Prepared For:

Eastern Interconnection Planning Collaborative

MRN-NEEM Modeling Assumptions and Data Sources

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1. INTRODUCTION

This document focuses on the basic data inputs to the MRN-NEEM model to enable review and refinement by the Eastern Interconnection Planning Collaborative ("EIPC") The MRN-NEEM model combines two state-of-the-art economic models: the Multi-Region National (MRN) model and the North American Electricity and Environment Model (NEEM). This integrated modeling approach provides a robust framework for examining electricity sector specific impacts in detail while also understanding the economy-wide impacts of specific climate policies.

For the EIPC project, Charles River Associates ("CRA") will use the integrated MRN-NEEM model to maintain macro-economic consistency among futures and within a set of sensitivities for a given future. An MRN-NEEM solution is a general equilibrium solution, meaning that all markets in the economy are at equilibrium. The primary reason that a general equilibrium solution is desirable in assessing energy markets is that significant policies (e.g., carbon policies) can affect energy demand growth and relative fuel prices. Such policies can also affect the penetration of electric vehicles, increasing electricity demand and reducing gasoline demand. Because energy is an input to most products in the economy, a carbon policy ripples through the entire economy affecting relative prices. NEEM is strictly a model of the electric sector so it cannot assess these macroeconomic dynamics when run as a stand-alone model. However, there may be situations where CRA will run NEEM by itself, typically for the purpose of sensitivity analysis.

This document begins with an overview of the integrated MRN-NEEM model. We then discuss the NEEM portion of the integrated model and then the MRN portion of the integrated model. Since running the MRN-NEEM model involves running NEEM and MRN in succession (until convergence is achieved between the two models), it is helpful to conceptualize and discuss the models separately.

2. MRN-NEEM OVERVIEW

2.1. OVERVIEW OF THE MRN SUB-MODEL

The top-down component of the integrated MRN-NEEM model is tailored from CRA's Multi-Region National (MRN) model. MRN is a forward-looking, dynamic computable general equilibrium (CGE) model of the United States. It is based on the theoretical concept of an equilibrium in which macro-level outcomes are driven by the decisions of self-interested consumers and producers. The basic structure of CGE models, such as MRN, is built around a circular flow of goods and payments between households, firms, and the government, as illustrated in Figure 1.

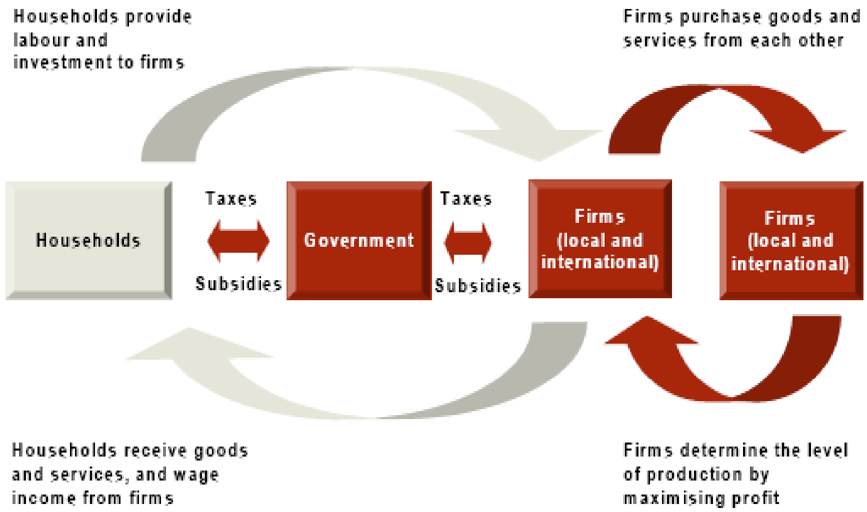


Figure 1. Circular Flow of Goods and Services and Payment

2.2. Overview of the NEEM Sub-model

The North American Electricity and Environment Model (NEEM) is a flexible, partial equilibrium model of the North American electricity sector that can simultaneously model both system expansion and environmental compliance over a 30- to 50-year timeframe.

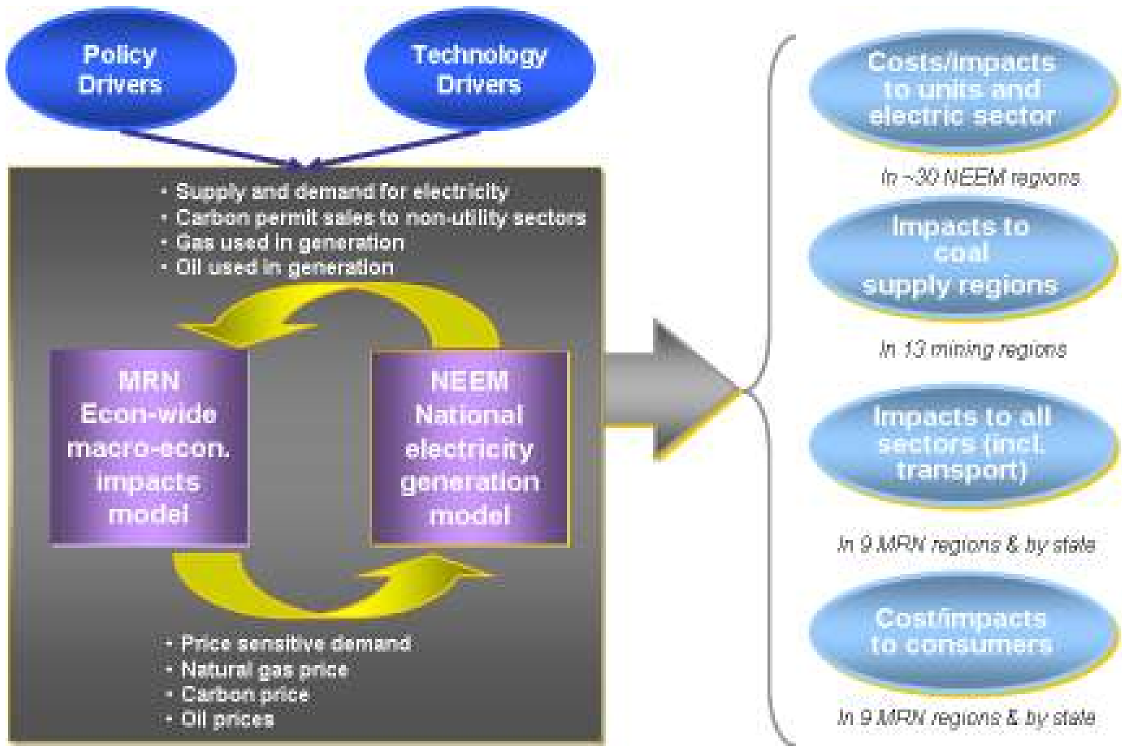
NEEM was developed by CRA to analyze the impact of environmental policy and major economic drivers on the electricity sector. The model calculates the “least-cost solution” to serve load, while complying with environmental policies and meeting resource adequacy requirements and major transmission constraints. NEEM can be used to model both regional and national environmental policies including direct taxes on emissions, emission caps, command-and-control policies, as well as renewable portfolio standards. In addition to forecasting zonal electricity and emissions prices, NEEM optimizes retirements, environmental retrofits, and construction of generating capacity.

The model employs detailed unit-level information on all of the generating units in the United States and large portions of Canada. In general, coal units of 200 MW or greater are represented individually in the model, and other unit types are aggregated within each NEEM region. NEEM models the evolution of the North American power system; taking into account demand growth, currently installed generation, future available generation technologies, pollution control technologies, and environmental regulations both present and future. The North American interconnected power system is modeled as a set of regions that are connected by a network of transmission paths. This paradigm is also referred to as a “transport model” or a “pipes-and-bubbles” model. Transfer limits are specified between the bubbles.

2.3. MRN-NEEM Integration Methodology

The MRN-NEEM integration methodology follows an iterative procedure to link top-down and bottom-up models. The method utilizes an iterative process where the MRN and NEEM models are solved in succession, reconciling the equilibrium prices and quantities between the two models. The solution procedure, in general, involves an iterative solution of the top-down general equilibrium model (MRN) given the net supplies from the bottom-up electric sector sub-model (NEEM), followed by the solution of the electric sector model (NEEM) based on a locally calibrated set of linear demand functions for the electric sector. The two models are solved independently using different solution techniques but are integrated through iterative solution points (see Figure 2).

Figure 2. MRN-NEEM Iterative Process



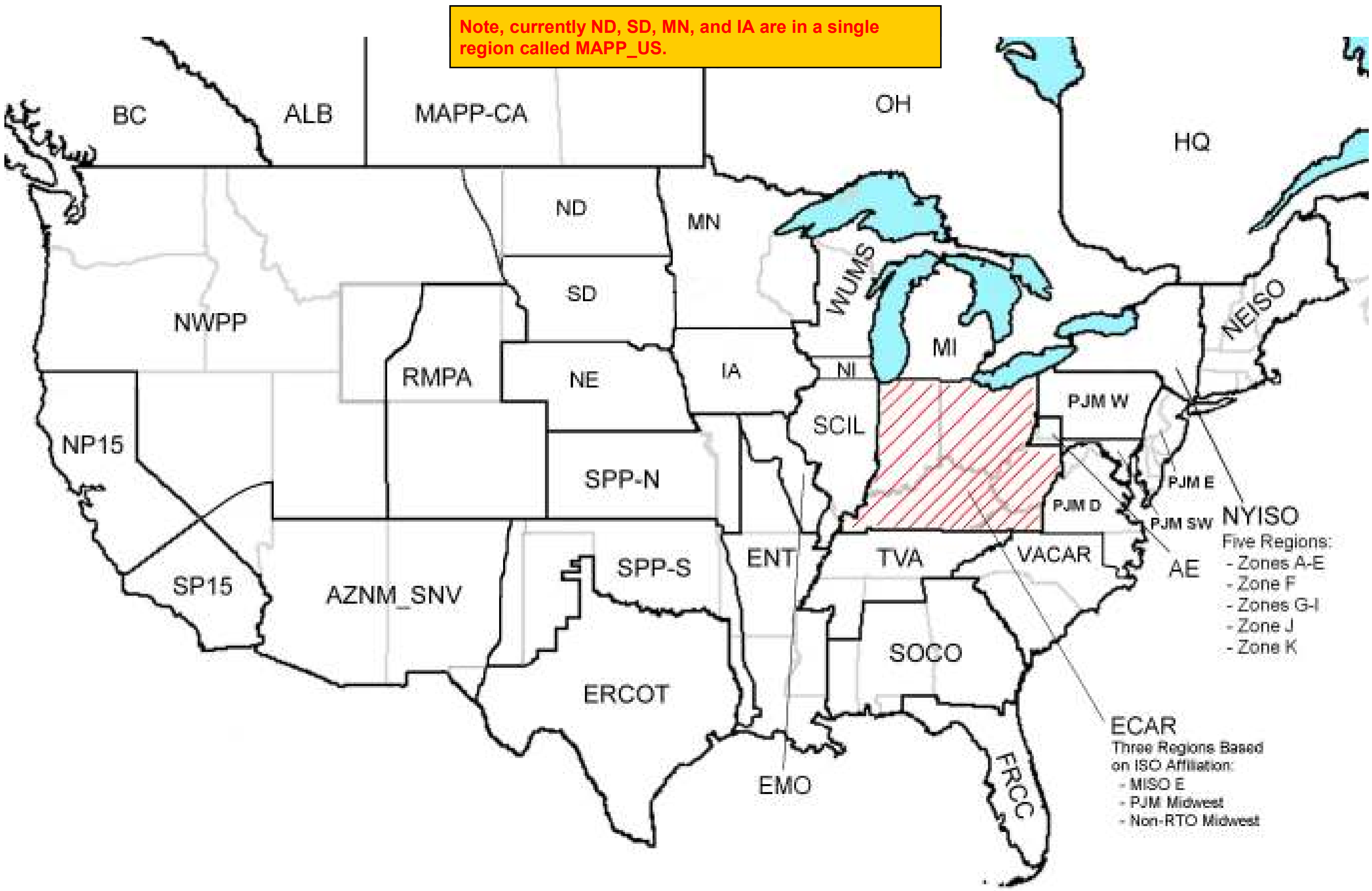
3. NEEM INPUTS AND DATA SOURCES

Unless otherwise noted, all financial data are reported in constant 2010 dollars.

3.1. NEEM REGIONS

Figure 3 contains a map of the 38 NEEM regions in the U.S. and Canada. As noted above, transmission constraints are not considered within a NEEM region, and transfer limits are used to represent transmission limitations between NEEM regions. The NEEM regions can be modified, but will require a breakdown of the load and generation and other regional input parameters for any additional regions. Presently NEEM regions do not include Maritimes provinces of Canada which are part of the Eastern Interconnection, i.e. New Brunswick and Nova Scotia. These provinces could be added to the model if appropriate information is provided to CRA.

Figure 3. NEEM Regions



3.2. ENERGY AND PEAK DEMAND

NEEM is a load-duration curve model. The typical NEEM model includes 20 load blocks, broken down as shown in Table 1. The total sums to 8,760 hours. Each region has a load-duration curve for the summer, the winter, and the shoulder seasons. The summer is defined as May through September; the winter includes December, January, and February; and the shoulder period includes March, April, October, and November.

The NEEM data file includes energy demand by NEEM region by load block by year. The data file also includes peak energy demands by NEEM region by year. In general, CRA bases regional energy and peak demands on forecasts provided by Regional Transmission Organizations (RTOs) where available or otherwise are taken from FERC 714 filings. For EIPC, CRA will use the RTO and FERC 714 forecasts for the next 10 years (e.g., 2020[1]). Beyond 2020, we will use the growth rates implied by AEO 2010 for the period of time between 2020 and 2035 (2035 is the end of the AEO 2010 forecast). After 2035, we will maintain the 2020-2035 growth rates through 2050.

Since there are fewer regions in NEEM than EIA uses to create the AEO forecasts, we will proportionally adjust the growth rates for the last five years of the 714 and RTO forecasts (e.g., 2016-2020) to match the aggregate growth rates in AEO 2010 during the period after 2020. This will maintain differences in growth among NEEM regions (implied by FERC 714 filings and RTO forecasts) that comprise a single AEO region. For example, if two NEEM regions comprise one AEO region and one NEEM region has a high growth rate (in the last 5 years of the 714 forecast) while the other has a low growth rate (in the last 5 years of the 714 forecast), we will adjust each of these proportionally while meeting the AEO region's growth rate overall. Thus, in the post-2020 period, we will have AEO 2010 regional growth rates in the aggregate, with finer detail at the NEEM regional level based on the last five years of the FERC 714 and RTO forecasts. In regard to peak load after 2020, we will apply the same growth rate to peak as to energy (by NEEM region).

The annual energy demand is shaped into the load blocks. The load shapes used in NEEM are based upon 2006 actual load profiles from FERC Form 714 utility filings. Within each interconnection (western, eastern, ERCOT), the loads are sorted using the same chronology. This means that each region's load shape relates to all others within the interconnection according to the actual loads during 2006. The chronologies are different for the three separate interconnections.

[1] There may be some deviation from 2020 by region based on the available data.

Table 1: NEEM Load Blocks

Load Block	Season	Number of Hours
B1	Summer	10
B2	Summer	25
B3	Summer	75
B4	Summer	100
B5	Summer	200
B6	Summer	300
B7	Summer	400
B8	Summer	500
B9	Summer	800
B10	Summer	1,262
B11	Shoulder	25
B12	Shoulder	200
B13	Shoulder	600
B14	Shoulder	900
B15	Shoulder	1,203
B16	Winter	25
B17	Winter	100
B18	Winter	400
B19	Winter	700
B20	Winter	935
TOTAL		8760

The Energy Forecast by NEEM region is presented in Table 2, using the methodology discussed above. Control entities are mapped to NEEM regions as shown in Appendix A, Exhibit 1.

Table 2. Energy Forecast by NEEM Region

NEEM Region	2011 Energy (GWh)	2011-2020 Growth Rate	2020-2050 Growth Rate
AE	51,488	1.23%	0.82%
AZ_NM_SNV_Coal	124,203	1.88%	1.50%
EMO	65,661	1.06%	0.80%
ENT	140,835	1.31%	0.64%
ERCOT	316,195	1.69%	0.73%
FRCC	229,020	1.74%	1.30%
MAPP_US	159,237	0.79%	0.79%
MI	94,678	0.80%	0.70%
MISO_E	127,182	0.70%	0.65%
NE	29,481	1.81%	1.39%
NEISO	132,370	0.93%	0.90%
NI	107,579	2.35%	1.07%
NonRTO_Midwest	70,069	1.46%	1.10%
NP15	110,014	0.94%	0.77%
NWPP_Coal	246,983	1.30%	1.08%
NYISO_Capital	11,422	0.38%	0.35%
NYISO_Downstate	20,093	0.82%	0.51%
NYISO_LIPA	22,290	1.07%	0.83%
NYISO_NYC	52,697	0.95%	0.58%
NYISO_Upstate	53,942	0.80%	0.37%
PJM_D	100,466	2.31%	1.27%
PJM_E	151,269	1.50%	0.67%
PJM_Midwest	245,376	1.16%	0.56%
PJM_SW	70,368	1.37%	0.83%
PJM_W	79,664	1.62%	0.72%
RMPA	72,067	1.21%	1.21%
SCIL	52,155	0.77%	0.56%
SOCO	249,461	1.94%	1.11%
SP15	179,898	1.31%	1.21%
SPP_N	75,954	1.10%	1.04%
SPP_S	163,927	1.15%	0.80%
TVA	193,342	1.01%	0.31%
VACAR	236,109	1.62%	1.03%
WUMS	70,306	0.78%	0.51%
ALB	64,239	1.57%	1.41%
BC	63,168	1.15%	0.96%
OH	160,334	0.79%	0.59%

The peak demand forecast is presented in Table 3, using the methodology discussed above.

Table 3. Peak Demand Forecast by NEEM Region

NEEM Region	Reserve Margin Region	2011 Peak (MW)	2011-2020 Growth Rate	2020-2050 Growth Rate
AE	PJM	8,872	1.24%	0.82%
AZ_NM_SNV_Coal	AZ_NM_SNV	27,169	1.91%	1.50%
EMO	MISO	14,107	1.05%	0.80%
ENT	ENT	25,442	1.20%	0.64%
ERCOT	ERCOT	64,964	1.69%	0.73%
FRCC	FRCC	45,382	1.79%	1.30%
MAPP_US	MISO	32,116	0.76%	0.79%
MI	MI	19,930	0.78%	0.70%
MISO_E	MISO	25,494	0.68%	0.65%
NE	SPP	5,580	1.52%	1.39%
NEISO	NEISO	27,393	1.30%	0.90%
NI	PJM	23,372	2.01%	1.07%
NonRTO_Midwest	NonRTO_Midwest	12,100	1.14%	1.10%
NP15	CA	24,248	1.24%	0.77%
NWPP_Coal	NWPP	41,760	1.01%	1.08%
NYISO_Capital	NYISO	2,328	0.47%	0.35%
NYISO_Downstate	NYISO	4,366	0.67%	0.51%
NYISO_LIPA	NYISO	5,384	0.77%	0.83%
NYISO_NYC	NYISO	11,775	0.68%	0.58%
NYISO_Upstate	NYISO	9,207	0.76%	0.37%
PJM_D	PJM	20,488	2.41%	1.27%
PJM_E	PJM	33,727	1.39%	0.67%
PJM_Midwest	PJM	43,342	1.23%	0.56%
PJM_SW	PJM	14,800	1.44%	0.83%
PJM_W	PJM	13,318	1.43%	0.72%
RMPA	RMPA	12,556	1.34%	1.21%
SCIL	MISO	11,099	0.75%	0.56%
SOCO	SOCO	48,104	2.18%	1.11%
SP15	CA	35,048	1.31%	1.21%
SPP_N	SPP	15,530	1.92%	1.04%
SPP_S	SPP	32,752	1.06%	0.80%
TVA	TVA	34,986	1.59%	0.31%
VACAR	VACAR	46,538	1.53%	1.03%
WUMS	MISO	14,336	0.82%	0.51%
ALB	ALB	9,176	1.63%	1.41%
BC	BC	11,441	1.16%	0.96%
OH	OH	27,207	1.07%	0.64%

3.3. EXISTING GENERATOR INFORMATION

Aggregation of Units

The NEEM data file includes all existing generators in the United States and in selected regions of Canada. This includes coal-fired, natural gas-fired, steam oil/gas, nuclear, and renewable units. For purposes of model flexibility and solution speed many of the units are aggregated together based on unit type and unit size, as well as the location of the unit.

All existing coal units that are 200 MW or greater (based on summer capacity) are represented individually and not included in aggregates.

Coal units less than 200 MW and located within the same region are included in one of the three aggregates based on their capacity:

- Up to 100 MW (1_Coal)
- Between 100 MW and 150 MW (2_Coal)
- Between 150 MW and 200 MW (3_Coal)

In each region, natural gas and oil fired units are aggregated based on their heat rates:

Combined cycles:

- Up to 7,400 Btu/kWh (CC1)
- Between 7,400 and 8,200 Btu/kWh (CC2)
- Between 8,200 and 9,000 Btu/kWh (CC3)
- Greater than 9,000 Btu/kWh (CC4)

Gas-fired peakers:

- Up to 14,000 Btu/kWh (PeakG_1)
- Greater than 14,000 Btu/kWh (PeakG_2)

Oil-fired peakers:

- Up to 14,000 Btu/kWh (PeakO_1)
- Greater than 14,000 Btu/kWh (PeakO_2)

Steam Oil/Gas units in each region are aggregated on the basis of their heat rates:

- Up to 14,000 Btu/kWh (STOG1)
- Greater than 14,000 Btu/kWh (STOG_2)

All other types of units (*e.g.*, nuclear, wind, *etc.*) are aggregated together within each region.

Coal Unit Characteristics

The operating data for existing coal units in NEEM includes: installed capacity, planned outage days (PODays), forced outage rates, heat rates (MMBtu/MWh), unit types, planned and existing retrofit technologies, and plant configurations. NEEM also contains unit emission rates for NO_X and CO_2,[2] and information about the current coal being burned by each unit.

Data on the coal units comes from a number of sources. The source of the coal units operating in the United States is predominantly from EIA Form 816 and ES&D Database and matched against Energy Velocity data. Existing plant configuration also comes from a number of sources including the EIA Form 767, McIlvaine's database of controls, quarterly CEMS filings, and monitoring of the trade press. Planned outage information is from NERC Generating Availability Data System ("GADS") and is based on the plant type and unit size (for coal units). Forced outage rates also come from GADS. NO_x emission rates, planned and existing retrofits, installed capacities, and heat rates are the primarily based on data from Energy Velocity and cross-checked by CRA staff.

Information on each coal unit's initial coal is based on coal deliveries to that plant in the most recent year for which data is available.

Other Fossil-Fired Unit Characteristics

Important characteristics for the natural gas and oil-fired units are similar to those for the coal units. The set of existing natural gas-fired and oil-fired units is regularly pulled from an Energy Velocity data set based on NERC ES&D, EIA 860, CEMS and other data sources. NO_X emissions rates, installed capacities, and heat rates are based on Energy Velocity cross-checked by CRA staff. Planned and forced outage rates for these units are based on GADS.

Nuclear Unit Characteristics

Information on nuclear units is available from many sources including NERC ES&D, Nuclear Energy Institute, and GADS. Outage information has been set such that the capacity factor for nuclear generators is 89 percent (29 planned outage days and 3.2% forced outage rate), which is slightly below the capacity factor of the U.S. nuclear fleet over the last several years. Since nuclear generators will operate full out, the other important characteristic besides outages is capacity. Over the last several years many nuclear generators have increased their rated capacity through uprates. Many others are projected to add uprates over the next several years. NEEM includes these projected uprates based on AEO 2008 information.

Operations and Maintenance (O&M) Costs for Existing Units

Fixed and variable O&M costs ("FOM" and "VOM") for existing units are built up from base assumptions. CRA assumes a base FOM cost for each technology type using standard industry assumptions. Additions for necessary capital expenditures, retrofitting, and refurbishment are applied to the base cost. Necessary capital expenditure charges are applicable only to coal units and are assumed a constant $17/kW-yr in 2007$ ($17.90/kW-yr in 2010$). Retrofitting FOM is applicable only to coal units and covered in the Retrofits section of this document. Refurbishment charges are applied at the end of the unit's operating life, which is 60 years for coal units and nuclear units and 30 years for gas and oil-fired units. Refurbishment FOM for existing renewable units is not considered in NEEM.

Variable O&M is based on industry standard assumptions. Existing retrofits on coal units will increase the VOM on these units by the calculated retrofit VOM for that unit and type of retrofit

[2] SO2 and Hg emissions depend on the coal choice in NEEM.

(see Retrofits section). VOM for non-coal units consists solely of the base VOM. Table 4 shows existing unit FOM and VOM assumptions.

Table 4: Existing Operations & Maintenance costs (without Retrofits)

Unit Type	FOM ($2010/kW-yr)	VOM ($2010/MWh)
Coal	48.67	3.56
CC	29.68	2.37
Peak Gas	16.62	8.31
Peak Oil	22.55	8.31
STOG	37.15	2.37
Nuclear	112.77	2.37
Hydro	14.24	NA
Pumped Storage	23.74	NA
Photovoltaic	14.66	NA
Solar Thermal	60.32	NA
Wind	34.22	NA
Steam Wood	32.05	2.37
Landfill Gas	120.65	NA
Geothermal	89.76	NA

Renewables Characteristics

NEEM includes information on existing renewables generation including: hydroelectric, wind, geothermal, solar, biomass, and landfill gas. The capacity in each region is also based on information from Energy Velocity and is regularly updated. The intermittency of wind generation is simulated using hourly wind profile data aggregated into the load blocks using the 2006 chronology, consistent with the load block definitions.[3] The contribution of renewable resources toward reserve margin is shown on Table 5.

[3] Hourly wind dataset is NREL Eastern Wind Integration and Transmission study and Western Wind and Solar Integration study. Annual capacity factors are based on the 2004-2006 average capacity factors in the NREL dataset.

Table 5: Reserve Margin Contribution of Renewable Resources

NEEM Region	Technology	Reserve Contribution
All Regions	Photovoltaic	30%
All Regions	Solar Thermal	30%
California	Wind	25%
Canada	Wind	20%
ERCOT	Wind	9%
New York	Wind	10%
PJM	Wind	13%
SPP	Wind	6%
All Other Regions	Wind	15%

Installed Capacity by Region (all technologies)

Table 6 presents installed electric sector generation capacity by NEEM region as of 2010 for all technologies. Generators are mapped to NEEM regions based on the mapping in Appendix A, Exhibit 2.

Table 6: Installed Capacity by NEEM Region

NEEM Region	Installed Capacity - 2010 (GW)	Reserve Capacity - 2010 (GW)
AE	10.63	10.61
AZ_NM_SNV	10.91	10.91
EMO	13.40	13.18
ENT	42.75	42.75
ERCOT	85.28	77.13
FRCC	56.65	56.61
MAPP_US	39.21	34.03
MI	26.47	26.33
MISO_E	30.91	30.46
NE	8.27	8.14
NEISO	37.53	37.35
NI	28.59	27.17
NonRTO_Midwest	14.60	14.55
NP15	31.46	30.61
NWPP_Coal	13.97	13.97
NYISO_Capital	3.14	3.14
NYISO_Downstate	6.53	6.53
NYISO_LIPA	5.75	5.75
NYISO_NYC	9.90	9.90
NYISO_Upstate	16.33	15.18
PJM_D	22.62	22.39
PJM_E	31.95	31.93

NEEM Region	Installed Capacity - 2010 (GW)	Reserve Capacity - 2010 (GW)
PJM_Midwest	48.47	47.86
PJM_SW	12.44	12.44
PJM_W	32.27	31.64
RMPA	16.23	15.04
SCIL	15.17	14.98
SOCO	65.41	65.41
SP15	33.76	32.19
SPP_N	19.26	18.11
SPP_S	42.39	40.23
TVA	39.17	39.14
VACAR	48.36	48.35
WUMS	18.09	16.99
ALB	12.27	11.74
BC	14.13	14.04
OH	37.14	36.10
Grand Total	**1,001.41**	**972.86**

3.4. NEW GENERATOR INFORMATION

NEEM allows for the addition of a range of new generation types. These additions include both forced new generation, which is the result of new generation that is already under construction, and economic new generation, which is the result of additions to both lower total system costs and to comply with planning reserve requirements. Forced builds in general include new generation that is already under construction and is therefore likely to be completed. Information on units under construction is obtained from Energy Velocity as well as from trade publications.

A list of forced new builds is provided Appendix A, Exhibit 3 and a list of forced retirements is included in Appendix A, Exhibit 4.

NEEM currently allows the following types of new generation: natural gas combined cycle ("CC"), natural gas combustion turbine ("CT"), pulverized coal ("AC"), nuclear, integrated gasification combined cycle ("IGCC," also available with carbon capture/sequestration), and a range of renewable technologies. Renewable technologies include: wind ("WT"), solar photovoltaic ("PV"), solar thermal ("ST"), landfill gas ("LG"), biomass ("BM"), and geothermal ("GEO").

Costs and characteristics for these technologies are based on CRA research of public information and client data. The primary data source is EIA's AEO 2010 for baseline cost assumptions. New addition costs are shown in Table 7.[4]

[4] Renewables capital costs are exclusive of federal investment tax credits, federal cash grants, or the first-cost equivalent of the production tax credit. AEO 2010 does not assume extension of these federal subsidies, thus they are not reflected in long-term capital costs. Such policies could be modeled in NEEM, if desirable.

Table 7. New Build Costs and Characteristics

	Capital Costs		Performance Data			
Technology	AEO2010 Base Overnight Costs in 2010 (2008$/kW)	Long-Term All-in Capital Cost (2010$/kW)	Total FOM (2010$/kW-yr)	Total VOM (2010$/MWh)	2010 Heat Rate - HHV (Btu/kWh)	Long-Term Heat Rate - HHV (Btu/kWh)
Nuclear	3,308	4,374	122.34	0.52	10,488	10,488
Advanced Coal	2,078	2,440	29.00	4.83	9,200	8,740
CC	937	1,124	13.15	2.18	7,196	6,333
CT	653	786	12.76	3.76	10,788	8,550
IGCC	2,401	2,813	40.72	3.08	8,765	7,450
IGCC w/seq	3,427	4,102	48.57	4.68	10,781	8,307
Wind	1,837	2,298	31.91	0.01	NA	NA
Wind Offshore	3,492	4,406	89.54	0.01	NA	NA
Photovoltaic	5,879	6,840	12.31	0.01	NA	NA
Solar Thermal	4,798	5,714	59.80	0.01	NA	NA
Landfill Gas	2,430	2,982	120.33	0.01	13,648	13,648
Biomass	3,414	4,171	67.88	7.07	9,451	7,765
Geothermal A	1,666	2,066	173.40	0.01	NA	NA

New build costs in NEEM vary by region. Regional multipliers are provided in Appendix A, Exhibit 5. Regional multipliers are approximations of geographic cost differences based on EIA's AEO 2003. Regional cost factors have not been reported in subsequent editions of AEO although CRA has confirmed that EIA continues to use these same assumptions. They can be changed as needed and as new information arises.

Certain new generating technologies are unlikely to be available in all regions for resource or other reasons (e.g., regulatory). For example, there are not any new geothermal opportunities in Georgia. As a result, all generating options are not available in all regions. Also, some of the generating technologies are not currently commercially produced. For example, no new nuclear plants have been built in the United States in more than twenty years and IGCC with carbon capture/sequestration may not be available for some extended period of time. In these instances, the first year available is set well out into the future to reflect the technological barriers that must still be overcome. These inputs can vary by case.

To avoid large quantities of installations of certain generation types in a single year, NEEM also includes limits on how much of different generation types can be built annually in different years. For example, while the first nuclear power plant might become operational in 2015, it is unlikely that there will be 20 new plants in that year. Therefore, a user can enter annual limits on the quantities of given technologies that can be built in U.S. or for particular regions.

The maximum penetration over time in the U.S. or by region can also be specified. Regional constraints on new entry by technology are specified in Appendix A, Exhibit 6. The limits in the tables are based on publicly available sources and CRA's own assessments. For onshore and offshore wind, they are based on the base case from NREL's WinDS model assessment, mapped to the NEEM regions. They can be changed as needed and as new information arises.

3.5. RETROFITS

The NEEM data file includes environmental retrofits for existing coal-fired units to reduce emissions of SO_2, NO_X, Hg and CO_2. There is also a fuel switch option that requires capital investment.

Retrofit options currently include: flue gas desulfurization ("FGD") for removal of SO_2, selective catalytic reduction ("SCR"), and selective non-catalytic reduction ("SNCR") for removal of NO_X. Mercury retrofits include activated carbon injection ("ACI90") and ACI with a fabric filter ("RPJ90"). There is also a carbon capture and sequestration ("SEQ") retrofit to reduce CO_2 emissions, although this technology is not currently available and is not likely to be widely available for about ten years.

CRA's typical sources for information on the cost of retrofitting existing units with new emission control technologies are listed in Appendix A, Exhibit 7. The capital cost information for retrofits was initially based on EPA estimates included in documentation of the IPM model.[5] Capital costs and performance data for SNCR are still based on EPA estimates. Capital and performance costs for FGDs are now built up from the new methodology in EPA's IPM Model for Wet FGD technologies.[6] The base capital costs on FGDs include equipment, installation, buildings, foundations, electrical, minor physical/chemical wastewater treatment and retrofit difficulty.

The base cost is then increased by engineering and construction management costs, labor costs, and contractor profit and fees. The final project cost will further include financing and additional project costs. The fixed O&M costs for FGD installation are a function of additional operations staff, maintenance and labor materials, and administrative labor costs. The variable O&M costs are a function of reagent use and water costs, waste disposal, supplementary power costs, and water costs. Table 8 shows an example of the FGD retrofit costs for an uncontrolled coal unit of gross size 500 MW, heat rate 9,500 Btu/kWh, and an SO_2 rate of 3 lbs/MMBtu.

Table 8: Example of FGD Retrofit Costs

Retrofit	Unit Size (MW)	Capital Cost (2010$/kW)	Fixed O&M ($2010/kW-yr)	Variable O&M ($2010/MWh)
FGD	500	507.97	8.27	1.84

Cost curves for NO_x and mercury emissions controls have been developed from research by J Edward Chicanowicz. Capital costs and Fixed O&M for an SCR retrofit follows the following methodology:

$$\text{Capital Cost}_{SCR} = -44.3 * \ln(\text{Gross Unit Capacity in MW}) + 546.4$$

[5] EPA's model documentation of retrofit costs is available at http://www.epa.gov/airmarkets/epa-ipm/bc5emission.pdf.

[6] IPM Model – Revisions to Cost and Performance for APC Technologies. Sargent & Lundy 2010. http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/v410/Appendix51A.pdf.

$\text{Fixed O\&M}_{SCR} = 0.5\ \% * \text{Capital Cost}_{SCR}$

Variable O&M costs are based on the sum of the costs for labor, fuel, reagent, auxiliary power, and catalyst supply. Table 9 shows an example of the SCR retrofit costs for an uncontrolled coal unit with a capacity of 500 MW.

Table 9: Example of SCR Retrofit Costs

Retrofit	Unit Size (MW)	Capital Cost (2010$/kW)	Fixed O&M ($2010/kW-yr)	Variable O&M ($2010/MWh)
SCR	500	278.42	1.39	0.54

Capital and performance costs for mercury data are also from Chicanowicz research.[7] CRA models an option Advanced Carbon Injection ("ACI") technology for units currently equipped with a fabric filter. For units lacking a fabric filter, CRA models the cost of the mercury retrofit as the sum of a fabric filter installation and an ACI retrofit installation. The capital cost and FOM are a function of gross unit size; the VOM is a function of several assumptions regarding sorbent and disposal costs.

$\text{Capital Cost}_{ACI} = 1237.4 * (\text{Gross Unit Capacity in MW})^{-0.846}$

$\text{Capital Cost}_{FF} = 3071.7 * (\text{Gross Unit Capacity in MW})^{-0.4999}$

$\text{Fixed O\&M}_{ACI} = 68.02 * (\text{Gross Unit Capacity in MW})^{-0.894}$

$\text{Fixed O\&M}_{FF} = 15.174 * (\text{Gross Unit Capacity in MW})^{-0.584}$

Table 10 shows an example of the costs of installing an ACI and/or Fabric Filter for an uncontrolled coal unit with a capacity of 500 MW.

Table 10: Example of Hg Retrofit Costs

Retrofit	Unit Size (MW)*	Capital Cost (2010$/kW)	Fixed O&M ($2010/kW-yr)	Variable O&M ($2010/MWh)
ACI	500	7.21	0.29	0.37
FF	500	153.85	0.45	NA
ACI + FF	500	161.06	0.74	0.37

The effectiveness of different retrofits can be a function of the current plant configuration and/or the type of coal burned. The FGD retrofit is assumed to achieve a 98 percent incremental

7 Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Figure B-7]

reduction in SO_2 emissions. It is important to note that installation of the FGD retrofit results in a 2.1 percent heat rate penalty and a 2.1 percent capacity penalty.

Reductions of NO_X emission from SCR and SNCR vary depending on the initial NO_X rate of the coal unit. The SCR retrofit can provide a maximum incremental reduction of 90 percent and the SNCR can provide a maximum incremental reduction of 35 percent, but there is a minimum post-control NO_X rate that depends on the plant configuration and coal type. If the unit burns PRB fuel then the retrofit can reduce the NO_X rate to a minimum of 0.045 lbs/MMBtu. However, if the unit has either a cyclone boiler or a wet bottom boiler, then the minimum NO_X rate is 0.10 lbs/MMBtu. All other plant configurations are assumed to have a minimum NO_X rate of 0.06 lbs/MMBtu. The assumed effectiveness of both ACI90 and RPJ90 is a 90 percent incremental removal. This removal is incremental to any co-benefits achieved through any other equipment. Removal efficiencies, heat rate penalties, and capacity penalties are based on CRA's internal research. They are assumptions to the model and can be changed by the user.

In addition to forced retrofits, NEEM is capable of making economic retrofit decisions designed to minimize total costs in the model. For example, under a cap-and-trade policy, the model will select retrofits that minimize the costs associated with achieving the policy goal – taking into account both the costs of available retrofit technologies and the opportunity costs associated with replacing existing generating facilities with newer ones. Under an emission price policy, the model will only select retrofits that have a cost per ton removed lower than the specified emission price. Under a command-and-control policy, the model will either select the least-expensive retrofits to achieve compliance or it will retire the unit.

In addition to pollution control retrofits, coal units that do not currently have the capability to burn sub-bituminous coals[8] can add a fuel switch retrofit. This retrofit covers the costs of boiler modifications and coal handling equipment that would likely result from the addition of the capability of burning sub-bituminous fuels. This retrofit has a capital cost of between $90/kW and $120/kW for aggregate coal units and is $60/kW for stand-alone coal units. There is also a $0.50/MWh variable cost adder along with a 7.0 percent heat rate penalty and a 7.0 percent capacity penalty.

CRA's model also contains information about planned retrofits based on Energy Velocity. For modeling purposes, it is assumed that these retrofits will occur, but their FOM, VOM, & capital costs are the same as other new retrofits. Appendix A, Exhibit 8 provides a list of the planned retrofits currently in the model.

3.6. DISCOUNT RATE/COST OF CAPITAL

The discount rate is an important input because the model minimizes the *present value* of total system costs. Also, emissions allowance prices will tend to rise at the discount rate in the presence of emissions banking. The cost of capital/discount rate in the model is in real (i.e., net of inflation) terms and is 5%. (All MRN/NEEM calculations and results are in real dollars).

The cost of capital/discount rate must also be used in the construction of the build-up of the real capital charge rates used for new investments. These real capital charges rates are assessed

[8] Coal units that have the capability to burn sub-bituminous coals are denoted with a 1 in the "CanBurnPRB" field on the ExistingUnitData worksheet.

using the tax life and assumed operating life of each type of new asset to yield a zero (i.e., compensatory) net present value to investors. The capital charge rates for new construction are summarized in .

Table 11. Real Capital Charge Rates for New Construction

Technology	Operating Life (yrs)	FCR
NG Combined-Cycle	25	11.30%
NG Combustion Turbine	20	11.80%
Advanced Pulverized Coal, Coal IGCC, Coal IGCC-CCS	40	10.50%
Nuclear	40	11.20%
Photvoltaics	20	11.80%
Biomass	30	11.60%
Landfill Gas	20	11.80%
Wind	20	11.80%
Solar Thermal	20	11.80%
Geothermal	20	11.80%

3.7. EMISSIONS

One of the primary functions of NEEM is to determine compliance strategies with different environmental policies. NEEM has the flexibility to model many different types of environmental policies and in many forms.

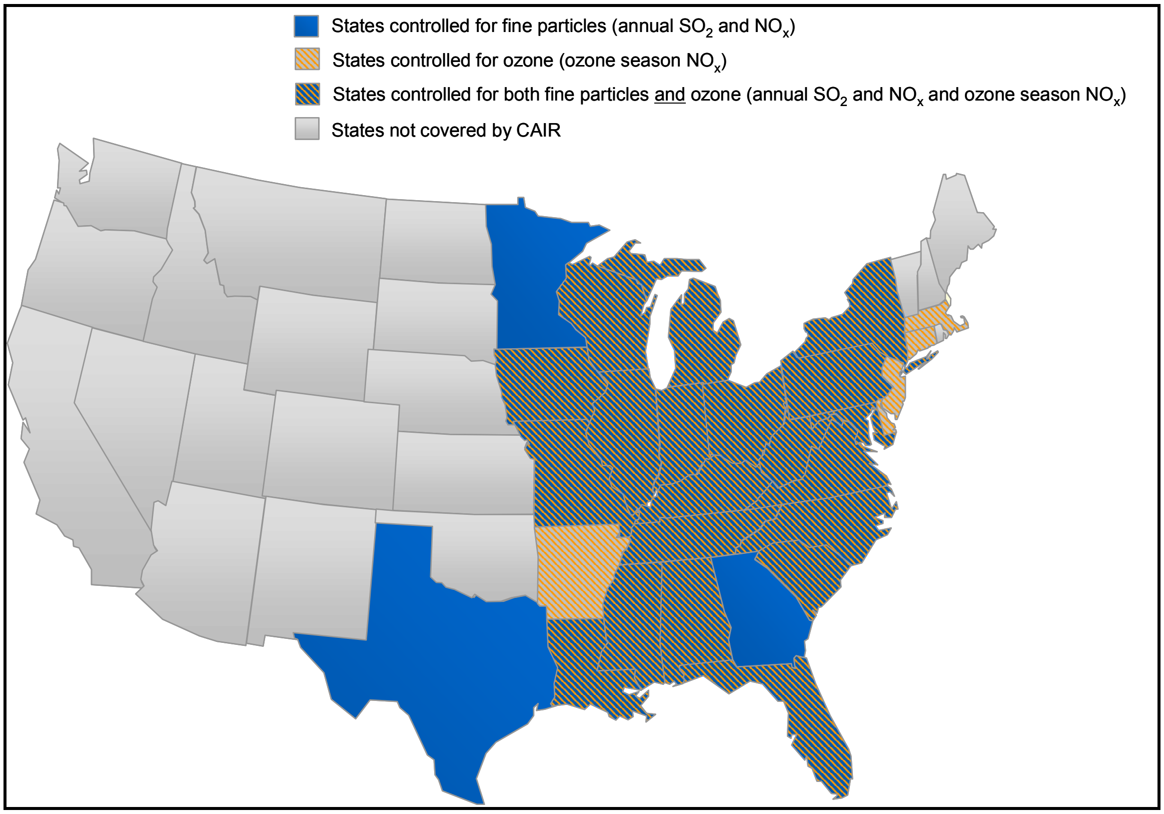
NEEM can model environmental policies affecting SO_2, NO_X, Hg, and CO_2. These policies can take on a number of different forms including caps, emissions prices (taxes), required emission rates, required emissions reductions (from inlet), and required technology. In addition, these policies or constraints can be applied nationally, regionally, by state, or even on particular units.

An important part of existing cap-and-trade regulations is the quantity of any banked allowances. Banked allowances are earned through early reductions below a capped level and can generally be applied in later years when a cap might be lowered. The EmissionBanking functionality includes information on beginning bank levels and allows for banking levels in any particular model year to be specified as well.

The following emissions policies are frequently included in NEEM runs: Regional Greenhouse Gas Initiative (RGGI), Title IV SO_2, Clean Air Interstate Rule ("CAIR") NO_X Annual, and CAIR NO_X Seasonal. It is likely that future rulings (such as the recently proposed Transport Rule or the forthcoming Hazardous Air Pollutant regulations) will substantially change the emission control programs for NO_X, SO_2 and Hg emissions. These programs can also be modeled.

Today's CAIR caps are quite complicated in their application as depicted in Figure 4.

Figure 4: Application of CAIR Caps



The emissions caps for CAIR and TitleIV are specified in Table 12 below. These constraints are inputs to the model and can be changed as desired. In the CAIR region, the trade-in ratio for SO_2 allowances is 2.00 in 2010 and 2.86 in 2015.

Table 12: Emission Caps for CAIR and Title IV

Emission Constraint	Pollutant	Year	Cap	Units
CAIR NO_x Seasonal	NO_x	2009	0.57	MM Short tons
CAIR NO_x Seasonal	NO_x	2015	0.48	MM Short tons
TitleIV SO_2	SO_2	2010	8.95	MM Short tons
CAIR NO_x Annual	NO_x	2010	1.52	MM Short tons
CAIR NO_x Annual	NO_x	2015	1.27	MM Short tons

In addition to modeling cap-and-trade programs and emission taxes, NEEM can also model command-and-control programs. Units can be forced to either install certain retrofits or retire in a given year.

The NO_x emissions from existing units come from EPA CEMS data. SO_2 and Hg emissions are a function of the pollutant content in the coal burned and the pollution control efficiency of the particular generation unit. The same is true for CO_2 emissions except that the CO_2 content of coals is relatively invariant and pollution control retrofits are not currently available (but could be in the future).

3.8. Renewable Portfolio Standards

The NEEM model includes renewable portfolio standards ("RPS") in those states that have passed such requirements. Sometimes these standards are referred to as renewable electricity standards ("RES"). A US-wide RPS can be included in the model, if desired. State RPS are included and adjusted to net out qualifying hydro resources and load that excluded from the policies. State RPS' are then aggregated into groups that correspond with NEEM regions; combined RPS requirements are then modeled as a function of the underlying NEEM regional demand and satisfied through qualified renewable resources within the region Solar carve-outs are modeled separately from general renewable requirements.

Each RPS is modeled as a minimum generation amount and can be met either through 1) generation from qualifying resources, or 2) an alternative compliance payment that is specified for each RPS. Texas and Kansas have renewable capacity requirements (as opposed to renewable generation requirements). The state RPS policies included in the model are shown in Table 13.

Table 13: State RPS Policies

State RPS	NEEM RPS	Component Pools	Requirement in 2020 (NEEM Pool Level)	Alternative Compliance Payment in 2020 ($2010/MWh)
PA	PJM	PJM_W, PJM_E, PJM_SW	14.3%	53.12
NJ	PJM	PJM_W, PJM_E, PJM_SW	14.3%	53.12
DE	PJM	PJM_W, PJM_E, PJM_SW	14.3%	53.12
MD	PJM	PJM_W, PJM_E, PJM_SW	14.3%	53.12
DC	PJM	PJM_W, PJM_E, PJM_SW	14.3%	53.12
PA Solar	PJM Solar	PJM_W, PJM_E, PJM_SW	1.3%	318.71
NJ Solar	PJM Solar	PJM_W, PJM_E, PJM_SW	1.3%	318.71
DE Solar	PJM Solar	PJM_W, PJM_E, PJM_SW	1.3%	318.71
MD Solar	PJM Solar	PJM_W, PJM_E, PJM_SW	1.3%	318.71
DC Solar	PJM Solar	PJM_W, PJM_E, PJM_SW	1.3%	318.71
AZ	AZNMSNV	AZ_NM_SNV	8.7%	39.31
NM	AZNMSNV	AZ_NM_SNV	8.7%	39.31
NV	AZNMSNV	AZ_NM_SNV	8.7%	39.31
AZ Solar	AZNMSNV Solar	AZ_NM_SNV	2.0%	235.89
NM Solar	AZNMSNV Solar	AZ_NM_SNV	2.0%	235.89
NV Solar	AZNMSNV Solar	AZ_NM_SNV	2.0%	235.89
WA	NWPP	NWPP	7.4%	48.52
OR	NWPP	NWPP	7.4%	48.52

State RPS	NEEM RPS	Component Pools	Requirement in 2020 (NEEM Pool Level)	Alternative Compliance Payment in 2020 ($2010/MWh)
MT	NWPP	NWPP	7.4%	48.52
WI	MRETS	MAPP_US	22.3%	41.79
MN	MRETS	MAPP_US	22.3%	41.79
IL	MRETS	MAPP_US	22.3%	41.79
MI	MI	MI	9.0%	45.43
OH	Ohio	PJM_Midwest, MISO_E, NonRTO_Midwest	2.9%	45.43
OH Solar	Ohio Solar	PJM_Midwest, MISO_E, NonRTO_Midwest	0.1%	151.41
KS	KS	SPP_N	NA	NA
MO	MO	EMO, ENT	3.1%	20.22
MO Solar	MO Solar	EMO, ENT	0.1%	121.37
CO	CO	RMPA	14.5%	59.35
CO Solar	CO Solar	RMPA	1.6%	356.10
CA	CA	NP15, SP15	30.4%	51.84
TX	TX	ERCOT	NA	NA
NY	NY	NYISO x 5	5.3%	31.10
MA	NEISO	NEISO	12.8%	61.53
CT	NEISO	NEISO	12.8%	61.53
ME	NEISO	NEISO	12.8%	61.53
RI	NEISO	NEISO	12.8%	61.53
NH	NEISO	NEISO	12.8%	61.53
MA Solar	MA Solar	NEISO	0.4%	612.39
NH Solar	NH Solar	NEISO	0.02%	163.31
NC	NC	VACAR	4.5%	22.17
NC Solar	NC Solar	VACAR	0.1%	133.04

NEEM also contains intermittent generation limits, which limit the amount of intermittent generation that can occur within a given NEEM region (or multiple NEEM regions) relative to the annual load of the region (or the same multiple set of regions). CRA typically assumes that intermittent generation cannot exceed 20% of each region's annual load. This assumption can be changed, if desirable.

3.9. Fuel Prices

The NEEM data file includes detailed inputs on natural gas, oil, and other (non-coal) fuel prices. Natural gas prices are provided on a seasonal basis for each year for each natural gas-fired unit in the model. There are three seasonal prices - summer, winter, and shoulder - that correspond with the three demand seasons. The natural gas prices are typically based on a combination of NYMEX Henry Hub futures and AEO 2010 forecasting; futures are typically used through 2012 and blended into AEO 2010 by 2015. The prices are then converted into regional delivered prices based on historical regressions of basis differentials. All prices are reported in $/MMBtu.

Assumed natural gas prices at Henry Hub can be found in Appendix A, Exhibit 9. Exhibit 10 provides mapping of NEEM regions to pipeline pricing points.

Distillate oil prices are calculated in a similar manner to the natural gas prices. They are primarily based upon NYMEX Light Sweet Crude Futures and EIA's Annual Energy Outlook 2010 projections of the world oil price. Oil prices in NEEM are only included as annual prices. These prices are also reported in $/MMBtu.

NEEM also includes fuel prices for nuclear fuel and biomass. The (non-coal) fuel prices in NEEM are used differently than many of the other inputs. Because NEEM does not typically model every year, most inputs used by NEEM are based on the model years (*e.g.*, if NEEM models 2010 and 2015 then it will use inputs for 2010 and 2015). However, fuel inputs used by NEEM will be an average of the fuel inputs of the represented model years (*e.g.*, if NEEM models 2010 and 2015, the 2010 model year would represent the years 2010 through 2014).

3.10. Hydroelectric and Pumped Storage

NEEM includes information on existing hydroelectric and pumped storage resources. No new hydroelectric or pumped storage resources are available in the model. Hydroelectric generation is limited in each season based on average levels of hydroelectric generation from CRA's GE MAPS assumptions. Pumped storage is assumed to have an efficiency of 75 percent.

3.11. Transmission

NEEM's regions have been created to address primary transmission limitations and constraints. Within a NEEM region there are no transmission limitations. Inter-regional transmission limitations will be represented based on input from EIPC planning engineers. Limits are represented in both directions (*e.g.*, from Region A to Region B and from Region B to Region A). Dummy regions are included to model joint transmission constraints into and out of a region or group of regions (dummy regions contain no load or resources). NEEM has the flexibility to allow for changes in transmission capacity over time. This is done as an input rather than through any model calculations.

3.12. Wheeling Charges and Hurdle Rates

Seams charges are applied by CRA in the NEEM model at the "seam" or border between regions. In the absence of seams charges, NEEM will optimize the dispatch of generation across the entire modeled footprint as if it were one balancing authority with traders and operators having perfect information about all load, resources and transmission congestion, and with no transmission wheeling charges payable for regional imports and exports.

In practice, there are impediments to trade that take place on a real-time basis, including wheeling charges and imperfect knowledge regarding flows outside of the control area. For example, trade with a neighboring region is often scheduled in blocks (e.g., eight peak hours) and the price observed by traders can change by the time that transmission service is arranged. In contrast, inside of a Day 2 RTO market, generator bids are accepted in real-time relative to the actual real-time hourly price. During prior Cost Benefit Analysis studies, CRA worked with trading analysts who estimated for CRA the price differential needed across borders before they would actively pursue trades. The cross-seam price differential needed ranged from $3 to $5 per MWh plus the applicable wheeling charge, depending on the nature of the market. An organized Day 2 market was perceived to have lower cross-seam trading friction than a traditional bi-lateral market given the improved transparency that such a market provides, the economic-based congestion management, and the existence of cross-seam agreements. In addition to these cross-seam trading friction hurdles, wheeling charges are assessed using the mid-point of each region's non-firm peak and off-peak point-to-point rate for "out" transactions. Seams charges are set to zero between NEEM regions within a contiguous market (e.g., PJM).

As inputs, NEEM has explicit wheeling charges that reflect administrative charges placed on wheel-out transactions. These inputs are defined for all possible pathways among the NEEM regions. Similarly, NEEM has inputs for transmission costs (inclusive of wheeling charges) that can be applied among the regions. Transmission costs include the wheeling cost and other market frictions. These charges are summarized for 2015 and 2020 in Exhibit 11.

3.13. Reserve Margin

There are two NEEM worksheets related to reserve margins. The first is the ReserveMargin worksheet. Each of the 38 NEEM regions is included in a reserve margin region. Some reserve margin regions include multiple NEEM regions, while others include only a single NEEM region. Each reserve margin region then has a specified reserve requirement that must be met (or exceeded) in each model year (see Table 14). The reserve requirement is calculated based off of the peak demand in each region in each year in the MaxDemand_Pool worksheet.

The other worksheet related to reserve margins is the ReserveDerate worksheet. Resources such as wind and solar generators are not dispatchable and therefore their full capacity cannot be counted toward the reserve requirement. For each of these existing and potential units the user specified a derate such that the capacity that counts towards the reserve requirement is the unit's capacity multiplied by the specified derate (see Table 5 above).

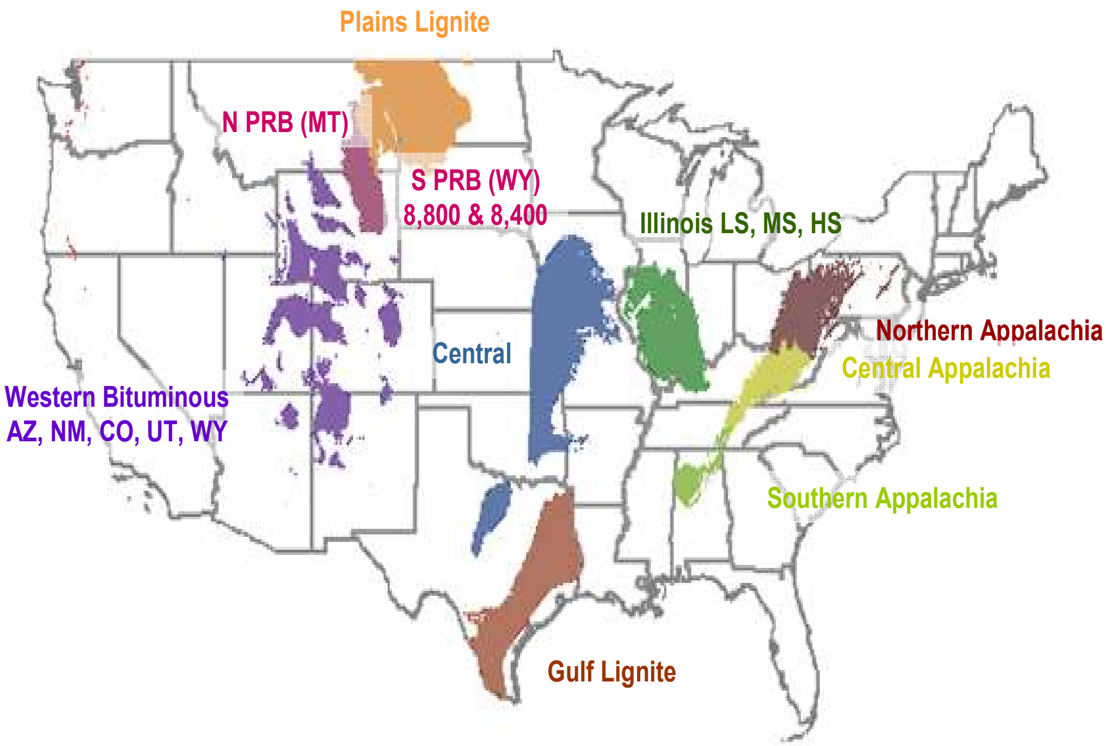
Table 14. Reserve Margin Regions and Requirements

Reserve Margin	Reserve Requirement	NEEM Region(s)
ALB	18.0%	ALB
AZ_NM_SNV	15.7%	AZ_NM_SNV
BC	18.0%	BC
CA	16.6%	NP15
		SP15
ENT	14.0%	ENT
ERCOT	NA	ERCOT
FRCC	16.0%	FRCC
HQ	15.0%	HQ
MI	15.0%	MI
MISO	15.4%	EMO
		MAPP_US
		MI
		MISO_E
		SCIL
		WUMS
NEISO	16.0%	NEISO
NonRTO_Midwest	14.0%	NonRTO_Midwest
NWPP	18.0%	NWPP
NYISO	16.5%	NYISO_Capital
		NYISO_Downstate
		NYISO_LIPA
		NYISO_NYC
		NYISO_Upstate
NYISO_LIPA	-2.5%	NYISO_LIPA
NYISO_NYC	-18.0%	NYISO_NYC
OH	14.0%	OH
PJM	15.3%	AE
		NI
		PJM
		PJM_D
		PJM_E
		PJM_Midwest
		PJM_SW
		PJM_W
PJM_E	-2.2%	PJM_E
PJM_MAAC	14.1%	PJM_E
		PJM_SW
		PJM_W
PJM_SW	-27.4%	PJM_SW
RMPA	14.0%	RMPA
SOCO	14.0%	SOCO
SPP	13.6%	NE
		SPP_N
		SPP_S
TVA	14.0%	TVA
VACAR	14.0%	VACAR

3.14. Coal Market Data

The coal market data include coal characteristics for 21 different coals, including coal supply curves and delivery costs to each existing and potential coal plant in the NEEM data set. The 21 coals were selected to represent the coal sub markets and production regions in the United States. The major production regions are shown in Figure 5.

Figure 5: NEEM Coal Production Regions



3.14.1. Coal Supply Information

The mine-mouth coal supply curves are based on a model of projected production capabilities and production costs at mines throughout the United States. Coal transport costs are input for each coal type and coal plant (in many cases, certain coals are not deliverable to certain plants). There are also lifetime limits for each type of coal, a dynamic constraint that is reflected in the delivered coal prices. Fixed equilibrium mine-mouth coal prices can be input to the model, if desirable.

3.14.2. Coal Quality

The characteristics of the different coals are summarized in Table 15. Characteristics of each coal used by the NEEM model are: rank of coal, SO_2 content (lbs/MMBtu), mercury content (lbs/TBtu), CO_2 content (lbs/MMBtu), and calorific content in Btu per pound of coal. There are four different ranks of coal within the NEEM coal file. These are bituminous, western bituminous ("WesternBit"), subbituminous, and lignite. These different classifications are required because of the different impacts different fuels have when they are burned.

The SO_2 content, Hg content, and heat content are based on information from Hellerworx. The CO_2 content of coals does not vary significantly, as such all coals in the model have the same CO_2 content, 207.9 lbs/MMBtu.

Table 15: Coal Characteristics

Coal Name	Rank	SO2	Hg	Btu/lb	MMBtu/Ton
Northern Appalachia High Btu Low Sulfur	Bituminous	2.44	12.30	12,840	26
Northern Appalachia High Btu High Sulfur	Bituminous	4.07	12.50	12,938	26
Northern Appalachia Low Btu Low Sulfur	Bituminous	1.76	16.00	12,098	24
Northern Appalachia Low Btu High Sulfur	Bituminous	3.77	20.90	11,516	23
Central Appalachia Compliance	Bituminous	1.12	5.90	12,507	25
Central Appalachia Hi Hg Btu Non-Compliance	Bituminous	2.00	8.20	12,325	25
Southern Appalachia	Bituminous	2.52	8.70	11,747	23
Illinois Basin Hi Sulphur	Bituminous	2.50	4.50	12,091	24
Illinois Basin Hi Sulphur	Bituminous	3.50	6.50	11,502	23
Illinois Basin Hi Sulphur	Bituminous	5.00	6.30	11,665	23
Central Basin	Bituminous	4.92	12.70	12,174	24
Gulf Lignite	Lignite	3.37	10.80	6,840	14
Lignite	Lignite	2.30	10.80	6,585	13
Montana Powder River Basin	Subbituminous	1.18	5.20	9,052	18
Northern (WY) Powder River Basin	Subbituminous	0.83	7.10	8,400	17
Southern (WY) Powder River Basin	Subbituminous	0.71	5.80	8,800	18
Wyoming - Other	Subbituminous	1.14	3.70	9,185	18
Rocky Mountain Colorado	WesternBit	0.98	3.70	11,218	22
Rocky Mountain Utah	WesternBit	1.28	4.10	11,790	24
Arizona Bituminous	Bituminous	0.93	4.20	10,915	22
New Mexico Bituminous	Bituminous	1.55	4.20	9,393	19
Import	Bituminous	1.00	5.50	12,000	24

4. MULTI-REGION NATIONAL MODEL (MRN)

4.1. Overview of MRN as a Stand-Alone Model

MRN is a top-down, computable general equilibrium (CGE) model of region-specific impacts and regional interaction in the U.S. economy. The CGE tracks every dollar that is spent through the economy to reduce carbon emissions, accounting for the economic gains in those sectors that provide the goods and services that result in emissions reductions, as well as the economic costs to those who incur these added expenditures. In addition, the negative impacts associated with declining demand under higher, policy-induced prices are captured. The model can also account for any changes in the distribution of wealth that result from the combined impact of emissions control spending and the disposition of the wealth associated with newly created allowances (in a cap-and-trade case). The results of a model run like this reflect the net impact to the U.S. economy after all the impacts on the winners and losers under a proposed policy have been estimated.

The model also assumes that implementation of a policy such as a carbon emissions cap will occur in a least-cost fashion with fully-functional, competitive product and allowance markets. The only limits imposed on the efficiency of a cap-and-trade market are those that are directly specified in a policy or Bill, such as when some sectors are not covered by the proposed cap scheme (even if placed in the offsets category). Leakage of some economic activities outside of the U.S. is also estimated for sectors that face competitors in other countries that do not have their own emissions caps (or have weaker caps).

The model works with perfect foresight of future prices and policy requirements. This means that the model does not include any costs due to uncertainty and “surprises” that will probably also be associated with compliance with a new policy. It also captures only a long-run equilibrium in all of the markets, and thus does not include any of the costs of an overly rapid shift in markets due to imposition of a new policy.

The CGE model solves for production levels, trade, relative prices, income, and consumption by accounting for technological as well as behavioral responses to changes in policy. The equilibrium is fully dynamic, meaning that investment decisions determine the future capital stock, which in turn determines future income and consumption. Furthermore, decisions to consume or invest are taken with correct expectations about future policy and opportunities (i.e., perfect foresight). Investment today requires foregoing consumption of current income. Consumer decisions maximize utility inter-temporally, which implies that an optimal financial trade-off is made between consumption today and consumption in the future.

Many of the impacts of policies to reduce carbon emissions indirectly increase the cost of production and consumption, and this has effects on the demand for all commodities. For example, a limit on the quantity of allowable emissions from electric utilities will result in higher electricity prices. Higher electricity prices will then raise production costs throughout the economy, but especially in sectors that use electricity-intensive production processes. As all sectors adjust their production processes to be optimized under post-policy prices, there are changes in demand for labor, materials and commodities, capital, and different types of fuels and primary energy sources.

4.2. Basics of General Equilibrium Models

The top-down sub-model of the integrated MRN-NEEM model is tailored from CRA International's Multi-Region National (MRN) model. MRN is a forward-looking dynamic computable general equilibrium model of the United States. It is based on the theoretical concept of an Arrow–Debreu equilibrium in which macro-level outcomes are driven by the decisions of self-interested consumers and producers as they are in the real economy. The basic structure of CGE models, such as MRN, is built around a circular flow of goods/services and payments between households, firms, and the government, as depicted in Figure 6. Consumers are represented by a single household sector in each region that maximizes utility subject to endowments of primary factors and all production sectors are assumed to be competitive with underlying technology exhibiting constant returns to scale. Households own and supply the factors of production (capital and labor) to firms that transform these factors into goods or services. Households receive payment from the firms for supplying factors of production (capital income and labor wages). Firms in the model maximize profit subject to technology constraints to determine the level of optimal production. Firms utilize the factors supplied by households and use intermediate inputs produced by other firms. Households consume goods and services using the wage (and capital) income from firms, while the firms receive payment for goods and services that are supplied to the market. Under the circular flow concept, there is a balance of goods, services, and payments across the economy.

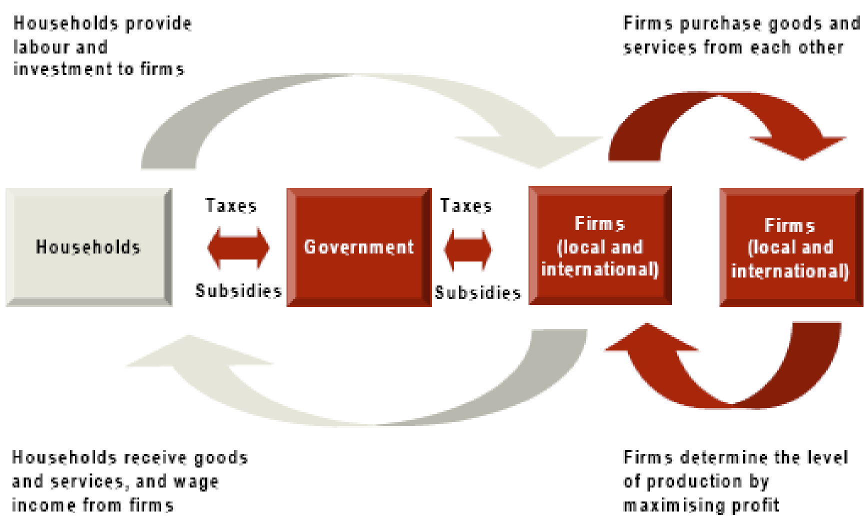


Figure 6. Circular Flow of Goods and Services and Payment

4.3. THE MRN PORTION OF MRN-NEEM IS A GENERAL EQUILIBRIUM MODEL

The theoretical basis for the version of MRN used in the integrated MRN-NEEM model is the same as that of the stand-alone MRN.[9] The only difference between the stand-alone MRN and the MRN sub-model of MRN-NEEM is the treatment of the sectors represented in the NEEM model. Since the NEEM model accounts for electricity and coal production in detail, MRN does not explicitly model these sectors. Thus, there are nine production sectors in MRN-NEEM rather than the eleven production sectors shown in Table 17. Individual states are rolled up to create the nine MRN regions (see Figure 7 for an illustrative map). The model assumes a single representative household for each region, a federal government, and the production sectors.[10] The production sectors in the model are disaggregated as listed in Table 16.[11]

Table 16. MRN Model's Sectors in MRN-NEEM Integrated Model

Energy Sectors	Non-Energy Sectors
Oil and gas extraction	Agriculture
Oil refining/distribution	Energy-intensive sectors
Gas distribution	Manufacturing
*	Transportation services
*	Services
	Motor Vehicles

* In the integrated MRN-NEEM model, the coal and electricity sectors are modeled using NEEM. Thus, these two sectors are shown as being part of MRN here.

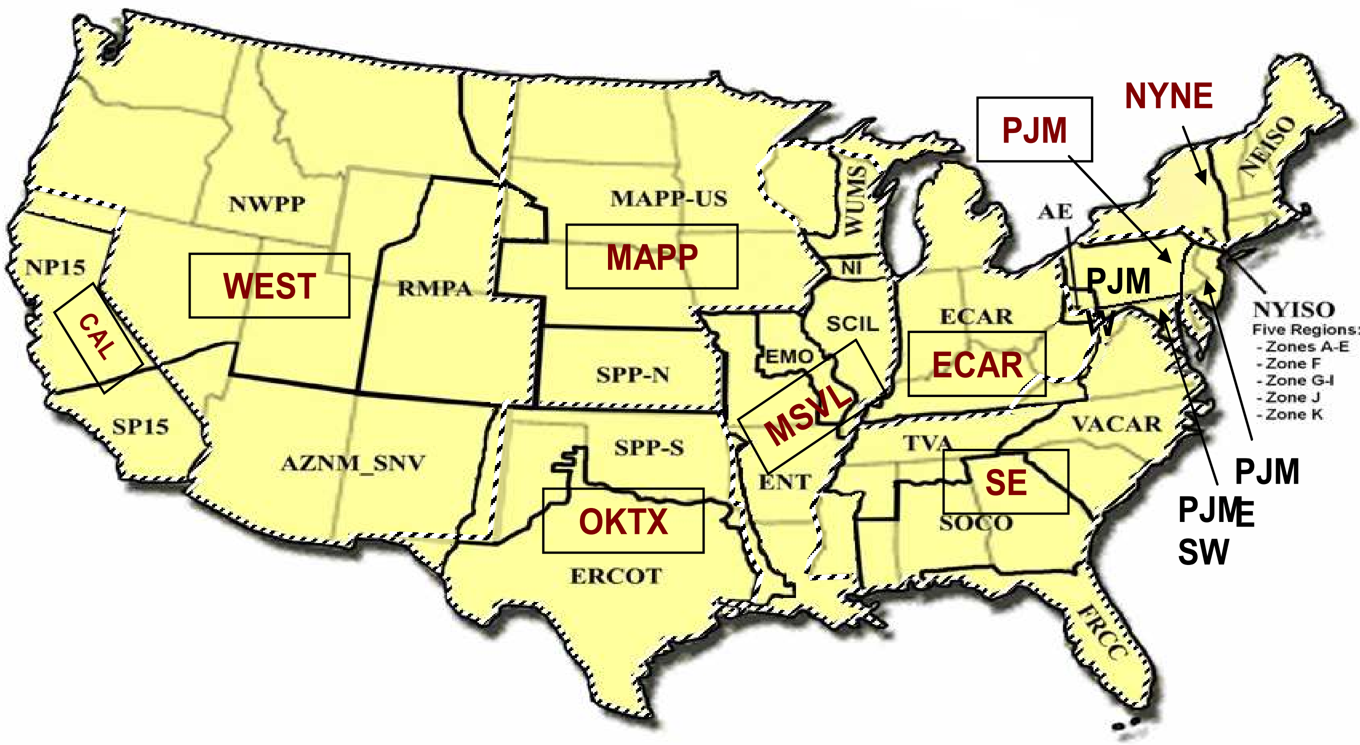
Consumers are represented as a single representative household that maximizes lifetime utility subject to its lifetime budget constraint. Utility in a given time period is measured by the consumption of goods. The budget constraint equates the present value of consumption gross of tax to the present value of income earned in the labor market and the value of the initial capital stock minus the value of post-terminal capital. In other words, consumers cannot consume more than the present value of their income and capital wealth. They typically will consume less than the present value of their income and capital wealth (in any year) in order to maximize utility over

[9] The standalone MRN model is a self-contained model that represents all sectors of the economy.

[10] The Regional and Federal government budgets are balanced over the model's analysis period. This is true for both the BAU case and the policy scenario(s). Any deficits incurred in a particular year need not be the same between the BAU case and the scenario, as long as each is balanced over entire analysis period.

[11] Note that electricity generation and coal production are modeled in the bottom-up model (NEEM) in the integrated model.

Figure 7. Illustrative Example of How MRN Regions Map to NEEM Regions (NEEM regions shown differ from those likely used for EIPC)



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many years. Households optimally distribute wealth over the model horizon by choosing how much output in a given period to consume and how much to forgo for future investment.

Two primary factors of production are supplied by the household sector: labor, which grows exogenously and is therefore an input to the model, and capital. In the model, depreciation of the capital stock depends on maintenance expenditures and vintage of the capital stock. The depreciation rate in the model is not assumed to be fixed. It is (endogenously) determined within the model and has an iso-elastic relation with maintenance expenditure and capital stock. This captures the notion that the capital stock (equipment and machinery) is maintained and repaired during its life and its level of use will determine how much maintenance occurs. This subtle notion is generally ignored in other models. The dynamics in the model are partially controlled by implementing an adjustment cost in the capital stock.

As with the consumer behavior, the federal government also maximizes its model-horizon utility subject to a model-horizon budget constraint. The government collects tax revenues at an average tax rate, purchases goods and services, and transfers income to the representative households in the model. The government maintains a balanced budget over the model horizon meaning that there is no change in the net foreign indebtedness over the time horizon of the model.

Firms in the model use capital, labor, energy, and material inputs to produce goods. Production of one good may require more of one input than the production of another good. For example, production of energy-intensive goods (e.g., aluminum) requires more energy inputs relative to the production of service goods. Moreover, embedded production is such that inputs are easily substituted in some cases but not in others.

The MRN model captures the substitutability of inputs for various sectors and technologies by employing a nested constant elasticity of substitution (CES) structure. In the MRN CES process, inputs are mixed at different tiers of the production tree to form composite goods – not unlike a cooking recipe. At the bottom of the production structure, coal and gas inputs are combined to form a coal-gas composite input which substitutes against electricity input. An energy composite of coal-gas-electricity is then combined with a capital-labor composite (value-added composite) input to form an aggregate energy-value-added composite. This composite is then combined with the rest-of-the-other-goods composite to produce a final commodity. The substitutability between inputs depends upon the assumed value of the elasticity of substitution and the initial share of the inputs. The higher the value of the elasticity of substitution, the easier it is to switch between inputs.

MRN is a national model and hence does not explicitly model other regions of the world. However, international trade is important in the real economy, so MRN roughly interacts with the rest of the world through simulated trade. International trade takes place in all goods except for crude oil. Crude oil in the model is treated as a homogenous good and is perfectly substitutable across all regions. All other goods are differentiated by their origin. That is, domestic and imported like-products are treated as imperfect substitutes. This is the classical Armington assumption referred to in trade economics. Imported goods and domestically produced goods are mixed to form an Armington aggregate good that is supplied to the domestic market for consumption and use in production. The value of the elasticity of substitution between the imported and domestic product influences the extent to which imported products can be substituted for domestic ones.

The MRN model is formulated as a mixed complementary problem (MCP) using the Mathematical Programming Subsystem for General Equilibrium (MPSGE) software (Rutherford 1995) and solved using the PATH solver within the Generalized Algebraic Modeling System (GAMS) (Brooke, Kendrick, Meeraus, and Raman, 2003). The model is calibrated to the MRN dataset and is solved in five-year intervals to 2050, with 2010 as the first year with calculated model results.

4.4. Modeling Carbon Abatement Policy Instruments in MRN

Fossil fuels are consumed by all sectors in the economy - production, households, and government. To incorporate carbon emissions in the model, a constructed emissions permit is tracked for three fossil fuel inputs: coal, natural gas, and refined petroleum. The MRN model tracks emissions from fossil fuel use by all sectors and agents at all times in the model. Careful tracking of carbon use by fossil fuel and by sector in the model is necessary because the level of carbon emissions is used as a carbon policy instrument for abatement policies. Carbon abatement policies are represented as either a fixed cap on the amount of emissions that are permitted or a tax on emissions. The cap or tax on emissions can be applied to a particular sector or to the economy as a whole.

Along the BAU case, demand for allowances equals emissions. Since the allowances are not scarce the permit price is zero in the BAU case (by definition). Under a carbon abatement policy, however, the number of available allowances is constrained and hence creates a market for allowances. Firms that are able to hold their emissions below the allowable limits are in the position to sell their excess allowances at the market price, while those firms that (as a result of higher marginal cost of abatement) exceed their allowable emissions will have to either buy allowances from the market or switch to less carbon-intensive generation technologies, whichever is cheaper. A key outcome of trading is that carbon emissions are abated at the least cost to the economy as a whole.

A simple example illustrates this point. Assume that there are two firms (Firm-A and Firm-B) in an economy where each firm emits 100 tons of emissions. Firm-A is assumed to be equipped with an efficient technology and is able to cut emissions at (a constant) $5 per ton while Firm-B's (constant) marginal cost of reducing a ton of emissions is $10. The government asks each to reduce 10 tons of emissions so that the government achieves its target of reducing 20 tons of emissions for the economy. If these two firms decide to their cut emissions individually, then the cost to Firm-A and Firm-B would be $50 and $100 respectively, and the total cost to the economy would be $150. However, since Firm-A has a much lower marginal cost of reduction than Firm-B it would be better for Firm-A to take the burden of cutting all of the emissions and Firm-B to buy the allowances from Firm-A at any price between $5 and $10 per ton. For example, Firm-B would be better off paying Firm-A $7.50 per ton than abating at $10 per ton in this simple example, and Firm-A would profit as well. Under such a case, if Firm-A reduces its emissions by an additional 10 tons, then the cost to Firm-A is an additional $50. Firm-A then sells 10 tons of emission allowances to Firm-B at $7.50 per ton generating $75 of revenue to Firm-A. Firm-A would have been compensated for its cost of additional abatement through its permit sale to Firm-B, making a profit of $2.50 per ton or $25 in total for its additional 10 tons of abatement. Firm-B would save the difference between the $100 it would have paid in abatement costs and the $75 it paid to Firm-A instead ($25 savings). The $75 payment from Firm-B to Firm-A is a transfer, not a net cost to the economy (as previously mentioned, Firm-A incurs $50 in additional cost to abate the emissions for which Firm-B needs to purchase allowances). The net cost to the economy after trading is just $100 ($5 per ton times 20 tons of abatement by Firm-A) rather than $150 per ton ($5 per ton times 10 tons for Firm-A's abatement plus $10 per ton times 10 tons for Firm-B's abatement). Thus, the reduction of 20 tons of emissions is achieved at the least net cost to the economy, with a saving of $50 compared to the total cost that would have been incurred without trading.

4.5. Important Drivers of the MRN Model

General equilibrium model results, in general, are driven by the representation of taxes, elasticity assumptions, value shares of inputs, BAU energy prices, and growth rate assumptions. Correct tax representation and parametric values of elasticities are key assumptions that drive the general equilibrium results. Input value shares are based on established social accounting matrices and in general the results are robust to changes in these input value shares; therefore, input value shares are a less important driver. The MRN model incorporates detailed tax representation for the value-added components (labor and capital). The model uses marginal and average tax rates on labor and capital at the State and Federal level, which are important for public finance policy analysis in MRN. The application of tax regimes in MRN closely resembles actual tax implementation at the State and Federal levels. Carbon policy impacts depend on real-world aspects of regional economic systems and global trade that are incorporated in the benchmark data and projections used to define the BAU case, and also on key parameters that describe how supply, demand, and trade flows respond to the effects of policy changes. The key parameters that determine these impacts are end-use demand elasticities for energy and other goods, elasticities of substitution between different forms of energy, energy supply elasticities, and Armington trade elasticities.

The parametric values of the elasticity of substitution (constant elasticity of substitution and constant elasticity of transformation) are exogenously set in the MRN model (i.e., they are model inputs). These values are drawn from secondary sources, past econometric studies, or from other similar model construct such as the EPPA model from MIT. The elasticity values determine the cost of tradeoffs between inputs under a policy and hence will determine the cost of the policy. Carbon abatement policy will have a direct impact on increasing the price of carbon-intensive inputs to production and also on the prices of consumption goods and services. If the production technology is such that it allows for easy substitution away from carbon-intensive inputs then there will be less of an impact as a result of carbon abatement policy. However, for energy-intensive industries, energy composes a large share of the input to production, and hence there will be less of an opportunity to substitute away from carbon-intensive inputs (fuels). The producer will either decrease inputs of carbon-based fuel or move to lower-carbon based fuels. This will result in an increase in the cost of production (compared to BAU) but is optimized with respect to post-policy prices. The price of energy-intensive goods will rise resulting in an adverse impact on the welfare of the consumer. Hence, the cost of production or consumption of carbon-intensive goods will rise and will ultimately have an adverse impact on the economy.

If the domestically produced energy-intensive good undergoes a price change relative to the imported energy–intensive good, the terms of trade between trading partners changes. Terms of trade compare the price of a region's exports to the price of its imports. An improvement in the terms of trade means that the prices of exports rise relative to the prices of imports, so that a region with improving terms of trade obtains a greater quantity of imports for each dollar's worth of exports. The Armington elasticity between a domestic and imported good determines how much of an imported good can be substituted at the expense of a domestically produced good. More substitution means that domestic production decreases while the exporting region's production increases, resulting in an increase in the exporting region's carbon emissions. Production is shifted from one region to another and so are carbon emissions. The Armington elasticity implicitly determines the level of carbon leakage to other regions in the presence of a policy that constrains carbon emissions.

4.6. Representation of Energy Efficiency Improvements

Autonomous energy efficiency improvement (AEEI) is built into the model's BAU case, that is, the number of MWh required to produce each unit of GDP declines over time in a manner that is a plausible extension of historical trends. AEEI includes both structural changes in the economy (i.e., the shift to a more service-oriented economy) and technology changes (i.e., increased penetration of energy-efficient technologies).

Demand-side energy efficiency is captured in the parameters of the model's production functions, including the energy sectors, the non-energy sectors, and the household sector. When electricity prices get higher (as under a carbon cap), more capital and labor (and possibly materials) are substituted for energy in the production of each unit of output. That is, production becomes less energy-intensive relative to the BAU case. An analogous shift occurs within households so that a unit of energy service (e.g., a particular number of lumens of light received, or the annual service of a refrigerator) require less energy because of the purchase and operation of more capital-intensive (but more energy-efficient) appliances. Households may also simply reduce their demand for energy services in response higher prices. Thus, household demand-response involves both increased adoption of energy-efficient technologies and behavioral changes that result in lower overall (direct) consumption of energy services. Because MRN is a general equilibrium model, final demand for products that contain embodied energy decrease (as the prices of products containing embodied energy rise under carbon cap) – this indirectly lowers energy demand in the model.

The model's demand response implies an elasticity of about -0.2 in the short-run, but approximately -0.6 in the long-run (e.g., after 5-10 years of continuously higher energy prices). The long-run elasticity indicates more demand response than utility planners often assume, but that is precisely because this is a long-run measure – in the long-run the capital stock of the economy becomes more energy-efficient in response to higher energy prices.

The MRN-NEEM model is not an engineering model; therefore, the model's results do not indicate specific, nameable energy-efficient technologies that were adopted more quickly under carbon policy versus the BAU case. An engineering-based model of the demand-side would identify these particular technologies because they would be completely specified as inputs. As a consequence, an engineering model would progressively step through available energy-efficient technologies (in order of increasing cost-effectiveness) as energy prices rise, potentially exhausting all such known technologies under more stringent carbon caps. Of course, a modeler using an engineering model can avoid the problem of exhausting known energy-efficient technologies by defining unknown technologies in the model that embody advanced energy-efficiency. In contrast, the MRN-NEEM model captures advanced energy-efficiency by its very nature because the possibilities for substituting capital (and labor and materials) for energy are never exhausted as energy prices rise in response to carbon policy. Again, the ease with which these substitutions occur is captured in the parameters of the model's production functions.

Since consumption of energy services and energy-containing products decline in response to carbon caps, economic welfare is reduced. The drop in welfare is somewhat offset by a shift to consumption of other goods, but the price-induced shift results in lower net welfare (as the optimal consumption bundle is altered). Similarly, welfare also is reduced because both energy and energy-containing products become more expensive under a carbon policy. In terms of net welfare, it does not matter if these increased costs are borne solely by households or if they are shared among households, appliance manufacturers, and utilities. The MRN-NEEM model does not capture the distribution of welfare impacts across these sectors.

4.7. MRN Data Inputs

Three components determine the baseline for the MRN-NEEM model: the dataset, the forecasts, and model assumptions. The dataset defines the economy in the benchmark year. The forecasts describe how the broad measures in the economy evolve over time such as GDP, carbon emissions, and electricity demand. But how the economy grows at the sectoral level and how electricity demand is met also depends on various model assumptions.

4.7.1. MRN Dataset

Data that characterize the interrelationships of commodity uses within the economy therefore are of primary importance in quantifying the impacts from alternative carbon regulations.

The starting point for constructing the baseline is the social accounting matrix, which provides a snapshot of the economy in the benchmark year 2002. The core component of the MRN dataset is based on the Social Accounting Matrix (SAM) developed by the Minnesota IMPLAN Group, Inc. (MIG) that represents the economic flows of 509 sectors of 50 states of the U.S. and the District of Columbia for the year 2002. The SAM provides data on employment, industry output, value added, institutional demand, national input-output structural matrices (use and make tables), and inter-institutional transfers. This dataset provides a snapshot of the economy for each of the U.S. states.

Conceptually, the SAM represents a "snapshot" of the economy at the current point along a dynamic growth path. MRN simulates the dynamic growth path into the future in the absence of major changes to policies that are "on the books" today. This initial growth path is known as the "business-as-usual" case, or BAU. In other words, the initial snapshot is for a single year but the BAU case is a forecast over many years. Calibration of the BAU case from the initial snapshot provided by the SAM is completed by incorporating growth forecasts for industries, population, and carbon emissions. Detailed sectoral mapping starting from the 509 IMPLAN sectors to the aggregate eleven sectors that will be used in the current study is presented in Appendix B.

Since carbon emissions are highly correlated with energy use, all the important energy sectors contained in the detailed SAM are represented as individual sectors in MRN.[12] CRA aggregates all of the remaining (non-energy) sectors in the SAM into five groups that capture the diversity in energy-intensity across all economic activities. MRN typically uses the eleven production sectors in Table 17.[13] MRN also accounts for household energy uses, as well as all the productive sectors of the economy, so that MRN can correctly account for individuals' responses to higher fuel costs caused by carbon abatement policies.

Table 17. Typical MRN Model's Sectors

Energy Sectors	Non-Energy Sectors
Gas Distribution	Agriculture
Oil and gas extraction	Energy-intensive sectors
Oil refining/distribution	Manufacturing
Coal extraction	Transportation services
Electricity generation	Services
	Motor Vehicles

Note: Coal extraction and electricity generation are part of MRN if MRN is run as a stand-alone model.

MRN tracks carbon dioxide emissions (stated as metric tonnes of carbon-equivalent) from fossil fuel combustion and assumes that the costs of reducing other greenhouse gases are comparable to the cost of reducing carbon dioxide emissions. To incorporate carbon emissions in the model, an emissions permit is tracked for each of the three fossil fuel inputs (refined oil, natural gas, and coal). When there is a carbon cap, a limited, fixed number of emissions allowances is assumed available in each modeled year. If that limit is less than the BAU emissions level, a scarcity of allowances (i.e., when demand for allowances exceeds their supply) will exist. This scarcity increases the price on carbon (starting from zero) up to the point where demand for the allowances is reduced to the limit of their supply. Limiting the number of allowances available imposes an emissions constraint, and the permit price reflects the marginal cost of abatement. Instead of running a carbon policy simulation as a cap-and-trade policy (specifying the quantity of emissions), we can also specify the permit price (and not the quantity of emissions). For practical reasons, we suggest the latter approach in the EIPC context.

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[12] Non-CO2 greenhouse gas emissions from coal extraction and oil and gas extraction are not modeled explicitly. An (exogenous or user-defined) offset supply curve based on emissions reductions in these and other natural resource-based sectors (e.g., agriculture) is used to represent the cost of supplying offsets.

[13] Coal extraction and oil and gas extraction are assumed to consume zero fossil fuels.

4.7.2. MRN Model Assumptions and Forecasts[14]

General equilibrium model results are influenced by initial tax representation, elasticity assumptions, value shares of inputs, and baseline energy prices, and growth rate assumptions. Weyant (2000) categorizes model assumptions into five key areas that help explain model impacts and results.[15] MRN model assumptions also fall under these categories and underpin model results. The MRN model assumptions are built on published data sources. Where data are available, we describe the methodology and sources while for unavailable data we clearly document our assumptions. In the following sections, we describe the MRN model's baseline forecasts and key assumptions such as backstop technologies, tax regime, elasticity values, and implied autonomous technical progress.

Default Elasticities and Tax Rates

For each region in MRN, there is a representative consumer or agent who makes decisions consistent with utility maximization. Utility in a given time period is the Constant Elasticity of Substitution (CES) composite of consumption and leisure. The elasticity of substitution between the aggregate consumption good and leisure is determined by the leisure supply elasticity. In the MRN model, we assume a compensated labor supply elasticity of 0.25 resulting in effective elasticity of substitution between consumption and leisure of about 0.8. Over the computed finite horizon, the representative agent optimally allocates spending between consumption and leisure in each time period. The consumer's inter-temporal utility is generated combining intra-temporal utilities with an inter-temporal elasticity of 0.5. In more technical terms, household utility is defined by a constant elasticity of supply (CES) infinite sum of discounted transitory utility.

The MRN model incorporates detailed tax rates for the value added components (labor and capital). Regional marginal and average tax rates on labor and capital at the state and federal level are shown below in Table 18 and Table 19. Firms and consumers in the MRN model make investment and labor supply decisions based on the marginal tax rates, while the Government's tax revenues are computed based on the average rates. The tax regime in the model closely resembles actual tax implementation at the State and Federal level.

The tax paid by the consumer and producers are either accrued to the State government or the Federal government. In addition to capital and labor tax rates, MRN also employs federal and state level lump sum taxes which are adjusted to ensure that the governments maintain a balanced budget. The presence of an initial distortionary tax in the MRN means that its resulting solution reflects a "second best" world in which tax interaction effects are captured. "Double dividend" effects also can be calculated, if specified as part of the policy implementation. That is,

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[14] Weyant (2000) identifies three areas of input assumptions for climate change policy analysis: (i) population and economic activity; (ii) energy resource availability and prices; and (iii) technology availability and costs.

[15] The five determinants of climate change cost estimates are "(i) projections for base case GHG emissions and climate damages; (ii) the climate policy regime considered (especially the degree of flexibility allowed in meeting the emissions constraints); (iii) the representation of substitution possibilities by producers and consumers, including how the turnover of capital equipment is handled; (iv) how the rate and processes of technological change are incorporated in the analysis ; and (v) the characterization of the benefits of GHG emissions reductions in the study, including especially how and what benefits are included." Weyant (2000).

we can simulate the effects of policy scenarios where revenue of permit auction revenues would be recycled to the economy by decreasing the marginal capital or labor tax rates. Similarly, we can simulate the effects of increasing marginal tax rates to offset erosion of the tax base. However, for our default values, we specify compensating lump-sum transfers that do not cause any alteration in marginal tax rates.

Table 18. Average and Marginal State Taxes on Capital and Labor Income[16]

State	Average		Marginal	
	Capital	Labor	Capital	Labor
AL	3.3%	3.3%	3.8%	3.8%
AR	3.8%	4.8%	4.3%	5.3%
AZ	3.6%	3.1%	4.1%	3.6%
CA	4.6%	5.9%	8.1%	7.0%
CO	3.8%	4.1%	4.3%	4.6%
CT	3.8%	4.5%	4.3%	5.0%
DC	7.9%	8.4%	8.4%	8.9%
DE	4.8%	4.0%	5.3%	4.5%
GA	4.7%	5.2%	5.2%	5.7%
HI	4.6%	7.3%	7.1%	7.3%
IA	4.5%	5.9%	6.5%	6.1%
ID	4.4%	5.7%	7.1%	7.3%
IL	2.2%	2.5%	2.7%	3.0%
IN	2.6%	2.9%	3.1%	3.4%
KS	4.6%	5.8%	5.7%	6.0%
KY	4.8%	4.4%	5.3%	4.9%
LA	3.6%	2.9%	4.1%	3.4%
MA	4.3%	4.7%	4.8%	5.2%
MD	3.8%	3.9%	4.3%	4.4%
ME	5.3%	7.7%	7.7%	7.7%
MI	3.3%	3.6%	3.8%	4.1%
MN	4.4%	6.7%	7.1%	6.9%
MO	4.7%	4.4%	5.2%	4.9%
MS	3.9%	4.0%	4.4%	4.5%
MT	4.7%	4.6%	7.7%	5.6%
NC	4.2%	5.8%	7.3%	7.2%
ND	2.6%	2.9%	3.1%	3.4%
NE	6.2%	5.7%	6.7%	6.2%
NJ	4.8%	3.4%	5.3%	3.9%
NM	4.6%	5.4%	6.5%	6.4%
NY	5.6%	6.2%	6.1%	6.7%
OH	5.9%	5.0%	6.4%	5.5%
OK	4.5%	5.0%	5.8%	6.2%
OR	3.9%	5.4%	7.8%	8.6%
PA	2.1%	2.3%	2.6%	2.8%
RI	6.6%	5.3%	7.1%	5.8%
SC	3.9%	5.6%	3.5%	6.6%
UT	5.4%	5.5%	5.9%	6.0%
VA	4.7%	5.0%	5.2%	5.5%
VT	3.5%	5.6%	4.0%	6.1%
WI	4.5%	6.2%	5.0%	6.7%
WV	4.9%	5.4%	5.9%	5.8%

[16] States that do not impose state level taxes are not shown in the table.

Table 19: Average and Marginal Federal Taxes on Capital and Labor Income

	Labor	Capital
Average	18.9%	19.1%
Marginal	23.7%	19.7%

Substitutability of inputs in the MRN model is captured by employing a nested CES structure. The value of the elasticity of substitution determines the ease of substitution between inputs. Similarly, the value of elasticity of transformation determines switching on the output side. In the CES process, inputs are mixed at different tiers of the production tree to form composite goods. At the bottom of the production structure, coal and gas inputs are combined to form a coal-gas composite input which substitutes against electricity input according to the elasticity of substitution between the coal-gas composite and electricity (es_ele). An energy composite of coal-gas-electricity is then combined with a capital-labor composite (value-added composite) input using an elasticity of substitution (es_e) to form an aggregate energy-value-added composite. This composite is then combined with the rest-of- -goods composite (es_s) to produce a final commodity. The substitutability between inputs depends upon the assumed value of elasticity of substitution and the initial share of the inputs. The higher the value of elasticity of substitution, the easier it is to switch between inputs to make the same output. Producers also have the choice to supply to the domestic or the export markets. The elasticity of transformation between the supplied goods determines the level of supply given the relative prices. Similarly, the value of the elasticity of substitution between the imported and domestic product (es_dm) will influence the extent to which imported products can be substituted for domestically produced product. Table 20 below provides values for these elasticities.

Natural resource goods (natural gas and crude oil) are produced using fixed resources and rest-of-goods inputs. The top level elasticity of substitution between the fixed resource and other inputs are calibrated such that elasticity of supply is matched to the exogenously assumed values.[17] The parameter values for supply elasticities are assumed to be time varying (see Table 21 below). The natural gas and crude oil supply elasticity is assumed to be 0.6 and 0.3 in the short run, respectively, while in the long run both resources as elastically supplied (elasticity value of 1). The elasticity of substitution is computed to match the resource supply elasticity following Rutherford [1998], which depends upon the value share of the resource and the supply elasticity.

The elasticity values assumed for the production sectors, final demand, and Armington supply are shown in Table 20 and the resource supply elasticities are reported in Table 21.

[17] The elasticity values were based on values used in past MRN models which were based on secondary sources.

Table 20. Default values of Elasticities in the MRN model

		Non-energy Sectors					Energy Sectors			Final Demand		
		AGR	EIS	MAN	SRV	TRN	CRU	GAS	OIL	C	G	I
es_s	Top level elasticity									0.5	0.0	0.0
es_e	Energy versus value-added	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	NA	NA	NA
es_oil	Oil versus non-energy		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
es_va	Capital versus Labor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	NA	NA	NA
es_ele	Electricity versus Coal-gas	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.8	0.8
es_cg	Coal versus Gas	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
es_n	Non-energy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
etae	Elasticity of export supply	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0			
es_dm	Domestic versus imports	3.0	3.0	3.0	1.0	1.0	3.0	3.0	3.0			

NA: not applicable

Table 21. Default Resource Supply Elasticities in the MRN model

		2010	2015	2020	2025	2030	2035	2040	2045	2050
Crude Oil	CRU	0.30	0.51	0.65	0.76	0.83	0.88	0.91	0.94	0.96
Natural gas	GAS	0.60	0.72	0.80	0.86	0.90	0.93	0.95	0.97	0.98

Emissions, Energy prices, and Growth forecasts

The emissions forecast in the MRN model is based on the data from Energy Information Agency's Annual Energy Outlook (AEO) 2010, which provides estimates through 2035. Beyond 2035, we assume the carbon emission to grow by the growth rate observed in the last 10 years of AEO 2010 (2025-2035). Based on AEO, the national level forecast is proportionally scaled to the State level emissions according to the State level energy use. The MRN model's carbon emissions are adjusted to match the AEO 2010 level emissions by fossil fuel for the non-electric sectors. The electric sector carbon emission is endogenous to the NEEM model.

Energy price forecast assumptions are based on AEO 2010 energy prices. The cost impact of carbon policies also depends on the energy price forecast assumption. In particular, gas prices determine the amount of movement away from carbon-intensive coal to less carbon-intensive fuel, gas. We use the following energy price forecast for natural gas, coal, and crude oil based on AEO 2010.[18]

The MRN model assumes a uniform growth rate consistent with AEO 2010. The model assumes all regions grow at the national growth rate.[19]

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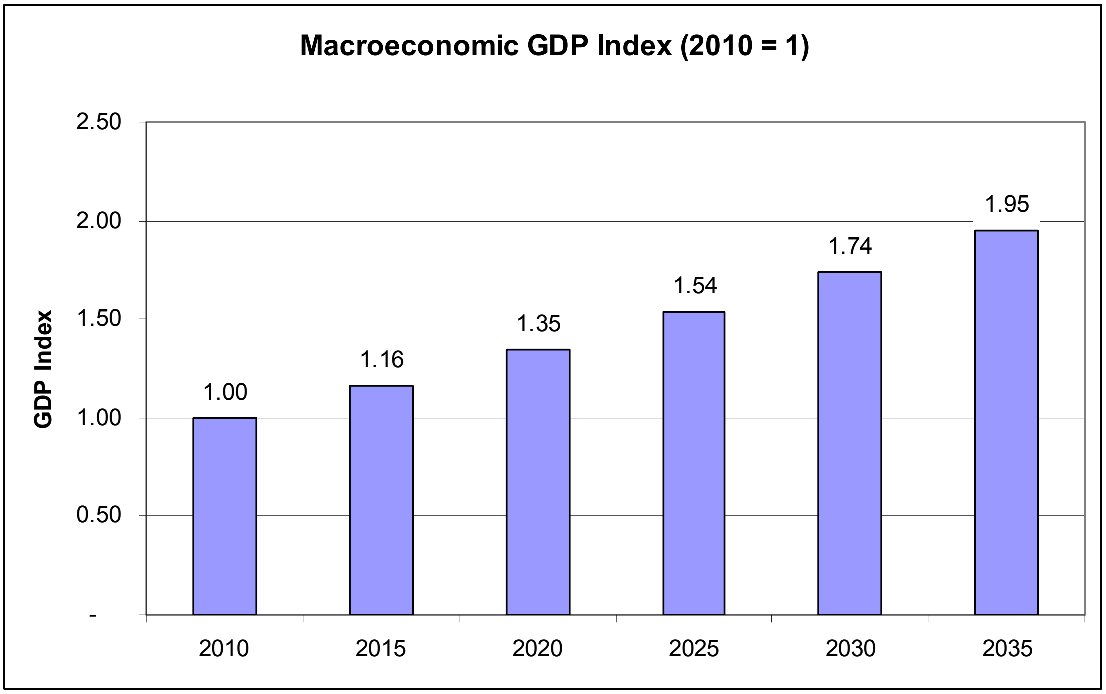
[18] We assumed that beyond the AEO 2010 forecasted period (beyond 2035) the crude price remains at 2035 prices.

[19] In the study, an exception is made for the electricity sector growth. This is assumed to be 1.5%.

Figure 8. Growth Index – United States



Source: AEO 2010 Reference Case

Technological Progress in the Baseline

MRN models technical changes as an exogenous scaling parameter often referred to as the autonomous energy efficiency improvement (AEEI).[20] The objective of this factor is to implement a decreasing energy use per dollar of output over time. This decrease is evident in the carbon intensity for the U.S which is consistent with the forecasted rate of improvement in emissions intensity. The baseline already includes many of the efficiency improvements that have been introduced in the policies that are part of the AEO2010.

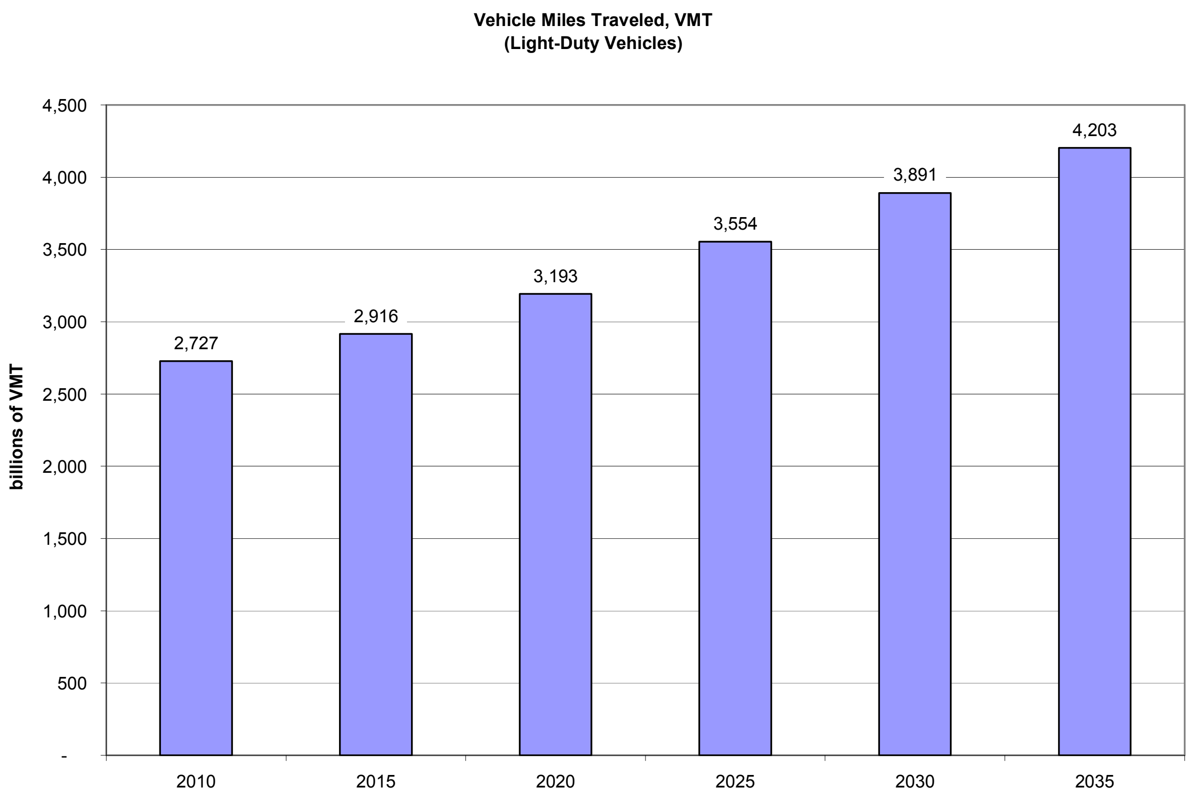
Vehicle Miles Traveled (VMT)

Along the baseline, on road VMT and the new car fuel economy is calibrated to match the AEO 2010. VMT for light-duty vehicles is provided in Figure 9. We model the miles per gallon (mpg) requirement of the Corporate Average Fuel Economy (CAFE) standards according to the data provided in AEO 2010.

[20] The scaling parameter is not arbitrary chosen but is calibrated to match model to published energy data sources. From a modeling perspective, the AEEI in the MRN model calibrated endogenously. The scaling factor (AEEI) is computed by targeting the input implied energy inputs (AEO price time quantity).

In carbon policy futures, VMT will be lower. The response is calculated within the MRN-NEEM framework (model output). The model is also capable of modeling low carbon fuel standards as a future.

Figure 9. VMT for Light-Duty Vehicles



Source: AEO 2010 Reference Case

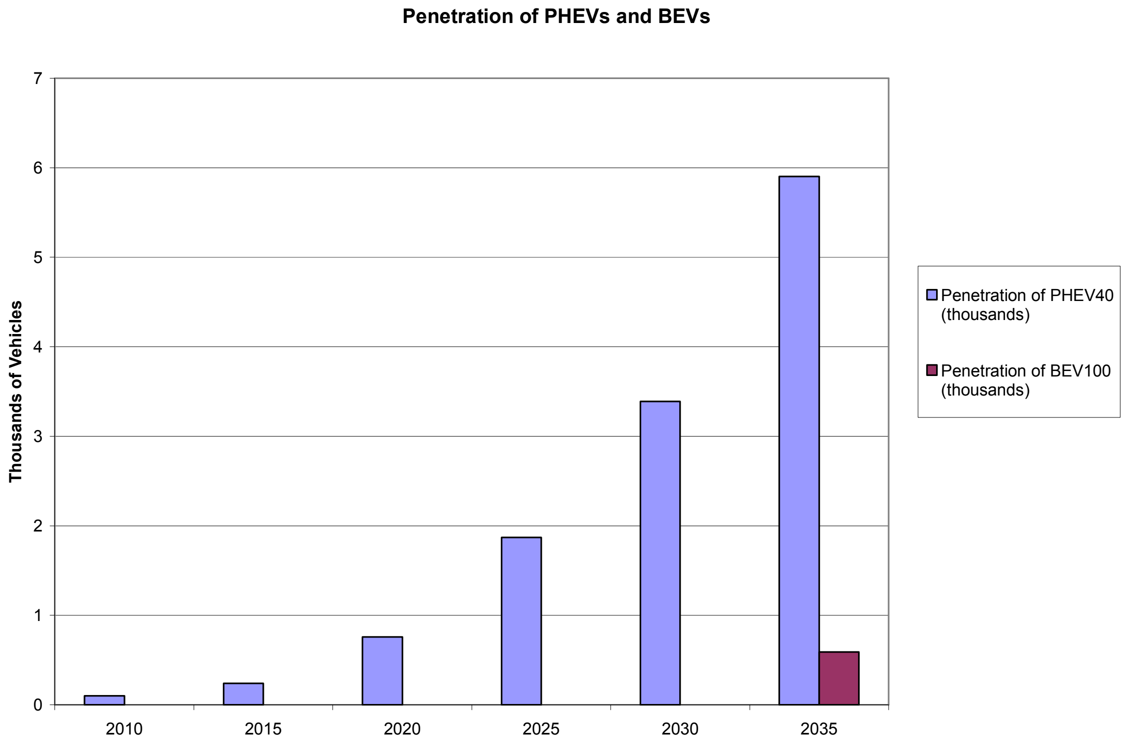
New Vehicle Technologies

The BAU penetration of plug-in electric vehicles (PHEVs) and battery electric vehicles (BEVs) is based on the AEO 2010 reference case. The data are shown in Figure 10.

The plug-to-wheels electricity usage for PHEVs and BEVs, the fraction of time that the PHEV operates as an electric vehicle, and the fuel efficiency of the PHEV's gasoline engine are CRA assumptions. The cost premiums of PHEVs and BEVs relative to conventional vehicles are also CRA assumptions.

In carbon policy futures, the penetration of PHEVs and BEVs will increase within the MRN-NEEM framework (model output).

Figure 10. PHEV and BEV Penetration



Source: AEO 2010 Reference Case

Transportation Fuel Emissions Factors

The CO2e emissions factors for gasoline, ethanol, and biodiesel come from the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA).

The CO2e emissions factors for gasoline, ethanol, and advanced biodiesel are 96 g CO2e/MJ, 73 g CO2e/MJ, and 19 g CO2e/MJ, respectively, for gasoline, corn ethanol, and advanced biodiesel.

Appendix A, Exhibit 1 - Mapping of Control Entities to NEEM Regions (for load mapping)

Planning Area	NEEM Region
Allegheney Power	AE
Arizona Electric Power Coop Inc	AZ_NM_SNV
Arizona Public Service Co	AZ_NM_SNV
El Paso Electric Co	AZ_NM_SNV
Nevada Power Co	AZ_NM_SNV
Public Service Co of New Mexico	AZ_NM_SNV
Salt River Project	AZ_NM_SNV
Tucson Electric Power Co	AZ_NM_SNV
WAPA Lower Colorado Region	AZ_NM_SNV
Ameren Corporation Control Area	EMO
Associated Electric Coop Inc	EMO
Columbia (MO) Water & Light	EMO
City of Conway	ENT
Entergy Services Inc	ENT
North Little Rock AR (City of)	ENT
Sam Rayburn G&T Electric Coop Inc	ENT
Clarksdale Public Utilities Commission	ENT
Louisiana Generating LLC	ENT
ERCOT	ERCOT
Florida Municipal Power Agency	FRCC
Florida Power & Light Co	FRCC
Gainesville Regional Utilities	FRCC
JEA	FRCC
Lakeland Dept of Electric Water Utilities	FRCC
Orlando Utilities Commission	FRCC
Progress Energy (Florida Power Corp.)	FRCC
Seminole Electric Coop Inc	FRCC
St Cloud (City of)	FRCC
Tallahassee FL (City of)	FRCC
Tampa Electric Co	FRCC
Algona Municipal Utilities	MAPP_US
Allete (Minnesota Power)	MAPP_US
Alliant Energy-West	MAPP_US
Ames Municipal Electric System	MAPP_US
Atlantic Municipal Utilities	MAPP_US
Basin Electric Power Cooperative	MAPP_US
Central Minnesota Municipal Power Agency	MAPP_US
Great River Energy	MAPP_US
Harlan Municipal Utilities	MAPP_US
Heartland Consumers Power District	MAPP_US
Hutchinson Utilities Commission	MAPP_US
Marshall Municipal Utilities	MAPP_US

MidAmerican Energy Company	MAPP_US
Minnesota Municipal Power Agency	MAPP_US
Minnkota Power Coop	MAPP_US
Missouri River Energy Services	MAPP_US
Montana-Dakota Utilities Company	MAPP_US
Muscatine Power & Water	MAPP_US
New Ulm Public Utilities	MAPP_US
Northern States Power Company	MAPP_US
NorthWestern Energy (South Dakota)	MAPP_US
Otter Tail Power Company	MAPP_US
Pella (City of)	MAPP_US
Rochester Public Utilities	MAPP_US
Southern Minnesota Municipal Power Agency	MAPP_US
Square Butte Electric Coop	MAPP_US
WAPA Upper Great Plains East	MAPP_US
Willmar Municipal Utilities Commission	MAPP_US
Consumers Energy Company	MI
Detroit Edison Company	MI
Wolverine Power Supply Coop Inc	MI
Duke Energy Corp.	MISO_E
Hoosier Energy REC, Inc.	MISO_E
Indianapolis Power & Light Company	MISO_E
Northern Indiana Public Service Company	MISO_E
Southern Indiana Gas & Electric Company	MISO_E
Wabash Valley Power Association	MISO_E
American Municipal Power-Ohio, Inc.	MISO_E
Indiana Municipal Power Agency	MISO_E
Hastings Utilities (NE)	NE
Lincoln Electric System	NE
Municipal Energy Agency of Nebraska	NE
Nebraska Public Power District	NE
Omaha Public Power District	NE
NEISO	NEISO
Commonwealth Edison	NI
Big Rivers Electric Corp	NonRTO_Midwest
Buckeye Power Inc	NonRTO_Midwest
East Kentucky Power Coop Inc	NonRTO_Midwest
Louisville Gas & Electric Co	NonRTO_Midwest
Ohio Valley Electric Corp	NonRTO_Midwest
Modesto Irrigation District	NP15
Pacific Gas & Electric Co	NP15
Sacramento Municipal Utility District	NP15
Turlock Irrigation District	NP15
Avista Corp	NWPP
Bonneville Power Administration	NWPP
Eugene Water & Electric Board	NWPP

Idaho Power Co	NWPP
NorthWestern Energy	NWPP
PacifiCorp	NWPP
Portland General Electric Co	NWPP
PUD No 1 of Chelan County	NWPP
PUD No 1 of Douglas County	NWPP
PUD No 2 of Grant County	NWPP
Puget Sound Energy Inc	NWPP
Seattle City Light	NWPP
Sierra Pacific Power Co	NWPP
Tacoma Power	NWPP
WAPA Upper Great Plains West	NWPP
NYISO Zone F	NYISO_Capital
NYISO Zone G	NYISO_Downstate
NYISO Zone H	NYISO_Downstate
NYISO Zone I	NYISO_Downstate
NYISO Zone K	NYISO_LIPA
NYISO Zone J	NYISO_NYC
NYISO Zone A	NYISO_Upstate
NYISO Zone B	NYISO_Upstate
NYISO Zone C	NYISO_Upstate
NYISO Zone D	NYISO_Upstate
NYISO Zone E	NYISO_Upstate
Dominion	PJM_D
Atlantic Electric	PJM_E
Delmarva Power & Light	PJM_E
Jersey Central	PJM_E
PECO	PJM_E
Public Service	PJM_E
Rockland Electric	PJM_E
American Electric Power	PJM_Midwest
Dayton Power & Light	PJM_Midwest
Duquesne Light Company	PJM_Midwest
First Energy	PJM_Midwest
Baltimore Gas & Electric	PJM_SW
PEPCO	PJM_SW
Metropolitan Edison	PJM_W
PennElec	PJM_W
PP&L and UGI	PJM_W
Black Hills Corp	RMPA
Colorado Springs Utilities	RMPA
Platte River Power Authority	RMPA
Public Service Co of Colorado	RMPA
Tri State G & T Association Inc	RMPA
WAPA Rocky Mountain Region	RMPA
Ameren (Illinois Power Co. Control Area)	SCIL

City of Springfield	SCIL
Southern Illinois Power Coop	SCIL
Alabama Power Co	SOCO
Georgia Power Co	SOCO
Gulf Power Co	SOCO
Mississippi Power Co	SOCO
Oglethorpe Power Corp	SOCO
PowerSouth Energy Coop	SOCO
South Mississippi Electric Power Association	SOCO
Southern Power Co	SOCO
MEAG Power	SOCO
Burbank (City of)	SP15
Imperial Irrigation District	SP15
Los Angeles Dept of Water & Power	SP15
Metropolitan Water District	SP15
San Diego Gas & Electric Co	SP15
Southern California Edison	SP15
City of Independence MO	SPP_N
City Utilities of Springfield (MO)	SPP_N
Empire District Electric Co (The)	SPP_N
Kansas City KS (City of)	SPP_N
Kansas City Power & Light Co	SPP_N
KCP&L Greater Missouri Operations	SPP_N
Sunflower Electric Power Corp	SPP_N
Westar Energy (KPL)	SPP_N
American Electric Power Co Inc (AEP West)	SPP_S
Cleco Corp	SPP_S
Golden Spread Electric Coop Inc	SPP_S
Grand River Dam Authority	SPP_S
Lafayette Utilities System	SPP_S
Louisiana Energy & Power Authority	SPP_S
Northeast Texas Electric Coop Inc	SPP_S
Oklahoma Gas & Electric Co	SPP_S
Oklahoma Municipal Power Authority	SPP_S
Southwestern Power Administration	SPP_S
Southwestern Public Service Co	SPP_S
Tex La Electric Coop of Texas Inc	SPP_S
Western Farmers Electric Coop	SPP_S
Arkansas Electric Cooperative	SPP_S
Fayetteville Public Service	TVA
Tennessee Valley Authority	TVA
Central Electric Power Coop Inc	VACAR
Duke Energy Carolinas LLC	VACAR
Greenville Utilities Commission	VACAR
Progress Energy Carolina	VACAR
South Carolina Electric & Gas	VACAR

South Carolina Public Service Authority	VACAR
Alliant Energy-East	WUMS
Dairyland Power Coop	WUMS
Madison Gas & Electric Company	WUMS
Upper Peninsula Power Company	WUMS
Wisconsin Electric Power Company	WUMS
Wisconsin Public Service Corporation	WUMS
WPPI Energy	WUMS

Appendix A, Exhibit 2 - Mapping of BA's to NEEM Regions (for generator mapping)

Plant Balancing Authority Area Name	NEEM Region(s)
Alberta Electric System Operator	ALB
Allegheny Power Service	AE
Alliant Energy	MAPP_US
Alliant Energy East	WUMS
Ameren	EMO, SCIL
American Electric Power	PJM_Midwest
American Electric Power West	SPP_S
Aquila Networks MPS	SPP_N
Arizona Public Service Co	AZ_NM_SNV
Associated Electric Coop Inc	EMO
Avista Corp	NWPP
Big Rivers Electric Corp	NonRTO_Midwest
Bonneville Power Administration	NWPP
British Columbia Hydro & Power Authority	BC
British Columbia Transmission Corp	BC
California Independent System Operator	NP15, SP15
Central & Southwest Services	SPP_S
Central Illinois Light Co	SCIL
Cleco Corp	SPP_S
Columbia Water & Light	EMO
Commonwealth Edison Co	NI
Dairyland Power Coop	WUMS
Dayton Power & Light	PJM_Midwest
Duke Energy Carolinas LLC	VACAR
Duke Energy Corp	MISO_E
Duquesne Light	PJM_Midwest
East Kentucky Power Coop Inc	NonRTO_Midwest
El Paso Electric	AZ_NM_SNV
Electric Energy Inc	SCIL
Empire District Electric Co	SPP_N
Entergy	ENT
ERCOT ISO	ERCOT
FirstEnergy	PJM_Midwest
Florida Municipal Power Pool	FRCC
Florida Power & Light	FRCC
Gainesville Regional Utilities	FRCC
Grand River Dam Authority	SPP_S
Great River Energy	MAPP_US
Homestead (City of)	FRCC
Hoosier Energy	MISO_E
Idaho Power Co	NWPP
IESO (Ontario)	OH

Illinois Power Co	SCIL
Imperial Irrigation District	SP15
Independence MO (City of)	SPP_N
Indianapolis Power & Light Co	MISO_E
JEA	FRCC
Kansas City KS (City of)	SPP_N
Kansas City Power & Light	SPP_N
KGE A Westar Energy Co	SPP_N
Lafayette Utilities System	SPP_S
Lake Worth Utilities	FRCC
Lincoln Electric System	NE
Los Angeles Dept of Water & Power	SP15
Louisiana Energy & Power Authority	SPP_S
Louisiana Generating LLC	ENT
Louisville Gas & Electric Co	NonRTO_Midwest
Madison Gas & Electric Co	WUMS
Michigan Electric Coordinated System	MI
MidAmerican Energy Co	MAPP_US
Mid-Columbia (includes CHPD,GCPD,DOPD)	NWPP
Minnesota Power Co	MAPP_US
Muscatine Power & Water	MAPP_US
Nebraska Public Power District	NE
Nevada Power Co	AZ_NM_SNV
New England ISO	NEISO
New Smyrna Beach Utilities Commission	FRCC
New York ISO	NYISO_Upstate, NYISO_Downstate, NYISO_Capital, NYISO_NYC, NYISO_LIPA
Northern Indiana Public Service Co	MISO_E
Northern States Power	MAPP_US
Northwestern Energy	NWPP
Oglethorpe Power Corp	SOCO
Ohio Valley Electric Corp	NonRTO_Midwest
Oklahoma Gas & Electric Co	SPP_S
Omaha Public Power District	NE
Otter Tail Power Co	MAPP_US
PacifiCorp	NWPP
PacifiCorp East	NWPP
PacifiCorp West	NWPP
PJM Interconnection	PJM_E, PJM_W, PJM_SW, PJM_Midwest
Portland General Electric	NWPP
PowerSouth Energy Coop	SOCO
Progress Energy Carolina East	VACAR
Progress Energy Carolina West	VACAR

Progress Energy Florida	FRCC
Public Service Co of Colorado	RMPA
Public Service Co of New Mexico	AZ_NM_SNV
PUD No 1 of Douglas County	NWPP
PUD No 2 of Grant County	NWPP
Puget Sound Energy Inc	NWPP
Sacramento Municipal Utility District	NP15
Salt River Project	AZ_NM_SNV
Seattle City Light	NWPP
Seminole Electric Coop Inc	FRCC
Sierra Pacific Power Co	NWPP
South Carolina Electric & Gas Co	VACAR
South Carolina Public Service Authority	VACAR
South Mississippi Electric Power Association	SOCO
Southern Co Services Inc	SOCO
Southern Illinois Power Coop	SCIL
Southern Indiana Gas & Electric Co	MISO_E
Southern Minnesota Municipal Power	MAPP_US
Southwestern Power Administration	SPP_S
Southwestern Public Service Co	SPP_S
Springfield IL City Water Light & Power	SCIL
Sunflower Electric Power Corp	SPP_N
Tacoma Power	NWPP
Tallahassee FL (City of)	FRCC
Tampa Electric Co	FRCC
Tennessee Valley Authority	TVA
Tucson Electric Power Co	AZ_NM_SNV
TXU Electric Co	ERCOT
Upper Peninsula Power Co	WUMS
Virginia Electric & Power Co	PJM_D
WAPA Desert Southwest Region	AZ_NM_SNV
WAPA Rocky Mountain Region	RMPA
WAPA Upper Great Plains Region East	MAPP_US
WAPA Upper Great Plains Region West	NWPP
Westar Energy	SPP_N
Western Farmers Electric Coop	SPP_S
Westplains Energy (KS)	SPP_N
Wisconsin Electric Power	WUMS
Wisconsin Public Service Corp	WUMS

Appendix A, Exhibit 3 - Forced New Builds

Plant Name	Unit	MW	Technology	On-line Year	Plant County	Plant State	NEEM Region
Clovis Wind	WT	5	WT	2011	Curry	NM	SPP_S
Solomon Forks Wind Farm	WT1 72	108	WT	2011	Thomas	KS	SPP_N
Bison Wind Project	WT1 16	37	WT	2011	Oliver	ND	MAPP_US
Bison Wind Project	WT 17 33	39	WT	2012	Oliver	ND	MAPP_US
Bent Tree Wind Farm	WT1 122	201	WT	2011	Freeborn	MN	MAPP_US
Chiquita Canyon Landfill	IC1	9	LFG	2011	Los Angeles	CA	SP15
ACE Boston Solar	PV1	2	PV	2012	Suffolk	MA	NEISO
Searchlight Solar	PV1	20	PV	2012	Clark	NV	AZ_NM_SNV
Dresden Energy Facility	CC	678	CC	2013	Muskingum	OH	PJM_Midwest
John W Turk Jr Power Plant	ST1	523	Coal	2013	Hempstead	AR	SPP_S
Prairie State Energy Campus	ST1	184	Coal	2012	Washington	IL	SCIL
Prairie State Energy Campus	ST2	184	Coal	2012	Washington	IL	SCIL
Ingrams Mill Farm	PV1	1	PV	2011	Chester	PA	PJM_E
Alta Wind Energy Center	WT1 100	75	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT101 150	75	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT151 200	75	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT201 234	51	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT235 291	84	WT	2011	Kern	CA	SP15
Elkins	GT1	20	CT	2011	Washington	AR	SPP_S
Elkins	GT2	20	CT	2011	Washington	AR	SPP_S
Elkins	GT3	20	CT	2011	Washington	AR	SPP_S
Aspen Power Lufkin Waste Wood Fa	ST	45	BM	2011	Angelina	TX	ERCOT
Chouteau	CC2	533	CC	2011	Mayes	OK	EMO
Hatchet Ridge Wind	WT1 44	101	WT	2011	Shasta	CA	NP15
Dry Fork Station	ST	362	Coal	2011	Campbell	WY	RMPA
Culbertson Peaker	GT	91	CT	2011	Roosevelt	MT	MAPP_US
Deer Creek Station	CC	300	CC	2012	Brookings	SD	MAPP_US
Bayonne Energy Center	GT1	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT2	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT3	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT4	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT5	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT6	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT7	64	CT	2011	Hudson	NJ	PJM_E
Bayonne Energy Center	GT8	64	CT	2011	Hudson	NJ	PJM_E
Dunlap Wind Farm	WT1 74	111	WT	2011	Carbon	WY	RMPA
Blooming Prairie	6	2	CT	2011	Steele	MN	MAPP_US
Gracey Wind Farm	WT	10	WT	2011	Not Reported	ON	OH
Naylor Wind Farm	WT1 5	10	WT	2011	Not Reported	ON	OH
North Malden Wind Farm	WT1 5	10	WT	2011	Not Reported	ON	OH
Richardson Wind Farm	WT1 5	10	WT	2011	Not Reported	ON	OH
Southside Wind Farm	WT1 5	10	WT	2011	Not Reported	ON	OH
Goshen II	WT1 83	62	WT	2011	Bingham	ID	NWPP
Chevron (City of) Brea Solar	PV	2	PV	2012	Orange	CA	SP15
Ivanpah 2 Solar	SS1	117	ST	2014	San Bernardino	CA	SP15
Ivanpah 1 Solar	SS1	120	ST	2014	San Bernardino	CA	SP15
Ivanpah 3 Solar	SS1	211	ST	2014	San Bernardino	CA	SP15
Gosfield Wind Project	WT1 22	50	WT	2011	Not Reported	ON	OH
Bruce A GS	1	0	NU	2011	Not Reported	ON	OH
Bruce A GS	2	0	NU	2011	Not Reported	ON	OH
Delta Power Plant	CC1	556	CC	2011	York	PA	PJM_W
Windy Point	WT177 189	30	WT	2011	Klickitat	WA	NWPP
Hudson Ranch Geothermal	GE	50	GEO	2012	Imperial	CA	SP15
Chevron Coalinga Solar	SS1	29	ST	2011	Fresno	CA	NP15
Chevron Canyon Crest Academy	PV	1	PV	2011	San Diego	CA	SP15
Chevron Lacosta Canyon High Scho	PV	1	PV	2011	San Diego	CA	SP15

Appendix A, Exhibit 3 - Forced New Builds

Chevron Mining Solar	SS1	1	ST	2011	Taos	NM	RMPA
Crofton Hills Wind Farm	WT1 14	42	WT	2011	Knox	NE	NE
Little Pringle Wind Farm	WT1 5	10	WT	2011	Hutchinson	TX	SPP_S
Little Pringle Wind Farm	WT6 10	10	WT	2011	Hutchinson	TX	SPP_S
Criterion Wind Power Generating Fa	WT 1 28	70	WT	2011	Garrett	MD	AE
J K Spruce	2	820	Coal	2011	Bexar	TX	ERCOT
V H Braunig	GT1	50	CT	2011	Bexar	TX	ERCOT
V H Braunig	GT2	50	CT	2011	Bexar	TX	ERCOT
V H Braunig	GT3	50	CT	2011	Bexar	TX	ERCOT
V H Braunig	GT4	50	CT	2011	Bexar	TX	ERCOT
SunPower T5 Solar Roof Tile Projec	PV	2	PV	2011	Maricopa	AZ	AZ_NM_SNV
Danielson Wind Farms	WT	20	WT	2011	Meeker	MN	MAPP_US
Tuana Gulch Wind Park	WT 1 8	17	WT	2011	Twin Falls	ID	NWPP
Lakeview Biomass	ST1	13	BM	2012	Lake	OR	NWPP
Cedro Hill Wind	WT1 100	150	WT	2011	Webb	TX	ERCOT
Bear Garden Generating Station	CC 2	580	CC	2011	Buckingham	VA	PJM_D
Virginia City Hybrid Energy Center	CFB	668	Coal	2013	Wise	VA	PJM_Midwest
Cliffside	6	800	Coal	2012	Cleveland	NC	VACAR
Kit Carson Windpower Project	WT1 34	51	WT	2011	Kit Carson	CO	RMPA
Blue Wing Solar	PV1	14	PV	2011	Bexar	TX	ERCOT
Edwardsport IGCC Station	IGCC	600	IGCC	2012	Knox	IN	MISO_E
Top of The World Windpower Proje	WT1 66	99	WT	2011	Converse	WY	NWPP
Top of The World Windpower Proje	WT67 110	101	WT	2011	Converse	WY	NWPP
Plum Point Energy	ST1	720	Coal	2011	Mississippi	AR	ENT
Papalote Creek Wind Farm	WT110 196	200	WT	2011	San Patricio	TX	ERCOT
Green Valley Landfill	4	1	LFG	2011	Greenup	KY	NonRTO_Midwest
Taloga Wind	WT1 54	130	WT	2011	Dewey	OK	SPP_S
Newman	CC5	148	CC	2011	El Paso	TX	AZ_NM_SNV
Iatan	2	102	Coal	2011	Platte	MO	SPP_N
Cedar Point Wind	WT1 139	250	WT	2012	Elbert	CO	RMPA
Top Crop Wind Farm	WT69 200	198	WT	2011	Livingston	IL	NI
Empire Generating	CC	639	CC	2011	Rensselaer	NY	NYISO_Capital
Kittyhawk	ST1	2	BM	2011	San Diego	CA	SP15
Keephills 3	3	248	Coal	2011	Not Reported	AB	ALB
Camp Reed Wind Farm	WT1 15	11	WT	2011	Gooding	ID	NWPP
Golden Valley Wind Park	WT1 8	6	WT	2011	Cassia	ID	NWPP
Lava Beds Wind Farm	WT1 12	9	WT	2011	Bingham	ID	NWPP
Milner Dam Wind Farm	WT1 13	10	WT	2011	Cassia	ID	NWPP
Oregon Trail Wind Park	WT 1 9	7	WT	2011	Twin Falls	ID	NWPP
Paynes Ferry Wind Park	WT1 14	10	WT	2011	Gooding	ID	NWPP
Pilgrim Stage Station Wind Park	WT 1 7	5	WT	2011	Twin Falls	ID	NWPP
Salmon Falls Wind Farm	WT1 14	11	WT	2011	Bingham	ID	NWPP
Thousand Springs Wind Park	WT 1-8	6	WT	2011	Twin Falls	ID	NWPP
Yahoo Creek Wind Park	WT1 14	10	WT	2011	Gooding	ID	NWPP
Farm Power Lynden	IC1	1	BM	2011	Whatcom	WA	NWPP
Fremont Energy Center	CC	703	CC	2011	Sandusky	OH	PJM_Midwest
R E Burger	4	0	Coal	2013	Belmont	OH	PJM_Midwest
R E Burger	5	0	Coal	2013	Belmont	OH	PJM_Midwest
Flat Water Wind Farm	WT1 40	60	WT	2011	Richardson	NE	SPP_S
Cane Island	CC4	300	CC	2011	Osceola	FL	FRCC
Point Comfort Cogeneration (NuCoa	CFB1	150	Coal	2011	Calhoun	TX	ERCOT
Dokie Wind Energy Project	WT1 48	73	WT	2011	Not Reported	BC	BC
Dokie Wind Energy Project	WT1 48	71	WT	2011	Not Reported	BC	BC
Camp Reed Wind Farm	WT1 15	11	WT	2011	Gooding	ID	NWPP
Golden Valley Wind Park	WT1 8	7	WT	2011	Cassia	ID	NWPP
Lava Beds Wind Farm	WT1 12	9	WT	2011	Bingham	ID	NWPP
Milner Dam Wind Farm	WT1 13	10	WT	2011	Cassia	ID	NWPP
Oregon Trail Wind Park	WT 1 9	7	WT	2011	Twin Falls	ID	NWPP

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Paynes Ferry Wind Park	WT1 14	11	WT	2011	Gooding	ID	NWPP
Pilgrim Stage Station Wind Park	WT 1 7	5	WT	2011	Twin Falls	ID	NWPP
Salmon Falls Wind Farm	WT1 14	11	WT	2011	Bingham	ID	NWPP
Thousand Springs Wind Park	WT 1-8	6	WT	2011	Twin Falls	ID	NWPP
Yahoo Creek Wind Park	WT1 14	11	WT	2011	Gooding	ID	NWPP
Inland Empire Energy Center	CS2	410	CC	2011	Riverside	CA	SP15
Longview Power	AB1	808	Coal	2011	Monongalia	WV	AE
Georgia Waste 2 Energy Toombs	ST1	9	LFG	2011	Toombs	GA	SOCO
Georgia Waste 2 Energy Toombs	ST2	9	LFG	2011	Toombs	GA	SOCO
Georgia Waste 2 Energy Toombs	ST3	9	LFG	2011	Toombs	GA	SOCO
Goodland Energy Resources	ST	22	Coal	2011	Sherman	KS	SPP_N
Whelan Energy Center	ST	15	Coal	2011	Adams	NE	NE
Iatan	2	465	Coal	2011	Platte	MO	SPP_N
Iatan	2	153	Coal	2011	Platte	MO	SPP_N
Spiritwood Energy	AB	99	Coal	2011	Stutsman	ND	MAPP_US
GV1 Solar	PV	2	PV	2011	San Joaquin	CA	NP15
Prairie Home Wind Power	WT1 6	0	WT	2011	Not Reported	AB	ALB
Whelan Energy Center	ST	35	Coal	2011	Adams	NE	NE
Whelan Energy Center	ST	80	Coal	2011	Adams	NE	NE
Hendricks Community Hospital	GEO6	1	CT	2011	Hendricks	IN	MISO_E
Buffalo Ridge II	WT1 105	210	WT	2011	Brookings	SD	MAPP_US
Dry Lake Wind	WT31 61	65	WT	2011	Navajo	AZ	AZ_NM_SNV
Elm Creek II Wind Project	WT1 62	149	WT	2011	Jackson	MN	MAPP_US
Fairfield Wind Project	WT 1 37	74	WT	2011	Herkimer	NY	NYISO_Upstate
Langley Gulch Power Plant	CC1	300	CC	2013	Payette	ID	NWPP
Cedar Creek Wind Energy	WT238 297	150	WT	2011	Weld	CO	RMPA
Cedar Creek Wind Energy	WT275 237	101	WT	2011	Weld	CO	RMPA
Henrico County Landfill	GT1 6	2	LFG	2011	Henrico	VA	PJM_D
Henrico County Landfill	GT2 6	2	LFG	2011	Henrico	VA	PJM_D
Beech Ridge Wind Farm (WV)	WT11 124	17	WT	2011	Greenbrier	WV	PJM_Midwest
White Oak Wind Farm	WT1 100	150	WT	2012	Grant	WI	WUMS
Nelson Energy Center	CC1	287	CC	2011	Lee	IL	NI
Nelson Energy Center	CC2	287	CC	2011	Lee	IL	NI
Vantage Wind Project	WT1 60	90	WT	2011	Kittitas	WA	NWPP
Jetstream Wind T OR C Hydrogen P	GT1	10	CT	2011	Sierra	NM	AZ_NM_SNV
Douglas L Smith Middle Basin Treat	IC1	1	LFG	2011	Johnson	KS	SPP_N
Douglas L Smith Middle Basin Treat	IC2	1	LFG	2011	Johnson	KS	SPP_N
Iatan	2	30	Coal	2011	Platte	MO	SPP_N
Kruger Energy Chatham Wind Proje	WT45 84	92	WT	2011	Not Reported	ON	OH
Kruger Energy Chatham Wind Proje	WT85 88	9	WT	2011	Not Reported	ON	OH
Soaring Heights Community Solar P	PV2	3	PV	2011	Pima	AZ	AZ_NM_SNV
UC San Diego	FC1	2	BM	2011	San Diego	CA	SP15
Terminal Island Renewable Energy	1	1	BM	2011	Los Angeles	CA	SP15
Terminal Island Renewable Energy	2	1	BM	2011	Los Angeles	CA	SP15
Pine Tree Wind	WT81 90	15	WT	2011	Kern	CA	SP15
Sandy Creek Energy Station	ST	900	Coal	2012	Mclennan	TX	ERCOT
Alta Wind Energy Center	WT1 100	75	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT101 150	75	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT151 200	75	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT201 234	51	WT	2011	Kern	CA	SP15
Alta Wind Energy Center	WT235 291	84	WT	2011	Kern	CA	SP15
Berkshire Wind Power	WT1 10	15	WT	2011	Berkshire	MA	NEISO
Medicine Hat	CT15	42	CT	2011	Not Reported	AB	ALB
Oak Creek Power Plant	2	51	Coal	2011	Milwaukee	WI	WUMS
Big Sky Wind Farm	WT1 114	239	WT	2011	Bureau	IL	NI
Laredo Ridge Wind	WT1 54	81	WT	2011	Boone	NE	NE
Iatan	2	100	Coal	2011	Platte	MO	SPP_N
Woodland Generation Station	IC1	8	CT	2012	Stanislaus	CA	NP15

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Woodland Generation Station	IC2	8	CT	2012	Stanislaus	CA	NP15
Woodland Generation Station	IC3	8	CT	2012	Stanislaus	CA	NP15
Woodland Generation Station	IC4	8	CT	2012	Stanislaus	CA	NP15
Woodland Generation Station	IC5	8	CT	2012	Stanislaus	CA	NP15
Woodland Generation Station	IC6	8	CT	2012	Stanislaus	CA	NP15
Port Arthur Refinery (MOTIVA)	GN36	42	CT	2012	Jefferson	TX	ENT
Port Arthur Refinery (MOTIVA)	GN37	42	CT	2012	Jefferson	TX	ENT
Port Arthur Refinery (MOTIVA)	GN38	42	CT	2012	Jefferson	TX	ENT
Port Arthur Refinery (MOTIVA)	GN39	42	CT	2012	Jefferson	TX	ENT
Whelan Energy Center	ST	80	Coal	2011	Adams	NE	NE
Madison Bell Power Plant	CC1	275	CC	2012	Madison	TX	ERCOT
Whelan Energy Center	ST	10	Coal	2011	Adams	NE	NE
Martin (FL)	CC5	0	CC	2011	Martin	FL	FRCC
West County Energy Center	CC3	1,250	CC	2011	Palm Beach	FL	FRCC
Minco Wind Farm	WT1 62	99	WT	2011	Grady	OK	SPP_S
Red Mesa Wind Farm	WT1 64	102	WT	2011	Cibola	NM	RMPA
John W Turk Jr Power Plant	ST1	71	Coal	2013	Hempstead	AR	SPP_S
Lodi Energy Center	CC	280	CC	2012	San Joaquin	CA	NP15
Mill Creek (MT)	GT1	50	CT	2011	Deer Lodge	MT	NWPP
Mill Creek (MT)	GT2	50	CT	2011	Deer Lodge	MT	NWPP
Mill Creek (MT)	GT3	50	CT	2011	Deer Lodge	MT	NWPP
Devon	15	50	CT	2011	New Haven	CT	NEISO
Devon	16	50	CT	2011	New Haven	CT	NEISO
Devon	17	50	CT	2011	New Haven	CT	NEISO
Devon	18	50	CT	2011	New Haven	CT	NEISO
Point Comfort Cogeneration (NuCoa	CFB2	150	Coal	2011	Calhoun	TX	ERCOT
Harry Allen (NV)	CC	520	CC	2011	Clark	NV	AZ_NM_SNV
John W Turk Jr Power Plant	ST1	14	Coal	2013	Hempstead	AR	SPP_S
Olmsted Waste Energy	3	6	LFG	2011	Olmsted	MN	MAPP_US
Orbit Energy	IC	2	CT	2011	Sampson	NC	VACAR
Jersey Valley Geothermal	GE1	15	GEO	2011	Pershing	NV	NWPP
Prairie State Energy Campus	ST1	616	Coal	2012	Washington	IL	SCIL
Prairie State Energy Campus	ST2	616	Coal	2012	Washington	IL	SCIL
Colusa Generating Station	CC1	660	CC	2011	Colusa	CA	NP15
Humboldt Bay	IC 1	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 10	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 2	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 3	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 4	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 5	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 6	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 7	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 8	16	CT	2011	Humboldt	CA	NP15
Humboldt Bay	IC 9	16	CT	2011	Humboldt	CA	NP15
Solana Generating Station	SS1	140	ST	2013	Maricopa	AZ	AZ_NM_SNV
Solana Generating Station	SS2	140	ST	2013	Maricopa	AZ	AZ_NM_SNV
McIntosh Caes	4	185	CT	2011	Washington	AL	SOCO
McIntosh Caes	5	185	CT	2011	Washington	AL	SOCO
Crayola Solar Park	PV1	1	PV	2011	Northampton	PA	PJM_W
Rye Patch	GE	13	GEO	2012	Pershing	NV	NWPP
Richmond (NC)	CC2B	570	CC	2011	Richmond	NC	VACAR
Ridgewind Wind Project	WT1 16	27	WT	2011	Murray	MN	MAPP_US
Silver Lake Solar Farm (NJ)	PV1	2	PV	2011	Middlesex	NJ	PJM_E
Yardville Solar Farm	PV1	5	PV	2011	Mercer	NJ	PJM_E
Roosevelt Biogas 1	10	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	11	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	12	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	13	2	LFG	2011	Klickitat	WA	NWPP

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Roosevelt Biogas 1	14	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	15	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	6	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	7	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	8	2	LFG	2011	Klickitat	WA	NWPP
Roosevelt Biogas 1	9	2	LFG	2011	Klickitat	WA	NWPP
Lower Snake River Wind Energy Pro	WT1 149	343	WT	2012	Garfield	WA	NWPP
Sunset Reservoir	PV	5	PV	2011	San Francisco	CA	NP15
Blue Lake Power LLC	GEN1	0	BM	2011	Humboldt	CA	NP15
Greenwich Windfarm	WT1 43	99	WT	2012	Not Reported	ON	OH
Talbot Windfarm	WT1 43	99	WT	2011	Not Reported	ON	OH
Prairie Home Wind Power	WT1 6	9	WT	2011	Not Reported	AB	ALB
US Doe SRS (F Area)	AB	20	BM	2012	Barnwell	SC	VACAR
Astoria Energy	CC2	720	CC	2011	Queens	NY	NYISO_NYC
Copper Mountain Solar	PV2	40	PV	2011	Clark	NV	AZ_NM_SNV
Seneca Sustainable Energy Project	ST1	19	BM	2011	Lane	OR	NWPP
Renaissance Geothermal	GE1	32	GEO	2013	Box Elder	UT	NWPP
Norfolk Solar Project	PV1	5	PV	2011	Not Reported	ON	OH
Swaco Facility	GT2	1	BM	2012	Franklin	OH	PJM_Midwest
Perdido Landfill	IC1	3	LFG	2011	Escambia	FL	SOCO
Nacogdoches Power Electric Genera	AB	100	BM	2012	Nacogdoches	TX	ERCOT
Cleveland County Power Plant	GT1	184	CT	2012	Cleveland	NC	VACAR
Cleveland County Power Plant	GT2	184	CT	2012	Cleveland	NC	VACAR
Cleveland County Power Plant	GT3	184	CT	2012	Cleveland	NC	VACAR
Cleveland County Power Plant	GT4	184	CT	2012	Cleveland	NC	VACAR
Cimarron I Solar	PV1	31	PV	2011	Colfax	NM	AZ_NM_SNV
Southwest	ST2	300	Coal	2011	Greene	MO	SPP_S
Firebag Cogeneration	GT2	80	CT	2011	Not Reported	AB	ALB
Firebag Cogeneration	GT3	80	CT	2011	Not Reported	AB	ALB
Boulder Wastewater Solar	PV	1	PV	2011	Boulder	CO	RMPA
SunEdison Davidson County Solar	PV2	12	PV	2011	Davidson	NC	VACAR
Norfolk Solar Project	PV1	5	PV	2011	Not Reported	ON	OH
John Sevier Combined Cycle Plant	CC1	880	CC	2012	Hawkins	TN	TVA
Lagoon Creek	CC	600	CC	2011	Haywood	TN	TVA
Watts Bar Nuclear	NP2	1,270	NU	2014	Rhea	TN	TVA
Texas Medical Center	GT	50	CT	2011	Harris	TX	ERCOT
Larimer County Landfill	IC1	1	LFG	2012	Larimer	CO	RMPA
Keephills 3	3	248	Coal	2011	Not Reported	AB	ALB
Coolidge Generating Station	1	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	10	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	11	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	12	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	2	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	3	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	4	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	5	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	6	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	7	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	8	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Coolidge Generating Station	9	61	CT	2011	Pinal	AZ	AZ_NM_SNV
Halton Hills Generating Station	CC	683	CC	2011	Not Reported	ON	OH
Kibby Wind Power	WT23 44	66	WT	2011	Franklin	ME	NEISO
Crayola Solar Park	PV1	1	PV	2011	Northampton	PA	PJM_W
Neal Hot Springs	GE1	26	GEO	2012	Malheur	OR	NWPP
Goshen II	WT1 83	62	WT	2011	Bingham	ID	NWPP
Keenan Wind Farm II	WT1 66	152	WT	2011	Woodward	OK	SPP_S
Green Energy Plant	IC1	5	LFG	2011	Yamhill	OR	NWPP
Burnsville Plant	UNT4	2	LFG	2011	Dakota	MN	MAPP_US

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Black Hills Colorado 1	GT1	76	CT	2012	Pueblo	CO	RMPA
Black Hills Colorado 1	GT2	76	CT	2012	Pueblo	CO	RMPA
Zachary Ridge LLC	WT4	2	WT	2011	Osceola	IA	MAPP_US
Oak Creek Power Plant	2	513	Coal	2011	Milwaukee	WI	WUMS
Oak Creek Power Plant	2	51	Coal	2011	Milwaukee	WI	WUMS
Dry Fork Station	ST	28	Coal	2011	Campbell	WY	RMPA
Lakefield Wind Project	WT1 134	201	WT	2011	Nobles	MN	MAPP_US

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Plant Name	Unit	MW	Technology	Retirement Year	Plant State	NEEM Region
Mesa Wind Developers (ZPI)	WT1 300	19.5	WT	2011	California	SP15
Mesa Wind Developers (ZPI)	WT301 460	10.4	WT	2011	California	SP15
Richard H Gorsuch	1	50	Coal	2011	Ohio	AE
Richard H Gorsuch	2	50	Coal	2011	Ohio	AE
Richard H Gorsuch	3	50	Coal	2011	Ohio	AE
Richard H Gorsuch	4	50	Coal	2011	Ohio	AE
Phil Sporn	5	495.5	Coal	2014	West Virginia	C_PhilSpor_5
Bountiful City	2	1.2	PeakG	2012	Utah	NWPP
Bountiful City	3	1.2	PeakG	2012	Utah	NWPP
Bountiful City	4	1	PeakG	2012	Utah	NWPP
Bountiful City	5	1	PeakG	2012	Utah	NWPP
Bountiful City	6	2.5	PeakG	2012	Utah	NWPP
Conesville	3	161.5	Coal	2013	Ohio	PJM_Midwest
B C Cobb	4	156.3	Coal	2018	Michigan	MI
B C Cobb	5	156.3	Coal	2018	Michigan	MI
J C Weadock	7	156.3	Coal	2018	Michigan	MI
J C Weadock	8	156.3	Coal	2018	Michigan	MI
J R Whiting	1	106.3	Coal	2018	Michigan	MI
J R Whiting	2	106.3	Coal	2018	Michigan	MI
J R Whiting	3	132.8	Coal	2018	Michigan	MI
Rothschild (WI)	TG2	5	STOG	2014	Wisconsin	WUMS
Buck Steam Station (NC)	3	80	Coal	2012	North Carolina	VACAR
Buck Steam Station (NC)	4	40	Coal	2012	North Carolina	VACAR
Cliffside	1	40	Coal	2011	North Carolina	VACAR
Cliffside	2	40	Coal	2011	North Carolina	VACAR
Cliffside	3	65	Coal	2011	North Carolina	VACAR
Cliffside	4	65	Coal	2011	North Carolina	VACAR
Dan River (NC)	1	70	Coal	2013	North Carolina	VACAR
Dan River (NC)	2	70	Coal	2013	North Carolina	VACAR
Edwardsport	7	40.2	Coal	2012	Indiana	MISO_E
Edwardsport	8	69	Coal	2012	Indiana	MISO_E
South Bay	2	136	STOG	2011	California	SP15
South Bay	ST1	136	STOG	2011	California	SP15
South Bay	5	15	PeakO	2013	California	SP15
Escondido	GEN1	44	PeakG	2011	California	SP15
Cromby Generating Station	1	187.5	Coal	2011	Pennsylvania	PJM_E
Cromby Generating Station	2	230	STOG	2011	Pennsylvania	PJM_E
Eddystone Generating Station	1	353.6	Coal	2011	Pennsylvania	C_Eddyston_1
Eddystone Generating Station	2	353.6	Coal	2013	Pennsylvania	C_Eddyston_2
Cape Canaveral	1	402	STOG	2011	Florida	FRCC
Cape Canaveral	2	402	STOG	2011	Florida	FRCC
Mitchell (GA)	3	163.2	Coal	2011	Georgia	SOCO
James de Young	3	11.5	Coal	2012	Michigan	MI
Webeque First Nation	GEN1	0.65	PeakO	2012	Ontario	OH
Haynes	5	343	STOG	2013	California	SP15
Haynes	6	343	STOG	2013	California	SP15
Big Cajun 1	1	113.6	STOG	2011	Louisiana	ENT
Big Cajun 1	2	113.6	STOG	2011	Louisiana	ENT
Blount Street	3	34.5	STOG	2012	Wisconsin	WUMS
Blount Street	4	20	STOG	2012	Wisconsin	WUMS
Blount Street	5	23	Coal	2012	Wisconsin	WUMS
Medicine Hat	5	13.4	PeakG	2011	Alberta	ALB
Medicine Hat	8	33.9	PeakG	2011	Alberta	ALB
Will County	1	187.5	Coal	2011	Illinois	NI
Will County	2	183.7	Coal	2011	Illinois	NI

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Contra Costa	6	359	STOG	2013	California	NP15
Contra Costa	7	359	STOG	2013	California	NP15
Potrero Power	PT03	226	STOG	2011	California	NP15
Potrero Power	PT04	52	PeakO	2011	California	NP15
Potrero Power	PT05	52	PeakO	2011	California	NP15
Potrero Power	PT06	52	PeakO	2011	California	NP15
Astoria Gas Turbines	10	31.8	PeakO	2011	New York	NYISO_NYC
Astoria Gas Turbines	11	31.8	PeakO	2011	New York	NYISO_NYC
Astoria Gas Turbines	12	31.8	PeakO	2011	New York	NYISO_NYC
Astoria Gas Turbines	13	31.8	PeakO	2011	New York	NYISO_NYC
Astoria Gas Turbines	2 1	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	2 2	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	2 3	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	2 4	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	3 1	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	3 2	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	3 3	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	3 4	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	4 1	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	4 2	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	4 3	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	4 4	46.5	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	5	19.2	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	7	19.2	PeakO	2015	New York	NYISO_NYC
Astoria Gas Turbines	8	19.2	PeakO	2015	New York	NYISO_NYC
Indian River Generating Station (DE)	1	81.6	Coal	2011	Delaware	PJM_E
Indian River Generating Station (DE)	3	176.8	Coal	2014	Delaware	PJM_E
Muskingum River	1	219.6	Coal	2016	Ohio	PJM_Midwest
Muskingum River	2	219.6	Coal	2016	Ohio	PJM_Midwest
Muskingum River	3	237.5	Coal	2016	Ohio	C_Muskingu_3
Muskingum River	4	237.5	Coal	2016	Ohio	C_Muskingu_4
Lambton GS	1	520	Coal	2011	Ontario	OH
Lambton GS	2	520	Coal	2011	Ontario	OH
Nanticoke	3	510	Coal	2011	Ontario	OH
Nanticoke	4	505	Coal	2011	Ontario	OH
Humboldt Bay	ST1	51.2	STOG	2011	California	NP15
Humboldt Bay	ST2	51.2	STOG	2011	California	NP15
Boardman (OR)	1	601	Coal	2020	Oregon	C_Boardman_1
Benning	15	290	STOG	2012	District of Columbia	PJM_SW
Benning	16	290	STOG	2012	District of Columbia	PJM_SW
Buzzard Point	E1	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	E2	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	E4	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	E5	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	E6	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	E7	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	E8	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W10	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W11	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W12	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W13	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W14	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W15	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W16	18	PeakO	2012	District of Columbia	PJM_SW
Buzzard Point	W9	18	PeakO	2012	District of Columbia	PJM_SW
Cape Fear	5	140.6	Coal	2018	North Carolina	VACAR
Cape Fear	6	187.9	Coal	2018	North Carolina	VACAR

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L V Sutton	1	112.5	Coal	2014	North Carolina	VACAR
L V Sutton	2	112.5	Coal	2014	North Carolina	VACAR
L V Sutton	3	446.6	Coal	2014	North Carolina	C_LVSutton_3
Lee	1	75	Coal	2013	North Carolina	VACAR
Lee	2	75	Coal	2013	North Carolina	VACAR
Lee	3	252.4	Coal	2013	North Carolina	C_Lee3_3
W H Weatherspoon	1	46	Coal	2018	North Carolina	VACAR
W H Weatherspoon	2	46	Coal	2018	North Carolina	VACAR
W H Weatherspoon	3	73.5	Coal	2018	North Carolina	VACAR
Crystal River	1	440.5	Coal	2020	Florida	C_CrystalR_1
Crystal River	2	523.8	Coal	2020	Florida	C_CrystalR_2
Kearny Generating Station	9	18.5	PeakG	2013	New Jersey	PJM_E
Arapahoe	3	46	Coal	2013	Colorado	RMPA
Cameo	1	25	Coal	2011	Colorado	RMPA
Cameo	2	50	Coal	2011	Colorado	RMPA
Cherokee (CO)	1	125	Coal	2012	Colorado	RMPA
Cherokee (CO)	2	125	Coal	2012	Colorado	RMPA
Cherokee (CO)	3	170.5	Coal	2018	Colorado	RMPA
Cherokee (CO)	4	380.8	Coal	2023	Colorado	C_Cherokee_4
Reeves	1	44	STOG	2013	New Mexico	AZ_NM_SNV
Reeves	2	44	STOG	2013	New Mexico	AZ_NM_SNV
Ridgetop Energy LLC	WT1	31.1	WT	2012	California	SP15
Ridgetop Energy LLC II	WT1	46.8	WT	2011	California	SP15
Somerset Station	SOM6	100	Coal	2012	Massachusetts	NEISO
251 Project	WGNS	18.4	WT	2012	California	SP15
Univ of Iowa Main	GEN1	3	Coal	2014	Iowa	MAPP_US
Univ of Iowa Main	GEN2	3	Coal	2014	Iowa	MAPP_US
Univ of Iowa Main	GEN6	15	Coal	2014	Iowa	MAPP_US
Empire	OE11	1.2	GEO	2012	Nevada	NWPP
Empire	OE12	1.2	GEO	2012	Nevada	NWPP
Empire	OE13	1.2	GEO	2012	Nevada	NWPP
Empire	OE14	1.2	GEO	2012	Nevada	NWPP
Howard M Down	9	16.5	STOG	2011	New Jersey	PJM_E
North Branch (WV)	1	80	Coal	2011	West Virginia	PJM_D
Jack McDonough	1	251	Coal	2013	Georgia	C_JackMcDo_1
Jack McDonough	2	252	Coal	2013	Georgia	C_JackMcDo_2
Scholz	1	46	Coal	2012	Florida	SOCO
Scholz	2	46	Coal	2012	Florida	SOCO
Dan River (NC)	3	142	Coal	2013	North Carolina	VACAR
Arapahoe	3	109	Coal	2013	Colorado	RMPA
MT Poso Cogeneration	TG01	57	Coal	2012	California	SP15
Hunlock Power Station	3	43	Coal	2010		PJM_W
Indian River Generating Station (DE)	2	89	Coal	2010	Delaware	PJM_E
Riverbend (NC)	4	94	Coal	2015	North Carolina	VACAR
Riverbend (NC)	5	94	Coal	2015	North Carolina	VACAR
Riverbend (NC)	6	133	Coal	2015	North Carolina	VACAR
Riverbend (NC)	7	133	Coal	2015	North Carolina	VACAR
W S Lee	1	100	Coal	2015	South Carolina	VACAR
W S Lee	2	100	Coal	2015	South Carolina	VACAR
W S Lee	3	170	Coal	2015	South Carolina	VACAR
Atikokan GS	1	211	Coal	2014	Ontario	OH
Lambton GS	3	489	Coal	2014	Ontario	OH
Lambton GS	4	502	Coal	2014	Ontario	OH
Nanticoke	1	490	Coal	2014	Ontario	OH
Nanticoke	2	490	Coal	2014	Ontario	OH
Nanticoke	5	490	Coal	2014	Ontario	OH
Nanticoke	6	490	Coal	2014	Ontario	OH

Appendix A, Exhibit 4 - Forced Retirements

Nanticoke	7	508	Coal	2014	Ontario	OH
Nanticoke	8	490	Coal	2014	Ontario	OH

Appendix A, Exhibit 5 - Regional Multipliers
AEO 2003

NEEM Region	Cost Multiplier
AE	0.996
AZ_NM_SNV_Coal	1.003
EMO	1.004
ENT	0.960
ERCOT	0.986
FRCC	0.961
MAPP_US	1.004
MI	1.004
MISO_E	1.004
NE	1.004
NEISO	1.070
NI	1.004
NonRTO_Midwest	1.004
NP15	1.100
NWPP_Coal	1.026
NYISO_Capital	0.960
NYISO_Downstate	1.087
NYISO_LIPA	1.245
NYISO_NYC	1.326
NYISO_Upstate	1.006
PJM_D	0.960
PJM_E	1.130
PJM_Midwest	1.004
PJM_SW	1.130
PJM_W	1.130
RMPA	1.003
SCIL	1.004
SOCO	0.960
SP15	1.100
SPP_N	0.997
SPP_S	0.997
TVA	0.960
VACAR	0.960
WUMS	1.004
ALB	1.040
BC	1.100
OH	1.100

Appendix A, Exhibit 6 - New Resource Limits

Technology		Capacity Limits (GW)								
Pulverized Coal	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	∞									
AZ_NM_SNV_Coal	∞									
EMO	∞									
ENT	∞									
ERCOT	∞									
FRCC	∞									
MAPP_US	∞									
MI	∞									
MISO_E	∞									
NE	∞									
NEISO	0.0									
NI	∞									
NonRTO_Midwest	∞									
NP15	0.0									
NWPP_Coal	∞									
NYISO_Capital	0.0									
NYISO_Downstate	0.0									
NYISO_LIPA	0.0									
NYISO_NYC	0.0									
NYISO_Upstate	0.0									
PJM_D	∞									
PJM_E	0.0									
PJM_Midwest	∞									
PJM_SW	∞									
PJM_W	∞									
RMPA	∞									
SCIL	∞									
SOCO	∞									
SP15	0.0									
SPP_N	∞									
SPP_S	∞									
TVA	∞									
VACAR	∞									
WUMS	∞									
ALB	0.0									
BC	0.0									
OH	0.0									
Total US			16	46	76	106	136	166	196	226

Technology		Capacity Limits (GW)								
Nuclear	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	∞									
AZ_NM_SNV_Coal	∞									
EMO	∞									
ENT	∞									
ERCOT	∞			0.8	2.9	4.9	7.9	7.9	7.9	12.0
FRCC	∞			2.0	3.3	4.7	6.0	7.3	8.7	10.0
MAPP_US	∞									
MI	∞									
MISO_E	∞									
NE	∞									
NEISO	∞			0.0	0.0	2.0	4.2	4.9	4.9	7.2

Appendix A, Exhibit 6 - New Resource Limits

NI	∞									
NonRTO_Midwest	∞									
NP15	0.0									
NWPP_Coal	∞									
NYISO_Capital	∞									
NYISO_Downstate	0.0									
NYISO_LIPA	0.0			1.0	2.0	5.3	7.3	10.2	10.2	10.2
NYISO_NYC	0.0									
NYISO_Upstate	∞									
PJM_D	15.0			2.0	6.7	11.3	16.0	20.7	25.3	30.0
PJM_Midwest	∞									
PJM_E	∞									
PJM_SW	∞			0.0	1.3	4.1	9.1	12.9	16.5	20.2
PJM_W	∞									
RMPA	∞									
SCIL	∞									
SOCO	∞									
SP15	0.0									
SPP_N	∞									
SPP_S	∞									
TVA	∞									
VACAR	15.0						Shares limits with PJM_D			
WUMS	∞									
ALB	0.0									
BC	0.0									
OH	0.0									
Total US	∞		1.4	6.0	21.0	50.3	106.5	150.7	209.1	267.5

Technology		**Capacity Limits (GW)**								
Wind	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	0.5									
AZ_NM_SNV_Coal	3.2									
EMO	0.2									
ENT	0.2									
ERCOT	10.5									
FRCC	0.0									
MAPP_US	106.6									
MI	0.3									
MISO_E	0.3									
NE	157.2									
NEISO_CT	0.3									
NEISO_MA	0.6									
NEISO_ME	3.5	0.34	1.42	2.42	3.42	4.42	5.42	6.42	7.42	7.58
NEISO_RI	0.3									
NEISO_NH	0.9									
NEISO_VT	2.0									
NI	0.5									
NonRTO_Midwest	0.1									
NP15	2.8									
NWPP_Coal	5.3									
NYISO_Capital	0.2									
NYISO_Downstate	0.1									
NYISO_LIPA	0.0	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
NYISO_NYC	0.0									
NYISO_Upstate	0.4									
PJM_D	0.7									

Appendix A, Exhibit 6 - New Resource Limits

PJM_Midwest	0.3									
PJM_E	0.3									
PJM_SW	0.3	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
PJM_W	0.3									
RMPA	339.5									
SCIL	1.3									
SOCO	0.0									
SP15	2.7									
SPP_N	2.5									
SPP_S	2.5									
TVA	0.4									
VACAR	1.4									
WUMS	0.6									
ALB	0.1									
BC	0.3									
OH	0.5									
All Other Regions										

Technology		**Capacity Limits (GW)**								
Offshore Wind	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	0.0									
AZ_NM_SNV_Coal	0.0									
EMO	0.0									
ENT	0.0									
ERCOT	0.0									
FRCC	0.0									
MAPP_US	0.0									
MI	4.4									
MISO_E	4.9									
NE	0.0									
NEISO_CT	0.2									
NEISO_MA	7.9									
NEISO_ME	0.2	8.54	8.54	8.54	8.54	8.54	8.54	8.54	8.54	8.54
NEISO_RI	0.2									
NEISO_NH	0.0									
NEISO_VT	0.0									
NI	1.0									
NonRTO_Midwest	4.9									
NP15	0.1									
NWPP_Coal	0.2									
NYISO_Capital	0.0									
NYISO_Downstate	0.0									
NYISO_LIPA	2.4									
NYISO_NYC	0.0									
NYISO_Upstate	0.5	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
PJM_D	14.4									
PJM_E	25.2	25.18	25.18	25.18	25.18	25.18	25.18	25.18	25.18	25.18
PJM_Midwest	4.9									
PJM_SW	0.0									
PJM_W	1.3	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
RMPA	0.0									
SCIL	0.0									
SOCO	0.0									
SP15	0.0									
SPP_N	0.0									
SPP_S	0.0									
TVA	0.0									

Appendix A, Exhibit 6 - New Resource Limits

VACAR	28.9									
WUMS	2.1									
ALB	0.0									
BC	0.0									
OH	0.0									
Total offshore		0	1	11	36	61	86	111	136	161

Technology		Capacity Limits (GW)								
Biomass	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	0.2									
AZ_NM_SNV_Coal	6.5									
EMO	2.4									
ENT	10.1									
ERCOT	4.1									
FRCC	2.0									
MAPP_US	10.8									
MI	6.1									
MISO_E	6.1									
NE	10.8									
NEISO_CT	0.3	0.03	0.06	0.07	0.10	0.13	0.23	0.34	0.34	0.34
NEISO_MA	0.3	0.03	0.06	0.07	0.10	0.13	0.23	0.34	0.34	0.34
NEISO_ME	0.3	0.03	0.06	0.07	0.10	0.13	0.23	0.34	0.34	0.34
NEISO_RI	0.3	0.03	0.06	0.07	0.10	0.13	0.23	0.34	0.34	0.34
NEISO_NH	0.3	0.03	0.06	0.07	0.10	0.13	0.23	0.34	0.34	0.34
NEISO_VT	0.3									
NI	0.7									
NonRTO_Midwest	6.1									
NP15	0.8	1.56	2.65	3.12	4.68	6.24	10.92	15.60	15.60	15.60
NWPP_Coal	9.0									
NYISO_Capital	0.2	0.02	0.03	0.04	0.05	0.07	0.13	0.18	0.18	0.18
NYISO_Downstate	0.8	0.02	0.03	0.04	0.05	0.07	0.13	0.18	0.18	0.18
NYISO_LIPA	0.0									
NYISO_NYC	0.0									
NYISO_Upstate	0.8	0.02	0.03	0.04	0.05	0.07	0.13	0.18	0.18	0.18
PJM_D	3.5									
PJM_Midwest	0.3									
PJM_E	6.1									
PJM_SW	0.8	0.73	1.24	1.45	2.18	2.91	5.09	7.27	7.27	7.27
PJM_W	1.6									
RMPA	3.7									
SCIL	6.5									
SOCO	6.6									
SP15	0.7					Shares limits with NP15				
SPP_N	6.4									
SPP_S	4.5									
TVA	7.4									
VACAR	7.0									
WUMS	3.2									
ALB	0.0									
BC	0.0									
OH	0.0									
Total US biomass			24	35	45	65	85	105	125	145

Technology		Capacity Limits (GW)								
Photovoltaic	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**

Appendix A, Exhibit 6 - New Resource Limits

AE	0.0									
AZ_NM_SNV_Coal	10.0									
EMO	5.0									
ENT	5.0									
ERCOT	10.0									
FRCC	10.0									
MAPP_US	2.0									
MI	1.3									
MISO_E	1.3									
NE	2.0									
NEISO	12.0									
NI	5.0									
NonRTO_Midwest	1.3									
NP15	10.0									
NWPP_Coal	5.0									
NYISO_Capital	2.0									
NYISO_Downstate	2.0	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.60	0.60
NYISO_LIPA	2.0									
NYISO_NYC	2.0	0.05	0.05	0.05	0.05	0.05	0.05	0.05		
NYISO_Upstate	2.0				Shares limits with non-NYC NYISO regions					
PJM_D	0.7									
PJM_E	2.0									
PJM_Midwest	1.3									
PJM_SW	2.0									
PJM_W	2.0									
RMPA	5.0									
SCIL	2.0									
SOCO	2.0									
SP15	10.0									
SPP_N	2.0									
SPP_S	2.0									
TVA	2.0									
VACAR	1.3									
WUMS	2.0									
ALB	0.0									
BC	0.0									
OH	0.1									
All Other Regions		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Technology		**Capacity Limits (GW)**								
Landfill Gas	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	0.1									
AZ_NM_SNV_Coal	0.0									
EMO	0.2									
ENT	0.1									
ERCOT	0.4									
FRCC	0.2									
MAPP_US	0.1									
MI	0.1									
MISO_E	0.1									
NE	0.1									
NEISO	0.7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NI	0.1									
NonRTO_Midwest	0.1									
NP15	0.6	0.24	0.39	0.66	0.66	0.66	0.66	0.66	0.66	0.66
NWPP_Coal	0.3									
NYISO_Capital	0.2									

Appendix A, Exhibit 6 - New Resource Limits

NYISO_Downstate	0.2									
NYISO_LIPA	0.2	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
NYISO_NYC	0.2									
NYISO_Upstate	0.2									
PJM_D	0.0									
PJM_E	0.1									
PJM_Midwest	0.1									
PJM_SW	0.1									
PJM_W	0.1									
RMPA	0.0									
SCIL	0.3									
SOCO	0.1									
SP15	0.6	Shares limits with NP15								
SPP_N	0.1									
SPP_S	0.1									
TVA	0.1									
VACAR	0.1									
WUMS	0.2									
ALB	0.0									
BC	0.0									
OH	0.0									
All Other Regions		2.54	5.51	5.51	5.51	5.51	5.51	5.51	5.51	5.51

Technology		**Capacity Limits (GW)**								
Geothermal	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	0.0									
AZ_NM_SNV_Coal	1.5									
EMO	0.0									
ENT	0.0									
ERCOT	0.0									
FRCC	0.0									
MAPP_US	0.0									
MI	0.0									
MISO_E	0.0									
NE	0.0									
NEISO	0.0									
NI	0.0									
NonRTO_Midwest	0.0									
NP15	0.6	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
NWPP_Coal	0.5									
NYISO_Capital	0.0									
NYISO_Downstate	0.0									
NYISO_LIPA	0.0									
NYISO_NYC	0.0									
NYISO_Upstate	0.0									
PJM_D	0.0									
PJM_E	0.0									
PJM_Midwest	0.0									
PJM_SW	0.0									
PJM_W	0.0									
RMPA	2.6									
SCIL	0.0									
SOCO	0.0									
SP15	1.5	Shares limits with NP15								
SPP_N	0.0									
SPP_S	0.0									
TVA	0.0									

Appendix A, Exhibit 6 - New Resource Limits

VACAR	0.0									
WUMS	0.0									
ALB	0.0									
BC	0.0									
OH	0.0									

Technology		Capacity Limits (GW)								
Solar Thermal	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	0.0									
AZ_NM_SNV_Coal	10.0									
EMO	0.0									
ENT	0.0									
ERCOT	0.0									
FRCC	0.0									
MAPP_US	0.0									
MI	0.0									
MISO_E	0.0									
NE	0.0									
NEISO	0.0									
NI	0.0									
NonRTO_Midwest	0.0									
NP15	0.1									
NWPP_Coal	0.0									
NYISO_Capital	0.0									
NYISO_Downstate	0.0									
NYISO_LIPA	0.0									
NYISO_NYC	0.0									
NYISO_Upstate	0.0									
PJM_D	0.0									
PJM_E	0.0									
PJM_Midwest	0.0									
PJM_SW	0.0									
PJM_W	0.0									
RMPA	9.4									
SCIL	0.0									
SOCO	0.0									
SP15	10.0									
SPP_N	0.0									
SPP_S	0.0									
TVA	0.0									
VACAR	0.0									
WUMS	0.0									
ALB	0.0									
BC	0.0									
OH	0.0									

Technology		Capacity Limits (GW)								
IGCC-CCS	**GW**	**Cap Limit**								
		2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
AE	∞									
ALB	0.0									
AZ_NM_SNV	∞									
BC	0.0									
EMO	∞									
ENT	0.0									
ERCOT	∞									
FRCC	∞									
HQ	0.0									

Appendix A, Exhibit 6 - New Resource Limits

MAPP_CA	0.0							
MAPP_US	0.0							
MI	∞							
MISO_E	∞							
NE	0.0							
NEISO	4.0							
NI	∞							
NonRTO_Midwest	∞							
NP15	∞							
NWPP_NucRenew	∞							
NYISO_Capital	∞							
NYISO_Downstate	∞							
NYISO_LIPA	0.0							
NYISO_NYC	0.0							
NYISO_Upstate	∞							
OH	∞							
PJM_D	∞							
PJM_E	∞							
PJM_Midwest	∞							
PJM_SW	∞							
PJM_W	∞							
RMPA	0.0							
SCIL	∞							
SOCO	∞							
SP15	∞							
SPP_N	0							
SPP_S	0							
TVA	∞							
VACAR	∞							
WUMS	∞							
Total US		2	12	32	62	92	122	152

Appendix A, Exhibit 7 - Retrofit Costs Source Information

Retrofit Type	Emissions Type	Capital Cost	Fixed O&M	Variable O&M
FGD	SO2	Sargent & Lundy. "IPM Model - Revisions to Cost and Performance for APC Technologies. Wet FGD Cost Development Methodology." August 2010. [Table 1]	Sargent & Lundy. "IPM Model - Revisions to Cost and Performance for APC Technologies. Wet FGD Cost Development Methodology." August 2010. [Table 1]	Sargent & Lundy. "IPM Model - Revisions to Cost and Performance for APC Technologies. Wet FGD Cost Development Methodology." August 2010. [Table 1]
SCR	NOx	Cichanowicz, J Edward. "Current Capital Cost and Cost-Effectiveness of Power Plant Emissions Control Technologies." January 2010. [Figure 6-1]	Cichanowicz, J Edward. "Current Capital Cost and Cost-Effectiveness of Power Plant Emissions Control Technologies." January 2010. [Table 6-1]	Cichanowicz, J Edward. "Current Capital Cost and Cost-Effectiveness of Power Plant Emissions Control Technologies." January 2010. [Table 6-1]
SNCR	NOx	EPA IPM 2006 Documentation	EPA IPM 2006 Documentation	EPA IPM 2006 Documentation
ACI	Hg	Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Figures B-6 and B-8]	Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Figure B-7]	Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Pages 65-66]; CRA discussion with Cichanowicz.
RPJ	Hg	Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Figures B-6 and B-8]	Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Figure B-7]	Cichanowicz, J Edward. "Testimony of J E Cichanowicz to the Illinois Pollution Control Board. A Review of the Status of Mercury Control Technology." July 28, 2006. [Pages 65-66]; CRA discussion with Cichanowicz.

Appendix A, Exhibit 8 - Forced Retrofits

Plant Name	Unit	Retrofit	Date Installed
Avenal Project	CC1	Selective Catalytic Reduction	6/1/2012
Baldwin Energy Complex	3	Dry Lime FGD	12/31/2010
Bear Garden Generating Station	CC 2	Selective Catalytic Reduction	6/30/2011
Blythe II	CC1	Selective Catalytic Reduction	12/31/2015
Cape Canaveral	CC	Selective Catalytic Reduction	6/1/2013
Cardinal	3	Wet Limestone	3/31/2011
Chesterfield	3	Flue Gas Desulfurization	6/30/2011
Chesterfield	4	Flue Gas Desulfurization	6/30/2011
Chesterfield	5	Flue Gas Desulfurization	6/30/2011
Chouteau	CC2	Selective Catalytic Reduction	3/1/2011
Cliffside	5	Wet Limestone	10/31/2010
Cliffside	6	Flue Gas Desulfurization	6/30/2012
Cliffside	6	Selective Catalytic Reduction	6/30/2012
Clifty Creek	1	Wet Limestone	6/30/2011
Clifty Creek	2	Wet Limestone	6/30/2011
Clifty Creek	3	Wet Limestone	6/30/2011
Clifty Creek	4	Wet Limestone	6/30/2011
Clifty Creek	5	Wet Limestone	6/30/2011
Clifty Creek	6	Wet Limestone	6/30/2011
Colorado Bend Energy Center	CC3	Selective Catalytic Reduction	6/30/2011
Colusa Generating Station	CC1	Selective Catalytic Reduction	11/1/2010
Coolidge Generating Station	1	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	2	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	3	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	4	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	5	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	6	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	7	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	8	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	9	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	10	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	11	Selective Catalytic Reduction	5/1/2011
Coolidge Generating Station	12	Selective Catalytic Reduction	5/1/2011
Coronado	CO1	Wet Limestone	4/1/2012
Coronado	CO2	Wet Limestone	5/1/2011
Dave Johnston	3	Dry Lime FGD	9/30/2010
Dave Johnston	4	Dry Lime FGD	6/30/2012
Dry Fork Station	ST	Flue Gas Desulfurization	6/1/2011
Dry Fork Station	ST	Selective Catalytic Reduction	6/1/2011
Edgewater (WI)	5	Selective Catalytic Reduction	10/31/2012
Empire Generating	CC	Selective Catalytic Reduction	9/30/2010
Goodland Energy Resources	ST	Dry Lime FGD	9/1/2010

Appendix A, Exhibit 8 - Forced Retrofits

Goodland Energy Resources	ST	Selective Catalytic Reduction	9/1/2010
Gowanus Gas Turbines	GT49	Selective Catalytic Reduction	5/30/2012
Great Falls Energy Center	CC2	Selective Catalytic Reduction	1/1/2012
Harry Allen (NV)	CC	Selective Catalytic Reduction	6/30/2011
Havana	6	Dry Lime FGD	12/1/2012
Hudson Generating Station	2	Dry Lime FGD	12/31/2010
Hudson Generating Station	2	Selective Catalytic Reduction	12/31/2010
Humboldt Bay	IC 1	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 10	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 2	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 3	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 4	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 5	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 6	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 7	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 8	Selective Catalytic Reduction	9/30/2010
Humboldt Bay	IC 9	Selective Catalytic Reduction	9/30/2010
Hunter	ST1	Wet Lime FGD	12/31/2010
Iatan	2	Flue Gas Desulfurization	10/31/2010
Iatan	2	Selective Catalytic Reduction	10/31/2010
J H Campbell	2	Selective Catalytic Reduction	9/30/2011
John W Turk Jr Power Plant	ST1	Dry Lime FGD	10/31/2012
John W Turk Jr Power Plant	ST1	Selective Catalytic Reduction	10/31/2012
Keephills 3	3	Dry Lime FGD	3/31/2011
Kleen Energy Project	CC	Selective Catalytic Reduction	4/1/2011
Kyger Creek	1	Flue Gas Desulfurization	3/31/2011
Kyger Creek	2	Flue Gas Desulfurization	3/31/2011
Kyger Creek	3	Flue Gas Desulfurization	3/31/2011
Kyger Creek	4	Flue Gas Desulfurization	6/30/2011
Kyger Creek	5	Flue Gas Desulfurization	6/30/2011
Lansing	4	Selective Catalytic Reduction	9/30/2010
Leland Olds 1 & 2	1	Wet Limestone	3/31/2011
Leland Olds 1 & 2	2	Wet Limestone	10/31/2010
Lodi Energy Center	CC	Selective Catalytic Reduction	6/30/2012
Longleaf Energy Station	ST1	Dry Lime FGD	6/1/2013
Longleaf Energy Station	ST1	Selective Catalytic Reduction	6/1/2013
Longleaf Energy Station	ST2	Dry Lime FGD	6/1/2013
Longleaf Energy Station	ST2	Selective Catalytic Reduction	6/1/2013
Longview Power	AB1	Selective Catalytic Reduction	3/1/2011
Longview Power	AB1	Wet Lime FGD	3/1/2011
Marsh Landing Generating Station	GT1	Selective Catalytic Reduction	5/1/2013
Marsh Landing Generating Station	GT2	Selective Catalytic Reduction	5/1/2013
Marsh Landing Generating Station	GT3	Selective Catalytic Reduction	5/1/2013
Marsh Landing Generating Station	GT4	Selective Catalytic Reduction	5/1/2013

Appendix A, Exhibit 8 - Forced Retrofits

Merrimack		1	Wet Limestone	12/31/2011
Merrimack		2	Wet Limestone	12/31/2011
Nacogdoches Power Electric Gener	AB		Selective Non-catalytic Reduction	4/30/2012
Nelson Energy Center	CC1		Selective Catalytic Reduction	6/30/2011
Nelson Energy Center	CC2		Selective Catalytic Reduction	6/30/2011
Oak Creek Power Plant		2	Selective Catalytic Reduction	8/31/2010
Oak Creek Power Plant		2	Wet Limestone	8/31/2010
Olmsted Waste Energy		3	Dry Lime FGD	4/30/2011
Olmsted Waste Energy		3	Selective Non-catalytic Reduction	4/30/2011
Panda Temple Generating Station	CC1		Selective Catalytic Reduction	5/31/2013
Panda Temple Generating Station	CC2		Selective Catalytic Reduction	12/31/2014
Plainfield Renewable Energy	AB		Dry Lime FGD	12/31/2010
Plainfield Renewable Energy	AB		Selective Non-catalytic Reduction	12/31/2010
Plant Carl	AB		Dry Lime FGD	12/31/2010
Plant Washington	ST1		Flue Gas Desulfurization	12/31/2013
Plant Washington	ST1		Selective Catalytic Reduction	12/31/2013
Prairie State Energy Campus	ST1		Selective Catalytic Reduction	8/31/2011
Prairie State Energy Campus	ST1		Wet Lime FGD	8/31/2011
Prairie State Energy Campus	ST2		Selective Catalytic Reduction	6/30/2012
Prairie State Energy Campus	ST2		Wet Lime FGD	6/30/2012
Quail Run Energy Center	CC3		Selective Catalytic Reduction	12/31/2011
R D Morrow		1	Wet Limestone	8/30/2011
R D Morrow		2	Wet Limestone	8/30/2011
Riviera	CC		Selective Catalytic Reduction	6/1/2014
Russell City	CC		Selective Catalytic Reduction	12/31/2013
Sandy Creek Energy Station	ST		Acid Gas Removal System	2/28/2012
Sandy Creek Energy Station	ST		Dry Lime FGD	2/28/2012
Sandy Creek Energy Station	ST		Selective Catalytic Reduction	2/28/2012
Scherer		1	Flue Gas Desulfurization	12/31/2013
Scherer		1	Selective Catalytic Reduction	12/31/2013
Scherer		2	Flue Gas Desulfurization	12/31/2013
Scherer		2	Selective Catalytic Reduction	12/31/2013
Scherer		3	Flue Gas Desulfurization	12/31/2013
Scherer		3	Selective Catalytic Reduction	12/31/2013
Scherer		4	Flue Gas Desulfurization	12/31/2013
Scherer		4	Selective Catalytic Reduction	12/31/2013
Sioux		1	Wet Lime FGD	9/30/2010
Sioux		2	Wet Lime FGD	9/30/2010
South Oak Creek		5	Selective Catalytic Reduction	12/1/2012
South Oak Creek		5	Wet Limestone	12/1/2012
South Oak Creek		6	Selective Catalytic Reduction	12/1/2012

Appendix A, Exhibit 8 - Forced Retrofits

South Oak Creek	6	Wet Limestone	12/1/2012
South Oak Creek	7	Selective Catalytic Reduction	6/1/2012
South Oak Creek	7	Wet Limestone	6/1/2012
South Oak Creek	8	Selective Catalytic Reduction	6/1/2012
South Oak Creek	8	Wet Limestone	6/1/2012
Southwest	ST2	Selective Catalytic Reduction	10/1/2010
Spiritwood Energy	AB	Selective Non-catalytic Reduction	10/1/2010
Stanton Energy Center	CC 2	Selective Catalytic Reduction	1/1/2011
Stony Brook (MA)	CC2	Selective Catalytic Reduction	12/31/2013
Sutherland (IA)	3	Selective Non-catalytic Reduction	10/31/2010
Taylorville Energy Center	IGCC	Selective Catalytic Reduction	12/31/2014
Towantic Energy Center	CC	Selective Catalytic Reduction	4/1/2013
Two Elk Energy Park	ST1	Flue Gas Desulfurization	6/30/2012
Two Elk Energy Park	ST1	Selective Catalytic Reduction	6/30/2012
W H Sammis	1	Selective Non-catalytic Reduction	12/31/2010
W H Sammis	3	Selective Non-catalytic Reduction	12/31/2010
W H Sammis	4	Selective Non-catalytic Reduction	12/31/2010
Walnut Creek Energy Park	GT1	Selective Catalytic Reduction	6/1/2013
Walnut Creek Energy Park	GT2	Selective Catalytic Reduction	6/1/2013
Walnut Creek Energy Park	GT3	Selective Catalytic Reduction	6/1/2013
Walnut Creek Energy Park	GT4	Selective Catalytic Reduction	6/1/2013
Walnut Creek Energy Park	GT5	Selective Catalytic Reduction	6/1/2013
West County Energy Center	CC3	Selective Catalytic Reduction	6/30/2011
Whelan Energy Center	ST	Dry Lime FGD	1/1/2011
Whelan Energy Center	ST	Selective Catalytic Reduction	1/1/2011

Appendix A, Exhibit 9 - Natural Gas Prices, Base Case
AEO 2010 Reference Case

Year	Henry Hub Spot Price (2010$/MMBtu)
2011	$ 5.85
2012	$ 6.36
2013	$ 6.31
2014	$ 6.27
2015	$ 6.46
2016	$ 6.57
2017	$ 6.58
2018	$ 6.63
2019	$ 6.70
2020	$ 6.84
2021	$ 6.94
2022	$ 7.14
2023	$ 7.17
2024	$ 7.12
2025	$ 7.20
2026	$ 7.37
2027	$ 7.51
2028	$ 7.76
2029	$ 8.01
2030	$ 8.29
2031	$ 8.64
2032	$ 8.75
2033	$ 8.79
2034	$ 9.01
2035	$ 9.15

Appendix A, Exhibit 10 - Natural Gas Basis Point Mapping

NEEM Region	Basis Point
AE	CNGL (25%), COLAP (25%), DOMS (50%)
AZ_NM_SNV	EPNB (50%), EPP (50%)
BC	WCST2 (100%)
ECAR	CHI (20%), CNGL (15%), COLAP (15%), DOMS (30%), MICMC (20%)
EMO	CHI (50%), VENT (50%)
ENT	HENRY (67%), VENT (33%)
ERCOT	SHIP (100%)
FRCC	FGTCG (100%)
HQ	DRACT (50%), TENN6 (50%)
MAPP_CA	VIKEM (100%)
MAPP_US	VIKEM (75%), VENT (25%)
NEISO	ALGCG (50%), DRACT (25%), TENN6 (25%)
NI	CHI (50%), VENT (50%)
NP15	MALIN (50%), PGECG (50%)
NWPP	NWWYO (20%), CIG (13%), NWSTA (27%), SUMAS (13%), MALIN (7%), KINGS (7%), QUEST (7%), KERN (7%
NYISO_Capital (F)	NIAG (50%), DOMS (50%)
NYISO_Downstate (G-I)	IROWA (50%), TRNON (50%)
NYISO_LIPA (K)	TRNY (100%)
NYISO_NYC (J)	TRNY (100%)
NYISO_Upstate (A-E)	DAWN (25%), DOMS (50%), NIAG (25%)
OH	NIAG (50%), DAWN (50%)
PJM	TETM3 (50%), TRNON (50%)
RMPA	CIG (50%), NWWYO (25%), CIG (25%)
SCIL	CHI (100%)
SOCO	TRS85 (50%), FGTMB (50%)
SP15	SOCAL (100%)
SPP_N	NGPLM (100%)
SPP_S	NGPLM (100%)
TVA	TETM1 (100%)
VACAR	TETM3 (50%), FGTMB (50%)
WUMS	CHI (100%)

Appendix A, Exhibit 11 - Wheeling Charges and Transmission Costs

From	To	Wheeling Costs 2010$/MWh		Transmission Costs 2010$/MWh	
		2015	2020	2015	2020
AE	PJM_W_AE_Dummy	0.0	0.0	0.0	0.0
ECAR_Dummy1	MISO_E	0.0	0.0	0.0	0.0
EMO	MAPP_US	0.0	0.0	0.0	0.0
EMO	SCIL	0.0	0.0	0.0	0.0
EMO	ENT	5.1	5.1	8.2	8.2
EMO	SPP_N	5.1	5.1	8.2	8.2
EMO	TVA	5.1	5.1	8.2	8.2
ENT	EMO	3.1	3.1	8.2	8.2
ENT	SOCO	3.1	3.1	8.2	8.2
ENT	SPP_S	3.1	3.1	8.2	8.2
ENT	TVA	3.1	3.1	8.2	8.2
ERCOT	SPP_S	3.1	3.1	8.2	8.2
FRCC	SOCO	3.1	3.1	8.2	8.2
HQ	HQ_Dummy	0.0	0.0	0.0	0.0
HQ	OH	8.2	8.2	13.3	13.3
HQ_Dummy	NEISO	8.2	8.2	13.3	13.3
HQ_Dummy	NYISO_Upstate	8.2	8.2	13.3	13.3
MAPP_CA	MAPP_US	0.0	0.0	0.0	0.0
MAPP_CA	OH	5.1	5.1	8.2	8.2
MAPP_US	EMO	0.0	0.0	0.0	0.0
MAPP_US	MAPP_CA	0.0	0.0	0.0	0.0
MAPP_US	WUMS	0.0	0.0	0.0	0.0
MAPP_US	NI_dummy	0.0	0.0	2.0	2.0
MAPP_US	OH	5.1	5.1	8.2	8.2
MAPP_US	NWPP_Coal	5.1	5.1	8.2	8.2
MAPP_US	NE	5.1	5.1	8.2	8.2
MAPP_US	RMPA	5.1	5.1	8.2	8.2
MI	PJM_Midwest	0.0	0.0	2.0	2.0
MI	OH	5.1	5.1	8.2	8.2
MISO_E	SCIL	0.0	0.0	0.0	0.0
MISO_E	NI_dummy	0.0	0.0	2.0	2.0
MISO_E	PJM_Midwest	0.0	0.0	2.0	2.0
MISO_E	NonRTO_Midwest	5.1	5.1	8.2	8.2
NE	SPP_N	0.0	0.0	0.0	0.0
NE	RMPA	2.0	2.0	5.1	5.1
NE	MAPP_US	2.0	2.0	5.1	5.1
NEISO	NYISO_Dummy2_In	0.0	0.0	3.1	3.1
NEISO	NYISO_LIPA	0.0	0.0	3.1	3.1
NEISO	HQ	7.1	7.1	10.2	10.2
NI	MAPP_US	0.0	0.0	2.0	2.0
NI	SCIL	0.0	0.0	2.0	2.0

NI	WUMS	0.0	0.0	2.0	2.0
NI	ECAR_Dummy1	0.0	0.0	2.0	2.0
NI_dummy	NI	0.0	0.0	0.0	0.0
NonRTO_Midwest	MISO_E	3.1	3.1	8.2	8.2
NonRTO_Midwest	PJM_Midwest	3.1	3.1	8.2	8.2
NonRTO_Midwest	TVA	3.1	3.1	8.2	8.2
NWPP_Coal	MAPP_US	3.1	3.1	8.2	8.2
NYISO_Capital	NYISO_Dummy2_Out	0.0	0.0	0.0	0.0
NYISO_Capital	NYISO_Dummy4	0.0	0.0	0.0	0.0
NYISO_Downstate	NYISO_Dummy1_Dowr	0.0	0.0	0.0	0.0
NYISO_Downstate	NYISO_Dummy2_Out	0.0	0.0	0.0	0.0
NYISO_Downstate	PJM_E_Dummy	5.1	5.1	8.2	8.2
NYISO_Dummy1_D	NYISO_LIPA	0.0	0.0	0.0	0.0
NYISO_Dummy1_D	NYISO_NYC	0.0	0.0	0.0	0.0
NYISO_Dummy1_U	NYISO_Downstate	0.0	0.0	0.0	0.0
NYISO_Dummy2_I	NYISO_Capital	0.0	0.0	0.0	0.0
NYISO_Dummy2_I	NYISO_Downstate	0.0	0.0	0.0	0.0
NYISO_Dummy2_I	NYISO_LIPA	0.0	0.0	0.0	0.0
NYISO_Dummy2_I	NYISO_Upstate	0.0	0.0	0.0	0.0
NYISO_Dummy2_C	NEISO	0.0	0.0	3.1	3.1
NYISO_Dummy3	NYISO_Capital	0.0	0.0	0.0	0.0
NYISO_Dummy3	NYISO_Dummy4	0.0	0.0	0.0	0.0
NYISO_Dummy4	NYISO_Downstate	0.0	0.0	0.0	0.0
NYISO_LIPA	NYISO_Dummy1_Up	0.0	0.0	0.0	0.0
NYISO_LIPA	NYISO_Dummy2_Out	0.0	0.0	0.0	0.0
NYISO_LIPA	NYISO_NYC	0.0	0.0	0.0	0.0
NYISO_LIPA	NEISO	0.0	0.0	3.1	3.1
NYISO_LIPA	PJM_E_Dummy	5.1	5.1	8.2	8.2
NYISO_NYC	NYISO_Dummy1_Up	0.0	0.0	0.0	0.0
NYISO_NYC	NYISO_LIPA	0.0	0.0	0.0	0.0
NYISO_NYC	PJM_E_Dummy	5.1	5.1	8.2	8.2
NYISO_Upstate	NYISO_Dummy2_Out	0.0	0.0	0.0	0.0
NYISO_Upstate	NYISO_Dummy3	0.0	0.0	0.0	0.0
NYISO_Upstate	OH	4.1	4.1	7.1	7.1
NYISO_Upstate	PJM_W_AE_Dummy	5.1	5.1	8.2	8.2
NYISO_Upstate	HQ	2.0	2.0	5.1	5.1
OH	MAPP_CA	1.0	1.0	6.1	6.1
OH	MAPP_US	1.0	1.0	6.1	6.1
OH	NYISO_Upstate	1.0	1.0	6.1	6.1
OH	MI	1.0	1.0	6.1	6.1
OH	HQ	1.0	1.0	6.1	6.1
PJM_D	VACAR	0.0	0.0	0.0	0.0
PJM_D	PJM_SW_Dummy	0.0	0.0	0.0	0.0
PJM_D	PJM_W_AE_Dummy	0.0	0.0	0.0	0.0
PJM_E	PJM_E_Dummy	0.0	0.0	0.0	0.0
PJM_E	NYISO_Downstate	3.1	3.1	6.1	6.1

PJM_E	NYISO_LIPA	3.1	3.1	6.1	6.1
PJM_E	NYISO_NYC	3.1	3.1	6.1	6.1
PJM_E_Dummy	PJM_E	0.0	0.0	0.0	0.0
PJM_E_Dummy	PJM_W_AE_Dummy	0.0	0.0	0.0	0.0
PJM_Midwest	AE	0.0	0.0	0.0	0.0
PJM_Midwest	PJM_D	0.0	0.0	0.0	0.0
PJM_Midwest	MI	0.0	0.0	2.0	2.0
PJM_Midwest	MISO_E	0.0	0.0	2.0	2.0
PJM_Midwest	NonRTO_Midwest	3.1	3.1	6.1	6.1
PJM_Midwest	VACAR	3.1	3.1	6.1	6.1
PJM_SW	PJM_SW_Dummy	0.0	0.0	0.0	0.0
PJM_SW_Dummy	PJM_D	0.0	0.0	0.0	0.0
PJM_SW_Dummy	PJM_SW	0.0	0.0	0.0	0.0
PJM_SW_Dummy	PJM_W_AE_Dummy	0.0	0.0	0.0	0.0
PJM_W	AE	0.0	0.0	0.0	0.0
PJM_W	PJM_W_AE_Dummy	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	AE	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	PJM_D	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	PJM_E_Dummy	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	PJM_Midwest	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	PJM_SW_Dummy	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	PJM_W	0.0	0.0	0.0	0.0
PJM_W_AE_Dumm	NYISO_Upstate	3.1	3.1	6.1	6.1
RMPA	NE	3.1	3.1	8.2	8.2
RMPA	MAPP_US	3.1	3.1	8.2	8.2
RMPA	SPP_N	3.1	3.1	8.2	8.2
SCIL	ECAR_Dummy1	0.0	0.0	0.0	0.0
SCIL	EMO	0.0	0.0	0.0	0.0
SCIL	MISO_E	0.0	0.0	0.0	0.0
SCIL	NI_dummy	0.0	0.0	2.0	2.0
SCIL	TVA	5.1	5.1	8.2	8.2
SOCO	ENT	5.1	5.1	10.2	10.2
SOCO	FRCC	5.1	5.1	10.2	10.2
SOCO	TVA	5.1	5.1	10.2	10.2
SOCO	VACAR	5.1	5.1	10.2	10.2
SPP_N	NE	0.0	0.0	0.0	0.0
SPP_N	SPP_S	0.0	0.0	0.0	0.0
SPP_N	EMO	2.0	2.0	5.1	5.1
SPP_N	RMPA	2.0	2.0	5.1	5.1
SPP_S	SPP_N	0.0	0.0	0.0	0.0
SPP_S	AZ_NM_SNV_Coal	2.0	2.0	5.1	5.1
SPP_S	ENT	2.0	2.0	5.1	5.1
SPP_S	ERCOT	2.0	2.0	5.1	5.1
TVA	EMO	3.1	3.1	8.2	8.2
TVA	ENT	3.1	3.1	8.2	8.2
TVA	NonRTO_Midwest	3.1	3.1	8.2	8.2

TVA	PJM_Midwest	3.1	3.1	8.2	8.2
TVA	SCIL	3.1	3.1	8.2	8.2
TVA	SOCO	3.1	3.1	8.2	8.2
TVA	VACAR	3.1	3.1	8.2	8.2
VACAR	NonRTO_Midwest	2.0	2.0	7.1	7.1
VACAR	PJM_D	2.0	2.0	7.1	7.1
VACAR	SOCO	2.0	2.0	7.1	7.1
VACAR	TVA	2.0	2.0	7.1	7.1
WUMS	MAPP_US	0.0	0.0	0.0	0.0
WUMS	NI_dummy	0.0	0.0	2.0	2.0

Appendix B

Sectoral mapping of IMPLAN Sectors based on NAICS 2002

EIPC Sector - 11 Sectors
MRN Sectors - 29 Sectors
IMPLAN Sectors - 509 Sectors

S.No.	EIPC Sector	Description	MRN Sector		Description
1	COL	Coal	1	COL	Coal
2	CRU	Natural Gas and Crude	2	CRU	Natural Gas and Crude
3	ELE	Electric Generation	3	ELE	Electric Generation
4	GAS	Natural Gas Distribution	4	GAS	Natural Gas Distribution
5	OIL	Refined Petroleum	5	OIL	Refined Petroleum
6	TRN	Transportation Services	6	TRN	Transportation Services Commercial
7	AGR	Agriculture	7	FOO	Food and Kindred Products plus tobacco and beverages
	AGR		8	AGR	Agriculture
8	SRV	Services	9	SRV	Services
	SRV		10	DWE	Owner-occupied dwellings
9	MAN	Manufactured and processed goods	11	RUB	Plastics and Rubber
	MAN		12	ELQ	Electrical Equipment and Appliances
	MAN		13	TRQ	Transportation Equipment
	MAN		14	MAC	Machinery
	MAN		15	MSC	Miscellaneous Manufacturing
	MAN		16	PRN	Printing and Related Support
	MAN		17	TEX	Textiles and Apparel and Leather
	MAN		18	COM	Computer and Electronic Products
	MAN		19	WOO	Wood Products and Furniture
10	M_V	Motor Vehicle	20	M_V	Motor Vehicles
11	EIS	Energy Intensive sectors	21	MIN	Metal and Nonmetal Mining
	EIS		22	ALU	Aluminum
	EIS		23	CHM	Chemicals
	EIS		24	FAB	Fabricated Metal Products
	EIS		25	CNS	Construction
	EIS		26	I_S	Iron and Steel
	EIS		27	OPM	Other Primary Metals
	EIS		28	PAP	Paper and Pulp Mills
	EIS		29	SCG	Nonmetallic Mineral Products - silica cement glass

Appendix B

Detailed IMPLN to MRN sector mapping

EIPC Sector	MRN Sector	IMPLAN Sector	Sector (NAICS code)	IMPLAN Description
AGR	AGR	1	Oilseed farming (1111A0:11111,11112)	Oilseed farming
AGR	AGR	2	Grain farming (1111B0:11113,11114,11115,11116,11119)	Grain farming
AGR	AGR	3	Vegetable and melon farming (111200:1112)	Vegetable and melon farming
AGR	AGR	4	Tree nut farming (111335:111335)	Tree nut farming
AGR	AGR	5	Fruit farming (1113A0:11131,11132,11133 exc. 111335)	Fruit farming
AGR	AGR	6	Greenhouse and nursery production (111400:1114)	Greenhouse and nursery production
AGR	AGR	7	Tobacco farming (111910:11191)	Tobacco farming
AGR	AGR	8	Cotton farming (111920:11192)	Cotton farming
AGR	AGR	9	Sugarcane and sugar beet farming (1119A0:11193,111991)	Sugarcane and sugar beet farming
AGR	AGR	10	All other crop farming (1119B0:11194,111992,111998)	All other crop farming
AGR	AGR	11	Cattle ranching and farming (112100:11211,11212,11213)	Cattle ranching and farming
AGR	AGR	12	Poultry and egg production (112300:1123)	Poultry and egg production
AGR	AGR	13	Animal production, except cattle and poultry and eggs (112A00:1122,1124,1125,1129)	Animal production, except cattle and poultry and eggs
AGR	AGR	14	Logging (113300:1133)	Logging
AGR	AGR	15	Forest nurseries, forest products, and timber tracts (113A00:1131,1132)	Forest nurseries, forest products, and timber tracts
AGR	AGR	16	Fishing (114100:1141)	Fishing
AGR	AGR	17	Hunting and trapping (114200:1142)	Hunting and trapping
AGR	FOO	46	Dog and cat food manufacturing (311111:311111)	Dog and cat food manufacturing
AGR	FOO	47	Other animal food manufacturing (311119:311119)	Other animal food manufacturing
AGR	FOO	48	Flour milling (311211:311211)	Flour milling
AGR	FOO	49	Rice milling (311212:311212)	Rice milling
AGR	FOO	50	Malt manufacturing (311213:311213)	Malt manufacturing
AGR	FOO	51	Wet corn milling (311221:311221)	Wet corn milling
AGR	FOO	52	Soybean processing (311222:311222)	Soybean processing
AGR	FOO	53	Other oilseed processing (311223:311223)	Other oilseed processing
AGR	FOO	54	Fats and oils refining and blending (311225:311225)	Fats and oils refining and blending
AGR	FOO	55	Breakfast cereal manufacturing (311230:31123)	Breakfast cereal manufacturing
AGR	FOO	56	Sugar manufacturing (311310:31131)	Sugar manufacturing
AGR	FOO	57	Confectionery manufacturing from cacao beans (311320:31132)	Confectionery manufacturing from cacao beans
AGR	FOO	58	Confectionery manufacturing from purchased chocolate (311330:31133)	Confectionery manufacturing from purchased chocolate
AGR	FOO	59	Nonchocolate confectionery manufacturing (311340:31134)	Nonchocolate confectionery manufacturing
AGR	FOO	60	Frozen food manufacturing (311410:31141)	Frozen food manufacturing
AGR	FOO	61	Fruit and vegetable canning and drying (311420:31142)	Fruit and vegetable canning and drying
AGR	FOO	62	Fluid milk manufacturing (311511:311511)	Fluid milk manufacturing
AGR	FOO	63	Creamery butter manufacturing (311512:311512)	Creamery butter manufacturing
AGR	FOO	64	Cheese manufacturing (311513:311513)	Cheese manufacturing
AGR	FOO	65	Dry, condensed, and evaporated dairy products (311514:311514)	Dry, condensed, and evaporated dairy products
AGR	FOO	66	Ice cream and frozen dessert manufacturing (311520:31152)	Ice cream and frozen dessert manufacturing
AGR	FOO	67	Animal, except poultry, slaughtering (311611:311611)	Animal, except poultry, slaughtering
AGR	FOO	68	Meat processed from carcasses (311612:311612)	Meat processed from carcasses
AGR	FOO	69	Rendering and meat byproduct processing (311613:311613)	Rendering and meat byproduct processing
AGR	FOO	70	Poultry processing (311615:311615)	Poultry processing
AGR	FOO	71	Seafood product preparation and packaging (311700:3117)	Seafood product preparation and packaging
AGR	FOO	72	Frozen cakes and other pastries manufacturing (311813:311813)	Frozen cakes and other pastries manufacturing
AGR	FOO	73	Bread and bakery product, except frozen, manufacturing (31181A:311811,311812)	Bread and bakery product, except frozen, manufacturing
AGR	FOO	74	Cookie and cracker manufacturing (311821:311821)	Cookie and cracker manufacturing
AGR	FOO	75	Mixes and dough made from purchased flour (311822:311822)	Mixes and dough made from purchased flour
AGR	FOO	76	Dry pasta manufacturing (311823:311823)	Dry pasta manufacturing
AGR	FOO	77	Tortilla manufacturing (311830:31183)	Tortilla manufacturing
AGR	FOO	78	Roasted nuts and peanut butter manufacturing (311911:311911)	Roasted nuts and peanut butter manufacturing
AGR	FOO	79	Other snack food manufacturing (311919:311919)	Other snack food manufacturing
AGR	FOO	80	Coffee and tea manufacturing (311920:31192)	Coffee and tea manufacturing
AGR	FOO	81	Flavoring syrup and concentrate manufacturing (311930:31193)	Flavoring syrup and concentrate manufacturing
AGR	FOO	82	Mayonnaise, dressing, and sauce manufacturing (311941:311941)	Mayonnaise, dressing, and sauce manufacturing
AGR	FOO	83	Spice and extract manufacturing (311942:311942)	Spice and extract manufacturing
AGR	FOO	84	All other food manufacturing (311990:31199)	All other food manufacturing
AGR	FOO	85	Soft drink and ice manufacturing (312110:31211)	Soft drink and ice manufacturing
AGR	FOO	86	Breweries (312120:31212)	Breweries
AGR	FOO	87	Wineries (312130:31213)	Wineries
AGR	FOO	88	Distilleries (312140:31214)	Distilleries
AGR	FOO	89	Tobacco stemming and redrying (312210:31221)	Tobacco stemming and redrying
AGR	FOO	90	Cigarette manufacturing (312221:312221)	Cigarette manufacturing
AGR	FOO	91	Other tobacco product manufacturing (312229:312229)	Other tobacco product manufacturing
COL	COL	20	Coal mining (212100:2121)	Coal mining
CRU	CRU	19	Oil and gas extraction (211000:211)	Oil and gas extraction
EIS	MIN	21	Iron ore mining (212210:21221)	Iron ore mining
EIS	MIN	22	Copper, nickel, lead, and zinc mining (212230:21223)	Copper, nickel, lead, and zinc mining
EIS	MIN	23	Gold, silver, and other metal ore mining (2122A0:21222,21229)	Gold, silver, and other metal ore mining
EIS	MIN	24	Stone mining and quarrying (212310:21231)	Stone mining and quarrying
EIS	MIN	25	Sand, gravel, clay, and refractory mining (212320:21232)	Sand, gravel, clay, and refractory mining
EIS	MIN	26	Other nonmetallic mineral mining (212390:21239)	Other nonmetallic mineral mining
EIS	MIN	27	Drilling oil and gas wells (213111:213111)	Drilling oil and gas wells
EIS	MIN	28	Support activities for oil and gas operations (213112:213112)	Support activities for oil and gas operations
EIS	MIN	29	Support activities for other mining (21311A:213113,213114,213115)	Support activities for other mining
EIS	CNS	33	New residential 1-unit structures, nonfarm (230110:23*)	New residential 1-unit structures, nonfarm
EIS	CNS	34	New multifamily housing structures, nonfarm (230120:23*)	New multifamily housing structures, nonfarm
EIS	CNS	35	New residential additions and alterations, nonfarm (230130:23*)	New residential additions and alterations, nonfarm
EIS	CNS	36	New farm housing units and additions and alterations (230140:23*)	New farm housing units and additions and alterations
EIS	CNS	37	Manufacturing and industrial buildings (230210:23*)	Manufacturing and industrial buildings

EIS	CNS	38	Commercial and institutional buildings (230220:23*)	Commercial and institutional buildings
EIS	CNS	39	Highway, street, bridge, and tunnel construction (230230:23*)	Highway, street, bridge, and tunnel construction
EIS	CNS	40	Water, sewer, and pipeline construction (230240:23*)	Water, sewer, and pipeline construction
EIS	CNS	41	Other new construction (230250:23*)	Other new construction
EIS	CNS	42	Maintenance and repair of farm and nonfarm residential structure (230310:23*)	Maintenance and repair of farm and nonfarm residential structures
EIS	CNS	43	Maintenance and repair of nonresidential buildings (230320:23*)	Maintenance and repair of nonresidential buildings
EIS	CNS	44	Maintenance and repair of highways, streets, bridges, and tunnel (230330:23*)	Maintenance and repair of highways, streets, bridges, and tunnels
EIS	CNS	45	Other maintenance and repair construction (230340:23*)	Other maintenance and repair construction
EIS	PAP	124	Pulp mills (322110:32211)	Pulp mills
EIS	PAP	125	Paper and paperboard mills (3221A0:32212,32213)	Paper and paperboard mills
EIS	PAP	126	Paperboard container manufacturing (322210:32221)	Paperboard container manufacturing
EIS	PAP	127	Flexible packaging foil manufacturing (322225:322225)	Flexible packaging foil manufacturing
EIS	PAP	128	Surface-coated paperboard manufactuing (322226:322226)	Surface-coated paperboard manufactuing
EIS	PAP	129	Coated and laminated paper and packaging materials (32222A:322221,322222)	Coated and laminated paper and packaging materials
EIS	PAP	130	Coated and uncoated paper bag manufacturing (32222B:322223,322224)	Coated and uncoated paper bag manufacturing
EIS	PAP	131	Die-cut paper office supplies manufacturing (322231:322231)	Die-cut paper office supplies manufacturing
EIS	PAP	132	Envelope manufacturing (322232:322232)	Envelope manufacturing
EIS	PAP	133	Stationery and related product manufacturing (322233:322233)	Stationery and related product manufacturing
EIS	PAP	134	Sanitary paper product manufacturing (322291:322291)	Sanitary paper product manufacturing
EIS	PAP	135	All other converted paper product manufacturing (322299:322299)	All other converted paper product manufacturing
EIS	SCG	143	Asphalt paving mixture and block manufacturing (324121:324121)	Asphalt paving mixture and block manufacturing
EIS	SCG	144	Asphalt shingle and coating materials manufacturing (324122:324122)	Asphalt shingle and coating materials manufacturing
EIS	SCG	145	Petroleum lubricating oil and grease manufacturing (324191:324191)	Petroleum lubricating oil and grease manufacturing
EIS	CHM	147	Petrochemical manufacturing (325110:32511)	Petrochemical manufacturing
EIS	CHM	148	Industrial gas manufacturing (325120:32512)	Industrial gas manufacturing
EIS	CHM	149	Synthetic dye and pigment manufacturing (325130:32513)	Synthetic dye and pigment manufacturing
EIS	CHM	150	Other basic inorganic chemical manufacturing (325180:32518)	Other basic inorganic chemical manufacturing
EIS	CHM	151	Other basic organic chemical manufacturing (325190:32519)	Other basic organic chemical manufacturing
EIS	CHM	152	Plastics material and resin manufacturing (325211:325211)	Plastics material and resin manufacturing
EIS	CHM	153	Synthetic rubber manufacturing (325212:325212)	Synthetic rubber manufacturing
EIS	CHM	154	Cellulosic organic fiber manufacturing (325221:325221)	Cellulosic organic fiber manufacturing
EIS	CHM	155	Noncellulosic organic fiber manufacturing (325222:325222)	Noncellulosic organic fiber manufacturing
EIS	CHM	156	Nitrogenous fertilizer manufacturing (325311:325311)	Nitrogenous fertilizer manufacturing
EIS	CHM	157	Phosphatic fertilizer manufacturing (325312:325312)	Phosphatic fertilizer manufacturing
EIS	CHM	158	Fertilizer, mixing only, manufacturing (325314:325314)	Fertilizer, mixing only, manufacturing
EIS	CHM	159	Pesticide and other agricultural chemical manufacturing (325320:32532)	Pesticide and other agricultural chemical manufacturing
EIS	CHM	160	Pharmaceutical and medicine manufacturing (325400:32541)	Pharmaceutical and medicine manufacturing
EIS	CHM	161	Paint and coating manufacturing (325510:32551)	Paint and coating manufacturing
EIS	CHM	162	Adhesive manufacturing (325520:32552)	Adhesive manufacturing
EIS	CHM	163	Soap and other detergent manufacturing (325611:325611)	Soap and other detergent manufacturing
EIS	CHM	164	Polish and other sanitation good manufacturing (325612:325612)	Polish and other sanitation good manufacturing
EIS	CHM	165	Surface active agent manufacturing (325613:325613)	Surface active agent manufacturing
EIS	CHM	166	Toilet preparation manufacturing (325620:32562)	Toilet preparation manufacturing
EIS	CHM	167	Printing ink manufacturing (325910:32591)	Printing ink manufacturing
EIS	CHM	168	Explosives manufacturing (325920:32592)	Explosives manufacturing
EIS	CHM	169	Custom compounding of purchased resins (325991:325991)	Custom compounding of purchased resins
EIS	CHM	170	Photographic film and chemical manufacturing (325992:325992)	Photographic film and chemical manufacturing
EIS	CHM	171	Other miscellaneous chemical product manufacturing (325998:325998)	Other miscellaneous chemical product manufacturing
EIS	SCG	182	Vitreous china plumbing fixture manufacturing (327111:327111)	Vitreous china plumbing fixture manufacturing
EIS	SCG	183	Vitreous china and earthenware articles manufacturing (327112:327112)	Vitreous china and earthenware articles manufacturing
EIS	SCG	184	Porcelain electrical supply manufacturing (327113:327113)	Porcelain electrical supply manufacturing
EIS	SCG	185	Brick and structural clay tile manufacturing (327121:327121)	Brick and structural clay tile manufacturing
EIS	SCG	186	Ceramic wall and floor tile manufacturing (327122:327122)	Ceramic wall and floor tile manufacturing
EIS	SCG	187	Nonclay refractory manufacturing (327125:327125)	Nonclay refractory manufacturing
EIS	SCG	188	Clay refractory and other structural clay products (32712A:327123,327124)	Clay refractory and other structural clay products
EIS	SCG	189	Glass container manufacturing (327213:327213)	Glass container manufacturing
EIS	SCG	190	Glass and glass products, except glass containers (32721A:327211,327212,327215)	Glass and glass products, except glass containers
EIS	SCG	191	Cement manufacturing (327310:32731)	Cement manufacturing
EIS	SCG	192	Ready-mix concrete manufacturing (327320:32732)	Ready-mix concrete manufacturing
EIS	SCG	193	Concrete block and brick manufacturing (327331:327331)	Concrete block and brick manufacturing
EIS	SCG	194	Concrete pipe manufacturing (327332:327332)	Concrete pipe manufacturing
EIS	SCG	195	Other concrete product manufacturing (327390:32739)	Other concrete product manufacturing
EIS	SCG	196	Lime manufacturing (327410:32741)	Lime manufacturing
EIS	SCG	197	Gypsum product manufacturing (327420:32742)	Gypsum product manufacturing
EIS	SCG	198	Abrasive product manufacturing (327910:32791)	Abrasive product manufacturing
EIS	SCG	199	Cut stone and stone product manufacturing (327991:327991)	Cut stone and stone product manufacturing
EIS	SCG	200	Ground or treated minerals and earths manufacturing (327992:327992)	Ground or treated minerals and earths manufacturing
EIS	SCG	201	Mineral wool manufacturing (327993:327993)	Mineral wool manufacturing
EIS	SCG	202	Miscellaneous nonmetallic mineral products (327999:327999)	Miscellaneous nonmetallic mineral products
EIS	I_S	203	Iron and steel mills (331111:331111)	Iron and steel mills
EIS	I_S	204	Ferroalloy and related product manufacturing (331112:331112)	Ferroalloy and related product manufacturing
EIS	I_S	205	Iron, steel pipe and tube from purchased steel (331210:33121)	Iron, steel pipe and tube from purchased steel
EIS	I_S	206	Rolled steel shape manufacturing (331221:331221)	Rolled steel shape manufacturing
EIS	I_S	207	Steel wire drawing (331222:331222)	Steel wire drawing
EIS	ALU	208	Alumina refining (331311:331311)	Alumina refining
EIS	ALU	209	Primary aluminum production (331312:331312)	Primary aluminum production
EIS	ALU	210	Secondary smelting and alloying of aluminum (331314:331314)	Secondary smelting and alloying of aluminum
EIS	ALU	211	Aluminum sheet, plate, and foil manufacturing (331315:331315)	Aluminum sheet, plate, and foil manufacturing
EIS	ALU	212	Aluminum extruded product manufacturing (331316:331316)	Aluminum extruded product manufacturing
EIS	ALU	213	Other aluminum rolling and drawing (331319:331319)	Other aluminum rolling and drawing
EIS	OPM	214	Primary smelting and refining of copper (331411:331411)	Primary smelting and refining of copper
EIS	OPM	215	Primary nonferrous metal, except copper and aluminum (331419:331419)	Primary nonferrous metal, except copper and aluminum
EIS	OPM	216	Copper rolling, drawing, and extruding (331421:331421)	Copper rolling, drawing, and extruding
EIS	OPM	217	Copper wire, except mechanical, drawing (331422:331422)	Copper wire, except mechanical, drawing

EIS	OPM	218	Secondary processing of copper (331423:331423)	Secondary processing of copper
EIS	OPM	219	Nonferrous metal, except copper and aluminum, shaping (331491:331491)	Nonferrous metal, except copper and aluminum, shaping
EIS	OPM	220	Secondary processing of other nonferrous (331492:331492)	Secondary processing of other nonferrous
EIS	I_S	221	Ferrous metal foundries (331510:33151)	Ferrous metal foundries
EIS	OPM	222	Aluminum foundries (33152A:331521,331524)	Aluminum foundries
EIS	OPM	223	Nonferrous foundries, except aluminum (33152B:331522,331525,331528)	Nonferrous foundries, except aluminum
EIS	FAB	224	Iron and steel forging (332111:332111)	Iron and steel forging
EIS	FAB	225	Nonferrous forging (332112:332112)	Nonferrous forging
EIS	FAB	226	Custom roll forming (332114:332114)	Custom roll forming
EIS	FAB	227	All other forging and stamping (33211A:332115,332116,332117)	All other forging and stamping
EIS	FAB	228	Cutlery and flatware, except precious, manufacturing (332211:332211)	Cutlery and flatware, except precious, manufacturing
EIS	FAB	229	Hand and edge tool manufacturing (332212:332212)	Hand and edge tool manufacturing
EIS	FAB	230	Saw blade and handsaw manufacturing (332213:332213)	Saw blade and handsaw manufacturing
EIS	FAB	231	Kitchen utensil, pot, and pan manufacturing (332214:332214)	Kitchen utensil, pot, and pan manufacturing
EIS	FAB	232	Prefabricated metal buildings and components (332311:332311)	Prefabricated metal buildings and components
EIS	FAB	233	Fabricated structural metal manufacturing (332312:332312)	Fabricated structural metal manufacturing
EIS	FAB	234	Plate work manufacturing (332313:332313)	Plate work manufacturing
EIS	FAB	235	Metal window and door manufacturing (332321:332321)	Metal window and door manufacturing
EIS	FAB	236	Sheet metal work manufacturing (332322:332322)	Sheet metal work manufacturing
EIS	FAB	237	Ornamental and architectural metal work manufacturing (332323:332323)	Ornamental and architectural metal work manufacturing
EIS	FAB	238	Power boiler and heat exchanger manufacturing (332410:33241)	Power boiler and heat exchanger manufacturing
EIS	FAB	239	Metal tank, heavy gauge, manufacturing (332420:33242)	Metal tank, heavy gauge, manufacturing
EIS	FAB	240	Metal can, box, and other container manufacturing (332430:33243)	Metal can, box, and other container manufacturing
EIS	FAB	241	Hardware manufacturing (332500:3325)	Hardware manufacturing
EIS	FAB	242	Spring and wire product manufacturing (332600:3326)	Spring and wire product manufacturing
EIS	FAB	243	Machine shops (332710:33271)	Machine shops
EIS	FAB	244	Turned product and screw, nut, and bolt manufacturing (332720:33272)	Turned product and screw, nut, and bolt manufacturing
EIS	FAB	245	Metal heat treating (332811:332811)	Metal heat treating
EIS	FAB	246	Metal coating and nonprecious engraving (332812:332812)	Metal coating and nonprecious engraving
EIS	I_S	247	Electroplating, anodizing, and coloring metal (332813:332813)	Electroplating, anodizing, and coloring metal
EIS	FAB	248	Metal valve manufacturing (332910:33291)	Metal valve manufacturing
EIS	FAB	249	Ball and roller bearing manufacturing (332991:332991)	Ball and roller bearing manufacturing
EIS	FAB	250	Small arms manufacturing (332994:332994)	Small arms manufacturing
EIS	FAB	251	Other ordnance and accessories manufacturing (332995:332995)	Other ordnance and accessories manufacturing
EIS	FAB	252	Fabricated pipe and pipe fitting manufacturing (332996:332996)	Fabricated pipe and pipe fitting manufacturing
EIS	FAB	253	Industrial pattern manufacturing (332997:332997)	Industrial pattern manufacturing
EIS	FAB	254	Enameled iron and metal sanitary ware manufacturing (332998:332998)	Enameled iron and metal sanitary ware manufacturing
EIS	FAB	255	Miscellaneous fabricated metal product manufacturing (332999:332999)	Miscellaneous fabricated metal product manufacturing
EIS	FAB	256	Ammunition manufacturing (33299A:332992,332993)	Ammunition manufacturing
ELE	ELE	30	Power generation and supply (221100:2211)	Power generation and supply
ELE	ELE	495	Federal electric utilities (S00101)	Federal electric utilities
ELE	ELE	498	State and local government electric utilities (S00202)	State and local government electric utilities
GAS	GAS	31	Natural gas distribution (221200:2212)	Natural gas distribution
M_V	M_V	344	Automobile and light truck manufacturing (336110:33611)	Automobile and light truck manufacturing
M_V	M_V	345	Heavy duty truck manufacturing (336120:33612)	Heavy duty truck manufacturing
M_V	M_V	346	Motor vehicle body manufacturing (336211:336211)	Motor vehicle body manufacturing
M_V	M_V	347	Truck trailer manufacturing (336212:336212)	Truck trailer manufacturing
M_V	M_V	348	Motor home manufacturing (336213:336213)	Motor home manufacturing
M_V	M_V	349	Travel trailer and camper manufacturing (336214:336214)	Travel trailer and camper manufacturing
M_V	M_V	350	Motor vehicle parts manufacturing (336300:3363)	Motor vehicle parts manufacturing
M_V	M_V	401	Motor vehicle and parts dealers (4A0000:441)	Motor vehicle and parts dealers
MAN	TEX	92	Fiber, yarn, and thread mills (313100:3131)	Fiber, yarn, and thread mills
MAN	TEX	93	Broadwoven fabric mills (313210:31321)	Broadwoven fabric mills
MAN	TEX	94	Narrow fabric mills and schiffli embroidery (313220:31322)	Narrow fabric mills and schiffli embroidery
MAN	TEX	95	Nonwoven fabric mills (313230:31323)	Nonwoven fabric mills
MAN	TEX	96	Knit fabric mills (313240:31324)	Knit fabric mills
MAN	TEX	97	Textile and fabric finishing mills (313310:31331)	Textile and fabric finishing mills
MAN	TEX	98	Fabric coating mills (313320:31332)	Fabric coating mills
MAN	TEX	99	Carpet and rug mills (314110:31411)	Carpet and rug mills
MAN	TEX	100	Curtain and linen mills (314120:31412)	Curtain and linen mills
MAN	TEX	101	Textile bag and canvas mills (314910:31491)	Textile bag and canvas mills
MAN	TEX	102	Tire cord and tire fabric mills (314992:314992)	Tire cord and tire fabric mills
MAN	TEX	103	Other miscellaneous textile product mills (31499A:314991,314999)	Other miscellaneous textile product mills
MAN	TEX	104	Sheer hosiery mills (315111:315111)	Sheer hosiery mills
MAN	TEX	105	Other hosiery and sock mills (315119:315119)	Other hosiery and sock mills
MAN	TEX	106	Other apparel knitting mills (315190:31519)	Other apparel knitting mills
MAN	TEX	107	Cut and sew apparel manufacturing (315200:3152)	Cut and sew apparel manufacturing
MAN	TEX	108	Accessories and other apparel manufacturing (315900:3159)	Accessories and other apparel manufacturing
MAN	TEX	109	Leather and hide tanning and finishing (316100:3161)	Leather and hide tanning and finishing
MAN	TEX	110	Footwear manufacturing (316200:3162)	Footwear manufacturing
MAN	TEX	111	Other leather product manufacturing (316900:3169)	Other leather product manufacturing
MAN	WOO	112	Sawmills (321113:321113)	Sawmills
MAN	WOO	113	Wood preservation (321114:321114)	Wood preservation
MAN	WOO	114	Reconstituted wood product manufacturing (321219:321219)	Reconstituted wood product manufacturing
MAN	WOO	115	Veneer and plywood manufacturing (32121A:321211,321212)	Veneer and plywood manufacturing
MAN	WOO	116	Engineered wood member and truss manufacturing (32121B:321213,321214)	Engineered wood member and truss manufacturing
MAN	WOO	117	Wood windows and door manufacturing (321911:321911)	Wood windows and door manufacturing
MAN	WOO	118	Cut stock, resawing lumber, and planing (321912:321912)	Cut stock, resawing lumber, and planing
MAN	WOO	119	Other millwork, including flooring (321918:321918)	Other millwork, including flooring
MAN	WOO	120	Wood container and pallet manufacturing (321920:32192)	Wood container and pallet manufacturing
MAN	WOO	121	Manufactured home, mobile home, manufacturing (321991:321991)	Manufactured home, mobile home, manufacturing
MAN	WOO	122	Prefabricated wood building manufacturing (321992:321992)	Prefabricated wood building manufacturing
MAN	WOO	123	Miscellaneous wood product manufacturing (321999:321999)	Miscellaneous wood product manufacturing
MAN	PRN	136	Manifold business forms printing (323116:323116)	Manifold business forms printing

MAN	PRN	137	Books printing (323117:323117)	Books printing
MAN	PRN	138	Blankbook and looseleaf binder manufacturing (323118:323118)	Blankbook and looseleaf binder manufacturing
MAN	PRN	139	Commercial printing (32311A:323111,323112,323113,323114,323115,323119)	Commercial printing
MAN	PRN	140	Tradebinding and related work (323121:323121)	Tradebinding and related work
MAN	PRN	141	Prepress services (323122:323122)	Prepress services
MAN	RUB	172	Plastics packaging materials, film and sheet (326110:32611)	Plastics packaging materials, film and sheet
MAN	RUB	173	Plastics pipe, fittings, and profile shapes (326120:32612)	Plastics pipe, fittings, and profile shapes
MAN	RUB	174	Laminated plastics plate, sheet, and shapes (326130:32613)	Laminated plastics plate, sheet, and shapes
MAN	RUB	175	Plastics bottle manufacturing (326160:32616)	Plastics bottle manufacturing
MAN	RUB	176	Resilient floor covering manufacturing (326192:326192)	Resilient floor covering manufacturing
MAN	RUB	177	Plastics plumbing fixtures and all other plastics products (32619A:326191,326199)	Plastics plumbing fixtures and all other plastics products
MAN	RUB	178	Foam product manufacturing (3261A0:32614,32615)	Foam product manufacturing
MAN	RUB	179	Tire manufacturing (326210:32621)	Tire manufacturing
MAN	RUB	180	Rubber and plastics hose and belting manufacturing (326220:32622)	Rubber and plastics hose and belting manufacturing
MAN	RUB	181	Other rubber product manufacturing (326290:32629)	Other rubber product manufacturing
MAN	MAC	257	Farm machinery and equipment manufacturing (333111:333111)	Farm machinery and equipment manufacturing
MAN	MAC	258	Lawn and garden equipment manufacturing (333112:333112)	Lawn and garden equipment manufacturing
MAN	MAC	259	Construction machinery manufacturing (333120:33312)	Construction machinery manufacturing
MAN	MAC	260	Mining machinery and equipment manufacturing (333131:333131)	Mining machinery and equipment manufacturing
MAN	MAC	261	Oil and gas field machinery and equipment (333132:333132)	Oil and gas field machinery and equipment
MAN	MAC	262	Sawmill and woodworking machinery (333210:33321)	Sawmill and woodworking machinery
MAN	MAC	263	Plastics and rubber industry machinery (333220:33322)	Plastics and rubber industry machinery
MAN	MAC	264	Paper industry machinery manufacturing (333291:333291)	Paper industry machinery manufacturing
MAN	MAC	265	Textile machinery manufacturing (333292:333292)	Textile machinery manufacturing
MAN	MAC	266	Printing machinery and equipment manufacturing (333293:333293)	Printing machinery and equipment manufacturing
MAN	MAC	267	Food product machinery manufacturing (333294:333294)	Food product machinery manufacturing
MAN	MAC	268	Semiconductor machinery manufacturing (333295:333295)	Semiconductor machinery manufacturing
MAN	MAC	269	All other industrial machinery manufacturing (333298:333298)	All other industrial machinery manufacturing
MAN	MAC	270	Office machinery manufacturing (333313:333313)	Office machinery manufacturing
MAN	MAC	271	Optical instrument and lens manufacturing (333314:333314)	Optical instrument and lens manufacturing
MAN	MAC	272	Photographic and photocopying equipment manufacturing (333315:333315)	Photographic and photocopying equipment manufacturing
MAN	MAC	273	Other commercial and service industry machinery manufacturing (333319:333319)	Other commercial and service industry machinery manufacturing
MAN	MAC	274	Automatic vending, commercial laundry and drycleaning machinery (33331A:333311,33	Automatic vending, commercial laundry and drycleaning machinery
MAN	MAC	275	Air purification equipment manufacturing (333411:333411)	Air purification equipment manufacturing
MAN	MAC	276	Industrial and commercial fan and blower manufacturing (333412:333412)	Industrial and commercial fan and blower manufacturing
MAN	MAC	277	Heating equipment, except warm air furnaces (333414:333414)	Heating equipment, except warm air furnaces
MAN	MAC	278	AC, refrigeration, and forced air heating (333415:333415)	AC, refrigeration, and forced air heating
MAN	MAC	279	Industrial mold manufacturing (333511:333511)	Industrial mold manufacturing
MAN	MAC	280	Metal cutting machine tool manufacturing (333512:333512)	Metal cutting machine tool manufacturing
MAN	MAC	281	Metal forming machine tool manufacturing (333513:333513)	Metal forming machine tool manufacturing
MAN	MAC	282	Special tool, die, jig, and fixture manufacturing (333514:333514)	Special tool, die, jig, and fixture manufacturing
MAN	MAC	283	Cutting tool and machine tool accessory manufacturing (333515:333515)	Cutting tool and machine tool accessory manufacturing
MAN	MAC	284	Rolling mill and other metalworking machinery (33351A:333516,333518)	Rolling mill and other metalworking machinery
MAN	MAC	285	Turbine and turbine generator set units manufacturing (333611:333611)	Turbine and turbine generator set units manufacturing
MAN	MAC	286	Other engine equipment manufacturing (333618:333618)	Other engine equipment manufacturing
MAN	MAC	287	Speed changers and mechanical power transmission equipment (33361A:333612,3336	Speed changers and mechanical power transmission equipment
MAN	MAC	288	Pump and pumping equipment manufacturing (333911:333911)	Pump and pumping equipment manufacturing
MAN	MAC	289	Air and gas compressor manufacturing (333912:333912)	Air and gas compressor manufacturing
MAN	MAC	290	Measuring and dispensing pump manufacturing (333913:333913)	Measuring and dispensing pump manufacturing
MAN	MAC	291	Elevator and moving stairway manufacturing (333921:333921)	Elevator and moving stairway manufacturing
MAN	MAC	292	Conveyor and conveying equipment manufacturing (333922:333922)	Conveyor and conveying equipment manufacturing
MAN	MAC	293	Overhead cranes, hoists, and monorail systems (333923:333923)	Overhead cranes, hoists, and monorail systems
MAN	MAC	294	Industrial truck, trailer, and stacker manufacturing (333924:333924)	Industrial truck, trailer, and stacker manufacturing
MAN	MAC	295	Power-driven handtool manufacturing (333991:333991)	Power-driven handtool manufacturing
MAN	MAC	296	Welding and soldering equipment manufacturing (333992:333992)	Welding and soldering equipment manufacturing
MAN	MAC	297	Packaging machinery manufacturing (333993:333993)	Packaging machinery manufacturing
MAN	MAC	298	Industrial process furnace and oven manufacturing (333994:333994)	Industrial process furnace and oven manufacturing
MAN	MAC	299	Fluid power cylinder and actuator manufacturing (333995:333995)	Fluid power cylinder and actuator manufacturing
MAN	MAC	300	Fluid power pump and motor manufacturing (333996:333996)	Fluid power pump and motor manufacturing
MAN	MAC	301	Scales, balances, and miscellaneous general purpose machinery (33399A:333997,3339	Scales, balances, and miscellaneous general purpose machinery
MAN	COM	302	Electronic computer manufacturing (334111:334111)	Electronic computer manufacturing
MAN	COM	303	Computer storage device manufacturing (334112:334112)	Computer storage device manufacturing
MAN	COM	304	Computer terminal manufacturing (334113:334113)	Computer terminal manufacturing
MAN	COM	305	Other computer peripheral equipment manufacturing (334119:334119)	Other computer peripheral equipment manufacturing
MAN	COM	306	Telephone apparatus manufacturing (334210:33421)	Telephone apparatus manufacturing
MAN	COM	307	Broadcast and wireless communications equipment (334220:33422)	Broadcast and wireless communications equipment
MAN	COM	308	Other communications equipment manufacturing (334290:33429)	Other communications equipment manufacturing
MAN	COM	309	Audio and video equipment manufacturing (334300:3343)	Audio and video equipment manufacturing
MAN	COM	310	Electron tube manufacturing (334411:334411)	Electron tube manufacturing
MAN	COM	311	Semiconductors and related device manufacturing (334413:334413)	Semiconductors and related device manufacturing
MAN	COM	312	All other electronic component manufacturing (33441A:334412,334414,334415,334416,	All other electronic component manufacturing
MAN	COM	313	Electromedical apparatus manufacturing (334510:334510)	Electromedical apparatus manufacturing
MAN	COM	314	Search, detection, and navigation instruments (334511:334511)	Search, detection, and navigation instruments
MAN	COM	315	Automatic environmental control manufacturing (334512:334512)	Automatic environmental control manufacturing
MAN	COM	316	Industrial process variable instruments (334513:334513)	Industrial process variable instruments
MAN	COM	317	Totalizing fluid meters and counting devices (334514:334514)	Totalizing fluid meters and counting devices
MAN	COM	318	Electricity and signal testing instruments (334515:334515)	Electricity and signal testing instruments
MAN	COM	319	Analytical laboratory instrument manufacturing (334516:334516)	Analytical laboratory instrument manufacturing
MAN	COM	320	Irradiation apparatus manufacturing (334517:334517)	Irradiation apparatus manufacturing
MAN	COM	321	Watch, clock, and other measuring and controlling device manufac (33451A:334518,334	Watch, clock, and other measuring and controlling device manufacturing
MAN	COM	322	Software reproducing (334611:334611)	Software reproducing
MAN	COM	323	Audio and video media reproduction (334612:334612)	Audio and video media reproduction
MAN	COM	324	Magnetic and optical recording media manufacturing (334613:334613)	Magnetic and optical recording media manufacturing
MAN	ELQ	325	Electric lamp bulb and part manufacturing (335110:33511)	Electric lamp bulb and part manufacturing

MAN	ELQ	326	Lighting fixture manufacturing (335120:33512)	Lighting fixture manufacturing
MAN	ELQ	327	Electric housewares and household fan manufacturing (335211:335211)	Electric housewares and household fan manufacturing
MAN	ELQ	328	Household vacuum cleaner manufacturing (335212:335212)	Household vacuum cleaner manufacturing
MAN	ELQ	329	Household cooking appliance manufacturing (335221:335221)	Household cooking appliance manufacturing
MAN	ELQ	330	Household refrigerator and home freezer manufacturing (335222:335222)	Household refrigerator and home freezer manufacturing
MAN	ELQ	331	Household laundry equipment manufacturing (335224:335224)	Household laundry equipment manufacturing
MAN	ELQ	332	Other major household appliance manufacturing (335228:335228)	Other major household appliance manufacturing
MAN	ELQ	333	Electric power and specialty transformer manufacturing (335311:335311)	Electric power and specialty transformer manufacturing
MAN	ELQ	334	Motor and generator manufacturing (335312:335312)	Motor and generator manufacturing
MAN	ELQ	335	Switchgear and switchboard apparatus manufacturing (335313:335313)	Switchgear and switchboard apparatus manufacturing
MAN	ELQ	336	Relay and industrial control manufacturing (335314:335314)	Relay and industrial control manufacturing
MAN	ELQ	337	Storage battery manufacturing (335911:335911)	Storage battery manufacturing
MAN	ELQ	338	Primary battery manufacturing (335912:335912)	Primary battery manufacturing
MAN	ELQ	339	Fiber optic cable manufacturing (335921:335921)	Fiber optic cable manufacturing
MAN	ELQ	340	Other communication and energy wire manufacturing (335929:335929)	Other communication and energy wire manufacturing
MAN	ELQ	341	Wiring device manufacturing (335930:33593)	Wiring device manufacturing
MAN	ELQ	342	Carbon and graphite product manufacturing (335991:335991)	Carbon and graphite product manufacturing
MAN	ELQ	343	Miscellaneous electrical equipment manufacturing (335999:335999)	Miscellaneous electrical equipment manufacturing
MAN	TRQ	351	Aircraft manufacturing (336411:336411)	Aircraft manufacturing
MAN	TRQ	352	Aircraft engine and engine parts manufacturing (336412:336412)	Aircraft engine and engine parts manufacturing
MAN	TRQ	353	Other aircraft parts and equipment (336413:336413)	Other aircraft parts and equipment
MAN	TRQ	354	Guided missile and space vehicle manufacturing (336414:336414)	Guided missile and space vehicle manufacturing
MAN	TRQ	355	Propulsion units and parts for space vehicles and guided missile (33641A:336415,33641	Propulsion units and parts for space vehicles and guided missiles
MAN	TRQ	356	Railroad rolling stock manufacturing (336500:3365)	Railroad rolling stock manufacturing
MAN	TRQ	357	Ship building and repairing (336611:336611)	Ship building and repairing
MAN	TRQ	358	Boat building (336612:336612)	Boat building
MAN	TRQ	359	Motorcycle, bicycle, and parts manufacturing (336991:336991)	Motorcycle, bicycle, and parts manufacturing
MAN	TRQ	360	Military armored vehicles and tank parts manufacturing (336992:336992)	Military armored vehicles and tank parts manufacturing
MAN	TRQ	361	All other transportation equipment manufacturing (336999:336999)	All other transportation equipment manufacturing
MAN	WOO	362	Wood kitchen cabinet and countertop manufacturing (337110:33711)	Wood kitchen cabinet and countertop manufacturing
MAN	WOO	363	Upholstered household furniture manufacturing (337121:337121)	Upholstered household furniture manufacturing
MAN	WOO	364	Nonupholstered wood household furniture manufacturing (337122:337122)	Nonupholstered wood household furniture manufacturing
MAN	WOO	365	Metal household furniture manufacturing (337124:337124)	Metal household furniture manufacturing
MAN	WOO	366	Institutional furniture manufacturing (337127:337127)	Institutional furniture manufacturing
MAN	WOO	367	Other household and institutional furniture (33712A:337125,337129)	Other household and institutional furniture
MAN	WOO	368	Wood office furniture manufacturing (337211:337211)	Wood office furniture manufacturing
MAN	WOO	369	Custom architectural woodwork and millwork (337212:337212)	Custom architectural woodwork and millwork
MAN	WOO	370	Office furniture, except wood, manufacturing (337214:337214)	Office furniture, except wood, manufacturing
MAN	WOO	371	Showcases, partitions, shelving, and lockers (337215:337215)	Showcases, partitions, shelving, and lockers
MAN	WOO	372	Mattress manufacturing (337910:33791)	Mattress manufacturing
MAN	WOO	373	Blind and shade manufacturing (337920:33792)	Blind and shade manufacturing
MAN	MSC	374	Laboratory apparatus and furniture manufacturing (339111:339111)	Laboratory apparatus and furniture manufacturing
MAN	MSC	375	Surgical and medical instrument manufacturing (339112:339112)	Surgical and medical instrument manufacturing
MAN	MSC	376	Surgical appliance and supplies manufacturing (339113:339113)	Surgical appliance and supplies manufacturing
MAN	MSC	377	Dental equipment and supplies manufacturing (339114:339114)	Dental equipment and supplies manufacturing
MAN	MSC	378	Ophthalmic goods manufacturing (339115:339115)	Ophthalmic goods manufacturing
MAN	MSC	379	Dental laboratories (339116:339116)	Dental laboratories
MAN	MSC	380	Jewelry and silverware manufacturing (339910:33991)	Jewelry and silverware manufacturing
MAN	MSC	381	Sporting and athletic goods manufacturing (339920:33992)	Sporting and athletic goods manufacturing
MAN	MSC	382	Doll, toy, and game manufacturing (339930:33993)	Doll, toy, and game manufacturing
MAN	MSC	383	Office supplies, except paper, manufacturing (339940:33994)	Office supplies, except paper, manufacturing
MAN	MSC	384	Sign manufacturing (339950:33995)	Sign manufacturing
MAN	MSC	385	Gasket, packing, and sealing device manufacturing (339991:339991)	Gasket, packing, and sealing device manufacturing
MAN	MSC	386	Musical instrument manufacturing (339992:339992)	Musical instrument manufacturing
MAN	MSC	387	Broom, brush, and mop manufacturing (339994:339994)	Broom, brush, and mop manufacturing
MAN	MSC	388	Burial casket manufacturing (339995:339995)	Burial casket manufacturing
MAN	MSC	389	Buttons, pins, and all other miscellaneous manufacturing (33999A:339993,339999)	Buttons, pins, and all other miscellaneous manufacturing
OIL	OIL	142	Petroleum refineries (324110:32411)	Petroleum refineries
OIL	OIL	146	All other petroleum and coal products manufacturing (324199:324199)	All other petroleum and coal products manufacturing
SRV	SRV	18	Agriculture and forestry support activities (115000:115)	Agriculture and forestry support activities
SRV	SRV	32	Water, sewage and other systems (221300:2213)	Water, sewage and other systems
SRV	SRV	390	Wholesale trade (420000:42)	Wholesale trade
SRV	SRV	398	Postal service (491000:491110)	Postal service
SRV	SRV	399	Couriers and messengers (492000:492)	Couriers and messengers
SRV	SRV	400	Warehousing and storage (493000:493)	Warehousing and storage
SRV	SRV	402	Furniture and home furnishings stores (4A0000:442)	Furniture and home furnishings stores
SRV	SRV	403	Electronics and appliance stores (4A0000:443)	Electronics and appliance stores
SRV	SRV	404	Building material and garden supply stores (4A0000:444)	Building material and garden supply stores
SRV	SRV	405	Food and beverage stores (4A0000:445)	Food and beverage stores
SRV	SRV	406	Health and personal care stores (4A0000:446)	Health and personal care stores
SRV	SRV	407	Gasoline stations (4A0000:447)	Gasoline stations
SRV	SRV	408	Clothing and clothing accessories stores (4A0000:448)	Clothing and clothing accessories stores
SRV	SRV	409	Sporting goods, hobby, book and music stores (4A0000:451)	Sporting goods, hobby, book and music stores
SRV	SRV	410	General merchandise stores (4A0000:452)	General merchandise stores
SRV	SRV	411	Miscellaneous store retailers (4A0000:453)	Miscellaneous store retailers
SRV	SRV	412	Nonstore retailers (4A0000:454)	Nonstore retailers
SRV	SRV	413	Newpaper publishers (511110:51111)	Newpaper publishers
SRV	SRV	414	Periodical publishers (511120:51112)	Periodical publishers
SRV	SRV	415	Book publishers (511130:51113)	Book publishers
SRV	SRV	416	Database, directory, and other publishers (5111A0:51114,51119)	Database, directory, and other publishers
SRV	SRV	417	Software publishers (511200:5112)	Software publishers
SRV	SRV	418	Motion picture and video industries (512100:5121)	Motion picture and video industries
SRV	SRV	419	Sound recording industries (512200:5122)	Sound recording industries
SRV	SRV	420	Radio and television broadcasting (513100:5131)	Radio and television broadcasting

SRV	SRV	421	Cable networks and program distribution (513200:5132)	Cable networks and program distribution
SRV	SRV	422	Telecommunications (513300:5133)	Telecommunications
SRV	SRV	423	Information services (514100:5141)	Information services
SRV	SRV	424	Data processing services (514200:5142)	Data processing services
SRV	SRV	425	Nondepository credit intermediation and related activities (522A00:5222,5223)	Nondepository credit intermediation and related activities
SRV	SRV	426	Securities, commodity contracts, investments (523000:523)	Securities, commodity contracts, investments
SRV	SRV	427	Insurance carriers (524100:5241)	Insurance carriers
SRV	SRV	428	Insurance agencies, brokerages, and related (524200:5242)	Insurance agencies, brokerages, and related
SRV	SRV	429	Funds, trusts, and other financial vehicles (525000:525)	Funds, trusts, and other financial vehicles
SRV	SRV	430	Monetary authorities and depository credit intermediation (52A000:521,5221)	Monetary authorities and depository credit intermediation
SRV	SRV	431	Real estate (531000:531)	Real estate
SRV	SRV	432	Automotive equipment rental and leasing (532100:5321)	Automotive equipment rental and leasing
SRV	SRV	433	Video tape and disc rental (532230:53223)	Video tape and disc rental
SRV	SRV	434	Machinery and equipment rental and leasing (532400:5324)	Machinery and equipment rental and leasing
SRV	SRV	435	General and consumer goods rental except video tapes and discs (532A00:53221,5322	General and consumer goods rental except video tapes and discs
SRV	SRV	436	Lessors of nonfinancial intangible assets (533000:533)	Lessors of nonfinancial intangible assets
SRV	SRV	437	Legal services (541100:5411)	Legal services
SRV	SRV	438	Accounting and bookkeeping services (541200:5412)	Accounting and bookkeeping services
SRV	SRV	439	Architectural and engineering services (541300:5413)	Architectural and engineering services
SRV	SRV	440	Specialized design services (541400:5414)	Specialized design services
SRV	SRV	441	Custom computer programming services (541511:541511)	Custom computer programming services
SRV	SRV	442	Computer systems design services (541512:541512)	Computer systems design services
SRV	SRV	443	Other computer related services, including facilities management (54151A:541513,5415	Other computer related services, including facilities management
SRV	SRV	444	Management consulting services (541610:54161)	Management consulting services
SRV	SRV	445	Environmental and other technical consulting services (5416A0:54162,54169)	Environmental and other technical consulting services
SRV	SRV	446	Scientific research and development services (541700:5417)	Scientific research and development services
SRV	SRV	447	Advertising and related services (541800:5418)	Advertising and related services
SRV	SRV	448	Photographic services (541920:54192)	Photographic services
SRV	SRV	449	Veterinary services (541940:54194)	Veterinary services
SRV	SRV	450	All other miscellaneous professional and technical services (5419A0:54191,54193,5419	All other miscellaneous professional and technical services
SRV	SRV	451	Management of companies and enterprises (550000:55)	Management of companies and enterprises
SRV	SRV	452	Office administrative services (561100:5611)	Office administrative services
SRV	SRV	453	Facilities support services (561200:5612)	Facilities support services
SRV	SRV	454	Employment services (561300:5613)	Employment services
SRV	SRV	455	Business support services (561400:5614)	Business support services
SRV	SRV	456	Travel arrangement and reservation services (561500:5615)	Travel arrangement and reservation services
SRV	SRV	457	Investigation and security services (561600:5616)	Investigation and security services
SRV	SRV	458	Services to buildings and dwellings (561700:5617)	Services to buildings and dwellings
SRV	SRV	459	Other support services (561900:5619)	Other support services
SRV	SRV	460	Waste management and remediation services (562000:562)	Waste management and remediation services
SRV	SRV	461	Elementary and secondary schools (611100:6111)	Elementary and secondary schools
SRV	SRV	462	Colleges, universities, and junior colleges (611A00:6112,6113)	Colleges, universities, and junior colleges
SRV	SRV	463	Other educational services (611B00:6114,6115,6116,6117)	Other educational services
SRV	SRV	464	Home health care services (621600:6216)	Home health care services
SRV	SRV	465	Offices of physicians, dentists, and other health practioners (621A00:6211,6212,6213)	Offices of physicians, dentists, and other health practioners
SRV	SRV	466	Other ambulatory health care services (621B00:6214,6215,6219)	Other ambulatory health care services
SRV	SRV	467	Hospitals (622000:622)	Hospitals
SRV	SRV	468	Nursing and residential care facilities (623000:623)	Nursing and residential care facilities
SRV	SRV	469	Child day care services (624400:6244)	Child day care services
SRV	SRV	470	Social assistance, except child day care services (624A00:6241,6242,6243)	Social assistance, except child day care services
SRV	SRV	471	Performing arts companies (711100:7111)	Performing arts companies
SRV	SRV	472	Spectator sports (711200:7112)	Spectator sports
SRV	SRV	473	Independent artists, writers, and performers (711500:7115)	Independent artists, writers, and performers
SRV	SRV	474	Promoters of performing arts and sports and agents for public fi (711A00:7113,7114)	Promoters of performing arts and sports and agents for public figures
SRV	SRV	475	Museums, historical sites, zoos, and parks (712000:712)	Museums, historical sites, zoos, and parks
SRV	SRV	476	Fitness and recreational sports centers (713940:71394)	Fitness and recreational sports centers
SRV	SRV	477	Bowling centers (713950:71395)	Bowling centers
SRV	SRV	478	Other amusement, gambling, and recreation industries (713A00:7131,7132,71391,7139	Other amusement, gambling, and recreation industries
SRV	SRV	479	Hotels and motels, including casino hotels (7211A0:72111,72112)	Hotels and motels, including casino hotels
SRV	SRV	480	Other accommodations (721A00:72119,7212,7213)	Other accommodations
SRV	SRV	481	Food services and drinking places (722000:722)	Food services and drinking places
SRV	SRV	482	Car washes (811192:811192)	Car washes
SRV	SRV	483	Automotive repair and maintenance, except car washes (8111A0:81111,81112,811191,	Automotive repair and maintenance, except car washes
SRV	SRV	484	Electronic equipment repair and maintenance (811200:8112)	Electronic equipment repair and maintenance
SRV	SRV	485	Commercial machinery repair and maintenance (811300:8113)	Commercial machinery repair and maintenance
SRV	SRV	486	Household goods repair and maintenance (811400:8114)	Household goods repair and maintenance
SRV	SRV	487	Personal care services (812100:8121)	Personal care services
SRV	SRV	488	Death care services (812200:8122)	Death care services
SRV	SRV	489	Drycleaning and laundry services (812300:8123)	Drycleaning and laundry services
SRV	SRV	490	Other personal services (812900:8129)	Other personal services
SRV	SRV	491	Religious organizations (813100:8131)	Religious organizations
SRV	SRV	492	Grantmaking and giving and social advocacy organizations (813A00:8132,8133)	Grantmaking and giving and social advocacy organizations
SRV	SRV	493	Civic, social, professional and similar organizations (813B00:8134,8139)	Civic, social, professional and similar organizations
SRV	SRV	494	Private households (814000:814)	Private households
SRV	SRV	496	Other Federal Government enterprises (S00102)	Other Federal Government enterprises
SRV	SRV	499	Other State and local government enterprises (S00203)	Other State and local government enterprises
SRV	SRV	500	Noncomparable imports (S00300)	Noncomparable imports
SRV	SRV	501	Scrap (S00401)	Scrap
SRV	SRV	502	Used and secondhand goods (S00402)	Used and secondhand goods
SRV	SRV	503	State & Local Education (S00500)	State & Local Education
SRV	SRV	504	State & Local Non-Education (S00500)	State & Local Non-Education
SRV	SRV	505	Federal Military (S00500)	Federal Military
SRV	SRV	506	Federal Non-Military (S00500)	Federal Non-Military
SRV	SRV	507	Rest of the world adjustment to final uses (S00600)	Rest of the world adjustment to final uses

SRV	SRV	508	Inventory valuation adjustment (S00700)	Inventory valuation adjustment
SRV	DWE	509	Owner-occupied dwellings (S00800)	Owner-occupied dwellings
TRN	TRN	391	Air transportation (481000:481)	Air transportation
TRN	TRN	392	Rail transportation (482000:482)	Rail transportation
TRN	TRN	393	Water transportation (483000:483)	Water transportation
TRN	TRN	394	Truck transportation (484000:484)	Truck transportation
TRN	TRN	395	Transit and ground passenger transportation (485000:485)	Transit and ground passenger transportation
TRN	TRN	396	Pipeline transportation (486000:486)	Pipeline transportation
TRN	TRN	397	Scenic and sightseeing transportation and support activities for (48A000:487,488)	Scenic and sightseeing transportation and support activities for transportation
TRN	TRN	497	State and local government passenger transit (S00201)	State and local government passenger transit