Callide Oxyfuel Project (COP)

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(Project Director)

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8 – 9 September 2015
Presentation Overview

• Project background and history
• Project objectives and project description
• Project achievements
• Final steps
Callide Oxyfuel Project

Callide Oxyfuel Boiler (add-on)

Oxygen plant and CO₂ capture plant
Australian Energy Policy

- The Callide Oxyfuel Project was formulated under the Commonwealth Energy White Paper in 2004 – the aim was to support low emissions technologies
- In 2014 the Commonwealth launched its Direct Action Plan committing some $2.55 billion over 4 years through the Carbon Emissions Reduction Fund to support a GHG emissions reductions target of 5% below Yr 2000 levels, by Yr 2020
- The Commonwealth has proposed a further target for the Conference of Parties (COP21) in Paris from the end of November 2015, of 26 – 28% reduction in GHG emissions below Yr 2005 levels, by Yr 2030
- Australia’s Yr 2005 baseline is 612 MT CO2-e

Emissions Reduction Fund

The Emissions Reduction Fund is the centrepiece of the Australian Government’s policy suite to reduce emissions.
Active CCS Projects in Australia

Gorgon Project

Callide Oxy-Fuel

SW Hub Flagship

CTSCo-Wandoan

CO2CRC Otway Project

CarbonNet Flagship

Courtesy - ANLEC
Development of Oxyfuel technology

[Graph showing the development of oxyfuel technology over time, with various projects and their capacities marked on a timeline.]
Project History

- Project idea – September 2003
- COAL 21 (Australian) Road Map – March 2004
- Japan-Australia Oxyfuel MOU and Feasibility Study – September 2004 to April 2006
- Commonwealth Low Emission Technology Development Fund and COAL21 Fund – October 2006
- FEED study conclusion and Financial Investment Decision – March 2008
- Oxyfuel boiler operational June 2012
- CO₂ capture Plant operational December 2012
- Operations concluded March 2015
Overarching goals:
• Maintaining industry competitiveness and coal-based asset value
• Care for the environment
• Providing a framework for decision makers (especially Government) about which technology paths to pursue

Project objectives:
• Demonstrate a complete and integrated process of oxy-fuel combustion with CO₂ capture as the main goal, and near zero emissions of NOx, SOx, Mercury and other heavy metals
• Obtain detailed engineering design and costing data, and operational experience, to under-pin the commercial development and deployment of new and retrofit oxy-fuel technology applications for electricity generation
• Support CO₂ storage trials and demonstrations
Project concept - Oxy-fuel boiler

Oxyfuel Combustion

Air Separation Unit (ASU)

Coal Bunker

Mill

N₂, O₂

Air

O₂

Boiler

Flue Gas Treatment

Flue Gas Recirculation

Non-condensable Gases

CO₂

H₂O

CO₂ Processing Unit

Dehydration System

Forced Draft Fan

Induced Draft Fan

CPU

Stack

Boiler

Fabric Filter

Feed Water

Pri. Heater

Sec. Heater

Flue Gas Cooler
COP - Boiler works

- Induced Draft Fan
- H2O remover
- Flue Gas Cooler
- Prim. Heater
- Sec. Heater Outlet

The Callide A unit 4 boiler following the oxyfuel retrofit.
### COP – Air-mode/Oxy-mode comparison

<table>
<thead>
<tr>
<th></th>
<th>Air-Mode</th>
<th>Oxy-Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>O&lt;sub&gt;2&lt;/sub&gt; required (kg/h)</td>
<td>32,000</td>
<td>32,000</td>
</tr>
<tr>
<td>Net flue gas flow (kg/h)</td>
<td>169,300</td>
<td>52,100</td>
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<tr>
<td>Flue gas CO&lt;sub&gt;2&lt;/sub&gt; mol. %, dry</td>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td>Flue gas CO&lt;sub&gt;2&lt;/sub&gt; kg/h</td>
<td>35,400</td>
<td>35,400</td>
</tr>
</tbody>
</table>

**Air-fired Flue gas (mol. %)**

- CO<sub>2</sub>: 14%
- O<sub>2</sub>: 4%
- H<sub>2</sub>O: 8%
- SOx/NOx/Ar: 1%
- N<sub>2</sub>: 73%

**Oxy-fired Flue gas (mol. %)**

- CO<sub>2</sub>: 55%
- O<sub>2</sub>: 22%
- H<sub>2</sub>O: 18%
- N<sub>2</sub>: 18%
- SOx/NOx/Ar: 1%
CO₂ Capture Plant

- Designed as a CO₂ and NOx capture facility
- Low pressure flue gas pretreatment
- High pressure CO₂, NOx and inerts separation
- Overall design capacity of 75 t CO₂/day under optimised conditions
- Capture efficiency depends on NOx capture rate
ASU & CO₂ capture plant

Compressor

Coldbox

LP Scrubber

Quencher

Filters

HP Scrubber

Driers
Key demonstration items achieved

- Excellent Safety and Environmental performance
- 14,800 Generation hours
- 10,200 hours of actual oxy-firing operation
- 5,600 hours of CO₂ capture plant operation
- Demonstrated boiler turn-down to 50% Load Factor
- Demonstrated > 95% capture of SOx, NOx, particulates and trace metals
- Demonstrated high purity of CO₂ product (> 99.9%)
- Over 4,000 visitors to site, including some 280 international visitors to date
Demonstration - Test Conditions

Coals:
• Sub-bituminous and bituminous high volatile coals
• Blends of Callide coal with low-medium volatile bituminous coal (with low ash melting temperatures)
• Blends of Callide coal with semi-anthracite coal.

Noted that, oxy-firing compared to air-firing:
• Achieves improved combustion performance (by 50%) and is good for low volatile coals.
• Has lower flame temperature which is beneficial in combusting coals with low ash fusion temperatures.

Other parameters:
• Unit Load (15 to 30 MWe)
• Combustion O₂ level
• Flue gas recycle rate
• High-temperature and low-temperature in-situ material corrosion tests
Callide Oxyfuel Project (COP)/CO2CRC – CO2 Injection Test

- Injection test conducted to assess the geochemical effect of CO2 in the reservoir.
- Collaboration between COP and the CO2CRC.
- Test location: Nirranda South (Otway Basin) Victoria
- Injection 1400 m into Paaratte Sandstone formation
- New scientific knowledge obtained

<table>
<thead>
<tr>
<th>Callide Oxyfuel CO2 Product</th>
<th>Injection Date</th>
<th>Injection quantity (t)</th>
<th>CO2 (%)</th>
<th>O2 (ppm)</th>
<th>N2 (ppm)</th>
<th>NOx as NO2 (ppm)</th>
<th>SO2 (ppm)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure CO2</td>
<td>14 - 15 Oct. 2014</td>
<td>5.2</td>
<td>&gt;99.99</td>
<td>5</td>
<td>0</td>
<td>16</td>
<td>&lt; 0.1</td>
<td>Geochemical testing</td>
</tr>
<tr>
<td>CO2 + Impurities</td>
<td>8 - 9 Nov. 2014</td>
<td>4.5</td>
<td>99.3</td>
<td>6150</td>
<td>1100</td>
<td>9</td>
<td>67</td>
<td>Residual Saturation Test (how much CO2 does the rock hold)</td>
</tr>
</tbody>
</table>
Commercialization Activity

Commercialization activity has four parts:

1. Proactive engagement with Government to facilitate policy development around clean coal technology (manufacture and application)
2. Public dissemination to promote the merits and the commercial uptake of the technology
   • Industry presentations, scientific publications, cooperation with other projects wherever possible
3. Internal use of Intellectual Property (IP) to support the business interests of the Project participants
4. External business development:
   • Feasibility studies to be conducted in the Asia Pacific and elsewhere
   • Through International partnerships and consulting business
1. The Callide Oxyfuel Project was inspired by the technical collaboration already existing between Japan and Australia.
2. The Project was implemented and completed within the agreed time frames and budget.
3. The project goals have also been largely achieved including assessment of CO2 storage capacity in Queensland (Australia) and CO2 injection trials to understand more fully the effect underground on rock and water.
4. COP is recognised as the largest demonstration of oxy-firing in the world and has received over 4000 visitors.
5. The Project has demonstrated that the technology works at 30 MWe scale and is ready for scale-up to 200 to 300 MWe.
6. The final activity is focussed on IP capture and commercialization, and plant decommissioning.
7. Future deployment of CCS in Australia remains uncertain. There are initiatives overseas such as the White Rose project in North Yorkshire (426 MWe oxy-firing with 2 Mt CO2 capture/yr).

Collaboration between Japan and Australia, at Government and Industry level, has been the hallmark of this project and one of the main reasons for its success.

Sincere thank you to the Australian and Japanese Governments and to the project participants and supporters for their financial and technical contributions.
The following is a listing of some key, peer-reviewed publications from the Callide Oxyfuel Project for reference:


Callide Oxyfuel Project – Participants

Oxyfuel Project Partners

www.calliddeoxygenfuel.com