



MINNESOTA
Climate Change
Advisory Group



Overview of Issues, Assumptions, and Preliminary Results for the Minnesota Energy Supply GHG Forecast

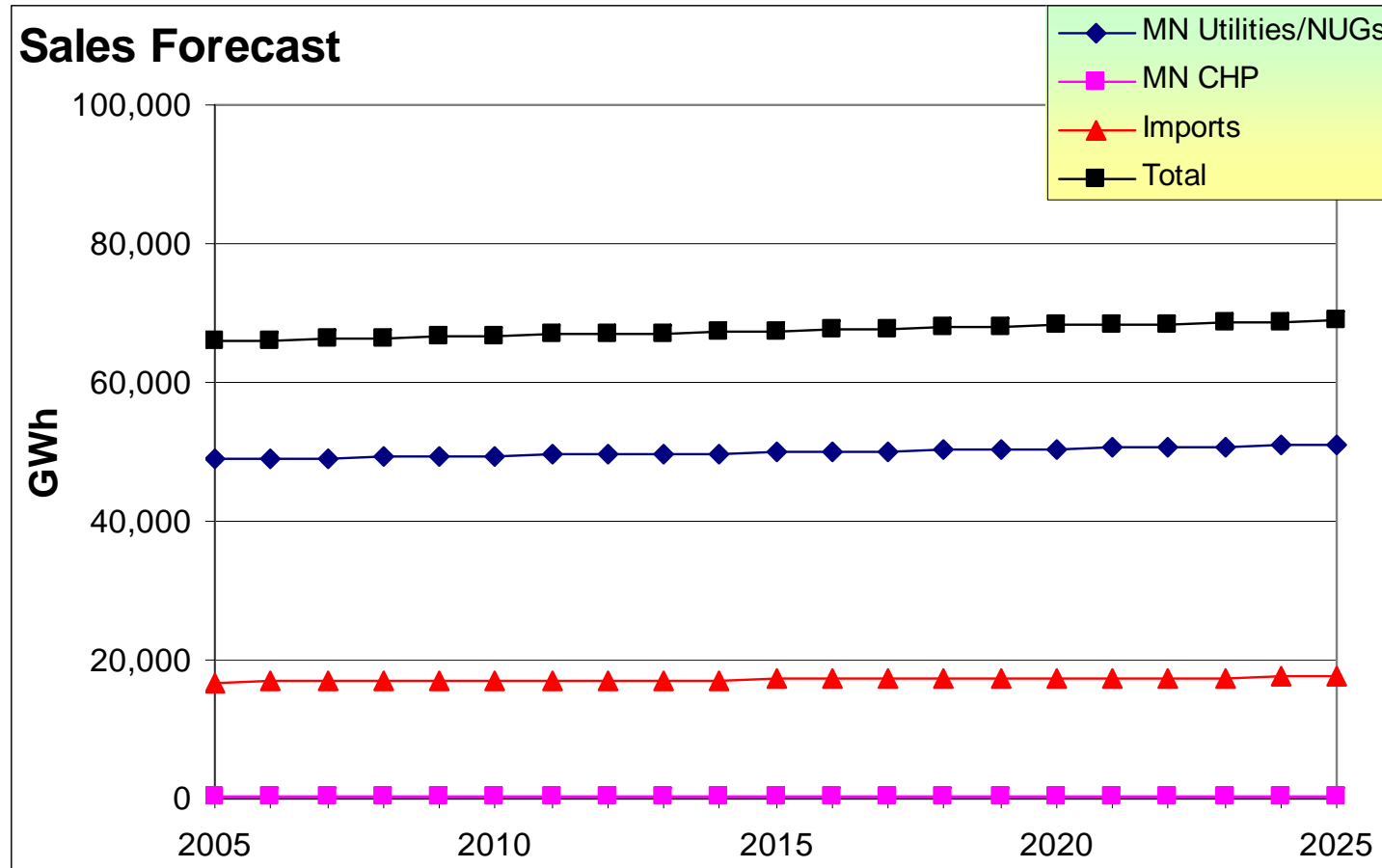
Bill Dougherty
16 October 2007

Outline

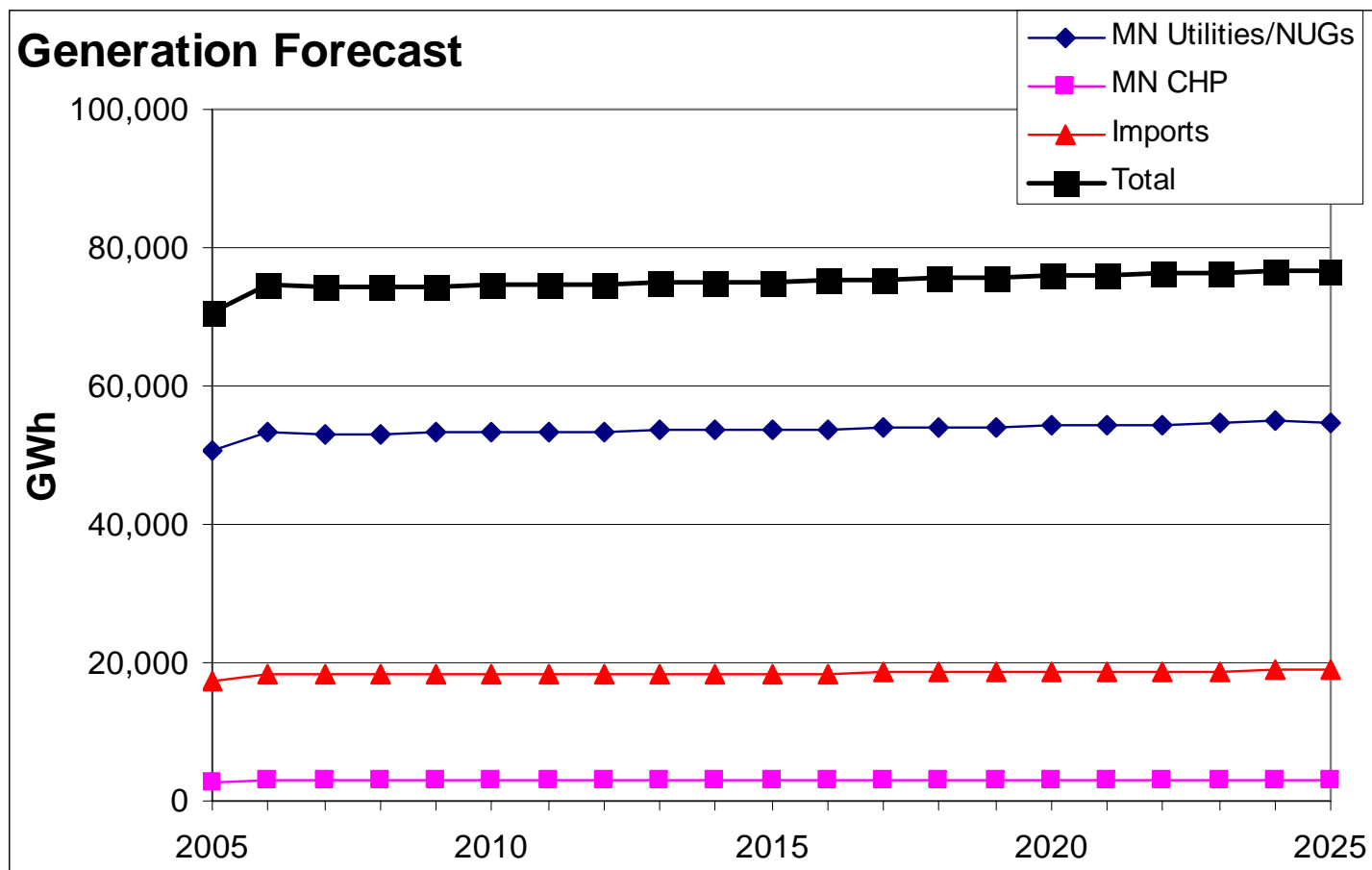
- Summary of results
- Framework
- Sales forecast - assumptions and preliminary results;
- Gross generation forecast - assumptions and preliminary results;
- Primary energy forecast - assumptions and preliminary results;
- Imported power forecast - assumptions and preliminary results;
- GHG emission forecast – assumptions and preliminary results.

Summary of results

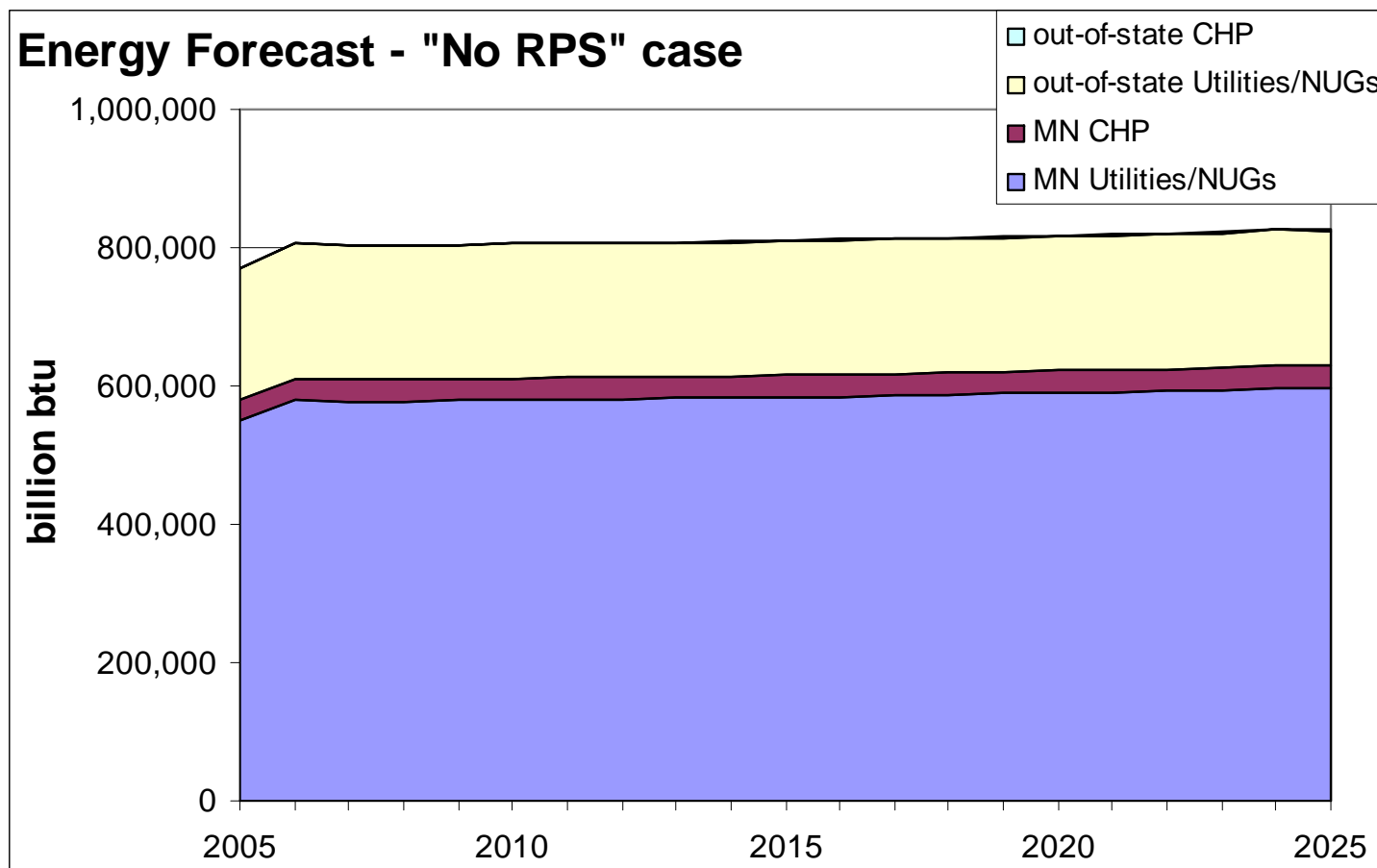
Electricity sales in MN....



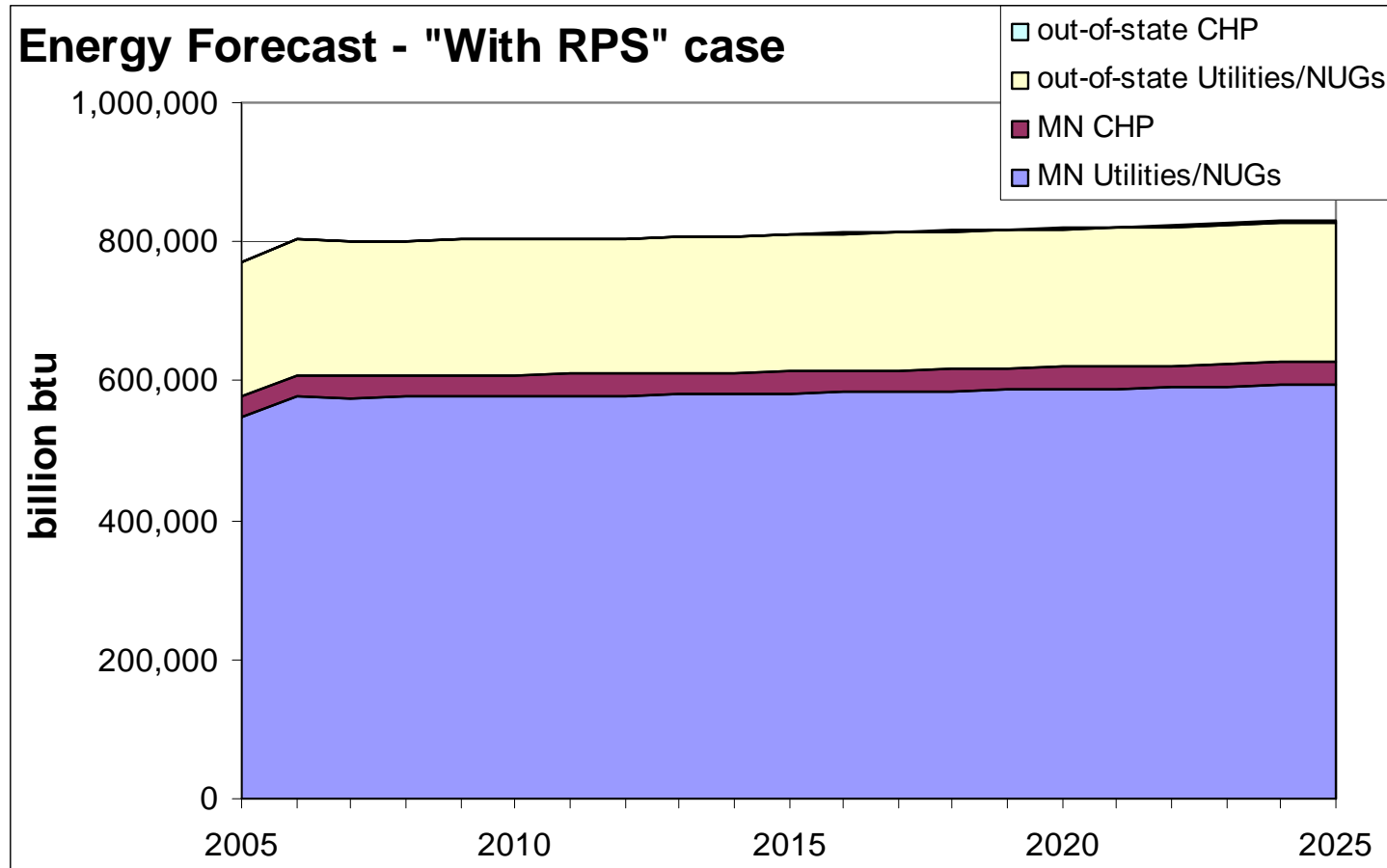
Gross generation associated with electricity sales in MN....



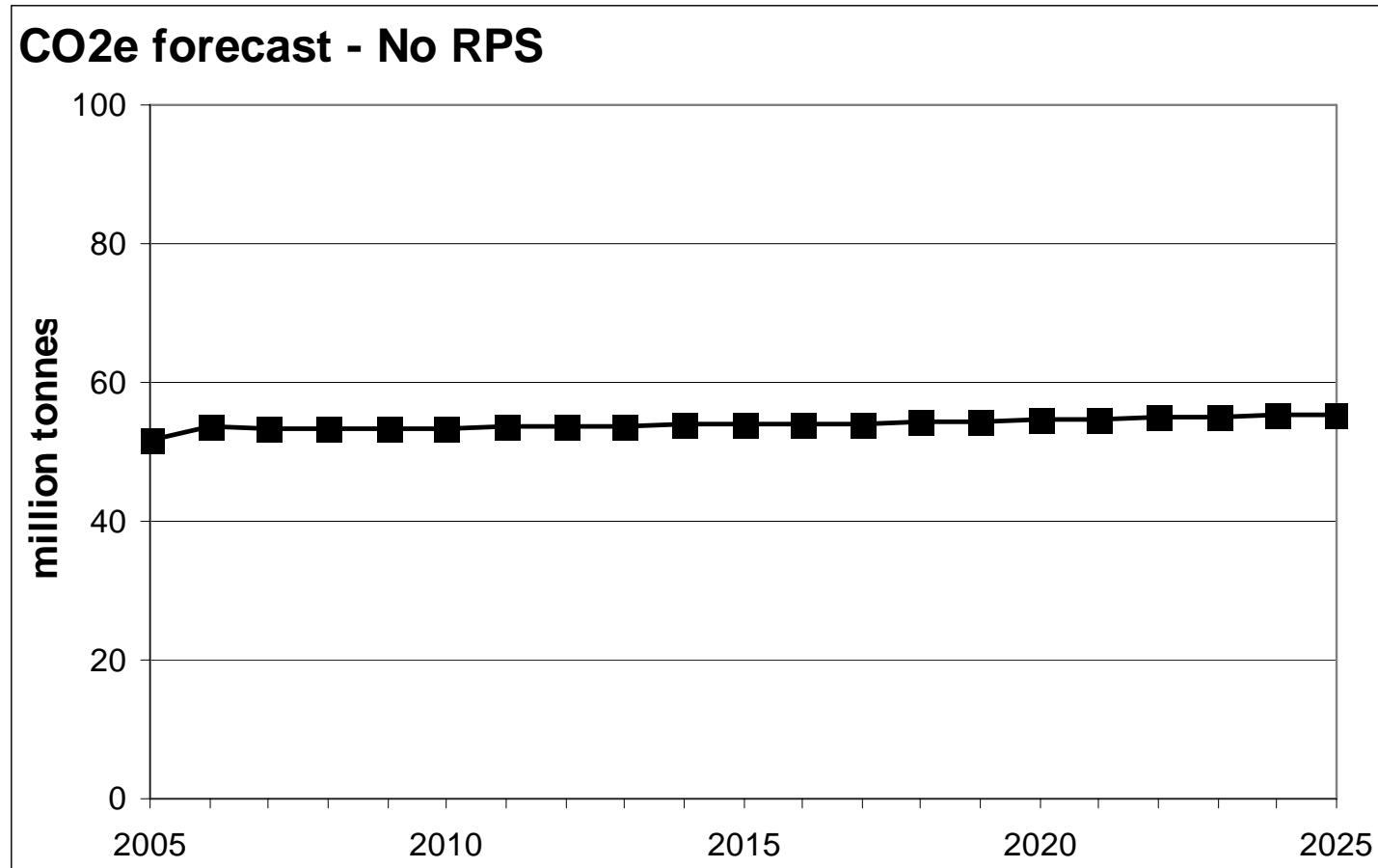
Primary energy use associated with electricity sales in MN in the "No RPS" case....



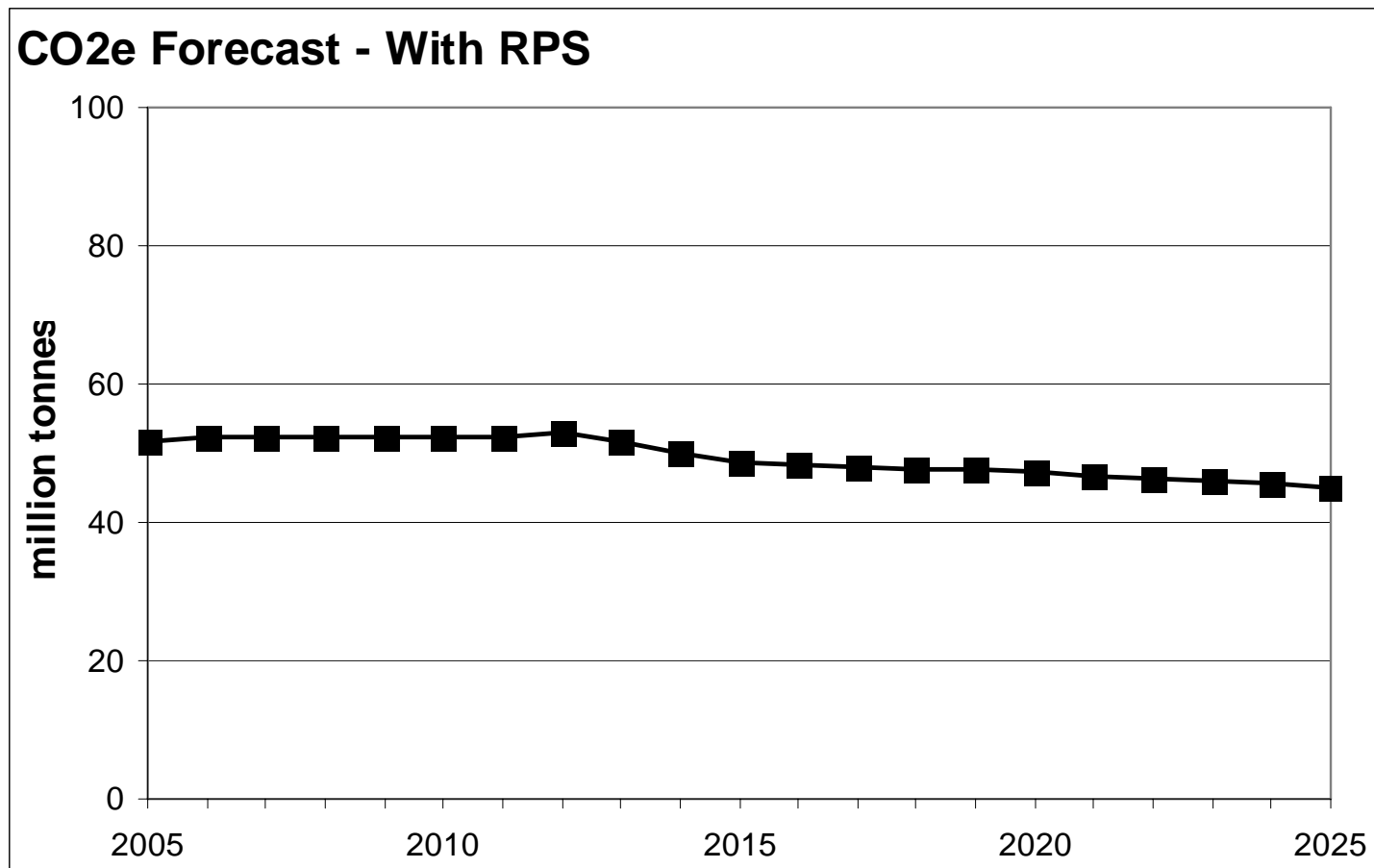
Primary energy use associated with electricity sales in MN in the "With RPS" case....



GHG emissions associated with electricity sales in MN in the “No RPS” case....



GHG emissions associated with electricity sales in MN in the “With RPS” case....



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Framework

My understanding of the TWG's underlying framework for developing the GHG forecast is as follows:

- Undertake a “bottom-up” forecast as opposed the to the current “top-down” forecast;
- Adopt a base year of 2005;
- Extend the forecast from the current end year of 2020 to an end year of 2025;
- Produce 2 Reference Case GHG forecasts as follows:
 - Without incorporating the recently passed renewable portfolio standard (RPS) legislation;
 - Incorporating the recently passed RPS legislation.
- Each of the above Reference Cases would incorporate the energy efficiency goals of recent legislation (216B.241)

In addition....

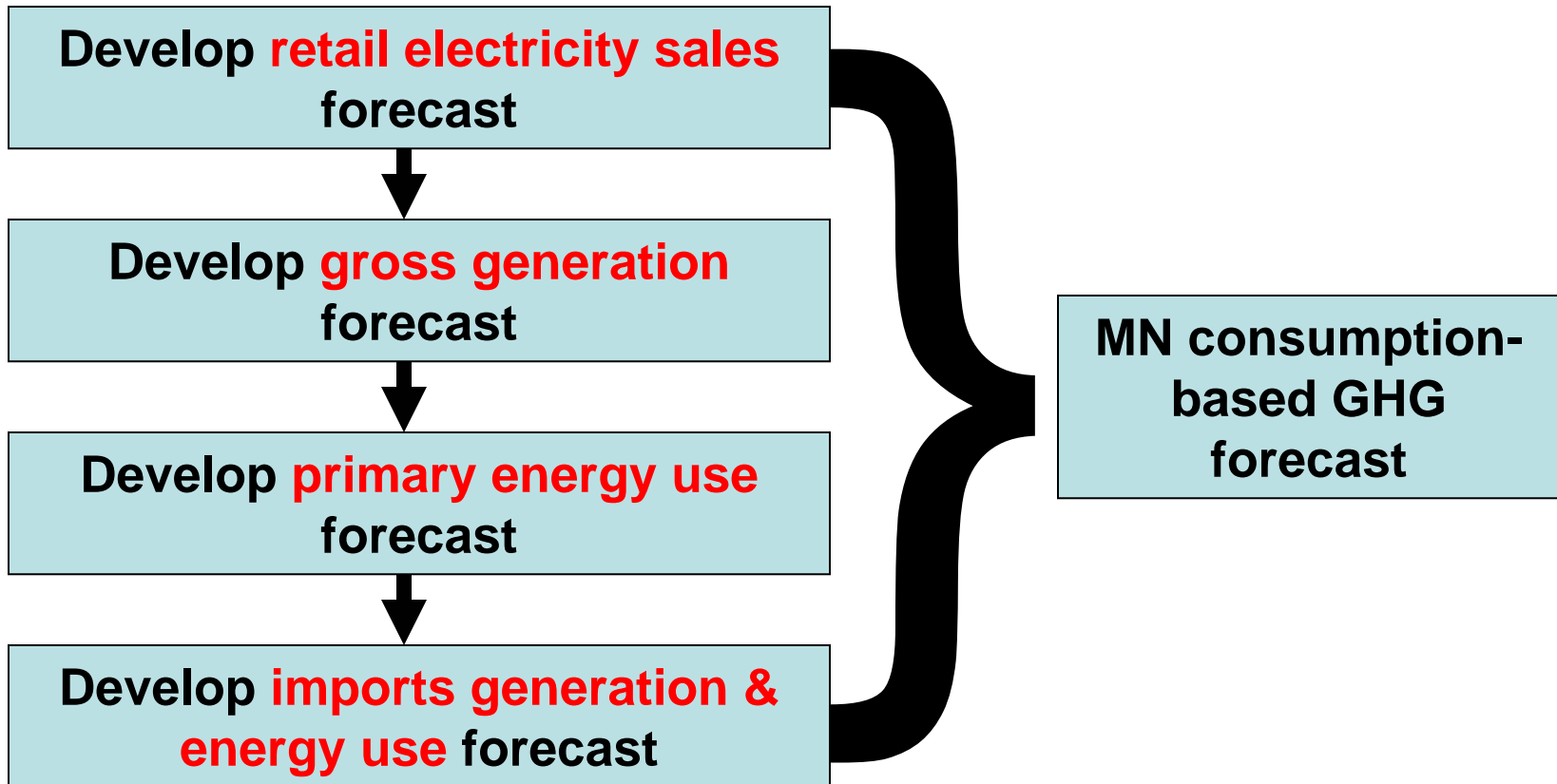
- The April 2007 version of the energy supply (ES) GHG forecast did not incorporate the emissions associated with combined heat & power (CHP) units;
- Currently, GHG emissions for CHP units are tracked in the residential, commercial, and industrial (RCI) GHG forecast;
- But..... the ES TWG has selected CHP as a priority for analysis;
- Therefore.... I would recommend that GHG emissions from CHP should be integrated into the ES forecast.

The basic approach I've used in this memo....

- Clearly present input data on MN energy system characteristics and expansion plans obtained so far
- Transparently establish key forecast assumptions regarding the following:
 - Sales;
 - Generation;
 - Primary energy use.
- On the basis of the above information, use standard emission factors and global warming potentials (GWPs) to determine CO₂-equivalent emissions associated with MN electricity demand
- Solicit feedback from the ES TWG regarding any input data that needs to be corrected;
- Solicit feedback from the ES TWG regarding any forecast assumptions that need to be revisited and/or revised

I've followed the steps in the flow diagram below

- For utilities..... non-utility generators.... commercial CHP...and... industrial CHP



The spreadsheet in which GHG emissions are calculated accompanies this memo....

- Please refer to the spreadsheet entitled “revised MN ES GHG forecast – 16 October 2007.xls”
- TWG members can modify the default forecast assumptions in that spreadsheet to assess the sensitivity of a set of assumptions on GHG emissions (i.e., the product of primary energy consumption and appropriate carbon dioxide-equivalent emission factors).

Default assumptions have been assumed for the following....

- **GHG emission factors**
- **Energy savings goals**
- **Shares of MN CHP generation to meet on-site and retail electricity demand**
- **Transmission and distribution losses (%)**
- **Ratio of MN utility/NUG/CHP sales to total sales**
- **Shares of MN utility/NUG generation to meet on-site and retail electricity demand**
- **Utility/NUG Capacity expansion profile**
- **New capacity characteristics**
- **Natural gas capacity type assumptions**
- **Retirement of 2005 capacity**
- **Utility & NUG capacity expansion - no RPS**

Continued.... default assumptions have been assumed for the following....

- **Utility & NUG capacity expansion - with RPS**
- **CHP generation mix - with and without the RPS**
- **Overall MN fuel composition, 2005**
- **Overall gross generation composition for out-of-state utilities/NUGs providing electricity to meet MN demand**
- **Overall gross generation composition for out-of-state CHP facilities providing electricity to meet MN demand**
- **Combustion efficiency for out-of-state utilities/NUGs providing electricity to meet MN demand**
- **Combustion efficiency for out-of-state CHP facilities providing electricity to meet MN demand**

The default assumptions can be readily changed by TWG members to explore alternative scenarios....

- My key objective is to have the TWG reach consensus on values for the complete set of default assumptions.
- Until then, the default assumptions included in the spreadsheet calculations are provisional

- in the pages that follow: **default assumptions are indicated in bold red font.**

Sales forecast

First, let's focus on the electricity sales for MN electric utilities and non-utility generators in 2005....

- Total retail electricity sales in MN for the 2005 Base Year were 66,019 GWh.
- Here's the breakdown of electricity sales by sector:

Sector	2005 (GWh)
Residential	21,743
Commercial	21,985
Industrial	22,266
Other	0
Transportation	25
Total Sales	66,019

MN electric utilities and non-utility generators have filed official sales forecasts up through 2020....

- Still in process of tracking down electricity sales forecasts for Minnesota power;
- The average annual electric sales growth rate (not including Minnesota Power) over the 2005-2025 period is 1.72% per year.

	2005	2010	2015	2020	(%/yr)
<u>Electricity sales (GWh)</u>					
Central Minnesota Municipal Power Agency	710	820	952	1,114	3.05%
Great River Energy	607	689	771	854	2.30%
Xcel	42,977	46,634	50,811	55,230	1.69%
Missouri River Energy Services	2,309	2,530	2,744	2,936	1.62%
Otter Tail Power	2,163	2,357	2,575	2,821	1.78%
Southern Minnesota Municipal Power Agency	102	107	112	117	0.89%
Minnesota Power	<i>in process of obtaining....</i>				<i>in process of obtaining....</i>
<i>Total</i>	48,868	53,138	57,966	63,071	1.72%

But... what about electricity sales by utilities and non-utility generators in 2025?

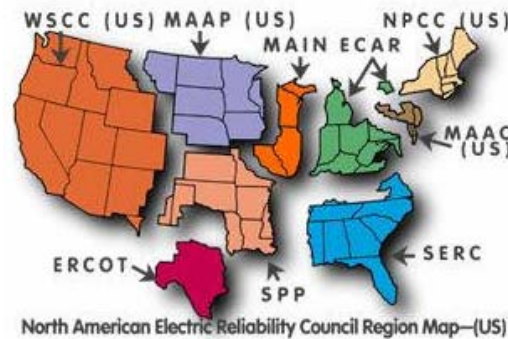
- **Default assumption: 1.5%/yr energy efficiency target**
- Using the above assumption results in an average growth rate of 0.22%/yr for the period 2005-2020.
- Electricity sales would be 51,017 GWh in 2025, as summarized in the table below.
- The implementation of the recent energy efficiency legislation results in a total of 17,652 GWh in avoided sales by 2025 relative to previously filed forecasts.

	2005	2025	Growth rate, 2005-2020 (%/yr)
Overall MN utility/NUG electricity sales (GWh)			
Total unadjusted utility sales	48,868	68,669	1.72%
Total adjusted utility sales	48,868	51,017	0.22%
Reduction from unadjusted utility plans	0	17,652	1.50%

How does the MN electricity sales growth rate compare to the growth rate of the surrounding MAPP region?

- The Annual Energy Outlook 2007 (AEO2007) shows that MAPP electricity sales grow annually by 1.40% and 1.32% for the periods 2005-2020 and 2005-2025, respectively, as summarized in the table below.
- These growth rates are significantly greater than the MN forecast.

Sector	Overall retail sales in MAPP (TWh)					MAPP Growth rate (%/yr)			
	2005	2010	2015	2020	2025	2005-10	2005-15	2005-20	2005-25
Residential	49.7	56.4	60.1	63.9	67.8	2.58%	1.93%	1.69%	1.57%
Commercial/Other	46.2	50.4	54.5	58.7	63.9	1.76%	1.67%	1.61%	1.63%
Industrial	48.9	53.0	55.2	55.9	56.6	1.61%	1.22%	0.89%	0.73%
Transportation	0.9	1.0	1.0	1.0	1.1	0.81%	0.77%	0.72%	0.67%
Total Sales	145.7	160.8	170.9	179.5	189.3	1.99%	1.61%	1.40%	1.32%



Now, let's focus on the electricity sale projection for MN commercial and industrial CHP facilities....

- I could not find sales data but I was able to find net generation data for MN CHP facilities, as summarized below for 2005.
- Total electricity cogenerated at commercial and industrial CHP facilities in MN was 2,815 GWh. This is about 5% of total net generation in MN in 2005.

Fuel Type	GWh	(billion btu)	(btu/kWh)
Coal	985	7,190	7,299
Hydroelectric	62	616	9,999
Natural Gas	1,037	10,277	9,906
Nuclear	0	0	0
Other	0	0	0
Other Gases	46	457	9,906
Other Renewables	658	10,946	16,646
Petroleum	27	140	5,175
Pumped Storage	0	0	0
Total	2,815	29,626	10,524

Most of the electricity cogenerated is used on-site rather than to meet retail electricity load....

- Nationally, the average breakdown between on-site and retail use is 82% and 18%, respectively, as summarized below for 2005 in the yellow-shaded row.
- In the MAPP region, the shares are similar, 87% and 13% on-site and retail use, as summarized in the green-shaded row.
- Default assumption: MN CHP facilities follow the same on-site use pattern as CHP facilities in the MAPP region.**

	Cogenerated electricity shares		
	on-site	retail	Total
NERC Region			
East Central Area Reliability Coordination Agreement	88%	12%	100%
Electric Reliability Council of Texas	79%	21%	100%
Mid-Atlantic Area Council	82%	18%	100%
Mid-America Interconnected Network	86%	14%	100%
Mid-Continent Area Power Pool	87%	13%	100%
Northeast Power Coordinating Council / New York	82%	18%	100%
Northeast Power Coordinating Council / New England	81%	19%	100%
Florida Reliability Coordinating Council	86%	14%	100%
Southeastern Electric Reliability Council	82%	18%	100%
Southwest Power Pool	83%	17%	100%
Western Electricity Coordinating Council / Northwest Power Pool Area	83%	17%	100%
Western Electricity Coordinating Council / Rocky Mountain Power Area and Arizona-	82%	18%	100%
Western Electricity Coordinating Council / California	79%	21%	100%
United States average	82%	18%	100%

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Before estimating retail sales from MN CHP facilities we need to understand T&D losses....

- AEO2007 provides estimates of T&D losses by region;
- In 2005, average T&D losses in the USA were 5.6%, and are projected to stay around this level through 2025 (see yellow-shaded row).
- In 2005, average T&D losses in the MAPP region were 4.7%, and are projected to increase to 6.6% by 2025 (see green-shaded row).
- **Default assumption: T&D losses in MN follow the same pattern as in the MAPP region over the 2006-2025 period.**

NERC Region	T&D losses (% of total net energy for load)				
	2005	2010	2015	2020	2025
East Central Area Reliability Coordination Agreement	4.4%	5.7%	5.4%	5.4%	5.4%
Electric Reliability Council of Texas	1.5%	5.3%	5.1%	5.1%	5.1%
Mid-Atlantic Area Council	12.9%	5.8%	5.4%	5.4%	5.4%
Mid-America Interconnected Network	2.2%	5.5%	5.2%	5.2%	5.2%
Mid-Continent Area Power Pool	4.7%	7.0%	6.6%	6.7%	6.6%
Northeast Power Coordinating Council / New York	7.8%	6.3%	6.0%	6.1%	6.1%
Northeast Power Coordinating Council / New England	7.5%	6.4%	6.0%	6.0%	6.0%
Florida Reliability Coordinating Council	2.6%	5.5%	5.1%	5.1%	5.1%
Southeastern Electric Reliability Council	5.5%	5.5%	5.2%	5.2%	5.2%
Southwest Power Pool	9.0%	6.5%	6.2%	6.2%	6.2%
Western Electricity Coordinating Council / Northwest Power Pool Area	8.9%	7.4%	7.0%	7.0%	7.0%
Western Electricity Coordinating Council / Rocky Mountain Power Area and Arizona-	5.5%	7.4%	7.0%	7.0%	7.0%
Western Electricity Coordinating Council / California	3.2%	7.7%	7.2%	7.2%	7.2%
United States average	5.6%	6.0%	5.7%	5.7%	5.7%

We can now estimate retail sales from MN commercial and industrial CHP facilities assuming the following....

- The net generation share from MN cogenerators available to meet retail electricity load is equal to the net generation share from cogenerators in the MAPP region;
- Using the assumptions described previously, forecasted retail electricity sales for CHP facilities increases from 346 GWh in 2005 to 361 GWh in 2025

Forecasted sales from CHP facilities

Actual net generation (GWh)
 Share available for retail load proposal (%) >>>
 Assumed net generation for retail load (GWh)
 T&D loss proposal (%) >>>
 Assumed actual sales (GWh)
 Annual sales growth proposal (%/yr) >>>
 Assumed forecasted sales (GWh)

2005 2010 2015 2020 2025

2,815				
13%	14%	42%	46%	53%
355				
2.5%	7.0%	6.6%	6.7%	6.6%
346				
0.22%	0.22%	0.22%	0.22%	0.22%
346	350	353	357	361

Just one more calculation before estimating total retail sales from MN energy supply facilities

- Currently, the amount of electricity generated in MN is insufficient to meet retail electricity demand in MN. The balance comes from electricity imported from other states and/or regions.
- The ratio of in-state sales by MN utilities, NUGs, and cogenerators to in-state electricity sales was 0.745 in 2005, as summarized in the table below.

	2005
<u>Forecasted overall sales in MN</u>	
Base year MN retail electricity sales (GWh)	66,019
Sales by MN utilities/NUGs (GWh)	48,868
Sales by MN CHP facilities (GWh)	346
Total sales by MN facilities (GWh)	49,214
Ratio of MN utility/NUG/CHP sales to total sales	0.745
Overall MN sales forecast (GWh)	66,019
Total sales by non-MN facilities (GWh)	16,805

We are now ready to estimate total retail sales from all MN energy supply facilities....

- Assuming the ratio of electricity sales by MN CHP units to total in-state electricity sales in 2005 holds over the 2006-2025 period, total retail sales are as summarized below

Forecasted overall sales in MN

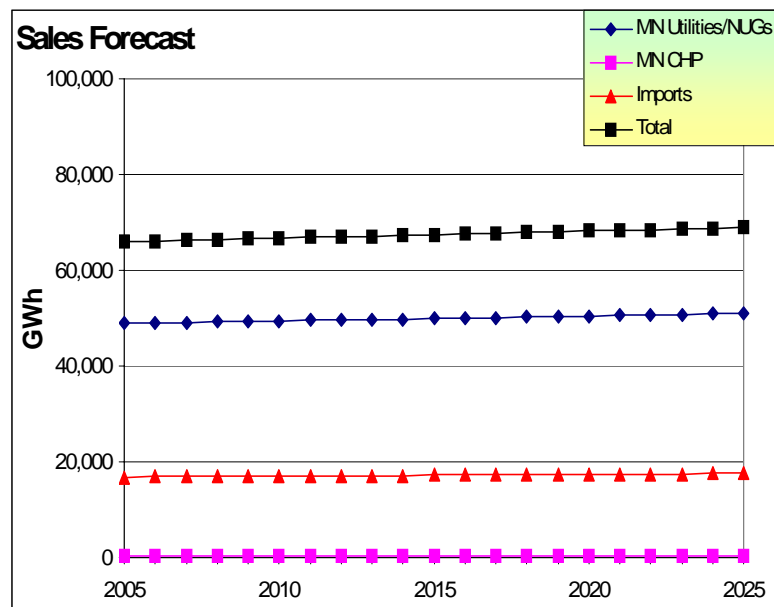
Base year MN retail electricity sales (GWh)
 Sales by MN utilities/NUGs (GWh)
 Sales by MN CHP facilities (GWh)
 Total sales by MN facilities (GWh)
 Ratio of MN utility/NUG/CHP sales to total sales
 Overall MN sales forecast (GWh)
 Total sales by non-MN facilities (GWh)

2005 2010 2015 2020 2025

66,019				
48,868	49,397	49,931	50,471	51,017
346	350	353	357	361
49,214	49,746	50,284	50,828	51,378
0.745	0.745	0.745	0.745	0.745
66,019	66,733	67,455	68,185	68,922
16,805	16,987	17,171	17,356	17,544

Finally, summarizing retail electricity sale forecast results... and the default assumptions....

- Total retail electricity sales by supply source are summarized below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of following default assumptions:
 - **Average annual sales growth rate;**
 - **Ratio of MN facility sales to total MN sales;**
 - **Share available from cogenerated electricity for retail sales; and**
 - **T&D losses**

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Gross generation forecast

First, let's focus on on-site electricity use at utility/NUG power stations

- Electric power production at utilities/NUGs is typically reported net of power used on-site. In order to reflect the total level of GHG emissions, an estimate of on-site power use is needed.
- AEO2007 provides estimates of on-site power use by region (see table below);
- **Default assumption: on-site power use at electric utilities/NUGs in MN follow the same pattern as in the MAPP region.**

NERC Region	Parasitic use at power plants (% of total generation)				
	2005	2010	2015	2020	2025
East Central Area Reliability Coordination Agreement	0.2%	0.2%	0.2%	0.2%	0.2%
Electric Reliability Council of Texas	2.6%	1.7%	1.6%	1.5%	1.4%
Mid-Atlantic Area Council	1.1%	0.9%	0.8%	0.8%	0.7%
Mid-America Interconnected Network	0.8%	0.6%	0.5%	0.5%	0.5%
Mid-Continent Area Power Pool	0.8%	0.3%	0.3%	0.3%	0.3%
Northeast Power Coordinating Council / New York	1.2%	1.0%	0.9%	0.9%	0.9%
Northeast Power Coordinating Council / New England	3.5%	2.6%	2.3%	2.1%	2.0%
Florida Reliability Coordinating Council	0.4%	0.6%	0.5%	0.5%	0.4%
Southeastern Electric Reliability Council	0.5%	0.9%	0.9%	0.8%	0.7%
Southwest Power Pool	0.1%	0.1%	0.1%	0.1%	0.1%
Western Electricity Coordinating Council / Northwest Power Pool Area	0.2%	0.1%	0.1%	0.1%	0.1%
Western Electricity Coordinating Council / Rocky Mountain Power Area and Arizona-New	1.9%	1.7%	1.6%	1.4%	1.3%
Western Electricity Coordinating Council / California	1.2%	1.1%	0.9%	0.9%	0.8%
United States average	0.9%	0.8%	0.8%	0.7%	0.7%

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Now, assuming on-site electricity use in MAPP is a good proxy for MN, let's estimate overall gross generation for all MN energy supply facilities....

- Using the previous default assumptions, gross generation of MN energy supply facilities is summarized below.

	2005	2010	2015	2020	2025
<u>Forecasted gross generation in MN</u>					
Sales by MN utilities/NUGs (GWh)	48,868	49,397	49,931	50,471	51,017
Sales by MN CHP facilities (GWh)	346	350	353	357	361
Total (GWh)	49,214	49,746	50,284	50,828	51,378
T&D losses (%)	3%	7%	7%	7%	7%
Net generation by MN utilities/NUGs (GWh)	50,124	53,114	53,486	54,067	54,645
Net generation by MN CHP facilities (GWh)	355	376	379	383	387
Total (GWh)	50,478	53,490	53,865	54,450	55,031
On-site use - utilities/NUGs (%)	0.8%	0.3%	0.3%	0.3%	0.3%
On-site use - CHP facilities (%)	87.4%	87.4%	87.4%	87.4%	87.4%
Gross generation by MN utilities/NUGs (GWh)	50,518	53,276	53,649	54,224	54,800
Gross generation by MN CHP facilities (GWh)	2,815	2,983	3,004	3,037	3,069
Total (GWh)	53,333	56,259	56,653	57,260	57,869

But, equally important as the overall gross generation level is the generation mix. Let's start with existing capacity for utilities and NUGs....

- The generation mix over 2005-2025 for MN utility and NUGs depends on planned additions and retirements and dispatch characteristics.
- In 2005, MN Nameplate capacity was 12.2 GW, with coal-fired, natural gas-fired and oil-fired stations representing about 45%, 25%, and 7% of total capacity, respectively.

Summary of MN utility and non-utility capacity, 2005

Fuel Type	MN Nameplate Capacity (MW)			
	Utilities	NUGs	Total	Share
Coal	5,239	252	5,491	45%
Hydroelectric	138	14	152	1%
Natural Gas	3,087	0	3,087	25%
Nuclear	1,737	0	1,737	14%
Other	0	0	0	0%
Other Gases	0	0	0	0%
Other Renewables	175	737	912	7%
Petroleum	831	2	833	7%
Pumped Storage	0	0	0	0%
Total	11,207	1,005	12,212	100%

Now, let's consider net generation of existing capacity for utilities and NUGs... here's what we know

- Net generation for MN utilities and NUGs in 2005 was 50.1 TWh, with coal-fired, natural gas-fired and oil-fired stations representing about 64%, 3%, and 2% of total net generation, respectively.
- **Default assumption: on-site power use at electric utilities/NUGs in MN follow the same pattern as in the MAPP region.**

Summary of MN utilityNUG net generation, 2005

Fuel Type	Net Generation (GWh)				Energy use (E9 btu)		Heat Rate (Btu/kWh)
	Utilities	NUGs	Total	Share	Total	Share	
Coal	30,515	1,409	31,924	64%	352,272	64%	10,949
Hydroelectric	575	61	636	1%	7,130	1%	11,132
Natural Gas	1,706	0	1,706	3%	19,251	4%	11,194
Nuclear	12,835	0	12,835	26%	133,974	24%	10,357
Other	0	0	0	0%	0	0%	0
Other Gases	0	0	0	0%	0	0%	0
Other Renewables	408	1,860	2,268	5%	28,229	5%	12,350
Petroleum	753	2	755	2%	7,915	1%	10,403
Pumped Storage	0	0	0	0%	0	0%	0
Total	46,791	3,332	50,124	100%	548,772	100%	10,863

Combining capacity and net generation, these were the dispatch characteristics for MN utilities and NUGs

- In 2005, coal-fired, natural gas-fired and oil-fired stations show gross capacity factors of about 66%, 6%, and 10%, respectively.

Summary of MN utility and non-utility capacity, 2005

Fuel Type	MN Capacity Factor (%)		
	Utilities	NUGs	Average
Coal	66%	64%	66%
Hydroelectric	48%	50%	48%
Natural Gas	6%	N/A	6%
Nuclear	84%	N/A	84%
Other	N/A	N/A	N/A
Other Gases	N/A	N/A	N/A
Other Renewables	27%	29%	28%
Petroleum	10%	12%	10%
Pumped Storage	N/A	N/A	N/A
Total	48%	38%	47%

Now, how does the net generation mix in MN compare to the MAPP region?

- Relative to the MAPP region for 2005, MN was:
 - less coal- and hydro-intensive,
 - more nuclear-, and oil-intensive, and
 - displayed a greater share of other renewable generation (i.e., wind).

FOR COMPARISON: MAPP and MN utilityNUG generation in 2005 (GWh)

Fuel Type	MAPP		MN	
	Total	Share	Total	Share
Coal	117,348	74%	31,924	64%
Hydroelectric	7,460	5%	636	1%
Natural Gas	4,160	3%	1,706	3%
Nuclear	24,687	16%	12,835	26%
Other	0	0%	0	0%
Other Gases	0	0%	0	0%
Other Renewables	4,047	3%	2,268	5%
Petroleum	908	1%	755	2%
Pumped Storage	0	0%	0	0%
Total	158,610	100%	50,124	100%

Capacity retirement data for MN

- I've not been able to find any capacity retirement data over the 2005-2025 period.
- **Default assumption: there are no planned capacity retirements in MN over the 2005-2025 period.**

Available capacity addition data for MN show an emphasis on NG-fired electric sector expansion

- Over the 2005-2010 period, most (93%) new utility/NUG capacity added in MN is natural-gas-fired combined cycle and combustion turbine units (48%), followed by non-hydro renewables (7%).
- Default assumption: annual capacity additions in MN over the 2005-2010 period are as shown below.**

MN Planned nameplate capacity additions (MW)

Fuel type	2005	2006	2007	2008	2009	2010	Total	Share
Coal	0	7	0	0	0	0	7	0%
Hydroelectric	0	0	0	0	0	0	0	0%
Natural Gas	0	531	290	1,108	300	0	2,229	93%
Nuclear	0	0	0	0	0	0	0	0%
Other	0	0	0	0	0	0	0	0%
Other Gas	0	0	0	0	0	0	0	0%
Other Renewables	0	99	64	0	0	0	163	7%
Petroleum	0	5	0	0	0	0	5	0%
Pumped Storage	0	0	0	0	0	0	0	0%
All Sources	0	642	354	1,108	300	0	2,404	100%

How is the MN electric sector expected to expand over the period of the forecast where data is not available?

- Please note that I have not been able to find a MN planned addition schedule over 2011-2025,
- Also, I have not been able to find a MN planned retirement schedule over 2005-2025;
- If this information is available, please let me know and I can readily incorporate it into the forecast;
- In the absence of this information, assumptions will be needed for the two Reference Cases (i.e., with and without the RPS), informed by the TWG's best judgment.
- To first order, I assumed that capacity expansion in MN will follow MAPP patterns

Net capacity additions in the MAPP region show regional electric sector expansion priorities of coal- and natural gas-fired generation....

- Over the 2005-2025 period, the MAPP region shows that most net new utility/NUG capacity added is natural-gas-fired combined cycle and combustion turbine units (48%), followed by coal steam (45%) and non-hydro renewables (7%).
- This pattern is also evident over the 2011-2025 period, with natural-gas-fired capacity at 50%, followed by coal steam at 50%.

Fuel type	MAPP net new capacity, 2005-2025 (MW)				MAPP net new capacity, 2011-2025 (MW)			
	Retirements	Additions	Net additions	Share	Retirements	Additions	Net additions	Share
Coal	325	2,642	2,317	45%	26	1,632	1,606	50%
Hydroelectric	0	9	9	0%	0	0	0	0%
Natural Gas	5	2,443	2,438	48%	0	1,605	1,605	50%
Nuclear	0	0	0	0%	0	0	0	0%
Other	0	0	0	0%	0	0	0	0%
Other Gas	0	0	0	0%	0	0	0	0%
Other Renewables	0	365	365	7%	0	0	0	0%
Petroleum	0	0	0	0%	0	0	0	0%
Pumped Storage	0	0	0	0%	0	0	0	0%
All Sources	330	5,458	5,128	100%	26	3,237	3,211	100%

NG-fired capacity additions in the MAPP region shows an emphasis on combustion turbines....

- Over the 2005-2025 period, the MAPP region shows most new NG-fired capacity being combustion turbines (75%).
- During 2011-2025 period, all new NG-fired capacity consists of combustion turbines.
- **Default assumption: for both the “No RPS” and “With RPS” cases, the mix of new NG-fired capacity in MN for the period 2011-2025 reflects the MAPP pattern for 2011-2025.**

	MAPP net new NG capacity, 2005-2025 (MW)				MAPP net new NG capacity, 2011-2025 (MW)			
	Retirements	Additions	Net additions	Share	Retirements	Additions	Net additions	Share
Combustion turbine	5	1,843	1,838	75%	0	1,605	1,605	100%
Combined cycle	0	600	600	25%	0	0	0	0%
total	5	2,443	2,438	100%	0	1,605	1,605	100%

Non-hydro renewable capacity additions in the MAPP region shows an emphasis on biomass and wind....

- Over the 2005-2025 period, the MAPP region shows most new non-hydro capacity being wind (81%), followed by biomass (15%) and MSW (4%).
- During 2011-2025 period, there is no new non-hydro renewable capacity projected.
- **Default assumption: for the “No RPS” case, the mix of new non-hydro renewable capacity in MN for the period 2011-2025 reflects the MAPP pattern for 2005-2025.**

	MAPP new other renewable capacity, 2005-2025 (MW)				MAPP new other renewable capacity, 2011-2025 (MW)			
	Retirements	Additions	Net additions	Share	Retirements	Additions	Net additions	Share
Geothermal	0	0	0	0%	0	0	0	0%
MSW	0	13	13	4%	0	0	0	0%
Biomass	0	56	56	15%	0	0	0	0%
Solar	0	0	0	0%	0	0	0	0%
Wind	0	296	296	81%	0	0	0	0%
total	0	365	365	100%	0	0	0	0%

How will the MN electric sector expand in the RPS scenario?

- It is not possible to use MAPP patterns as a basis for projecting utility/NUG capacity expansion in MN under the RPS due to the fact that the MN targets are more aggressive than assumptions in the AEO2007.
- During 2011-2025 period, RPS targets will likely be met by a combination of more renewable capacity, less coal-fired capacity, and purchases of renewable credits.
- **Default assumption: for the “With RPS” case, 40%, 40%, and 20% of new capacity in MN for the period 2011-2025 is NG, wind, and biomass, respectively.**

Performance characteristics for new capacity additions....

- Unit size, capacity factors, and heat rate assumptions are needed to estimate the generation and primary energy levels of new capacity over the forecast period.
- **Default assumption: performance characteristics for new capacity are based on AEO2007, as summarized below.**

Fuel type	Unit size (MW)	Capacity factor	Heat rate (btu/kWh)
Coal	600	75%	8,844
Hydroelectric	400	42%	11,308
Natural Gas			
Natural Gas Combustion turbine	160	10%	10,807
Natural Gas Combined cycle	250	75%	7,163
Nuclear	1,000	85%	10,520
Other	1	75%	N/A
Other Gas	1	75%	N/A
Other Renewables			
<i>Geothermal</i>	100	75%	36,025
<i>MSW</i>	100	75%	13,648
<i>Landfill gas</i>	100	75%	13,648
<i>Biomass</i>	100	75%	8,911
<i>Solar</i>	100	30%	10,280
<i>Wind</i>	50	30%	10,280
Petroleum	1	20%	10,568
Pumped Storage			

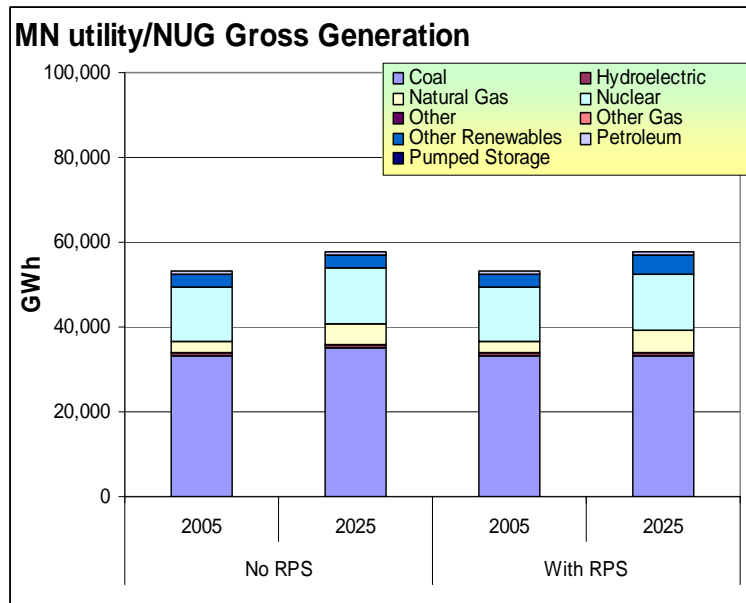
With the information presented in the previous slides, it is possible to estimate the gross generation mix....

- Methodology to project utility/NUG gross generation
 - A control total for annual MN gross generation was established for the period 2006-2025 (see earlier slides)
 - Gross generation from existing units was backed down relative to capacity retirement assumptions
 - Gross generation from new units was calculated relative to capacity factor and capacity mix assumptions
- Results with/without the RPS are summarized below:

Fuel type	Gross Generation (GWh)			
	No RPS		With RPS	
	2005	2025	2005	2025
Coal	33,160	35,060	33,160	33,173
Hydroelectric	702	702	702	702
Natural Gas	2,757	5,086	2,757	5,489
Nuclear	12,936	12,936	12,936	12,936
Other	0	0	0	0
Other Gas	46	50	46	50
Other Renewables	2,943	3,242	2,943	4,724
Petroleum	788	792	788	794
Pumped Storage	0	0	0	0
All Sources	53,333	57,869	53,333	57,869

Summarizing gross generation levels and fuel mix for utilities/NUGs... and the open questions....

- The gross generation forecast is summarized below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of following assumptions:
 - Capacity additions during the 2011-2025 period;**
 - Capacity retirements during the 2006-2025 period;**
 - Capacity factors for new fossil/renewable capacity; and**
 - Renewable capacity shares in the 2011-2025 period**

Now, let's focus on MN commercial and industrial cogenerators....starting with installed capacity in 2005...

- The generation mix over the forecast period will vary depending on the schedule of planned additions and planned retirements and the dispatch characteristics of CHP units.
- Electric nameplate capacity for MN cogenerators for the Base year of 2005 is 0.747 GW, with coal-fired, natural gas-fired and oil-fired stations representing about 25%, 46%, and 5% of total capacity, respectively.

Type	Nameplate Capacity	
	MW	Share (%)
Coal	185	25%
Hydroelectric	34	5%
Natural Gas	340	46%
Nuclear	0	0%
Other	11	0%
Other Gases	0	1%
Other Renewables	137	18%
Petroleum	40	5%
Pumped Storage	0	0%
Total	747	100%

CHP net generation and dispatch characteristics in 2005....

- Net generation for MN cogenerators in 2005 was 2.8 TWh, with coal-fired, natural gas-fired and oil-fired stations representing about 35%, 37%, and 1% of total net generation, respectively.
- In 2005, coal-fired, natural gas-fired and oil-fired stations showed gross capacity factors of about 61%, 35%, and 8%, respectively.

MN CHP dispatch			
Fuel Type	Generation (GWh)	Share (%)	Capacity factor (%)
Coal	985	35%	61%
Hydroelectric	62	2%	21%
Natural Gas	1,037	37%	35%
Nuclear	0	0%	0%
Other	0	0%	0%
Other Gases	46	2%	0%
Other Renewables	658	23%	55%
Petroleum	27	1%	8%
Pumped Storage	0	0%	0%
Total	2,815	100%	43%

Now, how does the CHP generation mix in MN compare to that of the MAPP region?

- Relative to the MAPP region for 2005, MN CHP units showed very different characteristics. They were:
 - less intensive regarding coal, other, and oil
 - more intensive regarding natural gas and other renewables

Fuel Type	2005				
	MAPP		MN		Difference
	GWh	Share (%)	GWh	Share (%)	
Coal	2,366	63%	985	35%	-28%
Hydroelectric	77	2%	62	2%	0%
Natural Gas	360	10%	1,037	37%	27%
Nuclear	0	0%	0	0%	0%
Other	61	2%	0	0%	-2%
Other Gases	74	2%	46	2%	0%
Other Renewables	753	20%	658	23%	3%
Petroleum	76	2%	27	1%	-1%
Pumped Storage	0	0%	0	0%	0%
Total	3,767	100%	2,815	100%	0%

How does net generation by CHP units in the MAPP region vary during the forecast period?

- The MAPP region shows net generation shares are projected to become
 - Much more coal-intensive, and
 - less intensive for all other fuels.

Fuel Type	2005					2025	
	MAPP		MN		Difference	MAPP	
	GWh	Share (%)	GWh	Share (%)		GWh	Share (%)
Coal	2,366	63%	985	35%	-28%	22,092	91%
Hydroelectric	77	2%	62	2%	0%	77	0%
Natural Gas	360	10%	1,037	37%	27%	795	3%
Nuclear	0	0%	0	0%	0%	0	0%
Other	61	2%	0	0%	-2%	68	0%
Other Gases	74	2%	46	2%	0%	74	0%
Other Renewables	753	20%	658	23%	3%	1,087	4%
Petroleum	76	2%	27	1%	-1%	172	1%
Pumped Storage	0	0%	0	0%	0%	0	0%
Total	3,767	100%	2,815	100%	0%	24,366	100%

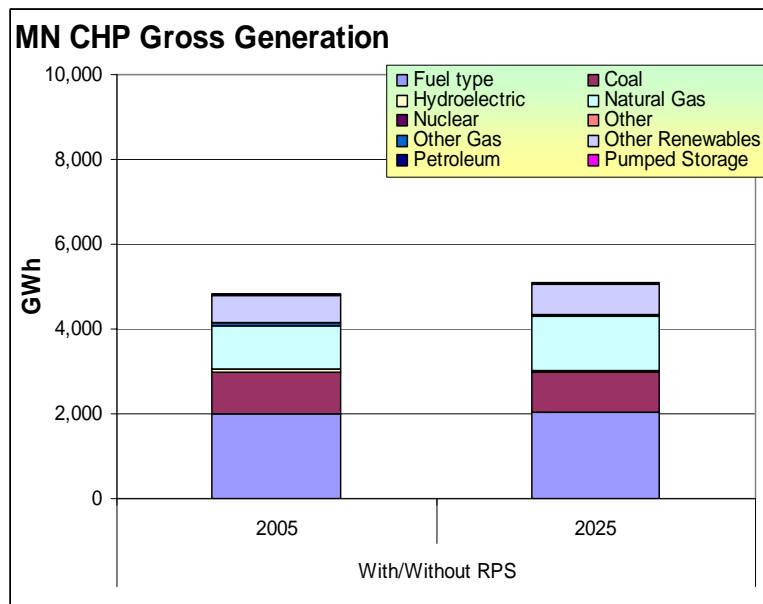
What then is the operative assumption regarding CHP system expansion during the forecast period?

- Unless an annual schedule of planned additions (by type) over 2011-2025 can be obtained, with a schedule of planned retirements (by type) over 2006-2025, I'm not able to estimate gross generation mix at CHP units using a bottom-up approach.
- **Default assumption: The change in MN CHP generation shares with/without the RPS between 2005 and 2025 are the same as the change in MN utility/NUG generation shares during that period in the “no RPS” case.**

Fuel type	2005	2025
Coal	35%	31%
Hydroelectric	2%	0
Natural Gas	37%	41%
Nuclear	0%	0
Other	0%	0
Other Gas	2%	0
Other Renewables	23%	23%
Petroleum	1%	1%
Pumped Storage	0%	0
All Sources	100%	100%

Summarizing gross generation levels and fuel mix for CHP units... and the open questions....

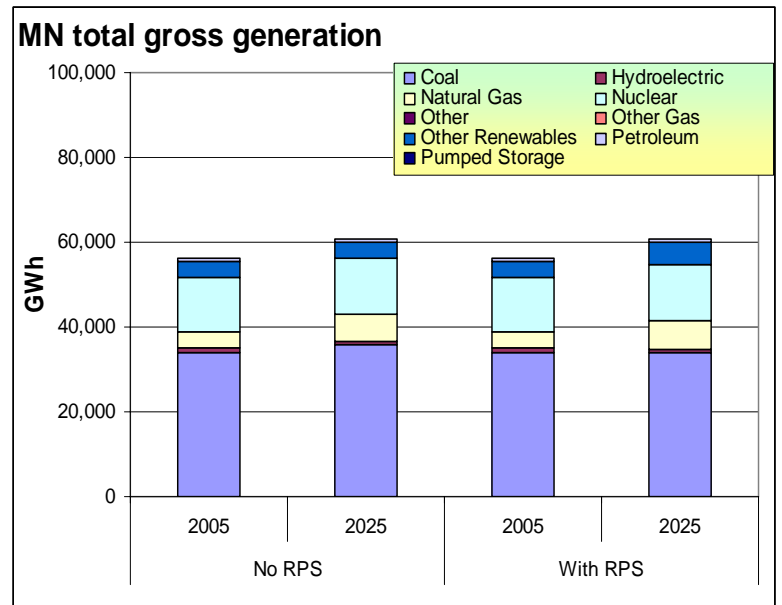
- The gross generation forecast is summarized below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of following assumptions:
 - Net generation shares over the 2006-2025 period;**
 - Impact of the recent RPS legislation on CHP system expansion;**

Finally, summarizing the gross generation forecast results for all energy supply facilities in MN....

- The total gross generation forecast is illustrated below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of assumptions identified earlier:

Primary energy forecast

First, let's consider the heat rate of existing capacity for utilities/NUGs... here's what we know for 2005....

- Combining gross generation estimates and primary fuel use data yields an estimate of the gross heat rate for 2005.

Fuel Type	Energy use (E9 btu)		Heat Rate (Btu/kWh)
	Total	Share	
Coal	352,272	64%	10,949
Hydroelectric	7,130	1%	11,132
Natural Gas	19,251	4%	11,194
Nuclear	133,974	24%	10,357
Other	0	0%	0
Other Gases	0	0%	0
Other Renewables	28,229	5%	12,350
Petroleum	7,915	1%	10,403
Pumped Storage	0	0%	0
Total	548,772	100%	10,863

With the information presented in the previous slides, it is possible to estimate primary energy use at power stations

- Methodology to project utility/NUG primary energy use:
 - Heat rates for gross generation from existing units is assumed to be constant over the forecast period;
 - Heat rates for gross generation from new units is based on assumptions reviewed earlier;
 - Primary energy use was calculated as the product of the gross generation projections and heat rate.
- Results are summarized below:

Fuel type	Primary energy use (billion btu)			
	No RPS		With RPS	
	2005	2025	2005	2025
Coal	352,272	373,485	352,272	352,825
Hydroelectric	7,130	7,130	7,130	7,130
Natural Gas	19,251	42,709	19,251	47,228
Nuclear	133,974	133,974	133,974	133,974
Other	0	0	0	0
Other Gas	0	0	0	0
Other Renewables	28,451	30,886	28,451	44,848
Petroleum	7,915	7,997	7,915	8,015
Pumped Storage	0	0	0	0
All Sources	548,995	596,183	548,995	594,021

Now, let's consider the heat rate of existing capacity for CHP facilities... here's what we know for 2005....

- Combining gross generation estimates and primary fuel use data yields an estimate of the gross heat rates for 2005 by fuel type.

Fuel Type	GWh	(billion btu)	(btu/kWh)
Coal	985	7,190	7,299
Hydroelectric	62	616	9,999
Natural Gas	1,037	10,277	9,906
Nuclear	0	0	0
Other	0	0	0
Other Gases	46	457	9,906
Other Renewables	658	10,946	16,646
Petroleum	27	140	5,175
Pumped Storage	0	0	0
Total	2,815	29,626	10,524

Average heat rates over the forecast period

- I have not been able to find data on heat rates for new CHP units over the forecast period for new CHP units in MN.
- **Default assumption: Average heat rates observed for 2005 hold for the period 2006-2025.**

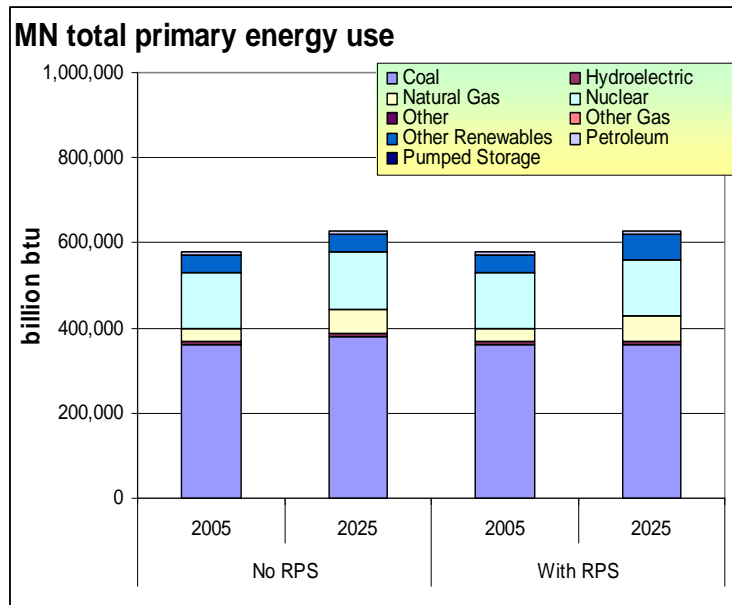
With the information presented in the previous slides, it is possible to estimate primary energy use at CHP facilities

- Methodology to project CHP primary energy use:
 - Heat rates for gross generation is based on the assumptions of constant heat rate (reviewed earlier);
 - Primary energy use was calculated as the product of the gross generation projections and heat rate.
- Results are summarized below:

Fuel type	Primary energy use (billion btu)	
	With/Without RPS	
	2005	2025
Coal	7,190	6,914
Hydroelectric	616	618
Natural Gas	10,277	12,583
Nuclear	0	0
Other	0	0
Other Gas	457	499
Other Renewables	10,946	11,909
Petroleum	140	123
Pumped Storage	0	0
All Sources	29,626	32,646

Summarizing the primary energy forecast results for all energy supply facilities in MN....

- The total primary forecast is illustrated below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of assumptions identified earlier:

Imported electricity forecast

First, let's focus on sales met by out-of-state electric supply, & gross generation associated with those sales

- Based on the assumptions referenced earlier, retail electricity sales associated with sources located outside MN were 16.8 TWh in 2005 and would be 17.5 TWh in 2025.
- Assuming MAPP T&D losses **(an earlier default assumption)**, gross generation associated with out-of-state suppliers is summarized below

Forecasted overall sales in MN (GWh)

	2005	2010	2015	2020	2025
MN utilities/NUGs	48,868	49,397	49,931	50,471	51,017
MN CHP facilities	346	350	353	357	361
Total imports	16,805	16,987	17,171	17,356	17,544
All Sources	66,019	66,733	67,455	68,185	68,922

Forecasted net generation associated with meeting MN electricity demand (GWh)

	2005	2010	2015	2020	2025
MN utilities/NUGs	50,124	53,114	53,486	54,067	54,645
MN CHP facilities	355	376	379	383	387
Total imports	17,237	18,265	18,393	18,593	18,792
All Sources	67,715	71,755	72,258	73,043	73,823

Forecasted gross generation associated with meeting MN electricity demand (GWh)

	2005	2010	2015	2020	2025
MN utilities/NUGs	50,518	53,276	53,649	54,224	54,800
MN CHP facilities	2,815	2,983	3,004	3,037	3,069
Non-MN facilities	17,372	18,321	18,449	18,647	18,845
All Sources	70,705	74,580	75,102	75,907	76,714

But, equally important as the overall gross generation level is the generation mix associated with imported power....

- In 2000, the Minnesota Energy Planning Report 2001 (page 15) provides a summary of the fuel mix associated with in-state and imported power
- **Default assumption: the 2000 fuel mix is a reasonable approximation for 2005.**

Fuel type	2000	2005
Coal	75%	75%
Hydroelectric	3%	3%
Natural Gas	1%	1%
Nuclear	17%	17%
Other	0%	0%
Other Gas	0%	0%
Other Renewables	3%	3%
Petroleum	0%	0%
Pumped Storage	0%	0%
Total	99%	99%

How do overall fuel use shares used to generate electricity at MN and MAPP utilities/NUGs compare?....

- In 2005, MAPP’s fuel mix is similar to MN’s fuel mix to generate electricity, showing an emphasis on coal and nuclear resources.

Fuel type	MN	MAPP	Difference
Coal	75.3%	74.9%	-0.3%
Hydroelectric	3.0%	4.4%	1.4%
Natural Gas	1.0%	2.6%	1.6%
Nuclear	17.1%	14.6%	-2.5%
Other	0.0%	0.0%	0.0%
Other Gas	0.0%	0.0%	0.0%
Other Renewables	3.0%	2.4%	-0.6%
Petroleum	0.0%	0.6%	0.6%
Pumped Storage	0.0%	0.0%	0.0%
Total	99.4%	99.5%	0.2%

Over the 2006-2025 period, how does the generation mix for out-of-state utilities/NUGs meeting MN electricity demand vary?....

- **Default assumption: the generation mix for MAPP utilities/NUGs over the forecast period is a reasonable basis by which to calculate the mix associated with MN electricity imports from these facilities.**

Fuel type	2005	2010	2015	2020	2025
Coal	73.8%	72.6%	73.0%	73.7%	73.5%
Hydroelectric	4.7%	7.2%	6.9%	6.5%	6.4%
Natural Gas	2.6%	0.9%	1.1%	1.6%	1.3%
Nuclear	15.5%	13.9%	13.3%	12.5%	12.3%
Other	0.0%	0.0%	0.0%	0.0%	0.0%
Other Gas	0.0%	0.0%	0.0%	0.0%	0.0%
Other Renewables	2.5%	4.7%	4.7%	4.4%	4.6%
Petroleum	0.6%	0.4%	0.4%	0.5%	0.4%
Pumped Storage	0.0%	0.0%	0.0%	0.0%	0.0%
Total	99.7%	99.7%	99.3%	99.1%	98.5%

Over the 2006-2025 period, how does the generation mix for out-of-state CHP facilities meeting MN electricity demand vary?....

- **Default assumption: the generation mix for MAPP CHP facilities over the forecast period is a reasonable basis by which to calculate the mix associated with MN electricity imports from these facilities.**

Fuel type	2005	2010	2015	2020	2025
Coal	0.2%	0.2%	0.5%	0.8%	1.4%
Hydroelectric	0.0%	0.0%	0.0%	0.0%	0.0%
Natural Gas	0.0%	0.0%	0.0%	0.0%	0.0%
Nuclear	0.0%	0.0%	0.0%	0.0%	0.0%
Other	0.0%	0.0%	0.0%	0.0%	0.0%
Other Gas	0.0%	0.0%	0.0%	0.0%	0.0%
Other Renewables	0.1%	0.1%	0.1%	0.1%	0.1%
Petroleum	0.0%	0.0%	0.0%	0.0%	0.0%
Pumped Storage	0.0%	0.0%	0.0%	0.0%	0.0%
Total	0.3%	0.3%	0.7%	0.9%	1.5%

With the info presented previously, it is possible to estimate the gross generation mix associated with imported power in the “No RPS” case....

- Methodology to project gross generation associated with imports:
 - A control total for annual gross generation imports was established for the period 2006-2025 (see earlier slides)
 - Gross generation from out-of-state units was calculated as the product of the control total and the assumed generation share
- Results *without the RPS* are summarized below for out-of-state utilities/NUGs and CHP facilities:

Fuel type	2005	2010	2015	2020	2025
Coal	12,847	13,329	13,575	13,883	14,110
Hydroelectric	816	1,320	1,268	1,211	1,206
Natural Gas	459	176	217	304	245
Nuclear	2,696	2,546	2,446	2,336	2,327
Other	1	1	1	1	1
Other Gas	1	1	1	1	1
Other Renewables	452	868	873	823	873
Petroleum	100	80	68	87	83
Pumped Storage	0	0	0	0	0
Total	17,372	18,321	18,449	18,647	18,845

Primary energy use associated with out-of-state gross generation from utilities/NUGS depends on their combustion efficiency during the forecast period....

- **Default assumption: heat rates for MAPP utility/NUGs over the forecast period is a reasonable basis to calculate primary energy use associated with MN electricity imports from these facilities.**

Fuel type	2005	2010	2015	2020	2025
Coal	11,206	10,732	10,693	10,597	10,592
Hydroelectric	10,280	10,280	10,280	10,280	10,280
Natural Gas	11,251	7,514	7,542	7,528	7,781
Nuclear	10,357	10,357	10,357	10,357	10,357
Other	0	0	0	0	0
Other Gas	0	0	0	0	0
Other Renewables	10,801	11,111	10,911	10,959	10,992
Petroleum	11,281	10,927	10,886	10,590	10,479
Pumped Storage	0	0	0	0	0
<i>Geothermal</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>MSW</i>	<i>13,648</i>	<i>13,648</i>	<i>13,648</i>	<i>13,648</i>	<i>13,648</i>
<i>Landfill gas</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>Biomass</i>	<i>10,241</i>	<i>13,004</i>	<i>11,644</i>	<i>11,943</i>	<i>11,839</i>
<i>Solar</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>Wind</i>	<i>10,280</i>	<i>10,280</i>	<i>10,280</i>	<i>10,280</i>	<i>10,280</i>

Primary energy use associated with out-of-state gross generation from CHP facilities depends on their combustion efficiency during the forecast period....

- **Default assumption: heat rates for MAPP CHP facilities over the forecast period is a reasonable basis to calculate primary energy use associated with MN electricity imports from these facilities.**

Fuel type	2005	2010	2015	2020	2025
Coal	7,299	7,299	7,299	7,299	7,299
Hydroelectric	10,279	10,279	10,279	10,279	10,279
Natural Gas	9,906	9,906	9,906	9,906	9,906
Nuclear	0	0	0	0	0
Other	0	0	0	0	0
Other Gas	9,906	9,906	9,906	9,906	9,906
Other Renewables	13,535	13,137	13,055	12,966	12,716
Petroleum	5,175	5,175	5,175	5,175	5,175
Pumped Storage	0	0	0	0	0
<i>Geothermal</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>MSW</i>	<i>21,940</i>	<i>21,940</i>	<i>21,940</i>	<i>21,940</i>	<i>21,940</i>
<i>Landfill gas</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>Biomass</i>	<i>12,868</i>	<i>12,858</i>	<i>12,842</i>	<i>12,830</i>	<i>12,818</i>
<i>Solar</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>Wind</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>

With the info presented previously, it is possible to estimate the primary energy use associated with imported power in the “No RPS” case....

- Methodology to project primary energy associated with imports:
 - Annual gross generation by fuel type associated with imports was established for the period 2006-2025 (see earlier slides)
 - Primary energy use at out-of-state units was calculated as the product of gross generation and corresponding heat rates
- Results *without the RPS* are summarized below for out-of-state utilities/NUGs and CHP facilities:

Fuel type	2005	2010	2015	2020	2025
Coal	143,830	142,940	144,829	146,639	148,595
Hydroelectric	8,386	13,568	13,035	12,449	12,399
Natural Gas	5,160	1,337	1,656	2,310	1,927
Nuclear	27,919	26,369	25,333	24,193	24,097
Other	0	0	0	0	0
Other Gas	8	7	7	8	8
Other Renewables	4,912	9,662	9,547	9,047	9,616
Petroleum	1,124	865	724	915	854
Pumped Storage	0	0	0	0	0
Total	191,340	194,748	195,131	195,560	197,496

The RPS and imported power

- MAPP's total renewable generation (i.e., including hydro and other renewables), is not adequate to meet incremental levels required to meet the MN RPS target in all years, given default assumptions.

	2005	2010	2015	2020	2021	2022	2023	2024	2025
RPS targets (%)	0%	0%	16%	19%	21%	22%	23%	24%	25%
Retail electricity sales in MN (GWh)	66,019	66,733	67,455	68,185	68,332	68,479	68,626	68,774	68,922
Total MN generation (GWh)									
<i>Utilities/NUGs</i>	50,518	53,276	53,649	54,224	54,341	54,456	54,574	54,864	54,800
<i>CHP</i>	2,815	2,983	3,004	3,037	3,043	3,050	3,056	3,073	3,069
<i>Total</i>	53,333	56,259	56,653	57,260	57,384	57,506	57,630	57,937	57,869
Total out-of-state generation (GWh)									
<i>Utilities/NUGs</i>	17,320	18,270	18,327	18,480	18,510	18,489	18,519	18,585	18,560
<i>CHP</i>	51	51	122	166	177	237	248	282	285
<i>Total</i>	17,372	18,321	18,449	18,647	18,687	18,727	18,767	18,867	18,845
Total generation to meet MN demand (GWh)									
<i>Utilities/NUGs</i>	67,838	71,546	71,976	72,704	72,850	72,946	73,093	73,449	73,360
<i>CHP</i>	2,866	3,034	3,126	3,203	3,220	3,287	3,304	3,354	3,354
<i>Total</i>	70,705	74,580	75,102	75,907	76,070	76,233	76,397	76,803	76,714
Required renewable energy generation (GWh)	0	0	10,624	13,228	14,022	14,819	15,619	16,423	17,231
Total MN renewable energy generation (GWh)									
<i>Utilities/NUGs</i>	2,286	3,395	3,545	3,776	3,823	3,870	3,917	4,034	4,008
<i>CHP</i>	658	696	701	708	710	711	713	716	715
<i>Total</i>	2,943	4,092	4,246	4,485	4,533	4,581	4,630	4,750	4,724
Total out-of-state renewable energy generation (GWh)									
<i>Utilities/NUGs</i>	442	857	862	812	803	808	818	860	860
<i>CHP</i>	10	10	11	12	12	12	12	12	13
<i>Total</i>	452	868	873	823	815	820	830	872	873
Additional renewable energy generation required (GWh)									
<i>Utilities/NUGs</i>	0	0	5,435	7,809	8,550	9,281	10,011	10,647	11,465
<i>CHP</i>	0	0	70	111	124	137	149	154	169
<i>Total</i>	0	0	5,505	7,920	8,674	9,418	10,160	10,801	11,634
Upper limit of renewable generation from MAPP region (GWh)	4,176	8,552	8,955	8,846	8,815	8,862	8,946	9,385	9,415
Possible to obtain remaining renewable generation from MAPP?	Yes	Yes	Yes	Yes	Yes	No	No	No	No

With the info presented previously, it is possible to estimate the gross generation mix associated with imported power in the “With RPS” case....

- Methodology to project gross generation associated with imports:
 - Annual gross generation from non-renewable sources was backed down to meet the RPS targets on a pro-rata basis;
 - Annual gross generation from non-renewable sources was increased to meet the RPS targets.
- Results *with the RPS* are summarized below for out-of-state utilities/NUGs and CHP facilities:

Fuel type	2005	2010	2015	2020	2025
Coal	12,847	13,329	9,319	7,708	4,977
Hydroelectric	816	1,320	873	675	425
Natural Gas	459	176	148	168	87
Nuclear	2,696	2,546	1,685	1,304	820
Other	1	1	0	0	0
Other Gas	1	1	0	0	0
Other Renewables	452	868	6,378	8,743	12,507
Petroleum	100	80	46	48	29
Pumped Storage	0	0	0	0	0
Total	17,372	18,321	18,449	18,647	18,845

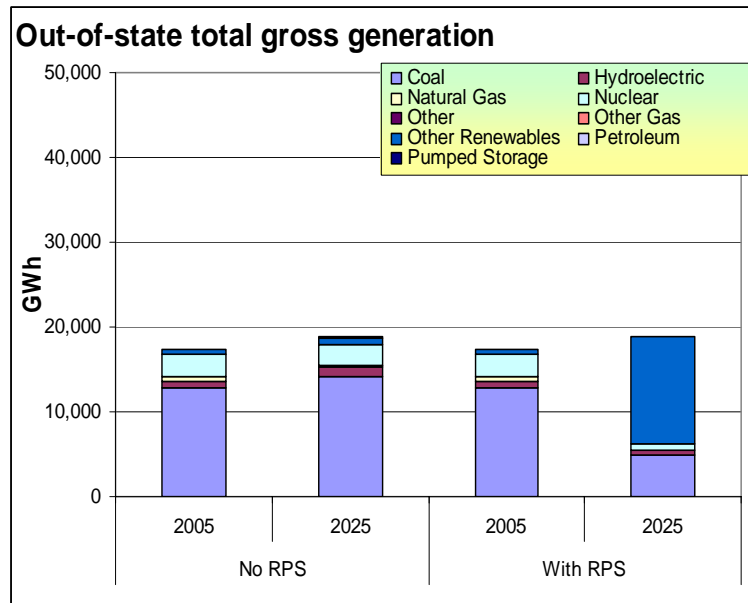
With the info presented previously, it is possible to estimate the primary energy use associated with imported power in the “With RPS” case....

- Methodology to project primary energy associated with imports:
 - Annual gross generation by fuel type associated with imports was established for the period 2006-2025 (see earlier slides)
 - Primary energy use at out-of-state units was calculated as the product of gross generation and corresponding heat rates
- Results *with the RPS* are summarized below for out-of-state utilities/NUGs and CHP facilities:

Fuel type	2005	2010	2015	2020	2025
Coal	143,830	142,940	99,526	81,543	52,392
Hydroelectric	8,386	13,568	8,975	6,944	4,368
Natural Gas	5,160	1,337	1,119	1,268	681
Nuclear	27,919	26,369	17,450	13,501	8,488
Other	0	0	0	0	0
Other Gas	8	7	3	2	3
Other Renewables	4,912	9,662	69,762	96,059	137,791
Petroleum	1,124	865	495	508	301
Pumped Storage	0	0	0	0	0
Total	191,340	194,748	197,330	199,824	204,025

Summarizing imported gross generation characteristics... and the open questions....

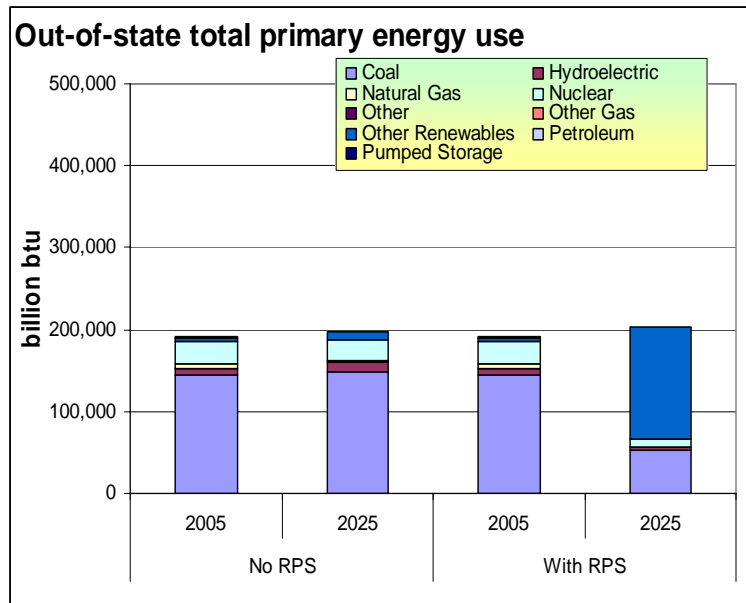
- The imported power forecast is summarized below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of following assumptions:
 - Generation mix associated with imported power from utilities/NUGs;**
 - Generation mix associated with imported power from CHP facilities**

Summarizing imported primary energy characteristics... and the open questions....

- The imported power forecast is summarized below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of following assumptions:
 - Combustion efficiency of generation associated with imported power;**
 - On-site energy use in the region where imported power originates; and**
 - T&D losses in the region where imported power originates;**

GHG emission forecast

To develop the GHG emission forecast, a set of emission factors is needed

- **Default assumption: Average GHG emission factors are summarized below**

	CO2 (tCO2/mmbtu)	CH4 (tCH4/E9 btu)	N2O (tN2O/E9 btu)	CO2e (tCO2e/mmbtu)
Subbituminous coal	0.0955	0.0011	0.0015	0.0959
Natural gas	0.0536	0.0032	0.0006	0.0539
Residual oil	0.0780	0.0032	0.0006	0.0783
Diesel oil	0.0724	0.0032	0.0006	0.0727
Petroleum coke	0.1000	0.0032	0.0006	0.1003
LPG	0.0625	0.0285	0.0006	0.0633
Refuse derived fuel (fossil)	0.0413	0.0285	0.0026	0.0427
MSW (fossil)	0.0413	0.0205	0.0026	0.0426
Refuse derived fuel (biomass)	0.0000	0.0205	0.0049	0.0019
MSW (biomass)	0.0000	0.0205	0.0049	0.0019
Wood, waste wood and sawdust	0.0000	0.0317	0.0042	0.0020
Nuclear	0.0000	0.0000	0.0000	0.0000
Landfill gas	0.0536	0.0000	0.0000	0.0536
Wind	0.0000	0.0000	0.0000	0.0000
Solar/PV	0.0000	0.0000	0.0000	0.0000
Other	0.0536	0.0000	0.0000	0.0536
Oil	0.0780	0.0032	0.0006	0.0783
Waste solvent	0.0732	0.0032	0.0006	0.0734

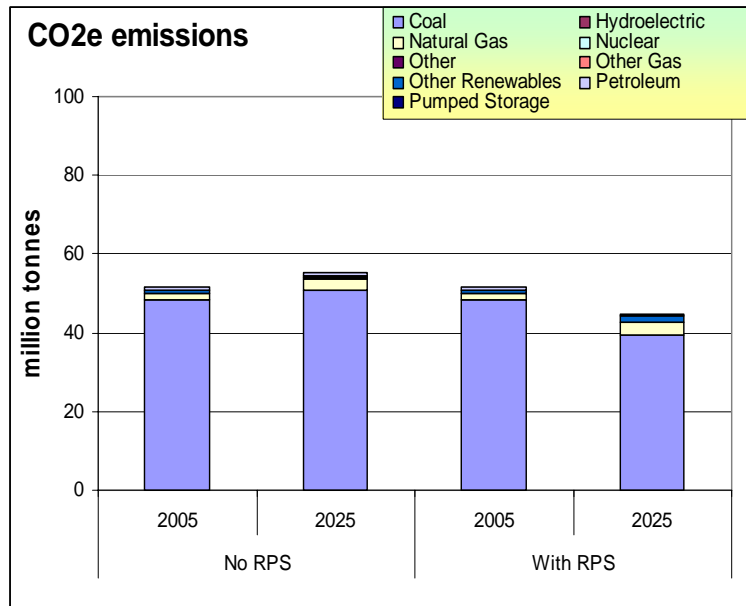
With the info presented previously, it is possible to estimate annual GHG emissions (CO2-equivalent) for the “No RPS” and “With RPS” cases....

- Methodology to project GHG emissions:
 - CO2e emissions are calculated as the product of total primary energy associated with meeting MN electricity demand and corresponding CO2e emission factors
- Results *with and without the RPS* are summarized below:

Fuel type	CO2e emissions (million tonnes)			
	No RPS		With RPS	
	2005	2025	2005	2025
Coal	48.3	50.8	48.3	39.5
Hydroelectric	0.0	0.0	0.0	0.0
Natural Gas	1.9	3.1	1.9	3.3
Nuclear	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0
Other Gas	0.0	0.0	0.0	0.0
Other Renewables	0.6	0.6	0.6	1.4
Petroleum	0.7	0.7	0.7	0.7
Pumped Storage	0.0	0.0	0.0	0.0
All Sources	51.5	55.2	51.5	44.9

Summarizing the GHG emission forecast ... and the open questions....

- The GHG emissions forecast is summarized below using the assumptions proposed earlier;



- TWG feedback is requested regarding the adequacy of following assumptions:
 - GHG emission factors**