Canadian Emissions Reduction Innovation Network

# CANADA EMISSIONS REDUCTION INNOVATION NETWORK (CERIN) PUBLIC REPORT

## 1. PROJECT INFORMATION:

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|---|---|
| **Project Title:** | Zero Emissions Heavy Oil Wellsite |
| **Emissions Reduction Scope/Description:** | Scope 1 Direct emissions on wellsite |
| **Applicant (Organization):** | Canadian Natural Resources Limited |
| **Project Completion Date:** | March 31, 2023 |

## 2. EXECUTIVE SUMMARY:

Canadian Natural Resources Limited (Canadian Natural) has set a target to reduce the amount of emissions from its operations. Canadian Natural has a demonstrator zero Scope 1 emissions pad site. The zero emissions pad prototype eliminated methane and carbon dioxide (CO2) emitted to the atmosphere while maintaining the effectiveness of surface operations.

The brownfield location was selected with 4 operating heavy wells and 2 production tanks. All gas fired equipment was replaced with electrically powered equipment to remove any onsite combustion for energy. Casing and tank vents were tied in to a gas collection system removing any sources of methane venting. The site was operated from early October 2022 and continues to operate at the time of writing this report.

## 3. KEY WORDS

- Heavy Oil
- Zero Emissions
- CHOPS
- Vapor Recovery

## 4. APPLICANT INFORMATION:

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|---|---|
| **Applicant (Organization):** | **Canadian Natural Resources Limited** |
| **Address:** | 2100, 855 - 2 Street S.W. Calgary, AB T2P 4J8 |
| **Applicant Representative Name:** | Matt Fallen |
| **Title:** | Production Engineer |
| **Applicant Contact Information:** | (403) 517-6700 |

## 5. LEAD CONTRIBUTING PARTNER INFORMATION:

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|---|---|
| **Organization:** | **Canadian Natural Resources Limited** |
| **Address:** | 2100, 855 - 2 Street S.W. Calgary, AB T2P 4J8 |
| **Representative Name:** | Matt Fallen |
| **Title:** | Production Engineer |

## 6. PROJECT PARTNERS

For this project, 2 prototype Vapor Recovery Units were sourced from LCO Technologies to allow for live site testing for their product development. Canadian Natural would like to acknowledge LCO for their contribution to this project.

# A. INTRODUCTION

## 1. SECTOR

The focus of this project was to support the Oil and Gas Industry's reduction of Scope 1 emissions, specifically at wellsites designed for the extraction of cold flow heavy oil found in northeastern Alberta (i.e. CHOPS). On a typical wellsite (see Figure 1), natural gas or propane is used as fuel for heating recovered heavy oil in storage tanks and fuel for engines in wellsite hydraulic systems. Low volumes of solution gas can escape from the heated storage tanks. Depending on the number of wells on a single wellsite, multiple tanks and engines can be installed increasing the amount of fuel used and methane vented.

*Figure 1: Typical Heavy Oil Multi-well Pad Site*

## 2. PROJECT SPECIFIC INFORMATION

The focus of this project was converting an existing heavy oil wellsite to be a zero Scope 1 emission wellsite. The site consisted of the following emission sources:

- Natural gas fueled engines driving hydraulic pumps to power wellhead drives for oil production and a casing gas compressor.
- 2 1000bbl vented production tanks.
- 220kW gas fired heaters contained in each production tank to maintain oil emulsion temperatures at 80°C.
- Casing gas regulators to manage pressures in fuel system.

Each of these sources had to be replaced with a zero Scope 1 emission solution that would not impact the oil production of the wells on the pad, increase the complexity of operating the wellsite or materially change the layout of the existing wellsite.

## B. METHODOLOGY

Rather than doing small bench or individual implementations of emission reducing technology it was decided to modify an operating brownfield wellsite. A location was selected that had existing connections to natural gas and electricity infrastructure to focus the scope of the project on the wellsite emission reducing design rather than greenfield connection to existing infrastructure. Pilot testing was completed over the winter months where ambient temperatures dropped below -40°C. This is typically the time when larger amounts of fuel is burned and can be a challenging operating environment.

The following table outlines the emission source and the technology applied to eliminate the emission source.

| Emission Source | Type of Emission | Elimination Method |
|---|---|---|
| Gas fired Engines for Hydraulic Systems | $CO_2$ emissions from combustion of natural gas | Replace all gas fired engines with electric motors to power hydraulic pumps. |
| Production tank venting | Low volumes of methane released out of solution from the oil emulsion being stored and heater in tanks. | Replace tank with a sealed system with a vapour/gas recovery system to manage tank headspace pressure. |
| Gas fired heaters in production tanks. | $CO_2$ emissions from combustion of natural gas | Replace tank heater with electric heaters. |
| Venting from gas regulators and process systems. | Low volumes of methane released for pressure control | Replace regulators with zero bleed/vent systems or connect vent to low pressure gas recovery system. |

## C. PROJECT RESULTS AND KEY LEARNINGS

### 1. GAS FIRED ENGINES

The production method used on this pad is Cold Heavy Oil Production with Sand (CHOPS). CHOPS requires artificial lift to produce oil, specifically downhole progressive cavity pumps. These pumps have the ability to co-produce heavy oil emulsion and formation sand. On surface, the pumps are driven using a wellhead top drive system. Typically, hydraulic motors are used in wellhead top drive. The hydraulic power system uses a natural gas engine as the prime mover. For this pilot, the natural gas engines were replaced with electric motors to remove any combustion of natural gas.

Along with the wellhead top drives, the casing gas compressors are also driven hydraulically. On the pilot all the casing gas compressor natural gas prime movers were replaced with electric motors.

*Figure 2: Electric/Hydraulic Pump Package*

This modification to the wellsite has been very successful over the duration of the pilot. No reliability or operability issues were experienced.

## 2. PRODUCTION TANK VENTING

In this pilot, the tanks were changed out with a 16 ounce per square inch sealed tanks. Pressure protection was added to the tank in case of over or under pressurization during operations. To maintain the tank pressure, a methane blanket gas system and vapor recovery unit (VRU) was installed. All gas collected from the vapor space of the tank was combined with the well casing gas and shipped offsite via a fuel gas pipeline connection.

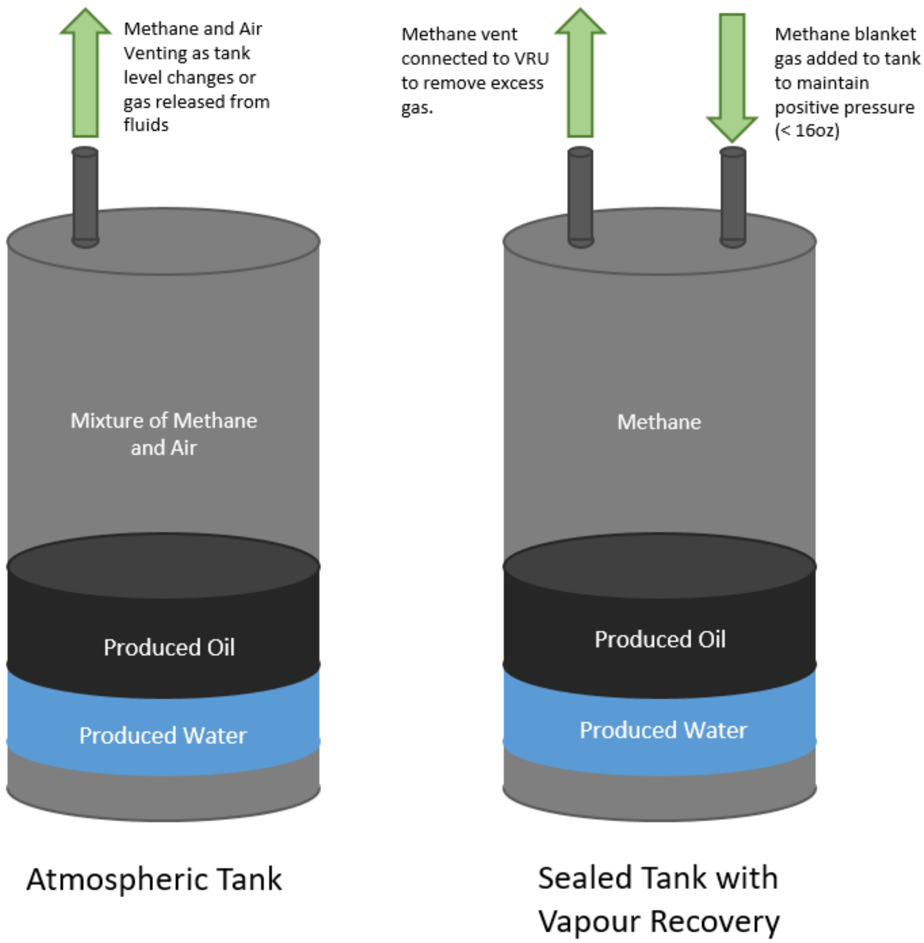


*Figure 3: Sealed Tank Conversion*

Two variations of VRUs were piloted on the wellsite. The first used a pressure regulated connection to the casing gas compressors and the second system was dedicated VRU compressors.

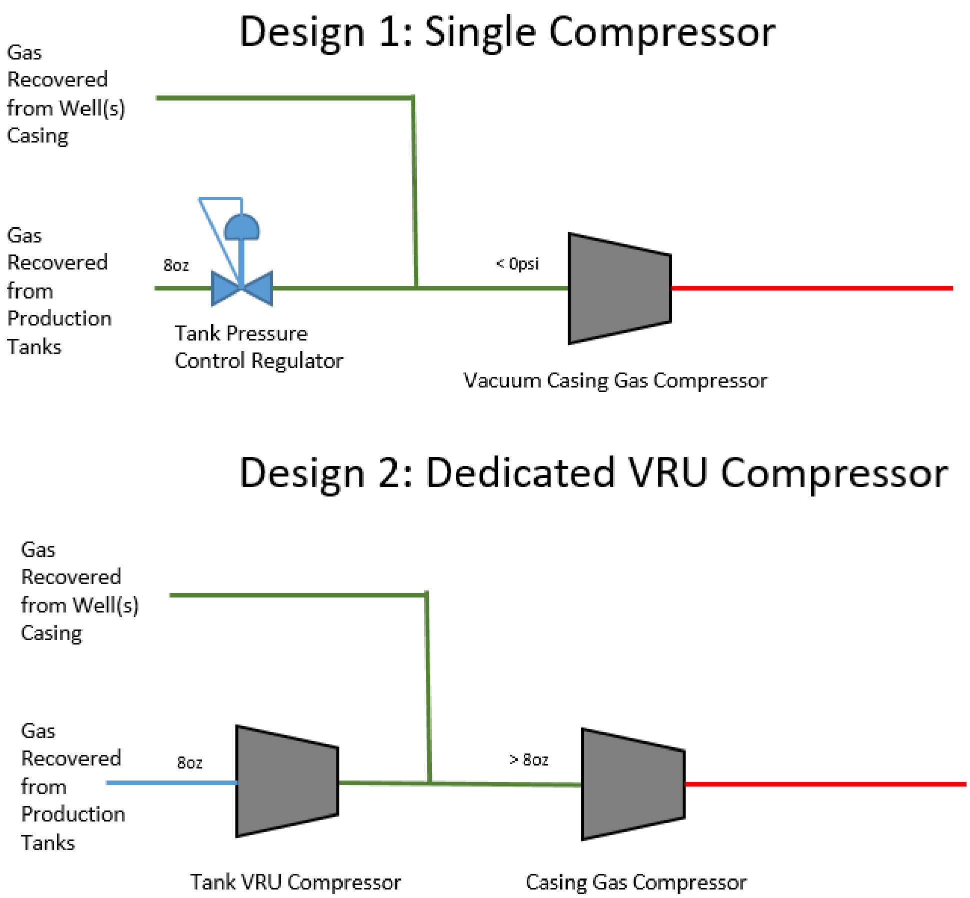


*Figure 4: Tank Gas Recovery Designs*

The wells on the pilot wellsite ran with the casing gas compressor at vacuum pressures. This allowed the casing gas compressor to function as a VRU along with a casing gas compressor. This system was successful in maintaining tank pressures. The weakness with this system is in the scenario when the casing gas pressure is not in vacuum.

The second option with two dedicated VRU compressors to manage the tank pressures and discharge the gas into the suction of the casing gas compressor. This design works for the scenario where the casing gas is not in a vacuum. As with the other design, this system was successful in maintaining tank pressures.

*Figure 5: Installation of Prototype LCO VRUs*

## 3. GAS FIRED HEATERS

Due to the high viscosity of heavy oil, the emulsion must be heated between 70°C -80°C to allow for initial separation of oil, water and sand produced from the well along with reducing the oil viscosity for pumping into shipping trucks. Heating is achieved through natural draft gas fired heaters installed into the production tanks. The gas fired heaters are typically rated for 220kW and controlled by the tank temperature.

For the pilot, to remove the direct emissions from combustion, electrical heaters were installed into the production tanks. 4, 60kW heaters were used at 2 elevations in the tank where the separated oil layer is located. Each heater was installed in a drywell to allow for servicing without draining the tank. Each heater has a dedicated temperature controller which referenced the fluid temperature near the heater.

*Figure 6: Production Tank Heaters*

Over the duration of the pilot ambient temperatures dropped below -40°C and the heaters easily maintained the fluid temperature. Overall this was a great success for the pilot as electrical tank heating was never used on a heavy oil site prior to this.

### 4. VENTING FROM REGULATORS AND PROCESS SYSTEMS

On the pilot, all regulator vents were connected back to the compressor inlet to ensure no methane was vented. This is a common practice at Canadian Natural and performed as expected.

## D. PROJECT AND TECHNOLOGY KEY PERFORMANCE INDICATORS

| Organization: | Current Study | Commercial Deployment Projection |
|---|---|---|
| | | |
| **Technology Readiness Level (Start / End):** | TRL 7/ TRL 9 | |
| **Scope 1 GHG Emissions Reduction (tCO2/yr/pad):** | 465 tCO2/yr * | 21,000 tCO2/yr+ |
| **Estimated Scope 1 GHG abatement cost ($/tCO2/pad)** | $4183/tCO2 | $132/tCO2 |
| **Jobs created or maintained:** | No changes to manpower. | No changes to manpower. |

*Prior to pilot, the wellsite consumed around 0.6e3m3/day. This gas was used onsite for tank heaters only since some of site was already electrified. Assuming a conversion factor for natural gas combustion of 2.121 tCO2e/e3m3.

+Based on a 10 well pad with VRU and all heaters converted to electric immersion.

## E. RECOMMENDATIONS AND NEXT STEPS

Overall the pilot was a technical success. Next steps included continuing to review the economics and evaluate the learnings for applications on other sites.