Preliminary Results for the Minnesota RCI Analysis of Standalone Mitigation Options

Bill Dougherty

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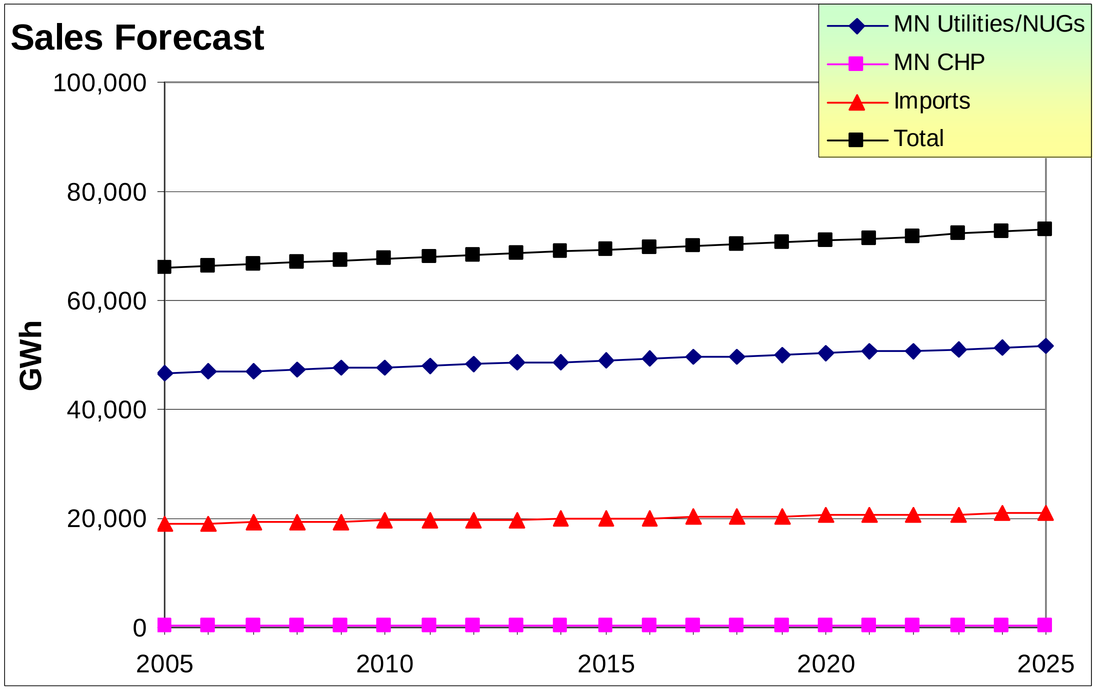
Outline

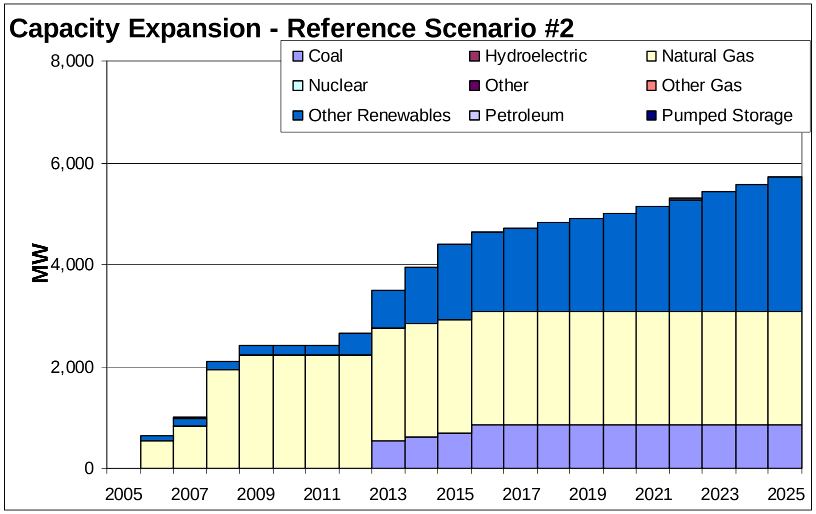
- Summary of results
- Framework
- Sales forecast
- Avoided cost estimate
- GHG emission forecast
- Analytical results of mitigation options (RCI-1, RCI-2, RCI-3, RCI-4, RCI-5, RCI-6, RCI-7, RCI-8, RCI-9, RCI-10)

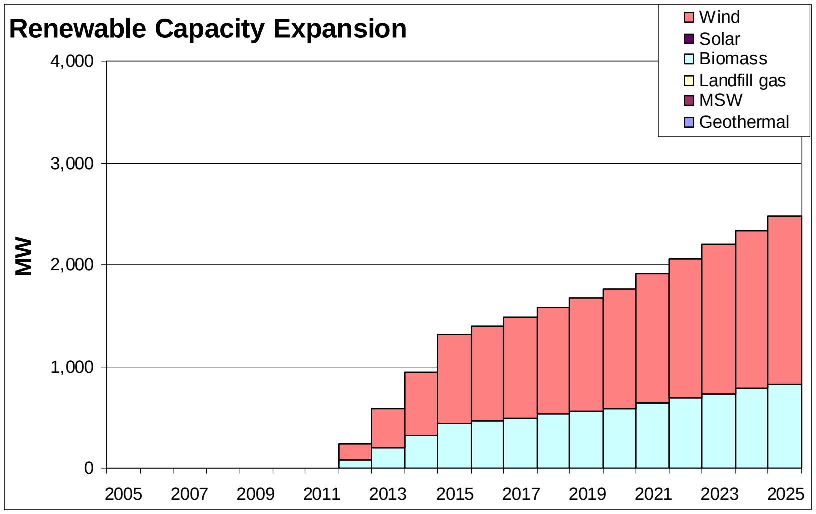
Summary of results

Projected electricity sales in MN….



Electric capacity expansion in MN ….



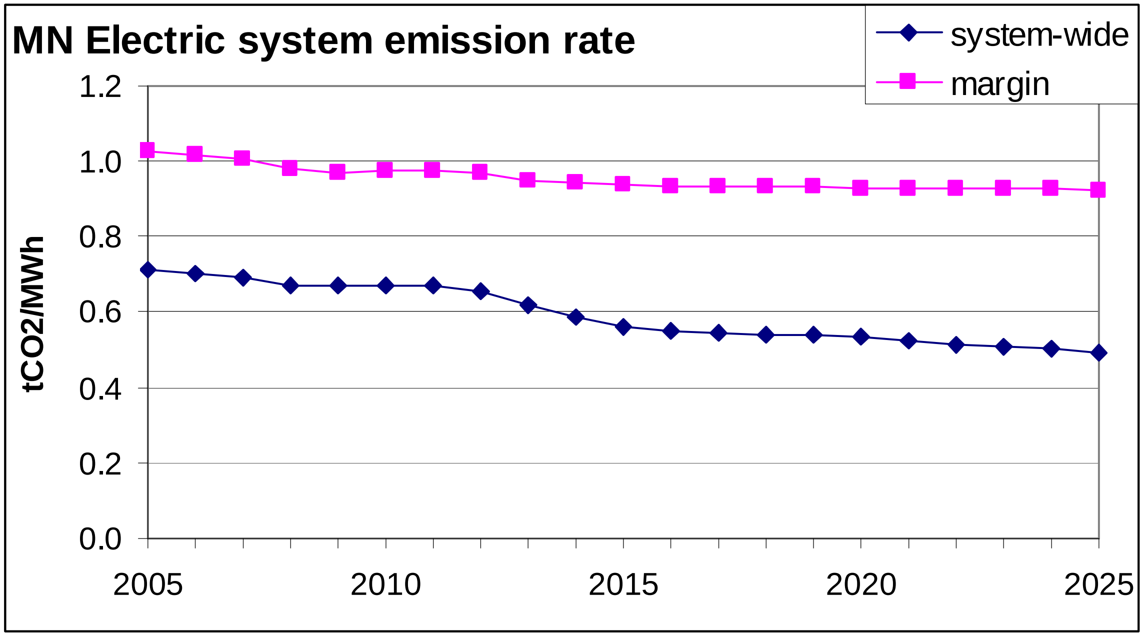


Avoided costs associated with electric capacity expansion in MN ….

Estimated MN Avoided costs (2005$/MWh)

Capacity	32
Transmission	1
Fixed O&M	6
Variable O&M	5
Fuel	28
Total	**71**

GHG emissions associated with electricity sales in MN ….



Summary of results ….

	GHG Reductions (million tonnes CO2e)			NPV of Costs (E6 2005$)	Cost of Saved Carbon (2005$/tCO2e avoided)
	Annual		Cumulative		
	2015	2025			
RCI-1	3.8	8.7	82.8	-$2,408	-$29.1
RCI-2	0.0	0.0	0.1	-$11	-$189.7
RCI-3	0.3	0.4	5.0	-$1	-$0.3
RCI-4	1.9	9.8	65.5	$1,803	$27.5
RCI-5	***still under preparation***				
RCI-6	2.5	12.9	82.8	-$3,075	-$37.1
RCI-7	***still under preparation***				
RCI-8	unquantified				
RCI-9	unquantified				
RCI-10	unquantified				

Framework

My understanding of the TWG's framework for developing the GHG mitigation analysis is as follows:

- Apply inputs from the energy supply TWG analysis as needed, namely:
  - Electric sector capacity expansion schedule
  - Avoided costs for electric sector expansion
  - T&D losses
  - Marginal GHG emission factors
- Undertake a "bottom-up" GHG forecast associated with all demand side options;
- Assume a planning horizon of 2005 - 2025;
- Consider a Reference Scenario that includes the recently passed RES and CIP legislation. For RCI-1, estimate savings assuming the pre-new CIP legislation context:

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

- Explicitly document input data from the ES TWG, including the following:
  - Planned capacity/retirement schedule
  - GHG emissions forecast
  - Avoided costs
- Explicitly document input data and results regarding the GHG mitigation analysis, including the following:
  - Cost & performance assumptions for RCI measures
  - Financial parameter and levelization assumptions
  - GHG reductions and costs associated with each of the quantifiable RCI mitigation options on a standalone basis
- Continue to solicit feedback from the RCI TWG regarding any input data or assumptions that needs to be corrected/revisited

I've followed the steps in the flow diagram below for the standalone analysis of RCI mitigation options….

Develop **retail electricity sales** forecast
↓
Develop **gross generation** forecast
↓
Develop **primary energy use** forecast
↓
MN consumption-based **GHG forecast**

MN avoided costs for electric expansion

Develop **cost & performance** assumptions for all RCI measures to be quantified

RCI-1
RCI-2
RCI-3
RCI-4
RCI-5
RCI-6
RCI-7

The spreadsheets accompanying this memo are….

- For the GHG forecast, please refer to the following spreadsheets developed by the ES TWG:
  - "MN ES GHG forecast; with RPS & EE; with & without coal capacity additions - 19 November 2007.xls"
- For assumptions used to develop avoided costs, please refer to the spreadsheet entitled: "Estimate of MN avoided costs for RCI TWG options analysis.xls"
- For analysis of mitigation options, please refer to the spreadsheets:
  - RCI-1.xls
  - RCI-2.xls
  - RCI-3.xls
  - RCI-4.xls
  - RCI-5.xls
  - RCI-6.xls
  - RCI-7.xls

As always….

- RCI TWG members can modify the default assumptions in spreadsheets to assess the sensitivity to alternative assumptions by changing values in yellow-shaded cells with a red border; E.g.:

Assumed start year for the new CIP legislation

2009

Assumption for improvement of the residential building code relative to the current residential building code in areas where the building code HAS BEEN adotpted and IS BEING enforced

1

1	no improvement in energy efficiency (default)
2	User-defined

Assumption for improvement of the residential building code relative to the current residential building code in areas where the building code has NOT been adotpted

1

1	improvement in energy efficiency of	3%	(default)
2	User-defined		

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**

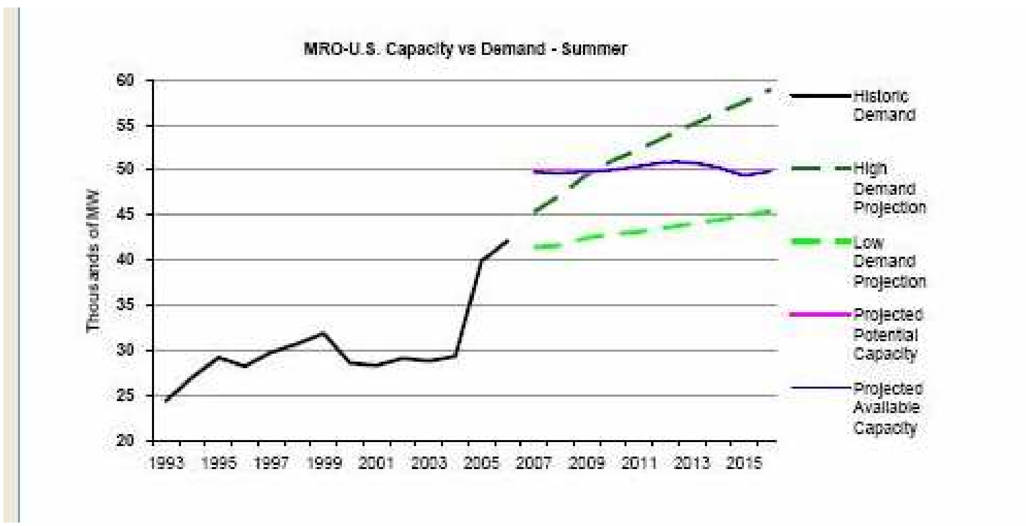
MN electric utilities and non-utility generators have filed official sales forecasts up through 2020….

- Based on
  - Certificate of Need applications for GRE, OTP, SMMPA, CMMPA, MRES
  - Advanced Forecast 2007 for Minnesota power;
  - Placeholders estimates for Xcel
- The average annual electric sales growth rate over the 2005-2020 period is 1.83% per year.

Electricity sales (GWh)	2005	2010	2015	2020	Growth rate, 2005-2020 (%/yr)
Central Minnesota Municipal Power Agency	710	820	952	1,114	3.05%
Great River Energy	607	689	771	854	2.30%
Xcel	31,712	34,410	37,493	40,753	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	9,052	11,681	12,292	12,616	2.24%
Total	46,655	52,596	56,940	61,210	1.83%

Input from ES TWG members regarding sales also shows high projected growth rates….

- NERC's October 2007 Long Term Reliability Assessment for the Midwest Reliability Organization-US,
  - 2007's energy consumption is expected to be 3.1% higher than in 2006,
  - 2.3%/yr expected over the next ten years (i.e., 2007-2016).
  - Census Bureau predicts that MN will have a MUCH higher population growth than any of the other states in the MRO over that time period, so MN's growth is likely to be higher.
- Historic and projected demand and capacity trends show the following



Direction by the ES TWG thus far put forward to the RCI TWG for consideration….

- Based on a decision reached by the ES TWG at its 25 October 2007 meeting, a **MN electricity sales growth rate equal to 0.5%/yr has been assumed for the 2006-2025 period**
  - This assumption includes the effect of the new CIP legislation (1.5%/year)
  - The leveled of embedded energy efficiency from past CIP measures is about 0.5%/yr
  - NOTE: This decision implies a growth rate below the average MN utility growth rate of 1.83%/yr and below NERC's October 2007 growth rate of 2.3%/yr, both of which do not include the effect of the recent CIP.

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		
NERC Region	on-site	retail	Total
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%**

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.**

	T&D losses (% of total net energy for load)				
NERC Region	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 331 GWh in 2005 to 365 GWh in 2025

Forecasted sales from CHP facilities	2005	2010	2015	2020	2025
Actual net generation (GWh)	2,815				
Share available for retail load proposal (%) >>>	13%	14%	42%	46%	53%
Assumed net generation for retail load (GWh)	355				
T&D loss proposal (%) >>>	6.8%	7.0%	6.6%	6.7%	6.6%
Assumed actual sales (GWh)	331				
Annual sales growth proposal (%/yr) >>>	0.50%	0.50%	0.50%	0.50%	0.50%
Assumed forecasted sales (GWh)	331	339	347	356	365

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 0.712 in 2005, as summarized in the table below.
- Note also that the ratio of CHP retail sales to total sales is quite low, 0.005 (i.e., 331/55,019).

Forecasted overall sales in MN	2005
Base year MN retail electricity sales (GWh)	66,019
Sales by MN utilities/NUGs (GWh)	46,655
Sales by MN CHP facilities (GWh)	331
Total sales by MN facilities (GWh)	46,986
Ratio of MN utility/NUG/CHP sales to total sales	0.712
Overall MN sales forecast (GWh)	66,019
Total sales by non-MN facilities (GWh)	19,033

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	2005	2010	2015	2020	2025
Base year MN retail electricity sales (GWh)	66,019				
Sales by MN utilities/NUGs (GWh)	46,655	47,825	49,025	50,254	51,515
Sales by MN CHP facilities (GWh)	331	339	347	356	365
Total sales by MN facilities (GWh)	46,986	48,164	49,372	50,610	51,880
Ratio of MN utility/NUG/CHP sales to total sales	0.712	0.712	0.712	0.712	0.712
Overall MN sales forecast (GWh)	66,019	67,675	69,372	71,112	72,896
Total sales by non-MN facilities (GWh)	19,033	19,511	20,000	20,502	21,016

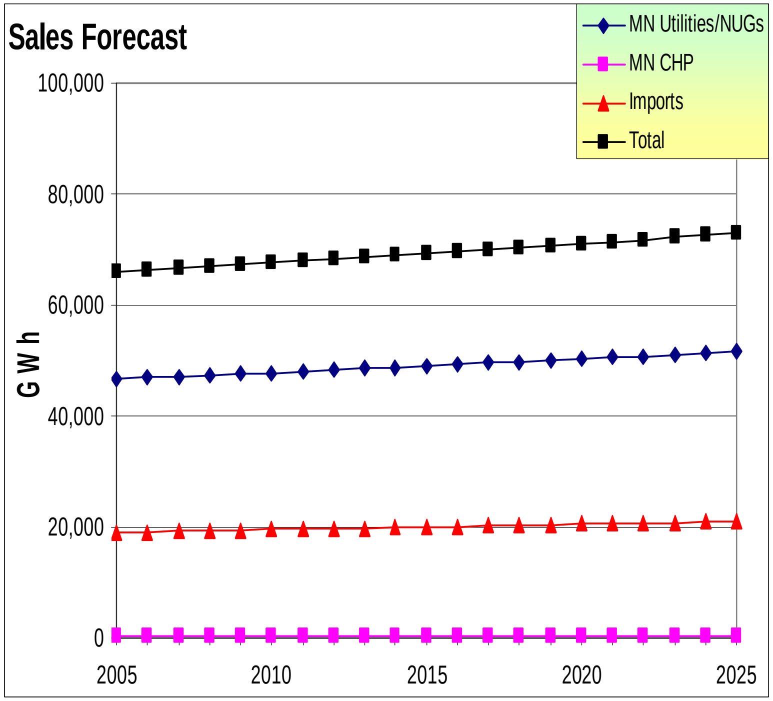
Given forecasted sale levels, we can make an estimate of total generation requirements from all MN energy supply facilities….

- Assuming T&D losses and parasitic load as per the MAPP average, generation requirements are as summarized below:

Forecasted gross generation in MN	2005	2010	2015	2020	2025
Sales by MN utilities/NUGs (GWh)	46,655	47,825	49,025	50,254	51,515
Sales by MN CHP facilities (GWh)	331	339	347	356	365
Total (GWh)	46,986	48,164	49,372	50,610	51,880
T&D losses (%)	7%	7%	7%	7%	7%
Net generation by MN utilities/NUGs (GWh)	50,068	51,424	52,516	53,835	55,178
Net generation by MN CHP facilities (GWh)	355	364	372	381	391
Total (GWh)	50,423	51,789	52,888	54,217	55,569
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)	50,462	51,582	52,675	53,991	55,335
Gross generation by MN CHP facilities (GWh)	2,815	2,891	2,953	3,027	3,102
Total (GWh)	53,277	54,473	55,628	57,018	58,437

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;

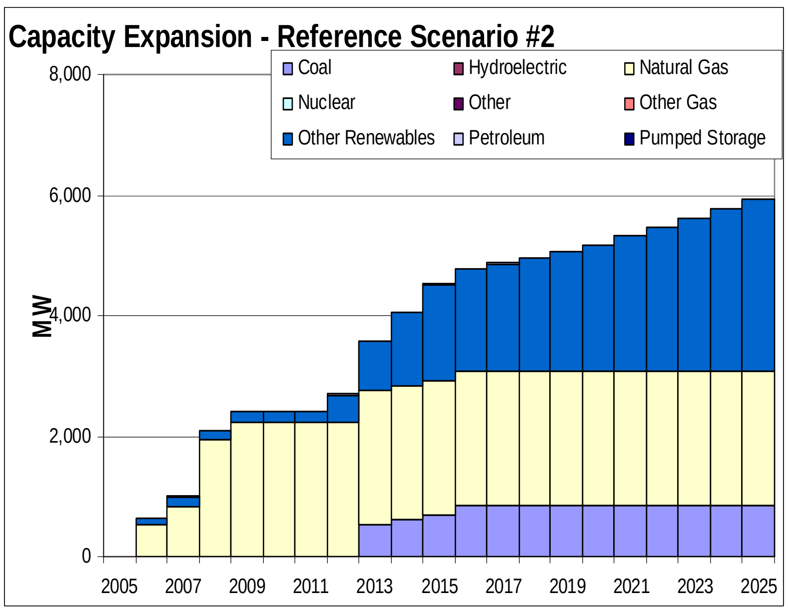


- To finalize the sales forecast, RCI TWG confirmation is sought regarding the following default assumptions:
  - **Average annual sales growth rate of 0.5%/yr which purports to fold in the effect of the recent CIP legislation;**

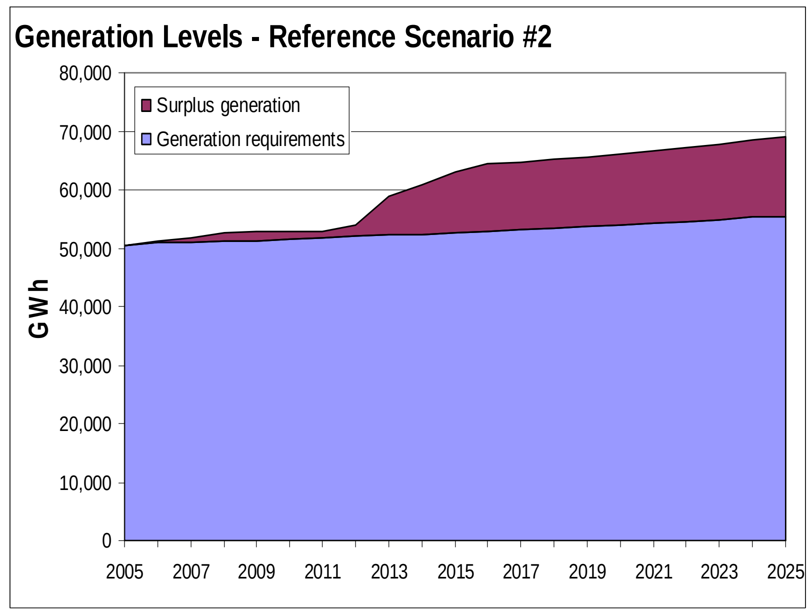
Avoided Cost Estimate

The ES TWG is assuming the following capacity expansion plan….

- Net cumulative capacity additions are summarized below for MN utilities/NUGs



- Gross generation levels associated with the expansion plan are as summarized below for MN utilities/NUGs



The RCI TWG has requested that the ES TWG weigh in on the appropriate magnitude of avoided costs ….

- Avoided costs have been discussed by the ES TWG
- The operating assumption regarding the nature of avoided costs (based on PURPA) used in the analysis is as follows:
  - Avoided costs are the fixed and running costs of an electric system which can be avoided by obtaining energy or capacity from qualifying facilities.
  - The avoided cost is the incremental cost of generating and delivering electric power that would not occur if an alternative source(s) were added to the system.
  - Avoided cost is the net savings that occur when additional demand is covered by a more effective source over the planning horizon
  - Avoided costs will differ depending on the capacity expansion scenario and the cost and performance assumptions regarding new capacity.
  - For the purposes of the RCI TWG, Reference Scenario #2 seems the most appropriate to use (i.e., includes all planned additions and recent RES/CIP legislation

Cost & performance assumptions for new capacity ….

- In the first draft of analyses, default cost & performance assumptions used in the analysis of RCI mitigation options were based on EIA assumptions used in the AEO2007
- At its 16 November meeting, the ES TWG indicated that the default EIA assumptions, particularly their capital cost assumptions, appeared too low and were not necessarily consistent with ES TWG member experience of actual costs
- Additionally, the TWG indicated that EIA's use of "overnight" capital costs did not account for important cost components associated with capital costs, namely interest during construction and company overhead

The ES TWG urged that additional sources be researched and compared with the EIA's cost & performance assumptions ….

- The following sources were considered in the development of a revised estimate of avoided costs
  - Assumptions for the Annual Energy Outlook 2007 entitled, "Assumptions to the Annual Energy Outlook 2007", April 2007
  - A study by the National Energy Technology Laboratory entitled, "Cost and Performance Baseline for Fossil Energy Plants", August 2007
  - A study by Black & Veatch for the National Renewable Energy Laboratory (still in draft form, unpublished)
- Before summarizing the cost & performance assumptions put forward by each of these studies, it is important to note that **each of the above sources publishes "overnight" capital costs**

The EIA's cost & performance assumptions ….

	Overnight Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate
	2005 $/kW	2005 $/kW	2005 $/kW-yr	2005 mills/kWh	%	btu/kWh
Pulverized coal	1,290	0	25.91	4.32	75%	8,844
Integrated gasification combined cycle - coal	1,492	80	36.4	2.8	75%	8,309
Coal integrated gasification combined cycle (Case 1)	NA	NA	NA	NA	NA	NA
Coal integrated gasification combined cycle (Case 2)	NA	NA	NA	NA	NA	NA
Coal integrated gasification combined cycle (Case 3)	NA	NA	NA	NA	NA	NA
Hydroelectric	1,500	80	13.13	3.30	47%	10,107
Natural Gas CT	420	0	3.36	11.40	50%	10,807
Natural Gas CC	603	0	11.75	1.94	75%	7,163
MSW	1,595	0	107.50	0.01	75%	13,648
Landfill gas	1,595	0	107.50	0.01	75%	13,648
Biomass	1,834	0	50.18	2.96	75%	8,911
Solar	4,320	80	10.99	0.00	35%	10,280
Wind	1,206	80	28.51	0	35%	10,280

NETL’s cost & performance assumptions ….

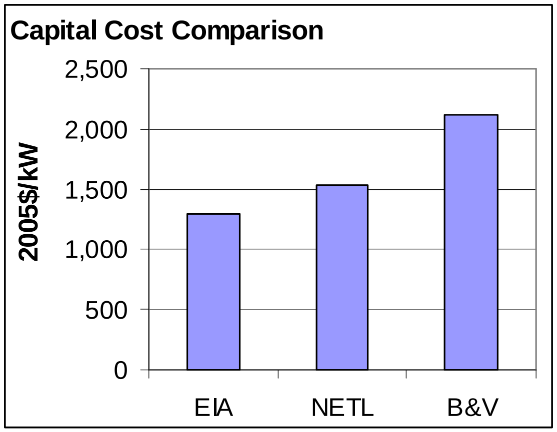
	Overnight Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate
	2006 $/kW	2006 $/kW	2006 $/kW-yr	2006 mills/kWh	%	btu/kWh
Pulverized coal (supercritical)	1,575	NA	25.18	4.87	85%	8,721
Coal integrated gasification combined cycle	NA	NA	NA	NA	NA	NA
Coal integrated gasification combined cycle (Case 1)	1,813	NA	35.28	6.49	80%	8,922
Coal integrated gasification combined cycle (Case 2)	1,733	NA	36.22	6.34	80%	8,681
Coal integrated gasification combined cycle (Case 3)	1,977	NA	35.19	6.32	80%	8,304
Hydroelectric	NA	NA	NA	NA	NA	NA
Natural Gas CT	NA	NA	NA	NA	NA	NA
Natural Gas CC	554	NA	9.82	1.32	85%	6,719
MSW	NA	NA	NA	NA	NA	NA
Landfill gas	NA	NA	NA	NA	NA	NA
Biomass	NA	NA	NA	NA	NA	NA
Solar	NA	NA	NA	NA	NA	NA
Wind	NA	NA	NA	NA	NA	NA

B&V's cost & performance assumptions ….

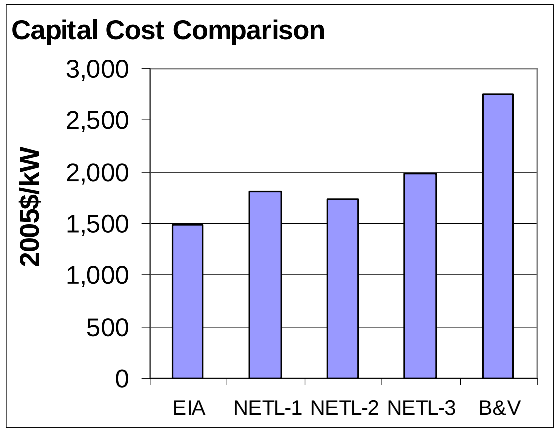
	Overnight Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate
	2005 $/kW	2005 $/kW	2005 $/kW-yr	2005 mills/kWh	%	btu/kWh
Pulverized coal	2,115	0	34.30	1.60	85%	9,200
Integrated gasification combined cycle - coal	2,756	0	37.00	3.80	80%	9,000
Coal integrated gasification combined cycle (Case 1)	NA	NA	NA	NA	NA	NA
Coal integrated gasification combined cycle (Case 2)	NA	NA	NA	NA	NA	NA
Coal integrated gasification combined cycle (Case 3)	NA	NA	NA	NA	NA	NA
Hydroelectric	NA	NA	NA	NA	NA	NA
Natural Gas CT	830	0	10.40	24.40	10%	9,266
Natural Gas CC	703	0	9.40	4.20	65%	6,990
MSW	NA	NA	NA	NA	NA	NA
Landfill gas	NA	NA	NA	NA	NA	NA
Biomass	3,076	0	50.20	3.20	80%	9,985
Solar	4,031	0	15.70	0.00	20%	10,280
Wind	1,601	0	11.2	5.3	35%	10,280

Comparing capital costs across the three sources for pulverized coal, IGCC, and NGCC (the capacity types common to each) ….

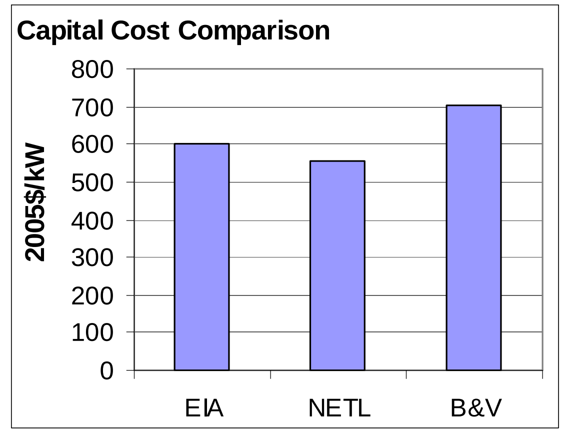
Pulverized coal



IGCC



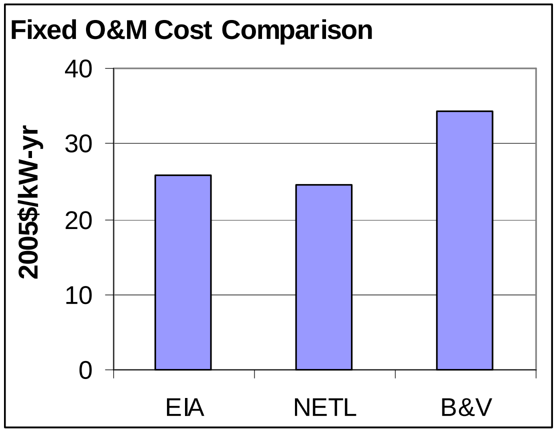
NGCC



- The following observations are offered:
  - The B&V study is highest across all three technologies
  - The NETL study is the midrange estimate for pulverized coal and IGCC, and the lowest estimate for NGCC

Comparing fixed O&M costs across the three sources for pulverized coal, IGCC, and NGCC ….

Pulverized coal



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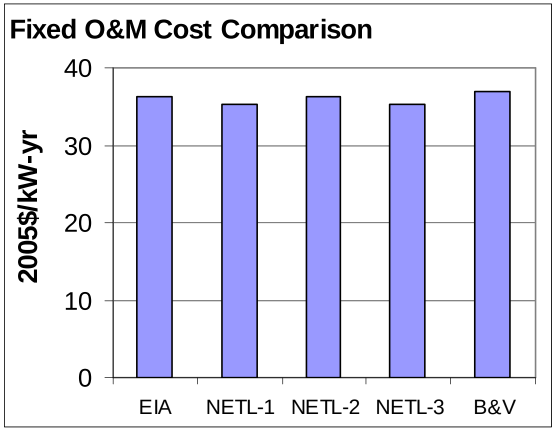
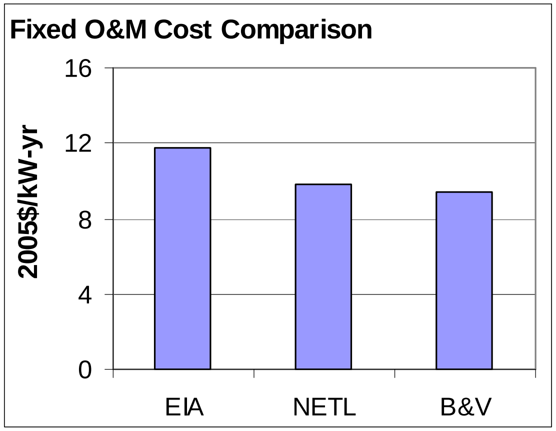


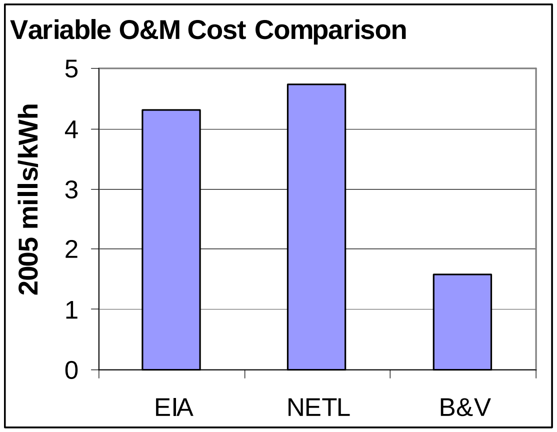
NGCC



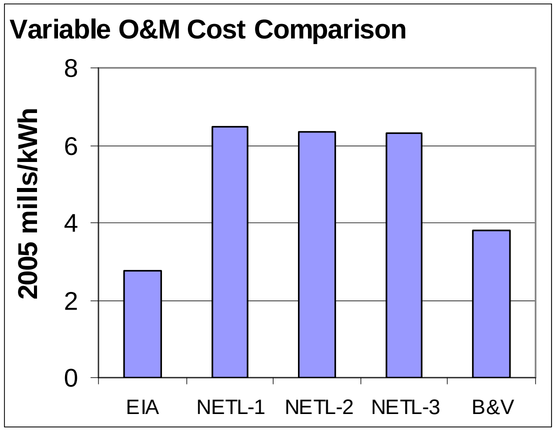
- The following observations are offered:
  - The B&V study is the highest estimate for pulverized coal and IGCC, and the lowest estimate for NGCC
  - The NETL study is the midrange estimate for IGCC and NGCC, and the lowest estimate for pulverized coal

Comparing variable O&M costs across the three sources for pulverized coal, IGCC, and NGCC ….

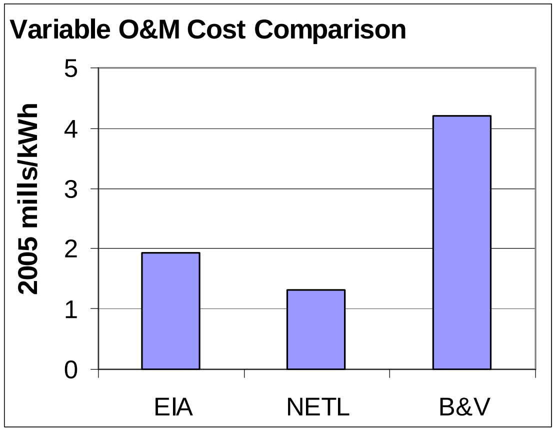
Pulverized coal



IGCC

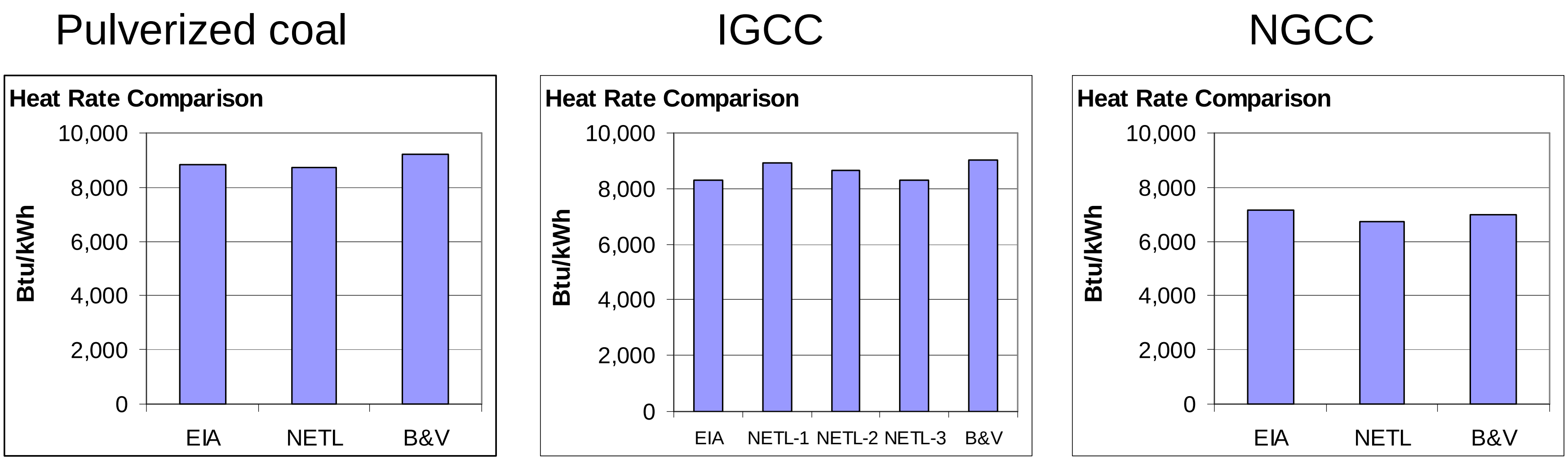


NGCC



- The following observations are offered:
  - The NETL study is the highest estimate for pulverized coal and IGCC, and the lowest estimate for NGCC
  - The B&V study is the highest estimate for NGCC, the lowest estimate for pulverized coal, and a midrange estimate for IGCC

Comparing heat rates across the three sources for pulverized coal, IGCC, and NGCC ….



- The following observations are offered:
  - ➢ All sources show relatively good agreement (i.e., within 10%)

To further compare the sources, levelized costs were developed for each ….

- Levelized costs are a way to integrate all cost components (i.e., capital, fixed O&M cost, variable O&M cost, and fuel cost) together with their design capacity factors and heat rates into a single cost parameter expressed in $/MWh
- They are defined as the present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs were levelized in real dollars (i.e., adjusted to remove the impact of inflation).
- To compute levelized costs, two additional bits of information are needed:
  - Financial parameters
  - Fuel price forecast

Financial parameter assumptions used to compute levelized costs for pulverized coal, IGCC and NGCC….

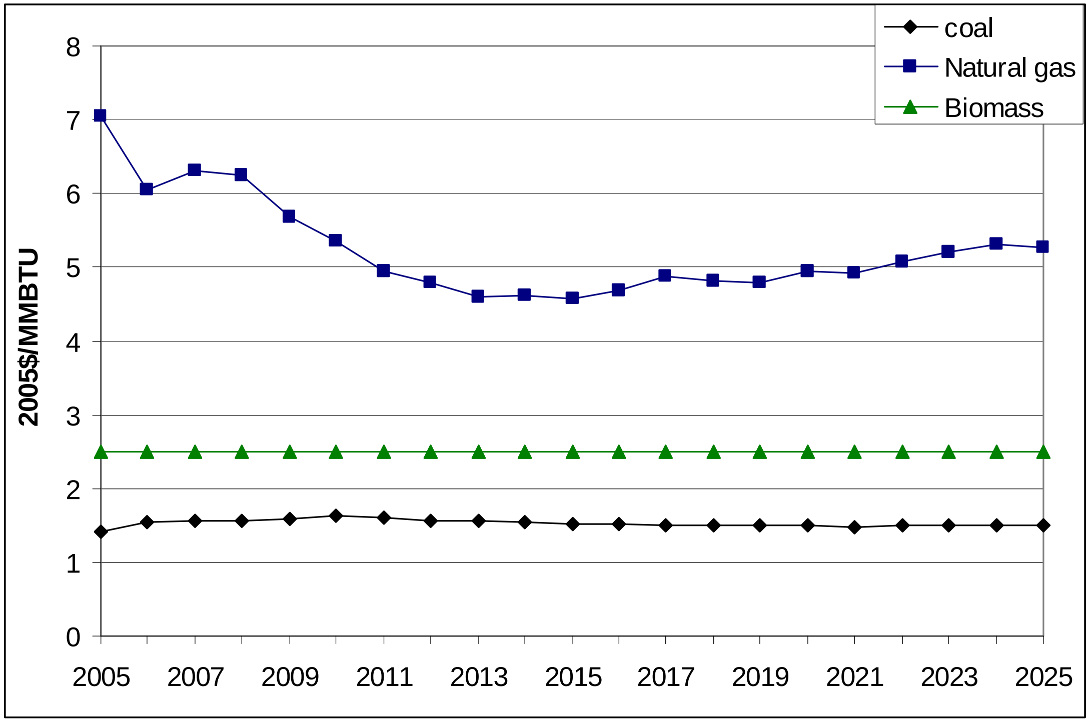
Parameter	Value
Annual Inflation in MN	2.5%
State Income Tax Rate	8%
Federal Income Tax Rate	35%
Effective Tax Rate	40%
Debt Fraction	50%
Equity Fraction	50%
Nominal cost of capital (debt)	9%
Nominal cost of capital (equity)	12%
Weighted nominal cost of capital	11%
After tax weighted cost of capital	9%
Plant economic life (years)	30
Levelization period (years)	20
real discount rate	5%
Fossil capital recovery factor	12%

Projected fuel price assumptions used to compute levelized costs for pulverized coal, IGCC and NGCC….

- Projected fuel prices are based on AEO2007 for delivered costs to electric power stations in the West North Central Census region

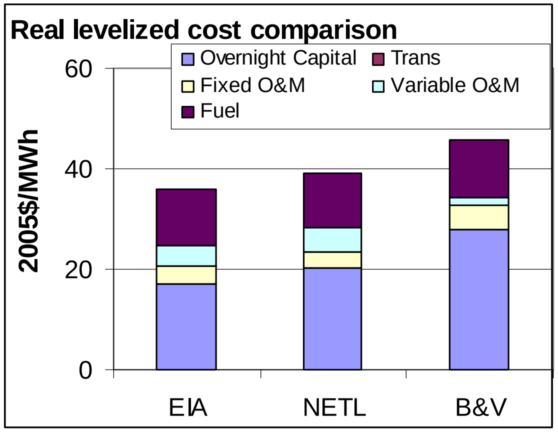
Assumed delivered fuel costs in the MAPP region to electric power stations (2005$/mmbtu)

	2005	2010	2015	2020	2025	Source
coal	1.40	1.62	1.53	1.49	1.51	AEO2007
Natural gas	7.04	5.36	4.58	4.94	5.26	AEO2007
Biomass	2.50	2.50	2.50	2.50	2.50	Assumption

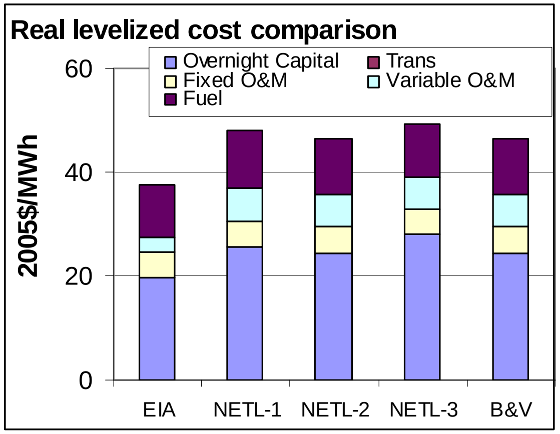


Comparing real levelized costs across the three sources for pulverized coal, IGCC, and NGCC ….

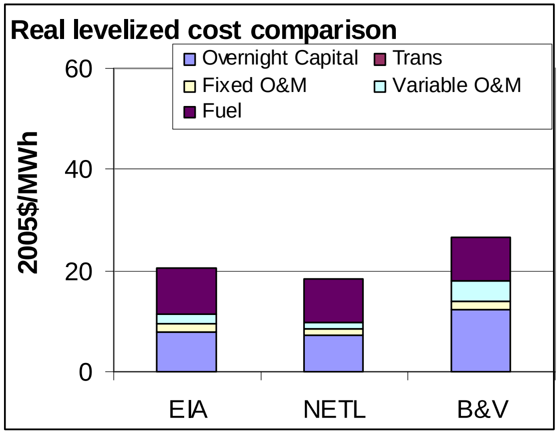
Pulverized coal



IGCC



NGCC

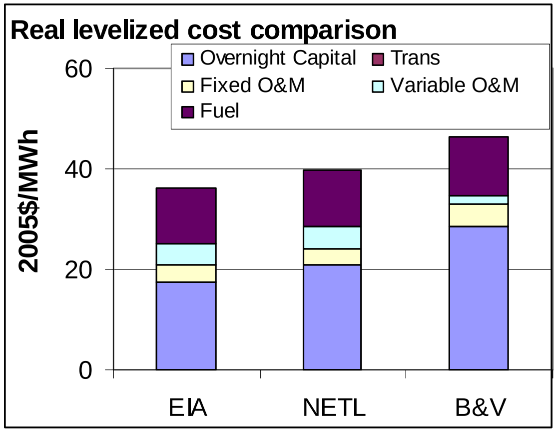


- The following observations are offered:
  - The B&V study is highest estimate for pulverized coal and NGCC
  - The NETL study is the highest estimate for IGCC, the lowest estimate for NGCC, and the midrange estimate for pulverized coal
  - The EIA study is the lowest estimate for pulverized coal and IGCC

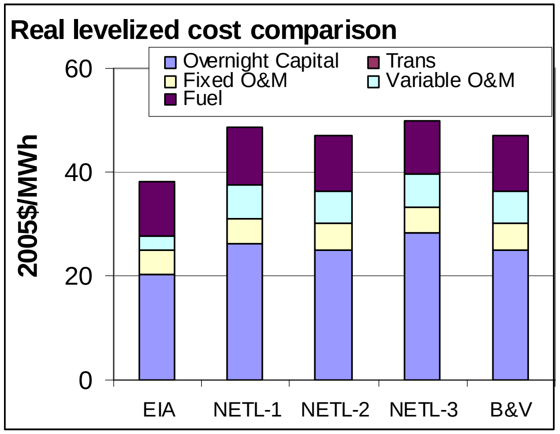
To account for EPC costs (i.e., engineer, procure, construct), a percent adder can be placed on the capital cost component

- Assume EPC costs can be approximated by a **2% adder**
- The resulting real levelized cost are slightly higher, as the comparison across the three sources for pulverized coal below shows

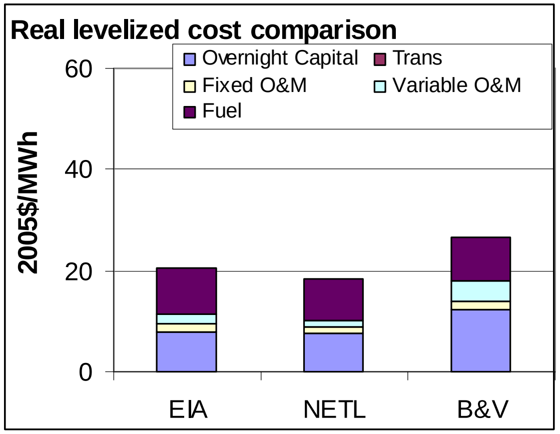
Pulverized coal



IGCC



NGCC



Proposed sources on which to base cost and performance assumptions used in the analysis ….

	Does the source provide cost and performance assumptions that can be used in the analysis?				Source proposed for analysis	
Capacity type	**EIA**	**NETL**	**B&V**	**Other**		**Basis for proposal**
Pulverized coal	YES	YES	YES	NA	**NETL**	Detailed and most recent study available
IGCC - coal	YES	YES	YES	NA	**NETL**	Detailed and most recent study available
NGCT	YES	NO	YES	NA	**EIA**	B&V study unpublished; EIA estiamtes reasonable on levelized basis, adjusted for EPC
NGCC	YES	YES	YES	NA	**NETL**	Detailed and most recent study available
Biomass	YES	NO	YES	NA	**EIA**	B&V study unpublished; EIA estiamtes reasonable on levelized basis, adjusted for EPC
Wind	YES	NO	YES	NA	**EIA**	B&V study unpublished; EIA estiamtes reasonable on levelized basis, adjusted for EPC

Proposed cost and performance assumptions used in the analysis ….

	Cost component							
	Overnight Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate		
	2005 $/kW	2005 $/kW	2005 $/kW-yr	2005 mills/kWh	%	btu/kWh	Source	EPC Percentage
Pulverized coal	1,607	0	34.30	1.60	85%	9,200	NETL	2%
IGCC	1,849	0	37.00	3.80	80%	9,000	NETL	2%
Natural Gas CT	428	0	3.36	11.40	15%	10,807	EIA	2%
Natural Gas CC	565	0	9.40	4.20	65%	6,990	NETL	2%
MSW	1,627	0	107.50	0.01	75%	13,648	EIA	2%
Biomass	1,871	0	50.18	2.96	75%	8,911	EIA	2%
Wind	1,230	80	28.51	0.00	35%	10,280	EIA	2%
Petroleum	420	0	11.40	3.36	10%	10,807	EIA	2%

Levelized costs associated with each expansion plan using the assumptions proposed ….

Estimated MN levelized costs (2005$/MWh) - All Scenarios

Capacity type	Capacity	Transmission	Fixed O&M	Variable O&M	Fuel	Total
Pulverized coal	20.4	0.0	4.5	1.6	13.8	40.3
IGCC	25.0	0.0	5.2	3.7	13.5	47.3
Hydroelectric	35.9	0.0	3.1	3.2	0.0	42.3
Natural Gas CT	31.6	0.0	2.5	11.2	57.2	102.5
Natural Gas CC	9.4	0.0	1.6	4.1	37.0	52.1
Nuclear	26.6	0.0	8.5	0.5	0.0	35.5
Other	0.0	0.0	0.0	0.0	0.0	0.0
Other Gas	0.0	0.0	0.0	0.0	0.0	0.0
Geothermal	42.5	0.0	34.7	0.0	0.0	77.1
MSW	24.0	0.0	16.0	0.0	0.0	40.1
Landfill gas	24.0	0.0	16.0	0.0	0.0	40.1
Biomass	27.6	0.0	7.5	2.9	21.8	59.8
Solar	139.4	2.6	3.5	0.0	0.0	145.5
Wind	38.9	2.6	9.1	0.0	0.0	50.6
Petroleum	47.5	0.0	12.8	3.3	69.3	132.8
Pumped Storage	0.0	0.0	0.0	0.0	0.0	0.0

Avoided costs associated with the assumed capacity expansion plan using the assumptions proposed ….

Estimated MN Avoided costs (2005$/MWh)

Capacity	32
Transmission	1
Fixed O&M	6
Variable O&M	5
Fuel	28
Total	**71**

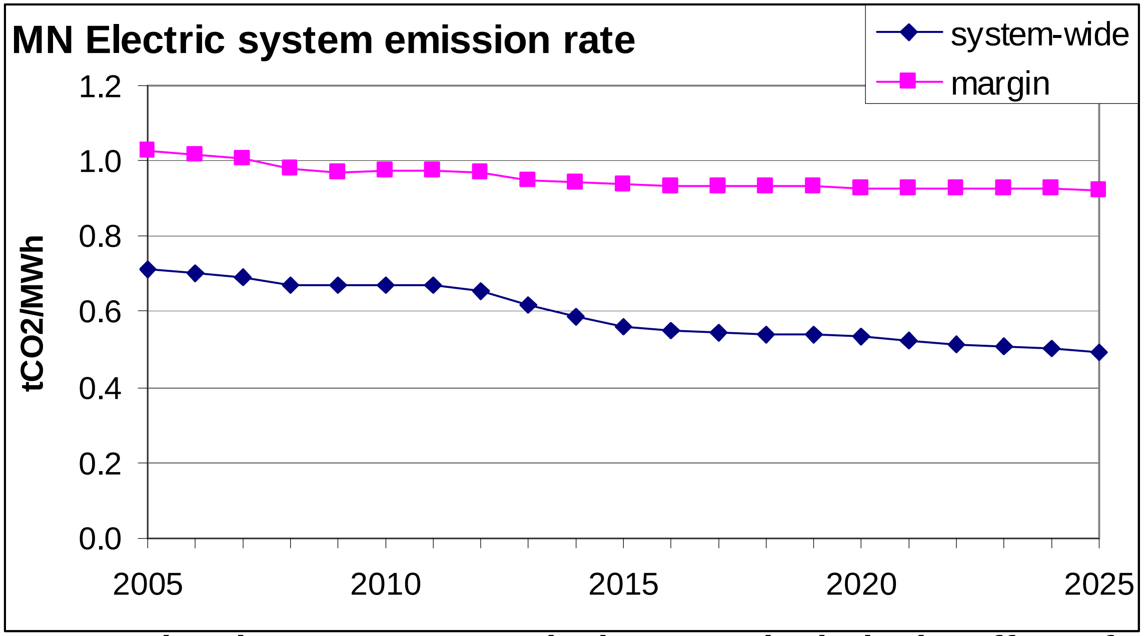
GHG emission forecast

To develop the GHG emission forecast for each Reference Scenario, a set of emission factors is needed ….

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

	CO_2 (tCO_2/mmbtu)	CH_4 (tCH_4/E9 btu)	N_2O (tN_2O/E9 btu)	CO_2e (tCO_2e/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 developed in the ES GHG forecast, it is possible to estimate the annual GHG emission rate associated with electric generation in MN ….



Note: the above systems emission rates include the effect of the recent RES/CIP legislation

RCI-1: CIP

The analysis of RCI-1 (Conservation Improvement Program) assumes the following basic assumptions…

Assumed start year for the new CIP legislation

2008

Current estimates of accumulated embedded energy efficiency and conservation in 2003 (new CIP activities as a percentage of total sales):

1

1	0.8%
2	0.5%
3	0.4%

Future program spending of the new CIP

1

1	Future spending proportional to 2003 levels (default)
2	User-defined

Marginal resource associated with electricity savings

1

1	coal & natural gas, prorata (default)
2	100% coal
3	system average

There are also a number of additional assumptions made, as follows…

Current estimates of first year cost effectiveness of MN CIP		
2003 expenditures by regulated utilities (million $)	$52	source: Office of the Legislative Auditor, State of Minnesota, 2005, "Evaluation Report: Energy Conservation Improvement Program", January, Table 1.3 on page 12
2003 savings from utility expenditures (GWh)	325	source: Office of the Legislative Auditor, State of Minnesota, 2005, "Evaluation Report: Energy Conservation Improvement Program", January, page 5
Average lifetime of measures (years)	15	
Lifetime savings from 2003 utility expenditures (GWh)	4,875	

Levelized cost associated with 2003 program spending (2005 $/MWh of sales avoided)	
projected inflation rate (2003-2005)	2.5%
real discount rate (%)	5%
Levelization period (years)	15
NPV (million 2005$/MWh)	$160
Real levelized cost (2005$/MWh)	$15.4

Results using default assumptions are …

Results assume the following assumptions:

New CIP responsible for savings equal to	**0.7%**	of annual sales
Avoided costs of new electric generation ($/MWh)	**71.5**	
Levelized costs of new CIP ($/MWh)	**15.4**	

Summary

	GHG Reductions (million tonnes CO2e)			NPV of Costs (E6 2005$)	Cost of Saved Carbon (2005$/tCO2e avoided)
	Annual		Cumulative		
	2015	2025			
without the RPS	3.8	8.7	82.8	($2,408)	-29.1

RCI-2
Building Codes

The analysis of RCI-2 (Improved Uniform Statewide Building Codes) assumes the following basic assumptions…

Assumed start year for the new CIP legislation

2009

Assumption for improvement of the residential building code relative to the current residential building code in areas where the building code HAS BEEN adotpted and IS BEING enforced

1

1	no improvement in energy efficiency (default)
2	User-defined

Assumption for improvement of the residential building code relative to the current residential building code in areas where the building code has NOT been adotpted

1

1	improvement in energy efficiency of	3%	(default)
2	User-defined		

Assumption for percent of the state population covered by current residential building codes

1

1	The percent of MN's population is	85%	covered by the current building code (default)
2	User-defined		

Assumption for future enforcement of the residential building code

1

1	100% Statewide (default)
2	User-defined

There are also a number of additional assumptions made, as follows…

Assumption for improvement of the commercial building code relative to the current commercial building code in areas where the building code HAS BEEN adotpted and IS BEING enforced

1

1	no improvement in energy efficiency (default)
2	User-defined

Assumption for improvement of the commercial building code relative to the current commercial building code in areas where the building code has NOT been adotpted

1

1	improvement in energy efficiency of	5%	(default)
2	User-defined		

Assumption for percent of the state commercial activity covered by current commercial building codes

1

1	Percent of MN's commercial sector,	85%	is covered by the current building code (default)
2	User-defined		

Assumption for future enforcement of the commercial building code

1

1	100% Statewide (default)
2	User-defined

Marginal resource associated with electricity savings

1

1	coal & natural gas, prorata (default)
2	100% coal
3	system average

Information on total housing units …

Source: U.S Census Bureau annual data, **released end of every July**: http://www.census.gov/popest/housing/HU-EST2005.html

Table 1: Annual Estimates of Housing Units for the United States and States: April 1, 2000 to July 1, 2005								
Geographic Area	**Housing unit estimates**						**April 1, 2000**	
	July 1, 2005	**July 1, 2004**	**July 1, 2003**	**July 1, 2002**	**July 1, 2001**	**July 1, 2000**	**Estimates**	**Census**
United States	124,521,886	122,676,668	120,969,394	119,381,715	117,868,605	116,295,167	115,904,474	115,902,572
Alabama	2,082,140	2,058,884	2,035,065	2,017,045	1,998,192	1,970,086	1,963,834	1,963,711
Alaska	274,246	271,528	268,144	265,514	263,053	261,389	260,963	260,978
Minnesota	**2,252,022**	**2,214,306**	**2,175,148**	**2,137,510**	**2,105,061**	**2,073,900**	**2,065,952**	**2,065,946**
Wisconsin	2,498,500	2,463,802	2,427,649	2,393,948	2,360,187	2,329,076	2,321,157	2,321,144
Wyoming	235,721	232,613	229,653	227,778	225,961	224,249	223,854	223,854

Information on new housing units …

Source: U.S Census Bureau annual data, **released end of every July**: http://www.census.gov/const/C40/Table2/t2yu200512.txt

Table 2u. New Privately Owned Housing Units, Authorized
Unadjusted Units for Regions, Divisions, and States

December 2005 Year-to-Date

	Total	1 Unit	2 Units	3 and 4 Units	5 Units or More	Num of Struc-tures With 5 Units or More
United States	2,147,617	1,681,184	39,402	44,558	382,473	22,024
West North Centra	118839	95,144	3,090	2,879	17,726	1,092
Iowa	16,733	12,712	322	495	3,204	187
Kansas	14,404	11,814	552	361	1,677	137
Minnesota	**35,877**	**29,276**	**312**	**500**	**5,789**	**313**
Missouri	31,278	24,732	1,586	1,026	3,934	266
Nebraska	10,922	9,547	162	99	1,114	83
North Dakota	3,835	2,186	58	118	1,473	62
South Dakota	5,790	4,877	98	280	535	44

Information on climatic data for MN …

July 2002-June 2003 State Heating Degree Days (HDD)

	HDD65	CDD65	RECS Climate Zone	% electric space conditioning Residential	Commercial
Minnesota	7402	619	1	16.1%	113.1%

Heating degree-days in Minnesota

Source: Department of Commerce (http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/hdd.200507-200607.pdf)

STATE : 21 MINNESOTA

SEASON	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
2005/2006	13	39	114	478	920	1471	1213	1395	1042	433	234	50
2005/2006	13	52	166	644	1564	3035	4248	5643	6685	7118	7352	7402
2005/2006	40.6	57.8	51.1	70.6	79.2	86.2	81.1	85.6	86.7	85.1	84.9	84.5

Cooling degree-days in Minnesota

Source: http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/cdd.200501-200607.pdf

STATE : 21 MINNESOTA

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2005	0	0	0	3	13	166	236	139	61	1	0	0
2005	0	0	0	3	16	182	418	557	618	619	619	619
2005	0	0	0	150	40	127.3	128.6	121.9	128.5	128.2	128.2	128.2

Information on the MN population forecast…

Minnesota Population

Source: Minnesota State Demographic Center, http://www.demography.state.mn.us/documents/MinnesotaPopulationProjections20052035.pdf

	2005	2010	2015	2020	2025	Growth rate (%/yr)
Minnesota	5,192,222	5,446,530	5,809,700	5,943,240	6,135,060	0.84%

Summary of MN 2005 data – residential buildings…

Residential buildings, 2005	
Total housing units	2,252,022
New housing units	37,716
Existing housing units	2,214,306
Ratio of new units to existing units	0.02
Total residential electricity sales (GWh)	21,743
Estimated electricity use in new residential units (GWh)	370
Electric space conditioning multiplier	0.16
Electricity use for space conditioning - new residenital buildings (GWh)	60
Savings multiplier reflecting improvement over current state code in enforced areas	0%
Savings multiplier reflecting improvement over current state code in unenforced areas	3%
Enforcement level of the current building code	85%
Future enforcement of the building code with the mitigation option in place	100%
Energy savings potential of new construction in areas where the code is enforced (GWh)	0.00
Energy savings of potential new construction in areas where the code is not enforced (GWh)	1.67
Total energy savings potential of new residential construction (GWh)	**1.67**

Summary of MN 2005 data – commercial buildings…

Commercial buildings, 2005	
Ratio of new to existing units	0.02
Total electricity energy use (GWh)	21,985
Energy intensity correction factor by climate zone and vintage	1.13
Percentage of electricity for heating, cooling, and lighting	54%
Commercial electricity used for heating, cooling, & lighting for new buildings (GWh)	241
Savings multiplier reflecting improvement over current state code in enforced areas	0%
Savings multiplier reflecting improvement over current state code in unenforced areas	5%
Enforcement level of the current building code	85%
Future enforcement of the building code with the mitigation option in place	100%
Energy savings potential of new construction in areas where the code is enforced (GWh)	0.00
Energy savings of potential new construction in areas where the code is not enforced (GWh)	1.81
Total energy savings potential of new commercial construction (GWh)	**1.81**

Results using default assumptions are …

Results assume the following assumptions:

Start-up year for uniform statewide codes	**2009**	
	Residential	Commercial
Improvement of building code relative to the current code in areas where it HAS BEEN adotpted and IS BEING enforced	0%	0%
Improvement of the building code relative to the current code in areas where it has NOT been adotpted	3%	5%
Percent of the state population covered by current building code	85%	85%
Future enforcement coverage of the building code	100%	100%

Marginal resource associated with electricity savings — coal & natural gas, prorata (default)

<u>Summary</u>

GHG Reductions (million tonnes CO2e)				
Annual			NPV of Costs	Cost of Saved Carbon
2015	2025	Cumulative	(E6 2005$)	(2005$/tCO2e avoided)
0.0035	0.0037	0.059	-11.2	-189.7

RCI-3: Green Buildings

The analysis of RCI-3 (Green Building Guidelines and Standards Based on Architecture 2030) assumes the following basic assumptions…

Assumed CO2 reduction targets to meet the Architecture 2030 Challenge (% relative to Reference Case)																				
2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
0%	0%	0%	0%	0%	60%	62%	64%	66%	68%	70%	72%	74%	76%	78%	80%	82%	84%	86%	88%	90%

There are also a number of additional assumptions made, as follows…

Source: MN GHG forecast developed for this process (based on the worksshet called "Energy Use and CO2" in a spreadsheet called GHGemitsum07_Working.xls)

Residential sector CO2e emissions (million metric tonnes CO2)						Growth Rates (%/yr)			
Fossil	2005	2010	2015	2020	2025	2005-2010	2010-2015	2015-2020	2020-2025
Coal	0.002	0.003	0.003	0.003	0.003	1.87%	-0.28%	-0.27%	-0.42%
Natural Gas	7.521	8.252	9.053	9.933	10.898	1.42%	0.78%	0.54%	0.15%
Propane-Air	0.013	0.015	0.016	0.018	0.019	0.35%	0.64%	0.31%	0.19%
Distillate Fuel Oil	1.095	1.201	1.318	1.446	1.586	0.35%	0.64%	0.31%	0.19%
LPG	1.306	1.433	1.572	1.725	1.892	0.35%	0.64%	0.31%	0.19%
Kerosene	0.012	0.013	0.015	0.016	0.018	0.35%	0.64%	0.31%	0.19%
Residual Fuel Oil	0.000	0.000	0.000	0.000	0.000	0.35%	0.64%	0.31%	0.19%
Motor Gasoline	0.000	0.000	0.000	0.000	0.000	0.35%	0.64%	0.31%	0.19%
subtotal	9.949	10.916	11.977	13.141	14.417				
Renewable									
Wood	0.000	0.000	0.000	0.000	0.000	1.78%	0.32%	0.61%	0.19%
Other Biomass	0.000	0.000	0.000	0.000	0.000	1.78%	0.32%	0.61%	0.19%
Ethanol	0.000	0.000	0.000	0.000	0.000	1.78%	0.32%	0.61%	0.19%
Geothermal	0.000	0.000	0.000	0.000	0.000	1.78%	0.32%	0.61%	0.19%
Solar	0.000	0.000	0.000	0.000	0.000	1.78%	0.32%	0.61%	0.19%
Wind	0.000	0.000	0.000	0.000	0.000	1.78%	0.32%	0.61%	0.19%
subtotal	0.000	0.000	0.000	0.000	0.000				
Total	9.949	10.916	11.977	13.141	14.417				

Information on commercial sector CO2e emissions …

Source: MN GHG forecast developed for this process (based on the workssheet called "Energy Use and CO2" in a spreadsheet called GHGemitsum07_Working.xls)

Commercial sector CO2e emissions (million tonnes CO2)						Growth Rates (%/yr)			
Fossil	2005	2010	2015	2020	2025	2005-2010	2010-2015	2015-2020	2020-2025
Bituminous coal	0.002	0.002	0.002	0.002	0.002	0.27%	0.92%	0.57%	0.75%
Subbituminous coal	0.115	0.117	0.122	0.126	0.131	0.27%	0.92%	0.57%	0.75%
Lignite	0.000	0.000	0.000	0.000	0.000	0.27%	0.92%	0.57%	0.75%
Natural gas	5.615	5.994	6.776	7.365	7.980	*1.32%*	*2.48%*	*1.68%*	*1.62%*
Propane-Air	0.000	0.000	0.000	0.000	0.000	-0.01%	1.27%	0.71%	1.03%
Distillate fuel oil	0.561	0.560	0.597	0.618	0.651	-0.01%	1.27%	0.71%	1.03%
LPG	0.230	0.230	0.245	0.254	0.267	-0.01%	1.27%	0.71%	1.03%
Kerosene	0.006	0.006	0.007	0.007	0.007	-0.01%	1.27%	0.71%	1.03%
Residual fuel oil	0.143	0.143	0.152	0.158	0.166	-0.01%	1.27%	0.71%	1.03%
Motor gasoline	0.095	0.095	0.101	0.105	0.110	-0.01%	1.27%	0.71%	1.03%
Waste oil	0.000	0.000	0.000	0.000	0.000	-0.01%	1.27%	0.71%	1.03%
Waste solvents	0.000	0.000	0.000	0.000	0.000	-0.01%	1.27%	0.71%	1.03%
Hazardous waste	0.000	0.000	0.000	0.000	0.000	0.00%	0.00%	0.00%	0.00%
subtotal	6.767	7.148	8.003	8.635	9.314				
Mixed Fossil and Renewable									
RDF	0.000	0.000	0.000	0.000	0.000	0.00%	0.00%	0.00%	0.00%
MMSW	0.000	0.000	0.000	0.000	0.000	0.00%	0.00%	0.00%	0.00%
subtotal	0.000	0.000	0.000	0.000	0.000				
Renewable									
Wood	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
Crop residues	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
Dried WWTP sludge	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
Other biomass	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
Ethanol (part of gasohol)	0.007	0.007	0.007	0.008	0.008	0.39%	0.92%	0.57%	0.75%
Geothermal	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
Solar	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
Wind	0.000	0.000	0.000	0.000	0.000	0.39%	0.92%	0.57%	0.75%
subtotal	0.007	0.007	0.007	0.008	0.008				
Total	6.774	7.155	8.010	8.642	9.322				

Information on projections for residential and commercial sector fuel to electricity ratios…

Ratios of fossil to electricity use (GWh/trillion btu)

Residential sector	2005	2010	2015	2020	2025
Coal	935,169	936,108	937,048	937,989	938,930
Natural Gas	168	168	168	168	168
Propane-Air	112,054	112,167	112,279	112,392	112,505
Distillate Fuel Oil	1,585	1,586	1,588	1,589	1,591
LPG	1,153	1,154	1,155	1,156	1,157
Kerosene	139,566	139,706	139,847	139,987	140,128
Residual Fuel Oil	0	0	0	0	0
Motor Gasoline	0	0	0	0	0

Commercial sector	2005	2010	2015	2020	2025
Bituminous coal	1,470,597	1,635,364	1,801,833	1,972,433	2,154,300
Subbituminous coal	20,269	22,540	24,834	27,185	29,692
Lignite	0	0	0	0	0
Natural gas	227	240	245	253	265
Propane-Air	0	0	0	0	0
Distillate fuel oil	3,129	3,529	3,821	4,153	4,473
LPG	6,604	7,448	8,063	8,764	9,440
Kerosene	270,973	305,608	330,871	359,601	387,360
Residual fuel oil	13,209	14,897	16,129	17,529	18,882
Motor gasoline	17,967	20,264	21,939	23,844	25,685
Waste oil	131,248,609	148,024,231	160,260,976	174,176,553	187,621,934
Waste solvents	0	0	0	0	0
Hazardous waste	0	0	0	0	0

Summary of MN 2005 data – new residential buildings…

Residential buildings, 2005	
Total housing units	2,252,022
New housing units	37,716
Existing housing units	2,214,306
Ratio of new units to existing units	0.02
Total residential electricity sales (GWh)	21,743
Energy intensity correction factor by climate zone and vintage	1.13
Estimated electricity use in new residential units (GWh)	419
Estimated fossil energy use in new residential units (billion btu)	
Coal	0.0
Natural Gas	2.5
Propane-Air	0.0
Distillate Fuel Oil	0.3
LPG	0.4
Kerosene	0.0
Residual Fuel Oil	0.0
Motor Gasoline	0.0
Total	3.13
Electric space conditioning multiplier	0.16
Electricity use for space conditioning - new residenital buildings (GWh)	68

Summary of MN 2005 data – new commercial buildings…

Commercial buildings, 2005	
Ratio of new to existing units	0.0180
Total electricity energy use (GWh)	21,985
Energy intensity correction factor by climate zone and vintage	1.13
Percentage of electricity for heating, cooling, and lighting	54%
Estimated electricity use in new commercial units (GWh)	448
Estimated fossil energy use in new commercial units (billion btu)	
Bituminous coal	0.0
Subbituminous coal	0.0
Lignite	0.0
Natural gas	1.973
Propane-Air	0.0
Distillate fuel oil	0.1
LPG	0.1
Kerosene	0.0
Residual fuel oil	0.0
Motor gasoline	0.0
Waste oil	0.0
Waste solvents	0.0
Hazardous waste	0.0
Total	2

Results using default assumptions are … …

Results assume the following assumptions:

CO2 reduction target by 2025	**90%**

Summary	GHG Reductions (million tonnes CO2e)				
	Annual		Cumulative	NPV of Costs (E6 2005$)	Cost of Saved Carbon (2005$/tCO2e avoided)
	2015	2025			
Residential Sector	0.161	0.250	2.9	-0.74	-0.25
Commercial Sector	0.114	0.171	2.0	-0.55	-0.27
Total	0.276	0.421	5.0	-1.29	-0.26

RCI-4: CHP

The analysis of RCI-4 (Incentives & Resources to Promote Combined Heat and Power) assumes the following basic assumptions…

Assumed start year for the new CHP facilities

2013

Assumption for CHP potential in MN based on most recent available estimates

1

1	Maximum of:	2,100	MW (default)
2	Minimum of:	1,600	MW (default)
3	User-defined		

Assumption for percentage of installed CHP by 2025

1

1	Up to specified potential (defaul)
2	User-defined

Marginal resource associated with electricity savings

1

1	coal & natural gas, prorata (default)
2	100% coal
3	system average

There are also a number of additional assumptions made, as follows…

Combined heat and power (CHP) cost and performance

	2010					2025				
Parameter	NG	Biomass	Coal	electricity	oil	NG	Biomass	Coal	electricity	oil
Average full-capacity-equivalent hours of operation	5,000	5,000	5,000			5,000	5,000	5,000		
Fraction of new capacity	90%	5%	5%			83%	18%	0%		
Average net heat rate by fuel (btu per kWh)	10,000	13,000	12,000			10,000	13,000	12,000		
Useable cogenerated heat output (% energy input)	40%	40%	40%			40%	40%	40%		
Fraction useable heat output replacing space/water/process heat	90%	90%	90%			90%	90%	90%		
Fraction of CHP heat output displacing thermal energy	75%	5%	0%	15%	5%	75%	5%	0%	15%	5%
Net efficiency of displaced boiler/heater thermal energy	85%	80%	80%	92%	80%	85%	80%	80%	92%	80%
Average overnight installed captial costs by fuel type (2005$/kW)	$2,000	$2,500	$2,500			$2,000	$2,500	$2,500		
CHP transmission cost (2005$/kW)	$0	$0	$0			$0	$0	$0		
Economic life of system (years)	20	20	20			20	20	20		
Fixed O&M costs (2005$/kW)	0	0	0			0	0	0		
Variable O&M costs (2005 $/MWh)	16.00	20.00	20.00			16.00	20.00	20.00		

Results using default assumptions are …

Results assume the following assumptions:

Start-up year for CHP	**2013**
Incremental installed CHP by 2025 (MW)	**2,100**
Marginal resource associated with electricity savings	coal & natural gas, prorata (default)

Summary

GHG Reductions (million tonnes CO2e)			NPV of Costs (E6 2005$)	Cost of Saved Carbon (2005$/tCO2e avoided)
Annual		Cumulative		
2015	2025			
1.90	9.78	65.5	1,803	27.5

RCI-5: High GWP emissions

The analysis of RCI-5 (Program to reduce emissions of non-fuel, high-global-warming-potential GHGs) is still underway. Preliminary results are expected at the time of the RCI TWG meeting on 28 November …

RCI-6: Non-utility strategies

RCI-6 (Non-utility Strategies and Incentives to Encourage Energy Efficiency and Reduce GHG Emissions) assumes the following basic assumptions… …

Start-up year for option

	1	
1	Use	2013
2	User-defined	

Average energy savings from application of measures associated with non-utility strategies and incentives in the residential sector (% relative to Reference Case)

	1	
1	Use	13%
2	User-defined	

Average energy savings from application of measures associated with non-utility strategies and incentives in the commercial sector (% relative to Reference Case)

	1	
1	Use	13%
2	User-defined	

Average energy savings from application of measures associated with non-utility strategies and incentives in the industrial sector (% relative to Reference Case)

	1	
1	Use	15%
2	User-defined	

There are also a number of additional assumptions made, as follows…

Annual technical assistance visits to residential sector customers

	1	
1	Use	10,000
2	User-defined	

Annual technical assistance visits to comercial sector customers

	1	
1	Use	1,500
2	User-defined	

Annual technical assistance visits to industrial sector customers

	1	
1	Use	300
2	User-defined	

Results using default assumptions are …

Results assume the following assumptions:

Start-up year for option	**2013**
Average energy savings from measures (% relative to Reference Case)	
Residential sector	**13%**
Commercial sector	**13%**
Industrial sector	**15%**
Annual technical assistance visits	
Residential sector	**10,000**
Commercial sector	**1,500**
Industrial sector	**300**

	GHG Reductions (million tonnes CO2e)				
	Annual				
Summary	2015	2025	Cumulative	NPV of Costs (E6 2005$)	Cost of Saved Carbon (2005$/tCO2e avoided)
Residential Sector	1.5	7.1	47.5	-14	-0.3
Commercial Sector	0.9	4.7	29.2	-2,927	-100.2
Industrial Sector	0.2	1.1	6.2	-133	-21.6
Total	2.5	12.9	82.8	-3,075	-37.1

RCI-7: Propane CIP

The analysis of RCI-7 (Conservation Improvement-type Program for Propane and fuel oil efficiency) is still underway. Preliminary results are expected at the time of the RCI TWG meeting on 28 November …

RCI-8
Energy Disclosure

By RCI TWG consensus, RCI-8 will not be quantified …

RCI-9

Technology-specific applications

By RCI TWG consensus, RCI-9 will not be quantified …

RCI-10
Support of federal standards

By RCI TWG consensus, RCI-10 will not be quantified …