ecoENERGY Innovation Initiative

Research and Development Component

Public Report

ecoEII UOSE048 Atmospheric leak detection as a tool for bitumen steam chamber and oil well integrity risk analyses.

Contents

1 Executive Summary

The energy sector is typically not yet very savvy at using low-level (sub-regulatory) fugitive emissions data to inform itself about operations. However, this type of data can be quickly and easily collected and eventually used to reduce companies' interaction with regulation, and to augment environmental performance.

Using advanced emission detection technologies, we can support clean development and improved environmental performance. In an Eco-Energy Initiative project running between 2012 and 2015, we developed an approach called Emissions Attribution using Computational Technologies (ExACT), which was widely applied in southeastern Saskatchewan for mapping emissions and air quality threats. This current project helped us refine our technology even farther, by allowed us to apply it in a new context, for detecting small emissions from the surface which would be indicative of subsurface failure (well integrity or caprock pressure breach). At the same time, we provided valuable datasets to industry partners. We applied the technique at a number of sites in the oil sands region, with operators including Cenovus Energy, Shell, and MEG Energy. We also applied the technique as planned at the University of Calgary and Carbon Management Canada Geoscience Field Research Centre, for baseline surveys. This is a site being used by oil sands and other Canadian operators for researching issues around subsurface containment and where the technique will be applied in future experiments. Each of these deployments targeted a different problem. Some were very focused on small spatial areas, at the request of the partner, while others consisted of large regional campaigns. ExACT was used in each case to demonstrate the presence, absence, or spatial distribution of emissions at the study sites. These data promoted many good discussions, and follow-up is still ongoing in many cases. Overall, we measured at more sites than planned, and the work between the St. Francis Xavier University – University of Calgary – Carbon Management Canada teams was seamless and paved the way for future collaborations.

2 Introduction

This project took a mobile leak detection strategy developed for Enhanced Oil Recovery (EOR) sites by St. Francis Xavier University (StFX), and adapted and tested it for use in the thermal oil sands projects as an early warning system for well or caprock integrity issues. The technology involves measuring the concentrations of several key gases in proximity to the soil surface, and applying computational algorithms that compensate for the magnitude and variability of background gases that may be present naturally in the area, before comparing the gas fingerprint to those of possible leak sources.

The project was conducted between April 1, 2015 and March 31, 2016. With excellent team spirit throughout the project, we worked very effectively with our collaborators at University of Calgary and Carbon Management Canada. The project involved four types of activity. The first was to establish from literature and company consultation the expected compositions and variability of natural background gases in the region, and the composition of ground-source gases associated with leakage. We then re-configured the instruments and any adapted algorithms as necessary for the new tasks. We also had to adapt for sites without dense road networks. Lastly, in the final 4-12 months of the project we completed field campaigns to test the technique. For some of the sites, some ground exploration was also required for verification purposes.

3 Background

Oil sand deposits are in the form of bitumen, which in its natural state is too viscous to flow. When bitumen is too deep (>80 m) to economically extract via surface mining, steam is injected to warm the bitumen, reducing the viscosity and allowing it to be pumped through horizontal well pairs to the surface. Several potential environmental problems have been associated with extraction of oil sands including fish tainting, leaks, and oil spills. In 2013, a blow-out at Canadian Natural Resources (CNRL) Primrose facility in northern Alberta, leakage allowed more than 26,000 barrels of steamed bitumen to seep into the boreal forest through ground fissures as long as 159 m, putting groundwater at risk.

The recent events at CNRL's Primrose site have connected the issues of well integrity and the presence of fractures within the caprock zone above the reservoir. These two issues work together to open conduits to the surface from high-pressure steam wells. If integrity issues exist, they will be signaled first by the arrival of production formation gases at the surface, as they are far less viscous than groundwater or bitumen and these gases will sneak preferentially through fractures and wellbore failure areas. If a sufficiently sensitive surface gas measurement technique was used regularly for site surveys, it could likely detect integrity and/or over-steaming issues long before any bitumen or formation water were to reach the surface.

This project took a mobile leak detection strategy developed for Enhanced Oil Recovery (EOR) sites by St. Francis Xavier University (StFX) and adapted and tested it for use in thermal oil sands projects as an early warning system for well or caprock integrity issues. The technology involves measuring the concentrations of several key gases in proximity to the soil surface, and applying computational algorithms that compensate for the magnitude and variability of background gases that may be present naturally in the area, before comparing the gas fingerprint to those of possible leak sources. The surveys were designed to conducted from a vehicle quickly, are highly sensitive, and can detect subtle leak plumes even when their absolute concentrations are still within the range of normal background levels.

Most producers rely on production, geophysical, and groundwater information to make decisions. But, many of these data sources are poorly distributed spatially. As a whole the energy sector has yet to become savvy at using low-level (sub-regulatory) fugitive emissions data to inform itself about operations. Low-level fugitive gas sensing can be very specific, and useful for attributing gas sources, and overall represents an excellent tool for operational sensing, to reduce companies' interaction with regulation, and to augment environmental performance. Using the strategies employed in this project, these data can be collected very quickly and conveniently at surface, and in a spatially-extensive fashion.

These tools should be adapted for use at oil sands sites and made available to oil sands producers as a potential arrow in the quiver.

4 Objective

The overall project objective was to adapt the mobile leak detection technology originally developed by StFX for EOR applications, for oil sands applications, and to demonstrate its feasibility and usefulness in the new context. In the end, the goal was to develop a highly sensitive, large-footprint detection gas survey technique for oil sands producers.

This technique could be used by oil sands producers to collect information related to both operations (integrity of production infrastructure), and environment (fugitive gases including pollutants or toxic gases, and GHGs). It could be used at several spatial scales, from small-scale infrastructure like wellheads, to large footprint surveys on caprock integrity. As with EOR, we expected at the end of this project to detect small fugitive gas leaks in the oil sands setting, which would provide early warning of larger problems that might result in lost production and/or environmental issues. These surveys could be repeated on a more regular basis than regular well pad surveys, since this screening technology is rapid and convenient.

5 Results of Project

5.1 Project Achievements

5.1.1 Achievement 1: Refined Approaches

- Though some of the data will remain locked by non-disclosure agreements (the tradeoff for having ventured onto company sites), this project advanced our understanding on the topic of fugitive emission surveys and provided needed data. Overall, we would say that fugitive emissions appear to be very well managed at oil sands SAGD sites, but when present they were easier to identify than expected even in high methane muskeg environments due to our additional (isotopic etc.) tracers. At more southerly sites where CO_2 injections are taking place or planned there was appreciable CO_2 noise with frequent combustion plumes on the landscape given combustion sources also produce high CO_2 anomalies. During all field visits, we exhaustively surveyed equipment and logged emission plumes, and attributed both geochemically and geospatially to the most probable sources of emission plumes.

In several cases we were able to repeat surveys. We logged background ambient atmospheric concentrations of methane, hydrogen sulphide, and other gases. We devised an approach for future projects that involves 1-3 additional gases that will allow us to geochemically peel apart these sources to avoid false positives. Overall, this project, and particularly the field work in the Q4, helped refine our approaches for fugitive emission detection, and it has also increased awareness within the partner companies.

5.2 Benefits

5.2.1 Benefit 1– Knowledge application and export

To the benefit of the Canadian economy, in February 2017, StFX signed a technology collaboration agreement with Altus Group for the exclusive worldwide commercialization usage rights of StFX's vehicle-based Emissions Attribution via Computational Techniques ("ExACT") gas leak detection technology. Altus Group is a Canadian Geomatics, Land Surveying, and Forestry Consulting company. We expect our technology to also be used elsewhere in the world. Additionally, other companies involved in this project have increased their level of knowledge, and therefore competitiveness.

6.1.3 Benefit 2 – Supporting Sustainable Development

Sustainable development of Canada's energy sector benefits from the new knowledge about emission patterns developed in this project. This benefit will be realized in the future as our knowledge is applied and regulatory measures are enhanced and adjusted. Novel measurement tools and data often contribute to higher levels of awareness and new discussions around environmental issues.

5.3 Technology/Knowledge Development Objectives

- Conducted surveys to support clean development and improved environmental performance, which would also demonstrate our ExACT survey technology and bring us together with potential partners.

The project overall has contributed to technology/knowledge advancement:

- Currently, many fugitive emissions go unmeasured, particularly if they fall below the regulatory thresholds. These emissions, while not dangerous directly to humans, can still lead to substantial greenhouse footprints. Small emissions may also signal early threats. ExACT has helped operators to identify, and in some cases, eliminate emissions of gases in large developments. By using ExACT within a leak

detection and repair program, operators can take proactive measures in reducing leakage, thereby lowering overall greenhouse gas emissions. We have seen this with operators who have partnered with us, where they would immediately go out to inspect sites where we had detected emissions.

The impact of this advancement of technology/knowledge on the energy industry in Canada and abroad:

- Our ExACT technology will make Canadian oil and gas companies more competitive on the international stage, and will form a nice commercialization opportunity for a capable licensee – which we will ensure is Canadian.
- Reducing or eliminating gas leaks will help operators protect Canadian groundwater, soils, and air.
- While this project was centered in western Canada, this project also has the potential to inform development of an Atlantic onshore oil and gas industry. We would be able to provide expertise in Atlantic Canada should moratoria be lifted to ensure that the industry is developed with sustainability in mind.
- We have catalyzed dialog regionally, nationally, and internationally about air quality and fugitive emissions. This is a multi-stakeholder issue that has involved regulators, operators, and non-governmental organizations.

5.4 Challenges and Barriers

5.4.1 Barrier/Challenge 1 – Technical Development of ExACT

- ExACT represents a very unique approach to collecting data in the lower atmosphere and a complex platform technology. This project pushed us to make adaptations for new environments, and our technical team responded well. It was beneficial to have this project run alongside the sunset of another Eco-Eii project which helped ensure that necessary expertise was available as required to share across projects.

5.4.2 Barrier/Challenge 2 – Site access

- We had some challenges arranging for field sites, and particularly completing logistics in the needed time interval which was very short. However, we did eventually get all fieldwork done roughly on the planned timeline, and in fact visited more sites than expected. We were particularly pleased about this outcome, again because of the challenge of the short-duration project.

6 Conclusion and Follow-up

Significance of outcomes:

- Across the industry we have improved emissions and containment monitoring with the development of new approaches. These new approaches can make Canadian operators more competitive, and generate opportunities within our environmental consulting industry (via commercialization).

Long-term outcomes:

- When it comes to informing emission management across Canada's industry, we have a huge opportunity with ExACT. We would like to see ExACT provide clearer information on what is emitting and what can/should be repaired to help meet targets faster (5 years instead of 10, for example). The technique would apply even to caprock breach, well integrity, and other similar applications for which high sensitivity would be prized.

Next steps with the ExACT technology:

- To estimate volumes. Regulators in particular seek some ability to make volumetric estimates with the mobile survey data. We can do this work by hand but automation for these large datasets is a virtual necessity. These algorithms must also be field validated with emissions of known magnitude.
- To establish development. Our instrument package varies from development to development because we build unique ratio identifiers based on the geochemistry and variability of background gases (natural and industrial) relative to the target gases. Our ability to serve operators is enhanced by this pre-existing knowledge. Therefore, it is important that we collect specific geochemisty data in priority developments for calibration and fine tuning of the measurement suite.
- Miniaturization. Our ExACT approach consists of computational filtering and interweaving of geochemistries and background corrections. The approach is equally applicable to unmanned aerial vehicles and "vessel of opportunity" data collection, where we can greatly improve the detection sensitivity of small-payload devices that will always otherwise suffer from poor resolution.
- Fit with FLIR thermal imaging infrared cameras. We can detect emissions roughly 100 times farther than a FLIR camera with our technique, although FLIR is still more useful for very close range work. The spatial scale at which FLIR is more effective than our technique has yet to be defined. We have purchased our very own FLIR camera with plans to perform FLIR inter-comparison tests.

Projects have been launched that address each of the aforementioned areas. Given the pressure to develop emission reduction technologies for near-immediate application, we are looking to secure additional funds for these projects to move them ahead at faster pace.

We have also secured some commercialization funding for ExACT through Innovacorp and the Atlantic Canada Opportunities Agency (Atlantic Innovation Fund and Learnsphere program). To date we have commissioned one market study and company scan. We are actively talking to possible licensees. And, we are launching some studies that will add market value in specific areas as described above to make it faster or cheaper, so as to drive adoption of our technology.

The Federal Government will be able to help further this technology and benefit the Canadian industry. Several provinces have expressed interest in exhaustive surveys and because the technology is already useful for collecting many types of information, it would be useful to take on a veritable pan-Canadian survey project. This would generate emissions benchmarking across the Canadian industry, and provide comparison against US developments, where many oversight publications have been peer-reviewed in the past several years. There is no such benchmarking literature or data for Canadian developments, and this places us at a disadvantage. However, ExACT has the potential to move us ahead of this curve. While my lab has tried to put a patchwork of cross-Canada projects together over the past year, our coverage is still somewhat spatially limited. We need more coverage of natural gas producing regions, conventional oil, heavy oil (CHOPS), eastern Bakken, and coal bed methane. A survey program like this would require a year to collect statistically significant bottom-up datasets across developments and regions. Such surveys would help identify the low hanging fruit in all developments.

It particularly makes sense that the federal government would have a keen interest in benchmarking across the industry since the 45% CH_4 emissions reduction targets come down from the federal level. Other partners in this work could be the Petroleum Technology Alliance of Canada and/or Sustainable Development Technology Canada. We have an agreed-upon approach with the province of Alberta to carry out semi-exhaustive surveys across that province. Similar interest exists in Saskatchewan, and smaller oil and gas producing regions, like Manitoba and New Brunswick, should be included as well.

The federal involvement will be an important partner in this work, along with operators and provincial regulators. We hope that our research, and similar projects, will put us far ahead of the US and Mexico in terms of knowing how to lower emissions.

We would like to thank Natural Resources Canada for its support of a very stimulating project.