Carbon Capture Demonstration Pilot Plant
Summary

1. Elcogas & Puertollano IGCC Plant.
2. Why CCS?
3. Carbon Capture Pilot Plant with H₂ Production
4. Economic aspects
European company established in April 1992 to undertake the planning, construction, management and operation of a 335 MW ISO IGCC plant located in Puertollano (Spain)
Puertollano IGCC Power Plant. Block Diagram
Values of IGCC Technology (I)

✓ **High efficiency.** Higher than other coal-based technologies & great potential of improvement: net 42% to 50%

✓ **Flexible feeding.** Coal (several qualities), alternative fuels (coke, biomass), availability of second fuel for combined cycle.

✓ **Product flexibility.** Power, H₂, CO₂, methanol, NH₃, gasolines, etc

✓ **Environment:**
  • Lower CO₂ emissions compared to other coal-based technologies. Higher potential to zero emission plants
  • Low acid gas emission (SO₂, NOₓ) and particles. Similar or better than NGCC plants
  • Lower wastes. Slag, fly ash, sulphur and salts are by-products

✓ **Economy:**
  • Very competitive fuel compared to natural gas. Variable cost per kWh with coal is very low compared to natural gas
  • Lower cost of CO₂ capture (pre-combustion)
  • Wastes are marketable products
Disadvantages of IGCC Technology

✗ Technology at demonstration state

✗ The four large coal-based plants (USA & EU) show 60-80% of IGCC availability (> 90 % considering auxiliary fuel)

✗ Main unavailability causes related with lack of maturity:
  ✓ Auxiliary system design: solid handling, downtime corrosion, ceramic filters, materials and suitable procedures
  ✓ Performance of last generation turbines with syngas or natural gas
  ✓ Excessive integration between units. High dependence and start-up delay
  ✓ More complex process compared to other coal-based plants. Learning is necessary. IGCC power plants using petroleum wastes show higher availability than 92%

✗ High inversion cost

✗ Investment costs of existing plants varies 1,500-2,000 €/kW installed (1990-1998)

✗ Currently, its estimation varies 2,000-4,000 €/kW installed
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IPCC. Emissions Reduction for Different Mitigation Alternatives

Climate Change Mitigation

CCS Within a Carbon Abatement Portfolio

- Baseline emissions 62 Gt
- CCS industry and transformation (9%)
- CCS power generation (10%)
- Nuclear (6%)
- Renewables (21%)
- Power generation efficiency and fuel switching (7%)
- End use fuel switching (11%)
- End use electricity efficiency (12%)
- End use fuel efficiency (24%)

CCS: a Key Part of a Low-cost GHG Strategy

- Without new policies, global emissions increase 130% by 2050, corresponding to a 4-7°C temperature rise
- CCS provides 1/5th of the needed CO₂ reductions in 2050
- Without CCS, cost of stabilisation rises by 70%
- CCS is the only low-carbon solution for coal, cement, and iron & steel sectors
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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:**

- $\text{CO}_2$ EMISSION REDUCTION IN UTILIZATION OF FOSSIL FUELS
- $\text{H}_2$ PRODUCTION BY GASIFICATION OF FOSSIL FUELS
- **DIVERSIFICATION** OF RAW FUELS AND PRODUCTS
- OTHER **ENVIRONMENTAL** IMPROVEMENTS
- **IGCC PROCESSES** **OPTIMIZATION**
- **DISSEMINATION** OF RESULTS
<table>
<thead>
<tr>
<th>Company</th>
<th>ELCOGAS, S.A (Spanish Utility)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Puertollano (Spain). Integrated in Puertollano IGCC Plant</td>
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<tr>
<td>Feed gas</td>
<td>Coal gas at 20-24 bar</td>
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<tr>
<td>Size</td>
<td>14 MWt (2% of total coal gas produced in IGCC Plant)</td>
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<tr>
<td>Technology</td>
<td>Pre-combustion Carbon Capture (90%). No Storage foreseen</td>
</tr>
<tr>
<td>Budget</td>
<td>Construction &amp; Commissioning: 12,5 M€</td>
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<tr>
<td>Frame</td>
<td>National Research Project, granted by Spanish Science and Innovation Ministry and Regional Government (JCCM)</td>
</tr>
<tr>
<td>Start date</td>
<td>2005</td>
</tr>
<tr>
<td>End date</td>
<td>Commissioning by June/July 2010.</td>
</tr>
</tbody>
</table>
To demonstrate the feasibility of capture of CO₂ and production of H₂ 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.

PROJECT OF PILOT PLANT IN EXISTING IGCC OF PUERTOLLANO IS PART OF A SPANISH NATIONAL INITIATIVE, “ADVANCED TECHNOLOGIES OF CO₂ CONVERSION, CAPTURE AND STORAGE” and it is coordinated with other related projects:

Project # 2 is to explore CO₂ capture with oxyfuel technology in a 20-30 MW 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
Carbon Capture Pilot Plant

Coal and Coke

GASIFICATION

Raw gas

183,000 Nm³/h

FILTRATION SYSTEM

Clean gas
2% of total flow (3600 Nm³/h)
22.6 bar / 130 ºC
60.5 % CO
22.1 % H₂

IP Steam

SHIFT REACTOR
(Sweet / Acid)
CO + H₂O → CO₂ + H₂

H₂ enriched gas
37.5 % CO₂
50.0 % H₂
3.0 % CO

CO₂ & H₂ SEPARATION
(aMDEA)

100 t/d

CO₂ / ¿SH₂?

H₂ raw (80% H₂)

40%

Tail gas (fuel)
50% H₂ / 1.3 bar

H₂ pure
2 t/d

99.99% H₂ at 15 bar

PURIFICATION & DESULPHURISATION

Clean gas

COMBINED CYCLE

Recycle gas compressor

Size of the installation: 1:50 ~ 14 MWₜₜ
Carbon Capture Pilot Plant

December 2008

3D artistical view
Carbon Capture Pilot Plant
Carbon Capture Pilot Plant
Carbon Capture Pilot Plant
Carbon Capture Pilot Plant
Carbon Capture Pilot Plant
Done:

- 100% engineering work
- 100% equipments supplied
- 100% construction

End commissioning: June/July 2010
End of programmed tests (under PSE): June 2010

KEY CONTRACTORS

- Engineering: Empresarios Agrupados
  - CO₂ Unit: Linde-Caloric
  - PSA Unit: Linde
  - Civil work: Local company (Construcciones Ocaña-Cañas)
  - Control: Zeus Control
  - Reactors: Tecnical
  - Heat exchangers: Tecnical and Boreal-Vila
  - Catalysts: Johnson Matthey
  - Piping and fitting: Local suppliers (Sidisa and Cuñado)
  - Control valves: SAMSON
  - Safety and relief valves: Tyco Valves and Controls
  - Manual valves: Local supplier (SAIDI)
  - Electrical components: GE Power
  - On-line analysis system: ABB Process Automation Division
Descripción Planta Piloto

Considerations about the CO$_2$ stream

- Very high purity (99.8% dry basis), at low pressure.
- The value of this stream lies in the knowledge acquired in the additional energy necessary to obtain it, and the cost that this capture implies.
- Elcogas does not foresee to send this stream to sequestration, though the amount of CO$_2$ captured (100 tons per day) are enough to carry out experimental tests (it is the double used in Ketzin).
- There is a EU directive about sequestration that has been recently incorporated to Spanish Regulation (though it did not exist at the beginning of the project).
- The Spanish Geological Institute (IGME) has recently elaborated a list of regions where CO$_2$ could be stored in Spain.
Descripción Planta Piloto

Demos and Technological Development CCS Initiatives

Carbon Capture Pilot Plant at Elcogas

Diagram showing the timeline and location of various carbon capture projects globally, including Elcogas.
Considerations about the different H\textsubscript{2} streams obtained

- **80% H\textsubscript{2} stream:** industrial viability of pre-combustion carbon capture is demonstrated for electricity production, because after N\textsubscript{2} dilution this stream can feed existing GT.

- But one of the great advantages of this technology os that from this stream and in a very efficient manner, high purity commercial H\textsubscript{2} (99.99\%) is obtained.

- In the pilot plant, the final destiny of both streams is for electricity production through the ga turbine.

- Elcogas does not foresee to sell pure H2, but it could be done in the future (permission is required, and investment are to be done to pressurise the stream).

- The amount of pure H\textsubscript{2} obtained (2 tonnes) in a day would allow a fuel cell vehicle to cover 25,000 km.
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## Elcogas. Variable cost of electricity

### Average data for year 2009

<table>
<thead>
<tr>
<th>Change of fuel</th>
<th>Fuel</th>
<th>Specific consumption (GJ_{PCS}/GWh)</th>
<th>Price (€/GJ_{PCS})</th>
<th>Partial cost (€/MWh)</th>
<th>Total cost (€/MWh)</th>
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<tbody>
<tr>
<td></td>
<td>NGCC</td>
<td>9.430</td>
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<tr>
<td>IGCC</td>
<td>Auxiliar NG</td>
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<td>7.86</td>
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<tr>
<td></td>
<td>Coal</td>
<td>2.332</td>
<td>3.20</td>
<td>7.46</td>
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<tr>
<td></td>
<td>Coke</td>
<td>5.986</td>
<td>1.22</td>
<td>7.31</td>
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</tr>
</tbody>
</table>
Evolution of fuel price and variable cost of electricity
Coproduction of H₂ and electricity

Better sell hydrogen

Better sell electricity

Minimum H₂ price considering fixed costs (O&M, spare) as function of time of H₂ Unit in operation per year (or tons per year)

- 290 h/y (or 70 t/y of H₂)
- 500 h/y (or 122 tons of H₂ per year)
- 900 h/y (or 200 tons of H₂ per year)
Elcogas considers this CO2 Capture and H2 production Pilot plant as a 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.
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