R & D plan results and experience in the Puertollano IGCC

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1. OPERATIONAL STATUS

2. R&D PLAN. REPORT
1. PUERTOLLANO IGCC POWER PLANT DESCRIPTION

Process description

Heat Recovery Steam Generator

Steam

Hot combustion gas

Coal preparation

HP Boiler

MP Boiler

Gasifier

Filtration

Water wash

Sulfur Removal

Sulfur Recovery

Clean syngas

Coal

Petroleum Coke

Limestone

Coal - N₂

Raw Gas

Quench Gas

Fly ash

Water to treatment

Tail Gas

Claus gas

Sulfur (99.8%)

Clean syngas

Sulfur

Recovery

N₂

O₂

Air Separation Unit

Compressed air

Flue gas to stack

Steam

Waste N₂

GAS TURBINE

135MWₐₙₙ

Cooling tower

G

STEAM TURBINE

200 MWₐₙₙ
1. PUERTOLLANO IGCC POWER PLANT: Operating data

1st 5 years: Learning curve
2003: Major overhaul Gas Turbine findings
2004 & 2005: Gas turbine main generation transformer isolation fault
2006: Gas turbine major overhaul & candle fly ash filters crisis
2007 & 2008: ASU WN₂ compressor coupling fault and repair MAN TURBO
1. PUERTOLLANO IGCC POWER PLANT: Operating data

Emissions in NGCC and IGCC modes

**Natural gas (mg/Nm³ at 6% O₂ dry)**

- SO₂: 29.2, 12.5, 8.4, 4.2, 4.2, 0.1
- Particles:
- NOₓ: 291.7, 250.0, 178.2

- EEC 88/609
- ELCOGAS Environmental Permit
- ELCOGAS 2009 average

**Coal gas (mg/Nm³ at 6% O₂ dry)**

- SO₂: 400, 200, 34.6, 137.6, 50, 5
- NOₓ: 650, 500, 200
- Particles: 50, 5, 0.12

- EU Directive 88/609/EEC
- ELCOGAS Environmental Permit
- ELCOGAS 2009 average
1. PUERTOLLANO IGCC POWER PLANT: Operating data

AVAILABILITY 2009

<table>
<thead>
<tr>
<th></th>
<th>Availability</th>
<th>Planned Outages</th>
<th>Unplanned Outages</th>
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<tbody>
<tr>
<td>IGCC</td>
<td>25.4%</td>
<td>9.9%</td>
<td>64.7%</td>
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<tr>
<td>Gasifier</td>
<td>12.2%</td>
<td>10.1%</td>
<td>77.7%</td>
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<td>Power Block</td>
<td>7.8%</td>
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<tr>
<td>ASU</td>
<td>7.5%</td>
<td>3.1%</td>
<td>89.4%</td>
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</tbody>
</table>
1. PUERTOLLANO IGCC POWER PLANT: Operating data

**IGCC UNAVAILABILITY 2009**

**Gasification**
- Gas Wet Treatment: 17%
- Quench Gas Recirculation: 1%
- Water Steam Systems & Boilers: 28%
- Mixing & Grinding Plant: 3%
- Dust Fuel Conveying & Feeding: 9%
- Start-Up Burner & Flame Monitors: 2%
- Slags: 8%
- Dry Deducing & Fly Ash Systems: 32%
- Sulphur Recovery & Tail Gas Recycle: 0%

**Combined cycle**
- Water-steam cycle: 7%
- Gas Turbine: 71%

**ASU**
- Gas Oxygen Production: 48%
- Waste Nitrogen Production: 47%
- Pure Nitrogen Production: 5%
- ASU: 18%
- BOP: 5%

**BOP**
- Auxiliary System: 37%
- DCS: 63%
- Electrical System: 0%

**Islands Unavailability**
- Gasification: 65%
- Combined Cycle: 12%
- ASU: 18%
- BOP: 5%
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1. OPERATIONAL STATUS

2. R&D PLAN. REPORT
PUERTOLLANO IGCC ACTIONS FOR THE FUTURE

OUR PLANS ARE BASED ON THE OPPORTUNITY THAT REPRESENTS TO HAVE AN OPERATIVE IGCC PLANT NOW AND FOR THE FUTURE CONTRIBUTION CAN BE RELEVANT IN SUSTAINABILITY ENERGY CONCERNS:

CLIMATE CHANGE MITIGATION & ENERGY SUPPLY RELIABILITY
Since 2007 ELCOGAS has defined a R&D Investment Plan to develop IGCC technology in order to decrease the environmental impact of power production as main target.

ELCOGAS presents a yearly results report of that R&D Plan to Spanish government for evaluation.

**MAIN LINES OF R&D PLAN ARE:**

- $CO_2$ EMISSION REDUCTION IN UTILIZATION OF FOSSIL FUELS
- $H_2$ PRODUCTION BY GASIFICATION OF FOSSIL FUELS
- **DIVERSIFICATION** OF RAW FUELS AND PRODUCTS
- OTHER **ENVIRONMENTAL** IMPROVEMENTS
- IGCC PROCESSES **OPTIMIZATION**
- **DISSEMINATION** OF RESULTS
2. ELCOGAS R&D INVESTMENT PLAN

Dissemination of results

- **Forum** participations. CO$_2$, H$_2$, and sustainability associations and Technological Platforms. European and Spanish. **Coordinating working groups in Technological Spanish Platforms.**
- Participation in **conferences**, seminars, congresses.
- **Consulting** services. Germany, China, Chile
- Attending and promoting technical **visits**. Generally international visits.

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Optimization of IGCC processes. Oriented to improve availability and costs.

- **Gasifier** materials. Life extension.
- Syngas **corrosion** processes. Optimization and tests of materials.
- Elimination of water leakages of **membrane** at reaction chamber.
- Ceramic **filters**. Many tests with alternatives have been done. Final assessment is to install a new filter system provided by Pall.
- **Gas Turbine** reliability improvement and life extension.
- Improvement of **integration** with ASU. *(Start up compressor).*
- **O&M** specific availability incidents analysis.
2. ELCOGAS R&D INVESTMENT PLAN

Other environmental improvements

- **Liquid wastes** reduction. Change of waste water treatment plant
- Improvement of syngas **cleaning** systems. Currently participating in project **AGAPUTE** (RFCS, 2004-08, to study improvements in syngas cleaning). Hg task.
- Improvements in **Sulphur** Recovery plant. In progress several modifications to improve availability and to reduce S emissions.
- Operation and additives **parameters** optimization. Included in AGAPUTE to study dosing of limestone, oxygen, steam, vs. concentration of contaminants in slags, fly ash and washing water
- Emissions reduction during start up and other **transitory** situations.

Cross correlation between limestone content in the fuel and Se bulk fly ash content
2. ELCOGAS R&D INVESTMENT PLAN

Diversification of raw fuels and products

Project PIIBE (ESP-CENIT). To impulse biofuels technologies in Spain. ELCOGAS coordinates the subproject about **biodiesel** from gasification by real co-gasification 10% of biomass and syngas characterization (F-T process in laboratory)

Agreement with a private European Company to install a pilot plant in IGCC of Puertollano to develop process to obtain **gasoline from syngas**

Project PEIXE VERDE. (ESP-PSE). Technical-economic study about **uses of syngas** as fuel for fishing ships in different scales of production

Co-gasification of car manufacture **wastes** (shredder fibres) was agreed with supplier.

Available to do tests of gasification of **different fuels** at large scale to help in design of new IGCC plants

Clean H₂ by gasification of fuels

H₂ production in IGCC. Project HYDROSEEP (RFCS, to study IGCC adaptation to H₂ production)

Study and tests of **new** processes of **H₂ purification**. Project SPHERA (ESP-CENIT)

Available to collaborate with new H₂ & Fuel Cells **Experimental National Centre** of Puertollano
CO$_2$ EMISSION REDUCTION

• **IGCC Efficiency Optimization**

  Analysis of viability to improve efficiency based on Critical Assessment of Puertollano IGCC design

  **Auxiliary** consumption optimization. New revision

  Development of **tools** to improve efficiency. Supervision on line of main (120) equipment efficiency. Installed and in tests

  Integration optimization. Improvement of **controls** to adjust heat & mass balances in real operation

  And

• **CO$_2$ capture for CCS with IGCC**
To demonstrate the feasibility of capture of CO\textsubscript{2} and production of H\textsubscript{2} in an IGCC that uses solid fossil fuels and wastes as main feedstock.

To obtain economic data enough to scale it to the full Puertollano IGCC capacity in synthetic gas production.

**TARGETS**

**PARTICIPANTS & BUDGET**

ELCOGAS – UCLM – Ciemat – INCAR CSIC 14 M€ (initially 18.5 M€)

**COORDINATED**

Project of pilot plant in existing IGCC of Puertollano is part of a Spanish national initiative, “Advanced technologies of CO\textsubscript{2} conversion, capture and storage” and it is coordinated with other related projects:

Project # 2 is to explore CO\textsubscript{2} capture with oxyfuel technology in a 20MW pilot plant. To be built in El Bierzo, NW of Spain. CIUDEN

Project # 3 is to study and regulate geological storage in Spain. IGME

Project #4 is to study public awareness of CCS technologies. CIEMAT
COAL + PETCOKE

GASIFICATION

Raw gas

Filtration System

183,000 Nm³/h

Purification & Desulphurisation

Clean gas

Combined Cycle

CO₂ Line – “Singular and strategic project PSE-CO₂”

Pilot plant size: 1:50 ~ 14 MWₜₜ
2. ELCOGAS R&D INVESTMENT PLAN.
CO2 line – “Singular and strategic project PSE-CO2”

Executed (March 2010)
✓ 100 % engineering work
✓ 100 % equipment supply
✓ 95 % construction

Start-up: April 2010
End of the tests to obtain data for different operating conditions and purity grades March 2011

MAIN SUPPLIERS

<table>
<thead>
<tr>
<th>Work</th>
<th>Supplier</th>
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<tbody>
<tr>
<td>Detailed engineering</td>
<td>Empresarios Agrupados</td>
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<td>CO2 unit</td>
<td>Linde-Caloric</td>
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<tr>
<td>PSA unit</td>
<td>Linde</td>
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<tr>
<td>Civil work</td>
<td>Construcciones Ocaña-Cañas</td>
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<td>Control system supply</td>
<td>Zeus Control</td>
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<td>Reactors supply</td>
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<td>Heat exchangers</td>
<td>Tecnical y Boreal-Vila</td>
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<td>Catalyst supply</td>
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<td>Electrical components</td>
<td>GE Power</td>
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<tr>
<td>Analyzers system</td>
<td>ABB División de automatización de procesos</td>
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</tbody>
</table>
2. ELCOGAS R&D INVESTMENT PLAN.
CO₂ line – “Singular and strategic project PSE-CO₂”
2. ELCOGAS R&D INVESTMENT PLAN.
CO₂ line – “Singular and strategic project PSE-CO₂”

Civil work (August 2009)

PSA unit buffers and absorbers (Linde)
2. ELCOGAS R&D INVESTMENT PLAN.
CO2 line – “Singular and strategic project PSE-CO₂”

Aerial view (November 2009)
2. ELCOGAS R&D INVESTMENT PLAN.
CO₂ line – “Singular and strategic project PSE-CO₂”

Aerial view (February 2009)

Operation display of the pilot plant
2. ELCOGAS R&D INVESTMENT PLAN.
CO2 line – “Singular and strategic project PSE-CO2”
4. ELCOGAS R&D INVESTMENT PLAN. CO$_2$ line

**Pilot plant** for CO$_2$ capture and production of H$_2$ and electricity with IGCC technology

Other activities: To be done after PSE as R&D platform:

- Water shift reaction **catalyst** optimization. Tests of different catalysts
- **New processes** to separate CO$_2$-H$_2$
- CO$_2$ different **treatment** processes
- Improvement of **integration** efficiency between CO$_2$ separation processes and IGCC plant

Other proposals from Industry or Research community to use the IGCC plant and its pilot plant to develop of process, equipments, components, or even pre-engineering of new plants with CCS and Zero emissions
R & D plan results and experience in the Puertollano IGCC

THANK YOU FOR YOUR ATTENTION

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