CHOPS Methane Challenge Business Case

Sponsored by Alberta Innovates and Husky Energy Inc.

1.0 Program Overview

In December 2017, the Government of Alberta (GOA) published the Climate Change Innovation and Technology Framework (CCITF) as the overarching guide for the government's investments in innovation and technology to reduce greenhouse gas (GHG) emissions, while preparing our province for the lower carbon economy of tomorrow. Building upon the success of the Alberta Small Business Innovation and Research Initiative (ASBIRI) a dedicated Clean Technology Commercialization (CTCOM) program has been developed.

2.0 Challenge Overview

2.1. Background

Significant amounts of heavy oil are produced in Alberta using a method called Cold Heavy Oil Production with Sand (CHOPS). CHOPS involves deliberate and aggressive production of sand using Progressive Cavity Pumps, with main production zones generally between 1-5 meters thick. Some of the benefits of CHOPS includes a short time from drilling to production and lower drilling costs, while shortfalls include a short well life (5-6 years) resulting in higher depletion costs, a low recovery factor (~8%) and higher sustainment and operating costs.

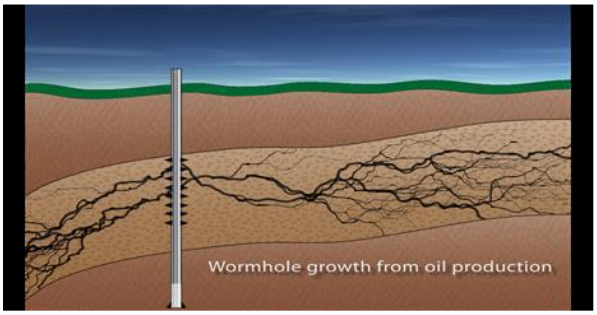

Fig. 1 Courtesy: Husky Energy

CHOPS typically produces accompanying solution gas due to agitation of the heavy oil in the formation in the production process, however recovery of this gas is not always economic. While the produced oil is deposited into a nearby tank and trucked away from the wellsite, recovery of the solution gas requires separate gas production infrastructure.

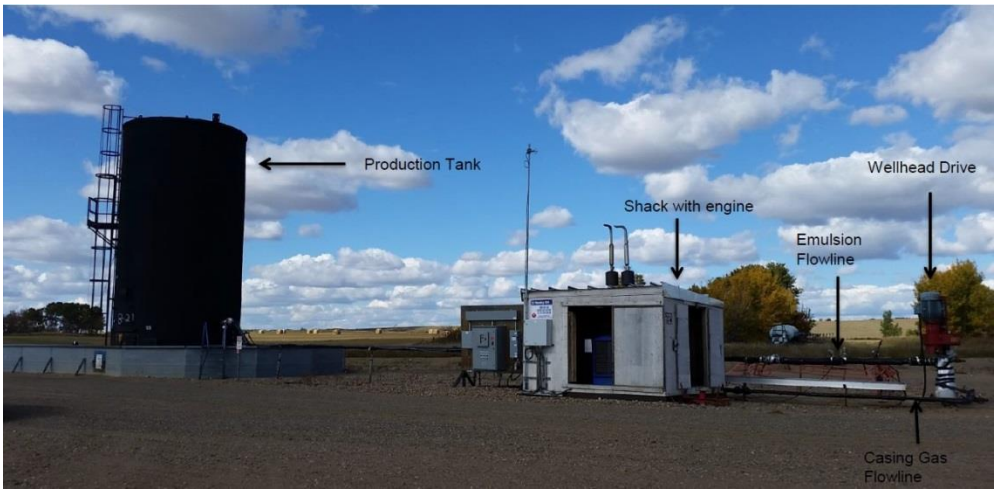

Fig. 2 Courtesy: Husky Energy

Depending on the volume (which in the short term can be sporadic and in the long term dynamic), location (possibly remote and isolated), quality, and other factors, the cost of solution gas recovery may exceed revenue from gas sales. These same factors lead to practical challenges measuring vented gas: cost & reliability. A meter sized for gas flow measured early in a well's life may not be useful 6 months later when rates could be drastically different. Free liquids present in solution gas complicate measurement, usually leading to higher equipment and maintenance costs.

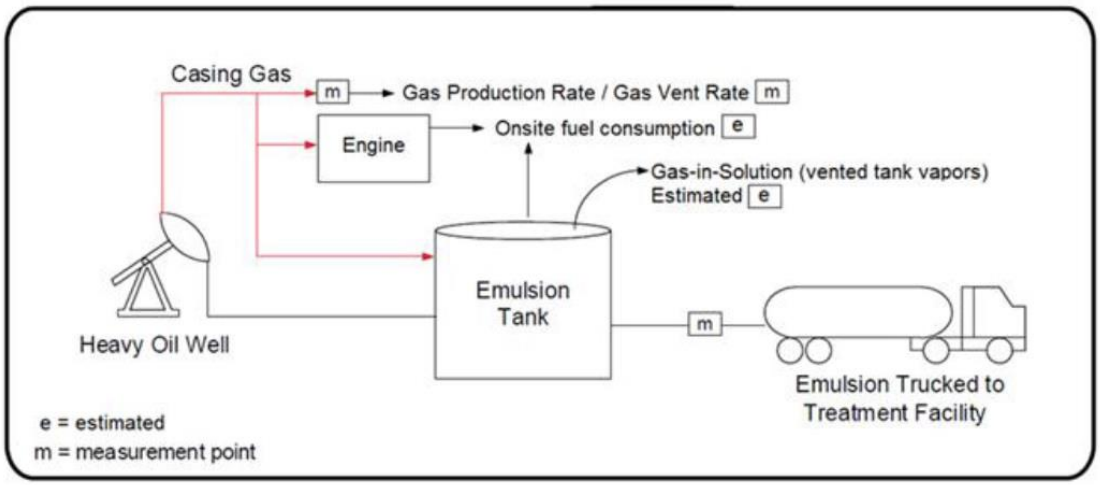

Fig. 3 Courtesy: Husky Energy

Current requirements for managing CHOPS gas emissions are provided by the Alberta Energy Regulator (AER) under Directive 17, which outlines measurement requirements, and Directive 60, which requires that vented casing gas is recovered when:

1. The gas volume is greater than 900 m3 /day per site and the conservation opportunity is deemed economic based on specific economic criteria;

2. The gas to oil ratio (GOR) is greater than 3000 m3 /m3;

3. A flare or incinerator is within 500 meters of a residence and the gas volume exceeds 900 m3 /day;

4. The AER requests that the gas is conserved, which is defined by the AER as recovery of produced gas for use as fuel for production facilities, for other useful purposes (e.g., power generation), for sale, or for beneficial injection into an oil or gas pool (e.g., pressure maintenance, enhanced oil recovery).

If the solution gas is not recovered, it is deemed waste gas and combusted (flared or incinerated) or vented depending on volumes. Generally speaking, gas volume over 500 m3/ day may not be vented and must be combusted or conserved, however the large majority of wells produce below this amount. Flaring, which is the most common method of combustion, is costly and often undesirable in the public eye. Combustion also requires relatively stable and sufficient volumes. For these reasons, CHOPS operations typically vent gas at a higher intensity than other methods of oil production in the province. The primary constituent of solution gas is methane, which carries a Global Warming Potential (GWP) 25 times that of carbon dioxide (CO2) over a 100 year period (and 72 times over a 20 year period). Alberta's oil and gas sector produces over 31.4 megatonnes of carbon dioxide equivalent (MMTC02e) of methane annually, which accounts for about 70% of the province's total methane emissions. In turn, about half of this amount is from venting.

Approximately 80% of vented volumes in Alberta take place in the Bonnyville and Wainwright regions and are related to cold heavy oil production (AER Upstream Petroleum Industry Flaring and Venting Report ST60B-2015). Federal and provincial governments and regulators are finalizing plans to implement carbon taxes and reduce methane emissions from the oil & gas sector. There are opportunities for significant and material reductions to Husky's and Alberta's GHG emissions by addressing vented solution gas, in the order of millions of tonnes of carbon dioxide equivalent.

Under the Climate Leadership Plan, the Government of Alberta will require reductions in methane emissions of 40-45 percent below 2014 levels by 2025, with regulations limiting vented methane to come into effect in 2023. New regulations are expected to be released in the near future by the AER. The Federal Government is expected to mandate similar reductions.

Heavy oil deposits through Alberta and Saskatchewan are in the range of 55 billion barrels in place with Alberta holding around one third of that total. The challenge is to reduce the environmental impact from production without becoming cost prohibitive. This would allow continued production and benefits to Alberta at the same time as aligning with Alberta's Climate Leadership Plan and reducing Husky's GHG intensity.

The proposed financial contributions towards this Challenge are as follows:

Organization	Contribution Framework
Alberta Innovates	Up to $1,000,000
Husky Energy	Up to $500,000

2.2. Technology Solution Characteristics

This challenge encompasses two distinct but complementary technology streams, the first targeting accurate **measurement** of vented casing gas and the second targeting **management** of surface casing vent gas and tank gas. The ideal technological solution would be able to both quantify the amount of vented methane while simultaneously reducing the impact of vented methane over and above existing methane management solutions (i.e., flaring and/or pipeline collection) as part of an integrated package. While integrated systems are preferable, they are not required.

Overall, solutions must:

- Be economically viable;

- Inflict a minimal footprint (i.e., not requiring additional land-leasing);
- Retain full functionality in extreme cold weather (less than -35 degrees Celsius);
- Be capable of communicating with existing SCADA systems.

Stream 1: Measurement

For the quantification component, solutions must also be capable of:

- Handling free liquids entrained in solution gas with minimal maintenance requirements;
- Quantifying a wide range of volumetric flow rates that fit the proposed regulatory limits (vented gas over 160m3 – 500m3/day).
- Providing relevant real-time data collection and analysis.

Stream 2: Management

For the alternative methane management component, solutions must also be capable of:

- Adapting to varying gas volumes and quality;
- Substantially reducing or eliminating target methane emissions;
- Operating without the need for a continuously fueled pilot;

Ideally, the solution would capture waste stream so it can be used as a beneficial product.

There is a preference towards technology solutions that are demonstration ready (Technology Readiness Levels 7 through 9). However, new methane venting regulations are not finalized and are not expected to be enacted immediately and so earlier-stage solutions would be considered, but weighed against anticipated time to market. This also includes technology transfer opportunities, whereby the technology was developed at an Alberta research institution and is available for license to the applicant.

2.3. Desired Impact

The CTCOM program is designed to deliver a meaningful, timely, and sustainable return on investment to the Province of Alberta. Therefore, the desired impacts of this Challenge are four-fold:

- ✓ Sustainable and measurable growth of competitive Alberta SMEs into the global market;
- ✓ Increased employment and retention of highly qualified personnel in the Province of Alberta;
- ✓ Significant, measurable and sustainable reduction of vented methane emissions from CHOPS;
- ✓ Enhanced global competitiveness and reputation of Alberta's energy resource sector.

The Alberta oil & gas industry produces methane emissions of approximately 31.4 MMTC02e per year (2014), which accounts for 70% of total provincial methane emissions and 25% of all C02e emissions from the upstream oil & gas sector. 48% of these methane emissions, or 15 MMTC02e, are from venting, with 6% from flaring or other sources and the remaining 46% from fugitive emissions or leaks.[1] As 95% of natural gas is methane, the vented emissions translate to approximately $100 million USD of lost revenues per year in Alberta alone, or $80 million USD per year for CHOPS.

The Challenge's potential quantitative impact on methane emissions is 12 MMTC02e based on the above emissions figures; however this would assume attainment of 100% effectiveness and market adoption.

[1] https://www.alberta.ca/climate-methane-emissions.aspx

3.0 Market Assessment

Because of the economic opportunities alongside the upcoming regulative framework at the provincial and federal levels, more companies are entering the methane emissions management market and more jobs are anticipated. According to MELA, of the over 170 companies in Canada that provide methane management solutions, 80% anticipate job growth in the next 12-18 months and three quarters of these companies have offices in Alberta (about half are headquartered in Alberta). Half of these companies are technology solution providers and the majority are considered SMEs.

There are roughly 10,000 CHOPS wells between Alberta and Saskatchewan, with production mostly concentrated amongst four companies – Husky Energy, CNRL, Devon Energy and Black Pearl Resources. There is very little foreign production, although CHOPS has been used with some success in China. The challenge with measuring and reducing vented casing gas from CHOPS production is that a system must be able to deal with low and intermittent flow volumes, combined with (typically) a lack of external power source and a wet gas stream causes issues in freezing temperatures. Thus, technologies that have been successfully deployed in other applications may not work given the unique considerations of CHOPS. However, if a technology is successfully deployed to address CHOPS emissions, it may be relevant to other upstream emissions sources.

3.1. Vented Methane Measurement Technologies

Measurement requirements in Alberta of vented gas emissions are outlined under the AER's Directive 17. The current accepted practice for measuring vented casing gas from CHOP sites is a GOR kit (Gas-to-Oil Ratio), which factors vent, fuel and tank vapor volumes as well as oil production (as the denominator). Minimum GOR testing frequency is based on the gas productivity rate – higher gas productivity requires more frequent testing, with continuous testing required on large emitting wells.

Wet casing and tank gas, variable and intermittent flow rates and locality (requires manual data collection) remain as obstacles for cost-effective, accurate and timely reporting. While a suitable technology may exist, none have yet been found and properly field tested. This not only impacts a producer's ability to meet regulatory requirements, but also to provide sufficient data verification for carbon offsets, tax calculations, fuel chargeback (for conservation) and royalty payments.

3.2. Methane Reduction Technologies

The two primary options for CHOPS gas conservation are compressors and separators. A compressor (combined with a dryer) will compress the gas and discharge it at a higher pressure in order to feed into a dry fuel gas network. Separators remove some of the entrained water from the gas, but do not serve to pressurize the gas. In order for a separator to be installed, the well must have sufficient casing pressure to get into the natural gas network. In order to install either of these options, the well must be tied into a fuel gas or natural gas system. As such, conservation is not always feasible due to proximity and systems limitations. For sites where conservation is not feasible, incinerators or flares are used, which is what this Challenge hopes to address and improve, if not replace.

The same operational challenges for effective methane measurement exist for reduction. Once again, these include wet casing and tank gas, variable flow rates and locality. If the gas is used as a fuel, the lines need to be heat traced and insulated to prevent freezing.

4.0 Industry Sponsor Overview

4.1. Husky Energy

Husky Energy Inc. is an integrated energy company, headquartered in Calgary, Alberta. Its common shares are publicly traded on the Toronto Stock Exchange under the symbol HSE. The Company operates in Canada, the United States and the Asia Pacific Region, with Upstream and Downstream business segments.

Husky has two core businesses. Its Integrated Corridor operates in Western Canada and the United States, where production is integrated with the Downstream business. Offshore the Company is focused in the Asia Pacific and Atlantic Regions.

4.2. Emissions Management Leadership

Husky addresses local and regional air quality and assesses equipment and facilities to seek ways to mitigate climate-related impacts.

Husky continues to focus on emission reduction activities, including capturing carbon dioxide (CO_2), minimizing fugitive emissions and managing flaring and venting activities, as well as reducing its energy consumption.

Carbon dioxide is captured at the Lloydminster Ethanol Plant to aid in enhanced oil recovery (EOR), which involves CO_2 being injected into reservoirs to increase oil production. The plant captures up to 250 tonnes a day of CO_2, with more than 225,000 tonnes used for EOR in heavy oil fields between 2012 and December 2015. About 30 tonnes of CO_2 a day are captured in an initial pilot project at the Pikes Peak South Lloyd Thermal Project for use in EOR. The Company is evaluating additional technologies.

The Company measures and reports emissions of greenhouse gases (GHGs) and criteria air contaminants, such as sulphur dioxide (SO_2) and nitrogen oxides. This provides an opportunity to forecast and evaluate reported emissions at the corporate and individual facility level.

Air quality and carbon management programs achieve regulatory compliance and are supported by Husky's Environmental Performance Reporting System, providing for transparency and consistent data.

Year-over-year improvement on its Carbon Disclosure Program (CDP) score led to Husky's inclusion on the Canadian Climate Disclosure Leadership Index. Its 2017 score of B reflects how the Company measures, discloses, manages and shares carbon and climate information.

5.0 Service Providers

Petroleum Technology Alliance Canada (PTAC)

PTAC Petroleum Technology Alliance Canada is a Canadian hydrocarbon industry association that serves as a neutral non-profit facilitator of collaborative R&D and technology development, and operates in partnership with all industry stakeholders to transform challenges into opportunities. By effectively leveraging financial resources and technical expertise through our proven model, PTAC has been able to support collaborative networks which advance innovative

R&D and technology development projects, that address pertinent industry challenges through activities which reduce costs, improve operational efficiencies, enhance environmental stewardship, increase reserves, production rate, and value added opportunities, advance regulatory development, and provide our industry with the social licence to operate.

By way of a contractual relationship, PTAC will provide marketing and technical support to the Challenge, including technical vetting of applicants and project facilitation, coordination, and management. Their primary contribution will be through their access to the Centre for Demonstration of Emissions Reduction (CeDER) mobile platform for field-scale testing of emissions reduction and capture technologies. They will also be involved in promoting the Challenge within their network as well as the applicant selection process by way of providing market awareness and conducting technical due diligence based on submissions. While marketing support will be provided pro bono, technical services and project facilitation, coordination, and management will be charged to the Challenge budget on a fee-for-service basis.

6.0 Process

6.1. Challenge Stages

The application process for this Challenge will take place in three stages:

Stage I: Opportunity Identification

This stage is open to the public and will require Applicants to submit an Expression Of Interest (EOI). The EOI will be used to assess and identify opportunities that align with the challenge, have a clear competitive advantage, have a viable path to market and will have a significant impact in Alberta within a reasonable timeframe.

Challenge Stream must be identified in the EOI (Measurement and/or Management).

Stage II: Corporate and Capital Readiness

This stage is by invitation only, with successful participants selected from Stage 1. Applicants will be required to submit their up-to-date year-end financial statements, a 5-year financial forecast and a basic business plan.

Stage III: Go-to-Market Plan

This stage is by invitation only, with successful participants selected from Stage 2. Applicants will be required to submit a proposal outlining the development/demonstration of their technology in collaboration with the appropriate partners, including academia or other industry, as well as letters of support (if applicable).

6.2. Evaluation Criteria

The scope of this challenge is focused on supporting the development and demonstration of viable near-market technology solutions for the measurement and management of CHOPS vented gas emissions that meet or exceed

existing and anticipated regulations. The solution provider must be a qualified Alberta SME and should have the capability of supporting their product through its lifetime (design, parts, maintenance, training, etc.) as well as experience in the Canadian oil and gas industry. Broadly, the evaluation criteria will focus on the opportunity, potential impact, and feasibility:

- ✓ The Opportunity.
  - **Market.** The optimal solution and provider will be strongly positioned to address a clearly characterized and quantifiable market that is significant both in Alberta and globally.
  - **Technology.** The optimal solution will be sufficiently developed to ensure a timeline to field demonstration of less than 1 year.
  - **Business.** The optimal solution will be commercialized by an Alberta SME with the experience, expertise, planning and financial resources to realize the potential of the technology as well as the capacity to support the product through its lifetime (design, parts, maintenance, training, etc.).
- ✓ The Impact.
  - **Alberta.** The impact to Alberta will need to be significant, measurable and timely. This impact may be related to social well-being and/or economic development through new venture creation, manufacturing facilities and/or direct supply-chain growth and maturation.
  - **SME.** Growth is expected in the form of increased revenue, new export market/customer acquisition, recruitment and retention of highly skilled workers, and follow-on investment.
  - **Environment.** Technology opportunities must provide sufficient GHG reductions to meet or preferably surpass pending regulations to ultimately enhance the sustainability of Alberta's environment.
- ✓ Project Feasibility.
  - **Outcomes.** The project must be outcome-focused with appropriate milestones, timelines, and resource allocations.
  - **Support.** The project must have the appropriate supports in place, including partners and financing needed to ensure success.

Key Performance Indicators (KPI) of the solution include:

Stream 1: Measurement:

- Volumetric capacity
- Power requirements
- Gas quality requirements including liquids
- Measurement accuracy
- Calibration requirements
- Data management
- Life cycle costs

Stream 2: Management:

- Volumetric capacity
- Gas quality requirements: allowable concentrations of methane, carbon dioxide, hydrogen sulfide
- Footprint: mass, height & diameter, volume
- Fuel requirements & expected waste streams
- Support logistics and full life cycle costs
- Spacing requirements