Design for a Coal IGCC Plant for the Co-Production of Electricity and H₂ in Pittsburgh, PA

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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

	Coal Feedstock	Conversion Losses (31.8%)			
		H ₂ Rich Gas (68.2%)	CCGT Losses (13.8%)Compressor Req. (4.0%) ASU Req. (0.9%) Aux. Power Req. (0.9%) Heat Rejection (0.3%)		
			CCGT Power Output (54.4%)	Electricity to Grid (41.6%)	
Gas	Gasifier Exit Gas WGS Exit Gas (mol./100 MBtu Coal) (mol./100 MBtu Coal		WGS Exit Gas (kg/100 <mark>MBtu Coal</mark>)	Gas Turbine al) (MBTU gas/ 100 Mbtu Coal)	
		$CO + H_2O \rightarrow CO_2 + H_2$			
H ₂	99,790	253,558	507.12	68.198	
со	153,768	1	8 <u>6</u>		
CO2	51,256	205,024	9,021.05	j	

Comparing Plant Efficiencies (LHV)

(%	6)	η _{plant} w/o CC	η _{plant} w/ CC
Coal-Fired Power Plant		35.0	26.0
100% Power Gasification Plant		47.3	41.6
100% H ₂ Gasification Plant		61.1	55.4
50% IGCC and 50% H ₂ Gasification Plant	t	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 CO₂ Capture & Sequestration (1,200 MWe)

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

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.



Sources: Energy Information Administration, *Quarterly Coal Report*, October-December 2008, DOE/EIA-0121 (2008/Q4) (Washington, DC April 2009); *Coal Industry Annual*, DOE/EIA-0584, various issues; and Annual Coal Report, DOE/EIA-0584(2003), various issues; *Electric Power Monthly*, March 2009, DOE/EIA-0226 (2009/03), (Washington, DC); and U.S. Department of Commerce, Bureau of the Census, "Monthly Report EM 545" and "Monthly Report IM 145.

Operating & Maintenance Costs

IGCC with CO₂ 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
Total (2010 US dollars)	100	62.6	\$ 484,939,000

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,	PC-Fired Plant	AFBC	PFBC	IGCC Plant
Ionic Species,CO2 and	(With Advanced	(With SNCR)	(Without	12 million of the second
byproducts	Pollution Controls)	11 11	SNCR)	Contractor and
SO ₂ ,	0.2	0.4	0.2	0.08
Ib/10 ⁶ Btu (Ib/MWh)	(2.0)	(3.9)	(1.8)	(0.7)
NO _X ,	< 0.15	0.09	0.2-0.3	0.09
Ib/10 ⁶ Btu (Ib/MWh)	(< 1.6)	(1.0)	(1.7-2.6)	(0.8)
PM10,	< 0.03	0.011	0.2-0.3	< 0.015
Ib/10 ⁶ Btu (Ib/MWh)	(< 0.3)	(0.12)	(1.7-2.6)	(<0.14)
CO_2 (Ib/kWh)	2.0	1.92	1.76	1.76
Server Brook Print		Contraction of the		The second second
HCl as Chloride	0.01	0.71	0.65	0.007
(Ib/MWh)	227. 3. 3. 1. 1.		A STATE A	
HF as Fluoride	0.003	0.05	0.05	0.0004
(Ib/MWh)	Child Charles Child	Test March 1995		
HCN as Cyanide	0.0003	0.005	0.005	0.00005
(Ib/MWh)			for the second	and the second second
Ammonia(Ib/MWh)	0	0.001	0.001	0.004
A ST BARRIE			El-El-V	
Water Usage,	1 750	1 700	1 555	750-1 100
(gallons/MWh)			a sugar sola	
Total Solids Generated	367	494	450	175
(Ib/MWh)	(Ash and Gypsum)	(Ash and Spent	(Ash and Spent	(Slag and Sulfur)
terms of the second		Sorbent)	Sorbent)	

CO₂ Emissions

9,000,000 tons of CO₂ produced annually (90%) 8,100,000 tons of CO₂ captured annually (10%) 900,000 tons of CO₂ 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 H₂ 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