Application of Oxy-Fuel CO_2 Capture for In-Situ Bitumen Extraction from Canada's Oil Sands

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The problem of CO_2 emissions from in-situ bitumen production

• Canada's oil sands are second only to Saudi Arabia with 13% of the world's proven oil reserves, or 170 billion barrels. The oil contained in the sands is bitumen, which does not flow at ambient temperatures; it needs to be either mined, or heated with steam for in-situ extraction.

• 80% of Canada's oil sands are currently accessible only through in-situ production methods; these result in much less land disturbance than mining and extraction, and generally have a smaller environmental footprint

• The bitumen is extracted using steam; Steam-Assisted Gravity Drainage (SAGD) is the leading technology, but is more energy and GHG intensive than mining and extraction because of the large steam requirements

• Current carbon emissions from SAGD facilities exceed 25 Mt/yr and are expected to be the oil sands sector's largest source of future GHG emissions growth

• A cost-effective solution for CO_2 capture from once-through steam generators (OTSG) is needed for both greenfield and retrofit applications to mitigate this expected growth in GHG emissions

Figure 2 – In-situ Production Site (4 OTSG boilers visible)

Oxy-fuel combustion as a cost-effective means to capture CO_2

Oxy-fuel combustion technology uses oxygen (95 - 97% by volume), produced from an air separation plant instead of air as the fuel oxidant. By substituting oxygen for air the flue gas volume is dramatically reduced, and it consists largely of CO_2 and water vapour. With this pre-concentration the CO_2 can be cost effectively purified via cryogenic methods, compressed and made available for sequestration. Oxy-fuel combustion has some unique advantages over post-combustion capture technologies for this application, and includes:

• Minimal amounts of steam are required for the capture equipment.

• Very low emissions of SO_X and NO_X and since no solvent is needed there will be no other potentially harmful emissions from the process.

• An oxy-fuel fired boiler will typically use 2-6% less fuel than a traditional air fired boiler because of the efficiency benefit of high temperatures recycled flue gas.

• Very high (>98%) CO_2 capture rates are feasible and very high recovery rates do not incur a significant incremental energy penalty.

• Recovery of the water vapour in the flue gas, resulting in large quantities of water being available for boiler makeup water and other uses.

• Oxy-fuel technology's ability to operate as either an air-fired or oxy-fired boiler provides the operator flexibility in design when regulations may still be in flux and when oil recovery operation is continued when the air separation unit is not available.

• Oxy-fuel combustion technology is fully applicable for retrofitting existing plants. The footprint near the boilers is relatively small, which is advantageous for retrofits.

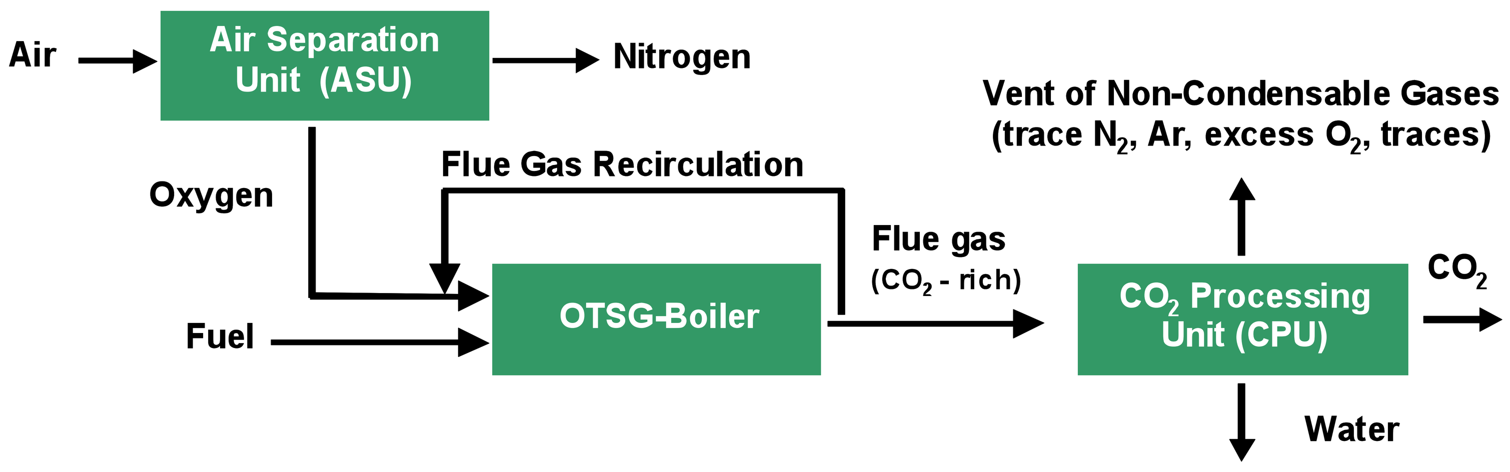

Figure 1 – Major Components for CO_2 Capture from OTSG units with Oxy-fuel Combustion

Project Participants

The Project Manager is Suncor Energy, and the primary technology provider for this project is Praxair. Other members include Devon Canada, Cenovus Energy, Statoil ASA and the CO_2 Capture Project (CCP). The CCP is an award-winning partnership of several major energy companies working to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage. Current members of CCP are BP, Chevron, ConocoPhillips, ENI, Petrobras, Shell, Suncor and associate member EPRI. To find out more visit www.co2captureproject.com

Project Objectives

To demonstrate that oxy-fuel combustion is a safe, reliable and cost-effective technology for CO_2 capture from once-through steam generators

Phase I – Design Basis and Economics (essentially complete)

• **Optimize integrated Oxy-Fuel/CO_2 Capture & Compression process**
- Study effect oxygen purity has on burner performance and **CO_2** recovery.
- Determine oxygen purity that yields the lowest overall $/Ton recovery cost.)

• **Determine changes to boiler heat transfer**
- CFD modeling to study differences between combustion modes
- Optimize boiler/oxy-fuel burner performance and identify potential boiler modifications.

• **Design flue gas cleanup and CO_2 compression (1500 psig)**
- Modification and optimization of Praxair commercial CO_2 purification

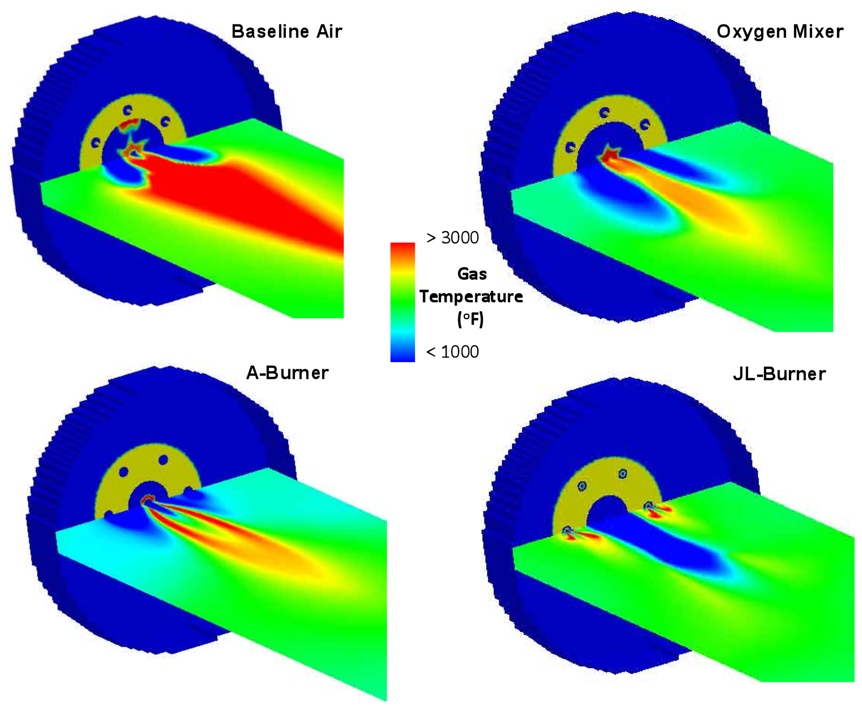

Figure 3 – Results of CFD modeling of air- and oxy-fired burners

Extensive computer modeling of the combustion process was used to understand the changes to the flame and to the heat transfer in the boiler when air is replaced with oxygen and flue gas recirculation.

Phase II – Combustion Test (2011-2012)

• **Key technical issues**
- Identify changes in heat transfer pattern and flame length
- Find best combustion solution (heat transfer, emission, oxygen pressure, stability)
- Determine level of flue gas recirculation

• **Field testing at boiler by Cenovus Energy in Christina Lake (Canada)**
- Liquid oxygen supply for flexibility and low investment
- Three combustion technologies: current burner (Coen), A- and JL-burners (Praxair)

Phase III – Combustion, Purification and Compression Test (Planned)

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