The Reliability of IGCC Power Generation Units

ACHEMA 2006
Frankfurt, 18th May 2006

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Overview

• SPS’s ORAP database
• Project goals and methodology
• Project schedule
• Some preliminary findings
• Conclusions
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• Specialists in syngas production from gasification and steam reforming

• Activities
  – Process integration
  – Project consultancy
  – Feasibility studies
  – Training seminars
  – Plant audits
Who is SPS?  What is ORAP?

- An Information Technology & Reliability Engineering Company — Since 1987
- Support the Electric Power & Industrial Process markets...
- Recognized leader through ORAP… the Most Comprehensive Global Database in Our Industry … Unbiased & Accurate
  - Monitors Gas & Steam Turbine Plants . . . ISO 9001 Certified
  - Database in place since 1976
  - Over 2,000 Units Worldwide, Over 20,000 unit years of operating information available . . .
  - Strong Influence on Industry Standards . . . ISO 3977 Standard
- Provide “Knowledge Based” Engineering Services & Software Products focused on:
  - Data analysis and evaluation… Availability & Reliability
  - Knowledge transfer… Benchmarking & “Best Practices”
  - Remote Monitoring… Real-Time Data for Maintenance & Life Planning

Reliable Data for Effective Decision Support through ORAP
Where is IGCC now?

✓ Superior environmental performance

✓ Higher efficiency

➢ Installed cost

? Reliability
Effect of Reliability

- +/- 5% Outage rate
- +/- 5% CAPEX
- +/- 5% Heat rate

Cost of Electricity US$/MWh
Current Reliability Performance

Plant A

Plant B

On stream
Not required/despatched
Planned outage
Unplanned outage
Reliability - BP, Gelsenkirchen

Source: Laege, 2002
Project Goals

• Establish reliable, evidence-based expectation for IGCC availability
  – Using public domain reliability data
  – Using actual plant data
  – Using common definitions
• Update prediction models with “best-of-class” plant data
• Identify strengths and weaknesses
  – Inside/outside core gasifier unit
Public domain literature
Potential Participating Plants

- 14 IGCCs
  - 8 solid feedstock
  - 6 liquid feedstock
- 11 chemical and refinery plants
  - 3 solid feedstock
  - 8 liquid feedstock
Include some chemical plants

• Increases sample for improved validation
• Provides representative data on
  – Oxygen supply
  – Gasification
  – Gas treatment
• Ammonia plants will supply data on CO$_2$ capture
  (and compression where integrated urea plant)
Project Schedule

✓ Data base structure and codes  July 2005
✓ Evaluate public domain data  End Aug 2005
✓ Preliminary findings  Oct 2005
• Plant interviews  ongoing
• Preliminary report  June 2006
• Detail evaluation & prediction model  End 2006
Some preliminary findings

• Air Separation Units
• Gasification Units
• Acid Gas Removal/ Sulfur Recovery Units
• Combined Cycle Units
• Overall Picture
### NERC GADS Data 2000-2004

<table>
<thead>
<tr>
<th>Type</th>
<th>Service Factor (%)</th>
<th>Capacity Factor (%)</th>
<th>Availability Factor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas-fired boilers</td>
<td>40.0</td>
<td>23.1</td>
<td>87.5</td>
</tr>
<tr>
<td>Oil-fired boilers</td>
<td>41.1</td>
<td>27.5</td>
<td>86.5</td>
</tr>
<tr>
<td>Coal-fired boilers</td>
<td>83.2</td>
<td>71.9</td>
<td>87.6</td>
</tr>
<tr>
<td>Aero-derivatives</td>
<td>5.1</td>
<td>3.7</td>
<td>93.0</td>
</tr>
<tr>
<td>Single Cycle GTs</td>
<td>4.3</td>
<td>3.8</td>
<td>93.1</td>
</tr>
<tr>
<td>Combined Cycle GTs</td>
<td>Not available</td>
<td>Not available</td>
<td>Not available</td>
</tr>
</tbody>
</table>

Source: DellaVilla, 2004
ASU: Public Domain Data

Unplanned outages

Puertollano
Buggenum
Polk
Wabash
Negishi

% Unplanned outages

0 1.5 3 4.5 6 7.5 9 10.5 12 12.5 15

1999 2000 2001 2002 2003
Gasification

Average of four plants

% Unplanned outage

2001 2002 2003

Black water
Scrubber
Dry Filtration
Syngas Piping
Syngas Coolers
Slag Disposal
Gasifier
Feed systems
Acid Gas Removal

Average of Four Plants

% Unplanned outages

0.00  2.50  5.00  7.50  10.00  12.50  15.00

1999  2000  2001  2002  2003

Yellow: Sulfur Recovery Unit
Red: Acid Gas Removal
Blue: COS Hydrolysis

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ORAP – Forced and Scheduled Outage

Simple Cycle Plant Forced Outage Factor and Scheduled Outage Factor
2000 - 2005
ORAP Data

- Aeroderivatives: Forced Outage Factor 3.7%, Scheduled Outage Factor 2.3%
- Mature Class: Forced Outage Factor 4.3%, Scheduled Outage Factor 1.2%
- F Class: Forced Outage Factor 2.2%, Scheduled Outage Factor 6.8%
# ORAP Data 2000-2005

## Simple Cycle Plant Statistics

<table>
<thead>
<tr>
<th></th>
<th>Service Factor (%)</th>
<th>Availability (%)</th>
<th>Reliability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeroderivative Utility</td>
<td>34.7</td>
<td>92.1</td>
<td>96.5</td>
</tr>
<tr>
<td>Non-Utility</td>
<td>55.3</td>
<td>94.3</td>
<td>97.9</td>
</tr>
<tr>
<td>E-Class Utility</td>
<td>18.2</td>
<td>94.1</td>
<td>98.8</td>
</tr>
<tr>
<td>Non-Utility</td>
<td>62.0</td>
<td>95.0</td>
<td>99.0</td>
</tr>
<tr>
<td>F-Class Utility</td>
<td>60.6</td>
<td>90.1</td>
<td>97.6</td>
</tr>
<tr>
<td>Non-Utility</td>
<td>55.2</td>
<td>91.7</td>
<td>98.1</td>
</tr>
</tbody>
</table>

Source: DellaVilla, 2004
Power Block: Public Domain Data

Note: Wabash data estimated from “Syngas not required”
Data for some plants/years incomplete
Overall Outage Data – Coal IGCCs

Average of four plants

% Unplanned outage

<table>
<thead>
<tr>
<th>Year</th>
<th>CCU</th>
<th>AGR-SRU</th>
<th>Gasifier</th>
<th>ASU</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Italian Resid IGCC Configurations

<table>
<thead>
<tr>
<th>ASU Integration</th>
<th>ISAB (Sicily)</th>
<th>Sarlux (Sardinia)</th>
<th>api Energia (Falconara)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None (Air Liquide)</td>
<td>None (Air Liquide)</td>
<td>None</td>
</tr>
<tr>
<td>Gasifier Feed rate</td>
<td>GE (2 gasifiers)</td>
<td>GE (3 gasifiers)</td>
<td>GE (2 gasifiers)</td>
</tr>
<tr>
<td>Pressure</td>
<td>3168 t/d 67 bar</td>
<td>3559 t/d 38 bar</td>
<td>1440 t/d ~60 bar</td>
</tr>
<tr>
<td>AGR</td>
<td>MDEA</td>
<td>Selexol</td>
<td>Selexol</td>
</tr>
<tr>
<td>Gas turbine</td>
<td>Siemens 2 x V94.2K</td>
<td>GE 3 x STAG 109E</td>
<td>Alstom 1 x 13E2</td>
</tr>
<tr>
<td>Power output</td>
<td>512 MW</td>
<td>551 MW</td>
<td>241 MW</td>
</tr>
<tr>
<td>Co-products</td>
<td>40,000 Nm³H₂/h 180 t/h steam</td>
<td>65 t/h steam</td>
<td></td>
</tr>
</tbody>
</table>
Performance of Italian Resid. IGCCs

Sources: Collodi, 2003; Arienti, 2005; Allevi, 2006, Jaeger, 2006
Sarlux IGCC 2002 Operation

On stream: 90.76%
Not required/despatched: 7.37%
Planned outage: 1.61%
Unplanned outage: 1.16%

Source: Collodi, GTC 2003
Improvement Targets for Coal IGCCs

- CCU
- Gas treating
- Gasification
- ASU
- Planned Outage

Achieved 2001-2003:
- CCU: 15%
- Gas treating: 5%
- Gasification: 10%
- ASU: 5%
- Planned Outage: 0%

2006 Target:
- CCU: 20%
- Gas treating: 6%
- Gasification: 10%
- ASU: 6%
- Planned Outage: 4%

2010 Target:
- CCU: 25%
- Gas treating: 7%
- Gasification: 15%
- ASU: 7%
- Planned Outage: 6%
Summary

• “Maybe folks are now beginning to realize that there is more to reliability than just a spare gasifier.”
• The introduction of advanced technology anywhere in the system has its attendant risks.
• Attention to detail in “standard” auxiliary units can contribute substantially to IGCC reliability.
• ORAP RAM tracking can help identify the areas for improvement
• Implementation of “lessons learned” at all levels is key to success.
Thank you

Any questions?

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http://www.higman.de/gasification/index.htm