



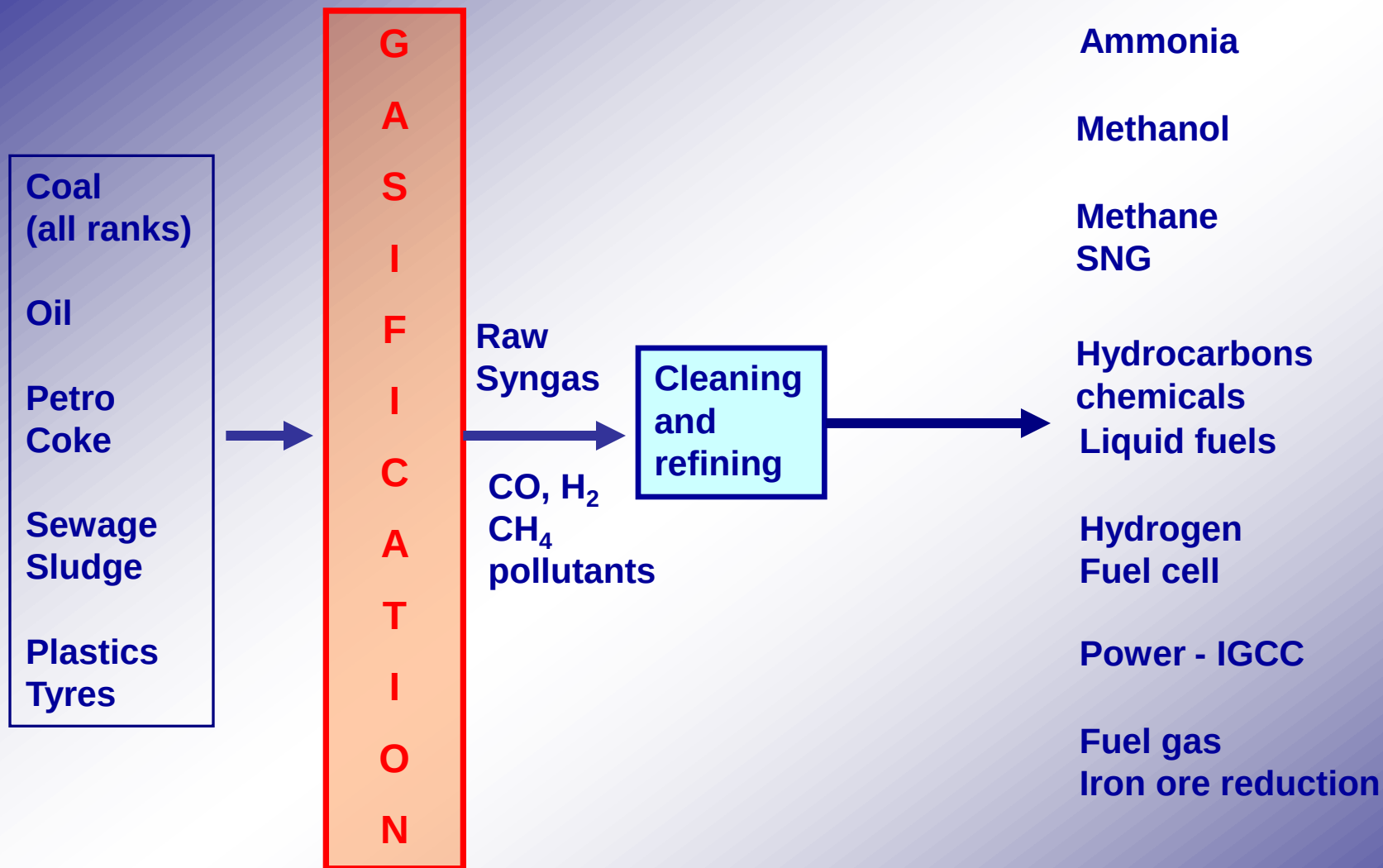
# Coal Gasification

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# What is Gasification



*Gasification is not new, practiced in various forms since 1792....*

# What is Coal



Carbon

Hydrogen

Sulfur

Oxygen

Nitrogen

Ash

Water

# Coal Gasification

*...how it differs from combustion...*

Combustion- *excess air*

Gasification- *excess fuel*

CO<sub>2</sub>



C



CO

H<sub>2</sub>O



H



H<sub>2</sub>

NO<sub>x</sub>



N



N<sub>2</sub>

H<sub>2</sub>S  
then to  
S



S



SO<sub>x</sub>

O<sub>2</sub>



O



flyash



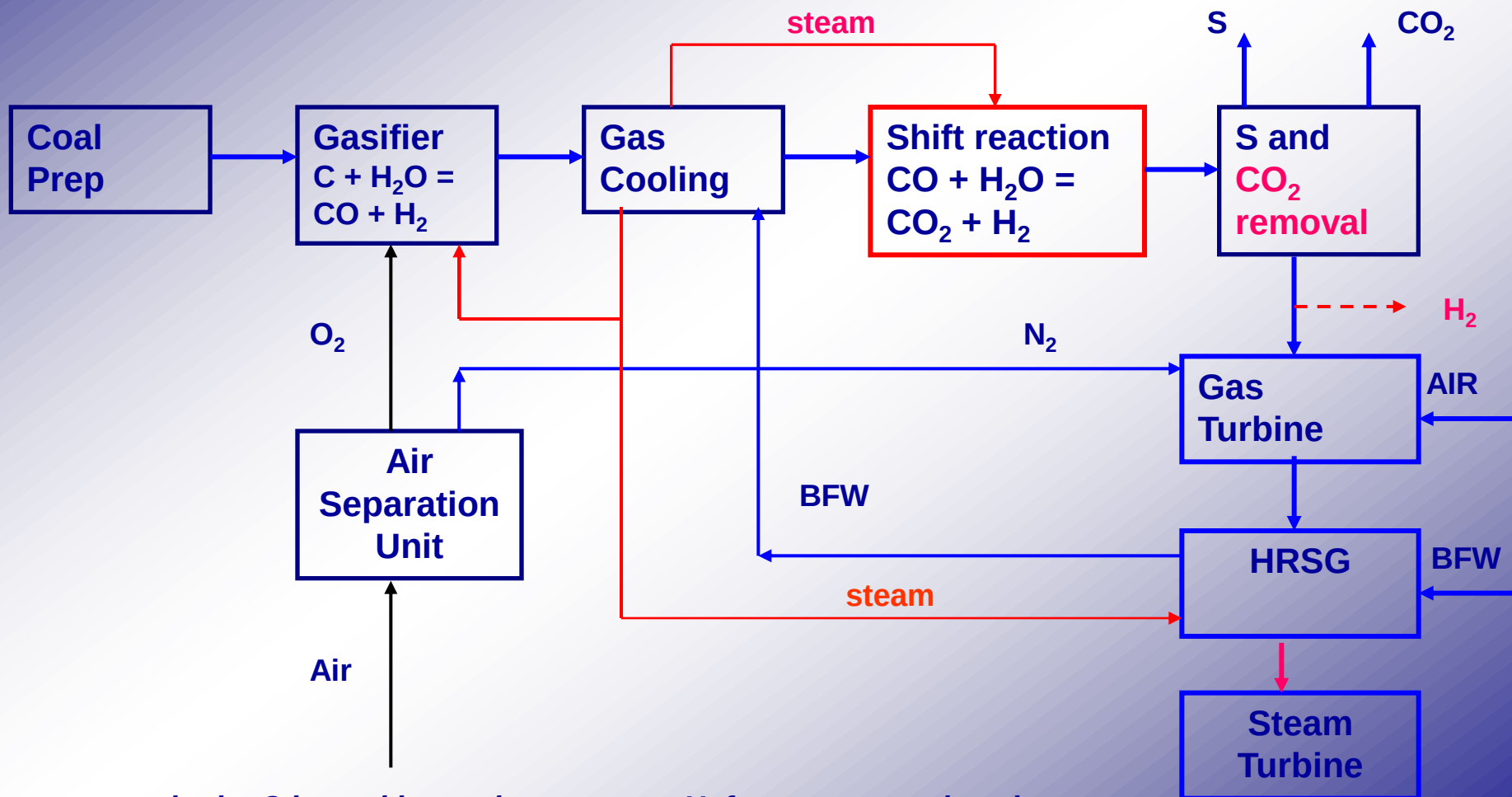
Ash



Mostly slag

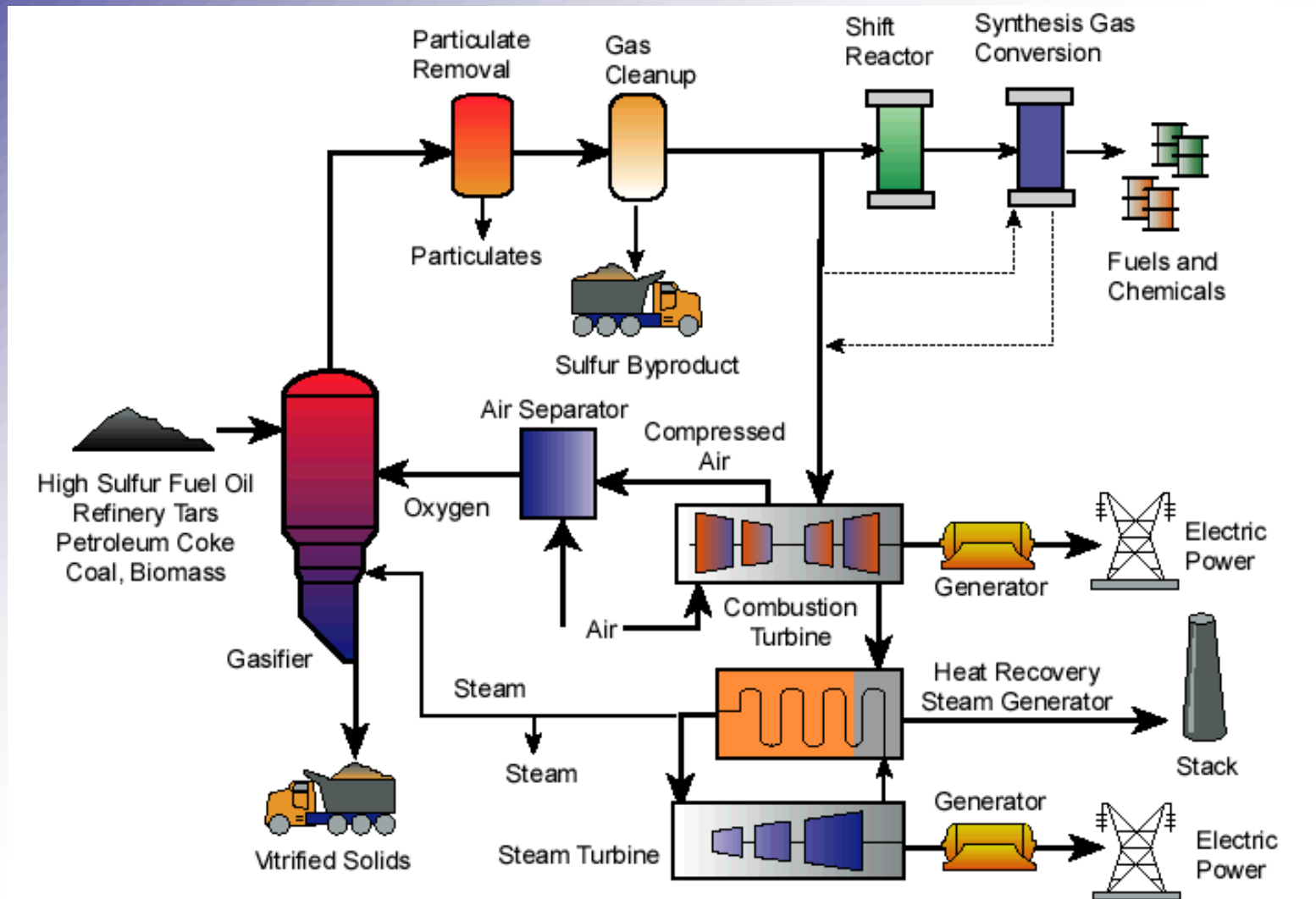
# Coal Gasification

*.....a means for co-production of power, fuels and chemicals....*



*Note: energy in the C in coal is used to generate  $H_2$  from water, and coal Co-production of power and  $H_2$  – base for subsequent chemicals production*

# Coal Gasification

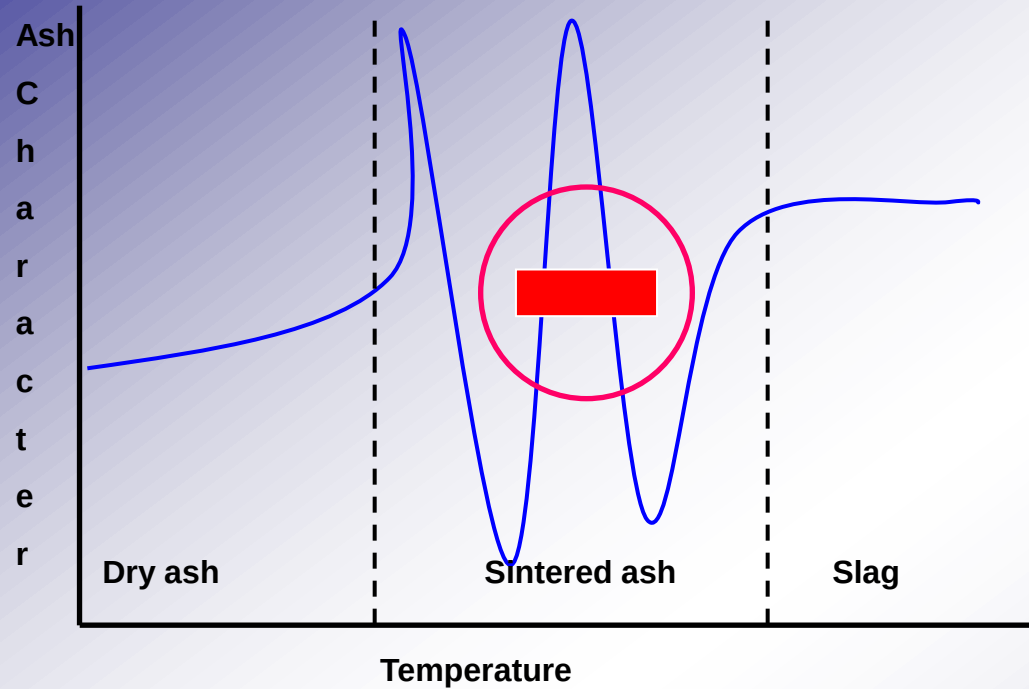




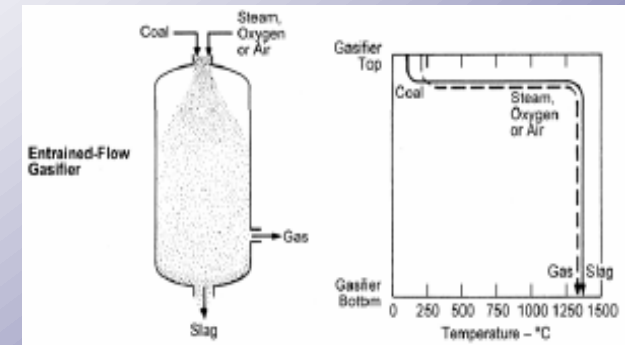
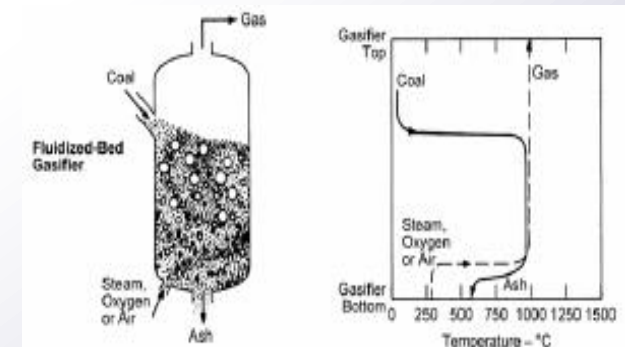
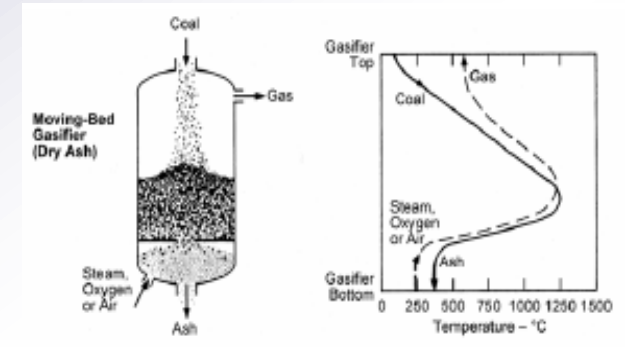
## Gasification – *summary of environmental impacts*

- CO<sub>2</sub> in a concentrated and pressurized form – more amenable to capture
- No SO<sub>x</sub>, S is in the form of H<sub>2</sub>S, can be captured as a S-byproduct
- Little NO<sub>x</sub> compared to combustion, below acceptable limits
- Particulate emission within permissible limits
- Heavy organics within acceptable limits
- Coal ash mostly glassy, trace elements confined into slag into a non-leachable form
- Mercury, if present in coal, can be captured using activated carbon bed
- Gasifier temperature destroys Furans and Dioxins, if formed
- Up to 25% less water usage than supercritical *pf* power plants

# Types of Coal Gasifiers



Air or  $O_2$  blown  
Steam –may or may not be required



Christiansen, 1996; IEACCC report

# Coal Gasification – Current Status

*Early large plants .. 250 MW class – mainly for power*



**Puertollano – Spain; Shell (Prenflo)**



**Buggenum – Netherlands; Shell**



**Wabash – USA; ConocoPhilips (E-Gas)**



**Polk – USA; GE (Texaco)**

***Both Dry and Slurry feeding.....***

# Coal Gasification – Current Status

*Early large plants ..... mainly for chemicals production*



Uses Lignite

Fertilizers  
NH<sub>3</sub> for chemicals  
Pesticides  
Solvent  
Resins  
Naphtha  
Liquid N<sub>2</sub>

CO<sub>2</sub>

Uses variety of coals

Olefins  
Polymers  
Solvent  
Wax  
Auto fuels  
Degreasers  
Grease  
Lubricant  
Fuel oil  
Phenol



**Great Plains Synfuel Plant North dakota**

<http://www.dakotagas.com/Companyinfo/index.html>



2.7 MT per year  
For EOR

**Weyburn pipeline**

<http://www.ptcr.ca/access/DesktopDefault.aspxhttp>

**Sasol – since 1955**

[http://sasol.quickreport.co.za/sasol\\_ar\\_2005/index.htm](http://sasol.quickreport.co.za/sasol_ar_2005/index.htm)

# Coal Gasification – Current Status

Several key players active in coal gasification .....

## ➤ General Electric – a major player in gas and steam turbines

- 3 plants start-up in China in 2005-06 – coal-to-ammonia and methanol
- 4 license agreements in China to work on coal-to-ammonia projects
- American Electric Power IGCC, Ohio – Commercial start-up in 2012
- American Electric Power IGCC, West Virginia – Commercial start-up in 2011
- Duke Energy IGCC, Indiana - Commercial start-up in 2011
- GE – BP, BP-Rio Tinto Joint Venture in Hydrogen Energy, GE-Bechtel tie-up for turnkey gasification offering
- Last week's acquisition of Stamet Pumps – a significant boost for their offering now into the sub-bituminous to low-moisture lignites

# Coal Gasification – Current Status

## ➤ Siemens – a major player in gas and steam turbines

- Acquired Future Energy gasification – suitable for bituminous and lignites
- Confirmed contracts for six 200-500 MW projects in China – coal-to-methanol and coal-to-ammonia
- Siemens-Fluor tie-up for turnkey gasification offering

## ➤ Shell – a major player in coal and petro-chemicals

- 15 coal gasification projects in China - coal-to-methanol and coal-to-ammonia
- JV agreements in Australian gasification projects
- Tie-up with Krupp UHDE, and Black & Veatch for turnkey IGCC offering

## ➤ Conoco Phillips

- 606 MW IGCC for Excelsior Energy in Minnesota
- Tie-up with Fluor for turnkey gasification offering



# Coal Gasification – Current Status

## ➤ Southern Company

- 285 MW proprietary transport reactor based IGCC in Orlando
- Supported by the US Government under its CCPI Round 2 funding
- Tie-up with KBR for design services

*Formation of these tie-ups – reduce front end engineering and development costs - Reduce the IGCC risks*

# Coal Gasification – Current Status

*...other major players...*

## ➤ Sasol, South Africa

- contracts signed for feasibility studies for coal-to-liquids projects in China and India

## ➤ Mitsubishi, Japan - a major player in turbines

- developing gasifier of its own
- building a 250 MW IGCC plant in Japan

## ➤ Hitachi

## ➤ J-Power

***Significantly improved IGCC potential due to the involvement of the top power industry vendors + some with state-of-the art GT + strong financial muscle***

# R&D requirements for Brazilian Coal

- Indigenous R&D capacity building – for Brazilian conditions and Brazilian coal properties – technology developed for coals elsewhere may not be directly applicable without tweaking
- Proper estimation of coal resource and coal/ash characterization
- Reducing ash content is key to utilization via gasification
  - Washability characteristics – yield, and yield improvement
  - Characterization of washery rejects
  - Use in CFBC for maximum energy extraction
- Gasification characteristics of parent coal and washed coal
  - entrained flow vs. fluidized bed gasification
  - C-conversion, gas composition
  - extent of pollutant emission – gaseous and solids
  - characterization of solid wastes
  - any ash related problems?

*....by no means complete.....*

# R&D requirements for Brazilian Coal

- Indigenous research centre – coordinated closely with the coal industry and the government – not working in isolation on academic research only
  - Focusing on practical issues – coordinated with the users of the entire fuel chain – geological sector, coal mining industry and coal utilities
  - In the process develop the skill base in R&D in the country – to cater for the need of the industry
  - Development of Skill base in experimental area, modeling and analytical support
- 
- Networking with other research centres and universities elsewhere in the world

# Does Coal Have a Role in Security of Supply?



**Key to Risk Management**  
**Diversification**  
**Diversification**  
**Diversification**

**Coal provides a much needed**  
**Diversity in the energy-mix**

## ***Coal's saving grace***

- **Abundant and well dispersed unlike natural gas or oil**
- **Secure**
- **Relatively affordable**