CCSD Communiqué

FACTSHEET #13

Oxyfuel technology status and CCSD capability statement

Terry Wall

The University of Newcastle

Summary

Oxy-fuel combustion uses oxygen for combustion instead of air. This technology has received great attention for its simplicity in the capture and sequestration of CO_2 emissions from fossil fuel combustion in either industrial processes or power generation

Summaries of recent developments of the technology were presented at the IEA Oxyfuel Network meeting in Windsor, Connecticut, USA in February 2007, which are summarised here. The recently announced Canadian SaskPower 300 MWe lignite coal oxy-combustion development is the first commercial announcement, which rejected IGCC as it was not economic for lignites, and chose oxyfuel over PCC.

Pilot-scale studies on oxyfuel have used standard pf test facilities with additions of oxygen supply, capability to recycle flue gas, and possibly CO2 compression capability. These typically have thermal inputs from 0.5 to 2 MWt.and include those of the IFRF, Air Liquide and CANMET as summarised here. . The CANMET facility is considered to be the best facility currently operating, and has been rebuilt in the past 18 months to include a larger furnace to facilitate flame studies, and also CO2 compression.

All Australian research in oxyfuel has been conducted in CCSD. The CCSD research program in Projects 3.4 and 3.5 has established a proven capability in

- Conducting pilot-scale coal testing in oxyfuel conditions, including impacts of recycle flue gas on emissions
- Heat transfer prediction in retrofit and purpose built oxyfuel plant
- Combustion performance testing of coals in oxyfuel and comparison with air performance

The last two capabilities are currently being utilised by Vattenfall as their 30 MWt pilot plant is being designed and constructed, with Vattenfall having contracted CCSD on consulting projects in these two areas.

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Introduction

Oxy-fuel combustion uses oxygen for combustion instead of air. This technology has received great attention for its simplicity in the capture and sequestration of CO_2 emissions from fossil fuel combustion in either industrial processes or power generation. Significant progress has been recently been made in this field. In fact, oxygen-fired coal combustion has been evaluated for a number of purposes for some 20 years. Early studies were based on the recycling of hot recycled flue gas (RFG) in metal heating furnaces in order to reduce furnace size and NO_x, more recently studies have been based on recycling of cold RFG and generating CO_2 suitable for sequestration.

The recent emphasis has been to apply the technology to obtain a high CO_2 concentration from coal combustion, the method having been demonstrated at a pilot scale and is used for enhanced oil recovery (EOR) in the US.

A schematic of a boiler using O_2/CO_2 given by Okawa et al (1997) is shown in Figure 1. Oxygen is separated from air and then mixed with a recycle stream of flue gases from the boiler. Fuel is fired in the resulting 'synthetic air' stream and the flue gases are partially recycled. Water vapor may be condensed from the flue gases to produce a stream of high CO_2 content.

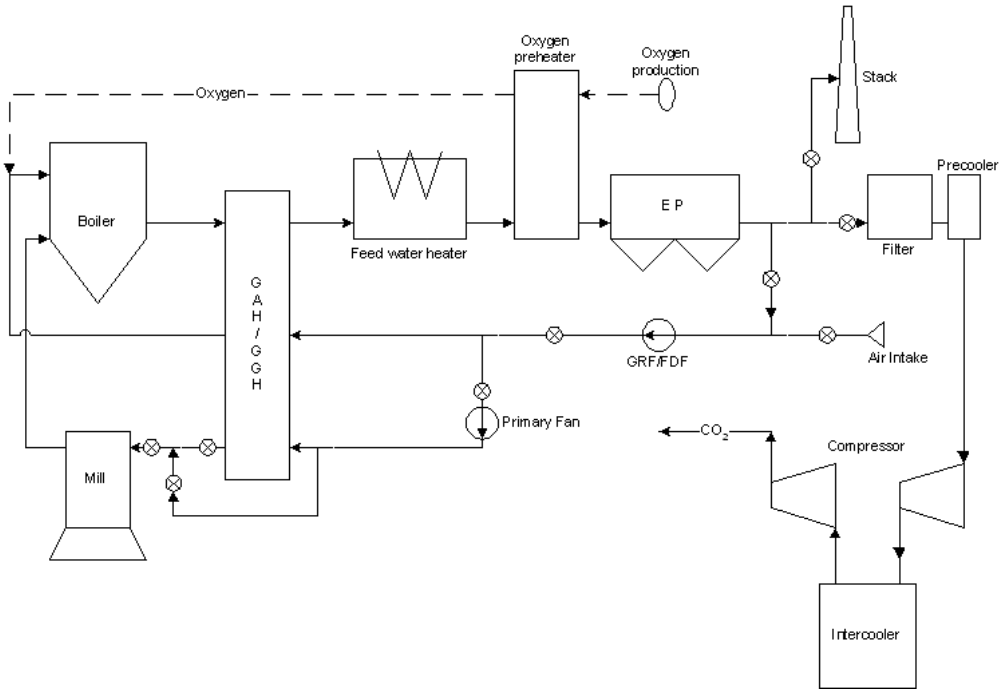

Figure 1. Pulverized coal-fired power plant using oxy firing and O_2/CO_2 combustion (Okawa et al, 1997; Yamada et al, 2000)

Oxy-fuel combustion and CO_2 capture from flue gases is a near zero-emission technology that can be adapted to both new and existing pulverised coal-fired power stations. In contrast to gasification and post-combustion options the technology does not require CO2 capture by solvents. The carbon dioxide is captured by cooling and compression to provide liquid carbon dioxide for subsequent transportation and storage.

In this form oxy-fuel involves modification to familiar PF coal technology to include oxygen separation, flue gas recycling, CO_2 compression, transport, and storage.

Oxyfuel technology status

When oxyfuel technology was first considered in Australia and the CCSD research effort commenced in 2004, there were no full-scale oxyfuel plants in operation

Presently, there are still no full-scale oxyfuel plants, but commercial plants are planned. An expanding effort involving pilot-scale experiments, laboratory work and theoretical work has provided improved understanding of design parameters and operational issues. There are many pilot-scale facilities in the US, Europe and Japan, viz., International Flame Research Foundation, Air Liquide, and CANMET in Canada which have been used to study the technology. Studies have also assessed the feasibility and economics of retrofits as well as new power plant. A summary of the dates and scales of oxyfuel projects is given on Figure 2.

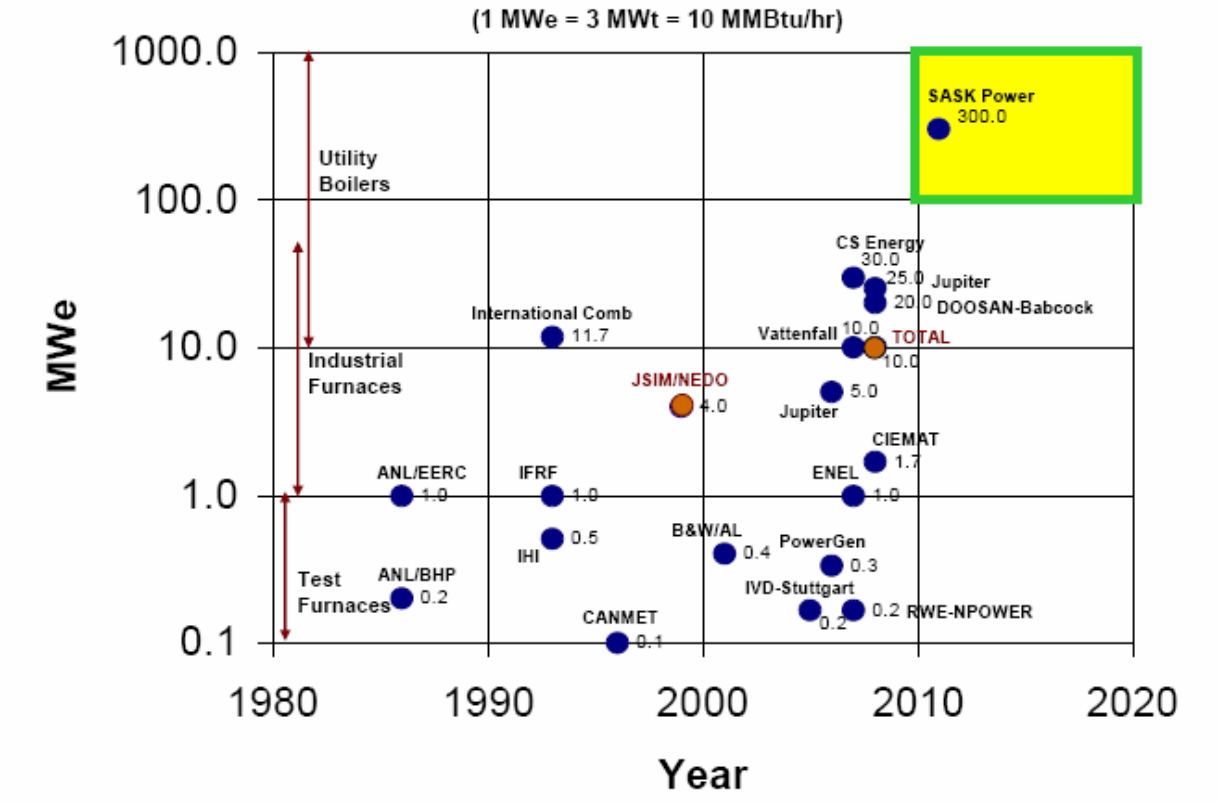

Figure 2: Summary of oxyfuel projects

Recently announced commercial and demonstrations plants of oxyfuel technology

Summaries of recent developments of the technology were presented at the IEA Oxyfuel Network meeting in Windsor, Connecticut, USA in February 2007, which are summarised here.

Commercial project

The recently announced Canadian SaskPower 300 MWe lignite coal oxy-combustion development rejected IGCC as it was not economic for lignites, and chose oxyfuel over PCC. This project has been called a feasibility study but this is a misnomer. The project will be put to tender, with selection mid-2007 but particular companies are involved - B&W, Air Liquide. CO2 can be used for EOR in same area as Weyburn project with 95% CO2, and some SO2, wheras current Weyburn project injects H2S. Plant will come online in 2011. Bob Stobbs of SaskPower gave the presentation; he heads the Canadian Clean Coal Coalition. An announcement on this project is awaited.

Demonstration projects

The Australia/Japan Callide-A coal 30 MWe demonstration project was presented by Chris Spero, with a project history, and current status. Some work to replace tubes, and improve the control system were identified, as well as the retrofit hardware. A geosequestration workshop is to be held as an aid for site selection. Financial close expected by mid-2007, operation from mid-2009, for 5 years.

The bitumen French Lacq oxy-boiler retrofit project in SW France of Total, France, uses high sulfur bitumen as the fuel and transports CO2 by pipeline as subcritical and injects it into an unused gas reservoir – to assess feasibility. It is a 30 MWt, is in a region where unused gas fields offer future sequestration sites. But the overall objective is an oxyfuel process with sulfur capture for steam production, the steam to enhance oil recovery, with CO2 sequestration. They considered PCC initially but selected oxyfuel

The German Vattenfall Schwartz Pumpe coal 30 MWt pilot-plant project was presented by Lars Stromberg. By 2020 a commercial technology is needed, Vattenfall has chosen oxyfuel with chemical looping as a later option. A larger demonstration of about 250MWt in 2012 is planned. Details are in the report from the 2006 IEA event. ALSTOM's association in the Vattenfall demonstration includes fabrication of their 30 MWt pilot plant boiler and burner of their pilot-plant but also in their test program. But ALSTOM is likely to offer tangentially fired plant for oxyfuel, wheras the combustion testing will be on wall-fired (swirled) burners. The pilot furnace will be downfired. A 200 MW pc facility by 2015 is proposed. B&W does the sulfur plant, Linde the O2 and compression. CO2 storage is being negotiated, with high purity CO2. The budget is now 70M Euro and 23 M Euro for operation over the period 2008~2012. The CO2 purity is high, but was not quoted.

The US coal Jupiter oxyfuel project was presented by Brian Patrick. At Orrville Utilities a 25 MWt demonstration is planned, with 25% capture of the 95% purity stream. No CO2 use is suggested at this time, and little information is available

Of these demonstrations, the Vattenfall plant is in construction, the others are heading towards financial close.

Status of oxyfuel pilot-scale research facilities

Pilot-scale studies on oxyfuel have used standard pf test facilities with additions of oxygen supply, capability to recycle flue gas, and possibly CO2 compression capability. These typically have thermal inputs from 0.5 to 2 MWt.and include those of the IFRF, Air Liquide and CANMET as given in Table 1. The CANMET facility is considered to be the best facility currently operating, and has been rebuilt in the past 18 months to include a larger furnace to facilitate flame studies, and also CO2 compression.

Table 1: Summary of operating pilot-scale facilities

Organisation	Furnace used	Focus of study	Reference
EERC and ANL, USA	10 Million Btu/h utility boiler pilot facility	• Demonstrating the technical feasibility of the CO_2 recycle boiler • Determining the ratio of recycle gas to O_2 for achieving heat transfer performance similar to air firing • Quantifying the observable operational changes such as flame stability, pollution emissions, and burnout • Providing a basis for scaling experimental results to commercial scale	Cited by Molburg et al, 2001
IFRF, Holland	IFRF Furnace #1: 2.5 MW, the furnace with internal square cross-section of 2×2m and 6.25 m long and an air-staged swirl burner	• Evaluating the combustion of pulverised coal in the mixture of O_2/RFG for retrofitting existing pulverised coal fired boiler to maximise the CO_2 concentration in flue gas. • Optimising O_2-RFG firing conditions to yield similar radiative and convective heat transfer performance to air firing • Evaluating the impact of O_2-RFG process on furnace performance, including flame ignition and stability, heat transfer, combustion efficiency, pollutant emissions, compared to air operation	Woycenko et al, 1995
IHI, Japan	IHI's 1.2 MW combustion-test furnace: a horizontal cylinder furnace with 1.3m inner diameter and 7.5m length and a swirl burner	• Combustion characteristics of pulverised coal in the O_2/CO_2 mixture	Kimura et al, 1995; Kiga et al, 1997; Nazaki et al, 1997
Air Liquide, B & W, USA	1.5 MW pilot-scale boiler with air staged combustion system	• Demonstrating the technical feasibility of conversion from air firing to O_2/RFG firing for large scale boiler • Highlighting the impacts of O_2-RFG process on pollutant (NOx, SO_2 and Hg) emissions and boiler efficiency	Châtel-Pélage et al, 2003

CANMET, Canada	CANMET Vertical Combustor Research Facility (0.3 MW): A cylindrical, down-fired and adiabatic vertical combustor with an inner diameter of 0.60m and a length of 6.7 m.	• Pulverised coal combustion behaviours in various O_2/RFG mixtures, compared with air combustion • Demonstrating the technical factors on the combustion performance	Croiset and Thambimuthu, 1999; Croiset et al, 2000; Croiset and Thambimuthu, 2001; Chui et al, 2003

Australia does not have an oxyfuel test facility, although discussions on the conversion of the ACIRL test facility have taken place. The Australia/Japan Oxyfuel Feasibility project has used the Aioi test facility of IHI in Japan to test three Australian coals. The retrofitted Callide A boiler will also allow coal testing and technology evaluation, but an Australian capability at pilot-scale is considered essentoial for realistic building of research capability.

A newly announced pilot plant development of the El Bierzo Facility for CO2 Abatement and Capture (of ~ 4 MW in Spain for oxyfuel and PCC to be built by end-2008) - which includes combustor, clean-up, and compression - of the University of Seville, suggest that Australia will quickly fall behind in its leading role oxyfuel expertise unless we use the Callide retrofit appropriately as a test and experimental facility. The Spanish facility facility has funds of 40 MEuro from the Spanish government, for 3 years, but needs other funds for its operation.

Australian and CCSD research and consulting capability

All Australian research in oxyfuel has been conducted in CCSD. The CCSD research program in Projects 3.4 and 3.5 has established a proven capability in

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