CCP

# $CO_2$ Capture Project (CCP) – Phase 3 Results and Phase 4 Program Development

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Raja Jadhav, Ph.D.

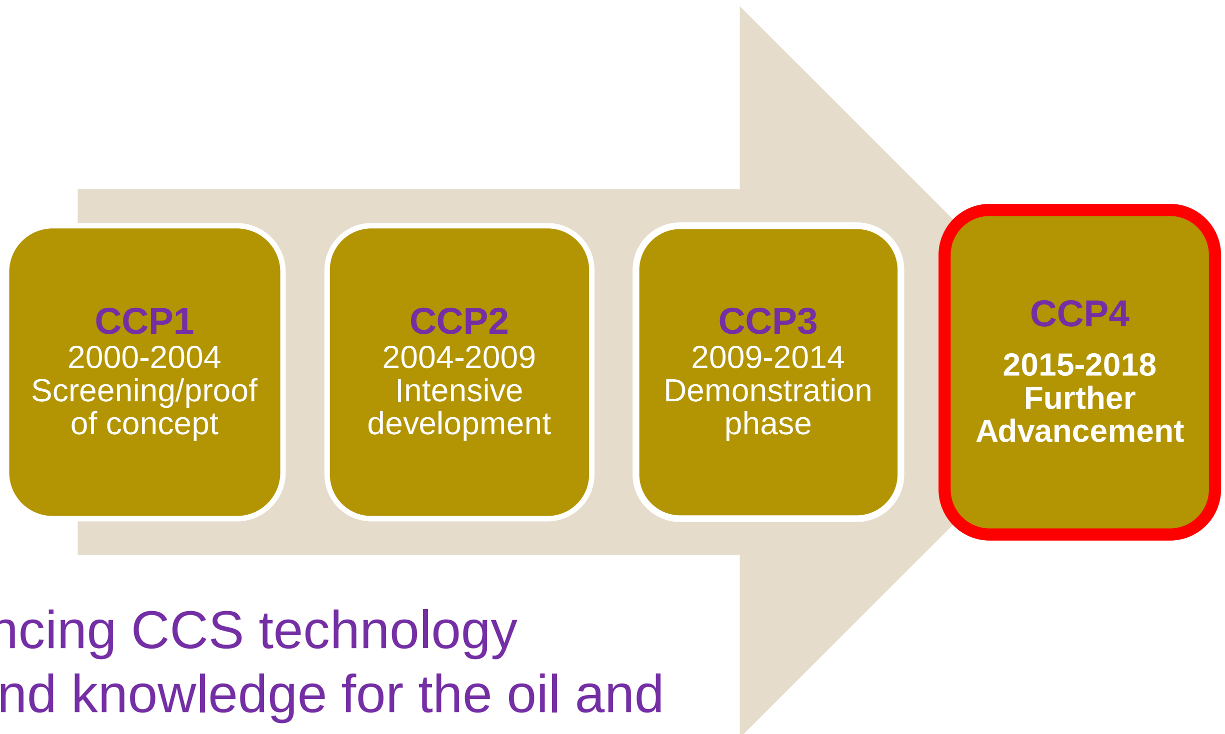
Chevron Energy Technology Company

# Contents

# $CO_2$ Capture Project (CCP) - Background

Over 15 years of support for CCS technology development

A collaboration among major oil & gas companies that covers capture, storage, economics and policy aspects of CCS.




CCP4: “Advancing CCS technology deployment and knowledge for the oil and gas industry”

# CCP – Background – (cont'd)

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## Characteristics of $CO_2$ Emissions in the Oil & Gas Sector

### Diverse Operations

- Refinery: FCC, heaters and boilers (H&Bs), cogens, SMR
- Heavy oil production: Once-through steam generators (OTSGs), cogens
- NGCC power generation
- LNG production: Gas turbine drivers
- Natural gas production

### Dispersed $CO_2$ Sources

- Operations are scattered over a large area (e.g., heaters and boilers); flue gas cannot be combined
- Cannot take advantage of "economy of scale" due to relatively small $CO_2$ volumes in some streams
- Restrictions on the available plot space in congested refineries

### Diverse $CO_2$ Gas Stream Characteristics

- $CO_2$ concentration in flue gas varies from 4–20 mol%. $CO_2$ in SMR $H_2$ plants available at high pressure (~20 bar)
- $CO_2$ emissions from a single source can vary from <100 tpd to >3,000 tpd
- Flue gas stream mostly clean with no particulates and SOx components

*However, the fundamentals of $CO_2$ capture remain the same and knowledge gained in the power industry can still be applied*

# CCP3 Program (2009 – 2014)

## CCP3 Program Objective: Move CCS towards commercial deployment by

- Increasing technical and cost knowledge
- Supporting the development of technologies to reduce $CO_2$ capture costs by 20-30%

## Scenarios

- Refinery: FCC, heaters and boilers (H&Bs), SMR
- Heavy Oil: Once-through steam generators (OTSGs)
- NGCC

## Approach

- Perform independent assessment of novel capture technologies
- Support lab, bench and pilot scale studies
- Carry out detailed economic assessment of select technologies

## CCP3 Program – At a Glance

- 21 Technical Studies by Foster Wheeler
- 2 Demonstrations (oxy-fired FCC, oxy-fired OTSG)
- 4 bench/pilot projects (oxy-burner testing, Pd membrane, CLC, enzyme post-C)
- 1 pilot test post-C solvent screening program (EERC)
- 5 preliminary evaluations of novel technologies
- 24 in-house economic evaluations

# Refinery FCC

## Oxy-FCC demonstration project

- 33 bpd hydrocarbon feed unit (~1 tpd $CO_2$ emission)
- Host: Petrobras, Brazil
- The field demonstration run confirmed the technical viability of the process.
- FCC in oxy-firing mode can enable a higher throughput (up to 3%) or allow a switch to processing heavier oil feeds while keeping the same product yield.
- Corrosion in the recycle compressor needs to be addressed.

## Economic assessment studies

- **Refinery FCC**: Post-C has cost advantage over oxy-C; however, the possibility of additional feed throughput may make oxy-C favored over post-C.


*•Image courtesy of Petrobras*

# Heavy Oil Production – Steam Generation

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## Oxy-OTSG demonstration project

- 50 MMBtu/h fuel input (~75 tpd $CO_2$ emission)
- Host: Cenovus Energy, Canada
- The field demonstration run confirmed the technical viability of the process.
- Similar temperature and flux profiles in air and oxy-firing

**Air-firing**


**Oxy-firing**


*Image courtesy of Cenovus Energy Inc.*

- *Suncor – Project Administrator, Project Manager*
- *Cenovus Energy – Site Participant, Project Leader*
- *Praxair, Inc. – Site Participant, Project Leader*
- *Other project partners and co-funders: CCEMC, CCP3, MEG Energy, Devon and Statoil*

CCEMC
Climate Change & Emissions Management Corporation

# CCP3 Economic Results

| | | | $CO_2$ captured | $CO_2$ captured | $CO_2$ avoided | $CO_2$ capture cost | $CO_2$ avoided cost |
|---|---|---|---|---|---|---|---|
| | | | tonne/h | % | % | $/tonne | $/tonne |
| **Refinery – USGC** | | **Fuel** | | | | | |
| FCC | Post-C | Carbon | 55.5 | 85.5 | 65.5 | 85 | 110 |
| FCC | Oxy-C | Carbon | 64.8 | 100.0 | 83.5 | 99 | 118 |
| Fired heaters | Post-C | Fuel gas | 26.6 | 85.0 | 65.0 | 109 | 144 |
| Fired heaters | Pre-C | Fuel gas | 284.0 | 90.0 | 76.0 | 102 | 146 |
| SMR | Post-C | Nat gas | 58.4 | 85.5 | 65.5 | 86 | 111 |
| **Oil Sands Steam Generation – Fort McMurray, Canada** | | | | | | | |
| OTSGs | Post-C | Nat gas | 67.4 | 90.0 | 76.0 | 159 | 221 |
| OTSGs | CLC | Nat gas | 63.3 | 100.0 | 86.0 | 184 | 222 |
| **Gas-fired Power Generation – USGC** | | | | | | | |
| NGCC | Post-C | Nat gas | 126.1 | 85.5 | 73.7 | 77 | 90 |

- Basis: 1Q 2014 costs
- Post-combustion solvent-based technology is still the most economic (or close second).
- The economic assumptions, such as, fuel cost, location factor, imported power cost/$CO_2$ footprint, process scale/configuration all have an impact on the cost numbers.

# CCP4 Program (2015–2018)

## CCP4 Focus

- Tactical Demonstration (near-mid term) -> Incremental improvement technologies (e.g., SMR pre-combustion capture)
- Strategic Deployment (mid-long term) -> Breakthrough technologies (e.g., post-combustion capture)

## CCP4 Projects Under Consideration (partial list)

| Scenario | Project/Study | Activities |
|---|---|---|
| Refinery | SMR pre-C capture technology development (mid-to-high TRL) | Perform economic assessment of a novel capture technology and support development |
| Various | Identify breakthrough technologies for post-C capture | Carry out techno-economic evaluations and support development |
| NG Treating | Understand/identify technologies for offshore $CO_2$ removal | Perform technology landscape study followed by a technology development |

# Summary and Conclusions

- Post-, pre- and oxy-combustion technologies were investigated at lab, bench, pilot and demo scale
- Post-combustion solvent-based technology is still the most economic (or close second)
  - Oxy-combustion not feasible or economically attractive (except for FCC)
- $CO_2$ avoidance costs are very high, especially for the Heavy Oil scenario due to the Alberta location
- Results from CCP3 are being used to develop the CCP4 program
  - Near to mid term – focus on incremental improvement (e.g., SMR pre-C capture)
  - Mid to long term – focus on breakthrough technologies (e.g., post-C capture)

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**Capture Team Members**

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# Questions/Discussion?