

# **Coal Gasification** Technology & Commercialization Overview

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# Outline

- What is coal gasification?
- How does an IGCC work?
- Cost comparison: IGCC vs other fossil options
- Overview of existing coal IGCC installations
- Overview of other coal gasification installations
- IGCC research, development & demonstration needs



# What is coal gasification?

- Similar to combustion but with less than half the amount of oxygen needed to fully burn the coal
  - Combustion: excess air
  - Gasification: excess fuel
- Usually done at higher pressure (>2.5 MPa) and with high purity O2 rather than air
  - Reduces size of downstream processing equipment
  - Decreases amount of coal that must be fully oxidized to generate the temperature needed to drive the gasification reactions
  - Increases the heating value of the produced syngas



#### **Combustion & Gasification Products**



Mole %

# **IGCC Environmental Attributes**

- <u>Sulfur</u> is removed (99.5-99.99%) from syngas as a saleable product (sulfur cake)
- <u>NOx</u> emissions are controlled by removing fuel-bound nitrogen with a water wash upstream and by flame temperature modulation via diluent addition in the gas turbine
- <u>Particulates</u> are removed from the syngas by filters and water wash upstream of turbine so emissions are negligible
- <u>Mercury</u> and other HAP's removed from the syngas by absorption in activated carbon bed
- <u>Water</u> use is lower than conventional coal
- <u>Byproduct</u> slag is vitreous and inert and often salable
- <u>CO<sub>2</sub></u> under pressure takes less energy to remove than from PC flue gas at atmospheric pressure





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#### **Costs of Electricity from New Fossil Fuel Power Plants with & without CO2 Capture**



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#### **Existing Coal-based IGCCs**



#### **Puertollano (Spain)**



Polk (Florida)



Wabash (Indiana)



Buggenum (NL)



# **Coal Based IGCC Plants**

Project/ Location	Combustion Turbine	Gasification Technology	Net Output MW	Start-Up Date
Nuon Buggenum Netherlands	Siemens V 94.2	Shell (Offered jointly with Krupp- Uhde)	253	Jan 1994
Wabash River, IN	GE 7 FA	E Gas (ConocoPhillips)	262	Oct 1995
Tampa Electric, FL	GE 7 FA	<b>Texaco</b> (GE Energy)	250	Sept 1996
ELCOGAS Puertollano Spain	Siemens V 94.3	<b>Prenflo</b> (Offered jointly with Shell)	300	Dec 1997



# Salient Characteristics of Major Gasification Technologies

Technology Name/	GE Energy	E-Gas	Shell
Design Feature	(formerly Texaco)	(ConocoPhillips)	
Feed System	Coal in Water Slurry	Coal in Water Slurry	Dry Coal. Lock Hopper & Pneumatic Conveying
Gasifier	Single Stage	Two Stage	Single Stage
Configuration	Downflow	Upflow	Upflow
Gasifier Wall	Refractory	Refractory	Membrane Wall
Pressure (psig)	500-1000	Up to 600	Up to 600
Notes	Offered as	Currently only	Currently only
	Quench or with	offered with Heat	offered with Heat
	Heat Recovery	Recovery	Recovery

## **GE Energy Quench Gasifier**



#### **Tampa Electric – Gasification Arrangement**



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# E-Gas Gasifier—As used at Wabash IGCC (Technology now owned by ConocoPhillips)









# **Coal IGCC- Historical Causes of Outage**

Project/Cause	Wabash	Tampa	Nuon	ELCOGAS
Coal Feeding	No	Minor	Minor	Yes
Injector Tip Life	90 days	60-90 Days	> 1 year	> 1 year
Refractory Wear	~ 2 years	~ 2 years	Not significant	Not significant
Slag Tap Blockage	Yes	Yes	No	Yes
Circ. Slag Water Erosion/Corrosion	Minor	Yes	Yes	Yes
Syngas Cooler Fouling	Yes – but can clean in situ	Radiant – No Convective - Yes	Minor – Rappers work well	Yes – but has not been major outage cause
Candle Filter Failure	Yes – but improved	Not applicable	No	Yes
Gas Turbine Vibration	No	No	Yes – but improved	Yes – improved but fuel switch is problematic

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## Other Gasification Plants with Operating Experience Relevant to Coal-based IGCC

- Eastman Chemical, Kingsport ,TN. 2x1300 tpd GE Quench gasifiers (1 op. + 1 Spare) operating since 1983. Mercury removal > 90% from syngas. Methanol and other chemical production. Eastman offers O&M services for IGCC.
- Ube Ammonia, Japan 4x500 tpd GE Quench gasifiers. Now use pet.coke. Ammonia production.
- SVZ Schwarze Pumpe, Germany. Noell gasifier. BGL gasifier. GE 6 B. Waste gasification.
- SUV Czech Republic. Two GE 9E CT's.
- Dakota Gasification 175 million SCFD SNG (2100 MWth equivalent). Clean up and Compression of CO<sub>2</sub> from coal gasification plant.



#### **Texaco (now GE) Coal Gasification Plants in China**

(Note: All Ammonia plants include CO<sub>2</sub> removal from the Syngas)

Location/Owner	Size mt/d	Product	Start up
Lunan	3x350	Ammonia	1993
Weihe	3x550	Ammonia Urea	1996
Shanghai Coking and Chemicals	2x550	Towns Gas Methanol Acetic Acid	1995
Huainan	3x350	Ammonia	2000



# **Shell Coal Gasification Projects in China**

(Note: All Ammonia plants will include CO<sub>2</sub> removal from the Syngas)

Location	Owner	Size mt/d	Product	Start up
Guangxi	Liuzhou Chemical	1200	Ammonia, Oxo	2005
Hubei	Shuanghuan Chemical	900	Ammonia	2005
Hubei	Anqing Sinopec	2000	Ammonia	2005
Liaoning	Dahua Chemical	1100	Methanol	2006
Yunnan	Yuntianhua	2700	Ammonia	2006
Yunnnan	Yunzhanhua	2700	Ammonia	2006
Inner Mongolia	Shenhua	2x2250	H <sub>2</sub> for Coal Liquefaction	2006
Henan	Yoncheng Chemical	2150	Methanol	2007

# **World Gasification Survey 2004**

- 117 Operating Plants, 385 Gasifiers
- Capacity 45,925 MWth
- Feedstocks 49% Coal, Petroleum Residuals 36%
- Products Chemicals 42%, Fischer-Tropsch 36%, Power 19%
- Growth Forecast 5% per annum



# **Worldwide IGCC Experience**

- Four coal based IGCC plants Tampa, Wabash, Buggenum and Puertollano.
- Eight operating IGCC plants based on Petroleum Residuals. Three more in construction. These plants represent considerable additional commercial operating experience for the many components that are common with coal based IGCC plants (ASUs, Gas clean up, Sulfur recovery, Combined Cycles, SCR etc).
- Cumulative Combustion Turbine experience on a wide variety of syngas compositions and heating values (range 100-350 Btu/SCF) is well over a million hours.





# **IGCC R&D Needed**

- Dry coal fed gasifiers need lower cost coal pressurization system (not lock-hoppers)
- New feed systems for slurry fed gasifiers to improve gasifier efficiency particularly for low rank coals. (e.g. flash drying, CO<sub>2</sub> slurry)
- Lower energy intensity coal drying methods (for dry feed gasifiers)
- More reliable thermocouples and temperature measurement
- Longer life gasifier refractory
- Longer gasifier feed injector life (slurry feed only)
- Improved materials for syngas coolers (lower cost, improved reliability)



# IGCC RD&D Ideas (cont.)

- On line pH measurement in circulating slag/ash loops
- On line slag analyses
- Investigate syngas & water vapor equilibrium properties in quench gasifier conditions
- Determine fate of trace elements (to support permitting)
- Simplified H2S removal with elimination of Claus plant
- Understand impact of syngas combustion on CT hot section metal temperatures and identify methods to mitigate de-rating of firing temperature on syngas
- IGCC dynamic models & adaptation for operator training
- Validate sequestration of CO2

