Worldwide Power and Gasification

Clean Coal Technology Options –
A Comparison of IGCC
vs. Pulverized Coal Boilers

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Presentation Highlights

- ChevronTexaco
- Clean Coal Landscape
- Gasification: Current Status of Technology
- Standards Project Initiative - Reference Plant
- Comparing Coal to Power Technologies: IGCC vs. PC Boiler Plants
- Next Generation – CO2 Capture with IGCC
- Conclusions
ChevronTexaco

- 53,000 employees; 180 countries
- > $100 billion in annual revenues
- 3rd in global reserves of oil
- 4th in global oil and gas production
- Sasol Chevron Joint Venture on Fischer-Tropsch liquids from natural gas
- Global Market Leader in Gasification
- Montebello Technology Center (MTC)
- Pittsburgh & Midway Coal Mining Co.
ChevronTexaco Worldwide Power & Gasification

- A wholly owned subsidiary of ChevronTexaco
- Global Market leader in gasification since 1948, over 130 plants licensed in last 52 years
- Both a process licensor and project owner
- First oil gasification plant in 1956
- First coal gasification plant in 1978
- 72 commercial gasification plants now operating or under construction / in advanced development
- Nominal Syngas capacity: 5.1 billion standard cubic feet/day
## ChevronTexaco Power Generation Portfolio

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Facility Size</th>
<th>Type</th>
<th>Online Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunrise Power Company</td>
<td>California</td>
<td>585 MW</td>
<td>Combined Cycle</td>
<td>2001/03</td>
</tr>
<tr>
<td>Tri-Energy Company</td>
<td>Thailand</td>
<td>700 MW</td>
<td>Combined Cycle</td>
<td>2000</td>
</tr>
<tr>
<td>North Duri Cogen</td>
<td>Indonesia</td>
<td>300 MW</td>
<td>Cogen (EOR)</td>
<td>2000</td>
</tr>
<tr>
<td>LG Power Company</td>
<td>Korea</td>
<td>950 MW</td>
<td>Comb. Cycle/Heat</td>
<td>2000</td>
</tr>
<tr>
<td>Darajat II</td>
<td>Indonesia</td>
<td>70 MW</td>
<td>Geothermal</td>
<td>2000</td>
</tr>
<tr>
<td>Black Mountain</td>
<td>Nevada</td>
<td>85 MW</td>
<td>Cogen (Thermal)</td>
<td>1992</td>
</tr>
<tr>
<td>Garnet Valley</td>
<td>Nevada</td>
<td>85 MW</td>
<td>Cogen (Thermal)</td>
<td>1992</td>
</tr>
<tr>
<td>March Point</td>
<td>Washington</td>
<td>140 MW</td>
<td>Cogen (Refinery)</td>
<td>1991, 1993</td>
</tr>
<tr>
<td>Sargent Canyon</td>
<td>California</td>
<td>36 MW</td>
<td>Cogen (EOR)</td>
<td>1991</td>
</tr>
<tr>
<td>Salinas River</td>
<td>California</td>
<td>36 MW</td>
<td>Cogen (EOR)</td>
<td>1991</td>
</tr>
<tr>
<td>Coalinga</td>
<td>California</td>
<td>36 MW</td>
<td>Cogen (EOR)</td>
<td>1991</td>
</tr>
<tr>
<td>Mid-Set</td>
<td>California</td>
<td>36 MW</td>
<td>Cogen (EOR)</td>
<td>1989</td>
</tr>
<tr>
<td>Sycamore</td>
<td>California</td>
<td>300 MW</td>
<td>Cogen (EOR)</td>
<td>1988</td>
</tr>
<tr>
<td>Kern River</td>
<td>California</td>
<td>300 MW</td>
<td>Cogen (EOR)</td>
<td>1985</td>
</tr>
</tbody>
</table>
Clean Coal Landscape
Clean Coal Landscape - USA

- Coal as a fuel for new power capacity in the USA is again on the table after the 1990s domination of natural gas
- All new USA coal-to-power capacity will use clean coal technology - environmental drivers will increasingly affect technology decisions
- Government incentives are increasing for clean coal technologies
- Some clean coal technology is cleaner than others
- Development of new coal plant projects must start now to be operating when the USA power capacity glut ends after mid-decade (2008 -2012)
- Recent IGCC experience has provided the foundation for the commercial reality of coal IGCC
- IGCC is a current viable choice for clean coal power capacity
Clean Coal Technology
US Government Current Initiatives

Clean Coal Power Initiative 2002: $330 Million Between A Number of Technology Demonstration Projects, selection by 1Q 2003. Expected to be a $2 billion program over 10 years.

US Congress: Federal Legislation in conference between Senate and House (HR 4), offering up to $2 billion in tax incentives for commercial projects, up to 4,000 MW IGCC. Gasification seen as sole technology now available to help with mercury and other metals (e.g., cadmium, lead) long-term.

States: Some states offering funding for clean coal projects using in-state coal.
Business Environment – The Marketplace for Gasification

- Market Forces Impacting Competitiveness
- Increasingly Stringent Emission Requirements
- NO\textsubscript{x}, SO\textsubscript{x}, Particulates, Mercury, and emerging CO\textsubscript{2} Issue
- Less Pricing Volatility With IGCC vs. Natural Gas
- Increasing Hydrogen Demands of Oil Refining
- Polygeneration (Power, Hydrogen, Steam, F-T liquids) Over Steam Methane Reforming
- Sulfur Reduction Mandates for Cleaner Transport Fuels
- This Will Create the Potential for Hydrogen and Fischer-Tropsch (zero sulfur diesel) applications
- Increased Use of Lower-Quality Fuels
- Higher Levels of Sulfur, Nitrogen, and Heavy Metals
Gasification: Current Status of Technology
ChevronTexaco Gasification Process

72 Facilities: Operating (66), Construction / Engineering (6)
125 Gasifiers: Operating (113), Construction/Engineering (12)
5.1 billion standard cubic feet/day Syngas (H2/CO) Nominal Capacity

Europe - 23
- Germany - 8
- France - 5
- Italy - 5
- U.K. - 2
- Spain - 2
- Sweden - 1

Asia - 26
- China - 14
- Japan - 6
- Singapore - 2
- India - 1
- South Korea - 1
- Taiwan - 1
- Australia - 1

Oldest Plant: 1958

Americas - 23
- USA - 23
- Oldest Plant: 1979

Oldest Plant: 1958

Oldest Plant: 1961
Current Licensed Syngas Capacity

Billion SCFD Additions by Decade

Power • Fertilizer • Chemicals • Hydrogen

Status of the ChevronTexaco Gasification Technology
## ChevronTexaco IGCC Experience

<table>
<thead>
<tr>
<th>Company</th>
<th>Size (MW)</th>
<th>Feedstock</th>
<th>Commercial Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool Water (USA)</td>
<td>100</td>
<td>Coal</td>
<td>1984-1989</td>
</tr>
<tr>
<td>Tampa Electric USA</td>
<td>260</td>
<td>Coal/Petroleum Coke</td>
<td>1996</td>
</tr>
<tr>
<td>El Dorado (USA)</td>
<td>42</td>
<td>Petroleum Coke</td>
<td>1996</td>
</tr>
<tr>
<td>SARLUX (Italy)</td>
<td>550</td>
<td>Visbreaker Tar</td>
<td>2001</td>
</tr>
<tr>
<td>ISAB (Italy)</td>
<td>510</td>
<td>Asphalt</td>
<td>2001</td>
</tr>
<tr>
<td>api Energia (Italy)</td>
<td>280</td>
<td>Visbreaker Tar</td>
<td>2001</td>
</tr>
<tr>
<td>ESSO Singapore</td>
<td>160</td>
<td>Cracked Tar</td>
<td>2001</td>
</tr>
<tr>
<td>Motiva LLC (USA)</td>
<td>160</td>
<td>Fluid Coke</td>
<td>2002</td>
</tr>
<tr>
<td>NMPRC (Japan)</td>
<td>350</td>
<td>Asphalt</td>
<td>2003</td>
</tr>
<tr>
<td>Normandie (France)</td>
<td>360</td>
<td>Visbreaker Tar</td>
<td>2006</td>
</tr>
<tr>
<td>PIEMSA (Spain)</td>
<td>800</td>
<td>Visbreaker Tar</td>
<td>2006</td>
</tr>
<tr>
<td>Citgo (USA)</td>
<td>680</td>
<td>Petroleum Coke</td>
<td>2006</td>
</tr>
</tbody>
</table>

- **Coal projects now being considered at 500 - 1,500 MW in USA**
Sarlux, Italy

- Sarroch (Cagliari), Italy
- 3771 sTPD heavy oil, 550MW + hydrogen + steam
- Three trains, quench type
- Initial startup 4/24/00
- In full commercial operation in 2001
- One of three IGCC’s in Italy now commercial, generating more than 1,300 MW power from clean syngas
Texaco Gasification Process

FEEDS
Alternatives:
• Asphalt
• Coal
• Heavy Oil
• Petroleum Coke
• Orimulsion
• Natural Gas
• Wastes

GASIFICATION
Gasifier
Oxygen

GAS CLEANUP
Syngas
Sulfur Removal
Gas & Steam Turbines

END PRODUCTS
Combined Cycle Power Block
Electricity Steam

Marketable Byproducts:
Sulfur

Marketable Byproducts:
Solids (ash)

Alternatives:
• Hydrogen
• Ammonia
• Chemicals
• Methanol
• Fischer-Tropsch Liquids (zero sulfur diesel)
Evolution of Coal IGCC/Coal Gasification

- **1970**: 25sTPD plant at Montebello USA research lab
- **1980**: 165sTPD (W. German) Coal to Oxo-chemicals
- **1980**: 800sTPD (W. German) Coal to Oxo-chem/H₂
- **1990**: 1100sTPD (USA) Coal to Methanol / Acetic Anhydride
- **1990**: 190sTPD (USA) Coal to Ammonia
- **2000**: 1650sTPD (China) Coal to Ammonia / Urea
- **2000**: 550sTPD (China) Coal to Ammonia
- **2000**: 2000sTPD / 250MW (USA) Coal to Power

**Locations**:
- **Huainan**: 900sTPD (China) Coal to Ammonia / Urea
- **Weihe**: 1650sTPD (China) Coal to Ammonia / Urea
- **Shanghai**: 1800sTPD (China) Coal to Town Gas / Methanol
- **Lunan**: 550sTPD (China) Coal to Ammonia
- **SAR**: 800sTPD (W. German) Coal to Oxo-chem/H₂
- **UBE**: 1650sTPD (Japan) Coal and Petroleum Coke to Ammonia
- **Cool Water**: 1000sTPD / 120MW (USA) Coal to Power
- **EASTMAN**: 1100sTPD (USA) Coal to Methanol / Acetic Anhydride
- **TVA**: 165sTPD (W. German) Coal to Oxo-chemicals

**Pilot**
- **RAG/RCH**: 25sTPD plant at Montebello USA research lab
ChevronTexaco
Standards Project Initiative (SPI)
Reference Plant
IGCC Product Concept

- A “product” development process that provides a focused forum for facilitating technology deployment, and design and cost optimization
- Improves “time to market” with shorter project development schedule and lower costs
- Establishes the groundwork for potential supplier alliances
- Establishing the product as a Reference Plant:
  - Provides a baseline on which to assess and incorporate technology advances
  - Allows for a menu of plant configuration and operation options
- Provides a data-point for comparison with Pulverized Coal generation options
ChevronTexaco
SPI - IGCC Reference Plant “Product”

• Why: Market need for standardized IGCC plant, initially targeted for coal
• When: Begun in 1999 and continues to work on improving the Reference Plant
• Who: ChevronTexaco supported by Bechtel, General Electric, and Air Liquide
• What: Development of a standard IGCC design and project execution concept
• Status: Selected a preliminary configuration (9/02 case) - enhancement is in process
SPI Reference Plant
Frame for Current Case

- 100% coal-to-power (no petroleum coke)
- no poly-generation in this study
- USA market
- Capacity > 500 MW
- GE turbines
- Back-up fuel available – nat gas
- Equity and license projects
- Bituminous coal (Eastern USA)
- Proven technology
IGCC Standards Project Initiative
Enhancing Commercial Performance

Commercial IGCC

- Capex
- Environmental
- Availability
- O&M
- Schedule
- Efficiency
IGCC Standards Project Initiative
Design concept selection - major focus areas

1. Radiant syngas cooler vs. quench gasifier design
2. Gasification pressure
3. Air integration between CTG and ASU
4. Moisturization and/or diluent of syngas feed to CTGs
5. ASU optimization
6. Spare gasification train
7. Number and size of component trains
8. Coal selection and slurry concentration
9. Acid Gas Removal (AGR) technology selection
SPI Reference Plant Configuration (current status)

- **6,600 STPD Coal**
  - Coal (1) Dry basis

- **Gasification**
  - 3 x 33% + Spare
  - Gasif Train #1
  - Gasif Train #2
  - Gasif Train #3
  - Spare Gasif Train

- **Low Temp Gas Cooling & Acid Gas Removal**
  - 3 x 33%
  - LTGC #1
  - AGR #1
  - LTGC #1
  - AGR #1
  - LTGC #1
  - AGR #1

- **SRU**
  - 2 x 50%
  - SRU #1
  - SRU #2

- **TGTU**
  - 1 x 100%
  - TGTU #1

- **HRSG/Steam Turbine**
  - 3 HRSGs
  - 1 Steam Turbine
  - CTG #1
  - HRSG #1
  - CTG #2
  - HRSG #2
  - CTG #3
  - HRSG #3
  - Steam Turbine

- **CTG**
  - 3 GE 7FAs

- **850 MW**
## SPI Reference Plant – Current Case
### Overall Plant Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>@ 59°F</th>
<th>@ 90°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Feed</td>
<td>STPD</td>
<td>6594</td>
<td>6443</td>
</tr>
<tr>
<td>Oxygen Feed</td>
<td>STPD</td>
<td>6358</td>
<td>6213</td>
</tr>
<tr>
<td>Water Consumed</td>
<td>klb/hr</td>
<td>4168</td>
<td>4168</td>
</tr>
<tr>
<td>Net Power Output</td>
<td>MWe</td>
<td>849</td>
<td>799</td>
</tr>
<tr>
<td>Sulfur Byproduct</td>
<td>LTPD</td>
<td>126</td>
<td>123</td>
</tr>
<tr>
<td>Slag and Fines (wet basis)</td>
<td>STPD</td>
<td>1149</td>
<td>1123</td>
</tr>
<tr>
<td>Treated Water Discharge</td>
<td>klb/hr</td>
<td>1063</td>
<td>1063</td>
</tr>
<tr>
<td>Plant Heat Rate (HHV)</td>
<td>BTU/kWh</td>
<td>8849</td>
<td>9190</td>
</tr>
<tr>
<td>Thermal Efficiency (HHV)</td>
<td>%</td>
<td>38.6</td>
<td>37.1</td>
</tr>
</tbody>
</table>
Comparing Coal-to-Power Technologies: IGCC (Integrated Gasification Combined Cycle) vs. Supercritical Pulverized Coal (PC) Boiler Plants
Fruit-basket of variables - The “Apples and Oranges” challenge of comparing coal-to-power technologies

$/kw
- location?
- Financed?
- Opex vs. capex
- Etc.

$'

Efficiency
- '99,'00,
- '01,'02 ?

In or Out?
- Solids disposal
- Coal pile
- Scrubbers, FGD
- Etc.

Type

Trade-offs

O&M ▲ Capex

Guarantees

Varying Regulations

C.O.D.

HHV → LHV

LDs

Union ← Non-union

Hg Removed?

Different Regulations, Different Countries

Emmissions Measure
- Lb/hr
- Lb/MWh
- % removed
- ppm

Availability ← Capacity Factor

Market segment

Union

'99,'00,

'01,'02 ?
Comparison categories – IGCC vs. State-of-art Supercritical PC Boiler plant

- Capex
- Plant availability
- O&M costs
- Plant performance - efficiency
- Implementation schedule
- Environmental
- Positioning for future - CO2 recovery
## IGCC vs. PC Boiler Plants
### Relative Comparison Summary

<table>
<thead>
<tr>
<th></th>
<th>IGCC</th>
<th>PC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital ($/kW installed)</td>
<td>☀</td>
<td>●</td>
<td>Both in $1,000 - $1,400 range</td>
</tr>
<tr>
<td>Regulated emissions</td>
<td>●</td>
<td>☀</td>
<td>Clear advantage with IGCC</td>
</tr>
<tr>
<td>Mercury emissions</td>
<td>●</td>
<td>☀</td>
<td>IGCC &gt;90%, PC undetermined</td>
</tr>
<tr>
<td>O&amp;M costs</td>
<td>☀</td>
<td>●</td>
<td>PCs are becoming more complex</td>
</tr>
<tr>
<td>Plant availability</td>
<td>☀</td>
<td>●</td>
<td>Both in 90%+ range</td>
</tr>
<tr>
<td>Schedule</td>
<td>☀</td>
<td>●</td>
<td>IGCC front end will improve with repeated projects</td>
</tr>
<tr>
<td>Product/Fuel flexibility</td>
<td>●</td>
<td>☀</td>
<td>IGCC capable of multi feeds, poly-gen</td>
</tr>
<tr>
<td>Efficiency</td>
<td>●</td>
<td>☀</td>
<td>Both technologies are improving</td>
</tr>
<tr>
<td>CO2 capture positioning</td>
<td>●</td>
<td>☀</td>
<td>IGCC pre-combustion, PC post</td>
</tr>
</tbody>
</table>

- ☀ = Category leader
- ☀ through ☀ = Standing relative to category leader
<table>
<thead>
<tr>
<th></th>
<th>IGCC</th>
<th>PC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex ($/kW)</td>
<td>1,300 – 1,400</td>
<td>1,100 – 1,300</td>
<td>Location and fuel dependent, IGCC Capex includes mercury system</td>
</tr>
<tr>
<td></td>
<td>- Power only case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Availability (%)</td>
<td>&gt; 90%</td>
<td>&gt; 90%</td>
<td>IGCC includes spare gasification train</td>
</tr>
<tr>
<td>O&amp;M costs ($/MWh)</td>
<td>7.00 – 9.00</td>
<td>3.00 – 5.00</td>
<td>Excludes solids disposal</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>38.5 - 40.5</td>
<td>36.0 - 37.5</td>
<td></td>
</tr>
<tr>
<td>Heat rate (HHV)</td>
<td>8860 - 8420</td>
<td>9480 - 9100</td>
<td></td>
</tr>
</tbody>
</table>

- More work (Value Improvement Processes, etc.) planned to further reduce Capital, Heat Rate and O&M costs for IGCC
SPI IGCC Reference Plant
Spare Gasification Train Included

Note: The spare gasification train cost for the SPI reference plant is approximately $60 MM

Adding a spare train increase project returns.

The breakeven point is typically higher than the 90% per train point.
The overall IGCC plant availability can match that of the PC boiler plants (>90%). An overall IGCC availability of >90% is reached with proven availability levels per gasification train by including a spare gasification train. Further improvements in availability of individual gasification trains will provide additional opportunities to reduce capital costs.
Why a Standard IGCC Product

IGCC Delivery: Today vs. The Product Vision

IGCC Today
- Planning: 12+
- Permitting: 18
- Feed: 6-8
- CPDEP Phase 2: $3-5 MM
- CPDEP Phase 3: $25-30 MM

IGCC Product
- Planning: 12
- Permitting: <18?
- Feed: 2
- CPDEP Phase 2: $1 MM
- CPDEP Phase 3: $10-15 MM

CPDEP = ChevronTexaco Project Development and Execution Process

NTP – Reliable Operation
Current IGCC ~ 54 mo.
Product IGCC ~ 38 mo.

As much as $15 MM less development costs through Phase 3. Still higher than PC costs and most owners’ expectations. Work continues to reduce costs.
Environmental Performance
IGCC’s Proven Pre-Combustion Clean-up of Syngas Fuel to the Gas Turbine

- **NOx:** current level of 15 ppm (@15% O₂)
  - NOx suppression in gas turbine by use of a diluent such as nitrogen or steam. No SCR required.

- **SOx:** Removal of 98 - 99+% S in feed
  - Conventional H₂S removal from syngas, technology practiced in chemical and refinery industries
  - SOx < 0.5 lb/MWh

- **Particulates**
  - Both water and amine washing of syngas prior to gas turbine, up to 15-20 stages.

- **Mercury (Hg)**
  - Chemical removal from syngas through use of sulfided activated carbon bed(s). 90+% achieved.

- **Carbon dioxide (CO₂)**
  - Separation from syngas through deep sulfur removal technology; creates a high purity CO₂ stream, proven in existing ammonia plants.
Environmental Performance – Air
Comparison with Supercritical PC Plants

<table>
<thead>
<tr>
<th></th>
<th>lb/MWh</th>
<th>lb/MMBtu</th>
<th>ppmv</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IGCC</td>
<td>PC</td>
<td>IGCC</td>
</tr>
<tr>
<td>SOx 1</td>
<td>0.47</td>
<td>1.19 3</td>
<td>0.053</td>
</tr>
<tr>
<td>NOx 2</td>
<td>0.50</td>
<td>0.72 3</td>
<td>0.057</td>
</tr>
<tr>
<td>CO</td>
<td>0.32</td>
<td>0.99</td>
<td>0.036</td>
</tr>
<tr>
<td>PM</td>
<td>0.06</td>
<td>0.16</td>
<td>0.007</td>
</tr>
<tr>
<td>VOC</td>
<td>0.01</td>
<td>0.04</td>
<td>0.001</td>
</tr>
</tbody>
</table>

1. Comparison assumes Eastern Bituminous Coal with 2.2 wt% sulfur
2. For IGCC, NOx is corrected to 15% O₂; For PC, NOx is corrected to 6% O₂
3. PC Plant requires SCR and wet FGD to accomplish above emissions for NOx and SOx.
Environmental Performance – Air (continued)  
Comparison with Supercritical PC Plants

Mercury Removal

<table>
<thead>
<tr>
<th></th>
<th>IGCC</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury Removal</td>
<td>&gt; 90 + %</td>
<td>~ 30 - 50%</td>
</tr>
</tbody>
</table>

- Proven mercury removal, at Eastman Chemical’s Kingsport, Tennessee gasification facility, from the compressed syngas upstream of the gas turbine. This allows mercury removal to be less expensive, less complex and with higher reliability. Testing reproducibility still an issue.
- The cost of mercury removal for PC plants can be an order of magnitude higher than the IGCC plant, due to the much higher volume of gas to treat in a PC.
- The cost increment to add 90% removal to an IGCC plant is estimated to be less than 0.3% and the increase the cost of electricity is less than 1%.

Environmental Performance – Air (continued)
Comparison with Supercritical PC Plants

<table>
<thead>
<tr>
<th></th>
<th>IGCC</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Production due to Relative Efficiency</td>
<td>Base</td>
<td>~ + 2 %</td>
</tr>
<tr>
<td>CO₂ Removal Incremental cost of electricity</td>
<td>1.5 – 2 ¢/kWh</td>
<td>&gt; 3 ¢/kWh</td>
</tr>
</tbody>
</table>

- IGCC CO₂ removal by absorption scrubber of compressed syngas. PC CO₂ removal by MEA scrubbing of flue gas.

Environmental Performance - Solids
Comparison with Supercritical PC Plants

<table>
<thead>
<tr>
<th></th>
<th>lb/MWh</th>
<th>lb/MMBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IGCC</td>
<td>PC</td>
</tr>
<tr>
<td>Ash</td>
<td>0</td>
<td>83</td>
</tr>
<tr>
<td>Slag</td>
<td>113</td>
<td>0</td>
</tr>
<tr>
<td>FGD Sludge</td>
<td>0</td>
<td>114 ²</td>
</tr>
<tr>
<td>Sulfur Recovered</td>
<td>14 ³</td>
<td>0</td>
</tr>
</tbody>
</table>

1. Comparison assumes Eastern Bituminous Coal with 10 wt% ash & 2.2 wt% sulfur & based on the latest CVX Reference Plant Data
2. For IGCC, 98+% of sulfur in coal recovered as elemental sulfur while for PC, sulfur in the coal ends up in the sludge
3. IGCC recovered sulfur is a saleable product, as solid sulfur or sulfuric acid.
Next Generation:
CO2 Capture with IGCC
IGCC as a Pre-Combustion CO₂ Capture Technology – Near Future

Coal, Petroleum Coke, Heavy Oil

Gasification

Water Gas Shift Reaction

CO + H₂O → CO₂ + H₂

Sour Shift

AGR / SRU

H₂

Mercury S CO₂

Power

H₂O

Note: Nine ammonia projects using CVX gasification in China currently remove CO₂, and recombine with Ammonia to produce Urea. Urea capacity is more than 4 million tons/year (Urea is a solid fertilizer).
Conclusions
Benefits of ChevronTexaco IGCC

• IGCC compares well with PC plants, with further cost reductions expected, and “is in the ballpark” on categories led by PC plants.

• Compared to alternative coal fossil technologies, IGCC provides:
  - Lowest NOx, SOx, Particulates and solid waste streams
  - Lower HAPS (Hazardous Air Pollutants)
  - Higher mercury removal (more than 95% expected)
  - Higher Efficiency through polygeneration

• Ready now for CO2 control scenarios: sequestration/injection for enhanced oil recovery

• Unique technology to utilize domestic energy sources (coal, pet coke) for cleaner energy, and provide future flexibility

• Provides strategic long-term options for local, regional and national energy security concerns