

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: 31 March 2008

Re: **Reference Case Outputs for TAG Review**

The following describes the ENERGY 2020 model outputs for the Reference Case including the impacts of the Energy Independence and Security Act (EISA). ***The outputs described in this memo differ very slightly from those discussed at the meeting of 28 March, reflecting the minor changes to availability requested at that time..***

The data inputs and assumptions underlying this Reference Case are described in the Assumptions Book.

1. Introduction

The data is presented for a set of milestone years established after discussion with the TAG. ENERGY 2020 provides data for all years in the modelled period should that be required.

ENERGY 2020 outputs typically display the data for about 70 economic sectors and other categories. The data presented below has been consolidated by sector based on the following sectors as agreed to with the TAG:

- Residential
- Commercial
- Pulp and Paper
- Other Energy Intensive Industries (*these include Smelting and Refining, Iron and Steel, Chemicals, Cement, Petroleum Refining, & mining*)
- Other Industry (including construction)
- Passenger Transportation
- Freight Transportation (including off-road)
- Agricultural
- Forestry
- Waste and Wastewater
- Power Sector

2. Economic Data:

- Population
- Households by housing type (single family, multi-family, other)
- Personal income (provided by REMI)
- Passenger transportation demand (Vehicle miles travelled)
- Employment and Gross Output by economic sector
- National Deflator (inflation rate) per REMI

A forecast of population growth and economic activity was provided from the REMI macro-economic model. This forecast projects future population growth, employment, personal income, and economic output (gross output). A discussion of the REMI economic forecast is included in the Assumptions Book. The discussion which follows focuses on modeling results from the ENERGY 2020 model.

ENERGY 2020 projected future housing types based on historic trends and economic activity. Housing in Wisconsin is dominated by single family dwellings. Over the next twenty years, the model projects a little change in the split between household types. ***These are unchanged from the prior versions of the reference case.***

3. Power Sector Data:

- Capacity (MW) by plant type
- Generation (GWh) by plant type
- Change in Capacity over period by plant type
- Change in Generation over period by plant type
- Sales (GWh) by sector
- Imports/exports to state
- Reserve margin

The model has been calibrated with historic information wherever possible. It should be noted, however, that the available data sources exhibit some differences due to differing definitions, reporting methods and other issues. The table below compares data from the model with some of the available data sources.

Comparison with Actual/Reported Values:

For 2004	Model Results	WI Stats^{1,2}	WI Stat Description
Total Generation Capacity (MW)	14,259	12,573 (a) 15,056 (b)	a) Owned generation used for Wisconsin loads, b) Total including owned & merchant
Total Generation Output (GWh)	60,445	57,987	Utility gen. inc. IPP, but excluding imports and losses.
Sales (GWh)	69,861	67,976	Sales to ultimate customers
Peak Load (MW)	12,958	13,001 - Peak 12,149 - Adjusted	Adjusted value is net of Interruptible and DR, capacity sales/purchases, etc..
For 2006	Model Results	WI Stats^{1,2}	WI Stat Description
Total Generation Capacity (MW)	15,983	12,762 (a) 16,238 (b)	a) Owned generation used for Wisconsin loads, b) Total including owned & merchant
Total Generation Output (GWh)	61,644	58,822	Utility gen. inc. IPP, but excluding imports and losses.
Sales (GWh)	74,289	69,809	Sales to ultimate customers
Peak Load (MW)	13,648	15,166 – Peak 14,022 - Adjusted	Adjusted value is net of Interruptible and DR, capacity sales/purchases, etc..

1. Demand (MW) data from: Strategic Energy Assessment Energy 2012: Final Report, Public Service Commission, February 2007, Table 2-01.

2. Energy (GWh) data from: 2007 Wisconsin Energy Statistics Report, page 46.

- Sales, total generation and capacity are in 2004 and 2006 are unchanged from prior results.
- Total capacity has been calibrated to the NEEDS database and compared with the Strategic Energy Assessment report for 2004 and 2006.
- Generation output has been calibrated to reported production by the Energy Information Administration and is slightly higher than values reported in the Wisconsin Energy Statistics.
- Peak loads shown from the model are unadjusted for demand reduction or interruptible loads. Modeled peak demand matches well for 2004 but is below the reported value for 2006. This is one of the reasons why the reserve margins shown for 2006, 2010 and 2015 shown in the following table appears to be high. Variations in the peak load are expected due to changing weather conditions at the time of the system peak but are not captured in the modeling.

Electricity Sales (GWh)						
Sector	2004	2006	2010	2015	2020	2024
Residential	19,203	20,148	21,817	23,091	25,071	26,818
Commercial	21,800	22,272	23,748	26,407	29,656	32,419
Industrial	28,438	31,226	33,155	35,687	41,843	46,331
Street Lights/Misc.	400	400	400	400	400	400
Resale	20	-	-	-	-	-
Total Sales	69,861	74,046	79,120	85,585	96,970	105,968
Net Imports to Region	9,416	12,402	(1,137)	3,411	11,046	14,151

Generation Output (GWh/year)						
Plant Type	2004	2006	2010	2015	2020	2024
Gas/Oil	3,146	6,226	10,509	9,326	9,251	12,136
Coal	42,141	40,043	54,909	54,020	54,226	54,226
Nuclear	11,888	12,234	12,115	12,802	12,802	12,802
Hydro	1,981	1,679	1,184	1,184	1,184	1,184
Landfill Gas/EFW	114	110	133	460	1,362	1,961
Wind	1,175	1,349	1,336	3,833	5,263	7,171
Other	-	4	72	549	1,835	2,336
Total	60,445	61,644	80,257	82,175	85,924	91,818

Generation Capacity (MW)						
Plant Type	2004	2006	2010	2015	2020	2024
Gas/Oil Combustn. Turbine			4,517	4,517	4,517	4,517
Gas/Oil Combined Cycle	5,248	6,793	2,679	2,680	2,682	4,083
Gas/Oil Steam			360	383	383	383
Coal	6,882	6,984	8,560	8,441	8,441	8,441
Nuclear	1,583	1,586	1,586	1,676	1,676	1,676
Hydro	447	447	447	447	447	447
Landfill Gas/EFW	60	52	52	93	294	370
Wind	39	121	502	1,314	1,756	2,335
Other	-	-	12	90	212	293
Total	14,259	15,983	18,715	19,640	20,407	22,546

Peak Loads (MW)	2004	2006	2010	2015	2020	2024
Annual Peak Load	12,958	13,616	14,494	15,686	17,689	19,287
Reserve Margin Calculation						
Adjusted Peak Load (<i>net of Demand Reduction and Interruptible Load</i>)	12,103	12,761	13,639	14,831	16,834	18,432
Adjusted Generation Capacity (<i>Including out-of-state generation devoted to WI & 15% of wind capacity</i>)	15,062	16,716	19,124	19,359	19,751	21,397
Estimated Reserve Margin -	23%	29%	38%	29%	16%	15%

- The reserve margin rises above target levels in 2010 to 2015 period and remains above target levels as planned new capacity and generation to meet the RPS is added. As mentioned above, the model does not attempt to reflect annual variations in peak demand due to weather variations or other factors. These variations in the peak load are not expected to have a material impact on GHG emissions from the power sector.
- For modeling purposes adjustments to reflect demand reduction, interruptible loads and out-of-state resources are assumed to remain at current levels.

The TAG and PSC provided a consolidated forecast of energy and demand growth for the state based on a weighted average of the compound growth rates submitted by utilities serving the state as part of their Strategic Energy Assessment (SEA) submissions.

These are the weighted averages of the compound growth rates requested for demand and energy in the SEA docket, the Commission’s biennial energy assessment for the years 2007 through 2014.

*PEAK DEMAND compound annual growth rate of 2.1%
TOTAL ENERGY compound annual growth rate of 1.8%*

Note: Numbers are preliminary and may be subject to minor revisions

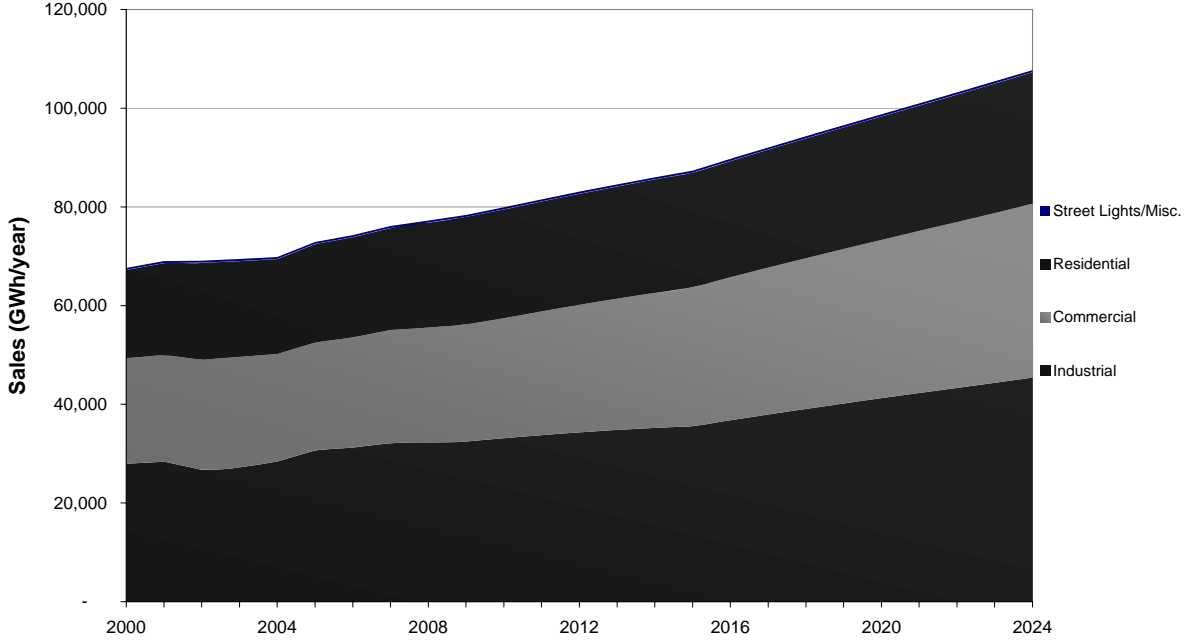
The model projects growth in peak demand over the period to 2024 at the same rate as the PSC forecast. Growth in energy sales in the model is slightly higher (by 0.3%) than the forecast by the PSC. It should be noted that the PSC forecast only extends to 2014, whereas the model projection runs to 2024. Inclusion of the EISA lowers electricity growth rates below the PSC forecast.

In-State Renewables	2015	2020	2024
- as % of Total Sales	5.7	8.2	10.3

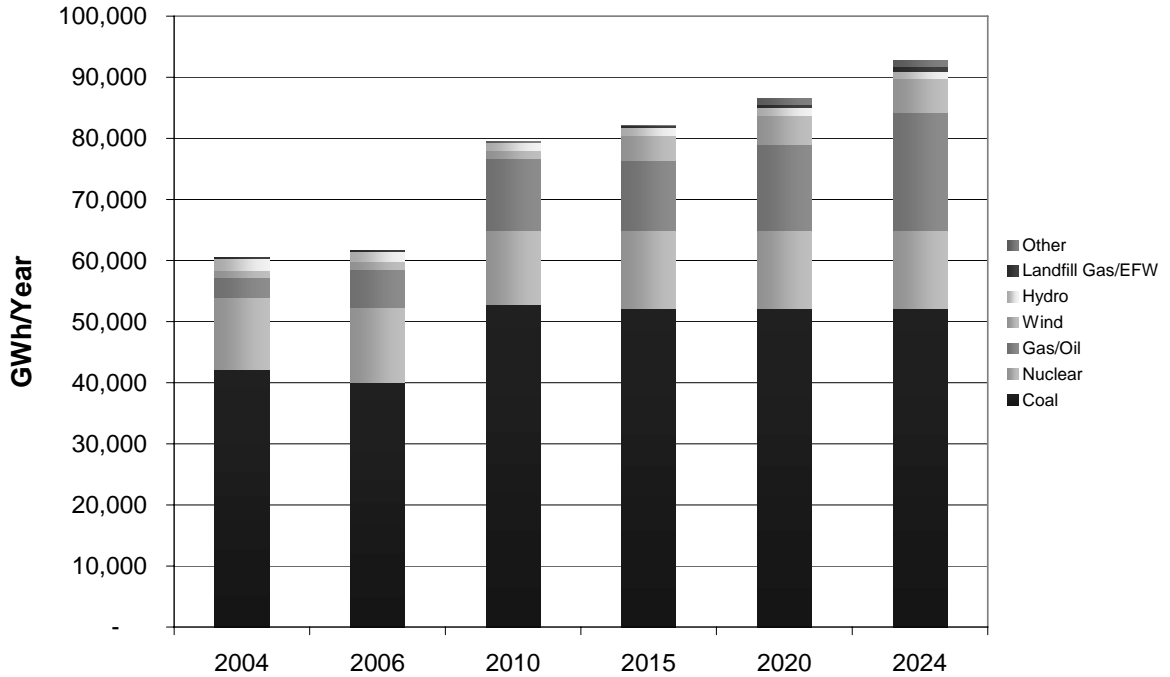
* Renewables defined as wind, solar, EFW, LFG and biomass.

The RPS provisions are met by wind, energy-from-waste, landfill gas and biomass by 2010; with the majority of the new supply from wind. Some solar is added in the latter part of the period. Approximately half of the renewable generation required to meet the target of 10% of sales is assumed to be developed out-of-state.

Electricity Sales Reference Case

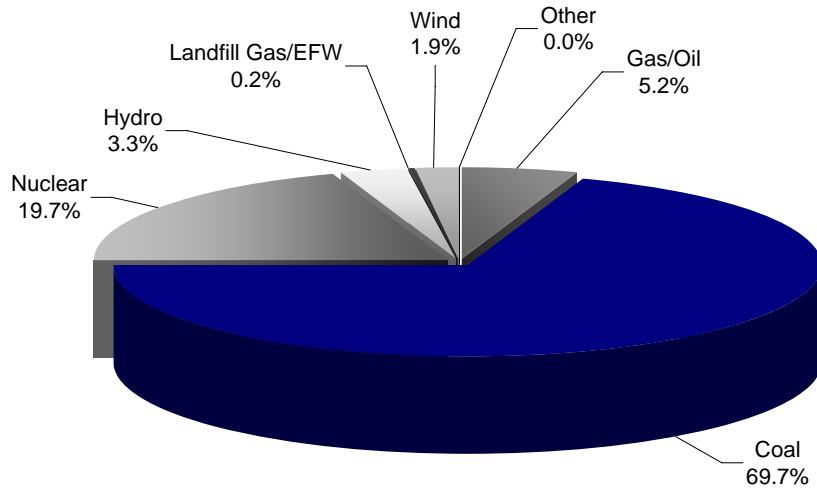


Generation Output



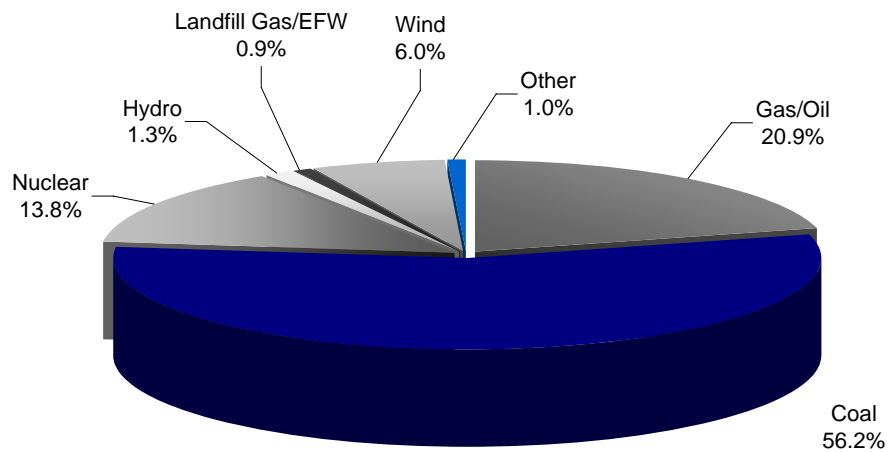
Generation by Type - 2004

Share of Generation (GWh) Output



Generation by Type - 2024

Share of Generation (GWh) Output



4. Transportation Data to be reviewed:

- Demand for transportation by type (passenger, freight, off road)
- Energy use for transportation by type (passenger, freight, off road)
- Vehicle efficiency (fleet average for passenger and freight)
- Ethanol as % of total passenger transportation fuel use

There are no changes in transportation energy use from prior results.

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. The figure below shows the projected increase in transportation demand, in terms of passenger miles traveled and tonne-miles of freight, for the historic and forecast period.

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Distance Travelled (millions of vehicle miles travelled)							
	2004	2006	2010	2015	2020	2024	Avg. % Chg. per year
Passenger	43,395	50,105	53,169	40,868	36,394	35,671	-0.98%
Freight	7,653	8,317	8,588	9,423	10,474	11,369	2.00%
Passenger Miles/person	7,930.4	9,036.0	9,349.2	6,990.8	6,000.7	5,678.3	-1.66%

Growth in transportation demand and energy use was reviewed against available information from the Wisconsin Department of Transportation.

The WI DoT forecast for the period 2005 to 2030 projects that passenger vehicle miles travelled (VMT) will increase at 1.32% per year, while commercial/freight VMT will grow at 2.00% per year. The BAU baseline provided by the DoT indicates 2005 personal vehicle miles travelled of about 64.7 billion and commercial/freight VMT of 11.4 billion.

NOTE

- Initial levels of VMT use for passenger transportation are below reported actual values however growth rates are higher than projected by the DOT.
- Initial levels of freight VMT are higher than DOT expectations but growth rates are lower than the DOT forecast.
- The efficiency of new vehicles rises by approximately 19% as a result of the requirements of the Energy Act.

Marginal Vehicle Efficiency (miles/gallon)						
	2004	2006	2010	2015	2020	2024
Light Gas Vehicles	30.9	32.1	33.7	36.9	41.9	45.4
Medium Vehicles	26.8	28.2	30.0	33.0	37.7	41.0
Heavy Vehicles	20.7	21.1	21.6	23.3	25.2	25.9
Heavy Diesel	20.7	21.2	21.8	23.6	25.5	26.3
	2004	2006	2010	2015	2020	2024
Ethanol as a % of Gasoline Used for Passenger Transportation*	2.8%	2.8%	4.2%	6.5%	9.0%	10.7%

*This represents total statewide use of ethanol.

Six of the counties in southeastern Wisconsin are covered by a requirement under the Clear Air Act¹ which requires that ethanol comprise at least 10% of all gasoline sold. According to information provided by the Transportation Working Group these counties represent approximately 25-30% of gasoline sales in the state.

Information on historic levels of ethanol use is also available from the Wisconsin Energy Statistics. According to the 2007 report, 8.7 trillion Btu's of ethanol were used in the state in 2004². Modeled levels of ethanol use are very close to reported values for the historic period.

Ethanol use increases from just under 3% of total fuel use to almost 11% by 2024 as a result of Energy Act requirements.

5. Fuel Use data:

- Demand by sector
- Energy use by fuel type

Total Energy Use (TBtu/year)						
Sector	2004	2006	2010	2015	2020	2024
Residential	275	278	291	300	316	330
Commercial	174	170	168	168	176	186
Paper	108	108	102	98	108	116
Other Energy Intensive Industry	75	78	78	80	89	96
Other Industry	138	146	150	157	177	193
Passenger Transportation	332	329	335	326	319	322
Freight Transportation	185	181	175	181	192	203
Agriculture	9	9	9	10	10	11
Power Sector	656	662	767	760	793	825
Total	1,952	1,959	2,075	2,080	2,180	2,283

¹ EPA fuel oxygenate rules designed to reduce VOC emissions in ozone non-attainment areas.

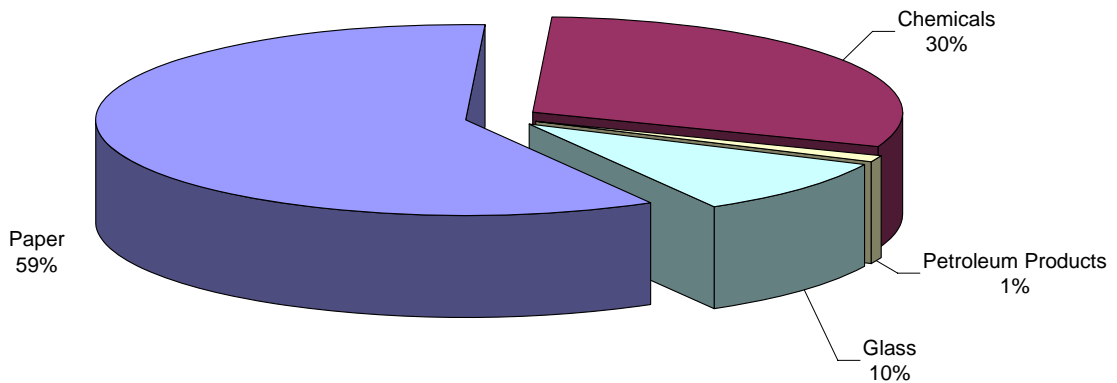
² 2007 Wisconsin Energy Statistics, page 60.

Total Energy Use (TBtu/year)						
Fuel Type	2004	2006	2010	2015	2020	2024
Aviation Fuel	12.9	13.3	14.1	14.9	16.2	17.3
Biomass	45.9	45.3	45.4	45.6	48.0	49.5
Coal	510.2	516.0	609.3	597.7	605.0	609.4
Diesel	176.7	175.3	169.5	172.0	181.5	191.5
Ethanol	8.6	8.6	12.9	19.5	26.4	31.4
Electric	236.9	251.3	268.6	290.7	329.5	360.2
Landfill Gas	-	1.8	1.8	6.3	18.6	26.8
LPG	2.3	2.2	2.2	2.2	2.4	2.5
Gasoline	316.2	312.4	312.9	297.7	283.7	282.4
Natural Gas	415.3	425.0	429.4	413.1	429.3	465.3
Nuclear	121.9	122.4	122.4	129.4	129.4	129.4
Oil, Unspecified	85.6	72.5	71.1	69.5	69.8	71.0
Solar	7.8	8.9	10.2	11.7	13.4	14.7
Other	11.2	4.0	5.4	9.7	26.4	31.6
Total -	1,952	1,959	2,075	2,080	2,180	2,283

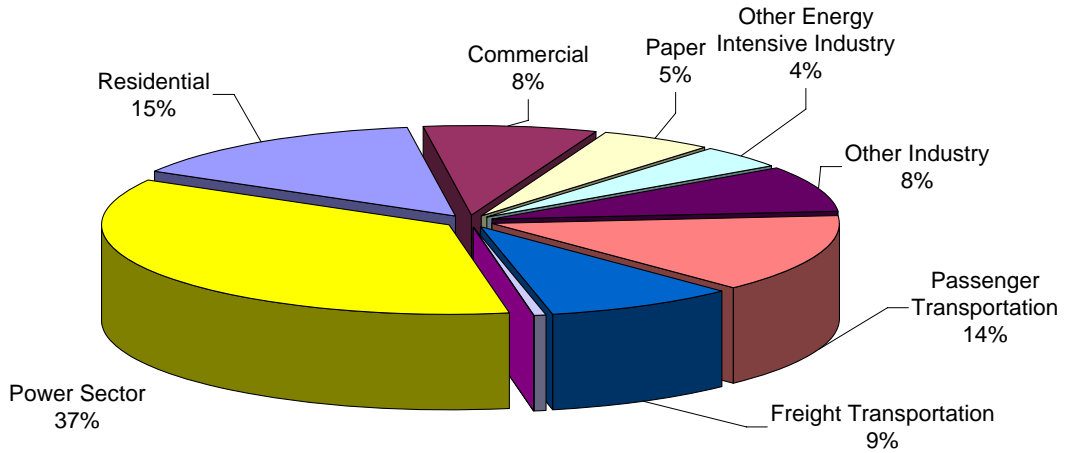
- Historic levels of energy use were calibrated with actual energy use reported in the Wisconsin Energy Statistics.

Where possible end use efficiencies were also calibrated to available data for Wisconsin. [Error! Not a valid link.](#)

Energy Intensive Industries 2004 Energy Use



Energy Use by Sector - 2024



6. Energy Price Data to be reviewed:

- Prices by fuel type by sector
- Energy prices based on high price scenario per TAG

Electricity prices are slightly below prior case. All other prices are unchanged from prior results.

Energy Prices (2007 \$'s)		2004	2006	2010	2015	2020	2024
Electricity							
	Units						
Residential	MWh	\$26.42	\$25.52	\$30.98	\$24.82	\$24.28	\$24.56
Commercial	MWh	\$11.28	\$14.05	\$13.48	\$13.48	\$13.48	\$13.48
Industrial	MWh	\$2.69	\$3.28	\$3.35	\$3.29	\$3.32	\$3.36
Average Retail	MWh	\$15.23	\$15.23	\$15.23	\$15.23	\$15.23	\$15.23
Natural Gas							
Residential	Mcf	\$13.44	\$16.63	\$16.73	\$15.50	\$15.84	\$15.84
Commercial	Mcf	\$11.91	\$14.85	\$14.21	\$14.21	\$14.21	\$14.21
Industrial	Mcf	\$11.08	\$12.83	\$13.33	\$13.33	\$13.33	\$13.33
Transportation Fuels							
Gasoline	gallons	\$2.34	\$3.29	\$3.29	\$3.55	\$3.74	\$3.83
Diesel	gallons	\$2.37	\$3.55	\$3.56	\$3.84	\$4.06	\$4.16
Biomass							
Residential	MBtu	\$5.20	\$11.53	\$11.50	\$13.53	\$15.10	\$15.84
Commercial	MBtu	\$3.76	\$10.09	\$10.06	\$12.09	\$13.66	\$14.40
Industrial	MBtu	\$3.76	\$10.09	\$10.06	\$12.09	\$13.66	\$14.40

- Energy prices for natural gas, oil, biomass and coal are specified exogenously based on the high energy price scenario.
- Electricity prices rise between 2004 and 2006 but remain relatively flat in real terms to 2024.

7. Emission Data to be reviewed:

- Emissions by sector and by fuel type
- Data will be available for Wisconsin, Region and rest of US (and Canada if needed) – data below is for WI only.

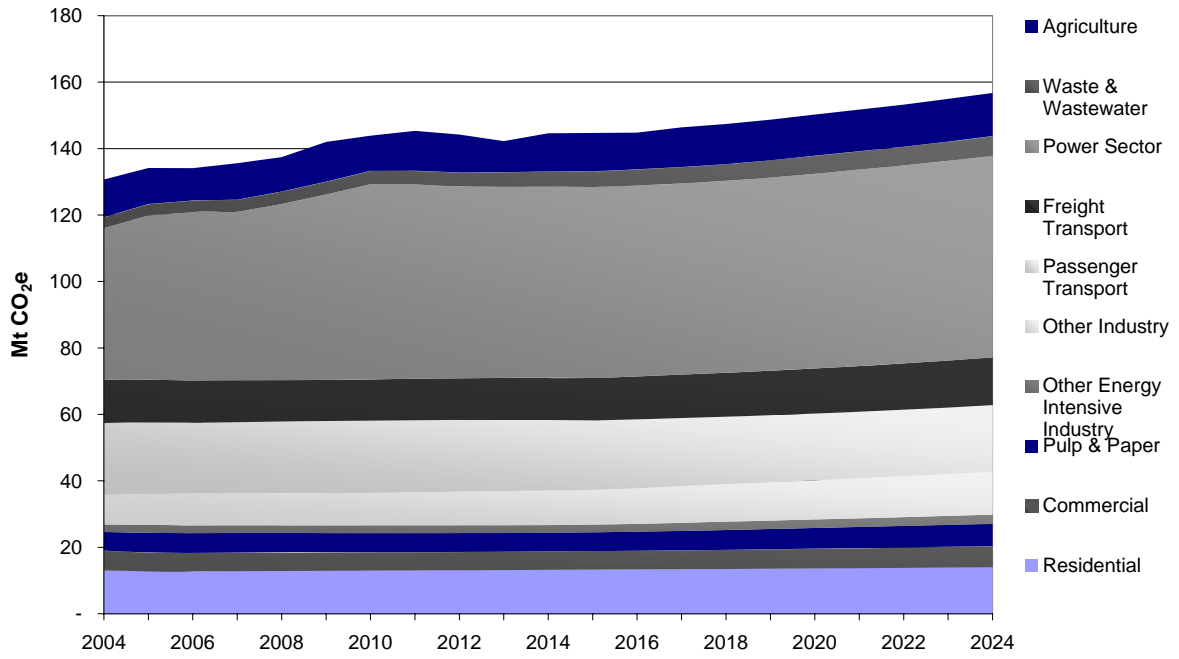
Emissions are approximately 3 Mt/year lower in the 2020-2024 period than in the prior version of the Reference Case.

GHG Emissions (Mt)	2004	2006	2010	2015	2020	2024	Average Annual % Change
Residential	13.1	12.9	13.2	13.3	13.6	13.9	0.3%
Commercial	5.9	5.6	5.2	4.7	4.5	4.5	-1.4%
Pulp & Paper	5.6	5.8	5.6	5.4	6.0	6.5	0.7%
Other Energy Intensive Industry	2.3	2.4	2.4	2.4	2.6	2.8	0.9%
Other Industry	8.9	9.4	9.7	10.3	11.6	12.6	1.7%
Agriculture	11.4	9.7	10.6	11.6	12.4	13.0	0.7%
Passenger Transport	21.6	21.4	21.8	20.9	20.1	20.1	-0.4%
Freight Transport	13.1	12.7	12.4	12.8	13.6	14.4	0.5%
Power Sector	45.6	49.9	59.3	57.3	57.6	58.6	1.3%
Waste & Wastewater	3.2	3.5	3.9	4.6	5.3	5.9	3.0%
Total Gross Emissions	130.7	133.4	144.0	143.3	147.3	152.4	0.8%
Land Use - Forestry	(8.2)	(8.2)	(8.2)	(8.2)	(8.2)	(8.2)	0.0%
Total Net Emissions	122.5	125.2	135.8	135.1	139.1	144.2	0.8%

Notes:

- The level of carbon sequestration from land use is based on the estimated level of carbon sequestration in forestry lands presented in the WinRock report prepared for the Task Force. This sink was not included in the WRI inventory.
- The WRI inventory for 2003 estimated emissions at 123.1 Mt. The model results, excluding estimated sinks, indicate gross emission of 130 Mt in 2004.
- The graphs which follow show how the model projects greenhouse gas emissions will change over the period and a breakdown of emissions by contributing sector in 2024.

GHG Emissions - Reference Case



GHG Reference Case Emissions 2024

