ecoENERGY Innovation Initiative

Research and Development Component

Public Report

Project: CCSE048

"Surface Containment Monitoring for Carbon Capture and Storage"

Contents

1 Project Snapshot

Project Title	Surface Containment Monitoring for Carbon Capture and Storage
Project Identification Number	CCSE048
Proponent	St. Francis Xavier University
Number of Participating Partners	8
Project Highlights	○ We developed a new platform emissions-detection technology that can be applied not only to CO_2-EOR seepage monitoring, but to rapid screening for any fugitive or vented emissions ○ Through outreach and add-on collaborative projects, we significantly increased the geographic scope and number of collaborators ○ We applied the technology in large regional emissions measurement campaigns in Saskatchewan for benefit of many government and industry stakeholders, and also conducted externally-funded mirror campaigns in other provinces and countries
Date submitted to NRCan	

2 Executive Summary

In the energy industry, sustainable development is now more important than ever. In partnership with the Saskatchewan Ministry of Environment, SESAA, Cenovus Energy Inc., and Altus Geomatics, we were able to develop and use our emissions detection technology in southeastern Saskatchewan, to take on oil and gas fugitive leak detection and monitoring challenges at a larger scale, and in a transparent and highly visible manner.

Based out of Nova Scotia and Saskatchewan, the project was broken up into two phases. The aims of Phase I were to produce clear recommendations for surface Monitoring Verification and Accounting (MVA), focusing particularly on techniques that could be applied on larger footprints and geographic scales. Phase II took advantage of a successful and award-winning truck-based mobile fugitive emissions technique that we developed early in the project. We used the system in Phase II to conduct regional surveys that could support clean development in a region that is under intense development pressure, improve environmental performance for operators participating in the work, and maximize opportunities for outreach and partnership. We were able to meet our overall objectives for the project.

In addition to meeting our project goals, regulators have been digesting information we have collected to understand fugitive and vented emissions patterns in their jurisdiction (as a function of type, age, and ownership of emitting infrastructure, etc.), which will help them pull appropriate policy levers to help meet new emission reduction targets. This project has had an important impact on the industry in terms of emissions measurement, which will lead the way to better management.

3 Introduction

The CCSE048 project ran in two phases. The first phase lasted from April 2012 to March 2015. The second "Enhancement" phase ran from April 2015 to March 2016. The project was based in Saskatchewan and Nova Scotia.

The project was initially structured around seepage detection at CO_2-Enhanced Oil Recovery (EOR) sites using large footprint (and convenient) detection techniques for Measurement, Monitoring, and Verification of CO_2 storage integrity. The project had inter-comparative research elements (comparison of technologies), and developmental elements (development of technologies). One important outcome of Phase I was the comparison of various different soil and groundwater tracer techniques for seepage detection. We found that certain tracers were clearly superior, and shared details and rationale in three publications that came out during the project (Risk et al. 2013, Nickerson and Risk 2013, Risk et al. 2015), all of which used the concept of signal-to-noise ratio (SNR).

But it was the developmental elements of our project that quickly surged. We had early successes in our development of a new truck-based platform monitoring technology that helped us quickly screen for emissions at large sites. This technology is similar to commercially-available vehicle-mounted systems, except that we are able to use our knowledge of tracers and gas ratios to greatly increase sensitivity, and to also understand which (or whose) specific sources are involved. The mobility of this monitoring system made it vastly superior to fixed Eddy Covariance and other techniques that we had started out using in the project that only measure about 1 km^2. While Eddy Covariance is technically a large footprint technology, the spatial scale of monitoring is not sufficient for a 215-km^2 development. Since our operator-collaborator was so keen on the potential of the mobile system, we prioritized its development and testing. The operator gave us both exhaustive feedback, and unfettered access to their operations for developmental purposes. At the same time we were able to teach them about their emissions patterns. This technology proved extremely successful as it was 1) fast and convenient, 2) not CO_2 specific but could be applied to any fugitive or vented emission, and 3) because industry and government very much threw their support behind it. In many cases were able to not only detect fugitive and vented emissions from the operator's operations, but neighbouring operators too – and to discriminate between emissions from operatory X or Y.

As discussed in the next section, the second "Enhancement" phase of the project took a broader view based on the outcomes of the first phase. The added breadth was both in terms of geography, and also in terms of emission type. We brought in additional partners who had regional interest, including the Southeastern Saskatchewan Airshed Association (SESSA), the

Saskatchewan Ministry of Environment, and Altus Geomatics who provided many useful datasets and in-field expertise. We conducted broad regional survey campaigns to understand fugitive emission patterns. The timeline for these surveys and data processing was compressed given the spatial scales involved, where we surveyed 8 blocks with a total area of 800 km^2, 6-8 times, over 2 seasons (summer, fall). These surveys brought us past several thousand wellpads, multiple times. Post Eco-Eii completion, we continued working on these results with other funding that we were able to secure. Results from these campaigns are now being shared with some of the project stakeholders. We have committed to share the results broadly at the American Geophysical Union Fall Meeting in San Francisco this December. Stakeholders, including NRCan, will have an opportunity to see the finalized results beforehand.

Subsequent to our first broad regional surveys in southeastern Saskatchewan, outside interest in the technology led us into work across the continent (and abroad). This project, which had started basically at one site in Saskatchewan in 2012, grew to be a multi-national initiative. We pulled in additional project partners and collaborators. By the end of the second phase of the project, and in part using parallel funding that we brought onboard as a consequence of Eco-Eii project outreach, we had used the technology with many operators and distribution companies. We also used the technology in projects of regional interest with government and non-governmental agencies including Saskatchewan Environment and Economy, Environment Canada, David Suzuki Foundation, the Southeastern Saskatchewan Airshed Association (SESAA), and others. We now also have cross-border initiatives underway with the US National Energy Technologies Laboratory at the Marcellus Shale Energy and Environmental Laboratory, and various partners in the UK. The technology was also successfully trialed in oil sands projects in a parallel 1-year Eco-Eii project that recently ended.

The success of our project, and technology development, is perhaps best illustrated by the fact we won awards for the technology during the course of the Eco-Eii project, including a Clean Air Leadership Award from Southeastern Saskatchewan Airshed Association (shared with Cenovus Energy Inc.), and an honourable mention for Best Oil and Gas Innovation of 2015 from Natural Resources Magazine (behind a new mining technology developed by the conglomerate Vale). We have also been able to secure follow-up funds from several sources, for specific research packages or to develop areas of application. The outcomes were vastly more positive than originally expected. We have only published one paper about our methods (Hurry et al. 2016), reflecting a much earlier variant, but more will follow. In part the publications have been delayed by the patent process, but as the patent application is now laid open we will be comfortable sharing more details of the algorithms.

NRCan Eco-Eii funding has allowed us to develop a technology that could augment current ones for the purposes of emission screening. ExACT helps reduce environmental impacts by allowing emissions of several types to be identified, characterized efficiently, and managed. Previously it was not feasible or cost effective to survey hundreds of wellpads in a development. The technology has excellent potential economic impact, and Canada has existing receptor capacity to see it succeed in the marketplace. From all facets, we have been extremely pleased with this project, and it has fit well with Canadian objectives for Science and Technology.

4 Background

Phase I of our project aimed to test signal-to-noise ratio (SNR) of various monitoring techniques used at Weyburn under the International Energy Agency Greenhouse Gas (IEAGHG) Weyburn-Midale Monitoring program, including soil gas sampling strategies (CO_2, $\delta^{13}CO_2$, $^{14}CO_2$), and soil surface CO_2 flux techniques, enhanced in some cases with biological modeling algorithms for noise reduction to enhance SNR. But in particular the operator had interests in large-footprint techniques, which hadn't really been applied under the IEAGHG Weyburn-Midale Monitoring program. This large-footprint 'gap' led directly to our development of the mobile fugitive emissions measurement platform.

Phase II (Enhancement) of our project originated because Southeastern Saskatchewan had matured a lot in terms of commercial CO_2 capture, pipelining, trading, and use. Infrastructure and pipelines were much more abundant than at the start of our initial project, yet were outside the phase I scope. Also, H_2S emission issues, including accidental deaths, had come to affect the region as oil and gas development has increased with the Bakken and EOR boom. In the background, there was also rising concern about the impact of methane from Bakken-style developments. The number of wells and drilling activities soared in the years 2011-2014 while our Phase I project was running. Since our technology was applicable to all problems simultaneously, Phase II aimed to generate broad regional understanding, for emissions of several gases, and with support of a larger regional stakeholder group including the local airshed association and the Saskatchewan government.

5 Objectives

5.1 Objective 1

The objective or our Phase I project was to produce clear recommendations for surface Monitoring Verification and Accounting (MVA). We accomplished this (as proposed) in several steps including:

Description: Data mining and re-interpretation of existing sources.

- *How we met the objective*: We took datasets from the IEAGHG project, but mainly the Kerr investigation where a broader array of seepage indicators were used, and re-analyzed these datasets with SNR in mind, to determine which soil gas and tracers would have been the most definitive had seepage ever been present.
- *Changes and rationale:* No substantive changes.
- *Impact:* We published three peer-reviewed papers providing clear guidance on what indicators to select, and how to select indicators (Risk et al. 2013, Nickerson and Risk 2013, Risk et al. 2015). These papers will help operators, but also will help regulators interpret the legitimacy of leakage claims. Based on the data we showed, the Kerr datasets should probably have not been treated seriously to begin with, because the indicators were flawed. These papers will help increase transparency, and set expectations. They might also result in smaller, less expensive, but more effective, surface and groundwater monitoring programs.

Description: Two year-round field experiments, one in Nova Scotia and one in Western Canada, to gather new data related to atmospheric MVA tools, done in differing ecotypes to characterize the noise component of signal-to-noise ratio (SNR).

- *How we met the objective*: We developed our mobile technique by regular measurement trials (and tweaks) in both geographic locales, and across all seasons. The differences in seasonal and topographical variation allowed us to develop an approach/ technology with applicability across all regions, and seasons.
- *Changes and rationale:* We had originally proposed to do this data collection with stationary instruments like Eddy Covariance. We did this in part, and do have some datasets for both regions that we hope to publish one day. But we focused much more of our fieldwork on the mobile technique because industry told us that it was of much higher utility and value to MVA.
- *Impact:* The technology we developed has value especially because it is applicable across regions, and all seasons. Some may remember that the Kerr investigations were delayed by months due to wet fields, which isn't acceptable response time. But in our project we eventually developed the capacity to map plumes in temperatures from -30^{o}C to +30^{o}C, on hills and on prairies.

Description: Ongoing development of new algorithms for SNR enhancement, for which we require the field data.

- *How we met the objective*: The new algorithm development was applied mainly to the mobile survey technique. These result in a roughly 10x higher plume detection sensitivity than commercial technologies, with fewer false positives. We can reliably detect plumes from a deviation in methane of only 10-100 ppb, which is well within the normal noise. The main consequence of improved sensitivity is that we can detect seeps or fugitive emissions from great distance (often km), which allows us to circulate very quickly within large developments to find emission sources.
- *Changes and rationale:* No substantial deviations. We did not originally expect that the algorithm development would be tied so closely to new technology development. But that combination worked very much to our favour because we developed something very unique and with high value.
- *Impact:* The algorithms that we developed form new IP, which were patented and which we hope to license to a Canadian company for use in oil and gas plume mapping (for emissions reduction).

The objectives of our Phase II project (Enhancement) included:

- *Description*: Conduct surveys to support clean development and improved environmental performance. Demonstrate our technology.
    - *How we met the objective:* We surveyed 8 areal blocks in SK with a total area of 800 km^2, 6-8 times, over 2 seasons (summer, fall). We passed several thousand well pads replicate times. We traveled well over 10,000 km, collecting over half a million near-surface concentrations for CH_4, H_2S, $\delta^{13}CH_4$, and CO_2.
    - *Changes and rationale:* No changes.
    - *Impact:* Preliminary interpretations from these surveys have already been provided to stakeholders. Based on feedback we will release final results over the coming months. They show fugitive and vented emission frequencies (portion of wellpads or infrastructure) in developed portions of the Bakken and Weyburn-Midale oilfields, and at the Aquistore CCS site. No CO_2 seeps were noted.

- *Description*: Conduct outreach.
    - *How we met the objective:* We workshopped our data and concepts with stakeholders in Canada and the UK.
    - *Changes and rationale:* While we originally envisioned workshops by invitation, held at a location of our choosing, we found that it was much easier to visit the offices of all our stakeholders, plus those of many others. Our quarterly reports document many such visits and in all we did many more workshops than originally expected to reach the envisioned audience. We also made several short vignette movies of a few minutes each related to the technique, and emission issues, so that we could create legacy communication resources that would extend beyond the life of the Eco-Eii funding (e.g. https://vimeo.com/166136164/a261b1f063). These movies will support our presentations in the future.
    - *Impact:* This outreach was largely responsible for the surge in interest in our technology. Not only did we increase value in the technology, we brought others onboard. These new partners added parallel funding, which resulted in surveys all across Canada, the US, and some work in the UK as well.

Overall we met our objectives for the project. This project will have an important impact on the energy industry because sustainable development is now more important than ever. With the recent Tri-Lateral agreement on CH_4 emissions reductions, and H_2S-related knock downs in many areas of Canada's energy industry, we are well positioned to provide operators with 1) indicators that work for the sites in question, 2) the capacity to quickly and cost-effectively scan large developments for toxic and/or greenhouse gas emissions. We can provide regulators with patterns and drivers of emissions, so that they can pull the right policy levers to meet the new targets. As a consequence of our outreach we are working with many operators, and energy policy departments/ministries in all western provinces. So, our approaches and expertise are reaching their targets effectively. We hope to commercialize the technology soon, so that it can be made available even more widely, and whatever Canadian firm takes it on will be able to see success across the continent, if not more broadly. Their success will benefit emission reduction strategies.

6 Results of Project

6.1 Project Achievements

6.1.1 Achievement 1 – ExACT Mobile Survey Technology

- Description: Truck-based analyzers and algorithms to map plumes and attribute them to specific sources on the landscape.
- Impact of Achievement: In the past 12 months we have performed over 100,000 km of driving two equipped trucks across Canada for/with about 25 energy sector partners – all of which originated from our Eco-Eii project. Demand for the technology, and data, continues to increase in light of new emission-reduction regulations. Thanks to Eco-Eii we are in the right place at the right time to provide information needed by operators and regulators.

6.1.2 Achievement 2 – MVA recommendations

- Description: Specifying gas survey indicators that actually work
- Impact of Achievement: Monitoring can get better, and allegations can be better judged. The Aquistore and Weyburn surface soil gas monitoring approaches now reflect the best practices that we have recommended in this project.

6.1.3 Achievement 3 – Regional technology application with partners

- Description: Through outreach we were able to build a unique stakeholder group consisting of government, operators, and non-governmental organizations.
- Impact of Achievement: All are interested in the data, and the energy-sector emission patterns that we were able to capture with ExACT. As a consequence we have entered into other parallel projects with these other partners. Already these new projects exceed the value of the original Eco-Eii project by at least 3 times.

6.2 Benefits

Every year, oil and gas developments worldwide emit more natural gas to the atmosphere than is produced by Norway's whole industry. These common gas leaks often go un-noticed, represent lost product, are potentially lethal, and also contribute to greenhouse warming. In Alberta alone, fugitive and vented gas emissions from the energy sector have the equivalent greenhouse impact of all personal vehicles in the province – times two. Regulations are tightening quickly, but locating leaks is still a challenge. We have developed a tool for efficient surveying of such emissions. Since their incidence is generally not well understood, ExACT can help manage emissions, and deliver substantial improvements. This will lead to a healthier environment, and will help us meet international greenhouse gas reduction targets. Additionally, new jobs will be created though ExACT commercialization. Ideally we would like to see our Tri-lateral obligations achieved in half the time (5 years, not 10) because of better data availability. This would result in millions of tons equivalent in greenhouse reduction.

Additionally, we have provided recommendations for surface monitoring of underground injection and storage of CO_2. Most national and international reports cite Carbon Capture, Utilization, and Storage (CCUS) as an important component of our low-carbon transition to new fuel types. Anything that can increase public acceptance of these projects, reduce threats, and increase monitoring effectiveness, all benefit the likelihood of project success.

Throughout this project, and our outreach, we have also worked with companies large and small across Canada, and provided them with opportunities and knowledge to increase their competitiveness.

Overall, because we developed the ExACT technology we were able to reach outside the confines of CCUS surface monitoring and into the broader energy sector. We demonstrated our ability able to tackle emissions monitoring projects, and issues, of broad relevance in the Canadian energy industry.

6.2.1 Benefit 1 – Streamlined CCUS Monitoring Programs

Simpler, more effective, and streamlined surface monitoring for CCUS benefits operators. This benefit was fully realized.

6.2.2 Benefit 2 – Understanding Emission Patterns and Incidence

Fugitive and vented emissions mapping for oil and gas (via ExACT technology) benefits operators and regulators alike. This benefit was realized, but there are more new patterns to be understood with further application of this technology. It should be applied at the provincial or national scale. If it were, we would have the knowledge to manage emissions better, and reduce them faster.

6.2.3 Benefit 3 – Internal Expertise

We developed significant new knowledge in this lab group, as did other project participants including Canadian companies and government. This benefit will pay dividends in future projects, where we are positioned well to help the industry.

6.2.4 Benefit 4 – Engagement

Throughout the project we were able to fluidly talk with operators, regulators, and non-governmental organizations. These groups often don't communicate with one another easily, but with transparent data as a currency, we are able to talk with all effortlessly. This benefit was fully realized, though it is possible we could assemble a low-emissions consortium for further work.

6.2.5 Benefit 5 – Supporting Sustainable Development

The new knowledge about emission patterns developed in this project benefits sustainable development of Canada's energy sector. This benefit will be realized in the future as our knowledge is applied. To some extent it is already being applied, for example in CCUS monitoring programs, or within energy companies when they commission surveys and immediately address problems that we identify. Both are helping reduce emissions from oil and gas, and CCUS, developments.

6.2.6 Benefit 6 – Knowledge application and export

We expect that our ExACT technology will be commercialized by a Canadian entity and also used elsewhere in the world, to the benefit of the Canadian economy. Additionally, other companies involved in this project have increased their level of knowledge, and therefore competitiveness.

6.3 Technology/Knowledge Development Objectives

The primary R&D objectives are described in section 5. They consisted of:

- Producing clear technical recommendations for surface Monitoring Verification and Accounting (MVA) for Carbon Capture, Utilization, and Storage (CCUS) sites.
- Conduct surveys to support clean development and improved environmental performance, which would also demonstrate our ExACT survey technology and bring us together with potential partners.

Our R&D Contributed to knowledge advancement in the following ways:

- We now have a better idea what makes a good surface MVA program, and how to do more effective monitoring with fewer geochemical indicators.
- We can expect to have reduced the potential for illegitimate leak allegations at CCUS sites, based on poorly chosen geochemical indicators.
- ExACT has helped operators to identify (and in some cases eliminate) emissions of gases in large developments. 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. By using ExACT within a leak detection and repair program, operators can take proactive action in reducing leakage, thereby reducing 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.

Impact on the energy industry in Canada and abroad:

- Our MVA recommendations have made their way into practice for both Weyburn and Boundary Dam/Aquistore, which is evidence that they have been well taken.
- Reducing or eliminating gas leaks will help operators protect Canadian groundwater, soils, and air.
- Our ExACT technology can 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.
- 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.
- 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.

.

Other than releasing the final results from the Eco-Eii final year surveys, we have several plans for the ExACT technology. These are documented in section 7.

6.4 Challenges and Barriers

6.4.1 Barrier/Challenge 1 – Technical Development of ExACT

- The ExACT project was very challenging, and consisted of enabling laboratory-grade instruments to perform across all weather conditions, plus developing numerous computer algorithms. The algorithms performed correction for ambient background levels, removed the influence of agricultural and other emissions, and performed geospatial attribution using wind speeds and direction. ExACT represents a very unique approach to collecting data in the lower atmosphere, and a complex platform technology. We overcame the barriers by training more people in the lab with computational tools, and working collaboratively.

6.5 Gender Based Analysis

For the purposes of government required statistics, please complete the following table describing how many full-time equivalent (FTE) positions were involved in the construction/delivery of the project and how many are involved in ongoing operations, including whether they are male or female:

Phase	Male	Female	Total
Project Planning/Construction/Delivery	2	1	3
Ongoing Operations	4	8	12
Total	6	9	15

7 Conclusion and Follow-up

The outcomes of this project include:

- Better techniques for surface Measurement, Verification, and Accounting at Carbon Capture, Utilization, and Storage projects. The improved techniques make monitoring cheaper and more effective, by cutting out the geochemical indicators of seepage considered "ambiguous", and prioritizing cost effective "definitive" indicators. As evidence of impact, the recommendations have been shared with the scientific and practitioner community, and successfully rolled into ongoing operations at Aquistore and Weyburn.
- A new technique for large-scale mapping of fugitive and vented emissions, called ExACT, which was developed somewhat before the recent interest in methane emissions reduction. So, we are well positioned for the future. Already as part of the Eco-Eii project several operators have used ExACT to understand their own emissions footprint across large (>50 km^2) developments, and to repair infrastructure that was determined to be anomalous – which has definitely already contributed to some emissions reduction. Also, regulators have been using information we have collected to understand fugitive and vented emissions patterns in their jurisdiction (age and ownership of emitting infrastructure, etc.), which will influence which policy levers they pull for emissions reduction.

Significance of outcomes:

- In both cases we have developed new approaches that improve emissions and containment monitoring, at CCUS sites, and across the energy industry. These new approaches can make Canadian operators more competitive, and generate opportunities within our environmental consulting industry (via commercialization).

Long-term outcomes:

- It is clearer that second-generation CCUS monitoring will be simpler and more effective, which improves the cost:benefit ratio of CCUS projects, which is one of the current barriers to wider implementation.
- We have a huge opportunity with ExACT to inform fugitive and vented emissions management across the Canadian industry. We would like to see ExACT help meet

targets faster (5 years instead of 10, for example), by providing clearer information on what is emitting, and what can/should be repaired.

7.1 Next Steps

Other than releasing the final results from the Eco-Eii final year surveys, we have several plans for the ExACT technology:

- *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.
- *Miniaturization*. Our ExACT approach consists of a computational filtering and interweaving of geochemistries and background corrections. The approach is equally applicable to UAV 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).
- *Development-specific geochemistries*. 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 in small fast projects is enhanced by this pre-existing knowledge. Therefore, it is important that we collect data in priority developments – basically for calibration and tuning of the measurement suite.
- *Fit with FLIR imaging cameras*. We are able to detect emissions from perhaps 100 times farther than a FLIR camera. But FLIR is still more useful for very up-close work. The spatial scale at which we pass off to FLIR has yet to be defined. Should we actually be doing full transits of wellpads, or is on-road detection is sufficient? We hope to perform FLIR inter-comparison tests, and we do have a camera arriving in the lab soon.

We have launched projects in all these areas. But, 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.

The Federal Government will be able to further help this technology and benefit the Canadian industry. Since 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 make sense for emissions benchmarking across the Canadian industry, and to compare against US developments for which many oversight publications have hit the peer-review literature in the past several years. We have no such benchmarking literature or data for Canadian developments, which puts us behind. However, ExACT has the potential to put us ahead. While we have tried to put a patchwork of cross-Canada projects together over the past year, our coverage is still somewhat limited. We need more coverage of natural gas producing regions, conventional oil, heavy oil (CHOPS), eastern Bakken, and coal bed methane. The survey program would probably take 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.

Particularly since the 45% CH_4 emissions reduction targets come down from the federal level, it makes sense that the federal government would have a keen interest in benchmarking across the industry. Other partners in this work could be the Petroleum Technology Alliance of Canada and/or Sustainable Development Technology Canada. We have already been talking with the province of Alberta about semi-exhaustive surveys across that province, and have an agreed-upon approach. There is definitely similar interest in Saskatchewan. And, we have already covered a good portion of British Columbia's operations to a level that is statistically significant and engaged the BC Oil and Gas Commission. And we should not forget about smaller oil and gas producing regions, like Manitoba and New Brunswick. Considering the events in Alberta this year, there is probably no funding for a large-scale survey initiative immediately. But, we will do some more new work in Alberta under the industry-funded Alberta Upstream Petroleum Research Fund (secured). Some relatively large-scale surveys may also go ahead in Saskatchewan, and things will become clearer later in the calendar year.

What is clear is that federal involvement and leadership could be extremely helpful in seeing our industry benchmarked properly from a ground-up perspective. It would put us far ahead of the US and Mexico in terms of knowing how to turn down emissions. Based on our ground experience, low-hanging fruit is abundant…and it could be formally characterized with a large-scale benchmarking effort to assist policymakers.

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

References cited in this report:

Hurry, J., Risk, D., Lavoie, M., Brooks, B.-G., Phillips, C.L., Göckede, M., 2016. Atmospheric monitoring and detection of fugitive emissions for Enhanced Oil Recovery. International Journal of Greenhouse Gas Control 45, 1–8. doi:10.1016/j.ijggc.2015.11.031

Risk, D., Lavoie, M., Nickerson, N., 2015. Using the Kerr investigations at Weyburn to screen geochemical tracers for near-surface detection and attribution of leakage at CCS/EOR sites. International Journal of Greenhouse Gas Control 35, 13–17.

Risk, D., McArthur, G., Nickerson, N., Phillips, C., Hart, C., Egan, J., Lavoie, M., 2013. Bulk and isotopic characterization of biogenic CO_2 sources and variability in the Weyburn injection area. International Journal of Greenhouse Gas Control 16, S263–S275.

Nickerson, N., Risk, D., 2013. Using subsurface CO_2 concentrations and isotopologues to identify CO_2 seepage from CCS/CO_2–EOR sites: a signal-to-noise based analysis. International Journal of Greenhouse Gas Control 14, 239–246.