Siemens Technology Improvements Enhance IGCC Plant Economics

Harry Morehead, Frank Hannemann, Siemens Power Generation
Gasification Technologies 2005
San Francisco, CA
October 12, 2005
Agenda

• Experience Update
• Product Enhancements
• Technologies in the Pipeline
• Integrated Approach to Improving Economics
Siemens Technology Improvements Enhance IGCC Plant Economics

- Siemens Power Generation
  - Group Executive Management: Klaus Voges, Ralf Guntermann, Norbert König, Randy Zwirn
  - Power Generation
    - Gas turbines and combined-cycle power plants
    - Steam turbines and power plants
    - Electrical generators
    - Plant Diagnostics
    - Operating Plant Service
  - Industrial Applications
    - Industrial size turbines and power plants
    - Turbo compressors
    - Oil and Gas Sector
    - Service
  - Instrumentation & Controls
    - Instrumentation and control systems
    - IT solutions for power plant management
  - Wind Energy
    - On shore and off shore renewable wind energy solutions
  - Stationary Fuel Cells
  - Joint Venture
    - Framatome Advanced Nuclear Power
      (Siemens stake 34%)
    - Voith Siemens Hydro
      (Siemens stake 35%)
  - Regional Offices Worldwide

Integrated global network for power generation
Siemens Worldwide Global Experience and Capabilities

- Comprehensive Power Plant Design, Operating Experience

- Single-Point Responsibility for Complete Plant

- Long-Term Partnership with Constructors and Vendors

- Partnership Concept with Owner/Operator

- Advanced Project Implementation Tools

Plant Design with O&M In Mind Over 110 Successful EPC Projects (~30 GW) / 43 O&M Contracts (~17 GW)

World (GW)

USA, Canada, Mexico

Western Europe

Eastern Europe

Africa & Middle East

Asia Pacific (w/o China)

Central & South America

China

- Steam Turbine
- Gas Turbine

… represent ~33% of U.S. fleet and ~20% of world’s installed base

FY00

FY03

535

679

330

174

8

15

55

25

72

25

22
## Experience on Syngas from Modern IGCC Plants

<table>
<thead>
<tr>
<th>Customer/Plant (Location)</th>
<th>Electrical Output (net)</th>
<th>Gas Turbine</th>
<th>Main Features</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hörde Steelworks (Dortmund, Germany)</td>
<td>8 MW</td>
<td>VM5</td>
<td>Blast-furnace-gas-fired, gas turbine as compressor drive</td>
<td>1960/2000</td>
</tr>
<tr>
<td>Handan Iron &amp; Steel (Handan, P.R. China)</td>
<td>20 MW</td>
<td>CW201</td>
<td>Blast-furnace-gas-fired gas turbine</td>
<td>1960</td>
</tr>
<tr>
<td>U. S. Steel Corp. (Chicago, USA)</td>
<td>208 MW</td>
<td>2 x W501D5</td>
<td>CC plant with integrated DOW coal gasification</td>
<td>1987</td>
</tr>
<tr>
<td>STEAG/Kellermann (Lünen, Germany)</td>
<td>163 MW</td>
<td>V93</td>
<td>First CC plant in the world with integrated LURGI coal gasification (hard coal)</td>
<td>1972</td>
</tr>
<tr>
<td>DOW Chemicals (Plaquemine, USA)</td>
<td>253 MW</td>
<td>V94.2</td>
<td>CC plant with integrated SHELL coal gasification (hard coal and biomass blend)</td>
<td>1993/94/95</td>
</tr>
<tr>
<td>Nuon Power Buggenum (Buggenum, Netherlands)</td>
<td>10 MW</td>
<td>Typhoon</td>
<td>CC plant with integrated drying gasification process (lignite)</td>
<td>1996</td>
</tr>
<tr>
<td>SYDKRAFT (Värnamo, Sweden)</td>
<td>300 MW</td>
<td>V94.3</td>
<td>CC plant with integrated PRENFLOR coal gasification (coal and petroleum coke blend)</td>
<td>1996/97/98</td>
</tr>
<tr>
<td>ELETTRA GLT (Servola, Italy)</td>
<td>180 MW</td>
<td>V94.2K</td>
<td>CC plant with steel-making recovery gas</td>
<td>2000</td>
</tr>
<tr>
<td>ARBRE (Eggborough, UK)</td>
<td>8 MW</td>
<td>Typhoon</td>
<td>CC plant with integrated biomass gasification</td>
<td>2002</td>
</tr>
<tr>
<td>EniPower (Sannazzaro, Italy)</td>
<td>250 MW</td>
<td>V94.2K</td>
<td>CC plant with integrated SHELL heavy-oil gasification</td>
<td>2005</td>
</tr>
</tbody>
</table>

1) 160 MW from syngas and 48 MW from natural gas; 2) Natural gas firing; 3) Oil firing
### Siemens Scope

<table>
<thead>
<tr>
<th>Customer/Plant (Location)</th>
<th>Siemens Scope</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOW Chemicals (Plaquemine, USA)</td>
<td>ASU main air compressor</td>
<td>1987</td>
</tr>
<tr>
<td>Nuon Power Buggenum (Buggenum, Netherlands)</td>
<td>ASU air compressor (for start-up) N₂ compressors, O₂ compressor</td>
<td>1993/94/95</td>
</tr>
<tr>
<td>Global Energy/Wabash River (West Terre Haute, USA)</td>
<td>ASU main air compressor O₂ compressor</td>
<td>1995</td>
</tr>
<tr>
<td>Tampa Electric/Polk County (Mulberry, USA)</td>
<td>ASU main air compressor N₂ compressors, O₂ compressor</td>
<td>1996</td>
</tr>
<tr>
<td>ELCOGAS (Puertollano, Spain)</td>
<td>IGCC plant Instrumentation &amp; control system Claus gas compressor IGCC plant optimization and integration study</td>
<td>1996/97/98</td>
</tr>
<tr>
<td>NPRC/Negishi (Negishi/Japan)</td>
<td>ASU main air compressor N₂ /air compressors, O₂ compressor</td>
<td>2003</td>
</tr>
</tbody>
</table>

### Siemens Technology Improvements Enhance IGCC Plant Economics

- **Air / N₂ / O₂ / Syngas Compressor Trains**
- **IGCC Plant Instrumentation and Control Systems**

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Siemens Technology Improvements Enhance IGCC Plant Economics

Power Generation 6

Morehead, New Unit Marketing
Agenda

- Experience Update
- Product Enhancements
- Technologies in the Pipeline
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### Gas Turbine IGCC Performance Estimates

[ISO Conditions] (Preliminary Study)

<table>
<thead>
<tr>
<th></th>
<th>SGT6-5000F</th>
<th></th>
<th>SGT6-6000G</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Natural Gas</td>
<td>Syngas</td>
<td>Natural Gas</td>
<td>Syngas</td>
</tr>
<tr>
<td>Gross GT Output, MW</td>
<td>210</td>
<td>232</td>
<td>279</td>
<td>296</td>
</tr>
<tr>
<td>NOx, ppmvd @ 15% O2 (w/o SCR)</td>
<td>25</td>
<td>15</td>
<td>25</td>
<td>15</td>
</tr>
</tbody>
</table>

Diluents: Natural Gas – Steam, Syngas – Nitrogen
Estimates based on SGT6-5000F with Syngas Combustion System, SGT6-5000F Emissions Verified in 2005

**Higher Output From Proven Gas Turbine Technology**
Today’s Fuel Flexible SGT6-5000F

**SGT6-5000F for IGCC Applications**

- Based on proven standard product and fleet experience
- Lessons learned from prior and current IGCC Plants are the foundation for adaptations for IGCC
- Full scale testing forms the basis for new technology improvements

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95%
Fleet Availability
SGT6-5000F Modifications for IGCC Applications

- Syngas Combustion System
- Syngas Fuel Supply / Purge Skid & Manifolds
- Diluent (N₂ or Steam) Injection Skid & Manifolds
- Extraction Air Skid & Manifolds
- Control System Modifications
- Enclosure Modifications
- Protection System Modifications
IGCC Power Block Design Based on:

- Syngas primary fuel with natural gas as backup fuel
- 2 x 1 turbine configuration
- 0-50% air-side integration capable
- Integrated steam cycle

*Based on the SGT6-5000F and SCC6-5000F 2X1 Reference Plant Design*
Agenda

- Experience Update
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Burner Development for Syngases and Hydrogen-enriched Gases

Advanced syngas/hydrogen burner to be used in F-class

Challenges:
- syngas/hydrogen highly reactive (flame speed, combustion temperature) ⇒ risk of flash-back
- high volume flux

Concept:
DLN combustion for syngas / hydrogen rich fuels

First design phase completed and high pressure combustion tests successfully performed

European R&D projects
- HEGSA
- encapco2

Operational Experience
Fuel Oil (diffusion)
Natural Gas (diffusion)
Syngas
Air

Buggenum, Puertollano and ISAB
Low Emission Combustion
Ultra Low-NO\textsubscript{x} IGCC Combustion Technology

**DOE / Siemens**

**Ultra Low NO\textsubscript{x} Combustion System for Fuel Flexible Gas Turbines**

**Program Objectives**
- < 2-3 ppm NO\textsubscript{x} w/o SCR
- Cost Effective and Retrofitable
- Fuel Flexible
  - Syngas, Natural Gas, H\textsubscript{2}

**Schedule**
- Currently in Phase 2
- Program Complete in 2007

**Goals for Phase 2**
- Select Final Basket Design for Syngas/Natural Gas
- Select Final Coating for Syngas/Natural Gas
- Perform Verification Testing at Module and Subscale Level
- Subscale Verification for Hydrogen Fuel
- Final Design for Fuel Flexible STG6-5000F Basket

**Combustor Technologies**
- NO\textsubscript{x} Emissions
- Diffusion
- RQL
- Lean Premix
- Catalytic

- Syngas
- NG Only
- Fuel Flexible

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Enabling Turbine Technologies for High-Hydrogen Fuels

DOE / Siemens
Advanced Hydrogen Turbine for FutureGen

Program Objectives (2015)

- Advanced GT with H2 and Syngas Operating Capability
- 3-5% Points Plant Efficiency Improvement from Gas Turbine
- Plant Capital Cost < 1000 $/kW

Schedule

- Program Start: Oct 1, 2005
- Phase 1: Two years
- Phase 2: Four years
- Phase 3: TBD

Goals for Phase 1

- Conceptual Design
- R&D Implementation Plan
Agenda

- Experience Update
- Product Enhancements
- Technologies in the Pipeline
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# Accelerating Market Acceptance of IGCC Reducing IGCC Capital Cost

## Standardized IGCC Reference Plant

- Maximize use of gasifier and gas turbine output
- Improved interfaces
- Optimized plant integration between gasifier island and combined cycle
- Reduction of contingencies

## Technology Advancements

- Technologies that lowers O&M and eliminates need for spare gasifier
- Technologies that have the potential for 50% cost reduction of gas clean up system
- Technologies that improve efficiency and lower capital cost

## Cost Reduction Target

$1300-1600/kW

Competitive Level with Other Coal Options
Technology Helps Improve IGCC Performance and Economics but…

It is the Business Structure of the Project that Makes it Happen!
Questions?

- IGCC Power Block for 60 Hz Applications
- 50 and 60 Hz Gas Turbine Generators with Syngas / Natural Gas (or Oil) Capability
- Steam Turbine Generators
- IGCC Plant Instrumentation and Controls
- IGCC Compression Solutions
- IGCC Power Block O&M Services