2017 Canadian GHG Emission Reductions Forum

Advancing the Low Carbon Economy Through Innovation and R&D

October 23, 2017 | Calgary Petroleum Club

Calgary, Alberta

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

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Forum Proceedings

8:00 AM		**Registration and Breakfast** *Brought to you by Black Gold Rush Industries*
8:20 AM		**Opening Remarks – Advancing the Low Carbon Economy Through Innovation and R&D** Soheil Asgarpour – President, PTAC Petroleum Technology Alliance Canada
8:30 AM		**Session 1: Panel – Advancing the Low Carbon Economy** *Advancing to a clean, low carbon resource economy offers Canada significant business, economic, and social opportunities, but how do we get there? This panel will take a closer look at the challenges currently facing the Canadian oil and gas industry in achieving a low carbon economy, and the opportunities for growth which lie ahead.* **Panel Chair: David Collyer -** Previous President and CEO, Canadian Association of Petroleum Producers, and Previous President and Country Chair, Shell Canada **Panelists:**
		Richard Dunn - Vice-President, Regulatory and Government Relations Canada, Encana Corporation
		Craig Stenhouse - Manager Technology Development, Cenovus Energy
		Cecile Siewe - Director General – CanmetENERGY Devon, Natural Resources Canada
		Mark Taylor - Executive Vice-President Operations Division, Alberta Energy Regulator
		Patrick McDonald - Director Climate and Innovation, Canadian Association of Petroleum Producers
10:00 AM		**COFFEE BREAK**
10:15 AM		**Session 2: Creating Sustainable Value – Transforming Emissions Challenges into Opportunities** *This session will focus on the Alberta Upstream Petroleum Research Fund's current air and emissions initiatives which have informed regulatory development, established best practices, and reduced the environmental footprint while lowering costs for all industry stakeholders.* **Speakers:**
	10:15 AM	**Randy Dobko** - Senior Source Standards Engineer, Alberta Environment and Parks *AUPRF Air Research Planning Committee Overview*
	10:20 AM	**Erica Emery** - Research Engineer, Saskatchewan Research Council *Technologies for the Mitigation of Low Volume Methane Emissions*
	10:40 AM	**Mike D'Antoni** - Vice President, GreenPath Energy *Leak Detection and Repair Baseline*
	11:00 AM	**Elizabeth O'Connell** - Fugitive Emissions Researcher, St. Francis Xavier University *Vehicle-Based Fugitive Emission Detection and Attribution within Alberta Energy Developments*
	11:20 AM	**Matthew Johnson** - Network Director, FlareNet *Flare Emissions from Unconventional Oil and Gas Extraction and Processing: An NSERC Strategic Network for Cleaner Fossil Fuels*

11:45 AM	**LUNCH** *Brought to you by the University of Calgary*	
12:45 PM	**Session 3: Accelerating the Innovation Agenda** *The Canadian oil and gas sector is currently cultivating an innovation eco-system through the development of disruptive technologies which reduce GHG emissions. This session will focus on the mechanisms currently in place to help technology providers successfully develop and deploy their technology solutions, and also take a closer look at the gaps that need to be filled in terms of technology innovation and execution.* **Speakers:**	
	12:50 PM	**Wayne Hillier** - Manager Alberta Operations, Canadian Association of Petroleum Producers *Roadmapping Methane Reductions*
	1:10 PM	**Steve MacDonald** - CEO, Emissions Reductions Alberta *Implementing Complete Solutions*
	1:30 PM	**Joseph King** - Program Director, Advanced Research Projects Agency – Energy, United States Department of Energy *U.S. DOE's Monitor Technology Development Program*
	1:50 PM	**Peter Garrett** - President, Innovate Calgary
	2:10 PM	**Gordon Lambert** - GRL Collaboration for Sustainability Inc. *Accelerating Energy Innovation and Technology Cycle Time: Barriers and Opportunities*
	2:30 PM	**Mike Crabtree** - Vice-President Energy, Saskatchewan Research Council *Getting New Technology Into the Field*
2:50 PM	**COFFEE BREAK**	
3:00 PM	**Session 4: Innovation At Work** *Efforts are underway at PTAC to launch dozens of technology projects alongside our partners, which will help guide industry towards the 45% reduction targets set to be achieved by 2025, and will further contribute to reduced energy consumption and low carbon production. This session will take a closer look at some of these technology project initiatives, expanding upon the potential impacts these innovative solutions will have on current and future industry operations.* **Speakers:**	
	3:00 PM	**Sean Hiebert** - Team Lead Operations Energy Efficiency, Cenovus Energy *Overview of the PTAC TEREE Committee and its Current Initiatives*
	3:10 PM	**Dean Jenkins** - Manager Government Relations, Encana Corporation *Advanced Methane Measurements Using Novel Ground-Based and UAV-Based Sensors*
	3:30 PM	**Cooper Robinson** - Managing Director, Cap-Op Energy *Methane Abatement Projects Platform (MAPP) Phase 2 - Analytics*
	3:50 PM	**Laura Chutney** - Managing Partner, Process Ecology *Energy and Emissions Reduction from a Gas Dehydrator using the GasPro VRU*
4:10 PM	**Closing Remarks**	
4:15 PM	**Networking Reception** *Brought to you by TSGI Corporation* **Student Poster Session** *Brought to you by FlareNet, Carleton University, the University of Alberta, the University of British Columbia, the University of Waterloo, and Western University*	

2017 Canadian GHG Emission Reductions Forum
- Advancing the Low Carbon Economy Through Innovation and R&D -

Evaluation and Feedback Form

Name: ______________________ Company: ______________________

1. a) Did this Forum meet your objectives? ☐ Yes ☐ No
   b) If you responded no, please comment below.

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2. Which presentations did you find most valuable?

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3. What topics do you suggest being covered at future PTAC Forums?

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4. a) Are there any knowledge gaps that have not been addressed?

   ☐ Yes ☐ No

   b) If you responded yes, please list and let us know whether you see a need or have an idea for a future collaborative project:

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5. How did you hear about this forum?

   ☐ PTAC Email ☐ PTAC Website ☐ Another company newsletter
   ☐ Word of Mouth ☐ Twitter/LinkedIn ☐ Other (please list)

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6. General comments/suggestions:

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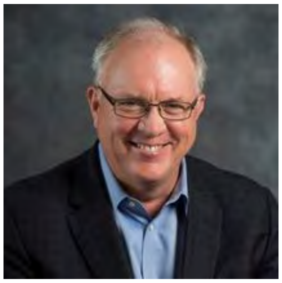
7. Would you like to receive electronic notifications from PTAC regarding upcoming forums, workshops, technical information sessions, RFPs, and other important messages?

   ☐ YES Email: ______________________

Session 1: Panel – Advancing the Low Carbon Economy

Panel Biographies



David Collyer - Previous President and CEO, Canadian Association of Petroleum Producers, and Previous President and Country Chair, Shell Canada

Dave Collyer is an experienced strategic and operational leader in the Canadian energy sector, with a strong focus on integration of technical, economic and public policy considerations in business decision-making. He currently provides consulting services to the Canadian energy sector and serves on a number of not-for-profit and corporate boards.

Mr. Collyer was President and CEO of the Canadian Association of Petroleum Producers (CAPP) from September 2008 until December 2014. In this capacity, he was responsible for leading CAPP's activities in education, communication and engagement, and policy / regulatory advocacy. Prior to joining CAPP, Dave Collyer was President and Country Chair for Shell in Canada. During his thirty-year career with Shell, Mr. Collyer held a broad range of technical, business, marketing, and senior leadership roles. He also participated in a two-year Executive Exchange assignment with the federal government in Ottawa (1989 to 1991) as Director, Supply Branch at the National Energy Board.

Dave Collyer holds a Bachelor of Science in Mineral Engineering specializing in Petroleum Engineering and a Masters of Business Administration, both from the University of Alberta.

Richard Dunn - Vice-President Canadian Government Relations, Encana Corporation

Richard joined one of Encana's predecessor companies in 1986, where he held various technical and leadership positions. Since the formation of Encana in 2002, Richard has been significantly involved with the formulation and implementation of strategies which have stimulated increases in Canadian oil and natural gas activity.

Richard completed his undergraduate studies in Mechanical Engineering at the University of British Columbia, and obtained his Masters in Chemical and Petroleum Engineering from the University of Calgary.

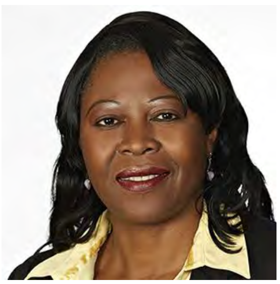
Richard serves on several executive committees and boards, including the Business Council of British Columbia's Executive Committee and Board of Governors as well as the Canadian Chamber of Commerce and Geoscience BC's Board of Directors. He also serves on the University of Calgary's Senate and actively supports Calgary's community and public education band programs.

Craig Stenhouse - Manager Technology Development, Cenovus Energy

As Manager, Technology Development, Craig is responsible for representing Cenovus at Canada's Oil Sands Innovation Alliance (COSIA). The guiding principle for COSIA is that all members will have greater success by collaborating on environmental innovation than through our individual efforts. As Chair of COSIA's Shareholder Steering Committee, Craig works with COSIA's Chief Executive and other member companies to develop and guide the long term, strategic oversight of COSIA.

Craig joined Cenovus's predecessor company in 2006 in the field of Corporate Responsibility, where he created and implemented Cenovus's Corporate Responsibility policy and external reporting, engaged with stakeholders, and advanced ethical business practices. His career over the past 15 years has focused on advancing the environmental and socio-economic performance of extractive industry companies.

Craig has provided strategic advice to a number of international companies, including Nexen, Canadian Natural Resources, Talisman Energy, Encana Corporation, ConocoPhillips Canada, Cameco, Marks & Spencer, Premier Oil, De Beers Diamond Trading Company, DHL and British American Tobacco. Craig holds a Master of Science degree from the London School of Economics and Political Science.

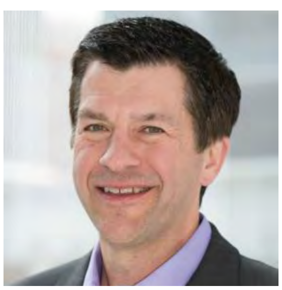


Cecile Siewe - Director General of CanmetENERGY-Devon, Natural Resources Canada

Cécile Siewe was appointed Director General of CanmetENERGY-Devon, Innovation and Energy Technology Sector, at Natural Resources Canada (NRCan) in May 2016. She is responsible for the management and direction of the Devon-based components of NRCan's CanmetENERGY research and technology innovation programs; and provides national leadership for the fossil fuel portfolio to drive sustainable energy development and use, and the mitigation of related environmental impacts with particular emphasis on unconventional oil and gas.

Prior to her appointment, Dr. Siewe worked in the private sector in the oil sands and heavy oil. For the past 10 years, she has held a number of management positions at Shell Canada, most recently as Technology Development Manager for Upgrading & Froth Treatment, Oil Sands Joint Venture. In addition to her private sector experience, she spent seven years working at the Canada Revenue Agency as a Regional Technology Advisor for Oil & Gas in the Scientific Research & Experimental Development Program (SRED).

Dr. Siewe has a Ph.D. in Chemical Engineering from Imperial College, University of London. She also holds an MBA from the University of Calgary and a Bachelor of Science in Industrial Chemistry from City University in London, UK.

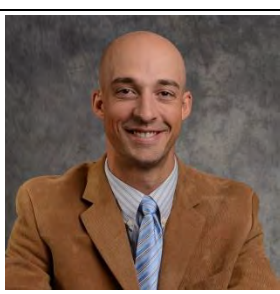


Mark Taylor - Executive Vice-President Operations Division, Alberta Energy Regulator

Mark Taylor has 30 years of experience in the oil and gas industry and is executive vice president of the Operations Division at the Alberta Energy Regulator (AER). Prior to this Mr. Taylor was senior vice president of Climate Policy Assurance/Closure & Liability.

Mr. Taylor graduated from the University of Saskatchewan in Mechanical Engineering and has worked in field and office roles for various companies throughout his career. Those companies include Amoco/BP, Alberta Energy Company (AEC)/Encana, Sinopec Daylight, and Mosaic Energy. Over the past 20 years, Mr. Taylor has led teams responsible for developing unconventional oil and gas assets in western Canada. These assets include the Horseshoe Canyon coalbed methane, Horn River shale, Montney gas, and Cardium oil.

Mr. Taylor has served on the board of directors for the Canadian Society for Unconventional Resources and as the chair of both the stakeholder engagement committee and the regulatory committee with this organization. Mark has been engaged firsthand with stakeholders in developing strategies that allow for the appropriate and continued development of western Canada's resource plays.



Patrick McDonald - **Director Climate and Innovation, Canadian Association of Petroleum Producers**

Patrick has been working with CAPP for over 3 years working on a number of different environmental policy related files. Before becoming part of the CAPP team, Patrick worked on oil sands related business with the Alberta Energy Regulator, its preceding organizations and at Suncor Energy as a Contact Engineer. Patrick received a bachelor's degree in chemical engineering from the Royal Military College of Canada in Kingston, Ontario.

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Effects of Steam-Assist on Industrial Flaring Emissions Control

Abbas Ahsan, Larry W. Kostiuk
University of Alberta

Abstract

In the oil and gas industry, flaring is a routine practice used to dispose of undesired flammable gases by burning them in a controlled manner. Depending on operating conditions, however, the flare combustion efficiency can drop, leading to the production of sooty, black smoke. According to climate scientists, this has dire environmental implications, since soot generated by gas flaring has been linked to the increased melting of Arctic sea ice. A popular method deployed in industry to improve flare combustion efficiency and curtail soot formation, called "steam-assist," is the addition of steam to the flare. Although this concept is promising, its implementation in industry is inconsistent and has led to major violations of flaring regulations.

Currently, there is a severe lack of quantitative data on the effect of steam on combustion efficiency. Too much steam, for instance, extinguishes the flame and allows waste hydrocarbon gases to escape into the atmosphere. Therefore, this research will seek to evaluate the effectiveness of steam-assist as a means of controlling flare emissions. A model steam-assisted flare will be designed and constructed based on established industry standards. A wide range of experiments will be performed using a variety of fuel gases and steam-assist configurations in order to represent the scope of industrial flaring practices. Data on combustion efficiency and soot formation will be collected, which will allow for comprehensive models to be built for predicting steam-assisted flaring emissions. This knowledge will better enable industry to develop fossil fuels while generating less pollution.

Calculating Flare Carbon-Conversion Efficiency and Species Emission Rates in a Closed-Loop Wind Tunnel

Joshua R. Armitage, Darcy J. Corbin, A. Melina Jefferson, Matthew R. Johnson
Energy and Emissions Research Laboratory, Carleton University

Abstract

Satellite data suggest worldwide flared volumes exceed 140 billion m^3 annually, where much of it is associated with development of unconventional oil and gas resources. Flaring in Canada has risen sharply in recent years, directly related to a rapid expansion in hydrofractured tight oil and tight gas developments. Data and models to accurately predict flare emissions are critically lacking such that current emission factors relied upon to calculate pollutant inventories and guide regulation are questionably relevant. Despite strong evidence that flares subjected to crosswinds can undergo fuel stripping mechanisms that degrade efficiency and lead to emissions of unburned fuel, the majority of published flare experiments have not considered the impact of a crosswind and there are essentially experimental data available on the effects of turbulent crosswinds on flare performance.

Accurate flare experiments over a wide range of possible scenarios may only be achieved in an environment where the wind conditions can be systematically controlled and manipulated. This work presents a methodology to determine the carbon conversion efficiency and species emission rates of a flare burning in a closed-loop wind tunnel. The developed methodology is based on solving the unsteady mass balance problem to relate accumulation rates of measured species in the wind tunnel to emission rates, while considering complicating factors such as infiltration and exfiltration of gases from the wind tunnel, potential for reburning of products within the wind tunnel, and presence of inert species in the fuel stream. The methodology is assessed by simulating a wide range of scenarios that are likely to be encountered, while calculating the achievable uncertainty in the determined carbon conversion efficiency.

Fugitive Emission Source Characterization Using Downstream Measurements

Carol A. Brereton[1], Lucy J. Campbell[2], Matthew R. Johnson[1]
[1]*Energy and Emissions Research Laboratory, Carleton University*
[2]*School of Mathematics and Statistics*

Abstract

Fugitive emissions are important sources of both greenhouse gas emissions and lost product. Sources of these emissions are often simple and economic to mitigate once located and quantified. However, facilities typically have large numbers of seals, valves, fittings, tanks etc. connected by pipe that all function as potential sources of emissions. Detecting sources quickly and efficiently among these potential emitters if and when a leak occurs allows for repair prioritization, improved reporting and overall lower emission releases.

Traditionally, visual IR camera inspection or manual component testing are used, though in recent years mobile drive-by and airborne surveys have increased. These methods, however, provide intermittent screening or component snapshots by design. Due to long intervals between measurements, leaks could potentially go unnoticed for long periods. This poster presents a scalar transport adjoint-based optimization method for locating and quantifying emission sources from downstream measurements. This can be used in conjunction with an in-place sensor network to find and quantify emission sources on a quasi-contiuous and automated basis. The method is demonstrated on the experimental release data from Project Prairie Grass, as well as on simulated simultaneous releases over a 3D representation of a partial Alberta gas plant

Measurements of Benzene Destruction Efficiency In a Lab-Scale Flare

Nicholas T. Brooker, Brian M. Crosland, Matthew R. Johnson
Energy and Emissions Research Laboratory, Carleton University

Abstract

Raw natural gas is generally saturated with water vapour that must be removed, typically using glycol dehydration units, before the gas can be introduced into the sales pipeline. The glycol used in the dehydration process also absorbs hydrocarbons, which can include BTEX compounds benzene, toluene, ethyl benzene, and xylene. In the dehydration process BTEX are often removed in a flash tank and then burned, along with other absorbed hydrocarbons, in a flare. Benzene is a health concern among humans, as it is classified as a known human carcinogen and can cause leukemia and abnormalities of the blood. Knowing the amount of benzene that escapes the flaring process is important.

Unfortunately there is currently a notable lack of quantitative information on the destruction efficiency of benzene in a flare. The objective of this project under FlareNet is to provide a useful model for benzene destruction efficiency in flares. This will be done using the Carleton Lab-Scale Flare by injecting vapourized benzene into gas compositions representative of what is found in glycol dehydrator flash gas. A Baseline 9100 Gas Chromatograph specially customized to quickly measure benzene concentrations above typical ambient levels is used to detect benzene concentration in the combustion products, allowing the destruction efficiency to be determined within calculated uncertainties.

Preliminary results are presented for benzene destruction in simple methane flares seeded to contain up to 1.2% benzene. Future work on this project will include further testing with pure fuels as well as industry representative gas compositions.

Field Measurements of Black Carbon Emissions from Gas Flaring using Sky-LOSA

Bradley M. Conrad, Matthew R. Johnson
Energy and Emissions Research Laboratory, Carleton University

Abstract

Recently, the quantification and mitigation of short lived climate pollutants (SLCPs) has garnered international attention, with all G8 countries being signatories to the United Nation's Climate and Clean Air Coalition (CCAC). One specific SLCP of interest is black carbon (BC), a particulate emission that is a product of incomplete combustion. Within the upstream oil and gas (UOG) industry, a significant anthropogenic source of BC is the process of flaring undesired gases associated with production. Despite the global scale of gas flaring however, models relating BC emissions to flare volumes (i.e. emission factors) are badly flawed. This is largely due to the relative lack of quantitative field measurement data, and is further hampered by the well-known sensitivity of flare BC emissions to flare gas composition, flow rates, design, and ambient conditions.

An emergent optical diagnostic, sky-LOSA (line-of-sight attenuation using skylight), has finally enabled the remote quantification of BC emissions from in-situ flares. To date, with support from the World Bank Global Gas Flaring Reduction partnership and CCAC among others, sky-LOSA has been deployed in seventeen field measurements in Uzbekistan, Mexico, Ecuador, and just this last year, Alberta. These field measurement data have indicated a more than four order of magnitude variation in absolute emission rate and have allowed for the derivation of a simple BC emission factor relation. Critical to the Canadian context, these data have also indicated a clear over-estimation in BC emissions from gas flaring using the single-valued emission factor of the Canadian Association of Petroleum Producers (CAPP). These data highlight the crucial need for further field measurements at Canadian facilities, with the goal of improving emissions inventories, deriving a more sophisticated BC emission factor relation, and enhancing the understanding of flare BC emissions in Canada's UOG industry.

Flaring during Refining and Upgrading: Effects of Air-Assist on Emissions Control

Hamza Ahsan, Larry W. Kostiuk
University of Alberta

Abstract

Part of routine practice in oil and gas production is the burning of flammable waste gases in an open-atmosphere flame, commonly known as flaring. In 2014, the total flared gas in Alberta's upstream oil and gas industry alone exceeded 1 billion cubic meters. Satellite data reveals that global flared volumes exceed 140 billion cubic meters annually. This amounts to 360 million tons of carbon dioxide, unburned hydrocarbons, and other harmful emissions.

A practical measure taken by flare operators to minimize incomplete products of flaring is the injection of high pressure air into the flame. The rapid inflow of air enhances fuel-air mixing and promotes a higher degree of combustion. However, recent studies have suggested that air-assisted flares often fail to perform as required by flaring regulations. This is the result of a lack of quantitative data regarding air-assisted flare emissions to properly guide the design, operation, and regulation of air-assisted flares.

The objectives of my research are to design, construct, and test bench-scale air-assisted flares and perform exploratory experiments to characterize emissions. To simulate full-scale air-assisted flares, I developed a model that captures the key performance parameters. The desired outcome of my research is gas and particulate emission characterization. Ultimately, I hope to provide fundamental insights into air-assisted flare emissions that will pave the way to full-scale experiments.

Effects of Sodium Chloride Solutions on Lab-Scale Flares

A. Melina Jefferson, Matthew R. Johnson
Energy and Emissions Research Laboratory, Carleton University

Abstract

During a well-completion, fluids returned to the surface are sent to separators and the gas is flared. Recent work at the Carleton Energy and Emissions Research lab investigates the potential effects on flares should any produced water carry through in the form of small aerosols. Detailed literature review shows that the composition of produced water during flowback tends to be high in salt content (sodium, chlorine, calcium, magnesium) and is similar in composition to that of naturally occurring formation water. Preliminary lab experiments with simple 5 and 15% NaCl solutions show that salt aerosols in the flare stream can affect complete combustion: carbon monoxide yields increase, particulate matter emissions increase, and the form of the particulate matter may be altered relative to that emitted by a standard flare. Further experiments are planned to bound the range of potential effects while considering a broader range of operating conditions.

Size distribution, mass-mobility, and effective density of soot particles generated from large-scale turbulent diffusion flames

Mohsen Kazemimanesh[1], Melina Jefferson[2], Alireza Moallemi[3], Kevin A. Thomson[3], Matthew R. Johnson[2], Jason S. Olfert[1]

[1] *Department of Mechanical Engineering, University of Alberta, Edmonton, AB, T6G 1H9, Canada*

[2] *Department of Mechanical & Aerospace Engineering, Carleton University, Ottawa, ON, K1S 5B6, Canada*

[3] *National Research Council of Canada, Ottawa, ON, K1A 0R6, Canada*

Abstract

Size distribution, mass-mobility, and effective density of soot particles generated from a large-scale turbulent diffusion flame was characterized under various fuel composition and exit velocity conditions. The turbulent diffusion flame was set up at Carleton University Lab-scale Flare (CULF) facility which allowed controlled experiments on turbulent flames up to approximately three meters tall at fuel gas flow rates up to ~250 SLPM (standard litres per minute at 0°C and 101.325 kPa). Three different burner sizes with a diameter of 38.1, 50.8, and 76.2 mm were used in this study. The fuel exit velocities at the burner tip were 0.5, 0.9, and 1.5 m/s and the fuel flow rates were adjusted accordingly for each burner size, which resulted in a range of flow rates from 60.5 to 246.2 SLPM. Three different fuel mixture compositions (light, medium, heavy) were tested which resembled Alberta flare gas composition. The fuel gas mixture had 6 components (i.e., C1 to C4 alkanes, carbon dioxide, and nitrogen) and the mole fraction of methane in the light, medium, and heavy composition was 0.925, 0.866, and 0.769, respectively.

Combustion products were diluted by the ambient air on the order of ~20:1 to ~120:1 as they were drawn in the collecting fume hood and insulated duct using a variable speed fan. Size distribution of soot particles was measured using a scanning mobility particle sizer (SMPS), sampling from the downstream of the duct and after the sample was further diluted by a factor of ~10:1 using an ejector diluter. Mass-mobility relation of soot particles were studied by a tandem arrangement of a differential mobility analyzer (DMA), a centrifugal particle mass analyzer (CPMA), and a condensation particle counter (CPC). Such arrangement was also used to determine the effective density of soot particles. The volatility of particles was studied by adding a catalytic stripper denuder between the DMA and the CPMA. Results showed that particle size distribution changed noticeably with the fuel mixture composition. Fuel mixtures with heavier hydrocarbons produced larger particles in size and higher number of particles per unit mass of fuel. Mass-mobility results showed that the effective density of particles for all test conditions did not change significantly. The average mass-mobility exponent, D_m, of particles was approximately 2.55 for all test conditions, which is in very good agreement with the reported value (D_m=2.49) for the mass-mobility exponent of particles from different combustion sources in the literature.

A Survey of Techniques for Optical Measurement of Flare Combustion Efficiency

Rodrigo B. Miguel, Samuel J. Grauer, and Kyle J. Daun
Department of Mechanical and Mechatronics Engineering, University of Waterloo

Abstract

Flaring is a common practice in the oil and gas industry, used to safely eliminate unwanted gases and vapours; mostly methane with lower concentrations of heavier hydrocarbons. The impact of these powerful greenhouse gases (GHG) is mitigated by converting them to carbon dioxide, which has a weaker GHG effect. The conversion efficiency of flaring under ideal conditions is near unity (>98%); however, variable environmental conditions, including the jet velocity, humidity, and presence of a crosswind, can dramatically reduce this rate. The mechanisms that influence combustion efficiency are complex and poorly understood. Moreover, existing studies are typically limited to point measurements, and thus systematically overestimate global combustion efficiency.

Recent progress in mid-infrared (IR) optics and electronics enables an optical approach that provides the spatial and temporal resolution needed to understand this problem. For example, the brightness of a pixel corresponds to the column density of participating gases along the corresponding line-of-sight (LOS). Optical gas diagnostics can infer ensemble column density data for multiple target molecules from a 2D IR image, used to compute the combustion efficiency. This procedure incorporates assumptions about the distribution of gas products throughout the flare.

Our poster reviews current state-of-the-art optical procedures for measuring the combustion efficiency of flares, and the corresponding equations that relate the optical data to combustion efficiency. These include a technique that compares spectrally-integrated data over four bands, collected using a mid-IR camera equipped with bandpass filters, or integrated hyperspectral data from an imaging FTIR spectrometer. Greater accuracy may be obtained comparing a line-by-line model to hyperspectral data, directly. This work forms a foundation for future experimental optical measurements made with a hyperspectral camera on an oil and gas flare.

Mitigation of Methane at Oil and Heavy Oil Production Sites in Alberta: A Techno-Economic Analysis of Industry Reported Data

David R. Tyner, , Matthew R. Johnson
Energy and Emissions Research Laboratory, Carleton University

Abstract

A site-by-site net present value (NPV) based techno-economic study of over 9000 conventional light and heavy oil sites (i.e. excluding mined oil sands) in Alberta was conducted to assess the cost of mitigating methane emissions using currently available technologies. Using site specific industry reported flaring and venting activity data, this analysis considers technical applicability and predicted costs for various mitigation options including: (i) installing infrastructure to tie-in excess gas to nearby pipelines, (ii) installing a flaring system (if not already present) to combust otherwise vented gas, (iii) use of catalytic conversion units or internal vapour combustors to combust vented casing gas at heavy oil sites, and (iv) use of two different line heaters technologies at heavy oil sites that allow the use of excess casing gas for onsite fuel demands (e.g. pumping and tank heating demands). At each site the economics are evaluated by assigning the least costly mitigation option (i.e. best NPV).

Under current economic conditions a small number (~300) heavy oil sites in the Peace River and Lloydminster regions exhibit economic (positive NPV) mitigation opportunities. However, for the majority of light and heavy oil sites, the current and foreseeable future price of natural gas implies mitigating methane comes at a cost to industry. This cost and associated methane reductions are explored on a cost per tCO_2e basis over a range of imposed carbon prices. In addition to the base analysis, the impact on mitigation and implications for overall provincial flaring are considered under: (i) a hypothetical tie-in policy and (ii) adjusting gas volumes to match recent airborne measurements.

UAV sensor package for trace gas emission rate estimation and black Carbon characterization

Miayan Yeremi
University of British Columbia

Abstract

Techniques for wind estimation, trace gas concentration measurement, such as CO2 and CH4, and miniaturized thermophoretic sampler, being developed for a UAV platform, will be presented. These techniques include use of UAV pre-existing onboard sensors to estimate wind vector, wavelength modulation spectroscopy (WMS) for trace gas concentration measurement, 3D printed thermophoretic sampler, for black carbon characterization, and a custom communication system developed to relay information between the UAV sensor package and ground station. In addition, a simple method for estimating trace gas emission rates from flares will be discussed. Finally, some preliminary results for WMS gas sensing will be presented.

Emissions from gas flaring

Ramin Dastanpour[1], Alberto Baldelli[1], Mohsen Kazemimanesh[2], Melina Jefferson[3], Alireza Moallemi[4], Vladimir Novaković[1], Morris Huang[1], Matthew Johnson[3], Kevin Thomson[4], Jason Olfert[2], Steve Rogak[1]

[1]*Department of Mechanical Engineering, University of British Columbia, Vancouver, Canada*

[2]*Department of Mechanical Engineering, University of Alberta, Edmonton, Canada*

[3]*Department of Mechanical and Aerospace Engineering, Carleton University, Ottawa, Canada*

[4]*Measurement Sciences and Standards, National Research Council of Canada, Ottawa, Canada*

Abstract

Worldwide flared volumes exceed 140 billion m^3 annually. Flaring is a major source of CO_2, black carbon (BC) and other air toxic emissions. Flarenet Strategic Network aims to provide a quantitative understanding of flare-generated pollutant emissions enabling science-based regulations and pollutant inventories, understanding climate and health impacts and mitigation strategies for the energy production sector.

First phase of this project involved investigation of emissions from a large scale laboratory flare. Soot particles were generated at the Flare Test Facility within the Energy & Emissions Research Laboratory at Carleton University. Flares up to 80 mm in diameter with turbulent flames up to 3 m tall were tested. Effects of fuel mixture, burner diameter, and effluent velocity on emissions were investigated. Experiments consisted of several gas and particulate analyzer; however this poster only focuses on the effective density, morphology, and Raman characterizations.

In these experiements, fuel mixtures with heavier hydrocarbons produced larger particles in size and higher number of particles per unit mass of fuel. Transmission Electron Microscopy (TEM) showed that the average primary particle diameter varied between 13 to 24 nm, while its geometric standard deviation varied between 1.3 and 1.7. No clear correlation was observed between the primary particle diameter and burner diameter and effluent speed. Similarly, effective density of particles for all test conditions did not change significantly. Average primary particle diameter was found to increase substantially with the size of the aggregates, regardless of the operating condition. Recent investigations showed that the primary particle diameter and mass-specific absorption cross section (MAC) increase with the aggregate size, even in a single operating condition (Dastanpour & Rogak, 2014; Dastanpour et al. 2017). This elaborates the need to investigate the size-ependency of the optical properties of flaring emissions.

The analysis of the spectra generated by Raman spectroscopy is a common method to obtain the chemical composition of soot nanoparticles. By analyzing the ratio of the characteristic peaks of soot, the degree of graphitization, the crystal sizes in disordered carbon, and the amount of amorphous carbon can be estimated. Furthermore, comparins Raman spectra allow to detect any difference in chemical composition among soot generated with different burining conditions.

Advancing the Low-carbon Economy by Integrating Biogenic Based Carbon Sequestration Technology into Oil & Gas Development Projects

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Abstract

Advancing the low-carbon economic agenda is a key climate change mitigation and sustainable development strategy. Shifting Alberta's economy towards a resilient low-carbon economic system hinges on the local industry and governments capacity to transform processes, systems and values supporting unsustainable economic practices(Cote, 2000). This transformation requires an adoption of more integrated cross-disciplinary and systems-thinking approaches (Bolton & Foxon, 2015) aimed at improving the economy's eco-efficiency. Shifting industrial development perceptions from linear input/output models to closed-loop industrial-ecological systems, creates more suitable conditions for recognizing and capitalizing on sustainable growth opportunities (Cote, 2000).

One industrial-ecology technology currently being researched by Natural Resource Canada's Canadian Wood Fibre Centre is the practice of diverting treated municipal waste water residuals (TMWWR) from standard disposal streams to local agricultural fields growing short rotation woody (SRW) biomass. There are five Alberta-based projects using this technology and they are being supported by AROWRN.ca.

By shifting perceptions of TMWWR from a waste to a resource and connecting them to SRW crops, several low-carbon economic opportunities emerge. For example carbon offset credits, biofuel feedstock production, and net carbon emissions reductions from land management activities (Nackley et al., 2013). Through linking municipal and agricultural systems, these projects simultaneously reduce waste, reclaim soil, and diversify revenue streams.

This research explores how oil and gas companies may benefit from applying the TMWWR and SRW technology to their project sites by examining industry specific low-carbon economy and sustainability opportunities.

University of Calgary - Taking Energy Research from GREAT to BEST
GLOBAL RESEARCH INITIATIVE IN SUSTAINABLE LOW CARBON UNCONVENTIONAL RESOURCES (GRI)

In September 2016, the Canada First Research Excellence Fund (CFREF) awarded the University of Calgary, in partnership with the Southern Alberta Institute of Technology (SAIT), $75 million to implement the Global Research Initiative in Sustainable Low Carbon Unconventional Resources (GRI), which aims to significantly reduce the carbon footprint of unconventional resource development and contribute to a climate-neutral energy system.

The GRI's three themes (Heavy Oil & Bitumen; Tight Oil & Gas; and CO2 Conversion) will generate clean tech solutions by seeking new, innovative fossil fuel-based energy systems that are low or even zero carbon, and will rapidly advance and deploy technologies that actively store or convert CO2.

Through local and international partnerships, clean technologies will be developed and tested at field scale with the aim of accelerating commercialization. Life Cycle Analysis and Early Technology Assessment techniques will be used to evaluate early-stage research.

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