Pilot-scale Evaluation of Oxy-fuel Combustion of Anthracite Coal with CO_2 Capture

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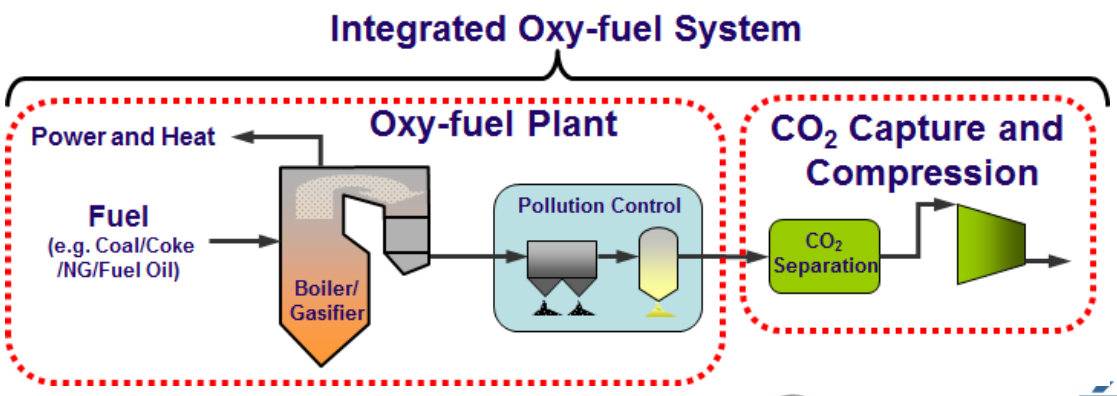
Overview

- Introduction
- CanmetENERGY's Integrated Oxy-fuel Pilot Plant
- Vertical Combustor Research Facility
- CO_2 Capture and Compression Unit
- Pilot-scale Test Parameters
- Presentation of Data
- Summary of Key Observations
- Future Work

Introduction

- Overall objective of this work is to study the behavior of an oxy-fuel coal combustion system with integrated CO_2 capture and compression
- This will be achieved by gathering and comparing data sets taken from the pilot-scale and pre-commercial scale facilities at CanmetENERGY and CIUDEN's respective laboratories
- Total of six pilot-scale tests scheduled to be performed at CanmetENERGY, of which preliminary data is presented here.



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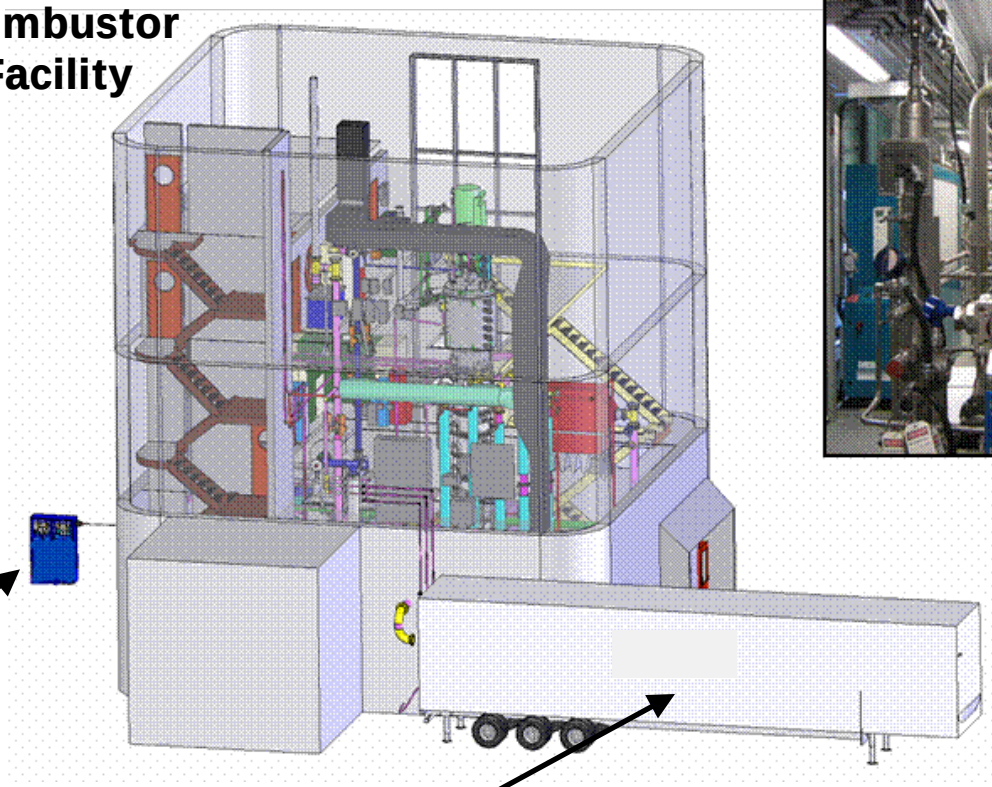
CanmetENERGY's Integrated Oxy-fuel Pilot Plant

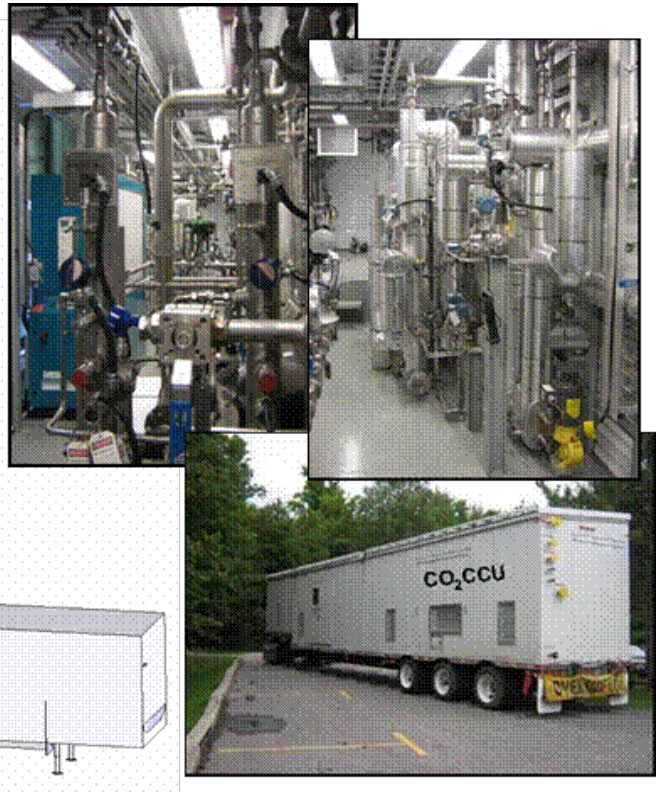
0.3 MW_{th} Oxy-fuel Vertical Combustor Research Facility (VCRF)



Synthetic Flue Gas System

CO_2 Capture and Compression Unit ($CanCO_2$)

Details of CO_2CCU



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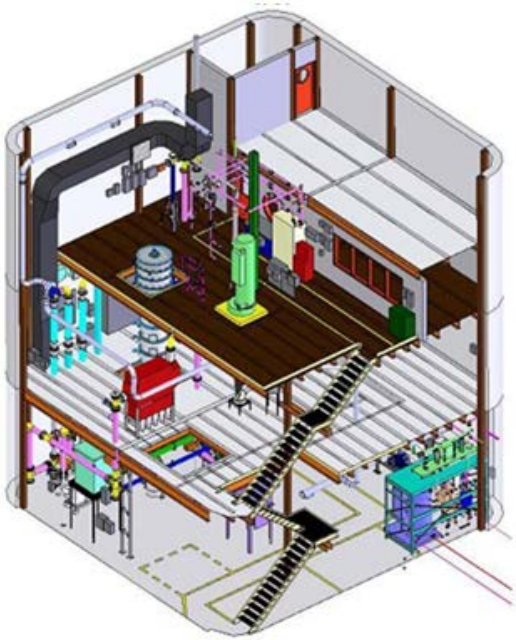
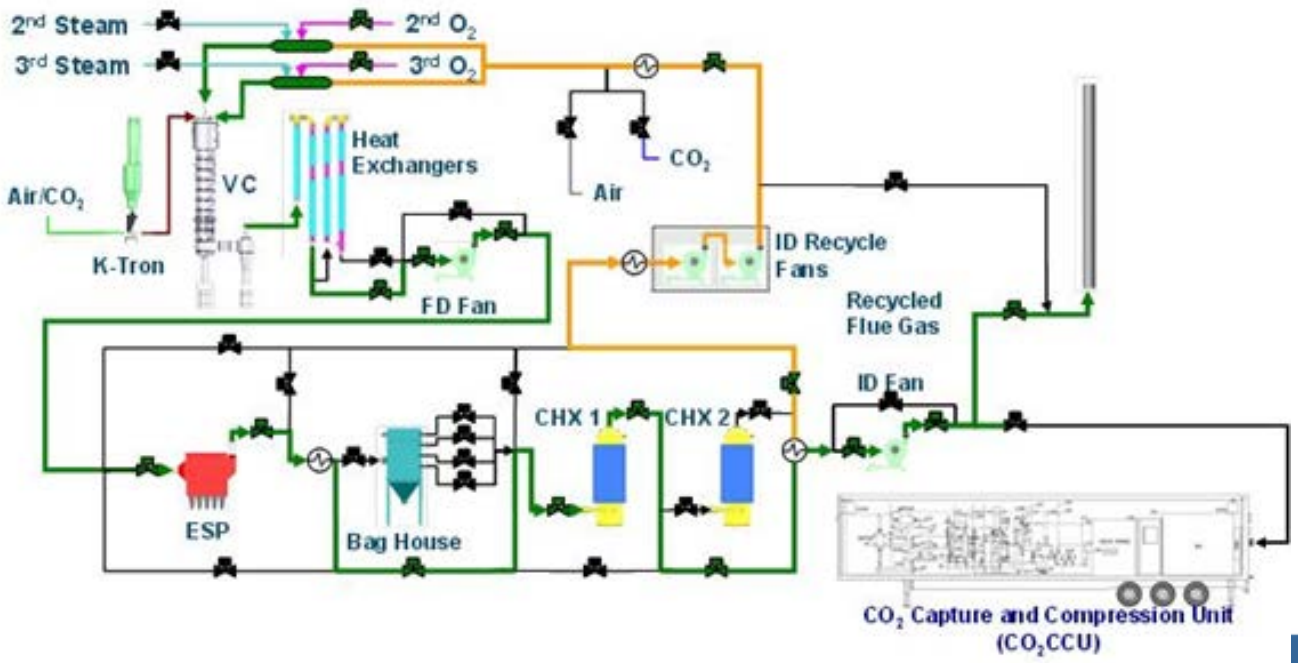
Vertical Combustor Research Faciltiy

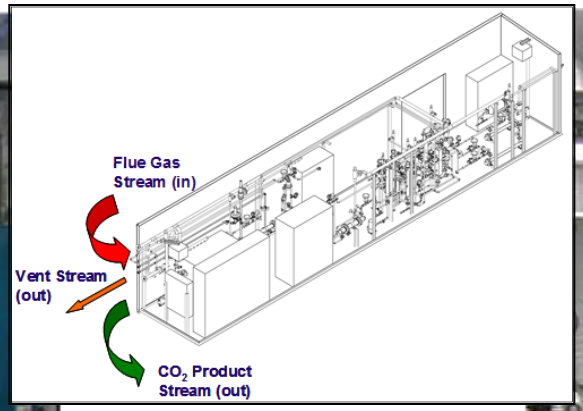
- Advanced flexible combustion research platform;
  - Firing Rate 0.3 MWth (1.0 X 10^6 Btu/h)
  - Fuels: Natural gas, Oil, Emulsion, Pulverized coal, Petcoke, Coal Slurry, etc.
  - Operational modes: air and oxy-fuel
  - Fully instrumented and equipped with standard pollution control devices (e.g. baghouse, ESP, activated carbon, sulfur scrubbers, etc.)
- Synthetic flue gas generation facility.



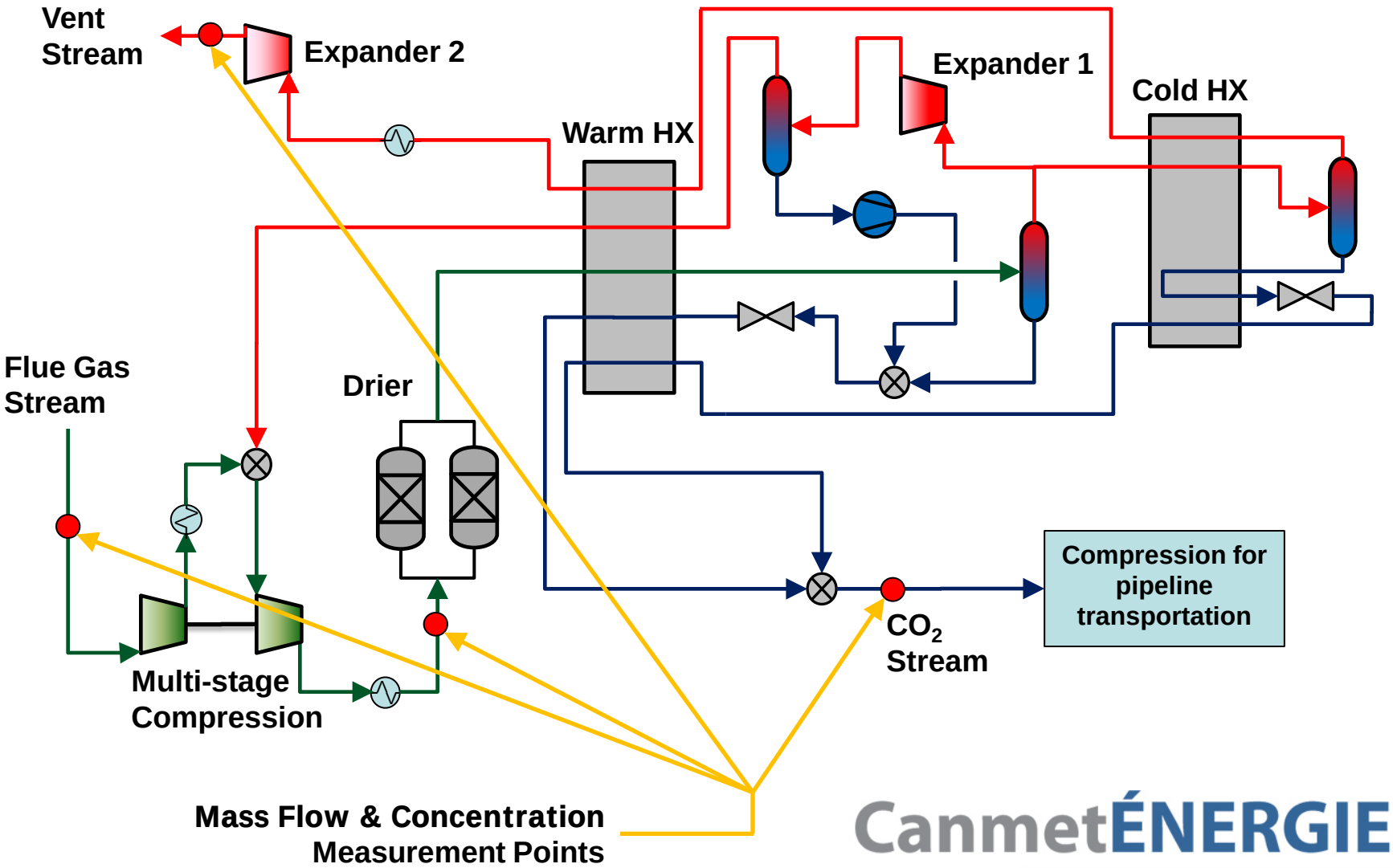


CO_2 capture and compression – CanCO_2 Research Facility

- CanCO_2 is operating based on CanmetENERGY's proprietary low-temperature auto-refrigeration physical separation process.
- Trailer-mounted transportable CO_2 capture and compression unit (3 tons/day)
- Operates as a multi-pollutant control unit (i.e., removing NO_x, SO_x and Hg, while capturing and processing CO_2)



CanCO$_2$ Research Facility – Flow Diagram



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Pilot-scale Test Parameters

- Firing rate: 0.3 MW_{th}; approximately 40-45 kg/h of coal
- Flow path:
  - Combustor → Baghouse → Condensing heat exchanger (CHX1) → $CanCO_2$, *recycle after CHX1*;
- ***No sulfur scrubbing***
- SO_x and NO_x capture within the $CanCO_2$
- Fuel type: Anthracite from Spain

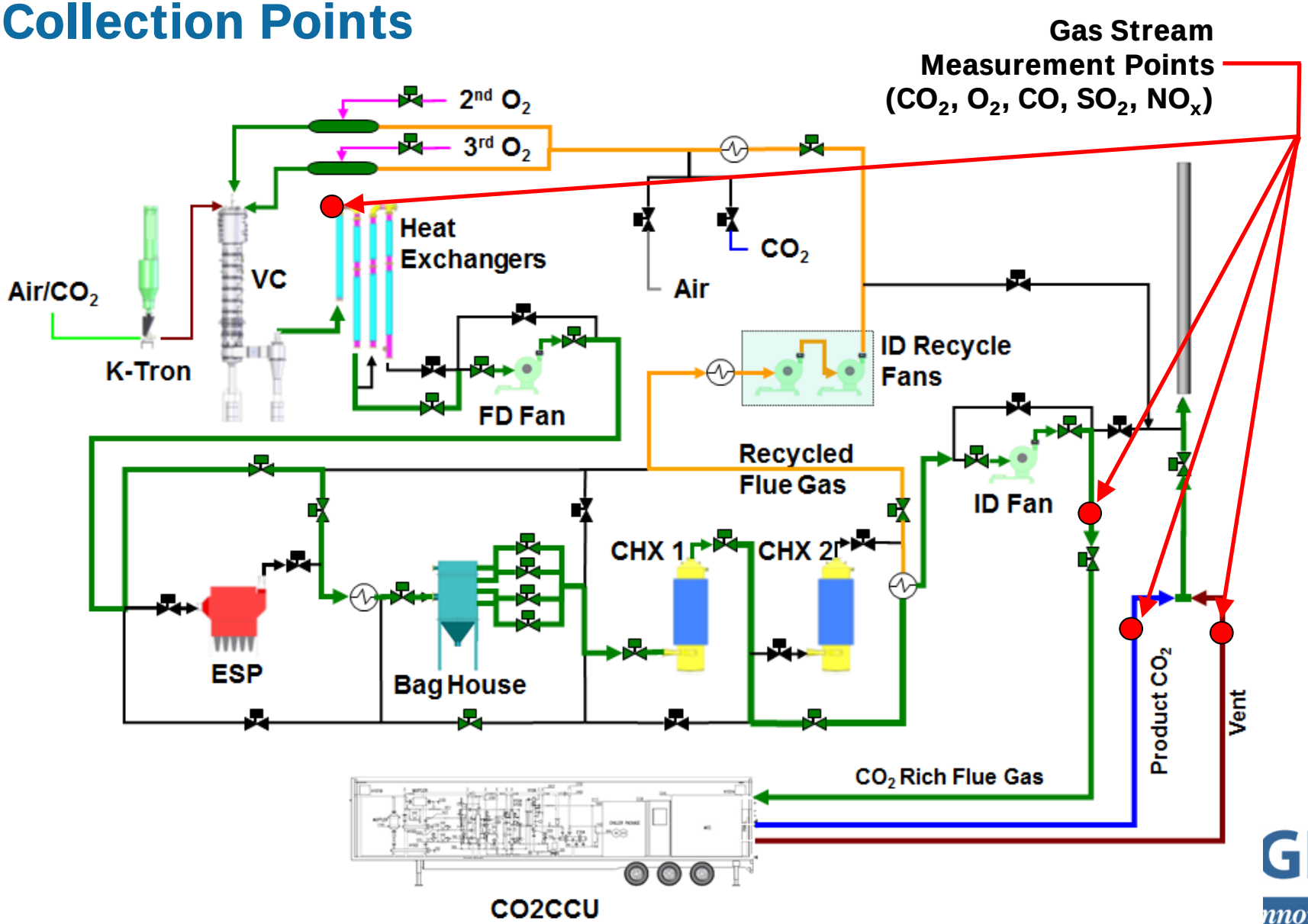
Proximate Analysis

Parameter	% Weight
Moisture	3.91
Ash	35.09
Volatiles	9.42
Fixed Carbon	51.58

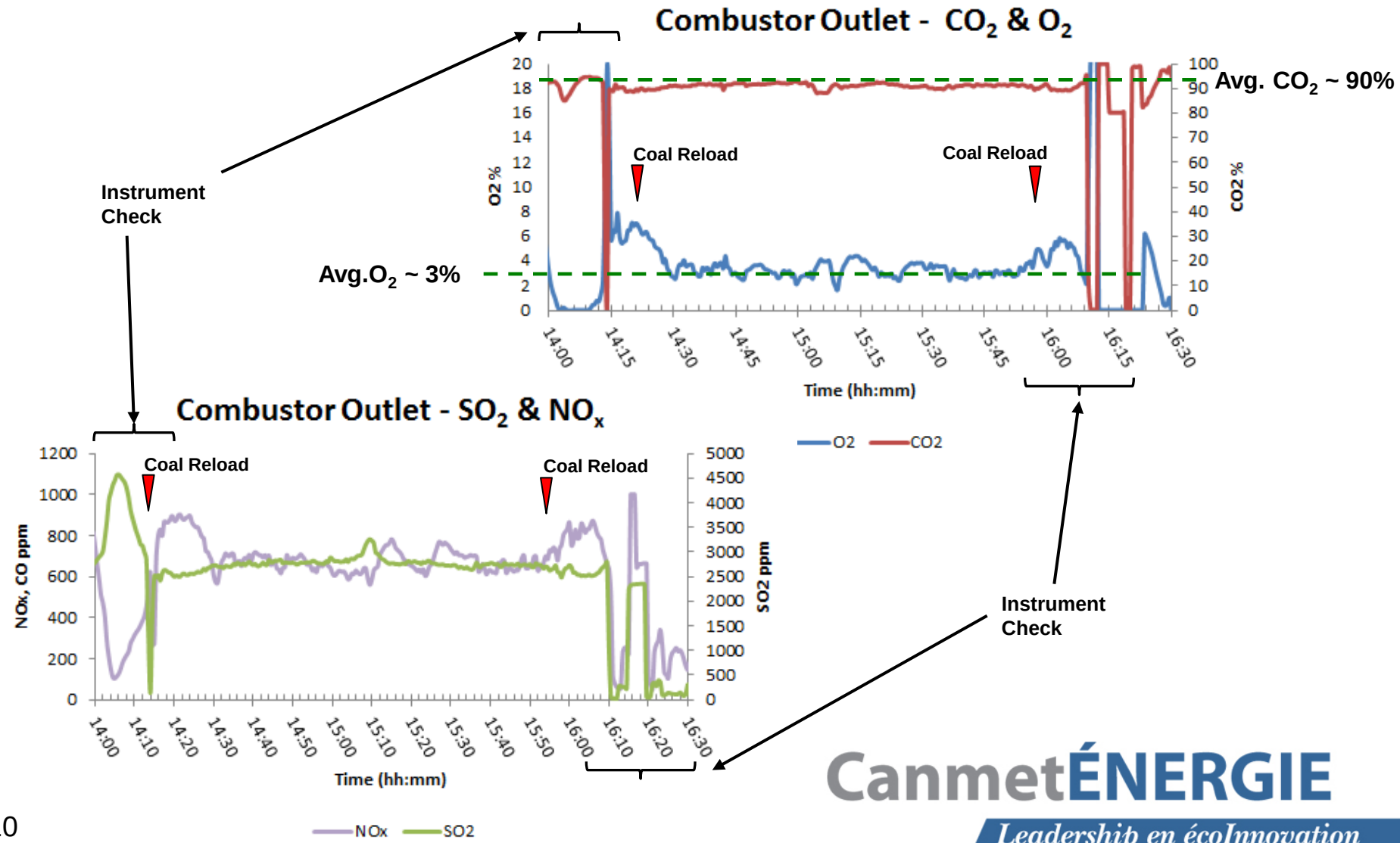
Ultimate Analysis

Parameter	% Weight
Carbon	54.4
Hydrogen	1.98
Nitrogen	0.82
Total Sulfur	1.27
Oxygen	2.53

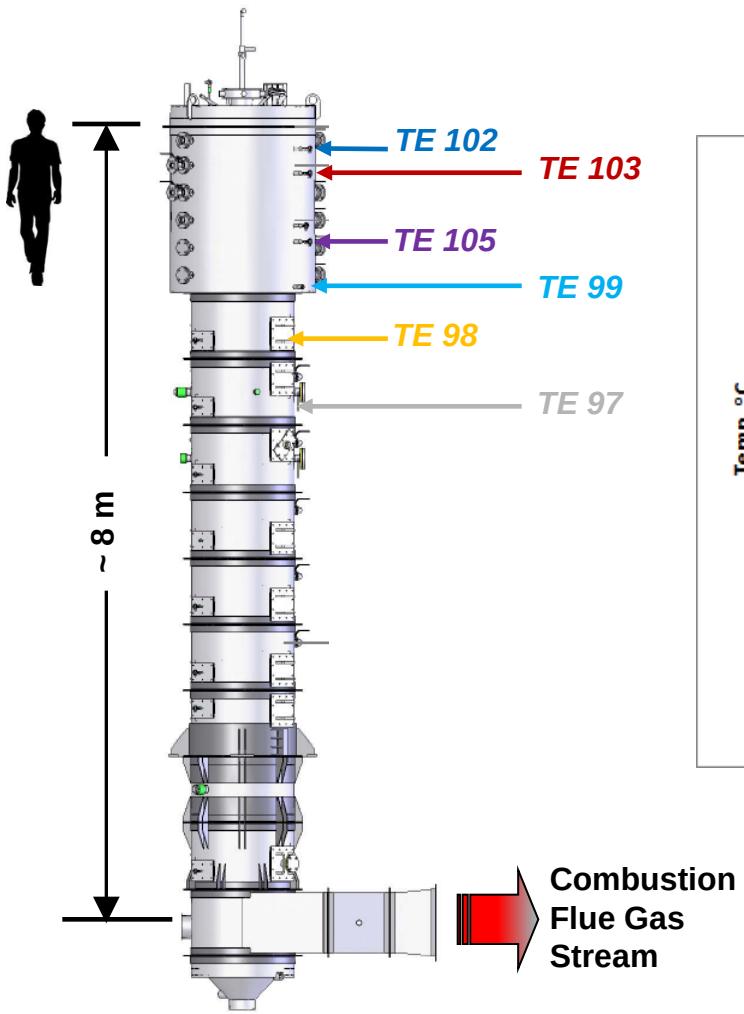
Experimental Results – VCRF Concentration Data Collection Points

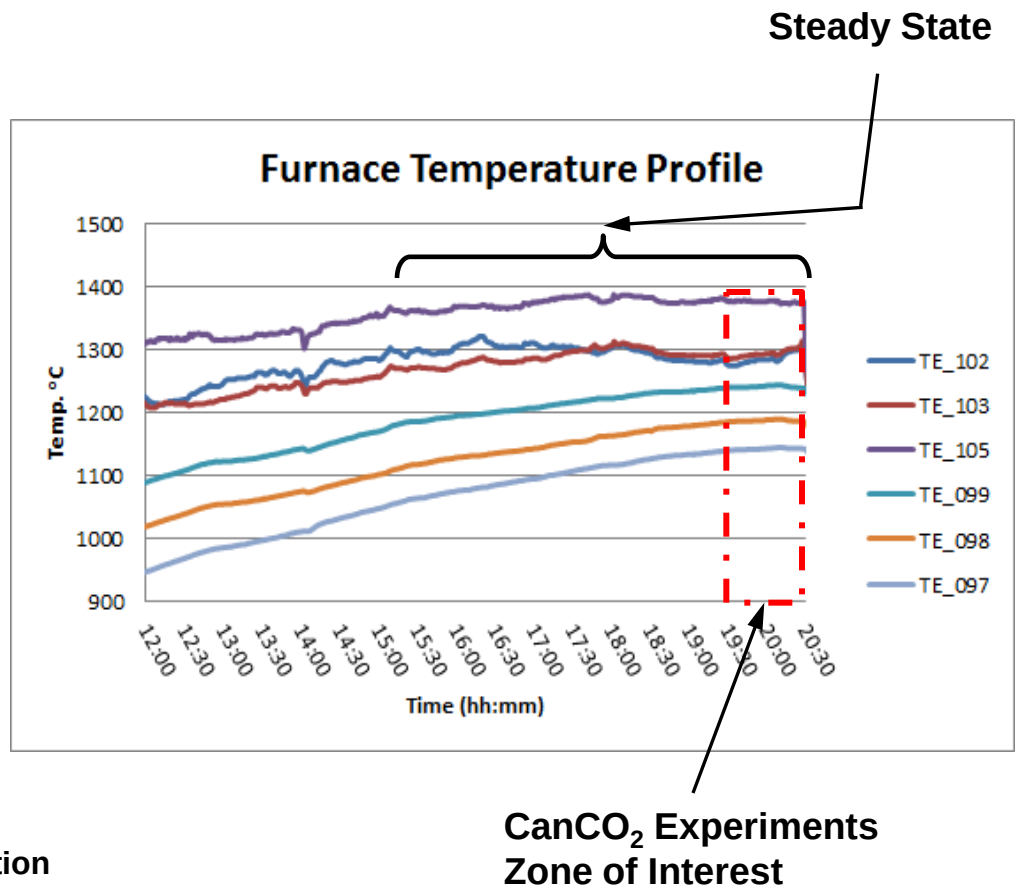


Experimental Results – VCRF Data



Experimental Results – VCRF Data continued





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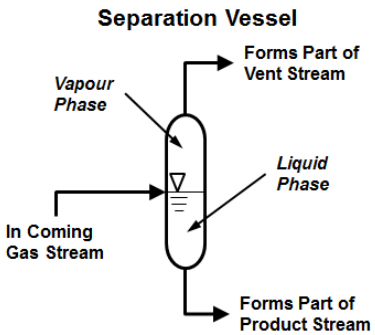
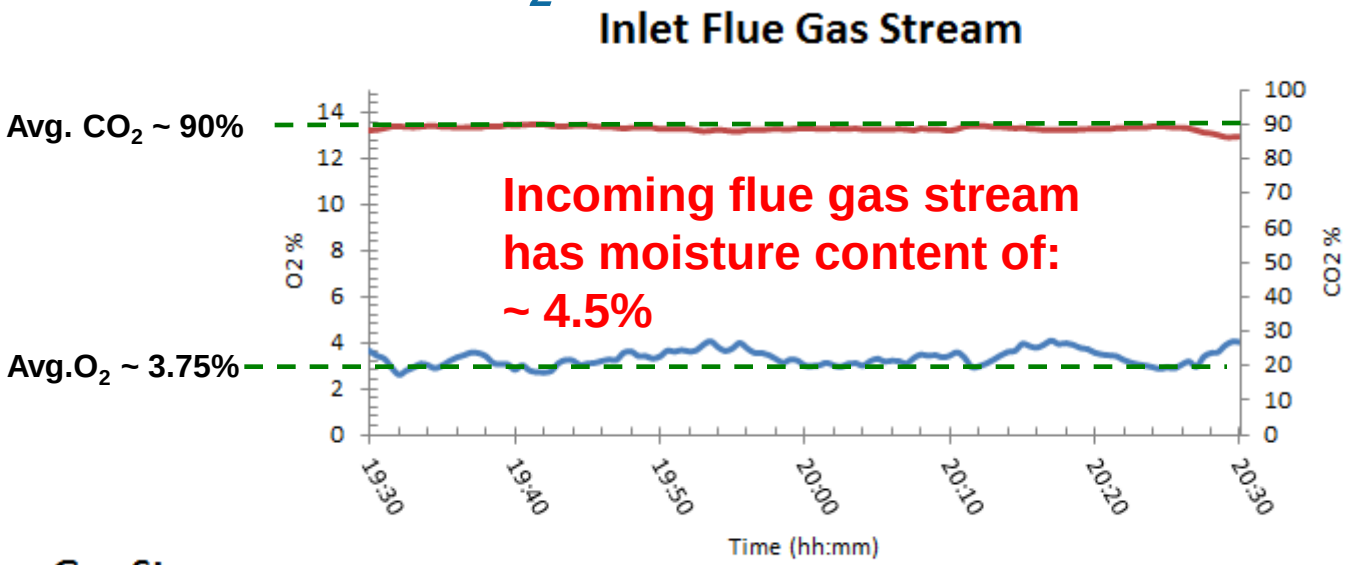
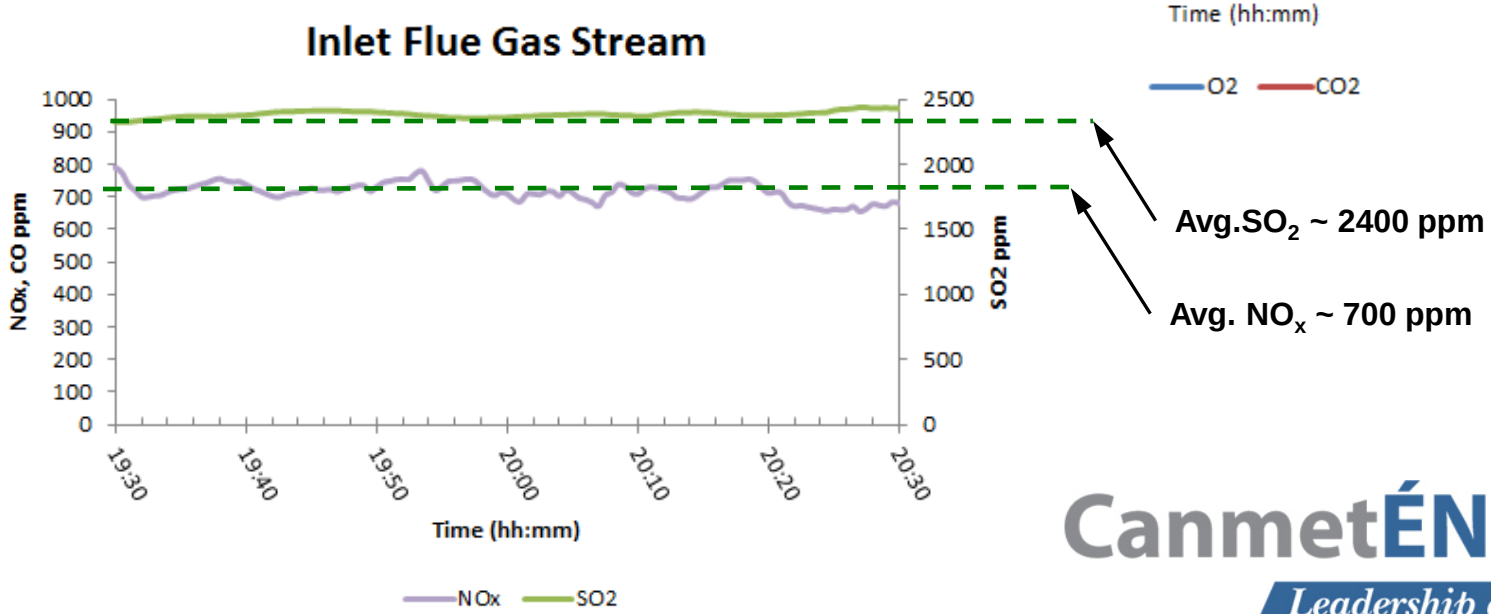
Experimental Results – $CanCO_2$ Data

Inlet Flue Gas Stream to $CanCO_2$







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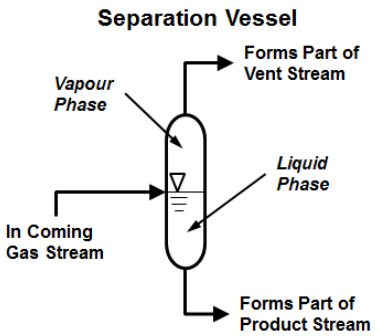
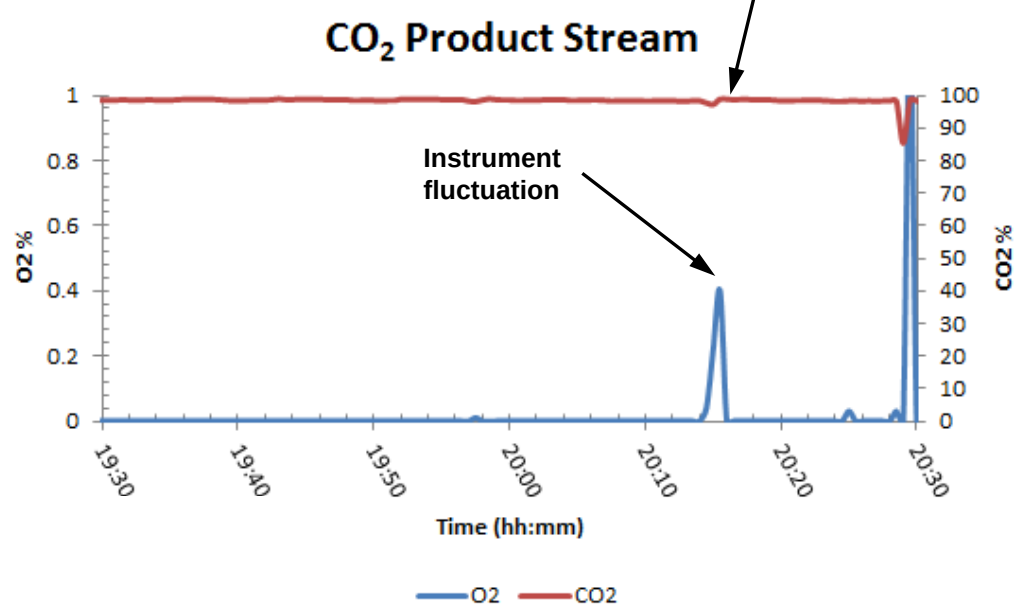
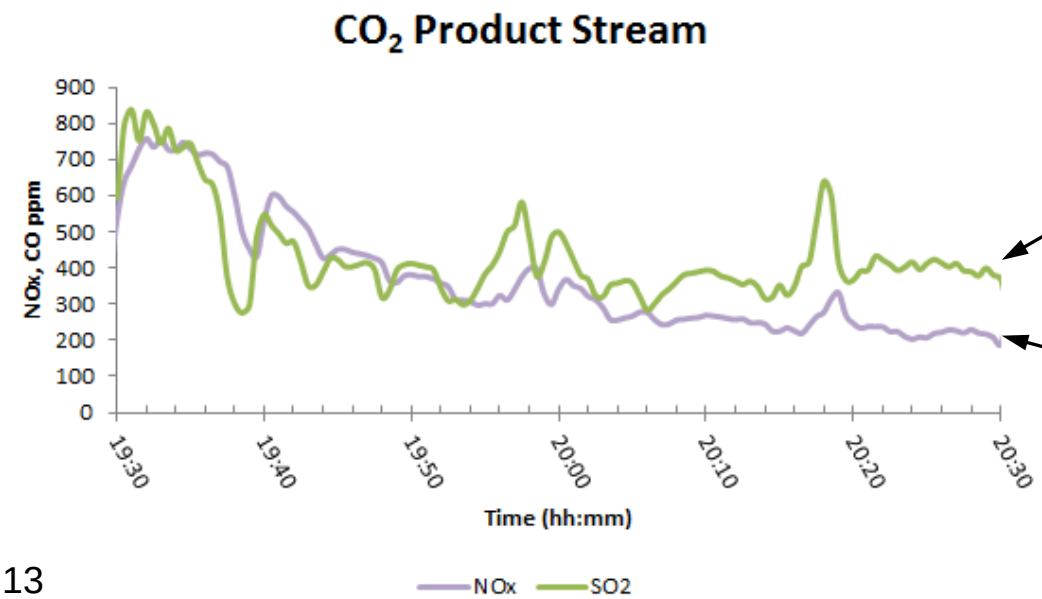
Experimental Results – CanCO_2 Data continued

Product Stream



CO_2 purity > 97%





SO_2 ~ 400 ppm
- Consistent with values upstream of dryer
- Normal given the properties of SO_2

NO_x ~ 300 ppm
- levels higher then expected, based on previous testing

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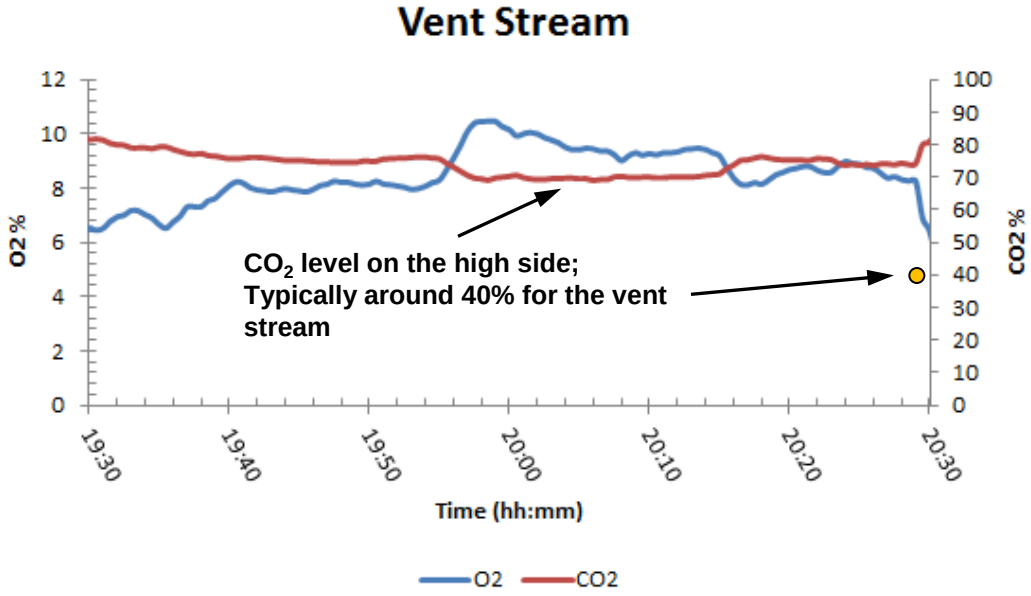
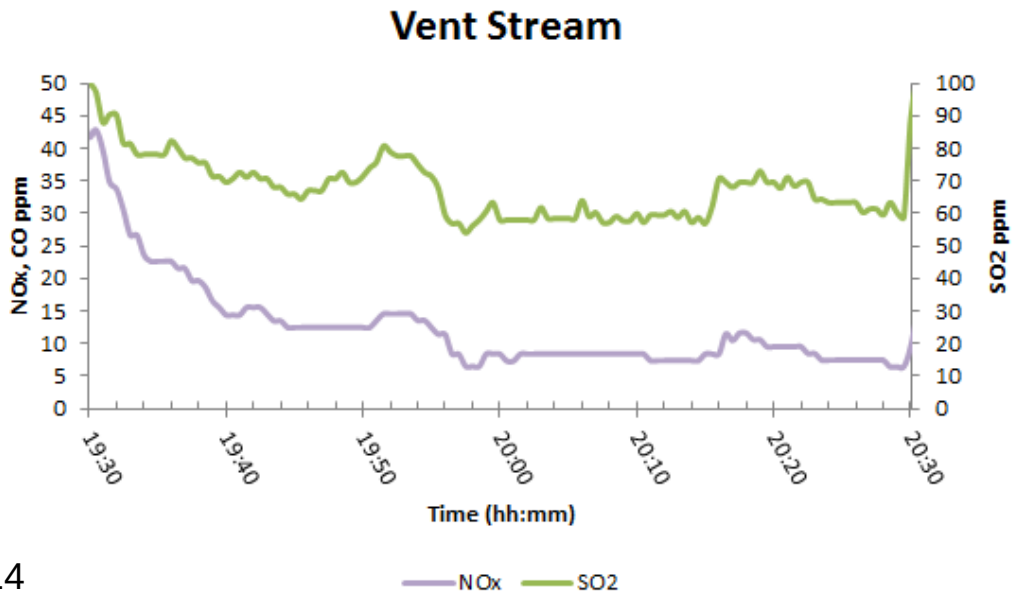
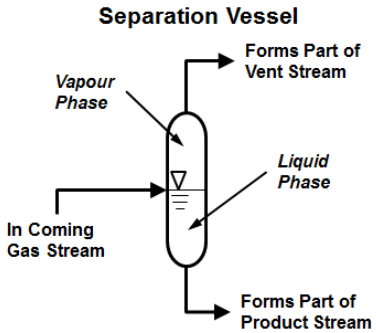
Experimental Results – CanCO_2 Data continued

Vent Stream

Note**, in spite of vent stream CO_2 concentrations, which approach ~ 80%, ***overall CO_2 recovery is approximately 75%







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Summary / Findings

- Combustion of anthracite coal posed on problems, overall good profomance
  - Typical flue gas composition: 90% CO_2, 3% O_2, 7% moisture, 2500 ppm SO_2, 800 ppm NO_x, CO < 100 ppm
- Minimal air infiltration noted, estimated at less than 5%
- CanCO_2 perform very well with a CO_2 recovery of 75% inline with simulation results.
- Capture of SO_2 and NO_x was observed in the CanCO_2, as demonstrated by the low levels of pollutants in the vent and product streams
  - 400 ppm SO_2 and 300 ppm NO_x in product stream
  - Less than 100 ppm of SO_2 and NO_x in vent stream

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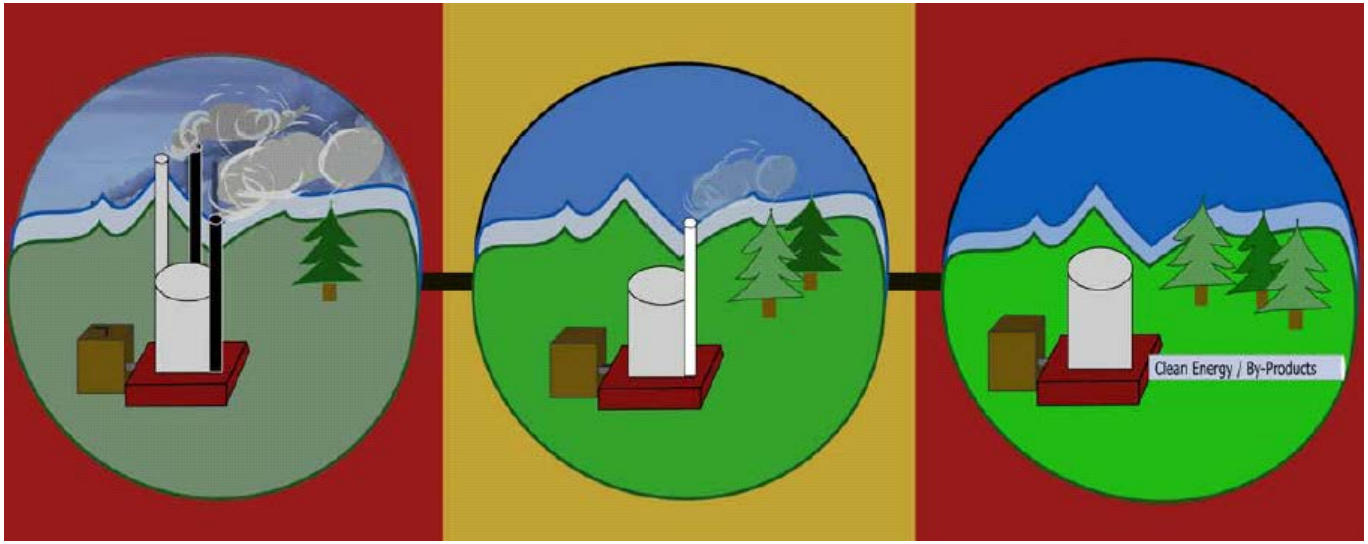
Future Work

- Complete the remains pilot-scale tests at CanmetENERGY
- Follow-up pilot-scale testing with pre-commercial testing at CUIDEN's oxy-fuel facility
- Compare and analyze the two data sets
- Collect more detailed data on the SO_x and NO_x capture within the the multistage compression block of the $CanCO_2$

Questions



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