 2005 and EIA 860 2006 respectively.

EPA Base Case v.4.10 does not include any assumption about the retirement year for generating units, except for existing nuclear units which must retire when they reach age 60. (See section 3.7 for a discussion of the nuclear lifetime assumption.) EPA Base Case v.4.10 does, however, provide economic retirement options to coal, oil and gas steam, combined cycle, combustion turbines, and nuclear units. This means that the model may elect to retire these units if it is economical to do so. In IPM, an early retired plant ceases to incur FOM and VOM costs. However, retired units do meet capital cost obligations for retrofits if the model projected a retrofit on the unit prior to retirement.

4.2.5 Unit Configuration

Unit configuration refers to the physical specification of a unit's design. Unit configuration in EPA Base Case v.4.10 drives model plant aggregation, modeling of pollution control options and mercury emission modification factors. NEEDS v.4.10 contains information on the firing and bottom type of coal steam boilers in the database. Great effort was taken to see that the inventory of existing and committed controls represented in EPA Base Case v.4.10 was comprehensive and as up-to-date as possible. The hierarchy of data sources used is shown in Table 4-6.

4.2.6 Model Plant Aggregation

While IPM is comprehensive in representing all the units contained in NEEDS, an aggregation scheme is used to combine existing units with similar characteristics into "model plants". The aggregation scheme serves to reduce the size of the model and makes the model manageable while capturing the essential characteristics of the generating units. The EPA Base Case v.4.10 aggregation scheme is designed so that each model plant only represents generating units from a single state. This design makes it possible to obtain state-level results directly from IPM outputs. In addition, the aggregation scheme supports modeling plant-level emission limits on fossil generation

The "model plant" aggregation scheme encompasses a variety of different classification categories including location, size, technology, heat rate, fuel choices, unit configuration, SO_2

emission rates and environmental regulations among others. Units are aggregated together only if they match on all the different categories specified for the aggregation. The 10 major categories used for the aggregation scheme in EPA Base Case v.4.10 are the following:

(1) Model Region
(2) Unit Technology Type
(3) Fuel Demand Region
(4) Applicable Environmental Regulations
(5) State
(6) Unit Configuration
(7) Emission Rates
(8) Heat Rates
(9) Fuel
(10) Size

Table 4-6 Data Sources for Unit Configuration in NEEDS v.4.10 for EPA Base Case v.4.10

Unit Component	Primary Data Source	Secondary Data Source	Tertiary Data Source	Other Sources	Default
Firing Type	Utility/RPO Comments	2005 EIA 767	--	--	--
Bottom Type	Utility/RPO Comments	2005 EIA 767	--	--	Dry
SO_2 Pollution Control	NSR Settlement or Utility/RPO Comments	EPA's Emission Tracking System (ETS) - 2006	2005 EIA 767	See Note	No Control
NO_x Pollution Control	NSR Settlement or Utility/RPO Comments	EPA's Emission Tracking System (ETS) - 2006	2005 EIA 767	See Note	No Control
Particulate Matter Control	NSR Settlement or Utility/RPO Comments	EPA's Emission Tracking System (ETS) - 2006	2005 EIA 767	1999 Hg ICR	--

Note:
In addition to the primary, secondary and tertiary data sources listed here, the following sources were consulted and emission controls were updated when corroborating information could be found: McILVAINE Utility Upgrade Database, ICAC (Institute of Clean Air Companies), and web sites of generating unit owners and operators.

Table 4-7 provides a crosswalk between actual plants and the aggregated "model plants" used in the EPA Base Case v.4.10. For each plant type, the table shows the number of real plants and the number of model plants representing these real plants in EPA Base Case v.4.10.[17]

[17]For readers interested in the intricacies of Table 4-7, here are several observations: (1) Depending on its capacity and fuel types combusted, an existing coal steam model plant may be provided with multiple scrubber and ACI retrofit options. As a result the total number of model plants representing scrubber and ACI retrofits may exceed the total number of model plants representing existing coal steam units. (See chapter 5 for a detailed description of the sulfur dioxide (scrubber) and mercury (ACI) retrofit options.) (2) The "Number of IPM Model Plants" shown for many of the "Plant Types" in the "Retrofits" block in Table 4-7 exceeds the "Number of IPM Model Plants" shown for "Plant Type" "Coal Steam" in the block labeled "Existing and Planned/Committed Units", because a particular retrofit "Plant Type" can include multiple technology options and multiple timing options (e.g., Technology A in Stage 1 + Technology B in Stage 2, the reverse timing, or both technologies simultaneously in Stage 1). (3) Since only a subset of coal plants is eligible for certain retrofits, many of the "Plant Types" in the "Retrofits" block that represent only a single retrofit technology (e.g., "Retrofit Coal with Selective Noncatalytic Reduction (SNCR)") have a "Number of of IPM Model Plants" that is a smaller than

Table 4-7 Aggregation Profile of Model Plants as Provided at Set Up of EPA Base Case v.4.10

Existing and Planned/Committed Units		
Plant Type	**Number of Units**	**Number of IPM Model Plants**
Biomass	161	71
Coal Steam	1,267	913
Combined Cycle	1,627	610
Combustion Turbine	5,474	2,225
Fossil_Other	21	14
Fuel Cell	4	4
Geothermal	211	8
Hydro	3,771	99
Import	2	2
Integrated Gas Combined Cycle	6	5
Landfill Gas	747	59
Non Fossil_Other[1]	241	73
Nuclear[2]	105	105
Oil/Gas Steam	685	435
Pumped Storage	151	21
Solar	92	37
Wind	458	57
Total	**15,023**	**4,738**

New Units		
Plant Type	**Number of Units**	**Number of IPM Model Plants**
New Biomass	--	64
New Coal with Carbon Capture	--	754
New Combined Cycle	--	32
New Combustion Turbine	--	32
New Fuel Cell	--	32
New Future Technology	--	160
New Geothermal	--	26
New IGCC	--	58
New Landfill Gas	--	96
New Nuclear	--	64
New Offshore Wind	--	690
New Onshore Wind	--	600
New SPC-DryFGD_SCR_ACI		27
New SPC-WetFGD_SCR	--	27
New Solar Thermal	--	55
New Solar PV	--	32

the "Number of IPM Model Plants" shown for "Plant Type" "Coal Steam". (4) The total number of model plants representing different types of new units often exceeds the 32 model regions and the specific totals vary from technology to technology for several reasons. First, some technologies have multiple vintages, which must be represented by separate model plants in each IPM region. Second, some technologies are not available in particular regions (e.g., geothermal is geographically restricted to certain regions, conventional pulverized coal is not provided as an option in CA-N).

Total	--	**2,749**

Retrofits		
Plant Type	**Number of Units**	**Number of IPM Model Plants**
Retrofit Coal with Activated Carbon Injection (ACI)	--	427
Retrofit Coal with ACI + SCR	--	1,076
Retrofit Coal with ACI + SCR + Scrubber	--	1,575
Retrofit Coal with ACI + SCR + Scrubber + CCS	--	1,708
Retrofit Coal with ACI + SNCR + Scrubber	--	357
Retrofit Coal with ACI + SNCR	--	447
Retrofit Coal with ACI + SNCR + Scrubber + CCS	--	161
Retrofit Coal with ACI + Scrubber	--	1,570
Retrofit Coal with ACI + Scrubber + CCS	--	1,372
Retrofit Coal with Selective Catalytic Reduction (SCR)	--	360
Retrofit Coal with SCR + Scrubber	--	2,281
Retrofit Coal with SCR + Scrubber + CCS	--	2,065
Retrofit Coal with Selective Noncatalytic Reduction (SNCR)	--	141
Retrofit Coal with SNCR + Scrubber	--	544
Retrofit Coal with SNCR + Scrubber + CCS	--	112
Retrofit Coal with Scrubber	--	587
Retrofit Coal with Scrubber + CCS	--	1,078
Retrofit Coal with CCS	--	14
Retrofit Oil Gas with SCR	--	281
Total	--	**16,156**

Early Retirements		
Plant Type	**Number of Units**	**Number of IPM Model Plants**
CC Early Retirement	--	610
Coal Early Retirement	--	6,178
CT Early Retirement	--	2,225
IGCC Early Retirement	--	5
Nuke Early Retirement	--	105
O/G Early Retirement	--	435
Total	--	**9,558**

Grand Total (Existing and Planned/Committed + New + Retrofits + Early Retirements): 33,201

Notes:

[1]Non Fossil_Other includes units whose fuel is municipal solid waste, tires, and other non-fossil waste.

[2]The 105 nuclear units include 104 currently operating units plus Watts Bar Nuclear Plant, Unit 2, which is scheduled to come online in 2014. All are listed in Appendix 4-3.

4.2.7 Cost and Performance Characteristics of Existing Units

In EPA Base Case v.4.10 heat rates, emission rates, variable operation and maintenance cost (VOM) and fixed operation and maintenance costs (FOM) are used to characterize the cost and performance of all existing units in NEEDS v.4.10. For existing units, only the cost of maintaining (FOM) and running (VOM) the unit are modeled. Embedded costs, such as carrying capital charges, are not modeled. The section below contains a discussion of the cost and performance assumptions for existing units used in the EPA Base Case v.4.10.

Variable Operating and Maintenance Cost (VOM)

VOM represents the non-fuel cost variable associated with producing a unit of electricity. If the generating unit contains pollution control equipment, VOM includes the cost of operating the control equipment. Table 4-8 below summarizes VOM assumptions used in EPA Base Case v.4.10. The values shown in this table were obtained using a procedure developed jointly by EPA's power sector engineering staff and ICF.

Table 4-8 VOM Assumptions (2007$) in EPA Base Case v.4.10

Capacity Type	SO_2 Control	Hg Control	NO_x Control	Variable O&M Range (mills/kWh)
Combined Cycle	--	--	No NO_x	2.63 - 7.67
			SCR	2.75 - 7.79
Coal Steam	Scrubbed - Dry	No Hg	No NO_x	3.66 - 5.05
			SCR	4.34 - 5.73
			SNCR	4.73 - 6.12
		ACI	No NO_x	4.62 - 6.02
			SCR	5.30 - 6.69
			SNCR	5.70 - 7.09
	Scrubbed - Wet	No Hg	No NO_x	2.48 - 3.87
			SCR	3.16 - 4.55
			SNCR	3.55 - 4.94
		ACI	No NO_x	3.44 - 4.83
			SCR	4.12 - 5.51
			SNCR	4.51 - 5.91
	Unscrubbed	No Hg	No NO_x	0.90 - 2.29
			SCR	1.58 - 2.97
			SNCR	1.97 - 3.37
		ACI	No NO_x	1.87 - 3.26
			SCR	2.54 - 3.94
			SNCR	2.94 - 4.33
Conventional Hydroelectric	--	--	--	6.66
Combined Turbine	--	No Hg	No NO_x	2.60 - 9.59
			SCR	2.73 - 9.71
Fuel Cell	--	--	--	9.7
Geothermal	--	--	--	8.3
IGCC	--	--	--	0 - 4.72
MSW/Landfill Gas	--	--	--	8.79

Capacity Type	SO_2 Control	Hg Control	NO_x Control	Variable O&M Range (mills/kWh)
Oil/Gas Steam	Scrubbed - Wet	No Hg	No NO_x	0.94 - 5.07
			SNCR	1.49 - 5.62
	Unscrubbed	No Hg	No NO_x	0.94 - 5.07
			SCR	1.06 - 5.19
			SNCR	1.49 - 5.62
Pumped Storage	--	--	--	8.37
Solar Photovoltaic	--	--	--	2.09
Solar Thermal	--	--	--	2.78
Wind	--	--	--	3.18
Wood/Biomass	--	--	--	6.98

Fixed Operation and Maintenance Cost (FOM)
FOM represents the annual fixed cost of maintaining a unit. FOM costs are incurred independent of achieved generation levels and signify the fixed cost of operating and maintaining the unit for generation. Table 4-9 summarizes the FOM assumptions used in EPA Base Case v.4.10. Note that FOM varies by the age of the unit. The values appearing in this table include the cost of maintaining any associated pollution control equipment. The values in Table 4-9 are based on FERC (Federal Energy Regulatory Commission) Form 1 data.

Heat Rates
Heat Rates describe the efficiency of the unit expressed as BTUs per kWh. The treatment of heat rates in EPA Base Case v.4.10 is discussed in Section 3.8.

Lifetimes
Unit lifetime assumptions in EPA Base Case v.4.10 are detailed in Sections 3.7 and 4.2.8.

SO_2 Rates
Section 3.9.1 contains a detailed discussion of SO_2 rates for existing units.

NO_x Rates
Section 3.9.2 contains a detailed discussion of NO_x rates for existing units.

Mercury Emission Modification Factors (EMF)
Mercury EMF refers to the ratio of mercury emissions (mercury outlet) to the mercury content of the fuel (mercury inlet). Section 5.4.2 contains a detailed discussion of the EMF assumptions in EPA Base Case v.4.10.

4.2.8 Life Extension Costs for existing units

The usable modeling time horizon in previous EPA Base Cases typically extended out only as far as 2030 and covered a period of roughly 20-25 years. In contrast, the modeling time horizon in EPA Base Case 4.10 extends to 2050 covers a period of almost 40 years. Due to this longer time horizon, provision had to be made in EPA Base Case v.4.10 for investments (beyond the routine maintenance of the power plant) that would be required to extend the life of existing units over this longer time horizon. The life extension costs for units with retirement options are summarized in Table 4-10 below. These costs were based on a review of FERC Form 1 data regarding annual capital expenditures over the last 10 – 15 years of the power plan.

Table 4-9 FOM Assumptions Used in EPA Base Case v.4.10

Prime Mover Type	Primary Fuel	SO_2 Control	Hg Control	NO_x Control	Age of Unit	FOM (2007$ /kW-Yr)
Combined Cycle	Oil & Gas	--	--	--	All Years	12.6
Conventional Hydroelectric	Water	--	--	--	All Years	14.3
Fuel Cell	Natural Gas	--	--	--	All Years	18.3
Gas Turbine	Oil & Gas	--	--	--	>30 years	8.8
					20-30 years	8.5
					0-20 years	3.7
Geothermal	Earth	--	--	--	All Years	21.6
IGCC	Coal	--	--	--	All Years	118.4
MSW/Landfill Gas	Landfill Gas	--	--	--	All Years	23.6
Nuclear	Nuclear	--	--	--	All Years	100.5
Pumped Storage	Water	--	--	--	All Years	18.3
Solar Photovoltaic	Sun	--	--	--	All Years	17.1
Solar Thermal	Sun	--	--	--	All Years	22.6
Steam Turbine	Coal	Scrubbed - Dry	No Hg	No NO_x	0 to 20 Years	42.2
					20 to 30 Years	44.2
					30 to 40 Years	55.1
					Greater than 40 Years	60.8
				SCR	0 to 20 Years	42.9
					20 to 30 Years	44.9
					30 to 40 Years	55.7
					Greater than 40 Years	61.4
				SNCR	0 to 20 Years	42.5
					20 to 30 Years	44.5
					30 to 40 Years	55.3
					Greater than 40 Years	61.1
			ACI	No NO_x	0 to 20 Years	42.4
					20 to 30 Years	44.4
					30 to 40 Years	55.2
					Greater than 40 Years	60.9
				SCR	0 to 20 Years	43.0
					20 to 30 Years	45.0
					30 to 40 Years	55.9
					Greater than 40 Years	61.6
				SNCR	0 to 20 Years	42.6
					20 to 30 Years	44.6
					30 to 40 Years	55.5
					Greater than 40 Years	61.2
		Scrubbed - Wet	No Hg	No NO_x	0 to 20 Years	43.2
					20 to 30 Years	45.2
					30 to 40 Years	56.0
					Greater than 40 Years	61.8
				SCR	0 to 20 Years	43.8
					20 to 30 Years	45.8

Prime Mover Type	Primary Fuel	SO_2 Control	Hg Control	NO_x Control	Age of Unit	FOM (2007$ /kW-Yr)
					30 to 40 Years	56.7
					Greater than 40 Years	62.4
				SNCR	0 to 20 Years	43.5
					20 to 30 Years	45.5
					30 to 40 Years	56.3
					Greater than 40 Years	62.0
			ACI	No NO_x	0 to 20 Years	43.3
					20 to 30 Years	45.3
					30 to 40 Years	56.2
					Greater than 40 Years	61.9
				SCR	0 to 20 Years	44.0
					20 to 30 Years	46.0
					30 to 40 Years	56.8
					Greater than 40 Years	62.6
				SNCR	0 to 20 Years	43.6
					20 to 30 Years	45.6
					30 to 40 Years	56.5
					Greater than 40 Years	62.2
		Unscrubbed	No Hg	No NO_x	0 to 20 Years	32.9
					20 to 30 Years	34.9
					30 to 40 Years	45.8
					Greater than 40 Years	51.5
				SCR	0 to 20 Years	33.6
					20 to 30 Years	35.6
					30 to 40 Years	46.4
					Greater than 40 Years	52.2
				SNCR	0 to 20 Years	33.2
					20 to 30 Years	35.2
					30 to 40 Years	46.1
					Greater than 40 Years	51.8
			ACI	No NO_x	0 to 20 Years	33.1
					20 to 30 Years	35.1
					30 to 40 Years	45.9
					Greater than 40 Years	51.7
				SCR	0 to 20 Years	33.7
					20 to 30 Years	35.7
					30 to 40 Years	46.6
					Greater than 40 Years	52.3
				SNCR	0 to 20 Years	33.3
					20 to 30 Years	35.3
					30 to 40 Years	46.2
					Greater than 40 Years	51.9
	Oil & Gas	--	--	No NO_x	0 to 20 Years	18.4
					20 to 30 Years	21.0
					30 to 40 Years	22.3
					Greater than 40 Years	28.4
				SCR	0 to 20 Years	19.3

Prime Mover Type	Primary Fuel	SO_2 Control	Hg Control	NO_x Control	Age of Unit	FOM (2007$ /kW-Yr)
					20 to 30 Years	21.9
					30 to 40 Years	23.2
					Greater than 40 Years	29.3
				SNCR	0 to 20 Years	18.6
					20 to 30 Years	21.2
					30 to 40 Years	22.5
					Greater than 40 Years	28.6
Wind	Wind	--	--	--	All Years	18.3
Wood/Biomass	Biomass	--	--	--	All Years	20.1

Table 4-10 Life Extension Cost Assumptions Used in EPA Base Case v.4.10

Plant Type	Lifespan without Life Extension Expenditures	Life Extension Cost as Proportion of New Unit Capital Cost (%)	Capital Cost of New Unit (2007$/kW)	Life Extension Cost (2007$/kW)
Coal Steam	40	7.0	2,918	204
Combined Cycle	30	9.3	976	91
Combustion Turbine & IC Engine	30	4.2	698	30
Oil/Gas Steam	40	3.4	2,699	91
IGCC	40	7.4	3,265	242
Nuclear	40	9.0	4,621	416

Note:
Life extension expenditures double the lifespan of the unit.

4.3 Planned-Committed Units

EPA Base Case v.4.10 includes all planned-committed units that are likely to come online because ground has been broken, financing obtained, or other demonstrable factors indicate a high probability that the unit will be built before 2012.

4.3.1 Population and Model Plant Aggregation

Like existing units, planned-committed units are contained in NEEDS. A comprehensive update of planned-committed units contained in NEEDS was performed for EPA Base Case v.4.10 using the information sources listed in Table 4-1 . Table 4-11 summarizes the extent of inventory of planned-committed units in EPA Base Case v.4.10 indicating its generating capacity by unit types.

Due to data confidentiality restrictions, NEEDS v.4.10 does not list the planned-committed units on a unit by unit basis. Rather, all units having similar technologies and located within the same model region are aggregated together as one record. Table 4-12 gives a breakdown of planned-committed units by IPM region, unit type, number of units, and capacity included in EPA Base Case v.4.10.

Table 4-11 Summary of Planned-Committed Units in NEEDS v.4.10 for EPA Base Case v.4.10

Type	Capacity (MW)	Year Range Described
Renewables/Non-conventional		
Biomass	495	2007 - 2012
Fuel Cell	3	2011
Geothermal	302	2007 - 2011
Hydro	91	2007 - 2011
Landfill Gas	279	2007 - 2011
Municipal Solid Waste	35	2007 - 2011
Non-Fossil Waste	235	2011
Pumped Storage	40	2011
Solar	687	2007 - 2011
Wind	26,295	2007 - 2011
Subtotal	28,462	
Fossil/Conventional		
Coal Steam	17,055	2007 - 2011
Combined Cycle	25,088	2007 - 2011
Combustion Turbine	9,648	2007 - 2011
Fossil Waste	274	2011
IGCC	1,230	2009 - 2011
Nuclear	1,180	2014
O/G Steam	115	2008 - 2011
Subtotal	54,590	
Grand Total	83,052	

Table 4-12 Planned-Committed Units by Model Region in NEEDS v.4.10 for EPA Base Case v.4.10

IPM Region	Plant Type	Capacity (MW)
AZNM	Biomass	24
	Coal Steam	400
	Combined Cycle	94
	Combustion Turbine	593
	Geothermal	95
	Solar	20
	Wind	130
CA-N	Combined Cycle	1,279
	Combustion Turbine	603
	Fuel Cell	1
	Geothermal	25
	Landfill Gas	17
	Solar	249
	Wind	2,533
CA-S	Biomass	2
	Combined Cycle	1,293
	Combustion Turbine	454
	Fuel Cell	2
	Hydro	5
	Landfill Gas	8

IPM Region	Plant Type	Capacity (MW)
	Pumped Storage	40
	Solar	255
	Wind	112
COMD	Combined Cycle	573
	Landfill Gas	6
	Wind	282
DSNY	Combined Cycle	635
ENTG	Biomass	14
	Coal Steam	665
	Combined Cycle	1,336
ERCT	Biomass	50
	Coal Steam	3,250
	Combined Cycle	3,266
	Combustion Turbine	639
	Fossil Waste	274
	Landfill Gas	16
	Non-Fossil Waste	10
	Solar	3
	Wind	7,669
FRCC	Combined Cycle	6,365
	Combustion Turbine	1,191
	Landfill Gas	21
	Municipal Solid Waste	16
GWAY	Coal Steam	1,800
	Landfill Gas	5
	Wind	1,177
LILC	Combined Cycle	350
MACE	Combustion Turbine	105
	Landfill Gas	27
	O/G Steam	9
	Solar	7
MACS	Combustion Turbine	30
	Landfill Gas	5
	O/G Steam	100
MACW	Biomass	30
	Landfill Gas	22
	Municipal Solid Waste	14
	Wind	480
	Landfill Gas	10
	Wind	480
MRO	Biomass	107
	Coal Steam	1,782
	Combined Cycle	1,204
	Combustion Turbine	878
	Hydro	11
	Landfill Gas	7
	Municipal Solid Waste	5

IPM Region	Plant Type	Capacity (MW)
	Non-Fossil Waste	25
	Wind	4,598
NENG	Biomass	44
	Combined Cycle	987
	Combustion Turbine	301
	Hydro	16
	Landfill Gas	11
	O/G Steam	6
	Solar	1
	Wind	650
NWPE	Biomass	1
	Coal Steam	1,112
	Combined Cycle	1,062
	Geothermal	182
	Hydro	12
	Solar	2
	Wind	266
NYC	Combustion Turbine	1
PNW	Biomass	31
	Combined Cycle	1,262
	Combustion Turbine	175
	Hydro	19
	Landfill Gas	10
	Non-Fossil Waste	58
	Solar	2
	Wind	2,584
RFCO	Combined Cycle	720
	IGCC	1,230
	Landfill Gas	26
	Non-Fossil Waste	3
	Wind	554
RFCP	Coal Steam	695
	Combined Cycle	580
	Landfill Gas	5
	Non-Fossil Waste	80
	Wind	264
RMPA	Coal Steam	768
	Combustion Turbine	658
	Hydro	9
	Landfill Gas	6
	Solar	15
	Wind	1,362
SNV	Combustion Turbine	720
	Solar	112
	Wind	189
SOU	Biomass	116
	Combined Cycle	1,237

IPM Region	Plant Type	Capacity (MW)
	Non-Fossil Waste	18
SPPN	Coal Steam	1,172
	Combustion Turbine	845
	Wind	651
SPPS	Coal Steam	660
	Combined Cycle	1,080
	Combustion Turbine	939
	Non-Fossil Waste	35
	Solar	8
	Wind	943
	Nuclear	1,180
	Wind	111
TVAK	Coal Steam	1,018
	Combustion Turbine	200
	Landfill Gas	5
UPNY	Biomass	25
	Hydro	13
	Landfill Gas	14
	Non-Fossil Waste	7
	Wind	826
VACA	Coal Steam	1,980
	Combustion Turbine	779
	Hydro	6
	Landfill Gas	18
	Solar	12
	Wind	38
VAPW	Combined Cycle	1,190
	Combustion Turbine	537
	Landfill Gas	31
	Solar	1
WUMS	Biomass	50
	Coal Steam	1,753
	Combined Cycle	575
	Landfill Gas	8
	Wind	396

Note:
Any unit that has an online year of 2007- 2011 was considered a Planned and Committed Unit

4.3.2 Capacity

The capacity of planned-committed units in NEEDS v.4.10 was obtained from the information sources reported above in Table 4-1 .

4.3.3 State and Model Region

State location data for the planned-committed units in NEEDS v.4.10 came from the information sources noted in Section 4.3.1. The state information was then used to assign planned-committed units to their respective model regions.

4.3.4 Online and Retirement Year

As noted above, planned-committed units included in NEEDS v.4.10 are only those units which are likely to come on-line before 2012. All planned-committed units were given a default online year of end of 2011 since this is the first analysis year in EPA Base Case v.4.10. The assumptions in EPA Base Case v.4.10 do not include a lifetime for planned-committed units.

4.3.5 Unit Configuration and Cost-and-Performance

All planned-committed units in NEEDS v.4.10 assume the cost, performance, and unit configuration characteristics of potential units that are available in 2012. A detailed description of potential unit assumptions is provided below in Section 4.4.

4.4 Potential Units

The EPA Base Case v.4.10 includes options for developing a variety of potential units that may be "built" at a future date in response to electricity demand and the constraints represented in the model. Defined by region, technology, and the year available, potential units with an initial capacity of 0 MW are inputs into IPM. When the model is run, the capacity of certain potential units is raised from zero to meet demand and other system and operating constraints. This results in the model's projection of new capacity.

In Table 4-7 the block labeled "New Units" gives a breakdown of the type and number of potential units provided in EPA Base Case v.4.10. The following sections describe the cost and performance assumptions for the potential units represented in the EPA Base Case v.4.10.

4.4.1 Methodology Used to Derive the Cost and Performance Characteristics of Conventional Potential Units

Cost and performance assumptions for potential units in previous EPA base cases were based primarily on data from the latest available Annual Energy Outlook (AEO) published by the U.S. Department of Energy's Energy Information Administration. However, an unprecedented run up in the costs of new generating units over the preceding 5 years prompted EPA to analyze other references in addition to the AEO for Base Case v.4.10. The cost escalation which was particularly noticeable for base load electric generating units, was generally attributed to international competition and, was increasingly seen as permanent. That is, there was a growing consensus that costs were not going to settle back to pre-2010 levels.

With this in mind, the power sector engineering staff in EPA's Clean Air Markets Division performed comparative cost analyses based on reports and discussions with government agencies, national technical laboratories, industry, academia, and various non-governmental organizations. The key sources reviewed included:

- U.S. Energy Information Administration: *Annual Energy Outlook 2008, 2009, 2010*[18]
- National Energy Technology Laboratory, Fossil Energy Power Plant Desk Reference (Bituminous Coal)[19]

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[18] U.S. Department of Energy, Energy Information Administration, Assumptions to the Annual Energy Outlook 2008: Electric Market Module, DOE/EIA-0554(2008), June 2008. www.eia.doe.gov/oiaf/archive/aeo08/assumption/electricity.html
U.S. Department of Energy, Energy Information Administration, Assumptions to the Annual Energy Outlook 2009: Electric Market Module, DOE/EIA-0554(2009), March 2009. www.eia.doe.gov/oiaf/archive/aeo09/assumption/electricity.html
U.S. Department of Energy, Energy Information Administration, Assumptions to the Annual Energy Outlook 2010: Electric Market Module, #:DOE/EIA-0554(2010), April 2010. www.eia.doe.gov/oiaf/aeo/assumption/electricity.html.

[19] U.S. Department of Energy, National Energy Technology Laboratory, *Fossil Energy Power Plant Desk Reference, Bituminous Coal and Natural Gas to Electricity Summary Sheets* DOE/NETL-

- U.S. Environmental Protection Agency, Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies[20]
- EPRI (Electric Power Research Institute): "Economic Assessment of Advanced Coal-Based Power Plants with CO_2 Capture"[21]
- Harvard University: "Realistic Costs of Carbon Capture"[22]
- Massachusetts Institute of Technology: "Update on the Cost of Nuclear Power"[23]
- Union of Concerned Scientists: Climate 2030 - A National Blueprint for a Clean Energy Economy[24]

4.4.2 Cost and Performance for Potential Conventional Units

The comparative analyses described in the preceding section resulted in the cost and performance characteristics shown in Table 4-13. They are based on EPA's engineering assessments. As seen in Table 4-13, EPA Base Case v.4.10 includes cost and performance characteristics for the following potential technologies: supercritical pulverized coal, advanced combined cycle, advanced combustion turbines, integrated gasification combined cycle (IGCC), advanced coal with carbon capture capabilities, and nuclear units. The cost and performance assumptions are based on the size (i.e., electrical generating capacity in MW) indicated in the table. However, the total new capacity that is added in a given model run for these technologies is not restricted to these capacity levels.

This table includes several components of cost. The total installed cost of developing and building a new plant is captured through the capital cost. It includes expenditures on pollution control equipment that new units are assumed to install to satisfy air regulatory requirements. The capital costs shown in Table 4-13 are typically referred to as "overnight" capital costs. They include engineering, procurement, construction, startup, and owner's costs (for such items as land, cooling infrastructure, administration and associated buildings, site works, switchyards, project management, licenses, etc). The capital costs in Table 4-13 do not include interest during construction (IDC). IDC is added to the capital costs shown in Table 4-13 during the set-up of a run. Calculation of IDC is based on the construction profile and the discount rate. Details on the discount rates used in the EPA Base Case v.4.10 are discussed in Chapter 8 under financial assumptions.

2007/1282, May 2007. http://www.netl.doe.gov/energy-analyses/pubs/Cost%20and%20Performance%20Baseline-012908.pdf

[20]U.S. EPA, Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies. EPA-430/R-06/2006, July 2006.

[21]Booras, G., *Economic Assessment of Advanced Coal-Based Power Plants with CO2 Capture*, a presentation at EPRI (Electric Power Research Institute) MIT Carbon Sequestration Forum IC, September 16, 2008.

[22]Al-Juaied, M and A Whitmore, ""Realistic Costs of Carbon Capture" Harvard Kennedy School. Belfer Center Discussion Paper 2009-08, July 2009. http://belfercenter.ksg.harvard.edu/files/2009_AlJuaied_Whitmore_Realistic_Costs_of_Carbon_Capture_web.pdf

[23]Du, Y., J.E. Parsons (2009). Update on the cost of nuclear power. MIT Center for Energy and Environmental Policy Research (CEEPR) Working Paper 09-004, May 2009. http://web.mit.edu/ceepr/www/publications/workingpapers/2009-004.pdf

[24]Cleetus R., S. Clemmer, and D. Friedman, *Climate 2030 - A National Blueprint for a Clean Energy Economy,* Union of Concerned Scientists, May 2009. http://www.ucsusa.org/global_warming/solutions/big_picture_solutions/climate-2030-blueprint.html#Download_the_Climate_2030_Blueprint_repo

Table 4-13 Performance and Unit Cost Assumptions for Potential (New) Capacity from Conventional Technologies in EPA Base Case v4.10

	Advanced Combined Cycle	Advanced Combustion Turbine	Nuclear	Integrated Gasification Combined Cycle – Bituminous	Integrated Gasification Combined Cycle – Subbituminous	Advanced Coal with Carbon Capture-Bituminous[1]	Advanced Coal with Carbon Capture – Subbituminous[1]	Supercritical Pulverized Coal - Wet Bituminous	Supercritical Pulverized Coal - Dry Sub-Bituminous
Size (MW)	560	170	1350	600	600	500	500	600	600
First Year Available	2015	2012	2017	2013	2013	2015	2015	2013	2013
Lead Time (Years)	3	2	6	4	4	4	4	4	4
Vintage #1 (years covered)	2012 - 2054	2012 - 2054	2012 - 2054	2012 - 2054	2012 - 2054	2012 - 2054	2015 - 2054	2012 - 2054	2012 - 2054
Availability	87%	92%	90%	85%	85%	85%	85%	85%	85%
Vintage #1									
Heat Rate (Btu/kWh)	6,810	10,720	10,400	8,424	8,062	10,149	9,713	8,874	8,937
Capital[2] (2007$/kW)	976	698	4,621	3,265	3,310	4,720	4,785	2,918	3,008
Fixed O&M (2007$/kW/yr)	14.4	12.3	92.4	47.9	48.2	60.5	61.0	28.9	28.6
Variable O&M (2007$/MWh)	2.57	3.59	0.77	1.32	1.15	1.67	1.46	3.43	2.27

Notes:
[1]For The term “Advanced Coal with Carbon Capture” is used here and in the output files for EPA Base Case v.4.10 to represent a variety of technologies that are expected to provide carbon capture capabilities. These include both supercritical steam generators with carbon capture and integrated gasification combined cycle (IGCC) with carbon capture. Although IGCC with carbon capture was used to define the cost and performance parameters that are implemented in EPA Base Case v.4.10, projections of “Advanced Coal with Carbon Capture” in EPA Base Case v.4.10 are not limited to this technology.
[2]Capital cost represents overnight capital cost.

Table 4-13 also shows fixed operating and maintenance (FOM) and variable operating and maintenance (VOM) components of cost. FOM is the annual cost of maintaining a generating unit. It represents expenses incurred regardless of the extent that the unit is run. It is expressed in units of $ per kW per year. VOM represents the costs incurred in running an electric generating unit. It is proportional to the electrical energy produced and is expressed in units of $ per MWh.

In addition to the three components of cost, Table 4-13 indicates the first year available, lead time, vintage periods, heat rate, and availability for each type of unit. Lead time represents the construction time needed for a unit to come online. Vintage periods are used to capture the cost and performance improvements resulting from technological advancement and learning-by-doing. Mature technologies and technologies whose first year available is not at the start of the modeling time horizon may have only one vintage period, whereas newer technologies may have several vintage periods. Heat rate indicates the efficiency of the unit and is expressed in units of energy consumed (Btus) per unit of electricity generated (kWh). Availability indicates the percentage of time that a generating unit is available to provide electricity to the grid once it has come on line. Availability takes into account estimates of the time consumed by planned maintenance and forced outages. The emission characteristics of the potential units are not presented in Table 4-13, but can be found in Table 3-11.

4.4.3 Short-Term Capital Cost Adder

Besides the capital costs shown in Table 4-13 and Table 4-16 EPA Base Case v.4.10 includes a short-term capital cost adder that kicks in if the new capacity in a specific model run year exceeds certain upper bounds. This is meant to reflect the added cost incurred due to short-term competition for scarce labor and materials. Table 4-14 shows the cost adders for each type of potential unit for model run years through 2030. The adder is not imposed after 2030 on the premise that by then market adjustments will have eliminated the short term scarcity experienced in earlier years.

Here's how these short-term adders work in Base Case v.4.10: The column labeled “Step 1” in Table 4-14 indicates the total amount of capacity of a particular plant type that can be built in a given model run year without incurring a cost adder. However, if the Step 1 upper bound is exceeded, then either the Step 2 or Step 3 cost adder is incurred. Above the Step 1 upper bound, the Step 2 cost adder applies until the cumulative capacity exceeds the Step 1 + Step 2 upper bound. Beyond that point, the Step 3 capital cost adder applies. For example, the Step 1 upper bound in 2012 for coal steam potential units is 25,301 MW. If no more than this total new coal steam capacity is built in 2012, only the capital cost shown in Table 4-13 is incurred. Between 25,301 and 42,168 MW (the sum of the Step 1 and Step 2 upper bounds, i.e., 25,301 MW + 16, 867 MW = 42,168 MW), the Step 2 cost adder of $967/MW applies. For all the new coal capacity built in that model run year (not just the increment of new capacity above the Step 1 upper bound of 25,301 MW), this extra cost is added to the capital cost shown in Table 4-13. If the total new coal steam capacity exceeds the Step 1 + Step 2 upper bound of 42,168 MW, then the Step 3 capacity adder of $2,500/MW is incurred. To determine if the upper bounds for plant type “Coal Steam” in Table 4-14 have been reached, one must sum the capacities added in a model run year for plant types Supercritical Pulverized Coal - Wet Bituminous and Supercritical Pulverized Coal - Dry Bituminous. The upper bound for “Coal Steam” applies to the sum of the capacity added in the model run year for these two plant types.

The short-term capital cost adders shown in Table 4-14 were derived from AEO assumptions.

4.4.4 Regional Cost Adjustment

The capital costs reported in Table 4-14 are generic. Before EPA implements these capital cost values they are converted to region-specific costs. This is done through the application of regional adjustment factors which capture regional differences in labor, material, and construction costs. The regional adjustment factors used in EPA Base Case v.4.10 are shown in Table 4-15. They were developed from AEO and are applied to both conventional technologies shown in Table 4-13 and to the renewable and non-conventional technologies shown in Table 4-16 below.

Table 4-14 Short-Term Capital Cost Adders for New Power Plants in EPA Base Case v.4.10 (2007$)

ID Number	Plant Type		2012			2015			2020			2030		
			Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
1	Biomass	Upper Bound (MW)	600	400	--	1,800	1,200	--	3,000	2,000	--	6,000	4,000	--
		Adder ($/kW)	--	1,410	3,646	--	1,410	3,646	--	1,410	3,646	--	1,410	3,646
2	Coal Steam	Upper Bound (MW)	8,434	5,622	--	25,301	16,867	--	42,168	28,112	--	84,336	56,224	--
		Adder ($/kW)	--	967	2,500	--	967	2,500	--	967	2,500	--	967	2,500
3	Combined Cycle	Upper Bound (MW)	46,469	30,979	--	139,406	92,937	--	232,344	154,896	--	464,687	309,791	--
		Adder ($/kW)	--	310	801	--	310	801	--	310	801	--	310	801
4	Combustion Turbine	Upper Bound (MW)	24,098	16,066	--	72,295	48,197	--	120,492	80,328	--	240,984	160,656	--
		Adder ($/kW)	--	213	551	--	213	551	--	213	551	--	213	551
5	Fuel Cell	Upper Bound (MW)	600	400	--	1,800	1,200	--	3,000	2,000	--	6,000	4,000	--
		Adder ($/kW)	--	1,987	5,138	--	1,987	5,138	--	1,987	5,138	--	1,987	5,138
6	Geothermal	Upper Bound (MW)	315	210	--	946	630	--	1,576	1,051	--	3,152	2,102	--
		Adder ($/kW)	--	1,981	5,123	--	1,981	5,123	--	1,981	5,123	--	1,981	5,123
7	IGCC and Advanced Coal with Carbon Capture	Upper Bound (MW)	2,400	1,600	--	7,200	4,800	--	12,000	8,000	--	24,000	16,000	--
		Adder ($/kW)	--	1,072	2,774	--	1,072	2,774	--	1,072	2,774	--	1,072	2,774
8	Landfill Gas	Upper Bound (MW)	600	400	--	1,800	1,200	--	3,000	2,000	--	6,000	4,000	--
		Adder ($/kW)	--	1,135	2,936	--	1,135	2,936	--	1,135	2,936	--	1,135	2,936
9	Nuclear	Upper Bound (MW)	11,230	7,487	--	33,690	22,460	--	56,151	37,434	--	112,301	74,867	--
		Adder ($/kW)	--	1,579	4,083	--	1,579	4,083	--	1,579	4,083	--	1,579	4,083
10	Solar Thermal	Upper Bound (MW)	106	70	--	317	211	--	528	352	--	1,056	704	--
		Adder ($/kW)	--	1,608	4,158	--	1,608	4,158	--	1,608	4,158	--	1,608	4,158
11	Solar PV	Upper Bound (MW)	54	36	--	54	36	--	90	60	--	180	120	--
		Adder ($/kW)	--	1,733	4,483	--	1,733	4,483	--	1,733	4,483	--	1,733	4,483

ID Number	Plant Type		2012			2015			2020			2030		
			Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
12	Onshore Wind	Upper Bound (MW)	23,000	19,670	--	29,505	19,670	--	49,174	32,783	--	98,348	65,566	--
		Adder ($/kW)	--	646	1,672	--	646	1,672	--	646	1,672	--	646	1,672
13	Offshore Wind	Upper Bound (MW)	600	400	--	1,800	1,200	--	3,000	2,000	--	6,000	4,000	--
		Adder ($/kW)	--	1,304	3,373	--	1,304	3,373	--	1,304	3,373	--	1,304	3,373

Note:
The term "Advanced Coal with Carbon Capture" is used here and in the output files for EPA Base Case v.4.10 to represent a variety of technologies that are expected to provide carbon capture capabilities. These include both supercritical steam generators with carbon capture and integrated gasification combined cycle (IGCC) with carbon capture. Although IGCC with carbon capture was used to define the cost and performance parameters that are implemented in EPA Base Case v.4.10 and shown in Table 4-13, projections of "Advanced Coal with Carbon Capture" in EPA Base Case v.4.10 are not limited to this technology.

Table 4-15 Regional Cost Adjustment Factors for Conventional and Renewable Generating Technologies in EPA Base Case v.4.10

Model Region	Region Description or Reliability Council Name	Regional Factor
AZNM	Western Electricity Coordinating Council - Arizona, New Mexico	1.003
CA-N	Western Electricity Coordinating Council - California North	1.058
CA-S	Western Electricity Coordinating Council - California South	1.058
COMD	Commonwealth Edison	1.004
DSNY	Downstate New York	1.043
ENTG	Entergy	0.960
ERCT	Texas Regional Entity	0.986
FRCC	Florida Reliability Coordinating Council	0.961
GWAY	Gateway	1.004
LILC	Long Island Company	1.879
MACE	Legacy Mid-Atlantic Area Council - East	0.996
MACS	Legacy Mid-Atlantic Area Council - South	0.996
MACW	Legacy Mid-Atlantic Area Council - West	0.996
MECS	Michigan Electric Coordination System	1.004
MRO	Midwest Regional Planning Organization	1.004
NENG	New England Power Pool	1.145
NWPE	Western Electricity Coordinating Council - Northwest Power Pool East	1.026
NYC	New York City	1.989
PNW	Western Electricity Coordinating Council - Pacific Northwest	1.026
RFCO	Reliability First Corporation - MISO	1.004
RFCP	Reliability First Corporation - PJM	1.004
RMPA	Western Electricity Coordinating Council - Rocky Mountain Power Area	1.003
SNV	Western Electricity Coordinating Council - Southern Nevada	1.003
SOU	Southern Company	0.960
SPPN	Southwest Power Pool - North	0.997
SPPS	Southwest Power Pool - South	0.997
TVA	Tennessee Valley Authority	0.960
TVAK	Tennessee Valley Authority - MISO-KY	1.004
UPNY	Upstate New York	1.043
VACA	Virginia-Carolinas	0.960
VAPW	Dominion Virginia Power	0.960
WUMS	Wisconsin-Upper Michigan	1.004

4.4.5 Cost and Performance for Potential Renewable Generating and Non-Conventional Technologies

The renewable and non-conventional generating technologies included as potential units in the EPA Base Case v.4.10 are conventional biomass boilers, biomass gasification combined cycle (BGCC), onshore and offshore wind (shallow and deep), geothermal, fuel cells, solar photovoltaic, solar thermal, and landfill gas. Table 4-16 summarizes the cost and performance assumptions in EPA Base Case v.4.10 for these potential units. Except for biomass, the parameters shown in Table 4-16 are based on AEO 2009. The size (MW) presented in Table 4-16 represents the capacity on which unit cost estimates were developed and does not indicate the total potential capacity that the model can build of a given technology. Due to the distinctive nature of generation from renewable resources, some of the values shown in Table 4-16 are averages or ranges that are discussed in further detailed in the following subsections. Also discussed below are additional types of data from sources other than AEO 2009 that play a role in the representation of these types of generation in EPA Base Case v.4.10.

Table 4-16 Performance and Unit Cost Assumptions for Potential (New) Renewable and Non-Conventional Technology Capacity in EPA Base Case v4.10

	Biomass Conventional Boiler[1]	Biomass Gasification Combined Cycle[1]	Fuel Cells	Geothermal	Landfill Gas			Solar Photovoltaic	Solar Thermal	Onshore Wind	Offshore Wind
					LGHI	LGLo	LGVLo				
Size (MW)	35	120	10	50	30			5	100	50	50
First Year Available	2013	2019	2013	2014	2013			2012	2013	2013	2013
Lead Time (Years)	3	4	3	4	3			2	3	3	3
Vintage #1 (years covered)	2012 - 2054	2020 - 2054	2012 - 2054	2012 - 2054	2012 - 2019	2012 - 2019	2012 - 2019	2012 - 2019	2012 - 2019	2012 - 2019	2012 - 2019
Vintage #2 (years covered)					2020 - 2029	2020 - 2029	2020 - 2029	2020 - 2029	2020 - 2029	2020 - 2029	2020 - 2029
Vintage #3 (years covered)					2030 - 2054	2030 - 2054	2030 - 2054	2030 - 2054	2030 - 2054	2030 - 2054	2030 - 2054
Availability	85%	85%	87%	87%	90%			90%	90%	95%	95%
Generation Capability	Economic Dispatch							Generation Profile			
Vintage #1											
Heat Rate (Btu/kWh)	13,500	-	7,930	29,655 - 397,035	13,648	13,648	13,648	0	0	0	0
Capital (2007$/kW)[2]	4,698	-	6,259	1,624 - 20,674	2,596	3,270	5,035	5,765	5,156	1,954	3,852 - 5,085
Fixed O&M (2007$/kW/yr)	85.2	-	5.7	151 - 219	114.3	114.3	114.3	11.7	56.8	30.3	89.5
Variable O&M (2007$/MWh)	11.60	-	47.92	0.00	0.01	0.01	0.01	0	0	0.00	0.00
Vintage #2											
Heat Rate (Btu/kWh)	-	9,800	-	-	13,648	13,648	13,648	0	0	0	0
Capital (2007$/kW)[2]	-	4,071	-	-	2,505	3,156	4,859	5,350	4,641	1,912	3,621 - 4,780
Fixed O&M (2007$/kW/yr)	-	48.3	-	-	114.3	114.3	114.3	11.7	56.8	30.3	89.5
Variable O&M (2007$/MWh)	-	8.83	-	-	0.01	0.01	0.01	0	0	0.00	0.00
Vintage #3											
Heat Rate (Btu/kWh)	-	-	-	-	13,648	13,648	13,648	0	0	0	0
Capital (2007$/kW)[2]	-	-	-	-	2,019	2,544	3,916	3,777	4,383	1,580	2,809 - 3,708
Fixed O&M (2007$/kW/yr)	-	-	-	-	114.3	114.3	114.3	11.7	56.8	30.3	89.5
Variable O&M (2007$/MWh)	-	-	-	-	0.01	0.01	0.01	0	0	0.00	0.00

Note:
[1] The biomass generating technologies shown in this table represent new capacity designed to burn biomass only. Assumptions for biomass co-firing at existing coal plants can be found in Table 5-14.
[2] Capital cost represents overnight capital cost.

It should be noted that the short term capital cost adder in Table 4-14 and the regional cost adjustment factors in Table 4-15 apply to the renewable and non-conventional generation technologies as they did to the conventional generation technologies

Biomass Electricity Generation
Two biomass generation technologies with separate vintage periods are offered as new (potential) units in EPA Base Case v.4.10. Conventional direct fired biomass boilers are offered in vintage period 1, i.e., 2012-2019. Based on engineering and market analysis that indicated that biomass gas combined cycle (BGCC) units will become commercially available by 2020, BGCC with its much more favorable heat rate and cost characteristics is provided as a potential unit from 2020 onward. Prepared by EPA's power sector engineering staff, the cost and performance characteristics of these two technology options are shown in Table 4-16.

Wind Generation
Previous EPA base cases only represented onshore wind generation. In addition to onshore wind, EPA Base Case v.4.10 includes offshore-shallow and offshore-deep wind generation. The following sections describe four key aspects of the representation of wind generation: wind quality and resource potential, generation profiles, reserve margin contribution, and capital cost calculation.

Wind Quality and Resource Potential: Wind resources are conventionally categorized into wind quality classes, ranging from class 1 (designated to be the least productive and reliable class for wind generation) to class 7 (designated to be the most productive and reliable class for wind generation). Areas designated as wind class 3 or higher are generally suitable for commercial wind turbine applications. Whereas previous EPA base cases only included wind classes 4, 5, and 6, EPA Base Case v.4.10 also includes class 3 and 7.

EPA worked with the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL), on a complete update of the wind resource assumptions for use in EPA Base Case v.4.10. The result is a complete representation of the potential onshore, offshore (shallow and deep) wind generating capacity (in MW) broken into four cost classes (described in greater detail below) in each IPM model region. Table 4-17, Table 4-18 , and Table 4-19 present the onshore, offshore shallow, and offshore deep wind resource assumptions that are used in EPA Base Case v.4.10.

Table 4-17 Onshore Regional Potential Wind Capacity (MW) by Wind and Cost Class in EPA Base Case v.4.10

IPM Region	Wind Class	Cost Class			
		1	2	3	4
AZNM	3	707	1,714	44	125,761
	4	42	329	27	33,741
	5	6	2,028	1,612	2,355
	6	214	447	264	512
	7	4	106	144	166
CA-N	3	1,269	--	--	8,646
	4	560	1,069	1,476	1,539
	5	79	631	746	765
	6	286	--	795	740
	7	12	352	--	399
CA-S	3	1,689	--	--	18,014
	4	1,323	1,460	1,402	2,536
	5	380	614	653	831
	6	118	--	435	540
	7	46	--	231	233
COMD	3	2	--	--	62,549
	4	19	260	--	312
DSNY	3	98	599	297	500
	4	64	--	--	268
	5	--	60	--	89
	6	--	--	30	29
	7	--	--	--	29
ENTG	3	1	1	--	2
	5	--	20	--	30
ERCT	3	3,230	--	1,198	321,950
	4	9,912	32,701	2,796	51,392
	5	396	1,415	899	1,484
	6	207	--	512	582
	7	5	--	--	20
GWAY	3	10	--	--	275,467
	4	--	621	580	922
LILC	3	--	--	872	567
	4	--	128	--	194
MACE	3	384	--	925	1,264
	4	9	--	--	163
	5	--	--	--	2
MACS	3	8	--	--	57
	4	2	5	--	10
	5	--	--	--	3
MACW	3	700	1,054	1,747	2,412
	4	182	--	636	477
	5	71	--	200	161
	6	--	26	--	46

IPM Region	Wind Class	Cost Class			
		1	2	3	4
MECS	3	3,571	--	--	35,633
	4	--	--	467	259
	5	--	11	--	12
MRO	3	17	--	--	2,021,548
	4	7	103	163,083	1,010,547
	5	2,052	22,146	68,431	156,014
	6	1,310	1,985	1,380	4,489
NENG	3	1,768	--	--	9,127
	4	737	1,128	--	1,968
	5	364	442	--	969
	6	28	356	471	438
	7	147	--	--	478
NWPE	3	1,913	--	--	630,559
	4	1,891	6,167	7,657	236,910
	5	353	1,058	3,600	50,582
	6	122	1,239	3,823	17,728
	7	205	1,517	755	1,755
PNW	3	216	902	354	74,323
	4	69	322	208	15,515
	5	11	86	122	3,483
	6	34	87	99	1,463
	7	18	116	79	190
RFCO	3	12,199	22,865	8,334	28,239
	4	--	--	--	64
RFCP	3	196	289	4,841	2,976
	4	82	354	--	466
	5	44	--	169	159
	6	41	--	148	96
	7	2	24	--	53
RMPA	3	1,327	--	--	409,831
	4	3,222	4,769	8,447	216,430
	5	2,546	7,038	15,851	58,990
	6	3,149	8,000	11,388	14,741
	7	619	6,188	2,151	6,748
SNV	3	--	--	--	2,707
	4	--	--	--	234
	5	9	--	--	39
	6	1	--	--	11
SOU	3	1	--	2	2
SPPN	3	1	--	--	454,442
	4	1,933	9,618	37,341	163,483
	5	--	--	--	839

IPM Region	Wind Class	Cost Class			
		1	2	3	4
SPPS	3	109	--	69	452,934
	4	2,945	11,388	44,398	349,741
	5	2,660	13,184	--	21,167
	6	3	105	111	170
	7	--	--	--	34
TVA	3	204	--	--	637
	4	--	121	166	155
	5	19	--	56	62
	6	3	--	19	16
	7	--	5	--	12
TVAK	3	4	--	--	220
	4	2	--	17	15
	5	--	--	--	5
	6	--	--	1	--
UPNY	3	--	2,822	3,346	3,675
	4	--	403	--	555
	5	--	95	--	114
	6	--	--	35	25
VACA	3	92	272	--	879
	4	33	60	--	124
	5	8	--	39	44
	6	4	--	30	27
	7	--	7	--	18
VAPW	3	--	261	--	352
	4	13	40	--	100
	5	5	--	34	35
	6	5	--	29	33
	7	--	11	--	17
WUMS	3	371	--	--	130,624
	4	57	49	64	84
	5	--	--	--	41

Table 4-18 Offshore Shallow Regional Potential Wind Capacity (MW) by Wind and Cost Class in EPA Base Case v.4.10

IPM Region	Wind Class	Cost Class		
		1	2	4
CA-N	3	497	995	995
	4	281	561	561
	5	43	86	86
	6	29	59	59
	7	1	3	3
CA-S	3	280	560	560
	4	139	277	277
	5	139	278	278
	6	114	228	228
	7	1	3	3
COMD	3	393	785	785
	4	981	1,963	1,963
DSNY	3	11	22	22
ENTG	3	43,021	86,041	86,041
	4	695	1,390	1,390
ERCT	3	14,372	28,745	28,745
	4	15,191	30,382	30,382
	5	4,457	8,915	8,915
FRCC	3	43,305	86,610	86,610
	4	6,120	12,240	12,240
LILC	3	693	1,385	1,385
	4	1,610	3,220	3,220
	5	1,851	3,703	3,703
	6	530	1,060	1,060
MACE	3	2,745	5,490	5,490
	4	8,161	16,323	16,323
	5	8,838	17,676	17,676
	6	5,123	10,246	10,246
MACS	3	1,066	2,132	2,132
	4	187	374	374
MACW	3	160	319	319
	4	136	271	271
	5	1,320	2,640	2,640
	6	5	11	11
MECS	3	2,349	4,699	4,699
	4	3,850	7,701	7,701
	5	5,451	10,903	10,903
	6	1,886	3,771	3,771
	7	6	13	13
MRO	3	399	798	798
	4	952	1,904	1,904
	5	348	696	696
	6	1	3	3

IPM Region	Wind Class	Cost Class		
		1	2	4
NENG	3	2,326	4,652	4,652
	4	3,134	6,269	6,269
	5	2,989	5,978	5,978
	6	6,157	12,314	12,314
	7	334	667	667
NYC	3	99	198	198
	4	253	506	506
	5	3	5	5
PNW	3	716	1,432	1,432
	4	1,651	3,303	3,303
	5	1,310	2,620	2,620
	6	204	407	407
	7	112	224	224
RFCO	3	686	1,371	1,371
	4	2,298	4,595	4,595
	5	5,664	11,328	11,328
	6	1,963	3,925	3,925
SOU	3	8,466	16,933	16,933
	4	4,903	9,806	9,806
	5	311	621	621
UPNY	3	884	1,768	1,768
	4	859	1,718	1,718
	5	659	1,318	1,318
VACA	3	6,229	12,458	12,458
	4	12,064	24,129	24,129
	5	13,709	27,418	27,418
	6	3,209	6,419	6,419
VAPW	3	1,990	3,981	3,981
	4	3,422	6,843	6,843
	5	3,886	7,772	7,772
	6	3,660	7,321	7,321
WUMS	3	2,272	4,544	4,544
	4	2,902	5,805	5,805
	5	1,832	3,664	3,664
	6	680	1,360	1,360

Table 4-19 Offshore Deep Regional Potential Wind Capacity (MW) by Wind and Cost Class in EPA Base Case v.4.10

IPM Region	Wind Class	Cost Class		
		1	2	4
CA-N	3	4,039	8,077	8,077
	4	25,846	51,693	51,693
	5	9,947	19,894	19,894
	6	21,282	42,565	42,565
	7	19,318	38,636	38,636
CA-S	3	10,721	21,441	21,441
	4	9,247	18,494	18,494
	5	14,402	28,805	28,805
	6	10,140	20,280	20,280
	7	169	339	339
COMD	4	1,028	2,055	2,055
	5	1,100	2,200	2,200
	6	950	1,900	1,900
ENTG	3	13,473	26,945	26,945
	4	10,730	21,461	21,461
ERCT	4	10,501	21,003	21,003
	5	6,548	13,096	13,096
FRCC	3	28,019	56,037	56,037
	4	53,858	107,715	107,715
	5	1,109	2,219	2,219
LILC	4	501	1,002	1,002
	5	431	861	861
	6	15,589	31,178	31,178
	7	5	10	10
MACE	3	11	22	22
	4	140	280	280
	5	1,049	2,099	2,099
	6	22,490	44,979	44,979
MACS	4	7	14	14
MACW	4	29	58	58
	5	557	1,114	1,114
MECS	3	220	439	439
	4	701	1,403	1,403
	5	7,710	15,420	15,420
	6	33,394	66,787	66,787
	7	45	90	90
MRO	3	354	707	707
	4	4,882	9,765	9,765
	5	3,283	6,566	6,566
	6	1,535	3,070	3,070
NENG	3	144	287	287
	4	1,754	3,508	3,508
	5	3,683	7,366	7,366
	6	59,338	118,676	118,676
	7	1,762	3,524	3,524

IPM Region	Wind Class	Cost Class		
		1	2	4
NYC	4	58	116	116
PNW	3	241	482	482
	4	813	1,625	1,625
	5	12,502	25,005	25,005
	6	34,795	69,589	69,589
	7	25,739	51,477	51,477
RFCO	4	9	19	19
	5	1,162	2,323	2,323
	6	507	1,014	1,014
SOU	3	8,765	17,529	17,529
	4	15,055	30,109	30,109
	5	2,169	4,339	4,339
UPNY	3	50	100	100
	4	1,506	3,011	3,011
	5	5,993	11,986	11,986
	6	465	930	930
VACA	4	2	3	3
	5	6,536	13,073	13,073
	6	23,687	47,373	47,373
VAPW	5	151	302	302
	6	16,150	32,300	32,300
WUMS	3	395	790	790
	4	3,533	7,066	7,066
	5	8,073	16,145	16,145
	6	39,059	78,119	78,119

Generation Profiles: Unlike other renewable generation technologies, which dispatch on an economic basis subject to their availability constraint, wind and solar technologies can only be dispatched when the wind blows and the sun shines. To represent intermittent renewable generating sources like wind and solar, EPA Base Case v.4.10 uses generation profiles which specify hourly generation patterns for a representative day in winter and summer. Each eligible model region is provided with a distinct set of winter and summer generation profiles for wind, solar thermal, and solar photovoltaic plants.

For Hour1 through Hour 24 the generation profile indicates the amount of generation (kWh) per MW of available capacity. The wind generation profiles were prepared with data from NREL. This provided the separate winter and summer generation profiles for wind classes 3-7 for onshore and offshore (shallow and deep) generation in each IPM region. (As an illustrative example Appendix 4-1 shows the generation profile for onshore wind in model region CA-N.) In IPM the seasonal average "kWh of generation per MW" (shown in the last row of the example in Appendix 4-1) is used to derive the generation from a particular wind class in a specific model region.

To obtain the seasonal generation for the units in a particular wind class in a specific region, one must multiply the installed capacity by the capacity factor (which represents the ratio of actual productivity in a time period to the theoretical maximum in the period). Capacity factor is the average "kWh of generation per MW" from the applicable generation profile multiplied by the number of days in the time period (i.e., summer or winter) to obtain the level of generation. The capacity factors for wind generation that are used in EPA Base Case v.4.10 were obtained from AEO 2010 and are shown in Table 4-20, Table 4-21, and. Table 4-22

Reserve Margin Contribution (also referred to as capacity credit): EPA Base Case v.4.10 uses reserve margins, discussed in detail in Section 3.6, to model reliability. Each region has a reserve margin requirement which is used to determine the total capacity needed to reliably meet peak demand. The ability of a unit to assist a region in meeting its reliability requirements is modeled through the unit's contribution to reserve margin. If the unit has 100 percent contribution towards reserve margin, then the entire capacity of the unit is counted towards meeting the region's reserve margin requirement. However, if any unit has less than a 100 percent contribution towards reserve margin, then only the designated share of the unit's capacity counts towards the reserve margin requirement.

All units except those that depend on intermittent resources have 100% contributions toward reserve margin. This means that all renewable resource technologies except wind and solar, have 100 percent contribution towards reserve margin in the EPA Base Case v.4.10. (Note Hydro, not considered a renewable technology, also has less than a 100% reserve margin contribution.)

Reserve margin contribution ratios are based on AEO 2010. Table 4-20, Table 4-21, and Table 4-22 present the reserve margin contributions apportioned to new wind plants in the EPA Base Case v.4.10 as derived from AEO 2010. The tables show the onshore and offshore (shallow and deep) reserve margins for each wind class in each model region.

Table 4-20 Onshore Reserve Margin Contribution an Average Capacity Factor by Wind Class and Model Region

IPM Model Region	Wind Class				
	3	4	5	6	7
AZNM	22%	24%	29%	34%	37%
CA-N	14%	16%	19%	22%	24%
CA-S	14%	16%	19%	22%	24%
COMD	18%	20%	--	--	--
DSNY	18%	20%	24%	28%	30%
ENTG	26%	--	35%	--	--
ERCT	19%	21%	25%	29%	32%
GWAY	18%	20%	--	--	--
LILC	18%	20%	--	--	--
MACE	18%	20%	24%	--	--
MACS	18%	20%	24%	--	--
MACW	18%	20%	24%	28%	--
MECS	22%	25%	30%	--	--
MRO	19%	21%	26%	30%	--
NENG	15%	16%	20%	23%	25%
NWPE	25%	28%	33%	39%	42%
PNW	25%	28%	33%	39%	42%
RFCO	22%	25%	--	--	--
RFCP	22%	25%	30%	35%	38%
RMPA	22%	24%	29%	34%	37%
SNV	22%	24%	29%	34%	--
SOU	26%	--	--	--	--
SPPN	24%	27%	33%	--	--
SPPS	24%	27%	33%	38%	42%
TVA	26%	29%	35%	41%	44%
TVAK	22%	25%	30%	35%	--
UPNY	18%	20%	24%	28%	--
VACA	26%	29%	35%	41%	44%
VAPW	26%	29%	35%	41%	44%
WUMS	18%	20%	24%	--	--
Average Annual Capacity Factor	29%	33%	39%	46%	50%

Table 4-21 Offshore Shallow Reserve Margin Contribution an Average Capacity Factor by Wind Class and Model Region

IPM Model Region	Wind Class				
	3	4	5	6	7
CA-N	15%	17%	20%	24%	25%
CA-S	15%	17%	20%	24%	25%
COMD	19%	21%	--	--	--
DSNY	19%	--	--	--	--
ENTG	27%	30%	--	--	--
ERCT	20%	22%	26%	--	--
FRCC	19%	21%	--	--	--
LILC	19%	21%	25%	29%	--

IPM Model Region	Wind Class				
	3	4	5	6	7
MACE	19%	21%	25%	30%	--
MACS	19%	21%	--	--	--
MACW	19%	21%	25%	30%	--
MECS	23%	26%	31%	37%	39%
MRO	20%	22%	27%	32%	--
NENG	15%	17%	21%	24%	26%
NYC	19%	21%	25%	--	--
PNW	26%	29%	35%	41%	44%
RFCO	23%	26%	31%	37%	--
SOU	27%	30%	36%	--	--
UPNY	19%	21%	25%	--	--
VACA	27%	30%	36%	43%	--
VAPW	27%	30%	36%	43%	--
WUMS	19%	21%	25%	30%	--
Average Annual Capacity Factor	31%	34%	41%	48%	52%

Table 4-22 Offshore Deep Reserve Margin Contribution an Average Capacity Factor by Wind Class and Model Region

IPM Model Region	Wind Class				
	3	4	5	6	7
CA-N	15%	17%	20%	24%	26%
CA-S	15%	17%	20%	24%	26%
COMD	--	21%	26%	30%	--
ENTG	27%	30%	--	--	--
ERCT	--	22%	26%	--	--
FRCC	18%	21%	25%	--	--
LILC	--	21%	25%	30%	32%
MACE	19%	21%	25%	30%	--
MACS	--	21%	--	--	--
MACW	--	21%	25%	--	--
MECS	23%	26%	31%	37%	40%
MRO	20%	23%	27%	32%	--
NENG	15%	17%	21%	24%	26%
NYC	--	21%	--	--	--
PNW	26%	29%	35%	41%	45%
RFCO	--	26%	31%	37%	--
SOU	27%	30%	36%	--	--
UPNY	19%	21%	25%	30%	--
VACA	--	30%	36%	43%	--
VAPW	--	--	36%	43%	--
WUMS	19%	21%	26%	30%	--
Average Annual Capacity Factor	31%	35%	41%	49%	53%

Capital cost calculation: EPA Base Case v.4.10 uses multipliers similar to the LT (long term) multipliers from the Energy Information Administration's NEMS model[25] to capture differences in the capital cost of new wind capacity caused by such factors as distance from existing transmission, terrain variability, slope and other causes of resource degradation, site accessibility challenges, population proximity, competing land uses, aesthetics, and environmental factors. Four cost classes are used in EPA Base Case v.4.10 with class 1 having the lowest cost adjustment factor (1) and class 4 having the highest adjustment factor (ranging from 2.48 to 2.67 depending on the model region and whether the wind resource is onshore, offshore shallow or offshore deep), as shown in Table 4-23. To the obtain the capital cost for a particular new wind model plant, the base capital costs shown in Table 4-16 are multiplied by the cost adjustment factor for the wind cost class applicable to the new plant.

Table 4-23 Capital Cost Adjustment Factors for New Wind Plants in Base Case v.4.10

	Cost Class			
	1	**2**	**3**	**4**
Onshore	1	1.2	1.5	2.5[1]
Offshore Deep Water	1	1.35	--	2.5
Offshore Shallow Water	1	1.35	--	2.5

Note:
[1]The Cost Adjustment Factor for Cost Class 4 Onshore is 2.5 for the majority of regions. Exceptions are as follows:
ERCT has a Cost Adjustment Factor for Cost Class 4 Onshore of 2.62
AZNM, RMPA, and SNV have a Cost Adjustment Factor for Cost Class 4 Onshore of 2.66
NWPE, PNW, SPPN, SPPS, and MRO have a Cost Adjustment Factor for Cost Class 4 Onshore of 2.67

Many factors figure in whether the model determines that adding wind capacity yields the greatest incremental improvement in the system-wide (least cost) solution available to the model at a particular point in the solution process. These factors include trade-offs between such items as the cost, capacity factor, reserve margin contribution, and dispatch capabilities and constraints on the new wind capacity relative to other choices. However, to perform its trade-off computations, the model requires the values described above.

As an illustrative example, Table 4-24 shows the calculations that would be performed to derive the potential electric generation, reserve margin contribution, and cost of new (potential) onshore capacity in wind class 7, cost class 2 in the CA-N model region in run year 2020.

[25]Revising the Long Term Multipliers in NEMS: Quantifying the Incremental Transmission Costs Due to Wind Power, Report to EIA from Princeton Energy Resources International, LLC. May 2007.

Table 4-24 Example Calculations Of Wind Generation Potential, Reserve Margin Contribution, And Capital Cost For Onshore Wind In CA-N At Wind Class 7, Cost Class 2

Required Data

Table 4-17	Potential wind capacity (C) =	352 MW
Appendix 4-1	Winter average generation (G_W) per available MW per hour =	559 kWh/MW
Appendix 4-1	Summer average generation (G_S) per available MW per hour =	422 kWh/MW
	Hours in Winter (H_W) season (October – April) =	5,088 hours
	Hours in Summer (H_S)season (May – September) =	3,672 hours
Table 4-20	Reserve Margin Contribution (RM) CA-N, Wind Class 7 =	24 percent
Table 4-16	Capital Cost (Cap_{2020}) in vintage range for year 2020 =	\$1,912/kW
Table 4-23	Capital Cost Adjustment Factor ($CAF_{ON,C2}$) for onshore cost class 2 =	1.2
Table 4-15	Regional Factor (RF)	1.058

Calculations

$$\begin{aligned} Generation\ Potential &= C \times G_W \times H_w + C \times G_S \times H_s \\ &= 352\,MW \times 559\,kWh/MW \times 5088\,hours + \\ &\quad 352\,MW \times 422\,kWh/MW \times 3672\,hours \\ &= 1{,}546\,GWh \end{aligned}$$

$$\begin{aligned} \text{Reserve Margin Contribution} &= RM \times C \\ &= 24\% \times 352\,MW \\ &= 84\,MW \end{aligned}$$

$$\begin{aligned} Capital\ Cost &= \text{Cap}_{2020} \times \text{CAF}_{\text{ON,C2}} \times RF \times C \\ &= \$1{,}912/\text{MW} \times 1.2 \times 1.058 \times 352 MW \\ &= \$854\ million\ dollars \end{aligned}$$

Solar Generation

Solar Resource Potential: No explicit constraint limit is placed on solar electric capacity in EPA Base Case v.4.10. However, since solar thermal is only feasible in areas with sufficient direct isolation, EPA Base Case v.4.10 includes the assumption that new solar thermal plants can only be built west of the Mississippi River. Solar photovoltaic is not limited to specific parts of the country.

Generation profiles: Like wind, solar is an intermittent renewal technology. Since it can only be dispatched when the sun shines, not on a strictly economic basis, it is represented in EPA Base Case v.4.10 with generation profiles which specify hourly generation patterns for typical winter and summer days in each eligible region. The generation profiles were prepared with data from AEO 2010, which provided separate winter and summer generation profiles for solar thermal and photovoltaic in each eligible IPM region. As an illustrative example, Appendix 4-2 shows the solar thermal and solar photovoltaic winter and summer generation profiles in model region AZNM.

Reserve margin contribution: The procedure described above for calculating the reserve margin contributions for wind generation was also used for solar generation. Table 4-25 presents the winter and summer average capacity factors (CFs) and reserve margin contributions by model region for new solar thermal and photovoltaic units in EPA Base Case v.4.10. The region-specific summer and winter capacity factors included in this table are metrics that provide a shorthand depiction of the hourly specific generation profiles for each region. They are based on AEO 2010 data. The assumptions in EPA Base Case v.4.10 for capacity factors and reserve margin contributions for existing units are also based on AEO 2010.

Table 4-25 Solar Reserve Margin Contribution and Average Capacity Factor by Model Region

Model Region	Solar Thermal			Solar Photovoltaic		
	Winter Average Capacity Factor	Summer Average Capacity Factor	Reserve Margin Contribution	Winter Average Capacity Factor	Summer Average Capacity Factor	Reserve Margin Contribution
AZNM	30%	42%	43%	25%	28%	28%
CA-N	32%	51%	53%	23%	28%	28%
CA-S	32%	51%	53%	23%	28%	28%
COMD				19%	23%	24%
DSNY				17%	22%	22%
ENTG				21%	23%	23%
ERCT	26%	35%	36%	22%	24%	25%
FRCC				23%	23%	23%
GWAY				19%	23%	24%
LILC				17%	22%	22%
MACE				18%	22%	23%
MACS				18%	22%	23%
MACW				18%	22%	23%
MECS				17%	23%	23%
MRO	18%	34%	36%	20%	23%	24%
NENG				19%	22%	23%
NWPE	23%	41%	18%	18%	25%	16%
NYC				17%	22%	22%
PNW	23%	41%	18%	18%	25%	16%
RFCO				17%	23%	23%
RFCP				17%	23%	23%
RMPA	30%	42%	43%	25%	28%	28%
SNV	30%	42%	43%	25%	28%	28%
SOU				21%	23%	23%
SPPN	22%	35%	37%	22%	24%	25%
SPPS	22%	35%	37%	22%	24%	25%
TVA				21%	23%	23%
TVAK				17%	23%	23%
UPNY				17%	22%	22%
VACA				21%	23%	23%
VAPW				21%	23%	23%
WUMS				19%	23%	24%

Geothermal Generation

Geothermal Resource Potential: Six model regions in EPA Base Case v.4.10 have geothermal potential. The potential capacity in each of these regions is shown in Table 4-26. The values are based on AEO 2010 data.

Table 4-26 Regional Assumptions on Potential Geothermal Electric Capacity

IPM Model Region	Capacity (MW)
AZNM	2,216
CA-N	662
CA-S	124
NWPE	4,555
PNW	1,336
RMPA	70
Grand Total	**8,963**

Note:
This data is a summary of the geothermal data used in EPA Base Case v.4.10

Cost Calculation: EPA Base Case v.4.10 does not contain a single capital cost, but multiple geographically-dependent capital costs for geothermal generation. The assumptions for geothermal were developed using AEO 2010 cost and performance estimates for 88 known sites. Both dual flash and binary cycle technologies[26] were represented. In EPA Base Case v.4.10 the 88 sites were collapsed into 26 different options based on geographic location and cost and performance characteristics of geothermal sites in each of the six eligible IPM regions where geothermal generation opportunities exist. Table 4-27 shows the potential geothermal capacity and cost characteristics for applicable model regions.

Table 4-27 Potential Geothermal Capacity and Cost Characteristics by Model Region

IPM Region	Capacity (MW)	Capital Cost (2007$)	FO&M (2007$/kW-yr)
AZNM	1,404	4,002	185.1
	196	4,675	206.8
	316	5,650	201.1
	294	7,744	192.2
	6	9,199	218.8
CA-N	575	1,624	185.1
	7	2,873	185.1
	80	4,214	206.2
CA-S	71	4,957	185.1
	48	5,679	185.1
	5	6,817	185.1

[26] In dual flash systems, high temperature water (above 400°F) is sprayed into a tank held at a much lower pressure than the fluid. This causes some of the fluid to "flash," i.e., rapidly vaporize to steam. The steam is used to drive a turbine, which, in turn, drives a generator. In the binary cycle technology, moderate temperature water (less than 400°F) vaporizes a secondary, working fluid which drives a turbine and generator. Due to its use of more plentiful, lower temperature geothermal fluids, these systems tend to be most cost effective and are expected to be the most prevalent future geothermal technology.

IPM Region	Capacity (MW)	Capital Cost (2007$)	FO&M (2007$/kW-yr)
NWPE	9	6,255	164.1
	24	8,337	164.1
	103	9,776	168.6
	1,165	11,465	179.6
	3,001	20,674	181.7
	137	4,523	185.1
	67	5,380	183.0
	12	3,428	218.8
	28	4,594	185.1
	9	8,210	185.1
PNW	268	3,890	151.5
	36	4,782	151.5
	420	5,211	156.3
	612	5,625	190.3
RMPA	70	5,820	185.1

Landfill Gas Electricity Generation

Landfill Gas Resource Potential: Estimates of potential electric capacity from landfill gas are based on the AEO 2010 inventory. EPA Base Case v.4.10 represents 3 categories of potential landfill gas units; "hi", "low", and "very low". The categories refer to the amount and rate of methane production from the existing landfill site. Table 4-28 summarizes potential electric capacity from landfill gas used in EPA Base Case v.4.10.

There are several things to note about Table 4-28. Since the potential electric capacity from new landfill gas units is based on AEO 2009, the limits listed in Table 4-28 apply to the NEMS (National Energy Modeling System) regions indicated in column 1. In EPA Base Case v.4.10 the sum of the new landfill gas electric capacity in the corresponding IPM regions shown in column 2 cannot exceed the limits shown in columns 3-5. As noted earlier, the capacity limits for three categories of potential landfill gas units are distinguished in this table based on the rate of methane production at three categories of landfill sites: LGHI = high rate of landfill gas production, LGLo = low rate of landfill gas production, and LGLVo = very low rate of landfill gas production. The values shown in Table 4-28 represent an upper bound on the amount of new landfill capacity that can be added in each of the indicated model regions for each of the three landfill categories.

The cost and performance assumptions for adding new capacity in each of the three landfill categories are presented in Table 4-16.

Table 4-28 Regional Assumptions on Potential Electric Capacity from New Landfill Gas Units (MW)

NEMS Region	IPM Region	Class		
		LGHI	LGLo	LGLVo
ECAR	RFCO, MECS, RFCP, TVAK	72	30	539
ERCOT	ERCT	12	26	316
MAAC	MACE, MACS, MACW	93	22	311
MAIN	WUMS, COMD, GWAY	83	92	495
MAPP	MRO	43	22	150
NY	DSNY, LILC, NYC, UPNY	54	27	142
NE	NENG	62	6	51
FL	FRCC	14	26	158

NEMS Region	IPM Region	Class		
		LGHI	LGLo	LGLVo
STV	SOU, TVA, ENG, VACA, VAPW	68	22	447
SPP	SPPN, SPPS	5	-	185
NWP	PNW, NWPE	27	58	185
RA	AZNM, SNV, RMPA	-	-	91
CNV	NA-N, CA-S	131	250	749
US		664	581	3,819

4.5 Nuclear Units

4.5.1 Existing Nuclear Units

Population, Plant Location, and Unit Configuration: To provide maximum granularity in forecasting the behavior of existing nuclear units, all 105 nuclear units in EPA Base Case v.4.10 are represented by separate model plants. As noted in Table 4-7 the 105 nuclear units include 104 currently operating units plus Watts Bar Nuclear Plant, Unit 2, which is scheduled to come online in 2014. All are listed in Appendix 4-3. The population characteristics, plant location, and unit configuration data in NEEDS, v.4.10 were obtained primarily from EIA Form 860 and AEO 2010.

Capacity: Nuclear units are baseload power plants with high fixed (capital and fixed O&M) costs and low variable (fuel and variable O&M) costs. Due to their low VOM and fuel costs, nuclear units are run to the maximum extent possible, i.e., up to their availability. Consequently, a nuclear unit's capacity factor is equivalent to its availability. Thus, EPA Base Case v.4.10 uses capacity factor assumptions to define the upper bound on generation from nuclear units. Nuclear capacity factor assumptions in EPA Base Case v.4.10 are based on an Annual Energy Outlook projection algorithm. The nuclear capacity factor projection algorithm is described below:

- For each reactor, the capacity factor over time is dependent on the age of the reactor.
- Capacity factors increase initially due to learning, and decrease in the later years due to aging.
- For individual reactors, vintage classifications (older and newer) are used.
- For the older vintage (start before 1982) nuclear power plants, the performance peaks at 25 years:
  - o Before 25 years: Performance increases by 0.5 percentage point per year;
  - o 25-60 years: Performance remains flat; and
- • For the newer vintage (start in or after 1982) nuclear power plants, the performance peaks at 30 years:
  - o Before 30 years: Performance increases by 0.7 percentage points per year;
  - o 30-60 years: Performance remains flat; and
- The maximum capacity factor is assumed to be 90 percent. That is, any given reactor is not allowed to grow to a capacity factor higher than 90 percent. However, if a unit began with a capacity factor above 90 percent, it is allowed to retain that capacity factor. Given historical capacity factors above 90 percent, the projected capacity factors range from 89 percent to 93 percent.

Cost and Performance: Unlike non-nuclear existing conventional units discussed in section 4.2.7, emission rates are not needed for nuclear units, since there are no SO_2, NO_X, CO_2, or mercury emissions from nuclear units.

As with other generating resources, EPA Base Case v.4.10 uses variable operation and maintenance (VOM) costs and fixed operation and maintenance (FOM) costs to characterize the cost of operating nuclear units. The heat rate, FOM, and VOM values from AEO 2010, which were used to characterize the cost and performance of existing nuclear units in EPA Base Case v.4.10 are shown in Appendix 4-03.

EPA Base Case v.4.10 also uses the nuclear capacity uprates from AEO 2010. These are shown in Table 4-29.

4.5.2 Potential Nuclear Units

The cost and performance assumptions for nuclear potential units that the model has the option to build in EPA Base Case v.4.10 are shown in Table 4-13 above. The cost assumptions were updated as part of the comparative analysis performed by EPA's power sector engineering staff. That update is described above in section 4.4.1.

Table 4-29 Nuclear Upratings (MW) as Incorporated in EPA Base Case v.4.10 from AEO 2010

Name	Plant ID	Unit ID	Year	Change in MWs
Arkansas Nuclear One	8055	1	2016	50.0
Arkansas Nuclear One	8055	2	2016	59.0
Brunswick	6014	1	2014	56.3
Brunswick	6014	2	2014	56.2
Byron Generating Station	6023	1	2019	116.4
Byron Generating Station	6023	2	2019	11.4
Catawba	6036	1	2016	67.7
Catawba	6036	2	2016	67.7
Duane Arnold	1060	1	2015	34.8
Fermi	1729	2	2016	67.0
Grand Gulf	6072	1	2015	76.7
Harris	6015	1	2017	54.0
Joseph M Farley	6001	1	2017	51.0
Joseph M Farley	6001	2	2017	52.0
Limerick	6105	1	2018	113.4
Limerick	6105	2	2018	113.4
McGuire	6038	1	2014	110.0
McGuire	6038	2	2014	110.0
Oconee	3265	1	2017	51.0
Oconee	3265	2	2017	51.0
Oconee	3265	3	2017	51.0
Peach Bottom	3166	2	2014	66.7
Peach Bottom	3166	3	2014	66.7
Perry	6020	1	2016	74.0
PSEG Salem Generation	2410	1	2015	70.4
PSEG Salem Generation	2410	2	2015	67.8
Quad Cities Generation	880	1	2013	52.0
Quad Cities Generation	880	2	2013	52.0
Sequoyah	6152	1	2013	69.0
Sequoyah	6152	2	2013	68.0
South Texas Project	6251	1	2013	76.8
South Texas Project	6251	2	2013	76.8
Surry	3806	1	2015	47.9
Surry	3806	2	2015	47.9
V C Summer	6127	1	2015	58.0
Waterford 3	4270	3	2016	69.1
Wolf Creek Generation	210	1	2017	70.0
Watts Bar Nuclear Plant	7722	2	2014	1,180

Appendix 4-1 Representative Wind Generation Profiles in EPA Base Case v.4.10

Illustrative Hourly Wind Generation Profile (kWh of Generation per MW of Electricity)

Winter Hour	Wind Class				
	3	**4**	**5**	**6**	**7**
01	268	361	492	504	635
02	268	359	488	503	633
03	269	355	483	498	629
04	263	345	464	483	613
05	253	326	430	454	580
06	243	310	396	424	544
07	236	297	374	402	518
08	233	291	372	395	514
09	230	282	371	391	511
10	227	276	372	389	510
11	225	276	374	391	510
12	226	280	376	394	508
13	226	283	376	396	505
14	228	287	381	400	507
15	227	288	385	402	511
16	228	289	390	404	517
17	231	289	394	406	524
18	240	296	405	415	538
19	250	309	423	433	558
20	259	325	444	453	580
21	267	339	464	473	601
22	271	350	479	488	618
23	271	357	488	498	629
24	268	360	491	502	633
Winter Average	**246**	**314**	**421**	**437**	**559**

Summer Hour	Wind Class				
	3	**4**	**5**	**6**	**7**
01	380	410	456	591	555
02	374	402	444	583	546
03	366	391	422	566	523
04	350	368	387	535	479
05	326	334	337	489	413
06	299	295	286	433	344
07	282	261	250	389	295
08	292	256	248	384	293
09	320	270	269	408	316
10	348	296	298	442	348
11	368	320	320	466	368
12	381	340	331	480	373
13	388	354	334	484	370
14	393	365	341	489	372
15	393	372	350	496	383
16	390	371	361	501	398
17	384	358	369	501	414
18	377	340	371	496	421
19	375	331	378	496	431
20	374	335	386	500	440
21	378	354	402	518	464
22	382	381	424	546	498
23	384	401	444	572	529
24	382	409	455	586	547
Summer Average	**362**	**346**	**361**	**498**	**422**

Notes:
Based on Onshore Wind in Model Region CA-N.
This is an example of the wind data used in EPA Base Case v.4.10

Appendix 4-2 Representative Solar Generation Profiles in EPA Base v.4.10

Illustrative Hourly Solar Generation Profile (kWh of Generation per MW of Electricity)

Winter Hour	Solar Thermal	Solar Photovoltaic
01	3	0
02	3	0
03	3	0
04	3	0
05	3	0
06	181	29
07	181	29
08	601	660
09	601	660
10	601	660
11	601	660
12	601	660
13	601	660
14	601	660
15	601	660
16	601	660
17	601	660
18	601	660
19	181	29
20	181	29
21	181	29
22	181	29
23	181	29
24	181	29
Winter Average	**336**	**312**

Summer Hour	Solar Thermal	Solar Photovoltaic
01	9	0
02	9	0
03	9	0
04	9	0
05	9	0
06	284	13
07	284	13
08	720	610
09	720	610
10	720	610
11	720	610
12	720	610
13	720	610
14	720	610
15	720	610
16	720	610
17	720	610
18	720	610
19	284	13
20	284	13
21	284	13
22	284	13
23	284	13
24	284	13
Summer Average	**426**	**284**

Notes:

Based on model region AZNM.

This is an example of the solar data used in EPA Base Case v.4.10

Appendix 4-3 Characteristics of Existing Nuclear Units

Region	State	Plant Name	ORIS Code_Unit Id	On-Line Year	Capacity (MW)	Heat Rate (Btu/kWh)	FOM (2007$ /kW-yr)	VOM (2007 mills/kWh)
AZNM	Arizona	Palo Verde	6008_1	1986	1,311	10,427	117.2	0.50
		Palo Verde	6008_2	1986	1,352	10,427	117.2	0.55
		Palo Verde	6008_3	1988	1,283	10,427	117.2	0.52
CA-N	California	Diablo Canyon	6099_1	1985	1,122	10,427	132.1	0.71
		Diablo Canyon	6099_2	1986	1,118	10,427	132.1	0.70
CA-S	California	San Onofre	360_2	1983	1,070	10,427	208.6	1.00
		San Onofre	360_3	1984	1,080	10,427	208.6	1.05
COMD	Illinois	Braidwood Generation Station	6022_1	1988	1,178	10,427	129.7	0.57
		Braidwood Generation Station	6022_2	1988	1,152	10,427	129.7	0.59
		Byron Generating Station	6023_1	1985	1,164	10,427	126.4	0.57
		Byron Generating Station	6023_2	1987	1,136	10,427	126.4	0.56
		LaSalle Generating Station	6026_1	1984	1,118	10,427	157.9	0.75
		LaSalle Generating Station	6026_2	1984	1,120	10,427	157.9	0.76
		Dresden Generating Station	869_2	1970	867	10,427	203.6	0.89
		Dresden Generating Station	869_3	1971	867	10,427	203.6	0.95
		Quad Cities Generating Station	880_1	1972	867	10,427	177.3	0.83
		Quad Cities Generating Station	880_2	1972	867	10,427	177.3	0.83
DSNY	New York	Indian Point 2	2497_2	1973	1,020	10,427	227.3	1.40
		Indian Point 3	8907_3	1976	1,025	10,427	199.2	0.96
ENTG	Arkansas	Arkansas Nuclear One	8055_1	1974	836	10,427	152.6	0.63
		Arkansas Nuclear One	8055_2	1980	988	10,427	152.6	0.65
	Louisiana	Waterford 3	4270_3	1985	1,152	10,427	162.7	0.61
		River Bend	6462_1	1986	967	10,427	193.7	1.03
	Mississippi	Grand Gulf	6072_1	1985	1,266	10,427	134.8	0.54

Region	State	Plant Name	ORIS Code_Unit Id	On-Line Year	Capacity (MW)	Heat Rate (Btu/kWh)	FOM (2007$ /kW-yr)	VOM (2007 mills/kWh)
ERCT	Texas	Comanche Peak	6145_1	1990	1,202	10,240	120.0	0.61
		Comanche Peak	6145_2	1993	1,202	10,317	120.0	0.63
		South Texas Project	6251_1	1988	1,280	10,427	121.6	0.59
		South Texas Project	6251_2	1989	1,280	10,427	121.6	0.58
FRCC	Florida	St Lucie	6045_1	1976	839	10,427	142.3	0.64
		St Lucie	6045_2	1983	714	10,427	142.3	0.71
		Turkey Point	621_3	1972	693	10,427	146.8	0.67
		Turkey Point	621_4	1973	693	10,427	146.8	0.66
		Crystal River	628_3	1977	851	10,427	181.5	0.81
GWAY	Illinois	Clinton Power Station	204_1	1987	1,043	10,427	200.1	0.97
	Missouri	Callaway	6153_1	1984	1,190	10,427	139.7	0.74
MACE	New Jersey	PSEG Salem Generating Station	2410_1	1977	1,174	10,427	159.9	0.77
		PSEG Salem Generating Station	2410_2	1981	1,130	10,427	159.9	0.79
		Oyster Creek	2388_1	1969	619	10,427	255.1	1.17
		PSEG Hope Creek Generating Station	6118_1	1986	1,196	10,427	147.5	0.84
	Pennsylvania	Limerick	6105_1	1986	1,134	10,427	127.6	0.55
		Limerick	6105_2	1990	1,134	10,427	127.6	0.54
MACS	Maryland	Calvert Cliffs Nuclear Power Plant	6011_1	1975	885	10,427	155.2	0.75
		Calvert Cliffs Nuclear Power Plant	6011_2	1977	874	10,427	155.2	0.72
MACW	Pennsylvania	Peach Bottom	3166_2	1974	1,112	10,427	172.7	0.81
		Peach Bottom	3166_3	1974	1,112	10,427	172.7	0.80
		PPL Susquehanna	6103_1	1983	1,283	10,427	172.1	0.89
		PPL Susquehanna	6103_2	1985	1,288	10,427	172.1	0.88
		Three Mile Island	8011_1	1974	786	10,427	170.9	0.82
MECS	Michigan	Fermi	1729_2	1988	1,122	10,427	155.9	0.80
		Palisades	1715_1	1972	778	10,427	197.2	1.14

Region	State	Plant Name	ORIS Code_Unit Id	On-Line Year	Capacity (MW)	Heat Rate (Btu/kWh)	FOM (2007$ /kW-yr)	VOM (2007 mills/kWh)
MRO	Iowa	Duane Arnold	1060_1	1975	581	10,427	208.4	1.11
	Minnesota	Monticello	1922_1	1971	646	10,427	187.8	1.02
		Prairie Island	1925_1	1974	551	10,427	162.3	0.82
		Prairie Island	1925_2	1974	545	10,427	162.3	0.83
	Nebraska	Fort Calhoun	2289_1	1973	478	10,427	219.4	1.19
		Cooper	8036_1	1974	767	10,427	223.6	1.29
NENG	Connecticut	Millstone	566_2	1975	882	10,427	205.4	1.10
		Millstone	566_3	1986	1,236	10,427	192.2	1.02
	Massachusetts	Pilgrim Nuclear Power Station	1590_1	1972	685	10,427	241.6	1.06
	New Hampshire	Seabrook	6115_1	1990	1,244	10,427	178.7	0.94
	Vermont	Vermont Yankee	3751_1	1972	620	10,427	203.8	1.06
PNW	Washington	Columbia Generating Station	371_2	1984	1,131	10,427	152.1	0.73
RFCO	Michigan	Donald C Cook	6000_1	1975	1,029	10,942	174.9	1.05
		Donald C Cook	6000_2	1978	1,077	10,848	174.9	1.08
	Ohio	Perry	6020_1	1987	1,231	11,000	160.1	0.80
		Davis Besse	6149_1	1977	887	11,000	158.1	0.90
RFCP	Pennsylvania	Beaver Valley	6040_1	1976	887	10,962	190.3	0.96
		Beaver Valley	6040_2	1987	887	10,946	190.3	0.90
SOU	Alabama	Joseph M Farley	6001_1	1977	851	11,794	138.5	0.71
		Joseph M Farley	6001_2	1981	860	11,650	138.5	0.68
	Georgia	Edwin I Hatch	6051_1	1975	876	10,427	146.9	0.77
		Edwin I Hatch	6051_2	1979	883	10,427	146.9	0.78
		Vogtle	649_1	1987	1,172	10,427	145.6	0.66
		Vogtle	649_2	1989	1,169	10,427	145.6	0.65
SPPN	Kansas	Wolf Creek Generating Station	210_1	1985	1,166	10,427	137.7	0.71

Region	State	Plant Name	ORIS Code_Unit Id	On-Line Year	Capacity (MW)	Heat Rate (Btu/kWh)	FOM (2007$ /kW-yr)	VOM (2007 mills/kWh)
TVA	Alabama	Browns Ferry	46_1	1974	1,225	10,550	99.9	0.40
		Browns Ferry	46_2	1975	1,286	10,215	99.9	0.42
		Browns Ferry	46_3	1977	1,337	10,215	99.9	0.40
	Tennessee	Sequoyah	6152_1	1981	1,150	10,123	115.4	0.48
		Sequoyah	6152_2	1982	1,127	10,202	115.4	0.45
		Watts Bar Nuclear Plant	7722_1	1996	1,121	10,266	139.1	0.64
		Watts Bar Nuclear Plant	7722_2	2014	1,180	10,266	92.4	0.49
UPNY	New York	Nine Mile Point Nuclear Station	2589_1	1969	621	10,427	193.5	0.98
		Nine Mile Point Nuclear Station	2589_2	1969	1,311	10,427	188.9	0.97
		James A Fitzpatrick	6110_1	1976	852	10,427	203.0	0.90
		R. E. Ginna Nuclear Power Plant	6122_1	1970	498	10,427	205.8	0.92
VACA	North Carolina	Brunswick	6014_1	1977	938	10,318	110.6	0.46
		Brunswick	6014_2	1975	937	10,397	110.6	0.46
		Harris	6015_1	1987	900	10,982	131.3	0.60
		McGuire	6038_1	1981	1,100	10,427	119.6	0.48
		McGuire	6038_2	1984	1,100	10,427	119.6	0.50
	South Carolina	H B Robinson	3251_2	1971	710	10,697	119.8	0.59
		Oconee	3265_1	1973	846	10,427	139.6	0.73
		Oconee	3265_2	1974	846	10,427	139.6	0.65
		Oconee	3265_3	1974	846	10,427	139.6	0.72
		Catawba	6036_1	1985	1,129	10,427	134.0	0.64
		Catawba	6036_2	1986	1,129	10,427	134.0	0.64
		V C Summer	6127_1	1984	966	10,427	143.5	0.80
VAPW	Virginia	Surry	3806_1	1972	799	10,427	120.7	0.58
		Surry	3806_2	1973	799	10,427	120.7	0.57
		North Anna	6168_1	1978	940	10,427	98.7	0.47
		North Anna	6168_2	1980	925	10,427	98.7	0.50

Region	State	Plant Name	ORIS Code_Unit Id	On-Line Year	Capacity (MW)	Heat Rate (Btu/kWh)	FOM (2007$ /kW-yr)	VOM (2007 mills/kWh)
WUMS	Wisconsin	Point Beach	4046_1	1970	599	10,427	202.3	0.97
		Point Beach	4046_2	1972	601	10,427	202.3	1.00
		Kewaunee	8024_1	1974	556	10,427	151.5	0.85