EXECUTIVE SUMMARY

In September 2021 the University of Waterloo (UW), Arolytics, Inc., and Carbon Management Canada (CMC) commenced a 3-year study to assess the potential of existing and emerging technologies for measuring methane emissions from upstream oil and gas sources, and develop uncertainties for these estimates.

Research commenced with a review of available technologies, which were categorized according to operating principle and applicability to various emission measurement scenarios. Manufacturer-specified performance characteristics were also summarized and tabulated. Based on these results, a subset of technologies was selected for detailed analysis: quantitative optical gas imaging (QOGI); truck-, drone-, and aircraft-based tunable diode laser-absorption spectroscopy (TDLAS); and aircraft-based near-wavelength and long-wavelength hyperspectral (HS) imaging.

This activity was followed by a more detailed assessment of the technologies. This was done in two ways: First, Monte Carlo simulations were performed using AroFEMP to calculate the expected reduction in methane emissions were the technologies incorporated into an alternative fugitive emissions management plan (alt-FEMP), relative to a standard OGI-based FEMP. Second, a laboratory-scale experimental study was carried out using QOGI cameras on a heated vent of methane to better understand the operating principles, characteristics, and capabilities of this technology.

The technologies were then deployed in three controlled-release field campaigns at CMC's field station in Newall County, Alberta[1]. The controlled releases were "semi-blind", meaning that the technology providers and operators knew the release locations, but not the release rates. A variety of measurement scenarios were considered, including stacks of various heights and an unlit flare; emissions from the top of a tank; and emissions from the side of a shed. The results highlighted how quantification accuracy was influenced by release rate, release scenario, and various environmental parameters (e.g., wind, ground temperature, and air temperature).

The final research phase is focused on developing techniques for quantifying the uncertainty attached to emission estimates. Uncertainty arises from a variety of sources, including measurement noise; uncertain model parameters (e.g., wind speed, air temperature); and structural errors caused by the approximations and simplifications made when deriving the measurement models. These errors introduce bias and variability in the estimates.

Two approaches have been developed to quantify uncertainty estimates, both based on Bayesian inference. The first approach is based on propagating measurement noise, model parameter uncertainty, and model error through the measurement equations. This approach focused on the truck based TLDAS system since the measurement equations (inverse Gaussian plume model) are straightforward and easy-to-use. In many cases, however, the model equations are highly complex and/or unavailable to a third-party operator. For this scenario, a second technique was developed that uses a set of controlled release measurements to develop an empirical likelihood model, which may be inverted to obtain uncertainties from subsequent measurements using the same technology. Finally, these models are being incorporated into a Monte Carlo simulation of an alt-FEMP, to assess the uncertainty attached to performance estimates for various methane emission management plans.

[1] While the Bridger GML was included in the analysis, they were unable to participate in field trials.