Gasification Opportunities in the Refining Industry

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Texaco Power and Gasification

Workshop on Gasification Technologies
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**Feeds**
- Oxygen

**Gasification**
- Alternatives:
  - Petroleum Coke
  - Coal
  - Heavy Oil/Residuals/Tar
  - Refinery Sludges
- Syngas
- Sulfur Recovery
- Sulfur Removal

**Gas Refining**
- Combustion Turbine
- HRSG
- Electricity
- Steam

**End-products**
- Chemicals
- Hydrogen
- Ammonia
- Methanol
- Co-products:
  - Sulfur
  - Solids

**End-products**
- Petroleum Coke
- Coal
- Heavy Oil/Residuals/Tar
- Refinery Sludges

**Feed**
- Oxygen
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<table>
<thead>
<tr>
<th>Gasification</th>
<th>Combustion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>C</td>
</tr>
<tr>
<td>H₂</td>
<td>H</td>
</tr>
<tr>
<td>N₂</td>
<td>N</td>
</tr>
<tr>
<td>H₂S</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td>O</td>
</tr>
</tbody>
</table>

**Non-Leachable Solids** → ASH → **Leachable Fly Ash**
GASIFICATION IS NOT INCINERATION

**GASIFICATION**

Purpose: Creation of valuable, usable products

Chemical conversion using limited amounts of oxygen:
- C to CO
- H to H2
- S to H2S, then pure S
- N to N2

High temps (2300-2700 F) and high pressure

Non-hazardous solids

**INCINERATION**

Purpose: Destruction of waste materials

Complete combustion using excess air:
- C to CO2
- H to H2O
- S to SO2
- N to NOx

Lower temps (1500-1800 F) and atmospheric pressure (0 psig)

Potentially hazardous ash
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Gasification Milestones

13 Startups Worldwide

1st IGCC Project Financing

1st Coke & Refinery By-Product Power License

1st Utility IGCC License

Cool Water IGCC

Commercial Coal Plant

Coal Demonstration

MRL Converted to Coal Feed

Commercial Liquid Feeds

Early Coal Work

1st License

Early Research

1940 '44 '50 '54 '56 '70 '76 '80 '82 '92 '94 '96 '00

13 Startups Worldwide
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72 Facilities: Operating (60), Construction / Engineering (12)
125 Gasifiers: Operating (102), Construction/Engineering (23)
5700 MMSCF/Day: Syngas (H2/CO) Nominal Capacity

Europe - 23
- Germany
- France
- Italy
- U.K.
- Spain
- Sweden

Asia - 26
- China
- Japan
- Singapore
- India
- South Korea
- Taiwan
- Australia

Oldest Plant: 1958
Oldest Plant: 1961

Americas - 23
- USA
- Oldest Plant: 1979
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Licensed Syngas Capacity

Billion standard cubic feet / day

Cumulative

5.1

2.6

0.5 0.6 0.5 0.9


Power Fertilizer Chemicals Hydrogen
### Recent Refinery Projects

<table>
<thead>
<tr>
<th>Company</th>
<th>Products</th>
<th>Feedstock</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Dorado (USA)</td>
<td>Power / Steam</td>
<td>Coke</td>
<td>Operating 1996</td>
</tr>
<tr>
<td>ISAB (Italy)</td>
<td>Power/Steam/H2</td>
<td>Asphalt</td>
<td>Operating 1999</td>
</tr>
<tr>
<td>api Energia (Italy)</td>
<td>Power / Steam</td>
<td>Visbreaker Tar</td>
<td>Operating 1999</td>
</tr>
<tr>
<td>SARLUX (Italy)</td>
<td>Power/Steam/H2</td>
<td>Visbreaker Tar</td>
<td>Operating 1999</td>
</tr>
<tr>
<td>Farmland (USA)</td>
<td>Ammonia</td>
<td>Coke</td>
<td>Operating 1999</td>
</tr>
<tr>
<td>Exxon Baytown</td>
<td>Power/Chemicals</td>
<td>Coke/Heavy Oil</td>
<td>Operating 2000</td>
</tr>
<tr>
<td>BOC (Australia)</td>
<td>Hydrogen</td>
<td>Refinery gases</td>
<td>Operating 2000</td>
</tr>
<tr>
<td>Delaware City (USA)</td>
<td>Power</td>
<td>Fluid Coke</td>
<td>Operating 2001</td>
</tr>
<tr>
<td>Singapore Hub</td>
<td>Chemicals</td>
<td>Heavy Oil</td>
<td>Operating 2001</td>
</tr>
</tbody>
</table>
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Global Refinery Environment

- Environmental Awareness
- Environmental Regulations
- Legislation Encouraging Independent Power Projects
- Crude Oil Quality
- Refinery Margins
- Value of Refinery Bottoms
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The Role of Gasification in Refineries

Gasification → Cracking and Product Polishing → Valuable Products

Bottoms (coke, resid, etc.) → H₂, Steam and Power → Gasification
- Clean Power Generation from Excess, Low-grade Refinery Residues
- Over 1,300 MW Total Generation Capacity, to Reduce Italian Electricity Imports
- Major Applications of Texaco Gasification Power Systems (TGPS) Technology
- JV Ownership, Project Financed for Minimum Capital Expenditure to Refinery
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Benefits to Refinery

• Reduce Operating and Maintenance Costs
  – Allows shutdown of Refinery boilers
  – Reduces NO\textsubscript{X} and SO\textsubscript{X} Emissions
  – Reduces coke handling

• Long Term, On-site Employment of Coke

• Competitive, Reliable Hydrogen, Boiler Feed Water, High & Low Pressure Steam

• Environmentally Superior Utilization of Coke
## Emissions Comparison

<table>
<thead>
<tr>
<th></th>
<th>Natural Gas Combined Cycle</th>
<th>Coal IGCC</th>
<th>Coal Fluidized Bed</th>
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</thead>
<tbody>
<tr>
<td>SCR</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Stack Gas Scrubber</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>3 ppm</td>
<td>&lt;9 ppm</td>
<td>85 ppm</td>
</tr>
<tr>
<td>Sulfur Recovery</td>
<td>—</td>
<td>&gt;98%</td>
<td>95%</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt; (lb/kWh)</td>
<td>0.81</td>
<td>1.95</td>
<td>2.26</td>
</tr>
</tbody>
</table>
Emerging Issues

CO₂ Emissions Control

- Introduction to Combustion Turbine for:
  - Power Augmentation
  - NOₓ Suppression

- High Pressure CO₂ Byproduct Allows:
  - Injection for Tertiary Oil Recovery
  - Injection into Aquifers
Other Emerging Issues

- **Mercury**
  - Coal IGCC Uses Ambient or Chilled Washing at High Pressure
  - Conventional Boilers Use Elevated Temperatures and Ambient Pressure
- **Particulates**
  - Coal IGCC Removes with Multi-Stage, High Pressure Washes
  - Conventional Boilers Removal Through Electrostatic Precipitation at Ambient Pressure
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**SCR Implications for IGCC**

### Conditions Comparison

<table>
<thead>
<tr>
<th></th>
<th>Boiler</th>
<th>IGCC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas Condition</strong></td>
<td>Particulate-Laden</td>
<td>Particulate Free</td>
</tr>
<tr>
<td><strong>SCR Location</strong></td>
<td>Between Boiler &amp; Air Heater</td>
<td>In the HRSG</td>
</tr>
</tbody>
</table>
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SCR Implications for IGCC

Environmental Concerns:

- Ammonia slip $\Rightarrow$ SO$_3$ and Ammonia will condense/react on HRSG surfaces
- Bisulfate deposits without presence of flyash
- Wash Water Salts
- Shutdown/Startup Emissions
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SCR Implications for IGCC

Operational Issues:

- Increased back pressure results in reduced power output
- Reduced HRSG effectiveness results in reduced steam production
- Increased startup/shutdown
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### IGCC Continues To Push The Envelope

<table>
<thead>
<tr>
<th>Year</th>
<th>Plant</th>
<th>Unit</th>
<th>Feedstock</th>
<th>NO&lt;sub&gt;x&lt;/sub&gt; Permit (ppmvd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Tampa Polk</td>
<td>7FA</td>
<td>Coal</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>PSI Wabash</td>
<td>7FA</td>
<td>Coal</td>
<td>25</td>
</tr>
<tr>
<td>1996</td>
<td>El Dorado</td>
<td>6B</td>
<td>Pet Coke</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nat. Gas:</td>
<td>25</td>
</tr>
<tr>
<td>2000</td>
<td>Motiva Delaware</td>
<td>6FA</td>
<td>Pet Coke</td>
<td>15</td>
</tr>
</tbody>
</table>
Gasification is a commercially proven technology which:

- Provides the Lowest $SO_X$ and $NO_X$ of Any Liquid or Solid Feed Technology
- Provides Competitive and Reliable Power, Steam, and Other Products to Our Customers
- Continues to Develop and Demonstrate Innovative Emission Control Technologies by Refining Syngas Prior to Feeding it to the Combustion Turbines