Advanced Methane Detection, Analytics and Monitoring Technologies

Final Report
June 12, 2019

Disclaimer

Petroleum Technology Alliance Canada and relevant project partners do not warrant or make any representations or claims as to the validity, accuracy, currency, timeliness, completeness or otherwise of the information contained in this report, nor shall they be liable or responsible for any claim or damage, direct, indirect, special, consequential or otherwise arising out of the interpretation, use or reliance upon, authorized or unauthorized, of such information.

The material and information in this report are being made available only under the conditions set out herein. No material from this report may be copied, reproduced, republished, uploaded, posted, transmitted or distributed in any way, unless otherwise indicated on this report, except for personal or internal company use.

Table of Contents

Executive Summary

This final report summarizes outcomes for the Advanced Methane Detection, Analytics and Mitigation project undertaken by Petroleum Technology Alliance Canada (PTAC) in collaboration with Cap-Op Energy, Cenovus Energy, Encana Corporation, General Electric Canada, the University of Calgary, Process Ecology Inc., Polar Star Canadian Oil and Gas Inc., Calscan Solutions, LCO Technologies, Husky Energy, and Repsol Oil and Gas Canada Inc. This project commenced on April 1, 2016 and concluded on September 20, 2018.

The project demonstrated a portfolio of near commercial (TRL 6 – 8) clean technologies for the detection, analytics and mitigation of methane emissions in the upstream oil and gas (UOG) sector and was composed of 2 themes: (1) Detection and Analytics, and (2) Mitigation. The robust solutions presented by these innovative technologies address challenges faced by regulators and operators and help to support the Canadian federal government's policy to reduce methane and volatile organic carbon (VOC) emissions by 40% - 45% by 2025.

The objectives of this project were to (1) demonstrate clean technologies, (2) demonstrate technologies for methane detection and measurement, (3) demonstrate technologies for methane emissions mitigation, and (4) to disseminate project activities. The project met all project objectives with the following achievements:

- Demonstration of two new clean energy technologies for the efficient, reliable, rapidly deployable, scalable detection and quantification of methane emissions.
- Demonstration of a suite of five methane detection and measurement technologies to varying degrees of reliability, scalability, deployment and effectiveness. Additionally, learnings generated during these phases of the project contributed to technical knowledge that will assist industry in methane detection and measurement research.
- Successful demonstrations of two, improved technologies for the mitigation of methane emissions.
- Project activities were successfully disseminated amongst PTAC's network and applicable committees by various means. Additionally, the academic publication of Phase 1.2 resulted in the dissemination of project activities and findings to a broader academic audience.

1 Introduction

The purpose of this project was to demonstrate a portfolio of near-commercial clean technologies for the detection, analytics and mitigation of methane emissions in the UOG sector in support of the Canadian government's policy to reduce such emissions between 40% - 45% by 2025. In 2011, Canadian greenhouse gas (GHG) emissions for upstream oil and gas flaring, methane venting and fugitives were 34.4 million tonnes CO_2e. Direct methane emissions accounted for 89% of this amount and were primarily composed of:

- 33% from fugitive emissions – Of which 16% arose from Surface casing vent flow (SCVF) and wellbore leaks, 11% from equipment leaks, and 6% from other sources.

- 30% from reported venting, which are the amounts reported to regulators from production accounting systems and are mostly composed of well casing vents in cold heavy oil.
- 26% from unreported venting, which was composed of several small releases from pneumatic equipment and other process sources.

In order to meet the federal government's emissions reduction targets by 2025, accounting for the emissions baseline is the first challenge. Prior to this project, the information required to establish this baseline did not exist at the accuracy and granularity required for compliance and assessment of fees or taxes. Measurement precision is challenged by the temporal irregularity of the flow and the fact that mechanical instrumentation will apply back pressure. While the emitting sources are known, there are over 100,000 sources and a central inventory did not exist. Establishing the baseline will require massive resources unless faster and scalable technologies are deployed. During this project, outcomes from Phases 1.1 – Advanced Methane Measurements using Novel Ground-based and UAV-based sensors (BHGE), 1.2 – Methane Emission Measurement using UAVs (UCalgary), and 1.4 – Baseline and Management Database (Cap-Op) allowed for better documentation and more precise measurements of methane emissions. Therefore, these phases assisted in the first step towards establishing a baseline for emissions.

While measurement is the first step, real reductions require safe, practical and affordable technologies. A key challenge is that most sources emit small intermittent volumes at low pressures. Some technologies exist, such as solar electric pumps and vent gas capture (e.g. Slip Stream) for conserving fugitives as engine fuel, however, their penetration rate is not high and industry requires additional tools, such as:

- Solutions for casing gas at isolated cold heavy oil well sites; the existing compression and trenched plastic pipe approaches infrequently meet cost criteria for maintaining production;
- Solutions for pneumatics where conservation options are not available;
- Improved reliability and cost of solar electric technologies;
- SCVF detection and remediation solutions with significantly higher reliability. The proposed project is a portfolio of innovative technologies that address all the above challenges.

In this project, outcomes from Phases 2.1 – Solar Instrument Air Compressor (LCO) and 2.2 – Improved Solar Electronic Control System (Calscan) demonstrated new technologies for reducing methane emissions.

The project was composed of 2 themes: (1) Detection and Analytics, and (2) Mitigation, as described below.

Methane Detection and Analytics

<u>Phase1.1 – Advanced Methane Measurements using Novel Ground-based and UAV-based Sensors</u>

Demonstration trials were performed at an Encana site of a novel Baker Hughes General Electric (BHGE) methane sensor system deployed using a ground-based platform and an unmanned aerial vehicle (UAV) platform including tools and analytics for detecting leaks and emissions.

Phase1.2 – Methane Emission Measurement using UAVs

The University of Calgary (UCalgary) sought to develop intelligent flight planning tools and algorithms to support fugitive emission localization using 2 different UAV-based methane detection technologies.

Phase1.3 – Satellite Detection of Change Algorithm for VOCs

St. Francis Xavier University (StFX) developed an algorithm with data from Cenovus to detect changes in emissions of methane and other volatile hydrocarbons (VOCs) with high resolution satellite data to allow fast monitoring over wide areas for detection of change.

Phase1.4 – Baseline and Management Database

The Methane Abatement Project Platform Analytics (MAPP Analytics) by Cap-Op Energy was built upon methane analytical tools and integrated with the existing Distributed Energy Efficiency Projects Platform (DEEPP) and MAPP, which offer tools compatible with the Petrinex reporting system. Petrinex is a joint government-industry strategic organization that facilitates efficient, standardized, safe and accurate management /exchange of data essential to Canada's upstream, midstream and downstream petroleum operations.

Phase1.5 – Methane Advisor

Process Ecology and Polar Star demonstrated the Methane Emissions Advisor™ software. The objective was to demonstrate that the software is as or more accurate, in calculating methane, VOC and GHG emissions than emission factor/spreadsheet-based estimations of emissions.

Mitigation

2.1 – Solar Instrument Air Compressor

Prototype demonstration by LCO Technologies in collaboration with Husky Energy of a small air compressor with low energy requirement to reduce the power budget and cost of instrument air for elimination of venting.

Phase 2.2 – Improved Solar Electronic Control System

Demonstration by Repsol of the improved Calscan electric solution (including "fail safe" electric Emergency Shutdown) for replacing pneumatic sand eliminating methane venting.

2 Background

The purpose of this project was to demonstrate a portfolio of near-commercial (TRL 6 – 8) clean technologies for the detection, analytic and mitigation of methane emissions in the UOG sector in support of the Canadian federal government's policy to reduce methane and VOC emissions by 40% - 45% by 2025. Before the commencement of this project, final decisions had yet to be made regarding applicable federal regulations, however, it was anticipated that provincial regulations would follow 1 – 2 years later. As an update, Canada's Federal government released their final publication of their Energy Efficiency Regulations in the Canada Gazette on June 12, 2019. A pre-publication was released in October 2018. Provincial regulations are currently in the final stages of completion. As such, there is a very short amount of time to affect massive changes in industry

infrastructure. The outcomes from this project have been shared with the provincial regulator as well as Federal government representatives to inform their regulatory development process.

In 2011, Canadian GHG emissions from the UOG sector were 120.8 million tonnes CO_2 equivalent. This number includes 34.4 million tonnes CO_2e in flaring, methane venting and fugitive emissions. Direct methane emissions were 1.54 million tonnes of methane. Direct methane emissions decreased by approximately 25% between 2000 and 201, primarily due to best practices. In order to meet government policy targets, additional annual reductions in the order of 15 million tonnes CO_2e will be required within three to five years. The easier reduction opportunities have already been realized. What remains is an inventory of hundreds of thousands of units emitting generally no more than 500 m^3/day, but predominantly less than 50 m^3/day. Addressing this challenge urgently requires:

- Understanding the composition of the baseline at the granularity required for investment, infrastructure modification, and compliance;
- Monitoring and inspecting a large variety of geographically dispersed and remote sites in a manner that allows increased frequency and reasonable use of skilled personnel;
- New, safe, reliable and practical mitigation technologies adapted to remote northern locations.

Achieving 45% emissions reductions will require investments in facilities estimated in the hundreds of millions of dollars and increases in operating costs to the same magnitude. Therefore, innovative, lower cost technologies (even incrementally lower in cost) will have a large beneficial impact due to leverage. Innovation is critically required using novel sensors, platforms such as satellites, airplanes, UAVs and road vehicles, cloud computing, analytics, as well as low-cost, less intrusive mitigation technologies.

3 Objectives

Methane emissions from the Canadian UOG sector originate predominantly from Alberta and Saskatchewan, and from light/medium and heavy oil production, natural gas production and SCVF. Thermal heavy oil production, such as the oil sands, only contributes 1% to methane emissions. As such, the objectives of this project were to:

3.1 Demonstrate Clean Technologies

- The objective was to demonstrate a suite of clean energy technologies that will enable real reduction in methane emissions in the UOG sector focusing on the major sources, namely cold light, medium and heavy oil production, natural gas production, and SCVF in Alberta and Saskatchewan.
- This objective was achieved through the demonstration of two clean energy technologies.

3.2 Demonstrate Technologies for Methane Detection & Measurement

- The objective was to demonstrate reliable, scalable, rapidly deployable and effective (with respect to human and financial resources) technologies for methane detection and measurement using novel remote sensing sensors, platforms and analytics.

- A suite of five methane detection and measurement technologies were demonstrated to varying degrees of reliability, scalability, deployment and effectiveness. These technologies include:
    - Phase 1.1 – Novel Ground-Based and UAV-Based Sensors from BHGE.
    - Phase 1.2 –A commercial drone-based methane sensing system.
    - Phase 1.3 –An algorithm for detecting VOCs.
    - Phase 1.4 – A Baseline and Management Database.
    - Phase 1.5 – A Methane Emissions Advisor platform.

3.3 Demonstrate Technologies for Methane Emissions Mitigation

- The objective was to demonstrate improved technologies for the mitigation of methane emissions from major sources such as pneumatic instruments, well casing and SCVFs, using advanced micro-combustion and novel solar electric system solutions.
- Two improved technologies for the mitigation of methane emissions were successfully demonstrated. These technologies include:
    - Phase 2.1 – Solar Instrument Air Compressor.
    - Phase 2.2 – Improved Solar Electronic Control System.

3.4 Disseminate Project Achievements

- The objective was to broadly and collaboratively disseminate project achievements and learnings in order to accelerate industry's trajectory to delivering on the policy goal of 45% reductions by 2025.
- This objective was achieved through various project dissemination activities through PTAC and other project partners.

4 Project Results

4.1 Project Achievements

4.1.1 Achievement 1 – Demonstrate Clean Technologies

Phase 1.1 was successful in demonstrating two new, successful clean energy technologies (SENTRY and UAV) for the efficient, reliable, rapidly deployable, scalable detection / quantification of methane emissions. According to the final report, BHGE is in a good position to offer these cost-effective technologies to the Canadian oil and gas industry, which will support industry specific reductions in GHG emissions. This achievement pertains directly to the project's overall objective of improving a suite of clean energy technologies for the oil and gas industry, long-term environmental and economic benefits, as well as, the increased competitiveness of Canada's clean tech industry.

4.1.2 Achievement 2 – Demonstrate Methane Detection / Measurement Technologies

Conclusions from Phase 1.2 indicated that the system had low emissions detection probabilities, and as such, did not produce a commercially viable technology. However, the demonstration of this technology was successful in generating several learning outcomes that will assist industry and research institutions in their future research endeavours. Additionally, the two studies generated from this phase are in line with this project's overall objective of increasing the awareness and understanding of technologies and processes associated with reducing air emissions, as well as, the increased availability of scientific and technical knowledge.

While none of the satellite-only products evaluated during Phase 1.3 could be utilized for compliance in current or future regulations, results indicated that some may play a role in detecting super-emitters quickly at remote sites under Alternative Leak Detection and Repair programs. As such, this phase has supported the increase of technical knowledge regarding the role of satellite-products in methane detection, and potentially opened a new testing scenario.

Phase 1.4 resulted in the commercialization of technology, specifically the Methane Data Integration Module and DEEPP MAPP Integration. Additionally, the prediction algorithm has been improved considerably enough that commercial viability may be possible with large datasets. Additionally, the database created and provided to oil and gas producers assisted in the increase of technical knowledge.

4.1.3 Achievement 3 – Demonstrate Methane Mitigation Technology

Initial field performance results from Phase 2.1 indicates that the solar battery design can be scaled down to control costs and installation time. Additionally, the field test indicated lower power consumption for the unit and that it consistently kept up with the demand of the system. As well, the project will have avoided carbon levy prices in 2023 due to reduced fuel usage on site and will reduce the regulatory and reporting obligation as part of Alberta's Directive 060 requirements. Further value creation will be measured by a 3rd party after one year of operation.

In general, all pumps tested during Phase 2.2 performed well. However, there were some pumps that outperformed their peer groups with respect to design and operability. Should future testing on selected pumps be favourable, Repsol may consider broader field implementation, which may assist industry in long-term GHG reductions.

4.1.4 Achievement 4 – Project Dissemination Activities

The following project dissemination activities occurred throughout this project:

- Phase 1.2 resulted in the following academic publication from the University of Calgary: Barchyn TE, Hugenholtz CH, Fox TA. [submitted]. Plume detection modeling of a drone-based natural gas leak detection system. Environmental Science & Technology.
- Phase 1.4 - MAPP Analytics: Cap-Op provided the MAPP-Inventory data collection application at no charge for oil and gas producers / field service providers.
- PTAC distributed the findings from this project on its website, throughout its network and with relevant committees:

- Repsol Oil & Gas Canada presented on the Solar Electric Controls (Phase 2.2) at PTAC's inaugural Methane Emissions Reduction Forum on November 28, 2018.
- The University of Calgary presented on Phase 1.2 at PTAC's 2019 Methane Emissions Reduction Forum.
- Husky Energy presented on Phase 2.1 at PTA's 2019 Methane Emissions Reduction Forum.

4.2 Project Challenges

4.2.1 Challenge 1

This project had hoped, *inter alia*, to demonstrate that the Methane Emissions Advisor software (Phase 1.5) is as or more accurate, in calculating methane, VOC and GHG emissions than emission factor/spreadsheet-based estimations of emissions. However, only one site was used during testing and proved to be a poor fit in validating data obtained from software predictions. It was determined that a different facility (with tanks venting directly into the atmosphere) would be a more appropriate test site. Additionally, Polar Star facilities were unable to clarify the data obtained during the analysis of field data earlier on in the project. As such, the tool remains un-validated for tank emissions to atmosphere in a specifically Alberta context. However, despite this challenge, the other Phases of this project did not encounter significant challenges or barriers.

4.2.2 Challenge 2

While successful in demonstrating the viability of a scalable solar battery design, an additional $11,000 plus overhead was required to cover the cost of overruns for Phase 2.1. These overruns were due to three specific challenges. First, the installation took additional time to implement due to the electrical scope (inaccurate drawings and insufficient solar capacity of the initial system). Second, there were delays due to a lack of clarity on the location of key components. Finally, the team had to troubleshoot the air compressor panel after start-up.

5 Conclusion and Follow-up

Overall, this project has been successful in advancing the commercialization of several technologies thereby improving the competitiveness of Canada's clean energy tech industry, resulting in long-term environmental and economic benefits, while generating new knowledge to inform improved regulations. For example, Phase 1.2 outlined the viability of specific technology with respect to evolving regulatory limits.

Principally, this project intended to demonstrate an improved suite of clean energy technologies (five detection / monitoring and two mitigation). While not all these field demonstrations resulted in commercially viable technology, each phase yielded unique learnings that will improve future technology R&D for long-term GHG and VOC reductions. For example, the technology demonstrated in Phase 1.5 remains un-validated due to several challenges, however, the conclusion outlined more suitable facility features that will enable the validation of collected data, for future work.

With respect to Phase 1.4, Cap-Op advanced work towards several objectives during the project, while shifting priorities in response to shifts in regulatory timeline and expectations from regulators. During the development of MAPP, the Alberta Climate Change Office (ACCO) published a new Standard for Offset Project Developers. In order to meet the new requirement of more frequent registrations of methane and other aggregated offset projects, Cap-Op redirected their efforts to ensure the functionality of MAPP matched the ACCO project registration requirement. This change allowed for the rapid commercialization of the Methane Data Integration Module for industry partners whose projects needed to be registered with the CSA/ACCO system. Additionally, the regulatory reporting functionality was deprioritized as a result of provincial and federal regulatory delays. As the provincial methane reporting framework is still under development (ONESTOP), it was not possible for Cap-Op to configure MAPP reporting outputs to ONESTOP inputs.

Results from Phase 1.3 found that none of the technology evaluated could be used for compliance in current or future regulations due to a lack of sensitivity around regulatory thresholds of interest. However, Flux Lab also concluded that flight-based measurements could be attractive for the near-term, due to declining regulatory limits.

5.1 Next Steps

Per NRCan reporting guidelines, PTAC will be contacting all partners involved in the project every year for five-years to request performance statistics and further updates. Additionally, with respect to Phase 2.2, the next step will be to conduct a well pilot, using the preferred pump in real time production conditions with the same metrics. If results from the pilot are favourable, Repsol may consider broader field implementation.