Meeting the Methane Challenge

Society of Petroleum Engineers – Calgary Section

January 23, 2018
Cap-Op Energy is a Canadian energy sustainability company whose mission is to make sustainability profitable. Cap-Op provides technological solutions and professional consulting services to innovative clients across the energy spectrum. We enable our clients, their sustainability projects and corporate sustainability programs through monetization of environmental attributes. Cap-Op has experience in all the major environmental credit markets across North America. Our software platforms help our clients multiple effectiveness and scale project yield.
Agenda

1. Why Regulate Methane?
2. Regulatory Status
3. Offsets Opportunity
4. Methane Abatement Technologies
Why are Governments Regulating Methane?
Different Greenhouse Gases warm the earth differently.

<table>
<thead>
<tr>
<th>Specified Gas</th>
<th>Formula</th>
<th>100-Year GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>CO₂</td>
<td>1</td>
</tr>
<tr>
<td>Methane</td>
<td>CH₄</td>
<td>25</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>N₂O</td>
<td>298</td>
</tr>
<tr>
<td>Sulphur Hexafluoride</td>
<td>SF₆</td>
<td>22,800</td>
</tr>
<tr>
<td>Perfluoromethane</td>
<td>CF₄</td>
<td>7,390</td>
</tr>
<tr>
<td>Perfluoroethane</td>
<td>C₂F₆</td>
<td>12,200</td>
</tr>
<tr>
<td>Perfluoropropane</td>
<td>C₃F₈</td>
<td>8,830</td>
</tr>
<tr>
<td>Perfluorobutane</td>
<td>C₄F₁₀</td>
<td>8,860</td>
</tr>
<tr>
<td>Perfluorocyclobutane</td>
<td>c-C₄F₈</td>
<td>10,300</td>
</tr>
<tr>
<td>Perfluoropentane</td>
<td>C₅F₁₂</td>
<td>9,160</td>
</tr>
<tr>
<td>Perfluorohexane</td>
<td>C₆F₁₄</td>
<td>9,300</td>
</tr>
<tr>
<td>Hydrofluorocarbons-23</td>
<td>CHF₃</td>
<td>14,800</td>
</tr>
<tr>
<td>Hydrofluorocarbons-32</td>
<td>CH₂F₂</td>
<td>675</td>
</tr>
<tr>
<td>Hydrofluorocarbons-41</td>
<td>CH₃F</td>
<td>92</td>
</tr>
<tr>
<td>Hydrofluorocarbons-43-10mee</td>
<td>C₃H₂F₁₀ (structure:CF₃CHFCHFCF₂CF₃)</td>
<td>1,640</td>
</tr>
<tr>
<td>Hydrofluorocarbons-125</td>
<td>C₂HF₅</td>
<td>3,500</td>
</tr>
<tr>
<td>Hydrofluorocarbons-134</td>
<td>C₂H₂F₄ (structure:CHF₂CHF₂)</td>
<td>1,100</td>
</tr>
<tr>
<td>Hydrofluorocarbons-134a</td>
<td>C₂H₂F₄ (structure:CH₂FCF₃)</td>
<td>1,430</td>
</tr>
<tr>
<td>Hydrofluorocarbons-143</td>
<td>C₂H₂F₃ (structure:CHF₂CH₂F)</td>
<td>353</td>
</tr>
<tr>
<td>Hydrofluorocarbons-143a</td>
<td>C₂H₃F₃ (structure:CF₃CH₂H)</td>
<td>4,470</td>
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<tr>
<td>Hydrofluorocarbons-152a</td>
<td>C₂H₄F₂ (structure:CH₃CHF₂)</td>
<td>124</td>
</tr>
<tr>
<td>Hydrofluorocarbons-227ea</td>
<td>C     (structure:CF₃CHFCF₃)</td>
<td>3,220</td>
</tr>
<tr>
<td>Hydrofluorocarbons-236fa</td>
<td>C₃H₂F₆ (structure:CF₃CH₂CF₃)</td>
<td>9,810</td>
</tr>
<tr>
<td>Hydrofluorocarbons-245ca</td>
<td>C₃H₂F₅ (structure:CH₂FCF₂CHF₂)</td>
<td>693</td>
</tr>
</tbody>
</table>

2007. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Adapted from Table 2.14, IPCC Fourth Assessment Report, 2007
Methane GHG Attributes

➢ 25 times GWP of CO₂ over 100 yrs (2007 IPCC)
   ➢ Updated to 28 (2014 IPCC)

➢ Major GHG impact but short lived

➢ Atmospheric life ~10 years
   ➢ water vapour ~1 week
   ➢ vCO₂ ~100 years

➢ Degrades to water and CO₂
Methane is the 2nd Largest Man-made GHG Source

EPA, 2015
Canada’s Total GHG Emissions

Regulating Methane Emissions in Canada
<table>
<thead>
<tr>
<th>Regulatory Maelstrom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Methane Regulations</strong></td>
</tr>
<tr>
<td>• Draft federal regulations</td>
</tr>
<tr>
<td>• Upcoming AER regulations</td>
</tr>
<tr>
<td>• Equivalency Agreement</td>
</tr>
<tr>
<td><strong>Emissions Management</strong></td>
</tr>
<tr>
<td>• MSAPR/BLIERS</td>
</tr>
<tr>
<td>• GFI/ZRF, other flaring regulations</td>
</tr>
<tr>
<td>• AER Directives (e.g. 17, 39, 60, etc.)</td>
</tr>
<tr>
<td><strong>Reporting Regulations</strong></td>
</tr>
<tr>
<td>• NPRI</td>
</tr>
<tr>
<td>• SGRR</td>
</tr>
<tr>
<td>• GGIRCA</td>
</tr>
<tr>
<td><strong>Emissions Taxation/Other</strong></td>
</tr>
<tr>
<td>• SGER/CCR</td>
</tr>
<tr>
<td>• Carbon levy/tax</td>
</tr>
<tr>
<td>• Low Carbon Fuel Standards (CA, OR, BC, ON?)</td>
</tr>
</tbody>
</table>
Regulation Summary

- **Benzene**
  - < 2 t/y
  - < 1 t/y

- **NOx**
  - $20/t
  - $30/t

- **Carbon Levy**
  - O&G processing exemption
  - AB starts
  - O&G processing exemption period ends

- **Fed. CO2 $ ECCC**
  - Reporting to 10kt CO2e
  - $10/t $20/t $30/t $40/t $50/t $50+/t

- **Methane: ECCC/AER**
  - Output Based Allocations starts
  - Reporting, LDAR (AB)
  - LDAR (ECCC), Well Completions, Compressors, Venting Pneumatics
  - AB and ECCC 45% Reduction Target

- **SGER**
  - $20/t 15% El* target
  - $30/t 20% El* target
  - SGER ends

*El refers to emissions intensity

Slide courtesy of: Keyera Corp. & Conoco Phillips Canada
O&G Methane Emission Challenge

➢ Cdn Upstream O&G production industry vents 30+ Mt CO₂/year
➢ AB, BC, Can, US, Mexico preparing methane regulations
➢ O&G producers need to invest in methane abatement equipment
➢ Struggle to allocate capital for energy efficiency projects in low price environment
### Federal Carbon Price
- $10/tonne in 2018 increasing annually to $50/tonne by 2022

### Methane Regulations
- 45% reduction from 2012 levels by 2025, from the oil and gas sector

### Carbon Market / Clean Fuel Standard
- 30 MT annual reduction in life cycle GHG from fuels by 2030

<table>
<thead>
<tr>
<th>Effective</th>
<th>Coverage</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LDAR</strong></td>
<td>2020</td>
<td>500 PPM with Method 21</td>
</tr>
<tr>
<td><strong>Compressors</strong></td>
<td>2020</td>
<td>Must measure, conserve emissions and meet limits</td>
</tr>
<tr>
<td><strong>Facility Venting</strong></td>
<td>2023</td>
<td>Facilities handling &gt;60,000 m³</td>
</tr>
<tr>
<td><strong>Pneumatic Devices</strong></td>
<td>2023</td>
<td>All gas-driven controllers (&gt;6 scfh) and pumps (&gt;20 L/d)</td>
</tr>
</tbody>
</table>
Offset Credits from Oil & Gas Operations
Paying for Energy Efficiency

Offset Credits

Regulations
Offsets are voluntary reductions
- paying others to reduce emissions at less cost than you can do yourself

Low-cost offset credits are needed by large final emitters who emit >100,000 tpy to reduce compliance cost

2017 - Tech fund price raised to $30/t-CO2e

2018 - *Specified Gas Emitters Regulation* replaced by *Carbon Competitiveness Regulation* effective January 1, 2018

Offset demand projected to increase under new CCI output based allocations system (2018)
SGER: Alberta Carbon Pricing Framework (Since 2007)

**Old System – Intensity Based**

**The Specified Gas Emitters Regulation:**
- Determines which facilities are specified emitters;
- Establishes baseline years and baseline emissions; and
- Mandates an emission intensity reduction relative to the baseline.

Specified Emitters (>100,000 t CO₂ point source/yr)

Reduce up to 20% emission intensity relative to baseline

**OPTIONS**
- Reduce Emissions
- Pay into the ‘Tech Fund’
- Purchase Carbon Offsets or EPCs
New System – OBAs

Output based allocation method
Still applies to emitters that release >100,000 t-CO2e/yr

Bottom 75% - compliance obligated

Top quartile performing emitters set the free allocation rate. Emitters that release more than their allocated emissions must pay for those emissions

Pay into the ‘Tech Fund’
Purchase Carbon Offsets or EPCs
Reduce Emissions

Reduction of total allocations by 1-2% yearly
Compliance Flexibility

- ACCO conducted focused engagement in July/August.
  - Policy goals: Maintain functional market, enable fiscal planning, and avoid recreating credit oversupply

Approach

- Revise the previous 30% to a base limit of 40% plus additional allowance for New credits starting at 10% in 2018
  - New credits are defined as 2017 vintage and newer.
  - Credits = EPCs and Offsets

<table>
<thead>
<tr>
<th>Policy Option</th>
<th>Credit Limit on 2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revised Approach – based on Engagement and Policy Phase-In</td>
<td>New and old</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>20%</td>
</tr>
</tbody>
</table>

- Create an expiry period for credit vintages where:
  - credits from 2014 and older expire after 2020 compliance
  - credits from 2015 expire after 2021 compliance
  - credits from 2016 expire after 2021 compliance
  - New credits from 2017 and newer expire after 8 years.
Baseline and Project Concepts of Carbon Credit Generation

Baseline emissions less project emissions equals Offset Credits!
Data Requirements

**ASSET DATA**
- Site Ownership
- Make/Model
- Serial Number
- Replacement dates

**OPERATION DATA**
- Inspection & Maintenance Logs
- Hours of Operation
- Stroke Count or Volume Injected
- Supply Pressure
- Gas Analysis
- Destruction Efficiencies
Criteria for Carbon Offsets in Alberta

Project-based emissions reductions/removals must:

- Occur in Alberta, from actions taken on or after January 2002;
- Result from actions not otherwise required by law, and above and beyond Business As Usual (BAU = 40% Industry Uptake);
- Be real, demonstrable, quantifiable, and verifiable using replicable means;
- Have clearly established ownership;
- Be counted once for compliance purposes;
- Quantified according to a government-approved protocol;
- Be verified by qualified persons; and
- Be registered on the Alberta Registry (gives serial numbers).
Reduction Opportunities: Vented vs. Fugitives

Controlled (Vents and Flares)
- Routine
  - Pneumatic Venting
  - Compressor Packing
  - Tank Vents
- Non-routine
  - Blowdowns / startups
  - Completions
  - Liquid Unloading

Uncontrolled (Fugitives / Leaks)
- Non-routine
- Routine
• Controllers and pumps make up 55% of vented emissions in oil and gas.

• Alberta Oil and Gas Facility Vents 28.8 Mt annually according to the National Inventory Report 1990-2011.

• This is a high-value opportunity to help Alberta meet its emissions reduction targets.
➢ Production in remote areas where electricity is unavailable or prohibitively expensive

➢ Self-generation of electricity is costly

➢ Most pneumatic instruments in upstream oil and gas applications are operated using fuel gas (80+% methane)

➢ Pneumatic instruments vent pressurized gas continuously or intermittently through static and dynamic consumption
# Emission Reduction Potential of Distributed Projects

<table>
<thead>
<tr>
<th>GHG Emitting Equipment</th>
<th>Total Alberta Equipment Count</th>
<th>Estimated Eligible Alberta Equipment Count</th>
<th>GHG Efficient Alternatives</th>
<th>Average Emissions Reduction (annual)</th>
<th>Average Capital Cost (Installed)</th>
<th>Estimated Total GHG Reduction Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-bleed Instruments</td>
<td>369,067</td>
<td>115,000</td>
<td>Low-bleed instruments</td>
<td>40 tCO$_2$e</td>
<td>$1,000 - 2,500</td>
<td>4,600,000 tCO$_2$e</td>
</tr>
<tr>
<td>Pneumatic Pumps</td>
<td>172,302</td>
<td>150,000</td>
<td>Low/No-bleed pumps</td>
<td>75 tCO$_2$e</td>
<td>$10,000 - 25,000</td>
<td>11,250,000 tCO$_2$e</td>
</tr>
<tr>
<td>Solution Gas Capture</td>
<td>19,000</td>
<td>8,000</td>
<td>Well site vent gas capture</td>
<td>500 tCO$_2$e</td>
<td>$20,000 - $60,000</td>
<td>4,000,000 tCO$_2$e</td>
</tr>
<tr>
<td>Vent gas (Engines)</td>
<td>31,968</td>
<td>10,000</td>
<td>Vent gas capture</td>
<td>1000 tCO$_2$e</td>
<td>$50,000 - $250,000</td>
<td>10,000,000 tCO$_2$e</td>
</tr>
<tr>
<td>Natural gas combustion engines</td>
<td>31,968</td>
<td>6,000</td>
<td>Air-fuel ratio controllers</td>
<td>600 tCO$_2$e</td>
<td>$150,000 - $300,000</td>
<td>3,600,000 tCO$_2$e</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>33 million tCO$_2$e</strong></td>
</tr>
</tbody>
</table>


Copyright 2017 Cap-Op Energy Inc.
Engine Management and Vent Gas Capture

- Upgrade engine fuel controller with REMVue® Air Fuel Ratio Controller.
- Captures compressor vent gas for use as fuel.
- Improves engine performance = increased production at lower cost
- Proven protocol - generating credits since 2011
- Large data management requirements

Proven O&G Offsets

15% Emissions Reductions

Retrofit
**Project Types**

<table>
<thead>
<tr>
<th></th>
<th>Greenfield</th>
<th>Brownfield (Retrofits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High to Low Bleed Controller Conversions</td>
<td>Not eligible</td>
<td>Eligible</td>
</tr>
<tr>
<td>Electrification (e.g., chemical injection pumps)</td>
<td>Eligible with alternative electricity source (e.g. solar)</td>
<td>Eligible</td>
</tr>
<tr>
<td>Instrument Air Systems</td>
<td>Eligible at well sites/pads only</td>
<td>Eligible</td>
</tr>
<tr>
<td>Vent Gas Capture and Destruction</td>
<td>Eligible (low-bleed baseline)</td>
<td>Eligible</td>
</tr>
</tbody>
</table>

**Clock is ticking**

Pneumatic Offset crediting sunsets January 1, 2023
Methane Abatement Technology
Target Opportunity

Pneumatic Pressure Controllers

Pneumatic Controller Retrofit

- Replace internal components of high-venting pneumatic controller to convert into a low-venting pneumatic controller
- The Fisher 4150 pressure controller is a workhorse of the Upstream O&G industry

Replace/Retrofit

High-Vent
Fisher Model 4150
Typical bleed rate 1.3 m³/hr
= ~ 145 tCO₂e/yr.

Low-Vent
Fisher Model C1
bleed rate 0.14 m³/hr
= ~ 15 tCO₂e/yr.

Emission Reduction
130 tCO₂e/yr
Simple example: one Fisher 4150 controller change out
Capitał cost of change out $2000
Baseline is 45 scfh, project is 5 scfh, so reduction is 35 scfh,
Roughly 380 GJ/yr x $2.00/GJ = $760 in Year 1.
Fuel savings alone => 3 year pay out.
Earning Carbon Credits
128 tCO2e/yr x $20/tCO2e = $2560 in Year 1
Fuel and Carbon Credits => $3320 in Year 1. For a $2000 change out
For 5 years => $16000
Prime Target Opportunity

Pneumatic Devices

Transducer Retrofits

- Replace internal components of high-vent pneumatic controller with low-vent pneumatic technology
- Proven low cost technology

Baseline
High Vent
Fisher 546 or i2P-100 (1st Gen)

Replace/Retrofit

Project
Low-Vent
Fisher i2P-100 (2nd Gen)
Chemical Pump Solar Electrification

- replaces power source for pneumatic pumps from supply gas to renewable electricity from solar power

Baseline
- High Vent Texsteam 5100 Gas-driven Chemical Injection Pump

Project
- Solar Chemical Injection Pump
Instrument Gas to Instrument Air Conversion

- Install compressed air system so that pneumatic equipment on-site operates on, and vents, air (instead of methane)

Baseline

Project

90%+ Emission Reduction
Vent Gas Capture

- Install piping at a facility to capture vent gas from pneumatic devices to use as a fuel source on site in non-engine applications

Baseline

96% Emission Reduction

Project
Best Practices

➢ Obtain Internal stakeholder buy-in
   ➢ Management, field, accounting, regulatory

➢ Management of Data Quality
   ➢ Project documentation & recordkeeping

➢ Collect inventory via contracted service provider

➢ Web enabled Field-to-Cloud data acquisition
   ➢ Smart phone entry, efficient, fast, accountable

➢ Consider core asset life cycle and divestitures
Sustainability Made Profitable

Carbon-Backed Financing

Pneumatic Conversions

Pneumatic Pressure Control

Fisher 4150 or equivalent

Fisher C1

Electro-Pneumatic Pressure Control

Fisher 546/546S

Fisher i2P-100 LB

... or HB to LB retrofit kit

Level Control

L2 Snap Acting Relay

L2 On-Off Relay Retrofit

PTAC 2017 Measurement Program
$1 Methane Compliance – with Carbon Backed Financing

Undiscounted Compliance Profit (Cost)

- Wait and See
- 5 year Program
- Rebates + 5 Year
- Rebates + 2 Year

40%+ Less Capital Required

*undiscounted
### Canadian Upstream Oil and Gas Eco-Efficiency Equipment and Operations Handbook

**Handbook Title Page and Introductory Information**

#### Table of Contents by Specification Sheet

1. Burner, Heaters, and Boilers
   1.1 - Facilities Design and Equipment
   1.1.1 Utherm High Efficiency Process Heater
   1.1.2 Black Gold Rush Industries Ltd All in One Rush Burner

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**5.1.1. Spartan Controls Ltd. – REMVue Air Fuel Ratio (AFR)**

**Description:**
REMVue® AFR Control systems allow engines to operate at different air fuel ratios than the original engine design, allowing them to run on less fuel gas. The REMVue®-AFR is a patented air fuel ratio control system, providing rich-to-lean conversion and engine control optimization. It is the only patented rich-to-lean conversion system available for rich-burn engines. The system can be configured to operate as a standalone control system, or it can be integrated with other hardware or software systems. The REMVue®-AFR is applied in a wide variety of rich burn or lean burn engines, resulting in an average of 15% fuel savings, improved readings, and reduced NOx emissions (US EPA compliance level).

**Technology Group**
- Engines and Compressors ➔ Facilities Design and Equipment

**Site Applicability**
- Oil and gas facilities: sweet and sour service, any rich-burn or lean-burn natural gas engine

**Emissions Reduction and Energy Efficiency**
Up to 2,000 tons CO₂ annually, depending on engine and tuning of the system.

**Economic Analysis**
- **Capital Cost:** Capital costs range from $40,000 to $60,000. However, these costs vary based on location, type of engine, and number of units purchased.
- **Installation Cost:** Installation costs range from $42,000 to $56,000 depending on the size of engine/compressor and the addition of optional features.
- **Operating Cost:** Improved engine optimization generally reduces operating costs by an average of 10%.
- **Maintenance Cost:** The REMVue®-AFR results in no additional maintenance costs as it does not require any special skills beyond existing operations.
- **Carbon Offset Credits:** The REMVue®-AFR is eligible for carbon offsets as per the Alberta Offset System Quantification Protocol for Engine Fuel Management and Vent Gas Capture Projects.

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Field Studies

Winning the Methane Challenge

Winning Strategies:
- Lowest cost abatement
- Maximum cost recovery
- Apply existing, proven technologies

Outcomes:
- Keep methane in the sales pipeline
- Industry leadership and stewardship
- Modern fleet, low production costs
Thank you

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Director Business Development
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Brian Sloof
Technical Manager
bsloof@capopenergy.com

Ph 403 457 1029
Cap-Op Energy has developed the premier energy efficiency platform for the oil & gas industry to automate and standardize the quantification of greenhouse gas credits (carbon offsets) from data acquisition through to verification and reporting. It offers significant savings and risk reduction to customers by coupling the power of cloud computing and project aggregation with years of industry expertise and best practices.
Our Team

**Adam Winter**
**Co-founder & President**
- 15 years experience in tech
- Works on the intersection of clean tech + information tech
- Focuses on strategy, funding

**Keith Driver**
**Co-founder & Director**
- Worked across N.A carbon regulations and quantification protocols, foremost expert on carbon reduction projects

**Cooper Robinson**
**Director**
P.Eng/HBA – expert in sustainability, clean tech and entrepreneurship

**Kevin Heal**
**Director of BD**
25 years experience in AB, oil & gas, power markets, clean energy

**Brian Sloof**
**Technical Manager**
P.Eng – 25 years experience in oil/gas, with 10 years in air emissions & GHG

**Majeed Punyandeh**
**Sr System Developer**
B.Eng – experienced GIS developer, design, spatial design systems

**Ahsan Syed**
**Consultant**
BSc/HBA – Sound technical and commercial experience and expertise