
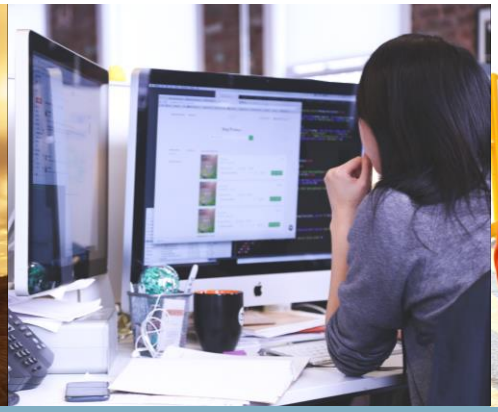


Case Studies from Alberta: Executing Profitable Methane Abatement Projects

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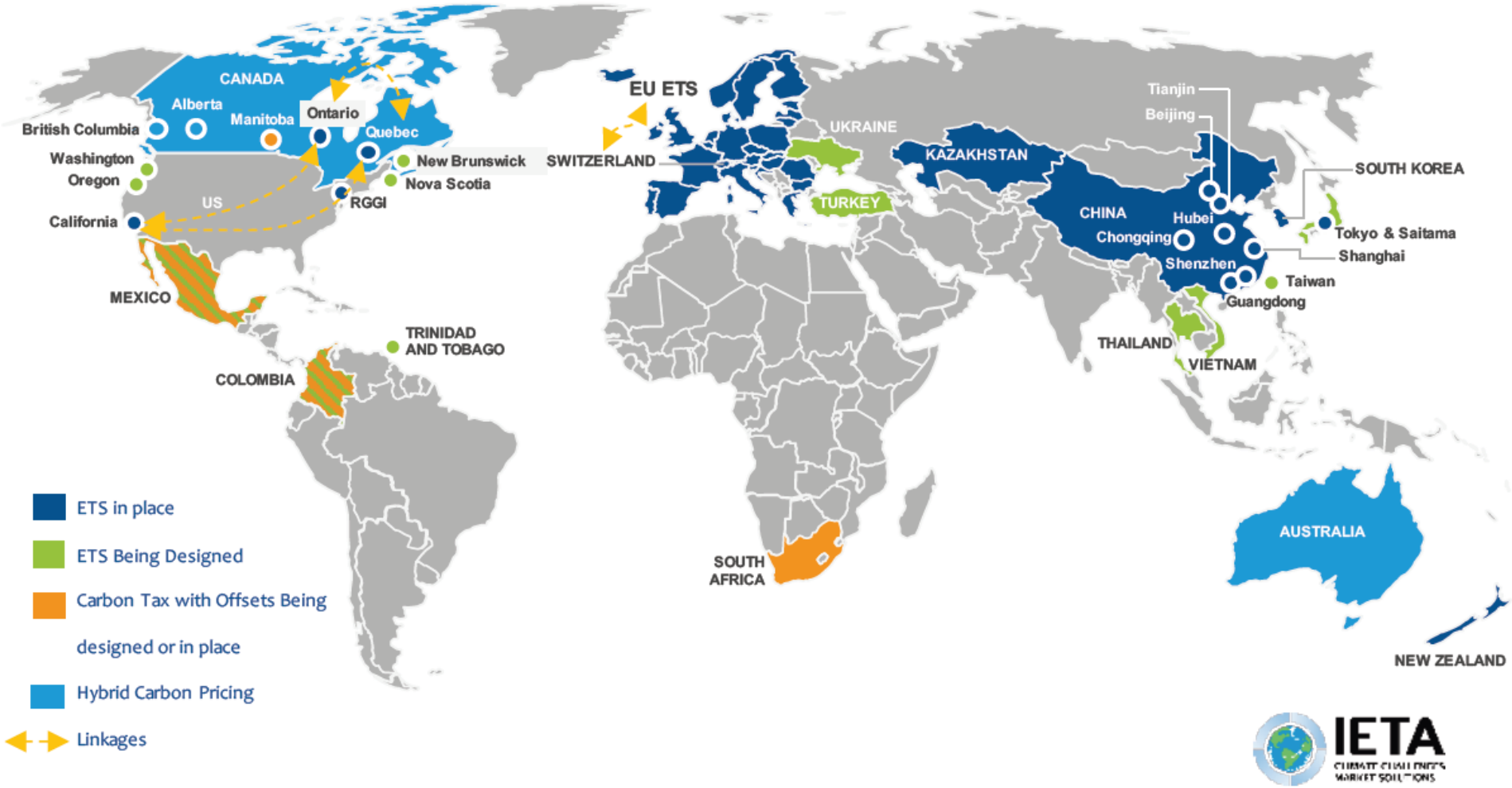
Sustainability Made Profitable

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

- Intro to GHGs and Methane in AB
- Methane Regulatory Environment
- High-Impact Methane Projects
- Case Studies
- Key Take-Away Points for Profitable Methane Abatement Projects
- Questions

CARBON MARKETS WORLDWIDE



IETA
CLIMATE CHALLENGES MARKET SOLUTIONS

How the Alberta Carbon Market Incentivizes Emission Reductions

CCR is based on the output based allocation method only applied to Emitters that release >100,000 t CO_2e

Bottom 75% - compliance obligated

TOP 25% - OBA rate setters

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

Outcomes from the Alberta emissions market

$2+ B Value of co-funded technology innovation projects (2011-2015)

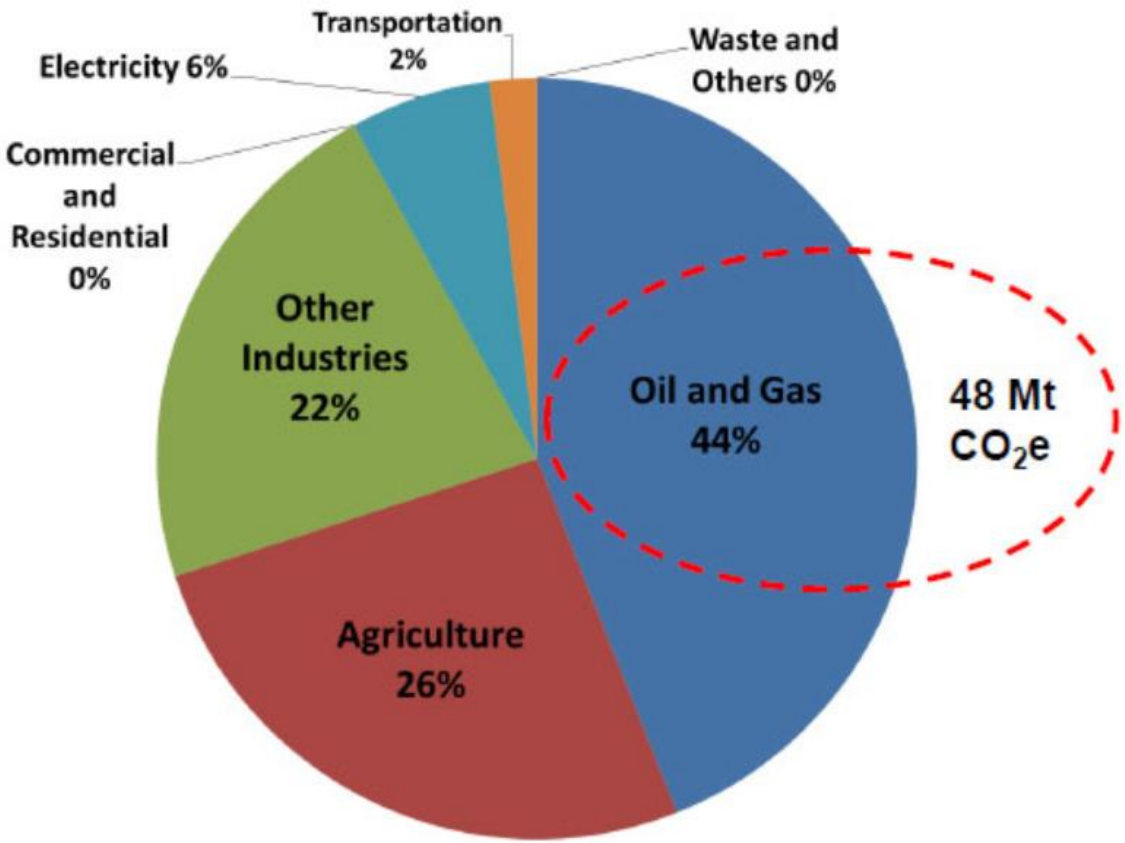
69 Mt CO_2e GHG Reductions from co-gen, offsets, facility improvements

$740 M Government Revenues collected through the technology fund

Other Indirect benefits including:

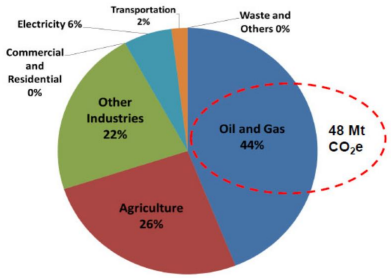
- New industry and jobs creation from the measurement, monitoring and verification of carbon offsets
- New investments in clean technology and emission reduction technology
- Expertise development & training of the Alberta workforce

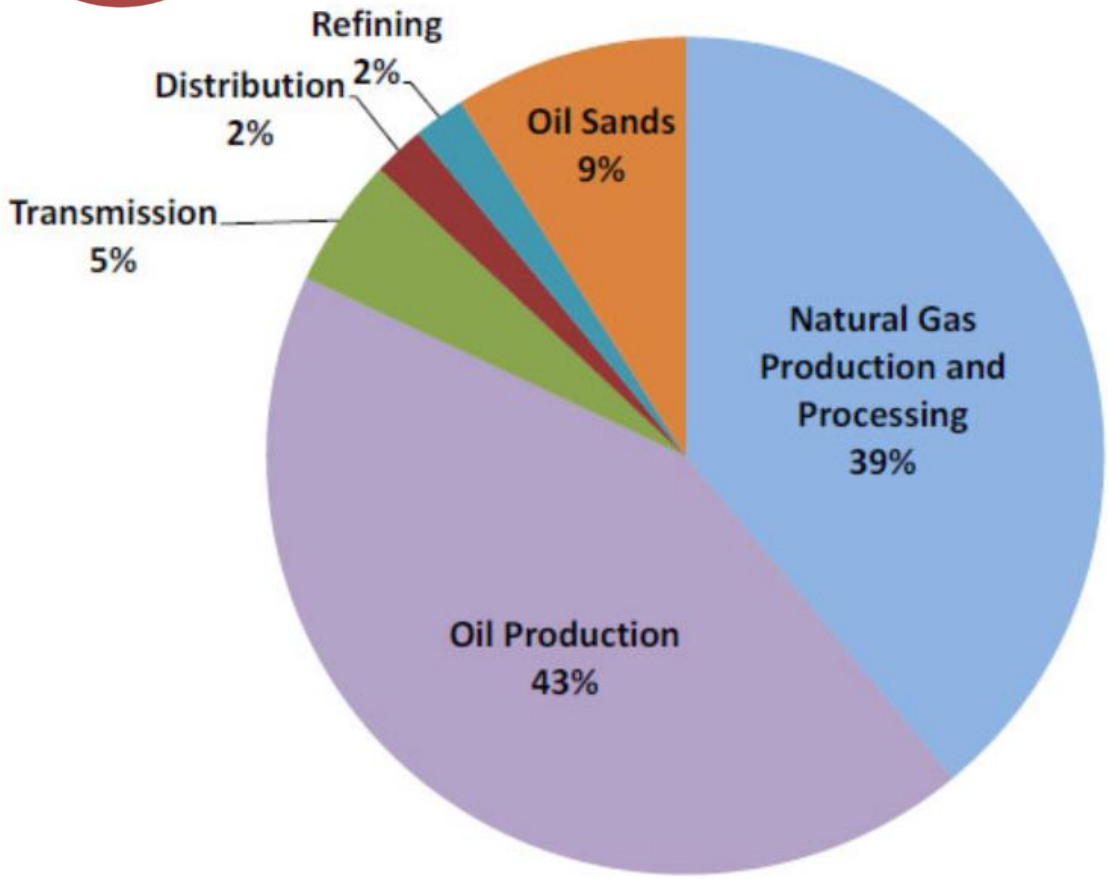
Canada's Methane Emissions



ECCC National Inventory (2015)

Oil and Gas Methane Emissions





ECCC National Inventory (2015)

Federal GHG Policies and Methane Regulation

Carbon Price	Methane Regulations	Carbon Market / Clean Fuel Standard
$10/tonne in 2018 increasing annually to $50/tonne by 2022	45% reduction from 2012 levels by 2025, from the oil and gas sector	30 MT annual reduction in life cycle GHG from fuels by 2030

	Effective	Coverage	Requirement
LDAR	2020	By spec. facility and component	Inspect 1-3x/year + repair in spec. time
Compressors	2022-2023	Centrifugal and reciprocating compressors	Must measure, conserve emissions and meet limits
Facility Venting	2018-2023	All upstream and pipeline facilities	Maximum allowed: 250 m^3/month
Pneumatic Devices	2022-2023	All gas-driven controllers and pumps (>20 L/d)	Must be low or no-bleed by effective date
Dehydrators	2022-2023	New and existing glycol dehydrators	68kg/d CH_4 (new)/ 136kg/d fleet avg.

Winning the Methane Challenge

Winning Strategies

- Lowest cost abatement
- Maximum cost recovery
- Apply robust, proven technologies

Outcomes

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

Illustrative: $1 Methane Compliance

15% discount rate to 2025

Case Studies in Methane Abatement

Air Fuel Ratio Control and Vent Gas Capture

Replacement

15% Emissions Reductions

Solution Gas Abatement

Replacement

80%+ Emissions Reductions

Pneumatic Controller Replacement/Retrofit

High-Vent

Retrofit

80%+ Emissions Reductions

Low-Vent

Case Study #1: Early Action Incentive for MSAPR Compliance

Air Fuel Ratio Control and Vent Gas Capture

Replacement

15% Emissions Reductions

E.g. REMVue™ AFRC and SlipStream™

- NOx reduction technologies can also reduce GHG emissions:
  - REMVue Air Fuel Ratio Controller and Slipstream VGC
- Proactive compliance with MSAPR is offset-eligible
- "Single-touch" philosophy can save costs when retrofitting engines
- Carbon offsets improve project ROI by 50%+
- Over 250,000 t CO_2e certified in Alberta by Cap-Op

EFM & VGC Project Overview

Economics

$115,000 - $180,000

Offsets Improve ROI by 50%

3-16 months (retrofit) with offsets

Project Benefits	Project Challenges
• Proven technology (10+ Years) • Above and beyond relative to regulatory requirements (offset eligible) • Over 500,000 t CO_2e developed to date, worth $15M	• Not enough awareness – major O&G producers lost millions in carbon value • Measurement & metering requirements and analytical approaches required for offset generation

Case Study #2: D60 / Early Action on Solution Gas Venting

Solution Gas Capture and Destruction

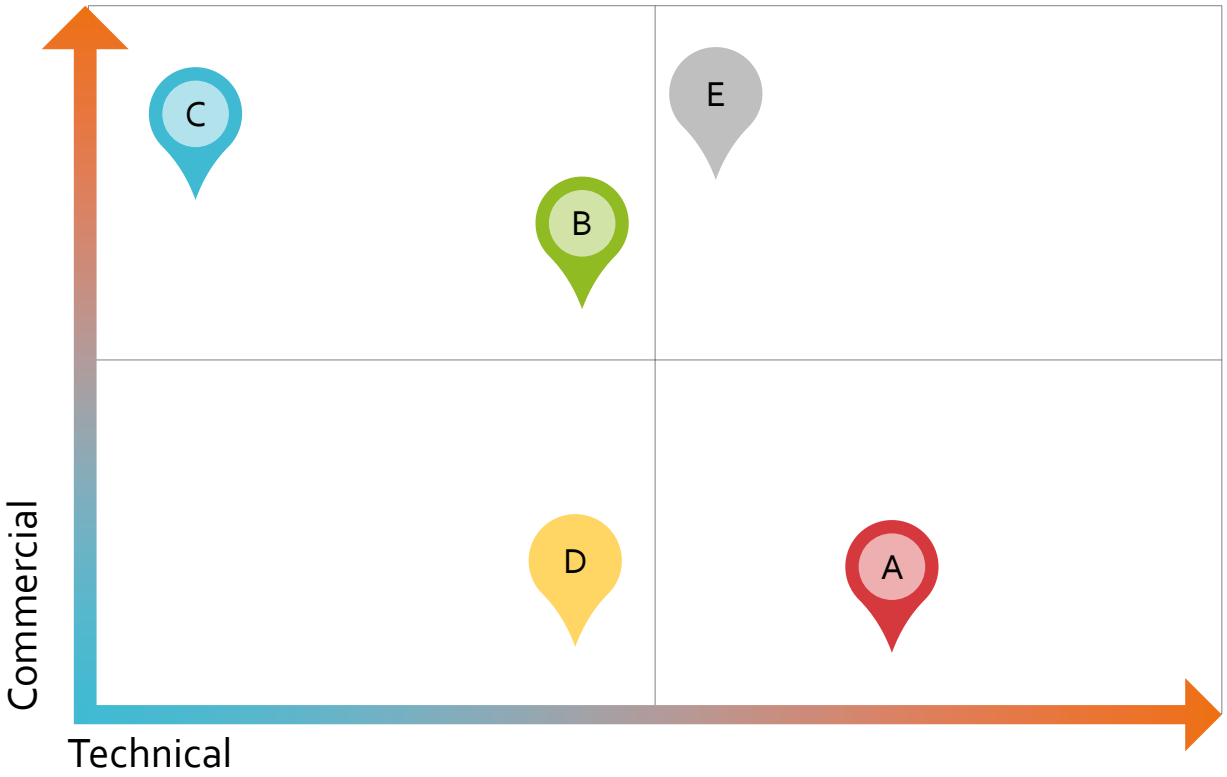
Abatement

80% Emissions Reductions

E.g. V3RU and BGR18 Combustor

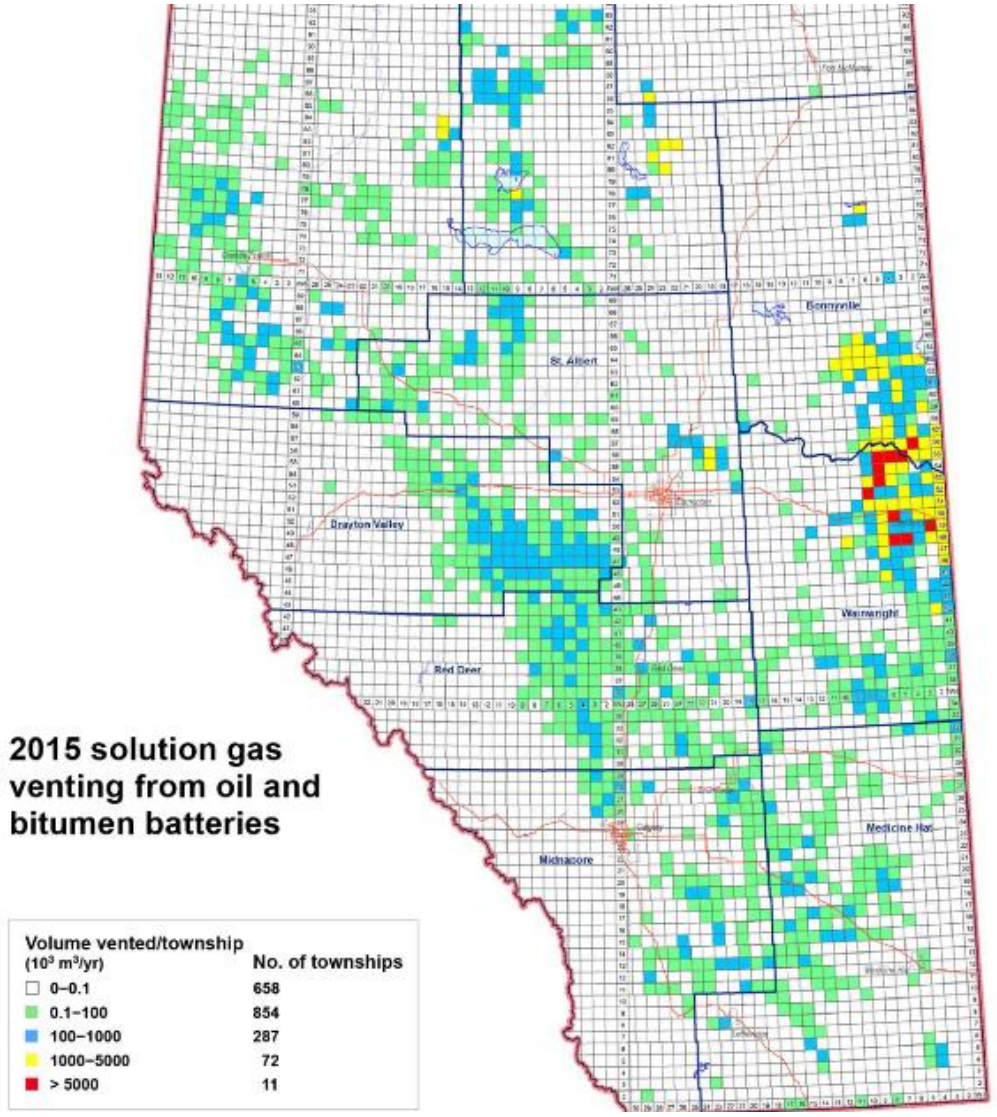
- Vent capture and combustion technologies reduce GHG emissions:
  - V3RU Gas Accumulator and BGR Combustor
- D60 (current) enforced down to 500 m^3/day
- Direct action towards addressing operations and regions with highest observed methane emission rates in Alberta (e.g. CHOPS, 3.6x higher)
- No business case without offsets – protocol in place for >5 years

Technology & Metering Challenges for Solution Gas Capture and Destruction



- **A** Technologies only recently becoming commercially available for addressing low flow/intermittent sources. Many challenges remain to achieve vent reduction targets.
- **B** Organizational focus is on addressing large vents and flares, which have their own – but different – challenges
- **C** Inconsistencies within Protocol, and between Protocol and D60
- **D** Low-flow, intermittent sources are very difficult to combust, uneconomical to "conserve."
- **E** Pneumatics protocol allows combustion, more technically feasible/mature options available but does not provide incentive for innovations to address low-pressure vent applications (<1 psi)

- **Red/Yellow:** Concentrated in CHOPS regions, but many of these townships are already regulated (may be subject to additional enforcement)
- **Blue pixels:** preliminary modeling suggests many contain targets
- **Green pixels:** must be near upper limit with only 1-2 sites per pixel



Solution Gas Capture and Destruction

Economics

$50,000 - $100,000

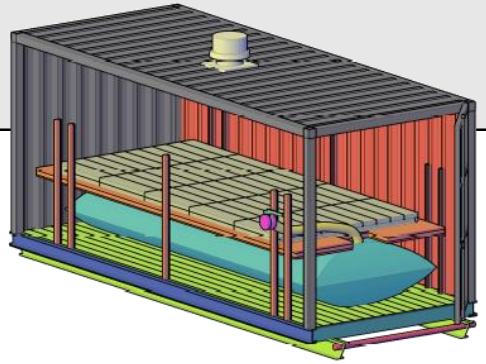
COSTS

Projects purely Offset-dependent

PAYBACK

8+ Months

Project Benefits	Project Challenges
• Proven off the shelf technology • Lots of potential project opportunities (60+ in upstream operations)	• Economics are completely dependent on offsets • Metering challenges, low-pressure & low-flow rates make it challenging, lots of potential technical barriers • Unclear offset protocol



Eligibility Discussions with Alberta Climate Change Office (ACCO)

- Solution Gas Conservation Protocol exists, has never been used due to various barriers
- Regulatory requirements focus on sites venting more than 500 m^3/day
  - Excludes fuel gas (pneumatics)
  - "The AER may investigate flared or vented volumes as low as 500 m^3/day **, or even lower,** if it appears that gas is stable"
  - "Conservation economics must be run every 12 months on flared or vented volumes of 900 m^3/day"
- While technology and innovation in low- and intermittent flow combustion progresses, substantial implementation barriers remain

ACCO: Enforce specific D60 language on eligibility of flaring and/or combustion as project condition; essentially, ability to combust proves ability to combust and therefore it becomes required

Case Study #3: Early Action Incentive for Pneumatic Control Instruments

Pneumatic Controller Replacement/Retrofit

Replacement

15% Emissions Reductions

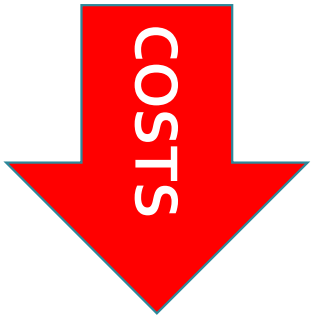
E.g. Fisher™ 4150 to Fisher™ C1

- More efficient technologies reduce GHG emissions:
  - Low- and No-bleed Pneumatic control instruments or pumps
- Proactive compliance with Federal or Provincial (pending) regulations
- Carbon offsets can improve payback from 8 years to 8 months
- Over 85,000 t CO_2e certified in Alberta by Cap-Op
- Finding and executing – efficiently – presents logistical challenges

High to Low- and No-Bleed Pneumatics Conversions

Economics

$250 - $12,000



+Gas savings
+Chemical Savings

6+ Months

Project Benefits	Project Challenges
• Proven off the shelf technology • Huge potential project opportunities remain (100,00+) • Clear regulatory incentive (required in both Federal and Draft Provincial Regs) • Benefits to reliability and compliance with CSA standards in some cases	• Data collection and logistics of organizing micro-projects over vast distances • Economics of projects can be severely impacted by efficiency • Measurement campaigns and emission factor development • Protocol was 4+ years in development

Pneumatics Offsets – Results Summary

First-ever Compliance-Grade Pneumatic Offsets	
Pumps	• Over 900M strokes • ~200 pumps replaced • Over 22,000 t CO_2e • 3 to 144 t CO_2e per pump • Pumps with stroke counters averaged 4x more credits
Control Instruments	• Nearly 6M venting hours • >800 control instruments replaced • Over 64,000 t CO_2e • 20 to 146 t CO_2e per controller • No 8760 venting hours/year
Overall	• >6,000 e^3m^3 saved = $? $400k? • 86,477 t CO_2e = $2.59M • Capital Costs est. $3.5M-$4M • Simple payback 12-14 months • Actual time between costs and return 8+ years

Data Requirement Examples for a Typical Project

Site Ownership

Make/Model

Serial Number

Inspection & Maintenance Logs

Replacement dates

ASSET DATA

OPERATION DATA

Hours of Operation

Stroke Count or Volume Injected

Flow Meter Reading

Gas Analysis

Destruction Efficiencies

Emission Reduction Potential of Distributed Projects

GHG Emitting Equipment	Total Alberta Equipment Count	Estimated Eligible Alberta Equipment Count	GHG Efficient Alternatives	Average Emissions Reduction (annual)	Average Capital Cost (Installed)	Estimated Total GHG Reduction Potential
High-bleed instruments	369,067	115,000	Low-bleed instruments	40 tCO_2e	$1,000 - 2,500	4,600,000 tCO_2e
Pneumatic Pumps	172,302	150,000	Low/No-bleed pumps	75 tCO_2e	$10,000 - 25,000	11,250,000 tCO_2e
Solution Gas Capture	19,000	8,000	Well site vent gas capture	500 tCO_2e	$20,000 - $60,000	4,000,000 tCO_2e
Vent gas (Engines)	31,968	10,000	Vent gas capture	1000 tCO_2e	$50,000 - $250,000	10,000,000 tCO_2e
Natural gas combustion engines	31,968	6,000	Air-fuel ratio controllers	600 tCO_2e	$150,000 - $300,000	3,600,000 tCO_2e
Total						**33 million tCO_2e**

Source: Cap-Op Energy, Alberta's Upstream Oil & Gas Assets Inventory Project – Opportunities to Reduce GHG Emissions, 2013.

Other ideas: PTAC Energy Efficiency Handbook

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

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

5.1.1. Spartan Controls Ltd. – REMVue Air-Fuel Ratio (AFR) | July 31, 2017

Description

REMVue® Air-Fuel Ratio 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 stand-alone control system, or it can be integrated with other hardware or software systems. The REMVue®-AFR can be applied to a wide variety of rich burn or lean burn engines, resulting in an average of 15% fuel savings, improved runtime, and reduced NOx emissions (MSAPR compliance levels).

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 CO_2e 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 $40,000 to $60,000 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.

PTAC CANADIAN UPSTREAM OIL & GAS ECO-EFFICIENCY EQUIPMENT AND OPERATIONS HANDBOOK | 1
ACCESSIBLE ONLINE AT: HTTPS://WWW.PTAC.ORG

https://www.ptac.org/canadian-upstream-oil-and-gas-eco-efficiency-and-operations-handbook-2/

1

Mechanism for early action incentive towards proactive compliance and monetize environmental leadership

2

Off-the-shelf technology is available today to enable forward compliance with high level of reliability

3

Incentives won't last forever – acting soon is the only way to ensure maximum cost recovery

Profitable Methane Abatement Key Take-aways

Questions?

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