

# Design for a Coal IGCC Plant for the Co-Production of Electricity and H<sub>2</sub> in Pittsburgh, PA

Presented By:

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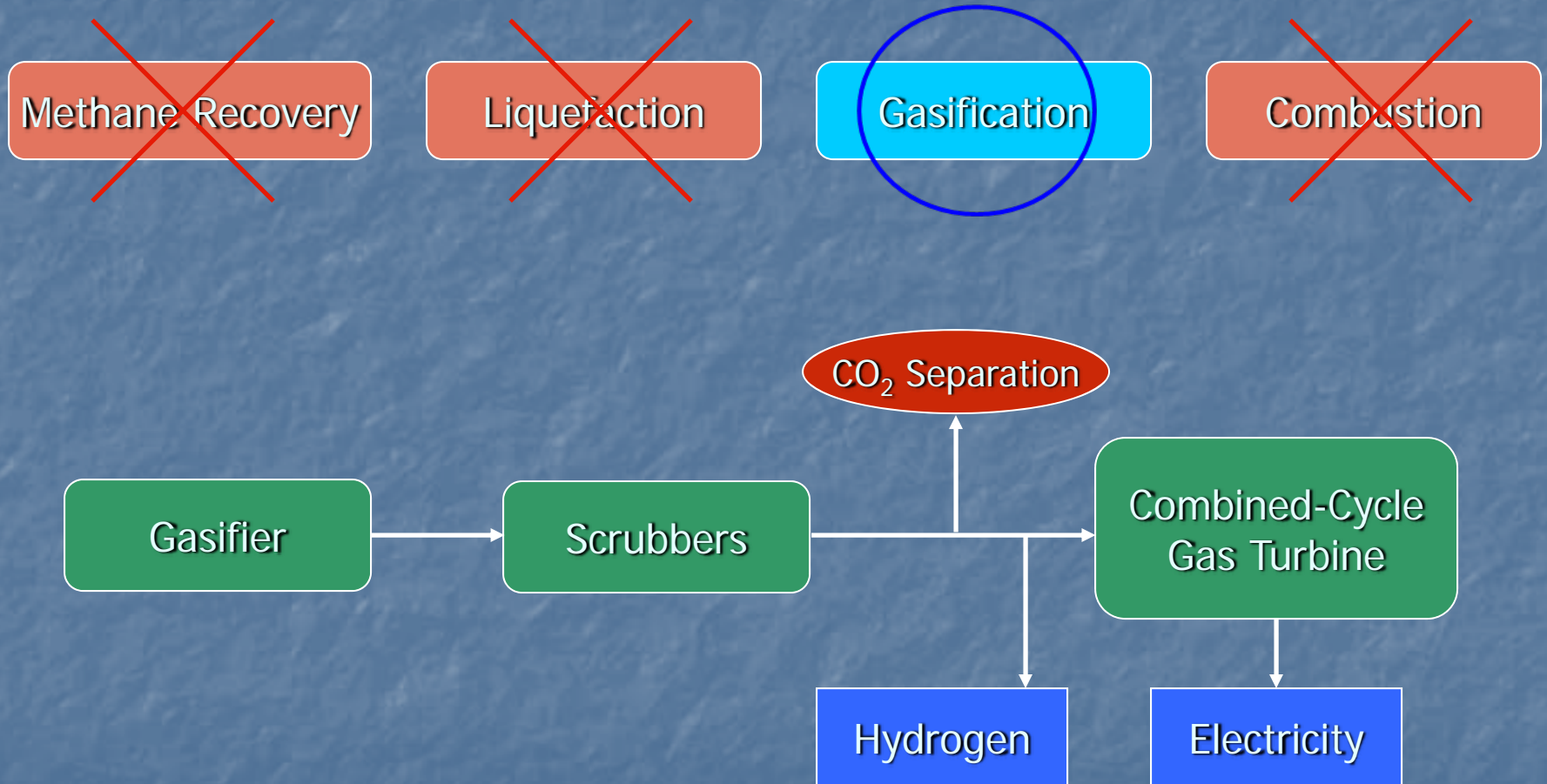
Daniel Kim

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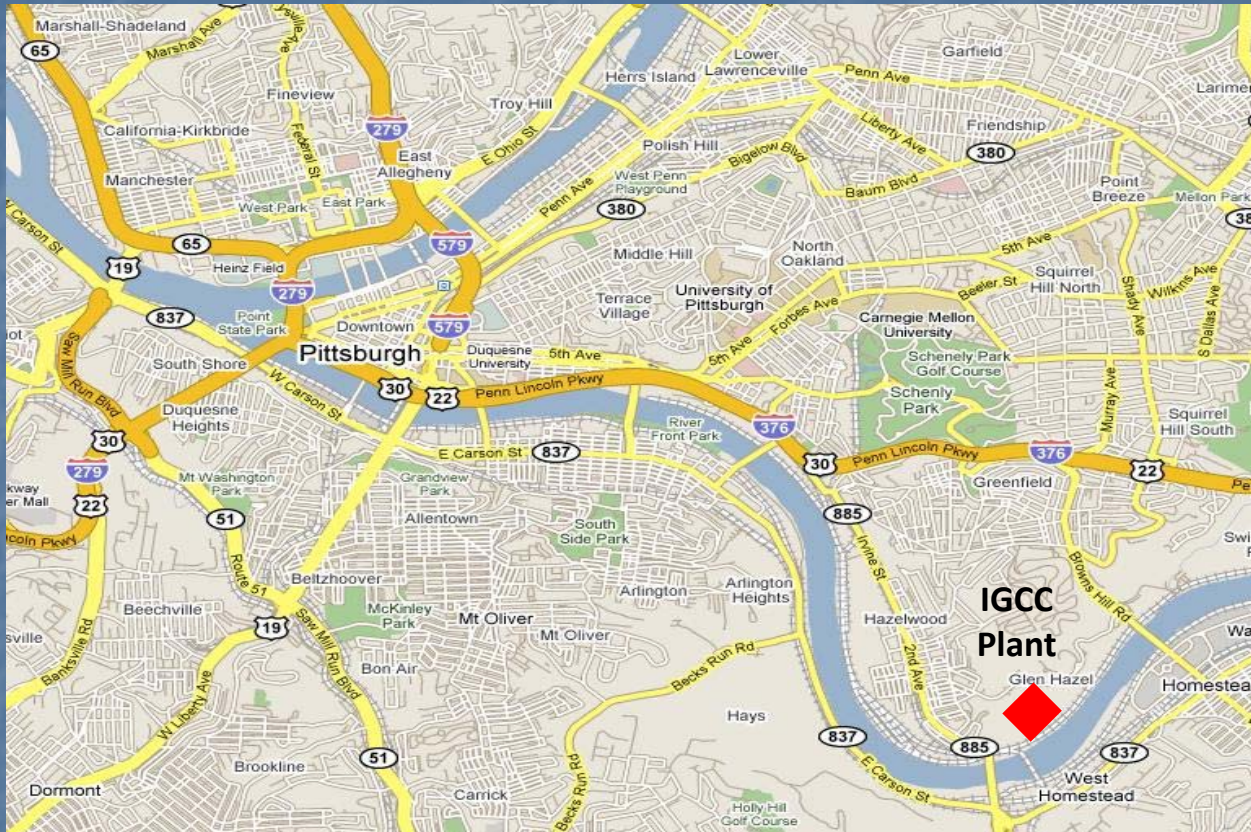
# Outline

- Overall Process Design
  - IGCC Co-production Process
  - Plant Location and Schematic
- Energy Balance
- Cost Analysis
  - Capital Cost
  - O & M Cost
- Environmental Evaluation

# Analysis of a Coal IGCC Co-production

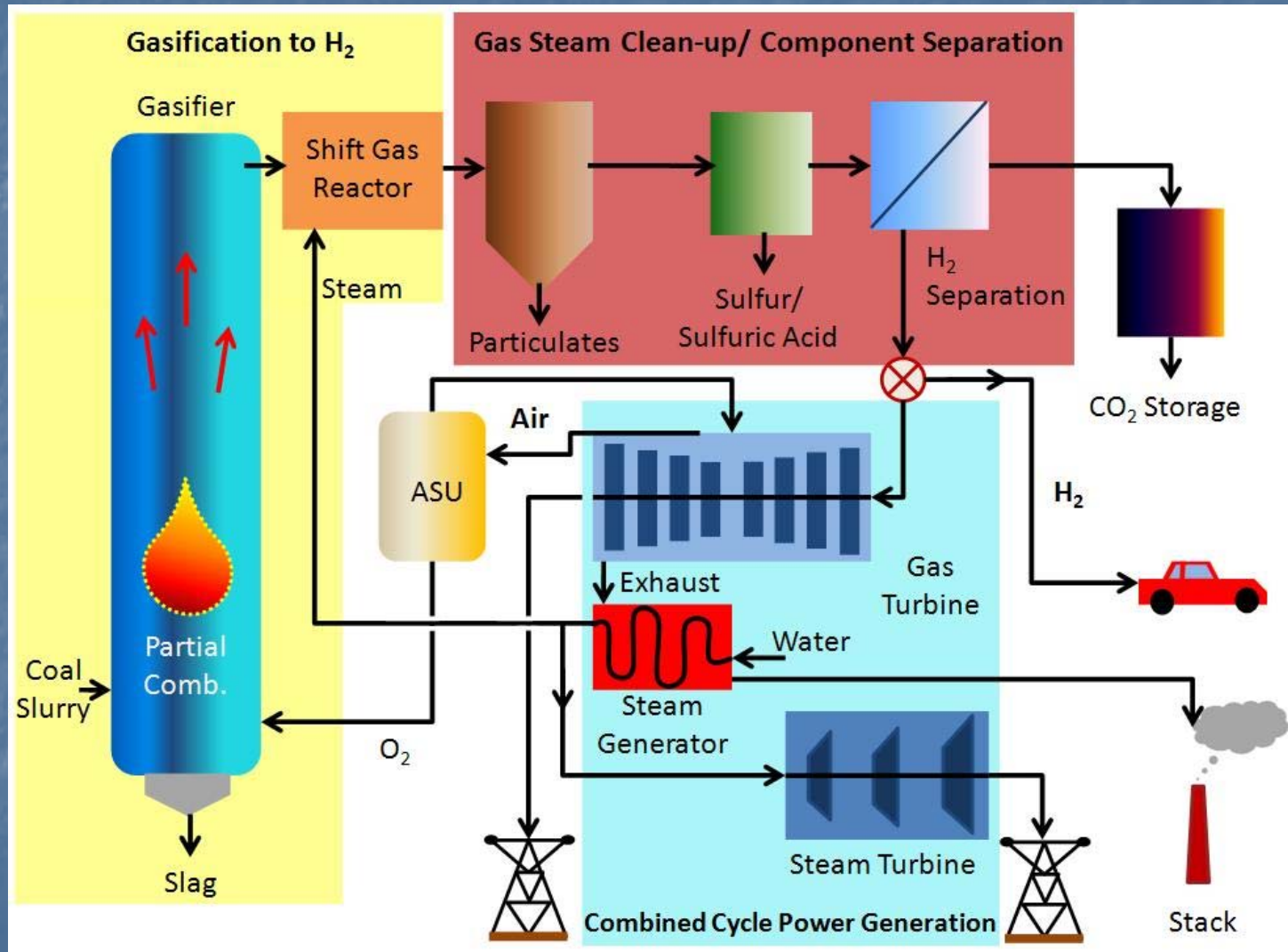


# Plant Location

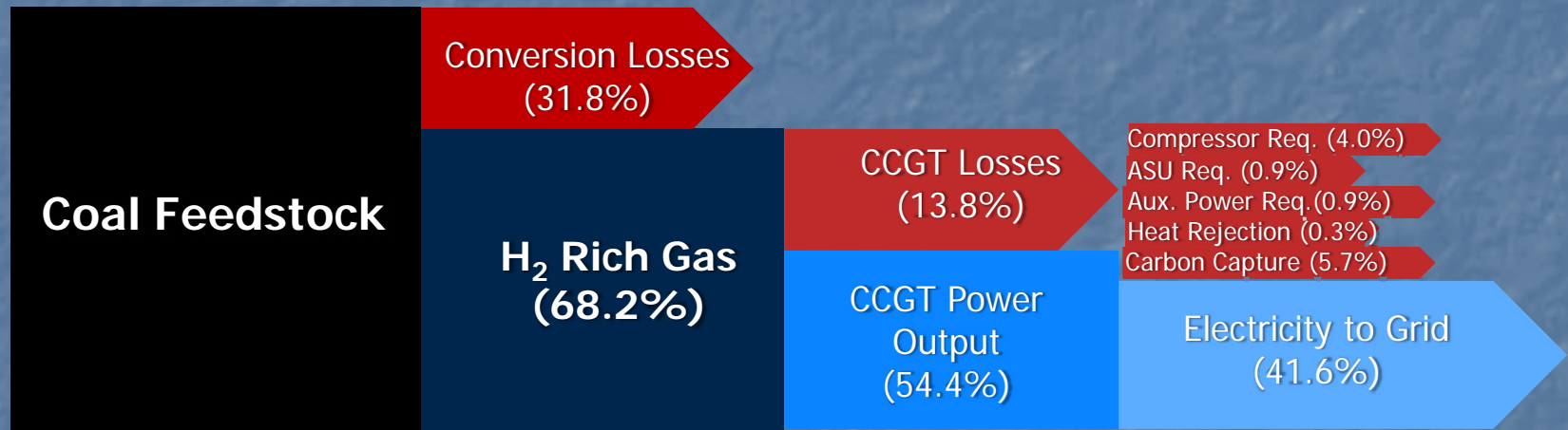


- On the Manongahela River
  - Coal Transportation
  - Water Management

# IGCC Co-production Plant Schematic



# Overall Plant Efficiency



Gas	Gasifier Exit Gas (mol./100 MBtu Coal)	WGS Exit Gas (mol./100 MBtu Coal)	WGS Exit Gas (kg/100 MBtu Coal)	Gas Turbine (MBTU gas/ 100 Mbtu Coal)
<b>CO + H<sub>2</sub>O → CO<sub>2</sub> + H<sub>2</sub></b>				
H <sub>2</sub>	99,790	253,558	507.12	68.198
CO	153,768	-	-	-
CO <sub>2</sub>	51,256	205,024	9,021.05	-

# Comparing Plant Efficiencies (LHV)

	(%)	$\eta_{\text{plant}}$ w/o CC	$\eta_{\text{plant}}$ w/ CC
Coal-Fired Power Plant		35.0	26.0
100% Power Gasification Plant		47.3	41.6
100% H <sub>2</sub> Gasification Plant		61.1	55.4
50% IGCC and 50% H <sub>2</sub> Gasification Plant		54.2	48.5

# IGCC Financial Assumptions

- Plant Size: 1,200 Mwe
- Heat Rate: 10,505 Btu/kWh
- Fuel Type: Pittsburgh #8 Coal
- Construction Duration: 3 years (01/2010 ~ 01/2013)
- Plant Life: 30 years (2013 ~ 2032)
- Capacity Factor: 80 %
  
- Total Cost = Capital Cost + O&M Cost



# Capital Costs

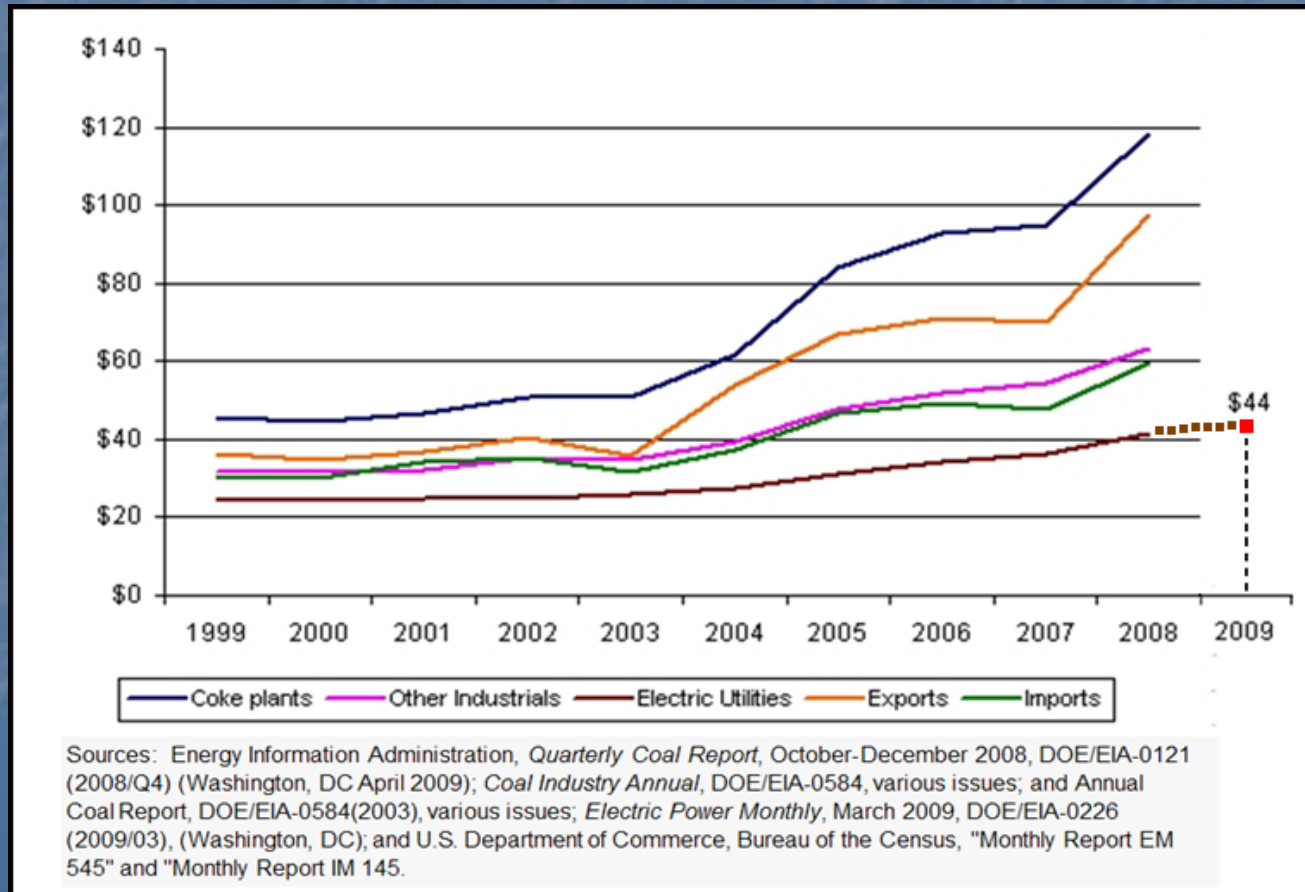
- IGCC with CO<sub>2</sub> Capture & Sequestration ( 1,200 MWe)

Item		%	\$/kWe	X 1,200 MWe
Base Plant	Slurry Prep & Feed	5	120	\$ 144,000,000
	Gasifiers	15	359	\$ 430,800,000
	WGS Reactor	8	191	\$ 229,200,000
	Turbine Generators	10	239	\$ 286,800,000
	Construction & Others	27.5	707	\$ 848,400,000
	<b>Total</b>	<b>65.5</b>	<b>1,566</b>	<b>\$ 1,879,200,000</b>
Gas Cleanup/CO <sub>2</sub> Capture & Compression		20.1	482	\$ 578,400,000
Air Separation Unit		14.3	342	\$ 410,400,000
<b>Total</b>		<b>100</b>	<b>2,390</b>	<b>\$ 2,868,000,000</b>

NOTE: Newer CFPP cost between \$1,750 - \$1,950 /kWe without CC

# Coal Price Forecast

- Coal Price (Bituminous) in Pennsylvania : **\$39.34/ton (2008)**
  - Coal price has annually increased \$2.23/ton (\$0.113/MMBtu) for the last decade.
  - In January 2028 (middle of plant life), it should be about **\$86/ton**.



# Operating & Maintenance Costs

- IGCC with CO<sub>2</sub> Capture & Sequestration (1,200 MWe)

- Coal Cost = 3,621,330 tons/yr X \$86 /ton = \$311.44 million/yr

Item	%	\$/MWh	Annual O&M Costs
Fixed O&M Cost	11.5	7.2	\$ 75,686,000
Variable O&M Cost	15.0	9.4	\$ 98,813,000
Coal Cost	73.5	-	\$ 311,440,000
<b>Total (2010 US dollars)</b>	100	62.6	<b>\$ 484,939,000</b>

- Production Cost Totals ( Capital Cost + O&M Cost )

- Capital Cost = \$2.868 billion
- O&M Cost = \$484,939,000 X 30 years = \$14.548 billion
- **Lifetime Cost (2010 US dollars) = \$ 17.416 billion**

# Environmental Performance

Criteria	Pollutants, Ionic Species,CO2 and byproducts	PC-Fired Plant (With Advanced Pollution Controls)	AFBC (With SNCR)	PFBC (Without SNCR)	IGCC Plant
SO <sub>2</sub> ,	Ib/10 <sup>6</sup> Btu (Ib/MWh)	0.2 (2.0)	0.4 (3.9)	0.2 (1.8)	0.08 (0.7)
NO <sub>x</sub> ,	Ib/10 <sup>6</sup> Btu (Ib/MWh)	< 0.15 (< 1.6)	0.09 (1.0)	0.2-0.3 (1.7-2.6)	0.09 (0.8)
PM10,	Ib/10 <sup>6</sup> Btu (Ib/MWh)	< 0.03 (< 0.3)	0.011 (0.12)	0.2-0.3 (1.7-2.6)	< 0.015 (<0.14)
CO <sub>2</sub>	(Ib/kWh)	2.0	1.92	1.76	1.76
HCl as	Chloride (Ib/MWh)	0.01	0.71	0.65	0.007
HF as	Fluoride (Ib/MWh)	0.003	0.05	0.05	0.0004
HCN as	Cyanide (Ib/MWh)	0.0003	0.005	0.005	0.00005
Ammonia	(Ib/MWh)	0	0.001	0.001	0.004
Water Usage, (gallons/MWh)		1 750	1 700	1 555	750-1 100
Total Solids Generated (Ib/MWh)		367 (Ash and Gypsum)	494 (Ash and Spent Sorbent)	450 (Ash and Spent Sorbent)	175 (Slag and Sulfur)

# CO<sub>2</sub> Emissions

- 9,000,000 tons of CO<sub>2</sub> produced annually
  - (90%) 8,100,000 tons of CO<sub>2</sub> captured annually
  - (10%) 900,000 tons of CO<sub>2</sub> emitted annually
- Carbon Tax
  - Between \$405 - \$810 million of carbon tax avoided annually



# Sulfur and Particulate Matter

- Low sulfur dioxide emissions
  - Achieved by sulfur capture in the Selexol AGR process
- Particulate discharge is minimal
  - Via the syngas quench
  - Via the syngas scrubber and gas-wash

# Conclusions

- Power and H<sub>2</sub> Gasification Plants
  - 50/50 case w/ CC: 48.5% operating efficiency
  - Total lifetime plant costs are competitive with CFPP
  - The most environmentally sound option for future coal usage

Thank You