Fundamentals of Gasification

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Gasification Technologies Workshop
Indianapolis, Indiana  June 8, 2004
Fundamentals of Gasification
Coal Gasification: How “Hot?”

“After taking its lumps, coal is hot again”

WSJ article, April 5, 2004
Gasification = clean coal technology
Gasification Defined

- Gasification converts carbon-based feedstocks into a clean gas that can be used to generate electricity
- Gasification feedstocks
  - Coal
  - Crude oil
  - Refinery residuals
  - Secondary manufacturing materials
Why coal now?

Remaining Ultimate Recoverable Fossil Fuel Resources

- **Oil**: Conventional: $1.7 \times 10^{12}$ boe, Unconventional: $4.4 \times 10^{12}$ boe
- **Natural Gas**: $1.7 \times 10^{12}$ boe
- **Coal**: $55 \times 10^{12}$ boe

## World Coal Reserves by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>% of Total Reserves</th>
<th>Reserves to Current Production (R/P) Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>26.2%</td>
<td>234</td>
</tr>
<tr>
<td>South and Central America</td>
<td>2.2%</td>
<td>381</td>
</tr>
<tr>
<td>Europe</td>
<td>12.7%</td>
<td>167</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>23.4%</td>
<td>&gt;500</td>
</tr>
<tr>
<td>Africa and Middle East</td>
<td>5.8%</td>
<td>246</td>
</tr>
<tr>
<td>Asia/Pacific</td>
<td>29.7%</td>
<td>147</td>
</tr>
<tr>
<td>World</td>
<td>100%</td>
<td>216</td>
</tr>
</tbody>
</table>

Source: *Gasification*, Higman and van der Burgt, 2002
[*NOTE: original source is BP 2002*]
Gasification v. conventional coal-fired plants

Gasification removes potential pollutants before the fuel is burned
The gasification process

- Gasifier
- Particulate Removal
- Gas Cleanup
- Shift Reactor
- Synthesis Gas Conversion
- Fuel Separation
- Oxygen
- Air Compressor
- Air Separator
- Combustion Turbine
- Heat Recovery Steam Generator
- Steam Turbine
- Electric Power Generation
- Recovered Solids
The IGCC Process

- Slurry Plant
- Oxygen Plant
- N₂ to Combustor
- Feed Water
- Radiant Syngas Cooler
- Coal Slurry
- Entrained-Flow Gasifier
- 90% Product Gas Cooler
- Raw Syngas
- Hot Gas Clean up
- Cyclone
- Particulates
- Syngas
- Sulfur Removal
- High Pressure Steam
- Black Water Recycled
- Steam
- Sulfuric Acid
- Sulfuric Acid Plant
- Combustor Generator
- Hot Exhaust Gas
- Stack
- Steam Turbine
- Combustion Turbine
- Heat Recovery Steam Generator
- Air
Principal Fossil Fuel Effluents

- $\text{SO}_x$
- $\text{NO}_x$
- $\text{CO}_2$
- Particulates

US: Total Vehicle Fuel Emissions

Source: US EPA/DOE
IGCC plant removes 98-99.5% sulfur with fewer, inert solids.
Less and non-hazardous solid wastes
No nitrous oxide
Reduced CO$_2$ emissions

[Diagram of a process flow showing components like slurry plant, oxygen plant, radiant syngas cooler, and slag disposal with highlighted steps for high pressure steam and black water recycling, sulfuric acid plant, and steam turbine.]
Liquid effluents
The CO₂ Issue

Energy system mix

CO₂ Emissions and Atmospheric Concentration

Source: Shell Long Term Energy Scenarios, 2002
Toward zero CO$_2$ emissions
Transition to Hydrogen

- Not found naturally in the pure state
- Energy carrier rather than energy source
- Fuel cells
- Local air quality improvement short-term
- Potential GHG reduction longer-term
- $billions to convert gasoline network
Transition to Hydrogen

Production of Hydrogen Energy
Clean Coal Technology

Sustainable Coal Utilization

Diagram showing the processes of gasification, gas treating, shift reaction, and the handling of coal, slag, building material, sulphur, transport fuel, electricity, and sequestration. The diagram includes water, carbon dioxide, and hydrogen as key elements in the process.