

## MEMORANDUM

To: Caroline Garber, Chief, Environmental Studies Section, WI DNR  
Kris Krause, Co-Chair, GWTF Technical Advisory Committee  
George Edgar, Co-Chair, GWTF Technical Advisory Committee

From: Glen Wood, ICF International (ICF), and  
Jeff Amlin, Systematic Solutions Inc. (SSI)

Date: September 27, 2007

Re: ***ENERGY 2020 – Overview of Data Needs and Key Variables***

ENERGY 2020 derives energy demands and resulting air emissions based on underlying economic activity, physical systems and processes and equipment efficiencies. The following memo provides a brief overview of the data inputs and assumptions used in the model well as the sources of data proposed for the Reference case. Our intent is to provide the TAG with an opportunity to review these assumptions and to identify areas in which there are opportunities to use Wisconsin-specific data that can contribute to improving the modeling effort.

As a multi-sector analytical tool, ENERGY2020 requires data and assumptions covering a broad range of economic sectors and their interactions. In most cases, the necessary data – both historical and projected – is available from the federal government (EIA, EPA, etc.). In past analyses, ENERGY2020 has relied heavily on these federal sources to populate and calibrate the model. Wisconsin is somewhat unique in that it has a long history of collecting and reporting energy data for the state and in maintaining active Demand Side Management programs. There may be instances in which the GWTF elects to use that data in place of data from federal sources.

ENERGY2020 requires both historical data and projections to calibrate and generate forward-looking projections. Historical data will be required from a base year (to be determined) to the last historic year (2004), for the calibration period (2004 to 2006). Projections for the period to be modeled (e.g. through 2034) will be gathered where possible to provide points of comparison and check the reasonableness of the projection.

For the purpose of the analysis, ICF/SSI will model interactions between Wisconsin and the surrounding states in the US mid-west, particularly with respect to electricity generation. To perform this broader regional analysis, the same data sources and assumptions used in ENERGY2020 for Wisconsin will generally be applied to other states. In determining which data sources to use for Wisconsin, consideration should be given to the potential impacts of using different sources of data for different states (or Wisconsin vs. other US states).

## 1 Population and Economic Data

Demographic data is required to generate demands for residential services. To the extent possible this data will be drawn from the same source used for the macro-economic modeling (REMI).

Description of Data/Input	Sources Used/Available
Total population, historical and growth over time	US Census Bureau
Population by housing type (single-family, multi-family, etc.)	US Census Bureau
Households by housing type (single-family, multi-family, etc.)	US Census Bureau
Personal income	US Bureau of Economic Analysis
Employment by sector	US Bureau of Economic Analysis

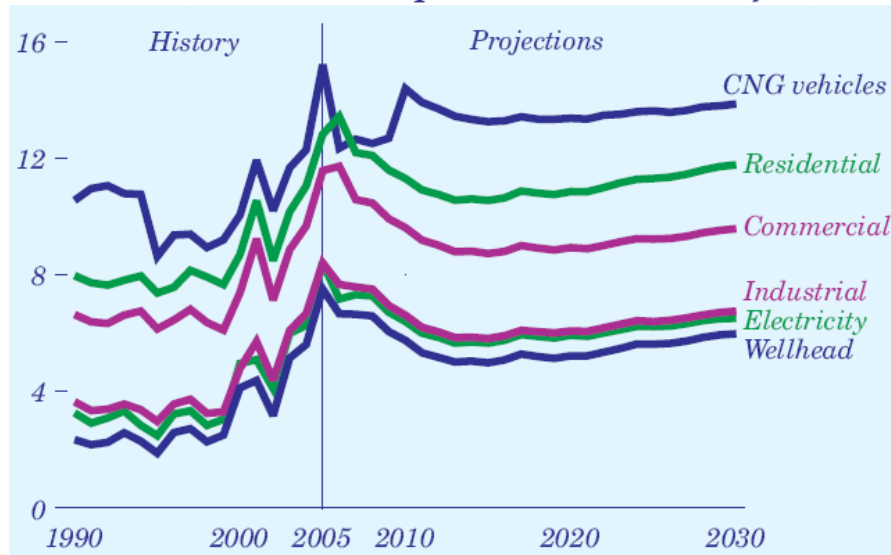
## 2 Price data

Energy prices for oil, natural gas, and coal significantly influence electricity prices and influence dispatch decisions as well as influencing consumer and business decisions in other sectors. These prices are largely dependent on international markets, although electric sector demand can influence natural gas prices.

- Oil prices in the model are based on U.S. D.O.E. Annual Energy Outlook (AEO) for 2007 to 2030. The figure below shows world oil prices used in the base case.
- Historic electricity prices used in the ENERGY 2020 are derived from utility financial statements obtained from the Energy Information Administration (EIA) Federal Electricity Regulatory Commission (FERC) Form 1.
- Power prices are calculated endogenously by the model based on generation costs and dispatch. The model calculates retail electricity prices, however, actual consumer prices may differ as a result of political, regulatory or market influences. The model will be calibrated to actual prices, within reasonable parameters, for the historic period.
- The wellhead price of natural gas in the model is based on U.S. Energy Information Administration's Annual Energy Outlook (AEO) 2007 through 2030 as shown below.
- The price of coal used in the model is based on the AEO 2007 to 2030. The EIA data provides both mine mouth prices and average delivered prices for electric power plants.

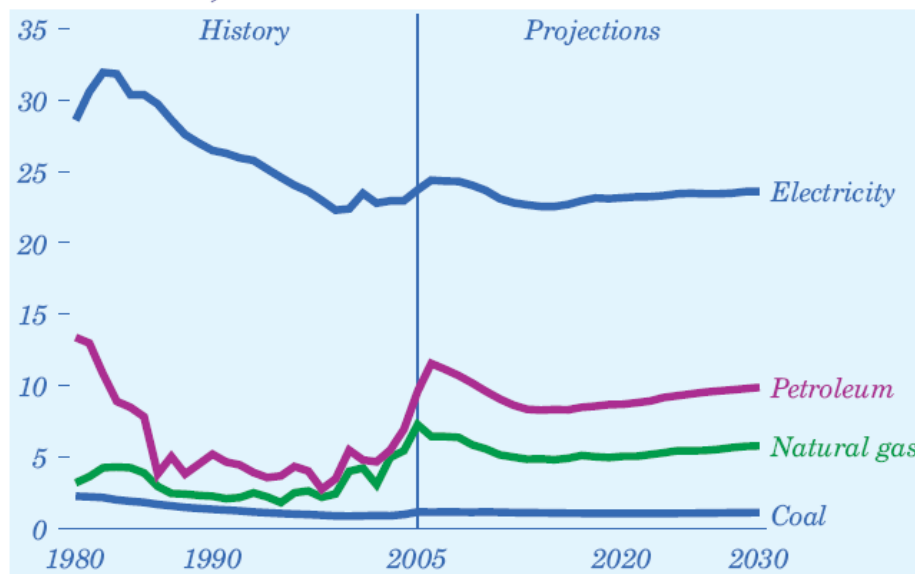
Description of Data/Input	Sources Used/Available
Coal	EIA Annual Energy Outlook (AEO) 2007
Oil and derived products	EIA Annual Energy Outlook (AEO) 2007
Natural Gas	EIA Annual Energy Outlook (AEO) 2007
Biomass	EIA Annual Energy Outlook (AEO) 2007

**Figure 73. Natural gas prices by end-use sector, 1990-2030 (2005 dollars per thousand cubic feet)**



Source: Oil and Gas Projections, IEA AEO 2007 to 2030  
[http://www.eia.doe.gov/oiaf/aeo/pdf/trend\\_4.pdf](http://www.eia.doe.gov/oiaf/aeo/pdf/trend_4.pdf)

**Figure 1. Energy prices, 1980-2030 (2005 dollars per million Btu)**



Source: Annual Energy Outlook 2007, EIA, page 4, Figure 1.

### 3 Historic Energy Data

ENERGY2020 models energy use at the end use level within each economic sector based on the existing physical stock and the efficiency of that stock. The database of device efficiencies in the model reflects both the average efficiency of energy use for current stocks and the

efficiency/energy alternatives available to end-users to serve new demand or replace existing stock.

The EIA surveys listed as data sources below (RECS, MECS, etc.) provide data by census region and division. Census-level data is shared into state-level data based on SEDS information and other available state-specific data.

Description of Data/Input	Sources Used/Available
<b>Residential Data</b> - Household income by housing type - No. of people per household - End-use consumption data, including fuels used for space and water heating, air conditioning, etc.	2001 EIA Residential Energy Consumption Survey (RECS), by Census Region and Division (2005 RECS in process) <a href="http://www.eia.doe.gov/emeu/recs/contents.html">http://www.eia.doe.gov/emeu/recs/contents.html</a>
<b>Commercial Data</b> - Floor area by sub-sector - End-use consumption data, including fuels used for space and water heating and energy intensities	2003 EIA Commercial Buildings Energy Consumption Survey (CBECS), by Census Region and Division (2007 CBECS underway) <a href="http://www.eia.doe.gov/emeu/cbecs/contents.html">http://www.eia.doe.gov/emeu/cbecs/contents.html</a>
<b>Industrial/Manufacturing Data</b> - Energy use by fuel for each sub-sector and end-use	2002 EIA Manufacturing Energy Consumption Survey (MECS), by Census Region (2006 MECS underway) <a href="http://www.eia.doe.gov/emeu/mecs/contents.html">http://www.eia.doe.gov/emeu/mecs/contents.html</a>
<b>State Energy Data:</b> - Energy consumption and expenditures by sector and energy source	2004 EIA State Energy Data System (SEDS) <a href="http://www.eia.doe.gov/emeu/states/seds.html">http://www.eia.doe.gov/emeu/states/seds.html</a>

If the TAG has Wisconsin-specific information that would provide a more accurate or detailed picture of energy use in the state, this information could be used to supplement the data available from the EIA. Examples could include:

- Information on existing appliance and equipment use, saturations of appliances and equipment that may differ or offer more specific information that is available from the US EIA energy use surveys. For example, state specific saturations for residential and commercial electric space heating, water heating and air conditioning.
- Information on market shares for new efficient appliances and equipment that may differ or offer more specific information than is available from US EIA data. For example, what percentage of new residential lights purchased in the state are CFL's vs. incandescent lights.

## 4 Historic Emission Data

### Emissions and Air Regulations Data

Emission factors by sector, end-use and fuel in ENERGY2020 are developed using historic emission data for the 6 Kyoto greenhouse gases (GHGs), including carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>), sulphur hexafluoride (SF<sub>6</sub>), Hydrofluorocarbons (HFC's) and Perfluorocarbons (PFCs).

Policy requirements (caps, etc.) for existing and assumed (non-climate) air regulations will also be required.

Input	Sources Used/Available
Emissions by sector, end-use, fuel and GHG	<ul style="list-style-type: none"> <li>US EPA (<a href="http://www.epa.gov/climatechange/emissions/usinventoryreport.html">http://www.epa.gov/climatechange/emissions/usinventoryreport.html</a>).</li> <li>Emissions for stationary sources available from WI DNR.</li> </ul>
Policy specifications	<ul style="list-style-type: none"> <li>US EPA</li> <li>Wisconsin DNR</li> </ul>

Modeled emissions will be compared with those presented in the “*Wisconsin Greenhouse Gas Emissions Inventory and Projections*” prepared for the GWTF by the World Resources Institute.

## 5 Electricity Sector Data

### Generation Data:

The power sector is a significant contributor to GHG emissions in Wisconsin. It differs from other sectors in the extent to which emissions associated with power use within the state may result in emissions outside the state. In recent years, imports of power into the state have ranged from 10-20% annually.

ENERGY 2020 contains information on every generating unit in the state, as well as in neighboring jurisdictions which may supply power to the state. The model will be populated with data describing the type, operation and performance of every generating unit in the state. In addition to plant-level data, the table below includes other inputs necessary to describe the electric system, including transmission capability.

Input	Sources Used/Available
Plant type	EPA National Electric Energy Data System (NEEDS)
Plant capacity	NEEDS
Plant historical generation	NEEDS
Plant fuel type	NEEDS

<b>Input</b>	<b>Sources Used/Available</b>
Plant fuel consumption	NEEDS
Plant emissions by pollutant	<ul style="list-style-type: none"> <li>• EPA</li> <li>• Emission rates for most pollutants available from NEEDS</li> <li>• WI specific information on stationary sources.</li> </ul>
Plant costs (operation and maintenance, variable and fixed)	NEEDS
Plant historical capacity factor	NEEDS
Plant availability (outages)	NEEDS
Plant owner and location	NEEDS
Planned capacity additions and retirements	WI PSC to provide Wisconsin specific information on planned additions and retirements.
Transmission capability	WI PSC and MISO data will be used to supplement data available from NERC (see below).

**Transmission Interconnections:**

Power flows between neighboring US states are modeled within ENERGY 2020 based on existing transmission capabilities and interconnections as obtained from NERC reports. Appendix A shows a map of the transmission regions used in the model as well as the values used in the model. Interconnection capacities used in the model were based on the IPM Model 2006, Table 3.0.

Historic generation by plant type will be calibrated with historic generation data available from the US EIA.

**Planned Capacity Changes:**

As part of the modeling process, ENERGY 2020 builds new capacity endogenously as needed to meet capacity and reserve requirements. At any given time, however, plans may already be in place to build, re-furbish, upgrade or retire generation facilities. These plans must be incorporated into the model in order to reflect decisions and commitments that have already been made. Of necessity, some decisions had to be made on which planned projects to incorporate in the model based on best judgment.

The Wisconsin DNR and PSC will provide information on planned capacity additions and retirements as well as transmission/interconnections to be used in the modeling exercise.

## Characteristics of New Generation:

The table below shows the characteristics and costs used by the ENERGY 2020 model for new electric generation added during the modeling period. The cost data and plant characteristics have been used in past modeling efforts<sup>1</sup> and were reviewed and adjusted based on a comparison with the IPM Base Case 2006<sup>2</sup> prepared for the U.S. EPA.

ENERGY 2020 determines dispatch decisions based on the marginal cost of each generation option; including variable O&M costs, fuel costs and the heat rate for each plant. Note that in the table below, variable O&M costs do not include energy costs; which are calculated by ENERGY 2020 based on the cost of fuel and the heat rate for each plant type.

<b>New Electric Generation Capacity Costs (2006\$)</b>	<b>Size MW</b>	<b>Capital Cost \$/kW</b>	<b>Fixed O&amp;M Costs \$/kW</b>	<b>Variable O&amp;M Cost \$/kWh</b>	<b>Heat Rate Btu/kWh</b>	<b>Lead Time Years</b>
Nuclear	1000	\$2,470	\$69.93	\$0.55	10,400	11
PC Conventional	600	\$1,279	\$38.96	\$2.98	8,763	4
Coal - IGCC	550	\$1,761	\$55.78	\$1.76	7,939	4
Oil/Gas Combined Cycle	250	\$586	\$16.43	\$2.50	6,577	3
Oil/Gas Combustion Turbine	160	\$392	\$6.75	\$2.47	8,920	2
Biomass Combined Cycle	100	\$1,847	\$50.37	\$3.25	8,911	4
Wind	50	\$1,185	\$28.62	\$0.00	-	3
Solar -Photovoltaic	100	\$2,702	\$52.69	\$0.00	-	3
Geothermal	n/a	n/a	n/a	n/a	n/a	n/a

While it is unlikely to appear in the Reference Case, ICF has developed cost information on Carbon Capture and Sequestration (CCS) systems for the power sector. We can provide the TAG with alternative cost estimates if that is appropriate when the group begins to consider policy options for the sector.

<sup>1</sup> Michigan Department of Environmental Quality, A Study of Economic Impacts from the Implementation of a Renewable Portfolio Standard and an Energy Efficiency Program in Michigan, prepared by NextEnergy Center and Systematic Solutions Inc., April 2007.

<sup>2</sup> IPM 2006 - Documentation for EPA Base Case 2006 - Section 4: Generating Resources; Table 4.13, Performance and Unit Cost Assumptions for Potential (New) Capacity from Conventional Fossil Technologies in EPA Base Case 2006.

<http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/Section-4.pdf>

## 6 Transportation

ENERGY 2020 models passenger, freight and off-road transportation separately based on different underlying drivers. Passenger and freight transportation are modeled by mode and vehicle type.

Growth in transportation demand and energy use will be reviewed against available information from the IEA and Wisconsin DoT.

The bulk of existing passenger transportation energy is used in personal vehicles. The model assumes no major increase in vehicle efficiency in the reference case. Vehicle efficiency levels used in the model correspond reasonably to statistics available from the US Bureau of Transportation and will be calibrated with data available for the state. The table below shows vehicle efficiencies for passenger and freight vehicles currently used in the model.

<b>Passenger Vehicle Efficiency (miles/gallon)</b>			
	<b>2000</b>	<b>2010</b>	<b>2020</b>
Small Gasoline	31.6	32.9	31.6
Medium Gasoline	26.8	29.3	28.6
Large Gasoline	20.8	21.4	21.0
Large Diesel	20.8	21.7	21.4
<b>Freight Vehicle Efficiency (miles/gallon)</b>			
	<b>2000</b>	<b>2010</b>	<b>2020</b>
Medium Gasoline	6.8	7.2	7.1
Heavy Diesel	5.8	6.0	6.1

## 7 Industry

ENERGY 2020 models 23 industrial sectors, although not all are applicable in all states. Of these, a small number are considered to be “energy intensive” industries, where energy use per dollar of output is typically an order of magnitude higher than for general manufacturing. Economic information for Wisconsin will be used to identify trends for these industries and the influence of these industries in the state.

We would request that the TAG provide information on any changes that have occurred since the historic year or which are anticipated in the next few years that would impact the relative contributions of these industry to the state economy.

## 8 Policy Environment

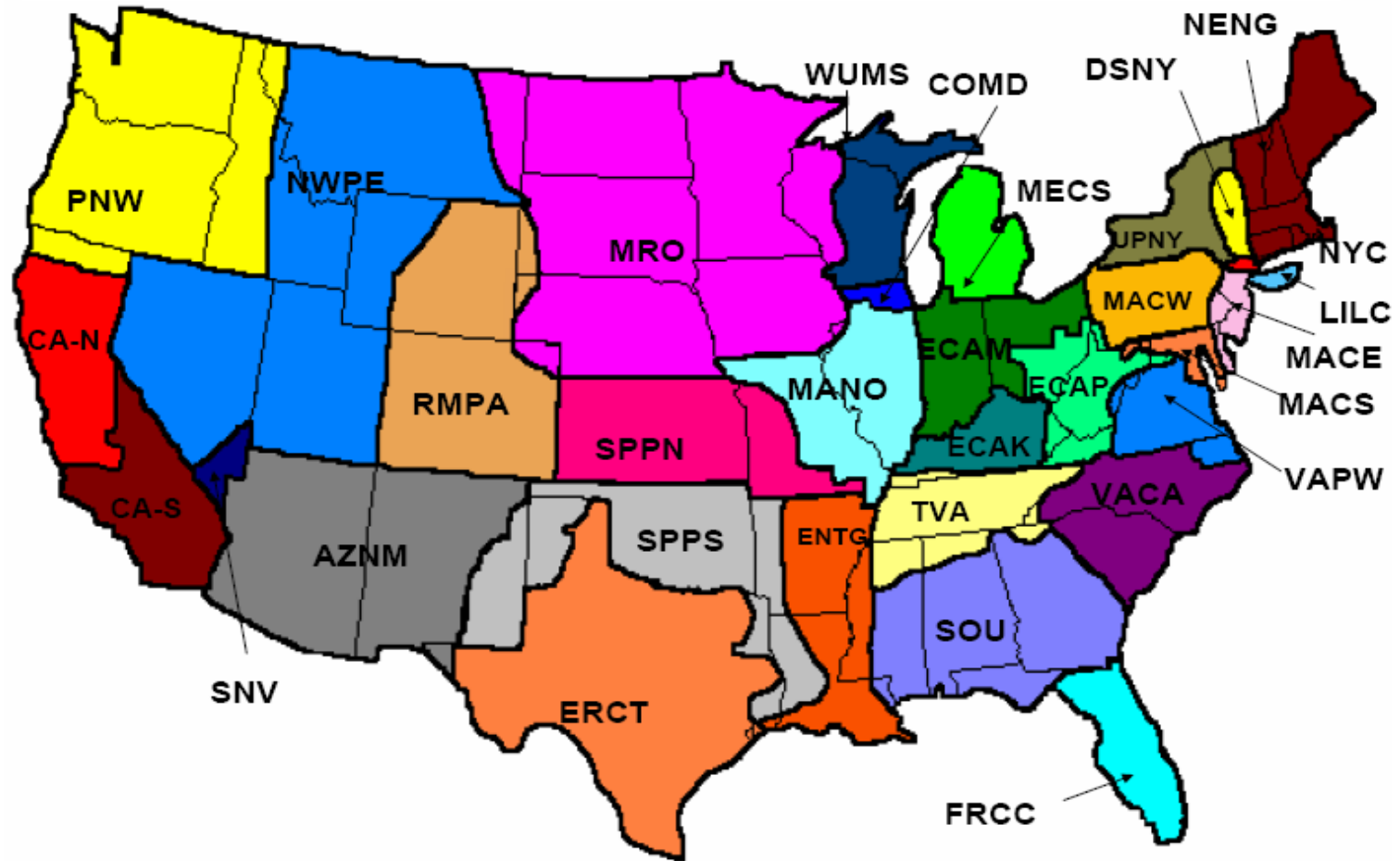
ENERGY 2020 builds on historic trends, known and projected prices and technologies to project future changes in energy use and emissions. Where policies, programs and regulations have changed, or are committed to change, exogenous adjustments to the model must be made to reflect these discontinuities. We would request that the TAG provide information on any such

changes that they are aware of that will influence future patterns of energy use. These might include:

- Renewable Portfolio Standards affecting the power, transportation or other sectors;
- Energy efficiency portfolio standard;
- DSM programs being provided by natural gas or power utilities;
- Regulatory changes affecting power sector air emissions that will affect future dispatch prices;
- Changes to building codes, appliance and equipment standards that would affect future energy consumption.

# Appendix A: Inter-regional Transmission Capacity In ENERGY 2020

Map of Power Regions



**Transmission Capabilities between Model Regions**

Region From	Region To	Energy Transfer Capability (MW)	Capacity Transfer Capability (MW)
MECS	ECAM	2,776	1,904
MECS	ECAP	3,900	683
ECAK	ECAM	3,365	1,225
ECAK	ECAP	1,000	175
ECAK	MANO	200	200
ECAK	TVA	1,500	632
ECAM	COMD	2,760	1,360
ECAM	ECAK	815	270
ECAM	ECAP	12,838	7,951
ECAM	MACW	3,100	2,274
ECAM	MANO	7,078	3,504
ECAM	MECS	4,603	825
ECAP	COMD	3,100	3,100
ECAP	ECAK	1,000	537
ECAP	ECAM	15,041	8,525
ECAP	MACS	2,500	350
ECAP	MACW	3,900	1,075
ECAP	MECS	3,700	1,762
ECAP	TVA	1,000	1,000
ECAP	VACA	3,002	2,042
ECAP	VAPW	3,080	953
ERCT	ENTG	1,001	1,001
ERCT	SPPS	1,574	1,574
MACE	DSNY	1,000	1,000
MACE	LILC	650	521
MACE	MACW	2,000	2,000
MACE	NYC	1,000	1,000
MACS	ECAP	2,500	750
MACS	MACW	3,500	3,000
MACS	VAPW	2,600	2,600
MACW	ECAM	2,208	504
MACW	ECAP	3,300	2,044
MACW	MACE	6,200	5,800
MACW	MACS	5,000	1,350
MACW	UPNY	1,155	1,155
MANO	COMD	1,100	1,100
MANO	ECAK	200	200
MANO	ECAM	6,299	1,848
MANO	ENTG	4,200	2,100
MANO	MRO	405	405
MANO	SPPN	1,300	1,300
MANO	TVA	1,812	1,812
COMD	ECAM	1,620	1,110
COMD	ECAP	4,500	788

Region From	Region To	Energy Transfer Capability (MW)	Capacity Transfer Capability (MW)
COMD	MANO	2,050	2,050
COMD	MRO	825	825
COMD	WUMS	825	825
WUMS	COMD	1,125	1,125
WUMS	MRO	270	270
MRO	COMD	610	610
MRO	ENTG	2,000	2,000
MRO	MANO	320	320
MRO	NWPE	200	200
MRO	RMPA	310	310
MRO	SPPN	2,000	2,000
MRO	WUMS	800	800
NENG	DSNY	700	700
NENG	LILC	431	431
UPSNY	DSNY	4,550	4,550
UPSNY	MACW	1,155	1,155
UPSNY	NENG	150	150
DNSY	LILC	1,300	1,300
DNSY	MACE	2,000	2,000
DNSY	NENG	1,120	1,120
DNSY	NYC	3,700	3,700
DNSY	UPNY	3,400	3,400
NYC	DSNY	2,000	2,000
NYC	LILC	250	250
NYC	MACE	500	500
LILC	DSNY	530	530
LILC	MACE	650	590
LILC	NENG	431	431
LILC	NYC	420	420
SPPN	ENTG	3,745	1,260
SPPN	MANO	1,200	1,200
SPPN	MRO	600	600
SPPN	SPPS	700	700
SPPS	AZNM	420	420
SPPS	ENTG	9,030	2,310
SPPS	ERCT	820	820
SPPS	SPPN	1,200	1,200
ENTG	MANO	910	140
ENTG	MRO	150	150
ENTG	SOU	2,250	2,250
ENTG	SPPN	1,120	140
ENTG	SPPS	4,494	735
ENTG	TVA	1,681	1,681
SOU	ENTG	2,950	2,950
SOU	FRCC	3,600	3,600
SOU	TVA	3,742	3,742

Region From	Region To	Energy Transfer Capability (MW)	Capacity Transfer Capability (MW)
SOU	VACA	2,158	2,158
FRCC	SOU	2,000	2,000
TVA	ECAK	2,000	1,073
TVA	ECAP	1,500	263
TVA	ENTG	2,919	2,919
TVA	MANO	1,550	1,550
TVA	SOU	2,258	2,258
TVA	VACA	864	864
VACA	ECAP	4,117	438
VACA	SOU	3,242	3,242
VACA	TVA	3,586	3,586
VACA	VAPW	1,942	1,942
VAPW	ECAP	5,460	1,952
VAPW	MACS	2,100	2,100
VAPW	VACA	1,849	1,849
CA-N	CA-S	3,700	3,700
CA-N	NWPE	150	100
CA-N	PNW	3,675	3,675
CA-S	AZNM	3,627	2,428
CA-S	CA-N	3,000	2,400
CA-S	NWPE	1,400	1,400
CA-S	PNW	3,100	3,100
CA-S	SNV	4,688	4,688
PNW	CA-N	4,000	4,000
PNW	CA-S	3,100	3,100
PNW	NWPE	1,505	1,505
RMPA	AZNM	690	690
RMPA	MRO	310	310
RMPA	NWPE	665	665
NWPE	AZNM	820	820
NWPE	CA-N	160	120
NWPE	CA-S	1,920	1,920
NWPE	MRO	150	150
NWPE	PNW	2,002	2,002
NWPE	RMPA	679	679
NWPE	SNV	300	250
AZNM	CA-S	3,627	2,428
AZNM	NWPE	850	850
AZNM	RMPA	690	690
AZNM	SNV	4,634	4,634
AZNM	SPPS	420	420
SNV	AZNM	4,785	4,785
SNV	CA-S	4,688	4,688
SNV	NWPE	300	300

Source: IPM Model 2006; Section 3.0 - Power Sector Operation Assumptions

Region From	Region To	Energy Transfer Capability (MW)	Capacity Transfer Capability (MW)
	<a href="http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/Section-3.pdf">http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/Section-3.pdf</a>		