# $CO_2$ Capture Project (CCP) Phase 3
## *Advancing to Deliver results*

Carbon Sequestration Leadership Forum – CSLF $CO_2$ Capture Interactive Workshop

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**Prepared by:**
David Butler (David Butler & Associates): Economics Team Lead
Mark Crombie (BP): CCP3 Program Manager
Leonardo F. de Mello (Petrobras): Capture Team
Ivano Miracca (eni): Capture Team Lead

**Presented by:**
Mark Crombie

# Project Overview

**The $CO_2$ Capture Project (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 (CCS). The CCP is currently in its third phase of activity:

- Phase 1 (CCP1, 2001-2004) technology screening/proof of concept – **completed**
- Phase 2 (CCP2, 2004-2009) intensive development – **completed**
- Phase 3 (CCP3, 2009-2013) demonstration – **on going**

**The CCP is funded primarily by:**

- Member and associate member contributions
- Government grants
- In-kind contributions

**CCP3 project members are:**

BP (Program Operator), Chevron, Eni, Petrobras, Shell and Suncor

# Program Objectives

**In order to help make CCS a practical reality, in reducing emissions from power plants and heavy industrial processes such as oil and gas refining and gas processing, the CCP aims to accomplish the following goals:**

- **Increase technical and cost knowledge** associated with $CO_2$ capture technologies and confirm that geological storage of $CO_2$ is a secure and viable means of reducing greenhouse gas emissions
- **Reduce $CO_2$ capture costs by 20-30%** by supporting the development of improved technologies
- **Quantify remaining assurance issues** surrounding geological storage of $CO_2$ through site assessments, field surveys and numerical approaches; and rapid dissemination of results to stakeholder groups
- **Validate cost-effectiveness of monitoring developments** with design and testing of emerging and integrated systems
- **Cooperate with interested parties to share information** about both capture and storage demonstrations

# CCP3 Team Overview

The project consists of four work teams, supported by Economic Modeling:

- **Capture**: aiming to reduce the cost of $CO_2$ capture from a range of refinery, in-situ extraction of bitumen and natural gas power generation sources
- **Storage Monitoring & Verification (SMV)**: increasing understanding and developing methods for safely storing and monitoring $CO_2$ in the subsurface
- **Policy & Incentives**: providing technical and economic insights needed by stakeholders, to inform the development of legal and policy frameworks
- **Communications**: taking rich content from the ongoing work of the other teams and delivering it to diverse audiences including: government, industry, NGOs and the general public
- **Economic Modeling**: building a fuller picture of the integrated costs for CCS

# Capture Team – Key Projects

**Technology demonstration**

- **Oxy-fired Fluid Catalytic Cracking (FCC) Pilot Plant demonstration**
  - Vacuum Gas Oil & Atmospheric Residue Feeds
- **Oxy-fired Once Through Steam Generators (OTSG)**
  - 50 MMBTU/hr OTSG retrofit

**Economic evaluation**

- A detailed study by Foster Wheeler on state-of-the-art technologies for the capture of $CO_2$
  - Refinery process heaters (4 x 150 MMBTu/hr) – US location
  - Regenerator of Fluid Catalytic Cracking (FCC) unit (60,000 bpd) – US location
  - Hydrogen production for chemical (Steam reforming) or fuel (Autothermal reforming) use – US location
  - Natural Gas Combined Cycle (NGCC) power station (400 MW) – European location *
  - Once-Through Steam Generator (OTSG) for Steam Assisted Gravity Drainage (SAGD) oil extraction – Alberta location *

**Development projects**

- Capture of $CO_2$ from refinery heaters using oxy-fired technology
- Chemical Looping Combustion
- Membrane Water Gas Shift

# Oxy-fired Fluid Catalytic Cracking (FCC) Pilot Plant demonstration

# FCC Testing Unit

## FCC Large Scale Pilot Unit

| Typical pilot plant | Test unit | Full scale unit |
|---|---|---|
| **Catalyst inventory** | x 150 → | x 280 to 2000 → |
| **Feed flow rate** | x 200 → | x 580 to 2000 → |

**Capacity**: cat. Inventory = 300 kg; feed flow rate = 200 kg/h (30 bpd) VGO; 1t/d $CO_2$ emission

# Pre-operation

## Objective:

perform short oxy-combustion trials to evaluate the operability of the entire system, identify possible limitations of the units and anticipate problems so that the test program may be entirely carried-out

## Learnings:

### FCC unit oxy-combustion operation:

- Air to oxygen transition is very fast and simple. However, there must be a close monitoring of excess $O_2$ in flue gas since it may reach very low levels as recycling occurs

**Action taken**: constant adjustment of $O_2$ flow rate during transition

# Pre-operation

## Learnings

### FCC unit oxy-combustion operation:

-The starting regenerator temperature is critical for stable operation. As the gas is recycled, this temperature significantly decreases and coke burn rate in the regenerator is affected.

**Action taken**: unit was adjusted to start operation at higher regenerator temperatures and a combustion promoter was used

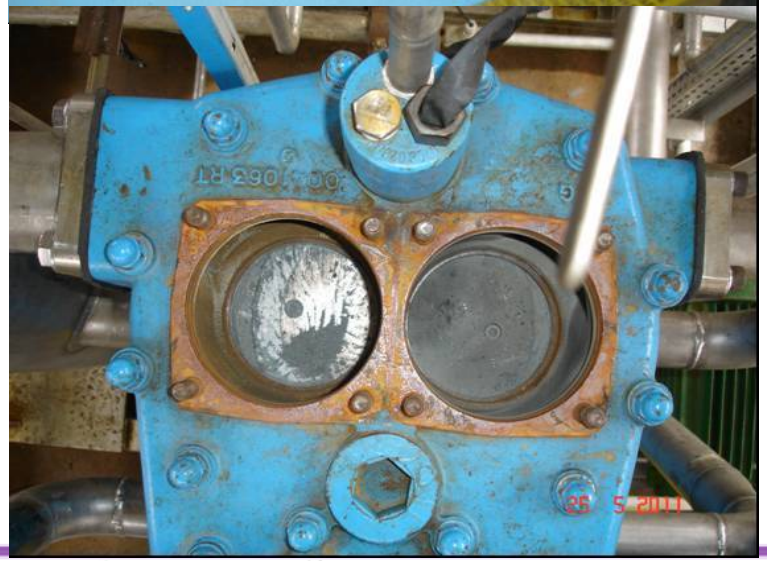
### Recycle Compressor

- After all oxy-combustion trials, the recycle compressor showed low efficiency and solid deposits were found inside both compression stages which obstructed suction and discharge valves.

- The solid deposits were analyzed and the results show they are corrosion product from the formation of sulfuric acid.

**Action taken**: adjustments in operation conditions, change in metallurgy and new design of compressor parts significantly improved compressor efficiency

# Pre-operation



# Pre-operation




# Final Remarks - FCC

- The technical viability of oxy-firing an FCC unit has been demonstrated on a large scale pilot test unit
- The transition from air to $O_2$ and back was shown to be fast and simple, however care must be taken with the excess oxygen in flue gas
- Corrosion inside the recycle compressor was observed as the oxycombustion flue gas has a very strong acidic property. Adequate handling of the gas is critical for long term operation.
- The initial results show for the same inert volumetric flow rate condition, there is an increase in feed rate conversion.
- The latest results indicate a $CO_2$ content in flue gas close to 95% (dry basis).

# Oxy-fired Once Through Steam Generators (OTSG)

# Oxy-combustion in Once-Through Steam Generator - OSTG

## Three Phase Project:

- Phase I (completed): Develop design basis and cost estimates for test and commercial scale OTSG
- Phase II (2011-13): Demo oxy-fuel combustion on 50 MMBTU/hr test boiler
- Phase III (proposed): Demo oxy-fuel combustion, compression and purification on test boiler

## Overall Objective:

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

*Image courtesy of Cenovus*

**Funding Partners:** Cenovus Energy (host site), $CO_2$ Capture Project, Devon, Praxair, Statoil, Meg Energy

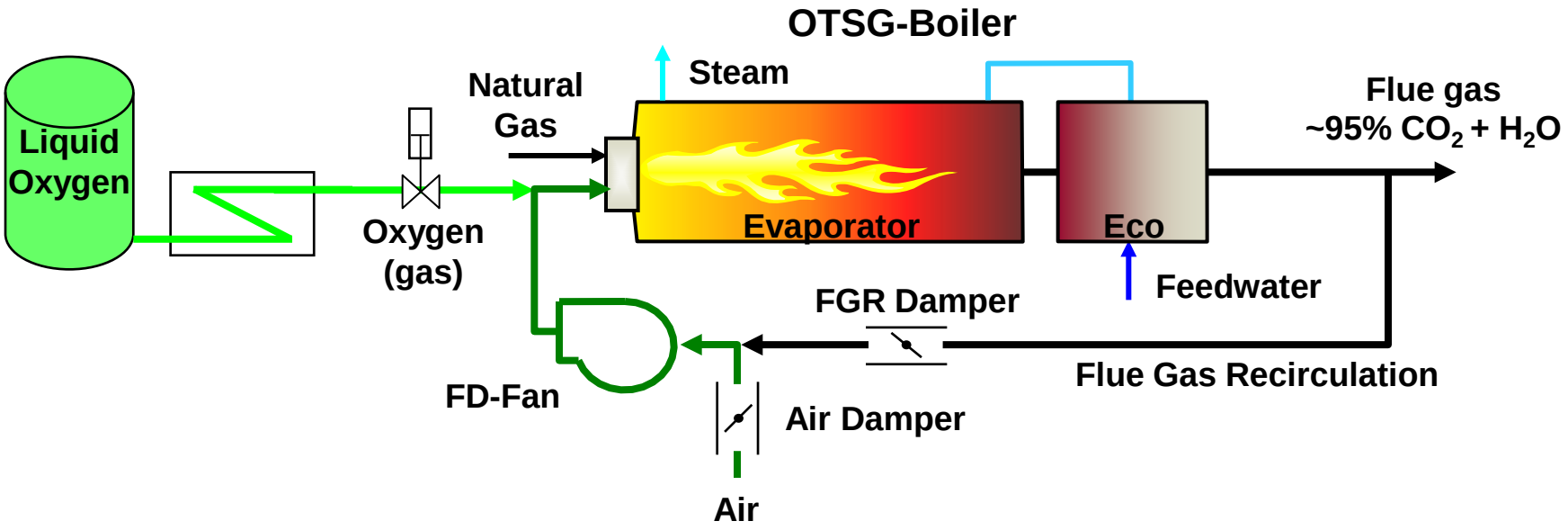
## Technology Providers:

Praxair – industrial gas & combustion technology
TIW Western – boiler technology

CCP3

# Phase II - Oxy-fuel Boiler Test

- Existing commercial OTSG Boiler at Cenovus Energy - Christina Lake
- Retrofit with flue gas recirculation
- Installation of oxygen supply and control integration




*Project will demonstrate technical viability and safety of oxy-fuel combustion at operating in-situ site*

# Questions?

# http://www.co2captureproject.org/

# End