# Investigation of the characteristics of ultrafine particles for improved PM emission factor reporting for flares

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GL 13-AU-ARPC-03

Flaring is often used in the energy and petrochemical sectors to dispose of unwanted flammable gases. Flaring is preferred to simply venting the gases since the global warming potential of CO2 is much lower than that of methane (IPCC, 2007). The United States Energy Information Administration estimated that 122 billion m3 of gas was flared or vented worldwide in 2008 (US Energy Information Administration, 2011), while in Alberta approximately 1.14 billion m3 was flared or vented in the upstream sector in 2008 (Johnson and Coderre, 2011). Particulate matter, a by-product of flaring, has received considerable attention because it can have an effect on human health and earth’s climate. However, potential effects are highly dependent on the particle size, shape (morphology), and chemical composition.

Accurate particulate matter (PM) size distribution and morphology data for flares are simply unavailable because of the challenges associated with effectively collecting particulates for online measurement or sampling. In order to improve PM emission factor estimates, two different methods are currently being explored. Firstly, a large-scale laboratory flare is being constructed at Carleton University, which will have similar combustion characteristics as flares used in the Canadian upstream oil and gas industry, but will allow for research in a controlled environment.Secondly, a remote sensing technique call sky-LOSA (line-of-sight attenuation) is being developed and tested to measure PM emission rates for flares in the field. The proposed research is intended to bring these two approaches together.

Detailed ultra-fine particulate measurements will be conducted on the large-scale flare at Carleton to better understand the size, morphology, and chemical composition of flare-generated particles. These data are needed to address key knowledge gaps identified by the PTAC steering committee with respect to ultra-fine particulate emissions in the upstream oil and gas industry. In addition, results will specifically enable improvements to the sky-LOSA technique so that more
accurate field measurements can be made in the future. Lastly, the data generated by this study can also be used to provide critical flare-generated particle properties required for other applications including

calculation of particle transport and dispersion in the atmosphere and modeling of the global warming and/or cooling potential of particles emitted by flares.

This research will address three policy issues: 1) Improving air emissions inventories through improved emissions factors and reporting methodologies; 2) Identification and estimation of sources of emission for substances of concern; and 3) Understanding the relationship between source emissions and ambient air concentrations. The first two issues will be addressed by improving the sky-LOSA technique by reducing the uncertainty in parameters that are used in its model, and quantifying the contributions of ultra-fine PM. The third issue will be addressed by providing particle properties that can be used in particle transport and dispersion models.

**Policy Issue**
Identification and estimation of sources of emission for substances of concern. Air quality objectives are continuously being reviewed and updated. To determine the impact of such policy changes, it is important for industry to understand the contribution UOG facilities have to the substances being reviewed. For example, as part of AENV ambient air quality objectives process, a list of priority substances have been put forward for review.

**Knowledge Gap**

Ambient Air Quality Objectives are routinely reviewed and revised. Future compounds of potential interest include:

- Mercury
- Ultrafine particulate matter
- Para-cresol
- Radionuclides
- PCB’s

  Source identification and quantification of these compounds at Upstream Oil and Gas Facilities is required

Final Report