OXY-CFB-300 COMPOSTILLA PROJECT

IEAGHG-OCC3

Presented by:

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Ponferrada - 11/09/2013
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0- INTRODUCTION - ENDESA CCS ACTIVITIES

**PRE-COMBUSTION**
- Coal
- ELCOGAS
- IGCC
- Gas reformer

**POST-COMBUSTION**
- Calcium looping (LA PEREDA)
- Chem. Absorption (COMPOSTILLA)
- Physical Absorption
- Membranes
- Cryogen.

**OXY-COMBUSTION**
- Direct
  - C.Cycle
  - Pulv. Coal
  - CFB. (OXYCFB300MW)
- Indirect
  - Chemical Looping
0- INTRODUCTION PROCESS EEPR PHASE 1

2008-2009
Anteproyecto COMPOSTILLA TERUEL
- Green Field
- 550 MWe
- LAGISZA
- ENDESA-FWEOy CFB-ASU-CPU
- IDOM
- PLANTA y COducto

2009
EEPR UE OXY-CFB-300
- COMPOSTILLA
- CFB 330
- Green Field
- FP7

2010-2012
T1.7 FEED PLANTA FWEOy/TR/EA FEED ASU –CPU AL/LINDE AP/PRAXAIR
- Desarrollo de Ingeniera Planta
- Modelo 3D
- Rediseño del ciclo.
- Diseño CFB

2013
FID
0- INTRODUCTION

CCS VALUE CHAIN

- CAPTURE TECHNOLOGY
  OXY - CFB Supercritical Boiler; wide fuel (domestic and imported) design range, including biomass

- CO2 TRANSPORT
  14” underground pipeline; 147 Km
  5,500 t/day; ~ 150 -110 bar

- CO2 STORAGE
  Deep saline formation
  Duero and Ebro basins

Consortium of the FLEXI BURN CFB FP7

Manufacturers

Utilities

1st Commercial scale FLEXI BURN CFB Power Plant

Research institutes

Demonstration Pilot Plant
30 MWth, CIUDEN

Laboratory and small pilot scale test (0.1-1MWth)

Concept

FLEXI BURN CFB

2009 - 2011

Industrial applicability
0- INTRODUCTION

EEPR – BENEFICIARIES

ENDESA GENERACION

CIUDEN

FOSTER WHEELER

ENDESA GENERACION

• General coordination and project management.
• FEED Capture, Transport and Storage.
• Permitting.
• Knowledge Sharing.
• Feasibility Studies and Risk Analysis.

CIUDEN

• CCS Technology Development Centres promoter
• Public Perception.
• Knowledge Sharing.

FOSTER WHEELER

• OXY-CFB Technology developer and provider.
• ASU-CPU integration.
• Knowledge Sharing.
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1- CAPTURE OXY- FUEL COMBUSTION PROCESS

Air separation ASU

N₂, (Ar)

Air

95-99 % O₂, (Ar, N₂)

CFB Boiler

Dust cleaning

CO₂/H₂O

Steam turbine

G

Flue gas recycle

Compression Purification CPU

CO₂

Transport & Storage

Vent gas

95-99 % O₂, (Ar, N₂)

Air separation ASU

N₂, (Ar)

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CFB Boiler

Dust cleaning

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Steam turbine

G

Flue gas recycle

Compression Purification CPU

CO₂

Transport & Storage

Vent gas

95-99 % O₂, (Ar, N₂)
1- CAPTURE – ASU

2x50% trains
1x100% “Cold box”
1- CAPTURE – BOILER
1- CAPTURE – CPU

2x50% RAW CO2 COMPRESSORS

2x50% TRANSPORT CO2 COMPRESSORS

BOILER

FGCC

AGR

TSA

MERCURY REMOVAL

COLD BOX

TRANSPORT
## 1- CAPTURE – MAIN DATA

### CO2 parameters (without compressor)

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<tr>
<th></th>
<th>Air</th>
<th>Oxy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO2 Captured (% weight CO2)</strong></td>
<td></td>
<td>91%</td>
</tr>
<tr>
<td><strong>CO2 Captured (ton/yr)</strong></td>
<td></td>
<td>1,287,007</td>
</tr>
<tr>
<td><strong>CO2 Emitted (ton/yr)</strong></td>
<td></td>
<td>218,417</td>
</tr>
<tr>
<td><em>(OXY+AIR)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>5606 equivalent operating hours OXY mode</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>394 equivalent operating hours AIR mode</em></td>
<td></td>
<td></td>
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### CO2 Captured (g/kWh)

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<tbody>
<tr>
<td><strong>CO2 Captured (g/kWh)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CO2 Emitted (g/kWh)</strong></td>
<td></td>
<td>89,8</td>
</tr>
<tr>
<td><strong>CO2 Avoided (g/kWh)</strong></td>
<td></td>
<td>766,8</td>
</tr>
</tbody>
</table>

### Compression for transport and injection of CO2

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<table>
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<tr>
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<tbody>
<tr>
<td><strong>Compressor consumption (MWe)</strong></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td><strong>Efficiency with compression % (PCI)</strong></td>
<td></td>
<td>33,3</td>
</tr>
</tbody>
</table>

### Power plant Characteristics

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<tr>
<th></th>
<th>Air</th>
<th>Oxy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUEL (kg/s)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COAL</td>
<td>28,5</td>
<td>30,9</td>
</tr>
<tr>
<td>LIMESTONE</td>
<td>7,44</td>
<td>7,99</td>
</tr>
<tr>
<td>Oxidant(Air/O2)</td>
<td>272</td>
<td>58,4</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
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<th>Oxy</th>
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</thead>
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<tr>
<td><strong>Power</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross power (MW)</td>
<td>299,8</td>
<td>345,2</td>
</tr>
<tr>
<td>Auxiliary consumption (MWe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASU</td>
<td>-</td>
<td>38,5</td>
</tr>
<tr>
<td>CPU</td>
<td>-</td>
<td>19,2</td>
</tr>
<tr>
<td>Others</td>
<td>29,8</td>
<td>34,8</td>
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<tr>
<td><strong>Net power, without compressor (MWe)</strong></td>
<td>270</td>
<td>252,7</td>
</tr>
<tr>
<td>Efficiency % (PCI)</td>
<td>41,1</td>
<td>35,4</td>
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2- TRANSPORT CO\textsubscript{2} LAYOUT APPROACH

\textbf{CO\textsubscript{2} Transport basics:}

- Flow: 63,8 kg/s
- Composition: 97,5 \% CO\textsubscript{2}
- Distance: 147 km
- Type: \textit{Underground} steel pipeline
2- TRANSPORT CO\textsubscript{2} DESIGN CONDITIONS

Dense phase (Liquid/Supercritical)

- Behaviour as a liquid (compressible)
- Reduced head losses (Low viscosity)
- Suitable specific volume (aprox. Water density)
- No thermal insulation required
2- TRANSPORT CO$_2$ BASIC DATA

- No Intermediate Pump station
- Inlet pressure: 150 bar
- Outlet pressure: 100 bar
- Inlet to outlet height difference: 350 m
- Max. height difference: 600 m

**Pipeline data:**

- Length: 147 km
- Diameter: 14”
- Pipe Quality: API 5L X70
- External coating: HDPE
- Burial Depth: > 1,5 m
2- TRANSPORT CO₂ TESTS

Release dispersion

Available dispersion software validation

Crack Arrest determination

Crack arrestor devices needs

Material behavior

Material selection

CO₂ & impurities Thermophysicals

Real fluid characteristics
2- TRANSPORT CO₂ STUDIES AND DOCUMENTS

Dispersion studies

Flow assurance studies

Basic Environmental Assessment

Environmental Assessment

HAZID

HAZOP

QRA

FEED - Front End Engineering and Design

Co-financed by the European Union
European Energy Programme for Recovery
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</table>
1. Pre-screening and ranking storage sites.
2. Sites Assessment.
3. The Site characterization and extensive characterization activities
4. Monitoring and risk management plan base line of CO2
5. Front-End-Engineering-Design (FEED)
1. An appraisal program and feasibility studies were carried out in the Duero basin to investigate its performance as a CO2 storage site.

2. A 3-D seismic survey and five wells was performed, to acquire data for reservoir and cap-rock characterization.

3. The dynamic data collected covered the overall CO2 storage basic parameters (permeability, pressure, temperature gradient, etc).

4. Development of Mechanical and geochemical models for the reservoirs, to confirm the required cap-rock and seals availability and reliability.

5. Several vertical flow simulations in CO2 injectors with transient effects, and associated reservoir geo-mechanics modeling were performed.
6. Evaluation of capacity, injectivity and containment to define the injection strategy was analyzed and defined as information for the FID.

7. The risk analysis and risk management were performed following the International references such as IEAGHG, adapted by NETL & European Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide – Guidance Document 2.

8. Based on risk analysis & constraints the monitoring plan was defined, as a basis, deep monitoring wells system were defined.

10. Finally Three injection and Five monitoring wells were established as injection strategy. Detail design of the wells were performed including its drilling program.

11. Duero site is able to storage the total amount of the CO2 produced in the lifetime of the OXY-CFB-300 under safety conditions.
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4- FID CONCLUSIONS - PRELIMINARY

➢ Technical

- Good forecast feasibility, with certain outstanding operating concerns that shall be fixed during a future construction phase with additional and focused detailed process simulation and R&D activities.

➢ Public Perception

- In general, good social acceptance is achieved in the plant vicinity although some particular contest could arise in the future during final storage permitting steps.

- The lack of dedicated authorization norms doesn't allow currently the completion of the required permitting process.

➢ Regulatory & Permitting

- Regarding the existing electrical system regulation, a commercial size demo-plant requires an specific retribution frame to operate the Plant in the pool market and to ensure a certain operating hours for a minimum of 15 years period.

- Specific founding program shall be implemented to compensate the technological risks and the additional operating CCS costs.

➢ Financial & Economical

- The support of the Administration and technologist Suppliers contribution are essential to complement the Promoters participation.
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