The Callide Oxyfuel Project - Boiler Retrofit and Test Plan

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Callide Oxyfuel Project Overview

Callide A Power Station
Owned by CE Energy
4 x 30 MWe
Steam 136 t/h at 4.1MPa, 465°C
Commissioned: 1965 – 69
Refurbished 1997/98
Placed in storage in 2002

Scope:
• No.4 Boiler refurbishment
• 2 x 330 TPD ASU
• Oxyfuel combustion Retrofit
• 70 TPD liquid CO_{2} recovery
• Trucking to CO_{2} reservoir
• Injection and monitoring
Callide Oxyfuel Project - Objectives

Outline
World first retrofit-case oxyfuel power plant
Largest capacity of 30MWe
Total process from CO$_2$ capture with power generation to CO$_2$ storage

1. **Demonstrate** a complete oxyfuel process in a retrofit application
2. Establish the design and operating requirements for large scale (commercial) retrofit and new-build oxy-fuel plants, including geological storage
3. **Estimate** Capital and Operating Expenditures for the next generation of oxyfuel near zero emission technology plants
4. **Demonstrate** CO$_2$ storage
   Injection and monitoring techniques
Status of Commissioning of Boiler

Commissioning works in air-firing mode
23 March, 2011 - First fire on fuel oil (diesel)
1 April, 2011 - Turbine to 3000rpm
11 April, 2011 - First coal fire in the furnace
13 April, 2011 - First synchronization
17 May, 2011 - Full load (30MWe)
(Combustion tuning, load swing & MFT testing)

Commissioning works in oxyfiring mode
12 March, 2012 - First oxygen injection to boiler
19 March, 2012 - Successful 100% RFG and oxyfiring
(Conversion of firing mode between air-firing and oxyfiring & MFT testing)
Presentation Overview

- Retrofit Design
  Process
  Combustion Mode Change
- R&D Test Plan
  Test Target
  In-furnace measurement
  Trace elements measurement
  Tube corrosion test
- Future Direction for IHI
## Callide Oxyfuel Process

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation output</td>
<td>30MW</td>
</tr>
<tr>
<td>Coal</td>
<td>Callide coal (High Ash, High Moist. and Low S)</td>
</tr>
<tr>
<td>Boiler inlet O2 concentration</td>
<td>27 vol%wet in oxy mode</td>
</tr>
<tr>
<td>Boiler outlet O2 concentration</td>
<td>3 vol%wet at 30MW</td>
</tr>
<tr>
<td>Supply O2 purity</td>
<td>98%&lt;</td>
</tr>
<tr>
<td>Target CO2 at stack inlet</td>
<td>55wet% in oxy mode</td>
</tr>
</tbody>
</table>

The diagram illustrates the Oxyfuel process with key components including:
- Coal bin
- Mill
- Boiler
- H2O remover
- GRF
- IDF
- FF
- Stack

- Supply O2 purity: 98%<
- Target CO2 at stack inlet: 55wet% in oxy mode

Heat recovery by feed water.
Combustion Mode Change

< Air ↔ Oxyfuel combustion mode change >

- Air ↔ Oxyfuel mode change with one push button
- Sequence run step by step

Air Mode (Start – 30MW) → Combustion Mode Change (24 – 30MW) → Oxyfuel Mode (24 – 30MW)

Steps:
- Step 1-1
- Step 1-2
- Step 1-3
- Step 2-1
- Step 2-2
- Step 2-3
Combustion Mode Change

Mode change is smoothly operated.

> Boiler outlet O2 is almost constant during the mode change.
> 1.5 – 2.0 hours is required for the mode change at this moment.
R&D Test Plan

Objectives

- Demonstration operation of ASU, Oxyfuel boiler and CO2-CPU
- Obtain the operation characteristics towards the commercialization of oxyfuel power plant for CO2 capture

◆ Oxyfuel boiler : Already start of operation from March 2012
◆ CO2-CPU : Scheduled the start of operation from October 2012
# R&D Test Plan

## Demonstration Test Target of Oxyfuel/CO2 capture

<table>
<thead>
<tr>
<th>No.</th>
<th>Evaluation Items</th>
<th>Index</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reliability of oxyfuel combustion power plant (ASU, boiler, CPU)</td>
<td>Continuous operation including mill change (hours)</td>
<td>1,000 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overall Availability Factor (actual operated hours / planned operation hours)</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>2</td>
<td>Influence by changing coal property on oxyfuel plant and CPU</td>
<td>Number of tested Coal</td>
<td>Callide Coal plus one or two other coal types</td>
</tr>
</tbody>
</table>
| 3   | Influence of oxyfuel operation characteristics, for example flue gas composition, on CPU performance | —                                                                   | - Evaluate capture rate versus CO2 concentration  
|     |                                                                                  |                                                                     | - Evaluate impact of impurities on materials          |
R&D Test of Oxyfuel boiler

- Operation characteristics with various parameters
  - Inlet-O2, Boiler outlet O2, Direct-O2, etc.
- In-furnace measurement
- Trace Elements measurement
- Tube corrosion test
- Inspection of equipment
In-furnace Measurement

Objectives

- Evaluation of simulation results with actual data of Callide-A boiler
- Upgrade of furnace simulation tool

Measurements

- Gas Temp
- Gas composition
- Heat flux

Simulation results: Heat absorption [W]
Trace Elements Measurement

Objectives

- Evaluation of TE behavior in the process of oxyfuel and CPU
- Collaboration with Macquarie university
Tube Corrosion Test

Objectives

➢ To evaluate the tube corrosion under oxyfuel condition

Candidate tube material

Austenitic: CC2328 (Ka-SUS304J1HTB)
  CC2115 (Ka-SUS310J1TB)
  SA213TP347HFG (Ka-SUSTP347HTB)
Ni-based: Alloy263, Alloy617
Fe-Ni-based: HR6W
Main Evaluation Items

Key demonstration items
- Oxyfuel & CO₂ capture operation
- Safety
- Durability
- Process control and optimisation
- Operation flexibility
- CO₂ capture rate & CO₂ purity
- Air ingress
- Cost data

- <Oxyfuel process>
  - Boiler efficiency
  - N & S behavior
  - Hg behavior

- <CO₂ capture process>
  - N & S behavior
  - Hg behavior

- Convective heat transfer
- Tube corrosion
- CO₂ conc., etc.
- Ash characteristics
- Safety
- Purity of CO₂
- Impurities

✓ Grindability and dry
✓ Mixing
✓ Flame stability
✓ Radiation heat transfer
✓ Combustion characteristics

- Oxyfuel & CO₂ capture operation
- Safety
- Durability
- Process control and optimisation
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- Cost data
IHI is one of pioneers for oxyfuel development starting R&D in 1989, and basic research and FS were performed in the 1990’s.
FS of demonstration was performed under the collaboration with Australian partners after 2004 and demonstration project was started in 2008.

• Stage 1: Basic
  - Basic research and FS (NEDO)
  - Collaboration with J-POWER

• Stage 2: Demonstration
  - Callide FS (NEDO)
  - Research (METI)

• Stage 3: Commercialization
  - Upgrading and R&D
  - Application to Callide A
  - Demonstration operation
  - FS of commercial plant (High efficiency + Oxyfuel)

Now (Sep. 2012)
Callide Oxyfuel Project is invaluable opportunity to gather the data and know-how of oxyfuel / CPU operation to realize CO2 capture technology and we have to obtain and analyze them towards the commercialization of this technology.
Thank you!

for more information:  www.callideoxyfuel.com