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Advisory Group



# Overview of Issues & Assumptions for Developing the Minnesota GHG Forecast

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# Outline

- 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;

# Framework

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

- Undertake a “bottom-up” forecast as opposed 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.

## **In addition....**

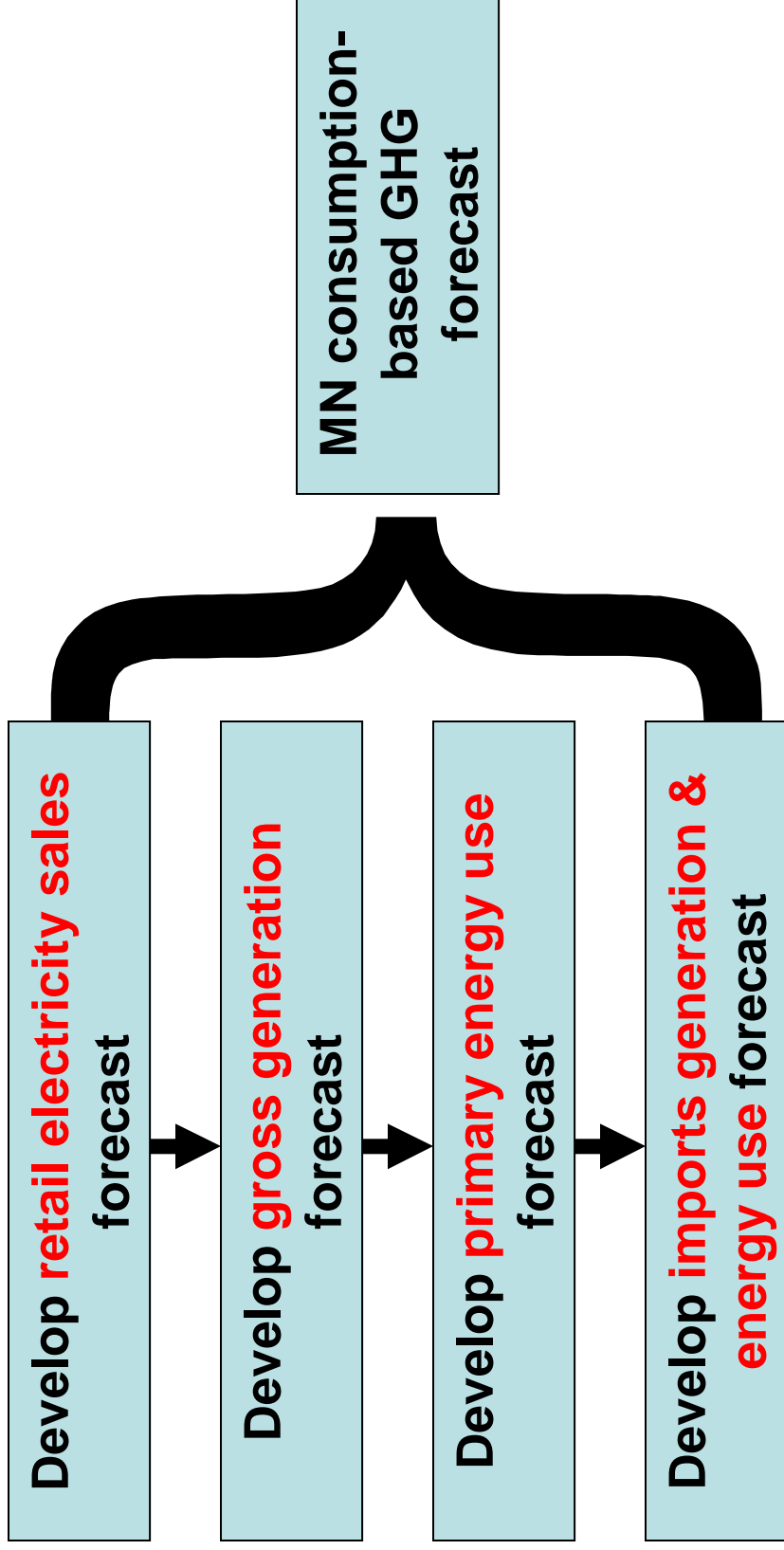
- The existing version of the energy supply (ES) GHG forecast does not incorporate the emissions associated with combined heat & power (CHP) units;
- Currently, GHG emissions for CHP units are tracked in the residential, commercial, and industrial (RCI) GHG forecast;
- But.... the ES TWG has selected 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.
- 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



## **GHG emissions are not included in this memo....**

- Once the TWG confirms or modifies the key forecast assumptions, it is straightforward to calculate GHG emissions as the product of primary energy consumption and appropriate carbon dioxide-equivalent emission factors.

# Sales forecast

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# First, let's focus on the electricity sale projection for MN electric utilities and non-utility generators....

- 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
<b>Total Sales</b>	<b>66,019</b>

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

- The average annual electric sales growth rate over the 2005-2025 period is 1.72% per year.

	MN utility/NUG Sales (GWh)					Growth rate (%/yr)		
	2005	2010	2015	2020	2020	2005-10	2005-15	2005-20
MN utility	710	820	952	1,114		2.92%	2.98%	3.05%
Central Minnesota Municipal Power Agency	607	689	771	854		2.57%	2.42%	2.30%
Great River Energy	42,977	46,634	50,811	55,230		1.65%	1.69%	1.69%
Xcel	2,309	2,530	2,744	2,936		1.85%	1.74%	1.62%
Missouri River Energy Services	2,163	2,357	2,575	2,821		1.73%	1.76%	1.78%
Offter Tail Power	102	107	112	117		1.01%	0.96%	0.89%
Southern Minnesota Municipal Power Agency	<b>48,868</b>	<b>53,138</b>	<b>57,966</b>	<b>63,071</b>		<b>1.69%</b>	<b>1.72%</b>	<b>1.72%</b>
<b>Average</b>								

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

- Using the average growth rate above of 1.72%/yr for the period 2005-2020, electricity sales would be 68,669 GWh in 2025, as summarized in the table below .

Sales by MN utilities, 2020 (GWh)	63,071
growth rate, 2005-2020 (%/yr)	1.72%
<b>Sales by MN utilities, 2025 (GWh)</b>	<b>68,669</b>

## How does the MN electricity sales growth rate compare to the growth rate of the 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.

Sector	Overall retail sales in MAPP (TWh)						MAPP Growth rate (%/yr)				
	2005	2010	2015	2020	2025	2025-10	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%		
<b>Total Sales</b>	<b>145.7</b>	<b>160.8</b>	<b>170.9</b>	<b>179.5</b>	<b>189.3</b>	<b>1.99%</b>	<b>1.61%</b>	<b>1.40%</b>	<b>1.32%</b>		



## An observation and question for the TWG...

- MN utility/NUG electricity sales are projected to grow 0.32%/yr more (i.e., 1.72%/yr minus 1.40%/yr during 2005-2020 period) than the AEO2007 estimate of overall sales for the surrounding region for the same period.
- ***Is an annual average growth rate for electricity sales in MN that exceeds the rate in the surrounding region a reasonable assumption?***

## Let's summarize the retail electricity sales projection for MN electric utilities and NUGs....

- Assuming that the average MN utility/NUG sales annual growth rates during the period 2020-2025 is the same as the average MN utility annual growth rate during the 2005-2020 period the retail electricity sales forecast for MN utilities/NUGs appears below.

MN utilities/NUGs	2005	2010	2015	2020	2025
Actual net generation (GWh)	50,124				
Actual sales (GWh)	48,868				
<b>Annual sales growth proposal (%/yr) &gt;&gt;&gt;</b>	<b>1.72%</b>	<b>1.72%</b>	<b>1.72%</b>	<b>1.72%</b>	<b>1.72%</b>
<b>Forecasted sales (GWh)</b>	<b>48,868</b>	<b>53,206</b>	<b>57,929</b>	<b>63,071</b>	<b>68,669</b>

## 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, or about 5% of total net generation in MN in 2005.

Fuel Type	MN net generation (GWh)				Share of MN net generation (%)			
	Utilities	NUGs	Cogenerators	Total	Utilities	NUGs	Cogenerators	Total
Coal	30,515	1,409	985	32,909	57.6%	2.7%	1.9%	62.2%
Hydroelectric	575	61	62	697	1.1%	0.1%	0.1%	1.3%
Natural Gas	1,706	0	1,037	2,744	3.2%	0.0%	2.0%	5.2%
Nuclear	12,835	0	0	12,835	24.2%	0.0%	0.0%	24.2%
Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
Other Gases	0	0	73	73	0.0%	0.0%	0.1%	0.1%
Other Renewables	408	1,860	482	2,749	0.8%	3.5%	0.9%	5.2%
Petroleum	753	2	177	931	1.4%	0.0%	0.3%	1.8%
Pumped Storage	0	0	0	0	0.0%	0.0%	0.0%	0.0%
<b>Total</b>	<b>46,791</b>	<b>3,332</b>	<b>2,815</b>	<b>52,939</b>	<b>88.4%</b>	<b>6.3%</b>	<b>5.3%</b>	<b>100.0%</b>

## 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.

NERC Region	Cogenerated electricity shares		Total
	on-site	retail	
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%
<b>Mid-Continent Area Power Pool</b>	<b>87%</b>	<b>13%</b>	<b>100%</b>
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%
<b>United States average</b>	<b>82%</b>	<b>18%</b>	<b>100%</b>

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

- The amount of electricity sold to MN end users is less than net electricity generation due to losses in the T&D system.
- Using the data available, I calculated T&D losses as 2.5% in MN, as summarized in the table below.

Fuel Type	MN utilities/NUGs		T&D losses (%)
	Net generation (GWh)	Sales (GWh)	
Utilities	46,791		
NUGs	3,332		
Total/average	50,124	48,868	<b>2.5%</b>

## But... the calculated T&D losses seem low....

- 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).

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%	5.4%
Electric Reliability Council of Texas	1.5%	5.3%	5.1%	5.1%	5.1%	5.1%
Mid-Atlantic Area Council	12.9%	5.8%	5.4%	5.4%	5.4%	5.4%
Mid-America Interconnected Network	2.2%	5.5%	5.2%	5.2%	5.2%	5.2%
<b>Mid-Continent Area Power Pool</b>	<b>4.7%</b>	<b>7.0%</b>	<b>6.6%</b>	<b>6.7%</b>	<b>6.6%</b>	<b>6.6%</b>
Northeast Power Coordinating Council / New York	7.8%	6.3%	6.0%	6.1%	6.1%	6.1%
Northeast Power Coordinating Council / New England	7.5%	6.4%	6.0%	6.0%	6.0%	6.0%
Florida Reliability Coordinating Council	2.6%	5.5%	5.1%	5.1%	5.1%	5.1%
Southeastern Electric Reliability Council	5.5%	5.5%	5.2%	5.2%	5.2%	5.2%
Southwest Power Pool	9.0%	6.5%	6.2%	6.2%	6.2%	6.2%
Western Electricity Coordinating Council / Northwest Power Pool Area	8.9%	7.4%	7.0%	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%	7.0%
Western Electricity Coordinating Council / California	3.2%	7.7%	7.2%	7.2%	7.2%	7.2%
<b>United States average</b>	<b>5.6%</b>	<b>6.0%</b>	<b>5.7%</b>	<b>5.7%</b>	<b>5.7%</b>	<b>5.7%</b>

## 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 (first red-shaded row);
- T&D losses in MN are 2.5% throughout the period 2005-2025 (second red-shaded row);
- The average annual retail electricity sales growth rate for cogenerators is the same as the average MN utility/NUG annual growth rate (third red-shaded row);

MN Cogenerators	2005	2010	2015	2020	2025
Actual net generation (GWh)	2,815				
Share available for retail load proposal (%) >>>	13%	13%	13%	13%	13%
Assumed net generation for retail load (GWh)	355				
T&D loss proposal (%) >>>	2.5%	2.5%	2.5%	2.5%	2.5%
Assumed actual sales (GWh)	346				
Annual sales growth proposal (%/yr) >>>	1.72%	1.72%	1.72%	1.72%	1.72%
<b>Assumed forecasted sales (GWh)</b>	<b>346</b>	<b>377</b>	<b>410</b>	<b>446</b>	<b>486</b>

## 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 0.75 in 2005, as summarized in the table below.

	2005
MN retail electricity sales (GWh)	66,019
MN retail electricity sales by MN facilities (GWh)	
Utilities/NUGs	48,868
Cogenerators	346
<b>Total</b>	<b>49,214</b>
<b>MN sales to total sales ratio proposal &gt;&gt;&gt;</b>	<b>0.75</b>
<b>Overall MN sales forecast (GWh)</b>	<b>66,019</b>

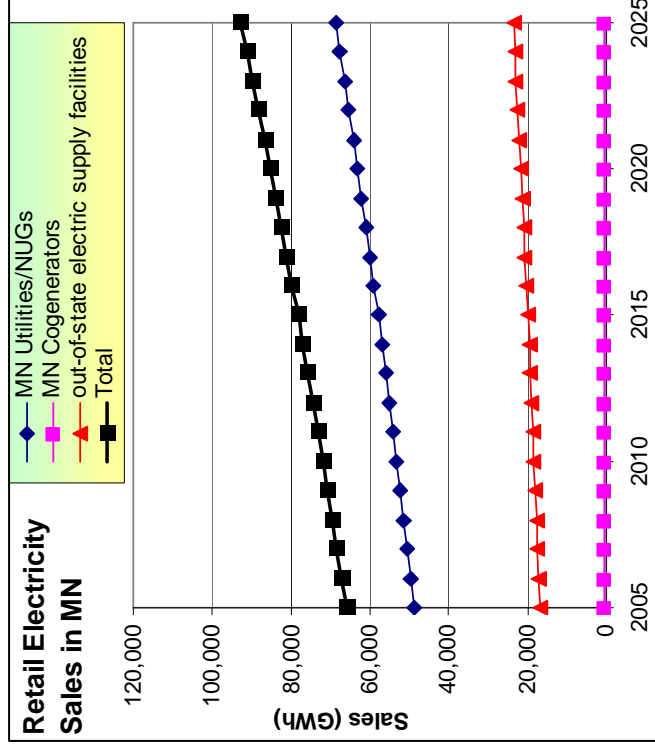
# We are now ready to estimate total retail sales from all MN energy supply facilities....

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

	2005	2010	2015	2020	2025
MN retail electricity sales (GWh)	66,019				
MN retail electricity sales by MN facilities (GWh)					
Utilities/NUGs	48,868	53,206	57,929	63,071	68,669
Cogenerators	346	377	410	446	486
<b>Total</b>	<b>49,214</b>	<b>53,582</b>	<b>58,339</b>	<b>63,517</b>	<b>69,155</b>
<b>MN sales to total sales ratio proposal &gt;&gt;&gt;</b>	<b>0.75</b>	<b>0.75</b>	<b>0.75</b>	<b>0.75</b>	<b>0.75</b>
<b>Overall MN sales forecast (GWh)</b>	<b>66,019</b>	<b>71,879</b>	<b>78,259</b>	<b>85,206</b>	<b>92,769</b>

# Finally, summarizing retail electricity sale forecast results... and the open questions....

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



- TWG feedback is requested regarding the adequacy of following 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**

# Gross generation forecast

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## 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, the TWG will need to estimate on-site power use.
- AEO2007 provides estimates of on-site electricity use by region;
- In 2005, average on-site electricity use in the USA was 0.9%, and is projected to decrease to 0.7% by 2025 (see yellow-shaded row).
- In 2005, average on-site electricity use in MAPP was 0.9%, and is projected to decrease to 0.3% by 2025 (see green-shaded row).

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%
<b>Mid-Continent Area Power Pool</b>	<b>0.8%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>0.3%</b>
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%
<b>United States average</b>	<b>0.9%</b>	<b>0.8%</b>	<b>0.8%</b>	<b>0.7%</b>	<b>0.7%</b>

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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 input data and assumptions (red-shaded rows), gross generation of MN energy supply facilities is summarized below.

MN facilities	2005	2010	2015	2020	2025
Retail sales (GWh)					
Utilities/NUGs	48,868	53,206	57,929	63,071	68,669
Cogenerators	346	377	410	446	486
Total	49,214	53,582	58,339	63,517	69,155
<b>T&amp;D loss proposal (%) &gt;&gt;&gt;</b>	<b>2.5%</b>	<b>2.5%</b>	<b>2.5%</b>	<b>2.5%</b>	<b>2.5%</b>
Net generation (GWh)					
Utilities/NUGs	50,124	54,573	59,417	64,691	70,433
Cogenerators	355	386	420	458	498
Total	50,478	54,959	59,837	65,149	70,932
<b>On-site use proposal (%) &gt;&gt;&gt;</b>	<b>0.8%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>0.3%</b>
<b>Share available for on-site use proposal (%) &gt;&gt;&gt;</b>	<b>87%</b>	<b>87%</b>	<b>87%</b>	<b>87%</b>	<b>87%</b>
Gross generation (GWh)					
Utilities/NUGs	50,544	54,740	59,597	64,876	70,634
Cogenerators	2,815	3,065	3,337	3,633	3,956
<b>Total</b>	<b>53,359</b>	<b>57,804</b>	<b>62,934</b>	<b>68,510</b>	<b>74,589</b>

## 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.

Type	MN Nameplate Capacity (MW)			Share
	Utilities	NUGs	Total	
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%
<b>Total</b>	<b>11,207</b>	<b>1,005</b>	<b>12,212</b>	<b>100%</b>

## 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.

Fuel Type	MN net generation (GWh)			Share (%)
	Utilities	NUGs	Total	
Coal	30,515	1,409	31,924	64%
Hydroelectric	575	61	636	1%
Natural Gas	1,706	0	1,706	3%
Nuclear	12,835	0	12,835	26%
Other	0	0	0	0%
Other Gases	0	0	0	0%
Other Renewables	408	1,860	2,268	5%
Petroleum	753	2	755	2%
Pumped Storage	0	0	0	0%
<b>Total</b>	<b>46,791</b>	<b>3,332</b>	<b>50,124</b>	<b>100%</b>

## 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 67%, 6%, and 10%, respectively.

Fuel type	Capacity factor, 2005 (%)		
	Utilities	NUGs	Average
Coal	67%	64%	67%
Hydroelectric	48%	50%	48%
Natural Gas	6%	N/A	6%
Nuclear	85%	N/A	85%
Other	N/A	N/A	N/A
Other Gases	N/A	N/A	N/A
Other Renewables	27%	29%	29%
Petroleum	10%	12%	10%
Pumped Storage	N/A	N/A	N/A
<b>Total</b>	<b>48%</b>	<b>38%</b>	<b>47%</b>

## 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).

Fuel type	MAPP		MN	
	TWh	Share	GWh	Share
Coal	117,348	74%	31,924	64%
Hydroelectric	7,460	5%	636	1%
Natural Gas	4,046	3%	1,706	3%
Nuclear	24,687	16%	12,835	26%
Other	558	0%	0	0%
Other Gas	0	0%	0	0%
Other Renewables	4,150	3%	2,268	5%
Petroleum	350	0%	755	2%
Pumped Storage	0	0%	0	0%
<b>All Sources</b>	<b>158,600</b>	<b>100%</b>	<b>50,124</b>	<b>100%</b>

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## 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 capacity added is natural-gas-fired combined cycle and combustion turbine units (48%), followed by coal steam (45%) and non-hydro renewables (7%).

Fuel type	Retirements	Additions	Net additions	Share
Coal	325	2,642	2,317	45%
Hydroelectric	0	9	9	0%
Natural Gas	5	2,443	2,438	48%
Nuclear	0	0	0	0%
Other	0	0	0	0%
Other Gas	0	0	0	0%
Other Renewables	0	365	365	7%
Petroleum	0	0	0	0%
Pumped Storage	0	0	0	0%
<b>All Sources</b>	<b>330</b>	<b>5,458</b>	<b>5,128</b>	<b>100%</b>

## How does net generation in the MAPP region vary during the forecast period?

- The MAPP region shows net generation shares are projected to become
  - more coal- and oil-intensive, and
  - less nuclear-, renewables-, and natural gas-intensive.

Fuel type	MAPP Generation share		Change
	2005	2025	
Coal	74.0%	78.8%	4.8%
Hydroelectric	4.7%	4.5%	-0.2%
Natural Gas	2.6%	1.3%	-1.2%
Nuclear	15.6%	13.2%	-2.3%
Other	0.4%	0.0%	-0.4%
Other Gas	0.0%	0.0%	0.0%
Other Renewables	2.6%	1.7%	-1.0%
Petroleum	0.2%	0.5%	0.2%
Pumped Storage	0.0%	0.0%	0.0%
<b>All Sources</b>	<b>100.0%</b>	<b>100.0%</b>	<b>0.0%</b>

## What new capacity is planned for MN during the forecast period?

- Planned additions for MN utilities and NUGs for 2006-2010 show that most of the planned capacity (2,229 MW or 93% of total additions) natural gas-fired;
- At least through 2010, available information suggests that the MN electric supply sector is likely to become
  - less coal-, oil-, nuclear-, and hydro-intensive, and
  - more natural gas- and renewable intensive (i.e., wind).

Fuel type	Planned nameplate capacity additions (MW)					Total
	2006	2007	2008	2009	2010	
Coal	7	0	0	0	0	7
Hydroelectric	0	0	0	0	0	0
Natural Gas	531	290	1,108	300	0	2,229
Nuclear	0	0	0	0	0	0
Other	0	0	0	0	0	0
Other Gas	0	0	0	0	0	0
Other Renewables	99	64	0	0	0	163
Petroleum	5	0	0	0	0	5
Pumped Storage	0	0	0	0	0	0
<b>All Sources</b>	<b>642</b>	<b>354</b>	<b>1,108</b>	<b>300</b>	<b>0</b>	<b>2,404</b>

## **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.

## For the Reference Case without the RPS....

- It seems reasonable to assume that new capacity added during the period 2011-2025 would continue the trend for natural gas-fired generation;
- Assuming all new capacity in the 2011-2025 period would be natural gas-fired.....

	2005 (MW)	2006-2010 Period (MW)			2011-2025 Period (MW)			2005-2025 Period (MW)			2025	
		Retired	Additions	Net additions	Retired	Additions	Net additions	Retired	Additions	Net additions	(MW)	(GWh)
Coal	5,491	0	7	7	0	0	0	7	0	7	5,498	32,238
Hydroelectric	152	0	0	0	0	0	0	0	0	0	152	641
Natural Gas	3,087	0	2,229	2,229	0	759	759	0	2,988	2,988	6,075	21,351
Nuclear	1,737	0	0	0	0	0	0	0	0	0	1,737	12,943
Other	0	0	0	0	0	0	0	0	0	0	0	0
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0
Other Renewables	912	0	163	163	0	0	0	0	163	163	1,075	2,695
Petroleum	833	0	5	5	0	0	0	0	5	5	838	766
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>12,212</b>	<b>0</b>	<b>2,404</b>	<b>2,404</b>	<b>0</b>	<b>759</b>	<b>759</b>	<b>0</b>	<b>3,163</b>	<b>3,163</b>	<b>15,375</b>	<b>70,634</b>

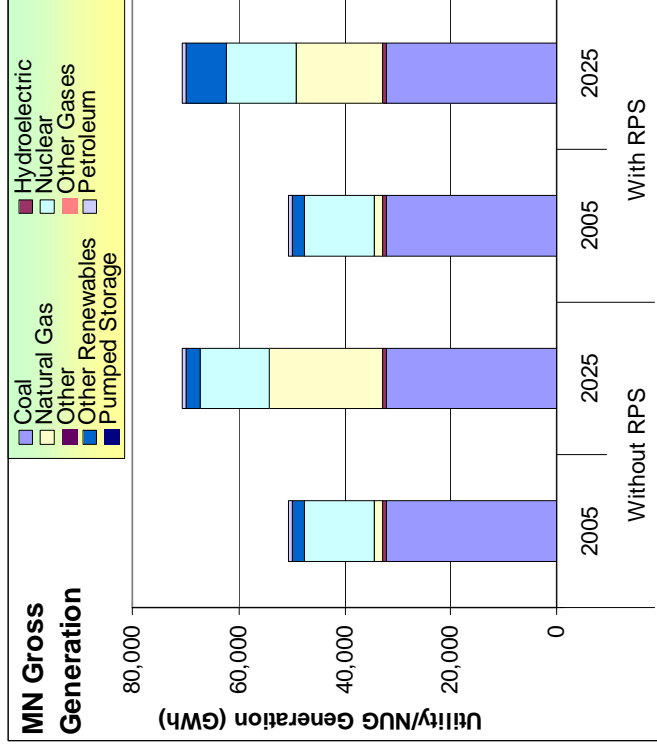
## For the Reference Case with the RPS....

- The 25% target by 2025 can be met by either in-state generation or the purchase of renewable energy credits by in-state generators;
- Eligible sources include solar, wind, hydro (<100 MW), renewably-generated H<sub>2</sub>, and biomass (including LFG, or RDF from MSW).
- It seems reasonable to assume that the share of in-state renewable generation. Assuming all new capacity in the 2011-2025 period would be renewable....

	2005 (MW)	2006-2010 Period (MW)			2011-2025 Period (MW)			2005-2025 Period (MW)			2025	
		Retired	Additions	Net additions	Retired	Additions	Net additions	Retired	Additions	Net additions	(MW)	(GWh)
Coal	5,491	0	7	7	0	0	0	0	7	7	5,498	32,238
Hydroelectric	152	0	0	0	0	0	0	0	0	0	152	641
Natural Gas	3,087	0	2,229	2,229	0	0	0	2,229	2,229	2,229	5,316	16,365
Nuclear	1,737	0	0	0	0	0	0	0	0	0	1,737	12,943
Other	0	0	0	0	0	0	0	0	0	0	0	0
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0
Other Renewables	912	0	163	163	0	1,099	1,099	0	1,262	1,262	2,174	7,681
Petroleum	833	0	5	5	0	0	0	0	5	5	838	766
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>12,212</b>	<b>0</b>	<b>2,404</b>	<b>2,404</b>	<b>0</b>	<b>1,099</b>	<b>1,099</b>	<b>0</b>	<b>3,503</b>	<b>3,503</b>	<b>15,715</b>	<b>70,634</b>

# 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 retirement 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 0.735 GW, with coal-fired, natural gas-fired and oil-fired stations representing about 25%, 46%, and 4% of total capacity, respectively.

Type	Nameplate Capacity	
	MW	Share (%)
Coal	185	25%
Hydroelectric	34	5%
Natural Gas	340	46%
Nuclear	0	0%
Other	11	1%
Other Gases	0	0%
Other Renewables	137	19%
Petroleum	28	4%
Pumped Storage	0	0%
<b>Total</b>	<b>735</b>	<b>100%</b>

## CHP net generation 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 6% of total net generation, respectively.

Fuel Type	MN net generation	
	GWh	Share (%)
Coal	985	35%
Hydroelectric	62	2%
Natural Gas	1,037	37%
Nuclear	0	0%
Other	0	0%
Other Gases	73	3%
Other Renewables	482	17%
Petroleum	177	6%
Pumped Storage	0	0%
<b>Total</b>	<b>2,815</b>	<b>100%</b>

## Combining capacity and net generation, these were the dispatch characteristics for MN CHP units in 2005....

- In 2005, coal-fired, natural gas-fired and oil-fired stations showed gross capacity factors of about 61%, 35%, and 72%, respectively.

Fuel type	Capacity factor (%)
Coal	61%
Hydroelectric	21%
Natural Gas	35%
Nuclear	N/A
Other	N/A
Other Gases	75%
Other Renewables	40%
Petroleum	72%
Pumped Storage	N/A
<b>Total</b>	<b>44%</b>

## 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 other renewables
  - more intensive regarding natural gas, other gases, and oil

Fuel type	Share (%)		Difference
	MAPP	MN	
Coal	63%	35%	-28%
Hydroelectric	2%	2%	0%
Natural Gas	10%	37%	27%
Nuclear	0%	0%	0%
Other	2%	0%	-2%
Other Gas	2%	3%	1%
Other Renewables	20%	17%	-3%
Petroleum	2%	6%	4%
Pumped Storage	0%	0%	0%
<b>All Sources</b>	<b>100%</b>	<b>100%</b>	<b>0%</b>

## 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	MAPP CHP Generation share		
	2005	2025	Change
Coal	63%	91%	28%
Hydroelectric	2%	0%	-2%
Natural Gas	10%	3%	-6%
Nuclear	0%	0%	0%
Other	2%	0%	-2%
Other Gas	2%	0%	-1%
Other Renewables	20%	4%	-16%
Petroleum	2%	1%	-1%
Pumped Storage	0%	0%	0%
<b>All Sources</b>	<b>100%</b>	<b>100%</b>	<b>0%</b>

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

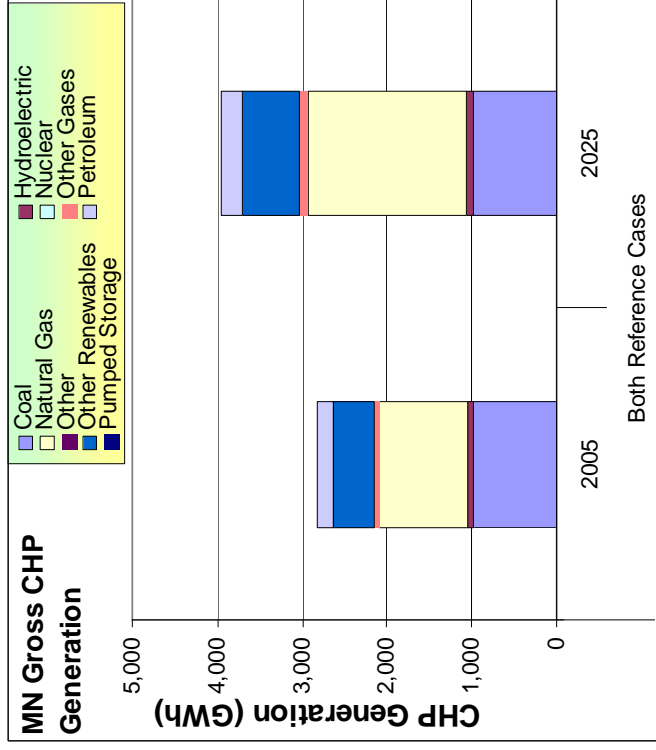
- Unless an annual schedule of planned additions (by type) over 2011-2025 can be obtained, with a schedule of planned retirements (by type) over 2006-2025, I'm not able to estimate gross generation mix at CHP units using a bottom-up approach.
- In the absence of such data, **assume that the cogeneration fuel mix over the 2005-2025 follows the trend of more natural gas and less coal, as evident for electric utilities/NUGs;**
- **Assume that this trend holds for both Reference Cases (i.e., with and without the RPS).**

Fuel Type	CHP Net Generation share (%)		CHP Net Generation (GWh)	
	2005	2025	2005	2025
Coal	35%	25%	985	989
Hydroelectric	2%	2%	62	87
Natural Gas	37%	47%	1,037	1,853
Nuclear	0%	0%	0	0
Other	0%	0%	0	0
Other Gas	3%	3%	73	102
Other Renewables	17%	17%	482	677
Petroleum	6%	6%	177	248
Pumped Storage	0%	0%	0	0
<b>All Sources</b>	<b>100%</b>	<b>100%</b>	<b>2,815</b>	<b>3,956</b>

10/8/2007

# 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;



10/8/2007

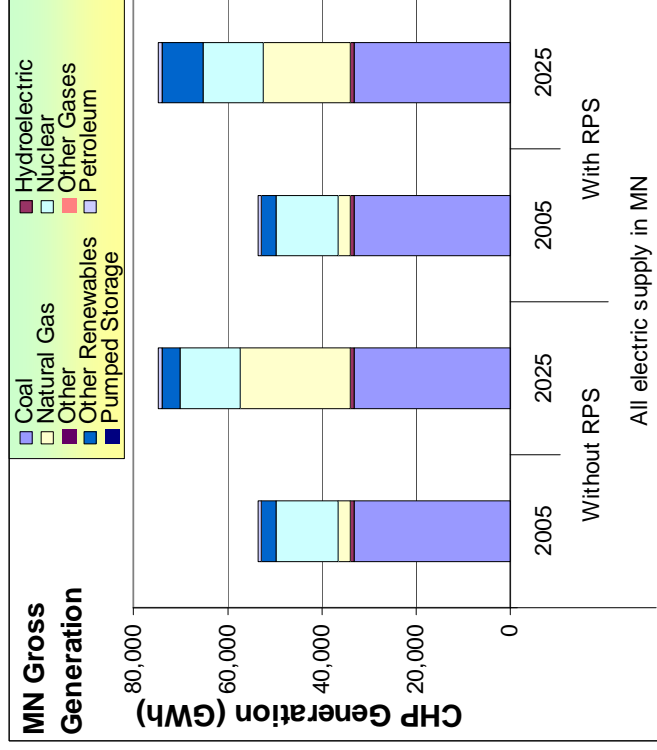
- TWG feedback is requested regarding the adequacy of following assumptions:

- **Net generation shares over the 2006-2025 period;**
- **Impact of the recent RPS legislation on CHP system expansion;**

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# 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 following assumptions identified earlier:

# Primary energy forecast

10/8/2007

Minnesota Climate Change Advisory Group

[www.mnclimatechange.us/](http://www.mnclimatechange.us/)

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Center for Climate Strategies

[www.climatestrategies.us](http://www.climatestrategies.us)

## 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.

	utility & NUG data, 2005		
Fuel type	Gross Generation (GWh)	Energy use (billion btu)	Heat rate (btu/kWh)
Coal	32,175	352,272	10,949
Hydroelectric	641	7,130	11,132
Natural Gas	1,720	19,251	11,194
Nuclear	12,936	133,974	10,357
Other	0	0	N/A
Other Gas	0	0	N/A
Other Renewables	2,286	28,229	12,350
Petroleum	761	7,915	10,403
Pumped Storage	0	0	N/A
<b>All Sources</b>	<b>50,518</b>	<b>548,772</b>	<b>10,863</b>

## Average heat rates over the forecast period ....

- Average heat rates over the forecast period by in-state utilities and NUGs will vary depending on capacity addition/retirement and capacity factor assumptions described earlier;

Fuel type	Average heat rates (btu/kWh)			
	Without RPS		With RPS	
	2005	2025	2005	2025
Coal	10,943	10,939	10,943	10,939
Hydroelectric	11,127	11,127	11,127	11,127
Natural Gas	11,188	7,338	11,188	7,440
Nuclear	10,351	10,351	10,351	10,351
Other	N/A	N/A	N/A	N/A
Other Gas	N/A	N/A	N/A	N/A
Other Renewables	12,344	12,040	12,344	10,351
Petroleum	10,398	10,398	10,398	10,398
Pumped Storage	N/A	N/A	N/A	N/A

## Summarizing primary energy use at utilities and NUGs over the forecast period ....

- Primary energy use at MN utilities and NUGs is forecasted to grow from 549 trillion btu in 2005 to 691 trillion btu in 2025 for the Reference Case without the RPS;
- Primary energy use at MN utilities and NUGs is forecasted to grow from 549 trillion btu in 2005 to 703 trillion btu in 2025 for the Reference Case with the RPS.

Fuel type	Primary energy use (trillion btu)			
	Without RPS		With RPS	
	2005	2025	2005	2025
Coal	352	353	352	353
Hydroelectric	7	7	7	7
Natural Gas	19	157	19	122
Nuclear	134	134	134	134
Other	0	0	0	0
Other Gas	0	0	0	0
Other Renewables	28	32	28	80
Petroleum	8	8	8	8
Pumped Storage	0	0	0	0
<b>Total</b>	<b>549</b>	<b>691</b>	<b>549</b>	<b>703</b>

## 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 rate for 2005.

Fuel type	CHP data, 2005		
	Gross Generation (GWh)	Energy use (billion btu)	Heat rate (btu/kWh)
Coal	985	7,190	7,299
Hydroelectric	62	616	9,999
Natural Gas	1,037	10,277	9,906
Nuclear	0	0	N/A
Other	0	0	N/A
Other Gas	73	849	11,704
Other Renewables	482	6,003	12,464
Petroleum	177	4,236	23,985
Pumped Storage	0	0	N/A
<b>All Sources</b>	<b>2,815</b>	<b>29,172</b>	<b>10,363</b>

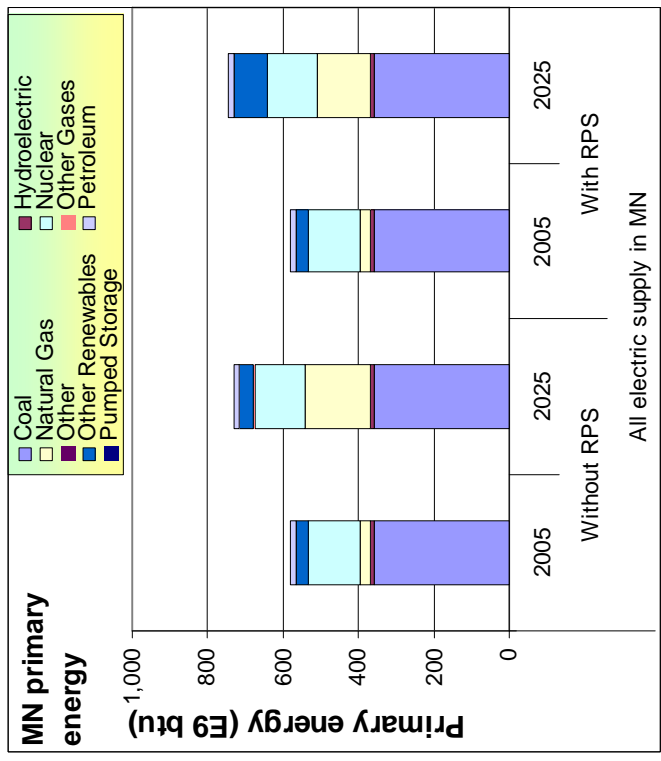
## Average heat rates over the forecast period ....

- 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.
- Assume that average heat rates observed for 2005 hold for the period 2006-2025;

Fuel type	Primary energy use (trillion btu)	
	2005	2025
Coal	7.2	7.2
Hydroelectric	0.6	0.9
Natural Gas	10.3	18.4
Nuclear	0.0	0.0
Other	0.0	0.0
Other Gas	0.8	1.2
Other Renewables	6.0	8.4
Petroleum	4.2	6.0
Pumped Storage	0.0	0.0
<b>Total</b>	<b>29.2</b>	<b>42.0</b>

# 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 following assumptions identified earlier:

# Imported electricity forecast

10/8/2007

Minnesota Climate Change Advisory Group

[www.mnclimatechange.us/](http://www.mnclimatechange.us/)

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Center for Climate Strategies

[www.climatestrategies.us](http://www.climatestrategies.us)

## First, let's focus on the sales met by electric supply located outside MN ....

- Based on the assumptions referenced earlier, retail electricity sales associated with sources located outside MN were 16.8 TWh in 2005 and would be 23.6 TWh in 2025.

	2005	2010	2015	2020	2025
Overall MN sales forecast (GWh)	66,019	71,879	78,259	85,206	92,769
Sales from electric supply sources (GWh)					
Within MN	49,214	53,582	58,339	63,517	69,155
<b>Outside MN</b>	<b>16,805</b>	<b>18,297</b>	<b>19,921</b>	<b>21,689</b>	<b>23,614</b>

# Now, let's establish overall gross generation by electric supply located outside MN that exports power to MN to meet its electricity demand ....

- To first order, it seems reasonable to assume that the T&D losses and on-site usage for imported power would be similar to characteristics of the MAPP region;
- Based on this assumption, gross generation associated with sources located outside MN to meet MN retail electricity demand were 17.8 TWh in 2005 and would be 25.4 TWh in 2025.

	2005	2010	2015	2020	2025
Sales from electric supply sources located outside MN (GWh)	16,805	18,297	19,921	21,689	23,614
<b>T&amp;D loss proposal (%) &gt;&gt;&gt;</b>	<b>4.7%</b>	<b>7.0%</b>	<b>6.6%</b>	<b>6.7%</b>	<b>6.6%</b>
Net generation from electric supply sources located outside MN (GWh)	17,626	19,674	21,339	23,235	25,294
<b>On-site use proposal (%) &gt;&gt;&gt;</b>	<b>0.8%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>0.3%</b>
<b>Gross generation from electric supply sources located outside MN (GWh)</b>	<b>17,774</b>	<b>19,734</b>	<b>21,404</b>	<b>23,301</b>	<b>25,365</b>

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

- Please note that the generation mix associated with imported power over the period 2005-2025 is not yet clear to me;
- Pending inputs from the TWG, I've assumed for now that the generation mix associated with imported power in 2005 is consistent with the MAPP region mix.

Fuel type	MAPP gross generation, 2005 (GWh)			
	Utilities & NUGs	CHP	Total	Share
Coal	118,333	2,366	120,699	74%
Hydroelectric	7,523	77	7,600	5%
Natural Gas	4,195	360	4,555	3%
Nuclear	24,894	0	24,894	15%
Other	0	61	61	0%
Other Gas	0	74	74	0%
Other Renewables	4,081	753	4,834	3%
Petroleum	916	76	992	1%
Pumped Storage	0	0	0	0%
<b>All Sources</b>	<b>159,942</b>	<b>3,767</b>	<b>163,709</b>	<b>100%</b>

## The MAPP generation mix associated with imported power changes during the forecast period.....

- MAPP’s gross generation mix remains fairly stable over the forecast period.

Fuel type	MAPP characteristics			
	Gross generation (GWh)		Gross generation shares (%)	
	2005	2025	2005	2025
Coal	120,699	171,500	74%	76%
Hydroelectric	7,600	13,077	5%	6%
Natural Gas	4,555	3,340	3%	1%
Nuclear	24,894	25,097	15%	11%
Other	61	68	0%	0%
Other Gas	74	74	0%	0%
Other Renewables	4,834	10,365	3%	5%
Petroleum	992	1,041	1%	0%
Pumped Storage	0	0	0%	0%
<b>All Sources</b>	<b>163,709</b>	<b>224,561</b>	<b>100%</b>	<b>100%</b>

# The combustion efficiency of the MAPP generation mix associated with imported power changes during the forecast period.....

- MAPP’s combustion efficiency improves across all fuels during the forecast period.

Fuel type	MAPP gross generation (GWh)		MAPP primary energy (E12 btu)		MAPP average heat rate (btu/kWh)		MAPP average heat rate improvement (%)
	2005	2025	2005	2025	2005	2025	2005-2025
Coal	120,699	171,500	1,326	1,582	10,986	9,227	-0.9%
Hydroelectric	7,600	13,077	78	134	10,280	10,280	0.0%
Natural Gas	4,555	3,340	47	20	10,361	5,928	-2.8%
Nuclear	24,894	25,097	258	260	10,351	10,351	0.0%
Other	61	68	1	1	10,351	10,351	0.0%
Other Gas	74	74	1	1	10,351	10,351	0.0%
Other Renewables	4,834	10,365	54	116	11,227	11,173	0.0%
Petroleum	992	1,041	10	9	10,420	8,745	-0.9%
Pumped Storage	0	0	0	0	N/A	N/A	N/A
<b>All Sources</b>	<b>163,709</b>	<b>224,561</b>	<b>1,775</b>	<b>2,123</b>	<b>10,843</b>	<b>9,453</b>	<b>-0.7%</b>

## The RPS and imported power ....

- MAPP's total level of renewable generation (i.e., including hydro and other renewables), exceeds the incremental level required to meet the MN RPS target.

	2005	2010	2015	2020	2025
RPS targets (%)	0%	0%	16%	19%	25%
Retail electricity sales in MN (GWh)	66,019	71,879	78,259	85,206	92,769
Required renewable energy generation (GWh)	0	0	12,326	16,530	23,192
MN renewable energy generation (GWh)	2,928	3,291	5,410	6,866	8,322
Additional renewable energy generation required (GWh)	0	0	6,916	9,664	14,870
Upper limit of renewable generation from MAPP region (GWh)	12,435	14,636	16,838	19,039	23,442
<b>Possible to meet incremental renewable generation from MAPP?</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>

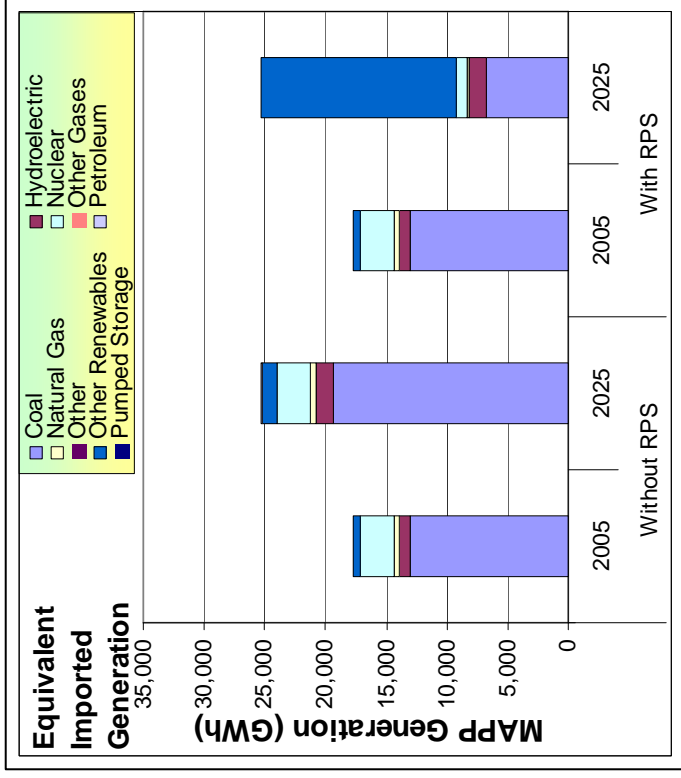
# Finally, we can estimate the gross generation mix and primary energy use associated with imported power ....

- The References Cases with and without the RPS show a significant impact on imported power;
- The gross generation and primary energy assumptions assume that the balance of renewable generation to meet MN's RPS targets result in a prorata reduction for all non-renewable energy sources from MAPP

Fuel type	MN imported power equivalents							
	Without RPS				With RPS			
	Gross generation (GWh)		Primary energy (E12 btu)		Gross generation (GWh)		Primary energy (E12 btu)	
	2005	2025	2005	2025	2005	2025	2005	2025
Coal	13,104	19,372	144	179	13,104	6,691	144	62
Hydroelectric	825	1,477	8	15	825	1,477	8	15
Natural Gas	495	377	5	2	495	130	5	1
Nuclear	2,703	2,835	28	29	2,703	979	28	10
Other	7	8	0	0	7	3	0	0
Other Gas	8	8	0	0	8	3	0	0
Other Renewables	525	1,171	6	13	525	16,041	6	179
Petroleum	108	118	1	1	108	41	1	0
Pumped Storage	0	0	0	0	0	0	0	0
<b>All Sources</b>	<b>17,774</b>	<b>25,365</b>	<b>193</b>	<b>240</b>	<b>17,774</b>	<b>25,365</b>	<b>193</b>	<b>267</b>

# Summarizing imported power 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;**
  - 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;**