

United States Environmental Protection Agency (EPA)
Coalbed Methane Outreach Program Webinar

Ventilation Air Methane Projects in the United States: Barriers and Potential Opportunities

February 27, 2020



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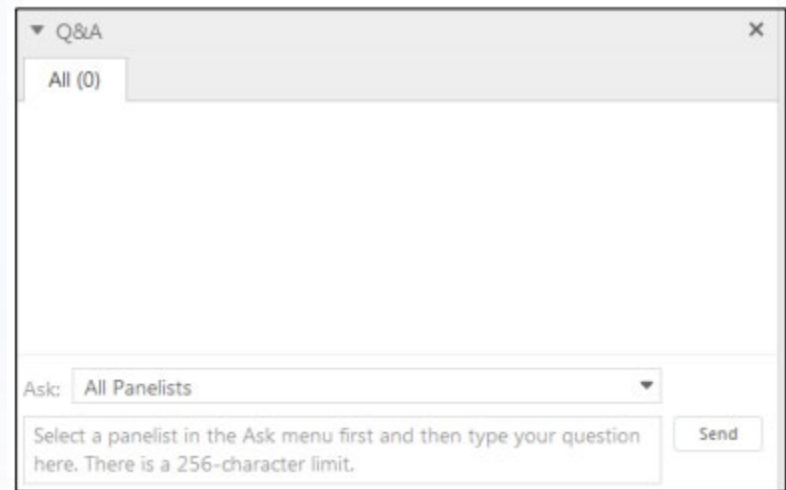
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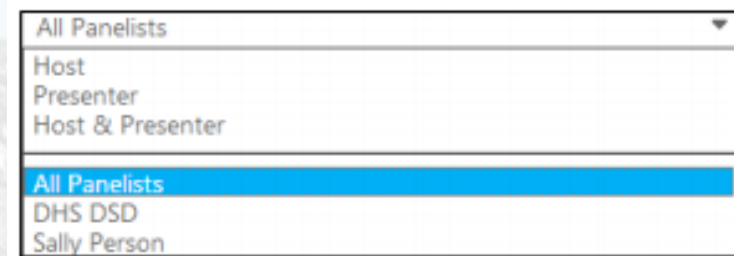
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Agenda

- Agenda
 - Volha Roshchanka, U.S. EPA Coalbed Methane Outreach Program
 - Michael Cote, Ruby Canyon Engineering
 - Dominique Kay, Biothermica
 - Chad Clark, Gulf Coast Environmental Systems
- Question and Answer Session



The views expressed by speakers on this webinar are solely those of the participants and EPA does not endorse any products or commercial services mentioned in this webinar.



Overview of the Coalbed Methane Outreach Program



Volha Roshchanka

**U.S. Environmental Protection Agency
Coalbed Methane Outreach Program**



**Coalbed Methane Outreach Program Webinar
February 27, 2020**

U.S. EPA's Coalbed Methane Outreach Program (CMOP)



- Our Focus

- Greenhouse gas emission reduction opportunities: coal mine methane (CMM) rather than coalbed methane (CBM)

- Our Mission

- Work with private sector to cost-effectively reduce CMM emissions through recovery and use projects

- Our Activities

- Identify profitable opportunities for CMM recovery
- Identify and help overcome market, regulatory, and technical barriers
- Offer technical and analytic support where appropriate
- Conduct direct outreach to coal mines





CMOP Resources

- CMOP Website (www.epa.gov/cmop)
 - Many resources, tools, and information related to ventilation air methane (VAM)
- Resources Updated in 2019
 - Webinar: [Abandoned Mine Methane as an Energy Source](#) (October 2019)
 - White paper: [Ventilation Air Methane \(VAM\) Utilization Technologies](#)
 - White paper: [Coal Mine Methane \(CMM\) Finance Guide](#)
 - Report: [Coal Mine Methane Recovery at Active and Abandoned U.S. Coal Mines: Current Projects and Potential Opportunities CMM Developments in the United States](#)
 - Report: [Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines \(2002-2016\)](#)
 - White paper: [Emerging Incentives for the Development of CMM Emission Reduction Projects](#)
 - White paper: [State Renewable Energy Programs](#)



State of the Ventilation Air Methane Abatement Industry and Potential Opportunities in the United States



Michael Coté
Ruby Canyon Engineering, Inc.

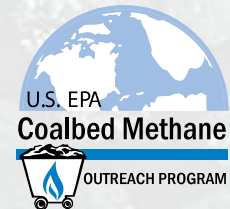


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Global Summary

VAM Emissions

- Coal mines account for approximately 9% of global anthropogenic methane emissions representing 900 million tonnes of CO₂e*
 - China, U.S., Russia, Australia, Ukraine, Kazakhstan, India, Poland
- VAM makes up about 70% of all coal mine methane emissions
- Shaft flows range from 300,000 – 1,200,000 ft³/min
- All commercial-scale VAM abatement projects employ regenerative thermal oxidation (RTO) technologies
- VAM projects continue to face technical, safety, policy, and financial barriers
- As of 2020, there are only 3 VAM projects operating globally including 1 in the United States



*Source: https://www.epa.gov/sites/production/files/2019-09/documents/epa_non-co2_greenhouse_gases_rpt-epa430r19010.pdf

CO₂e: Carbon dioxide equivalent

Global Barriers to VAM Project Development

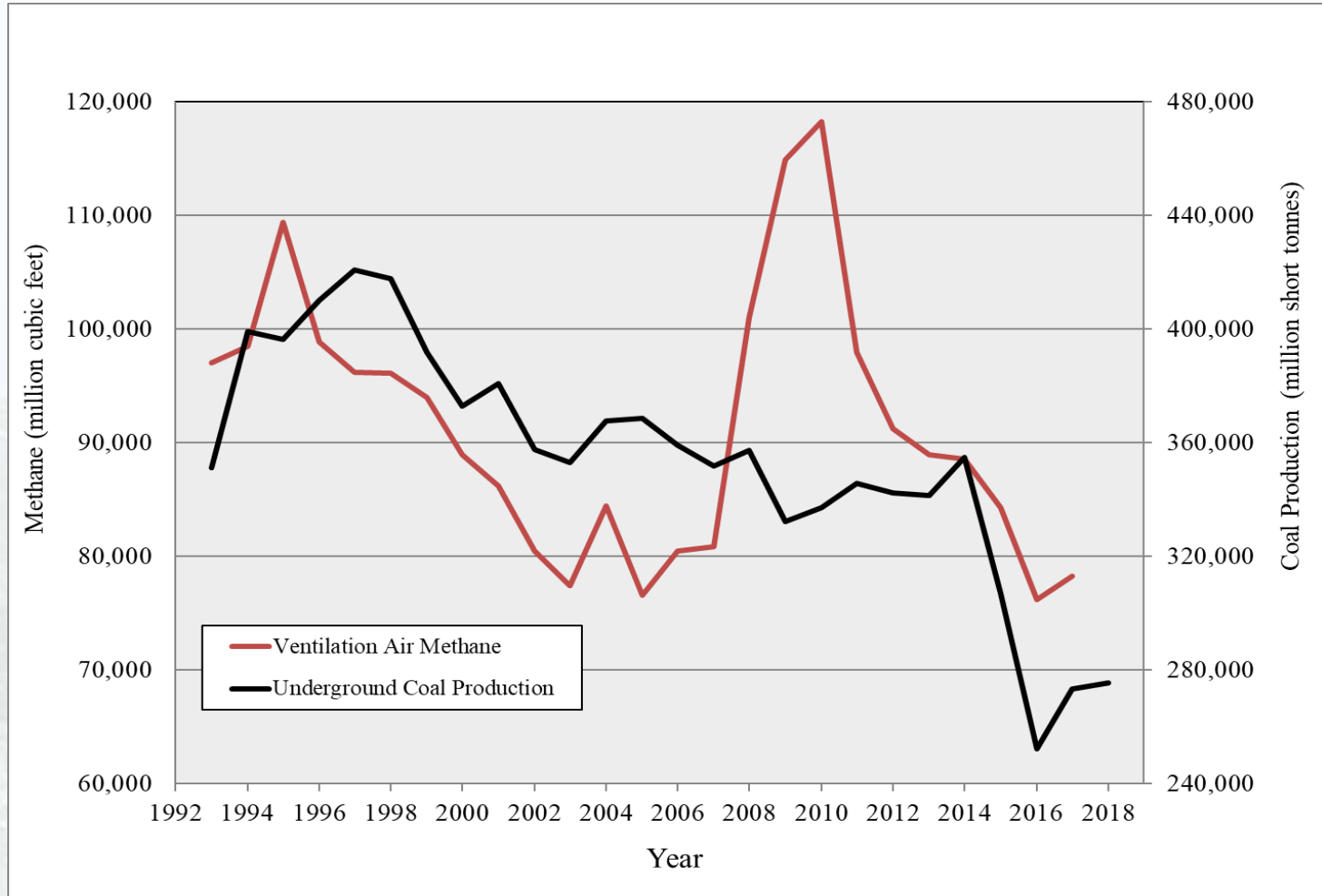
- In 2018 the Global Methane Initiative, a voluntary public-private partnership, brought together private sector mining companies, partner country government representatives, technology vendors, and others to discuss barriers to global VAM projects
- Top needs identified:
 - Address safety concerns, including:
 - Perception of potential ignition risk caused by oxidation of VAM (not settled in Australia)
 - Potential disruption to the coal mine (caused by back pressure on the fan)
 - Address policy and legal concerns:
 - Financial incentives and regulatory requirements
 - Coal Industry emissions targets
 - Address market and economic barriers:
 - The economics of energy recovery from VAM projects are challenging
 - Consider a range of potential incentives that could make the economics more profitable, including carbon credits, carbon tax, subsidies, tax credits, and green tariffs

Worldwide VAM Project Deployment

- Early Pilot Projects Deployed in the U.S., U.K., and Australia
 - U.K. – British Coal: 1994 (3 months)
 - Australia – BHP Billiton: 1997 (12 months)
 - U.S. – Consol abandoned mine: 2007 (18 months)
- Large Scale VAM Installations Beginning in 2007 in Australia, China, and U.S.
 - Australia – WestVAMP Electric Power Project: 2007 - 2016
 - China – ZhengZhou Abatement/Hot Water Project: 2008 - 2012
 - U.S. - Blue Creek No. 4 VAMOX Abatement Project: 2009 – 2013
 - China – SongZao Abatement/Hot Water Project: 2011 – 2016
 - China – DaTong Power Project: 2012 – 2016
 - U.S. – Marshall County Abatement Project: 2012 – *current*
 - China – GaoHe Power Project: 2015 – *current*
 - China – Sangzhang Power Project: 2019 – *current*
 - China – Gucheng Power Project: *2020 -*

VAM Opportunities in the United States

U.S. VAM Emissions versus Underground Coal Mine Production (1993-2018)



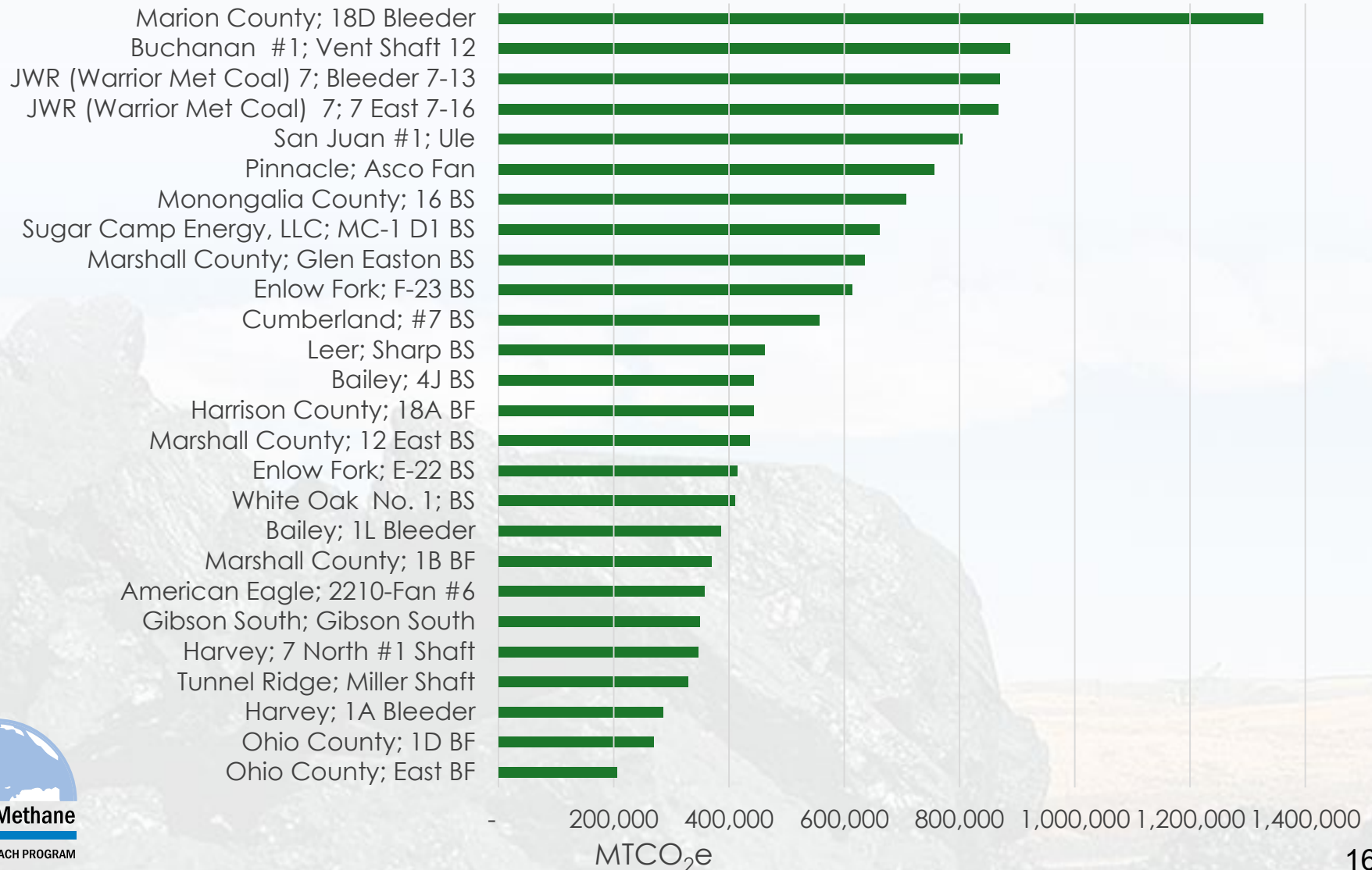
U.S. EPA (2019): Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017

Where are the VAM Recovery Project Opportunities in the United States?

- VAM abatement projects must be evaluated beyond total VAM emissions at the coal mine: they must consider concentrations at the mine shaft level
- A relatively small number of mines make up the most opportunities:
 - Approximately 70% of the high concentration coal mine shafts are located in Central and Northern Appalachian Coal Basins
 - According to the 2017 U.S. greenhouse gas (GHG) emissions inventory: 90% of U.S. VAM emissions comes from **42 coal mines** with emissions > 1 million ft³/day
- EPA studied U.S. coal mine methane shafts that might be good candidates for a VAM recovery project
 - A 2015 CMOP study found 28 U.S. coal mines with VAM emissions > 1 million ft³/day and at least one shaft with > 0.4% methane concentration (totaling 42 shafts)
 - <https://www.epa.gov/cmop/us-underground-coal-mine-ventilation-air-methane-exhaust-characterization>
 - Approximately 25 high-concentration shafts make up 20% of U.S. VAM emissions
 - Overall shaft level opportunities decreased from 2015 to 2018, but still represent more than 8 million metric tonnes CO₂e annually

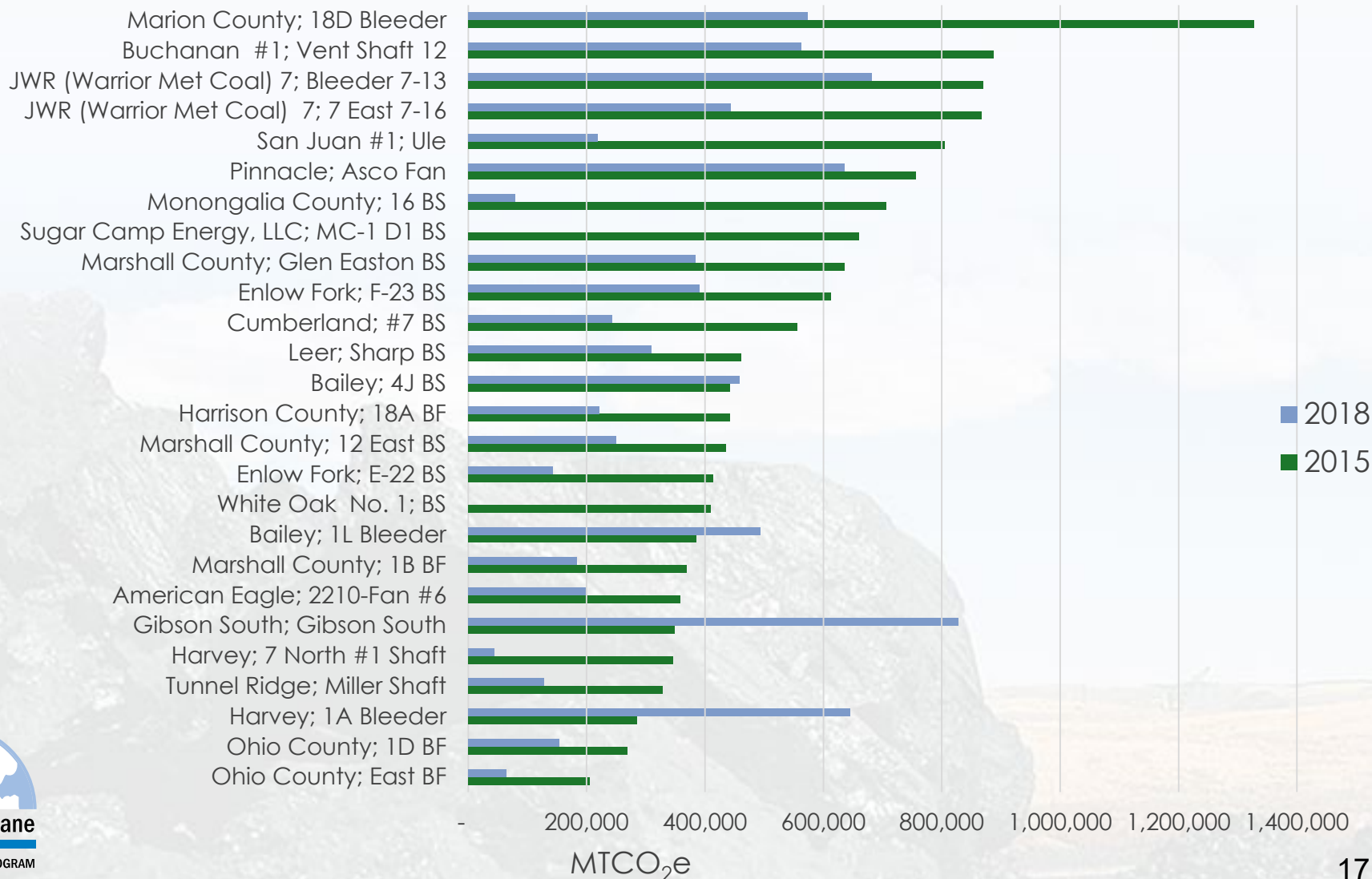
High Concentration Coal Mine Shaft Data- Comparison of 2015 and 2018 Emissions

2015 Mine Shafts

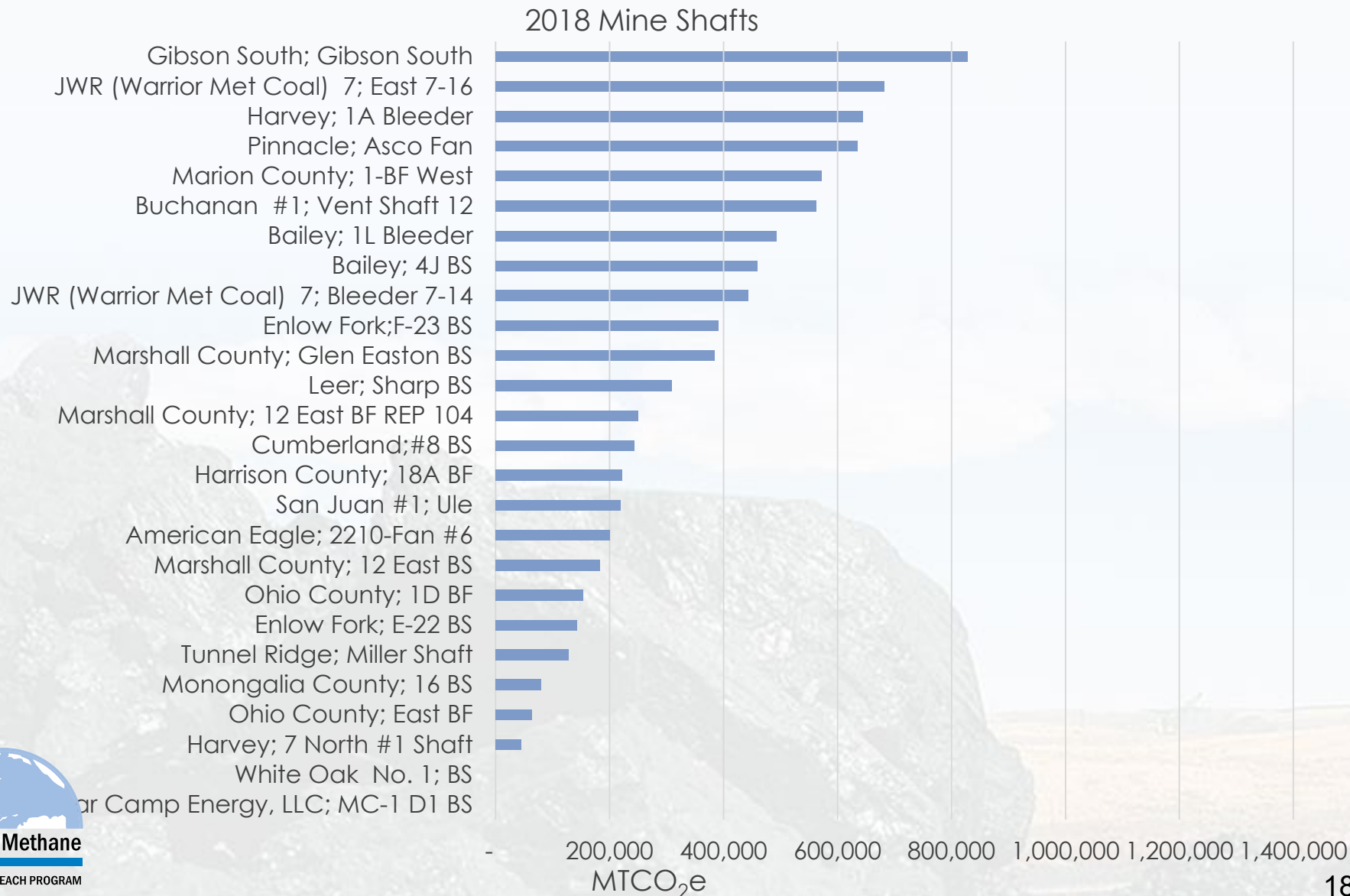


High Concentration Coal Mine Shaft Data- Comparison of 2015 and 2018 Emissions

2015 vs 2018 Mine Shafts

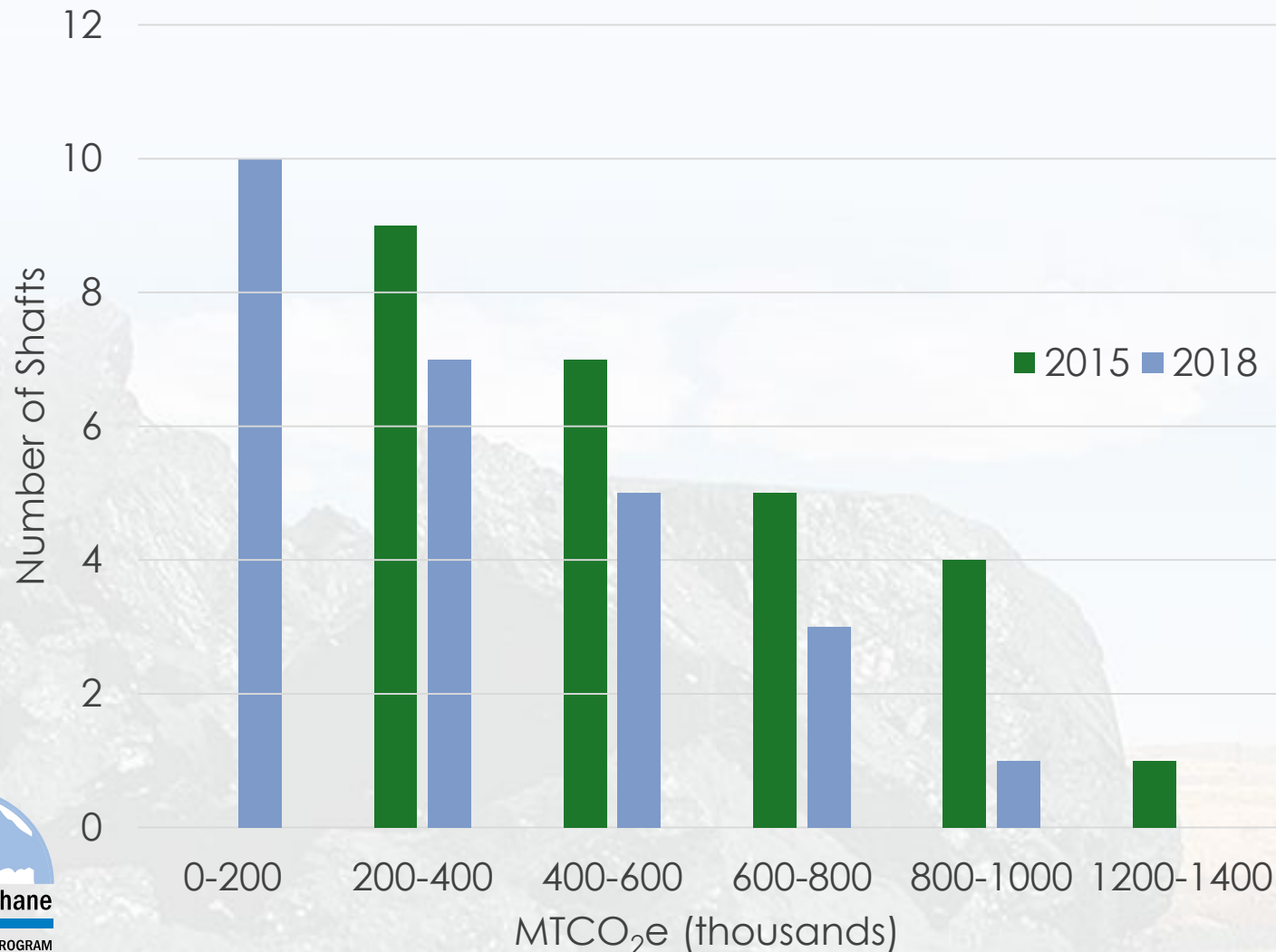


High Concentration Coal Mine Shaft Data-Comparison of 2015 and 2018 Emissions



High Concentration Coal Mine Shaft Data- Comparison of 2015 and 2018 Emissions

Mine Shafts by Size



Steps Towards Achieving More VAM Projects in the United States

- Assess the Overall VAM Opportunity
 - Potential emission reduction benefits
 - How much investment is needed?
- Address Policy and Legal Concerns
 - Mapping regulatory or gas ownership barriers
 - Role of coal mine methane offsets in voluntary and compliance carbon programs
- Address Market and Economic Barriers
 - What incentives besides carbon credits work?
 - Engage carbon finance community
 - Improve technology efficiencies and marginal costs with scale

Contact Information

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Barriers to Ventilation Air Methane Abatement Project Development in North America



Dominique Kay
Biothermica



Coalbed Methane Outreach Program Webinar
February 27, 2020



Outline

- **Vamox[®] RTO Technology**
- **Progress Made and Remaining Technical Barriers**
- **Incentives to Implement VAM Projects**
- **Projects Barriers in North America**
- **Projects Opportunities**

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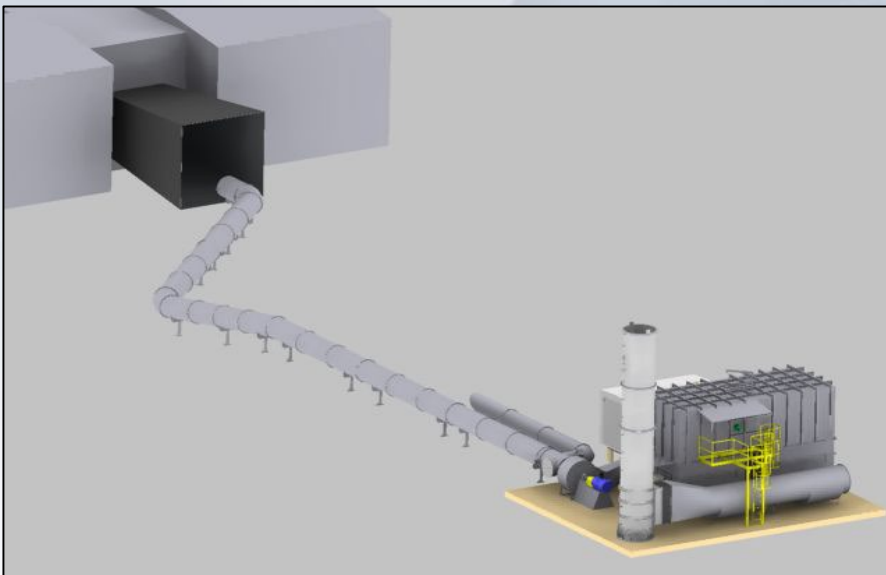


Vamox[®] RTO Technology



First VAMOX[®] RTO Project 2009-2013

- Walter Energy, No. 4 Mine (shaft 4-9), Brookwood, AL
- 1st VAM abatement project at an active U.S. coal mine
- Capacity → 30,000 scfm (10% of VAM flow captured)
- Methane (CH₄) Range → 0.3% - 1.2%
- 81,000 offset credits sold on Quebec-California Market





Large Scale VAMOX[®] System

- Flow capacity → up to 140,000 acfm (~238,000 m³/h)
- %CH₄ range → 0.3% - 1.2%
- Methane destruction efficiency → 97%
- Size, flow capacity and CH₄ range can be customized
- Credits @0.9%CH₄ → ~260,000 ktCO₂e/year
- Residual heat can be valued to provide additional income streams



Acfm: Actual cubic feet per minute
Nm³/h: Normal cubic meters per hour
ktCO₂e: Kilotonne of carbon dioxide equivalent

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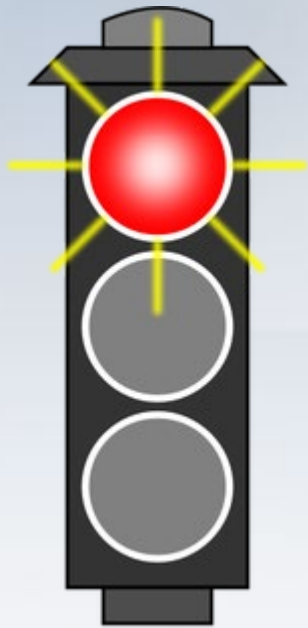


**Progress Made &
Remaining Technical Barriers**



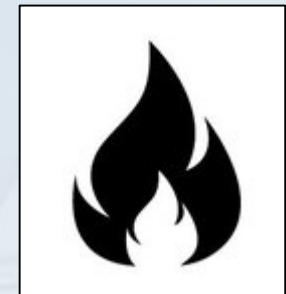
Safety is No Longer Holding Back Projects in North America

- Coal industry is gaining confidence in the safety of VAM abatement projects



~12 years ago

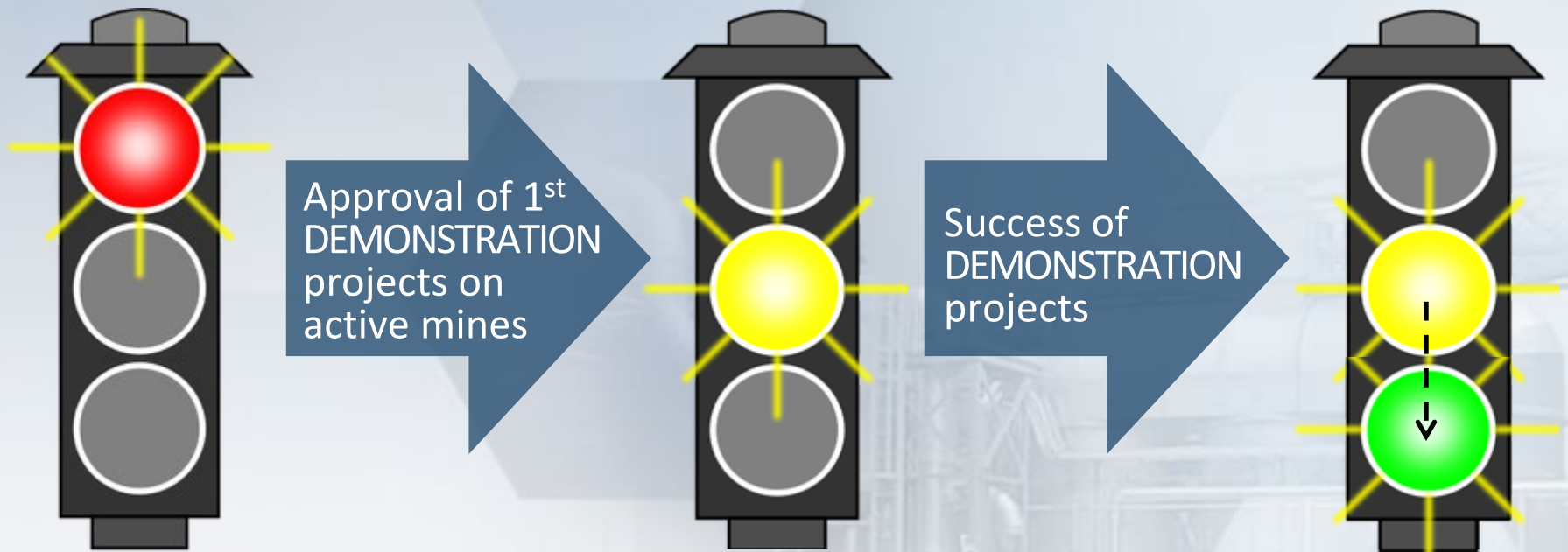
- **Main initial concerns:**
 - Risk of ignition
 - Risk of flashback to the mine
 - Disruption of mine ventilation capacity





Safety is No Longer Holding Back Projects in North America

- Coal industry is gaining confidence in the safety of VAM abatement projects



~12 years ago

Mine Safety and Health Administration (MSHA) approves on a case-specific basis

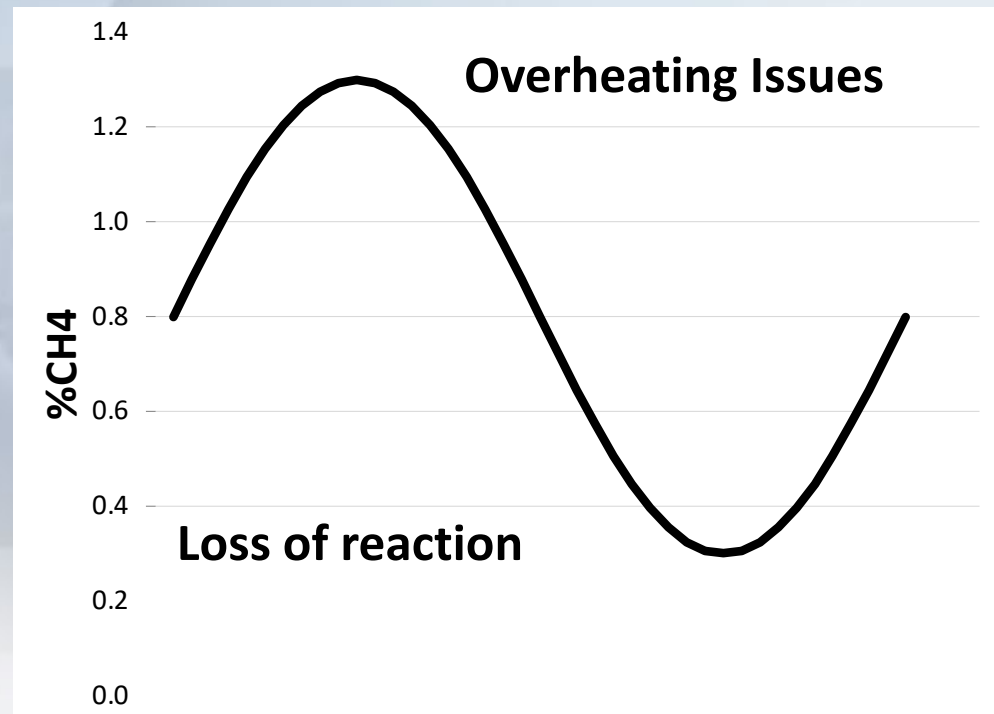


Technical Lesson Learned From Demonstration Projects

- RTO Design and Control strategies have been developed to handle fluctuations in $\text{CH}_4\%$

Challenges:

- ...at **HIGH** $\text{CH}_4\%$:
 - Prevent T° peak to compromise the integrity of the system
- ...at **LOW** $\text{CH}_4\%$:
 - Maintain RTO in operation without supplemental energy input (e.g., propane)





Remaining Technical Barriers

- **Implementing projects in hilly locations**
 - In some cases, no space at all available to host a VAM project



- **Handling VAM with very high level of particles**
 - In North America, dust level is typically not an issue
- **Generating high-grade heat or electric power when VAM concentration can't be stabilized**

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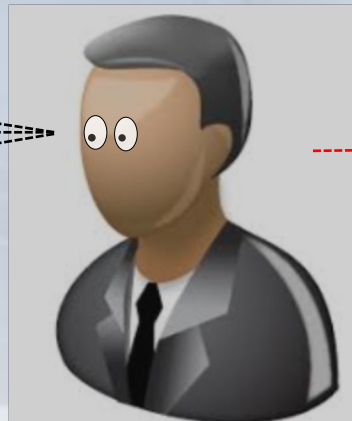
Incentives to Implement VAM Projects



Challenge:

Draw the Attention of Coal Mines

- At this time, VAM emissions are not limited or capped in most jurisdictions
- Coal mines focus on their core business. Why would they be interested in VAM project?



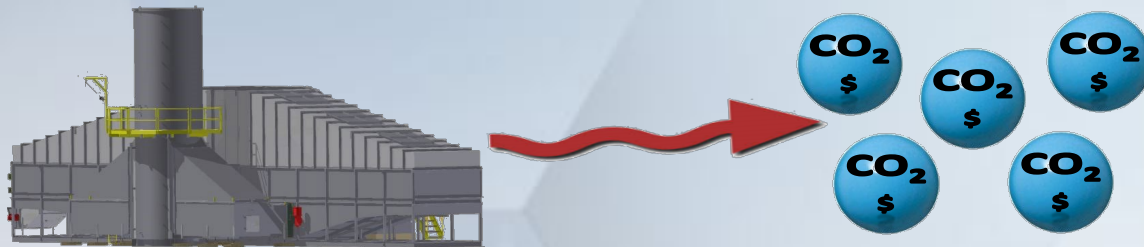
**VAM
PROJECT**



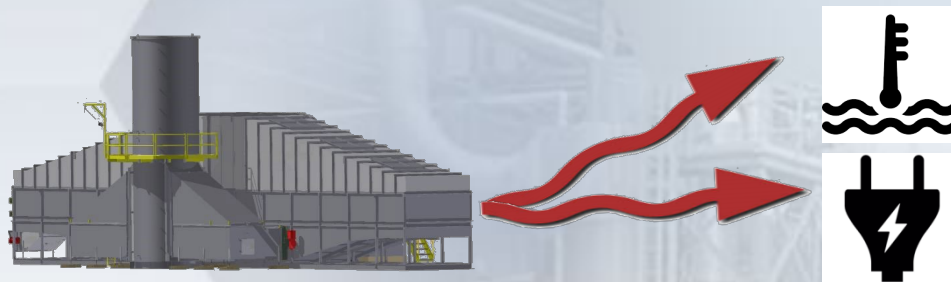
VAM Project Incentives

- **Two possible income streams**

1. Carbon credits (or carbon tax saving)



2. Energy production (heat and/or electric power)



- **Environmental footprint is becoming a selling point for mines**

- i.e., steel end-users such as car manufacturers are now carrying environment audits at Metallurgical (MET) coal mines

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Project Barriers in North America



Barriers to Energy Production

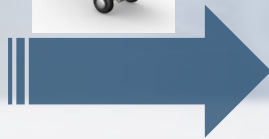
- **No need of thermal heat nearby VAM plant**
 - Most vent shafts are remotely located



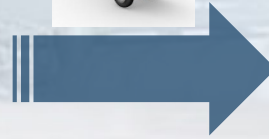
- **Shafts typically operational only 3-7 years**
 - Relocation of waste heat recovery system is costly



Shaft #1 (3-7 years)



Shaft #2 (3-7 years)



- **Limited availability of CMM to enrich and stabilize VAM**
- **Utility rate too low to provide appealing internal rate of return**



Carbon Project Opportunities Limited to USA

- **USA and Canada:** The only 2 jurisdictions in the world where offset carbon price is sufficiently high (~US \$15/tCO₂e)
- **CANADA:** No VAM project opportunities
- **USA: Only viable market**
 - 236* active underground coal mines
 - Due to the pressure applied on thermal coal market (long-term future uncertainty), MET coal mines are perceived as more appealing and are thus targeted in priority



U.S. MET COAL MINES

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Why have there been no VAM projects in the United States since 2012?

- The stars have not been aligned

MMC
PROTOCOL

CARBON
PRICE

POLICY
CERTAINTY

HEALTHY
COAL
BUSINESS

VENT SHAFT
WITH %CH₄↑
AND SPACE

- **2013-14:**
 - Wait for the Adoption of The Mine Methane Capture (MMC) Protocol by the California Air Resources Board (legally adopted in July 2014)
- **2015:**
 - Economic crisis in U.S. coal market (mines at risk of bankruptcy)
- **2016-2017:**
 - Uncertainty of Cap-and-Trade policy post 2020

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The Sky is Clearing Up ...



The Stars are Finally Aligned for VAM Projects!

- Proven safe and efficient RTO technologies available
- Quebec-California Cap-and-Trade Program extended to 2030
- Healthy U.S. coal market (especially MET coal)
- Good offset price (~15\$US/tCO₂e) → appealing income stream for project developers AND coal mines
- Many potential vent shafts with %CH₄ > 0.5%
- Increasing global mobilization to reduce GHG emissions → « greener » coal mines could get more sales opportunities
- The next challenge → Get the mines involved
 - Some mines are understaffed following coal market recovery so human resources are fully devoted to coal operation (little time for VAM Projects)
 - Our Mission: help mines to foresee the great value of VAM project

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Thank you!

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Barriers to Coal Mine Methane Abatement Project Development in North America



Chad Clark
Gulf Coast Environmental Systems



Coalbed Methane Outreach Program Webinar
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Gulf Coast Environmental
Systems

Barriers & Incentives for Coal Mine Methane Abatement Project Development in **North America**

BY. CHAD CLARK

TECHNICAL DIRECTOR

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GULF COAST ENVIRONMENTAL SYSTEMS (GCES)

Barriers / Incentives



Barrier: Electric sales don't make sense



Barrier: Inconsistencies and lack of understanding in carbon taxes, markets, and incentives



Incentive: funding opportunity – state-by-state participation adoption



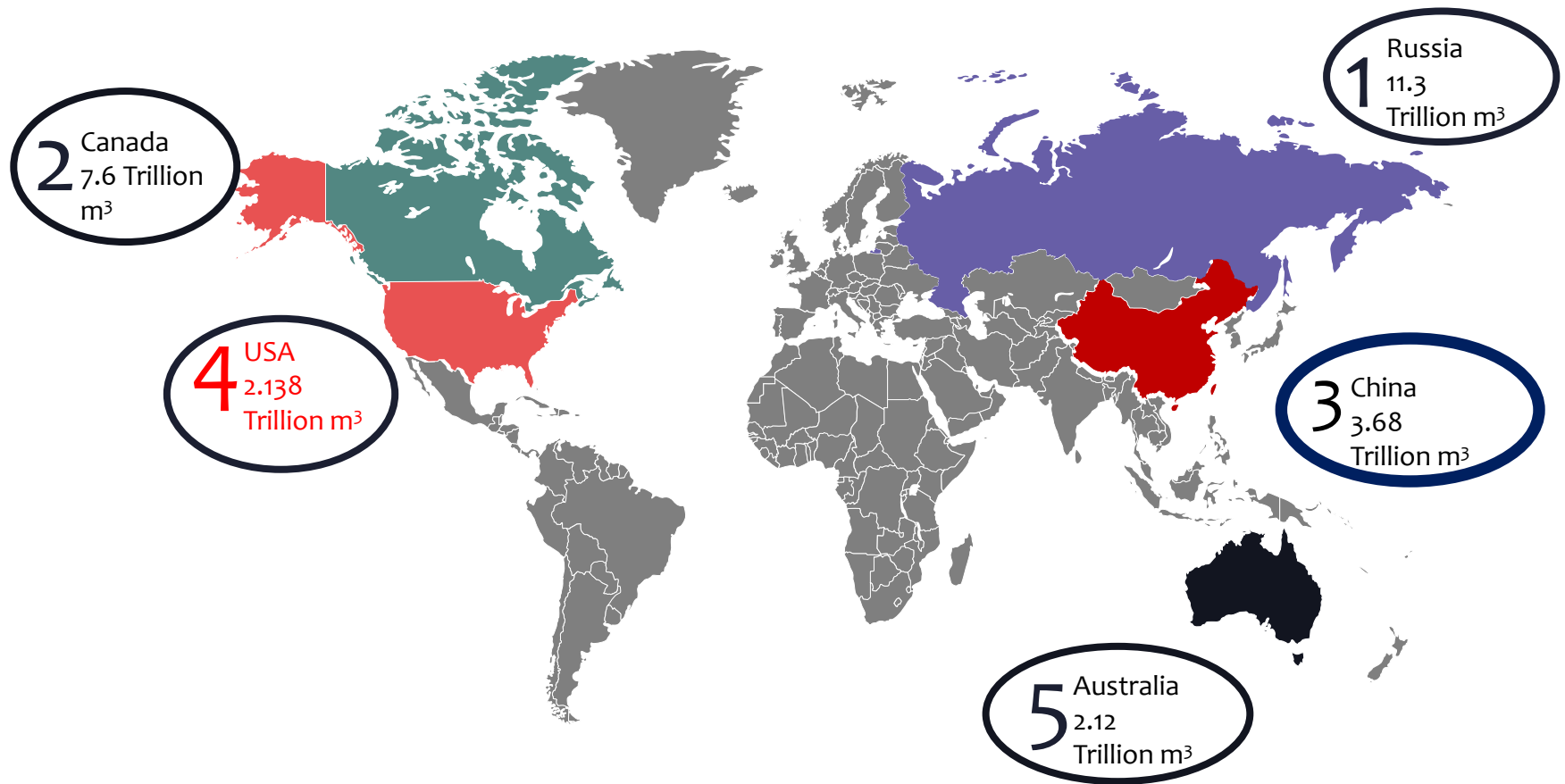
Incentive: Funding opportunity – 45Q



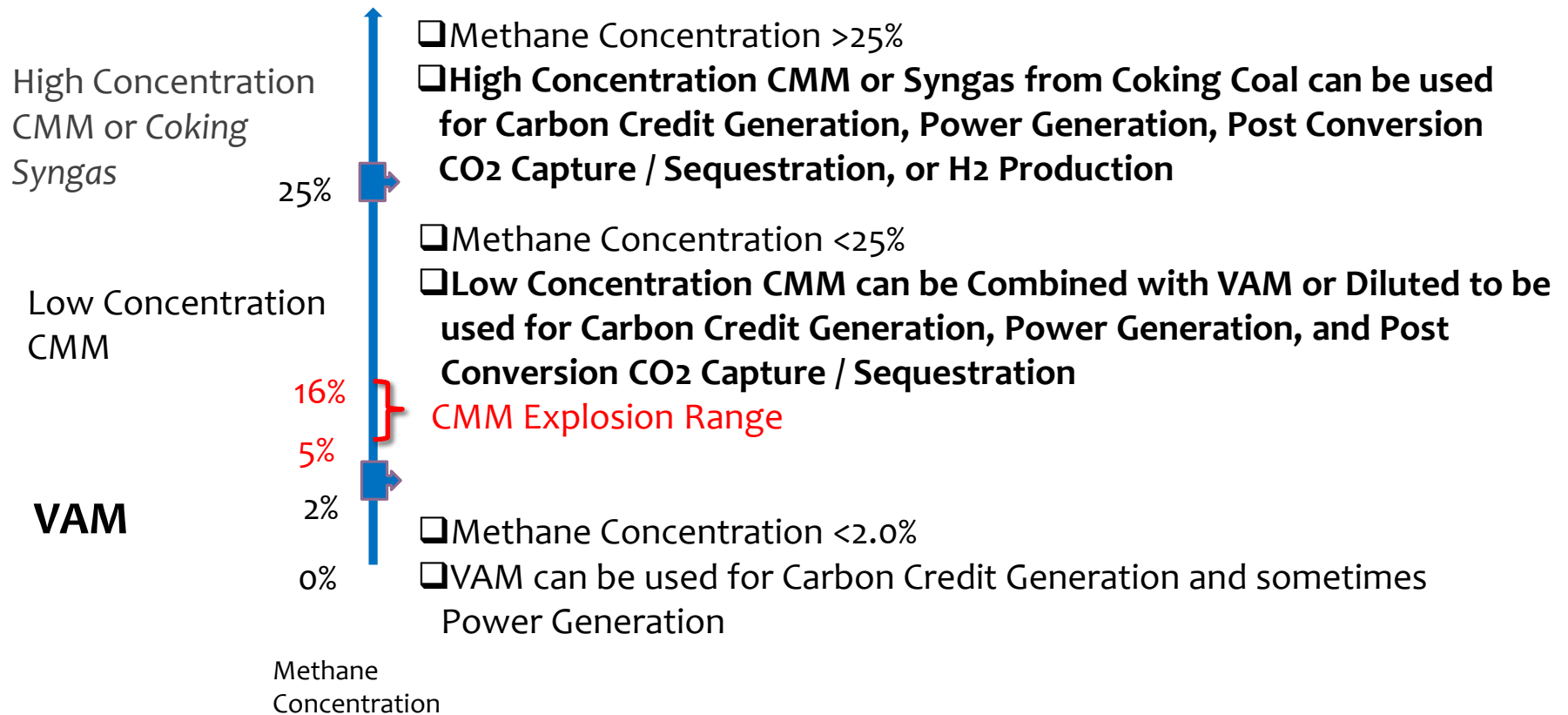
Finding a partner that can help manage VAM projects, and educate mine owners on the opportunities and funding mechanisms, as well as the value of the technologies available

Global Coal Mine Methane Reserves

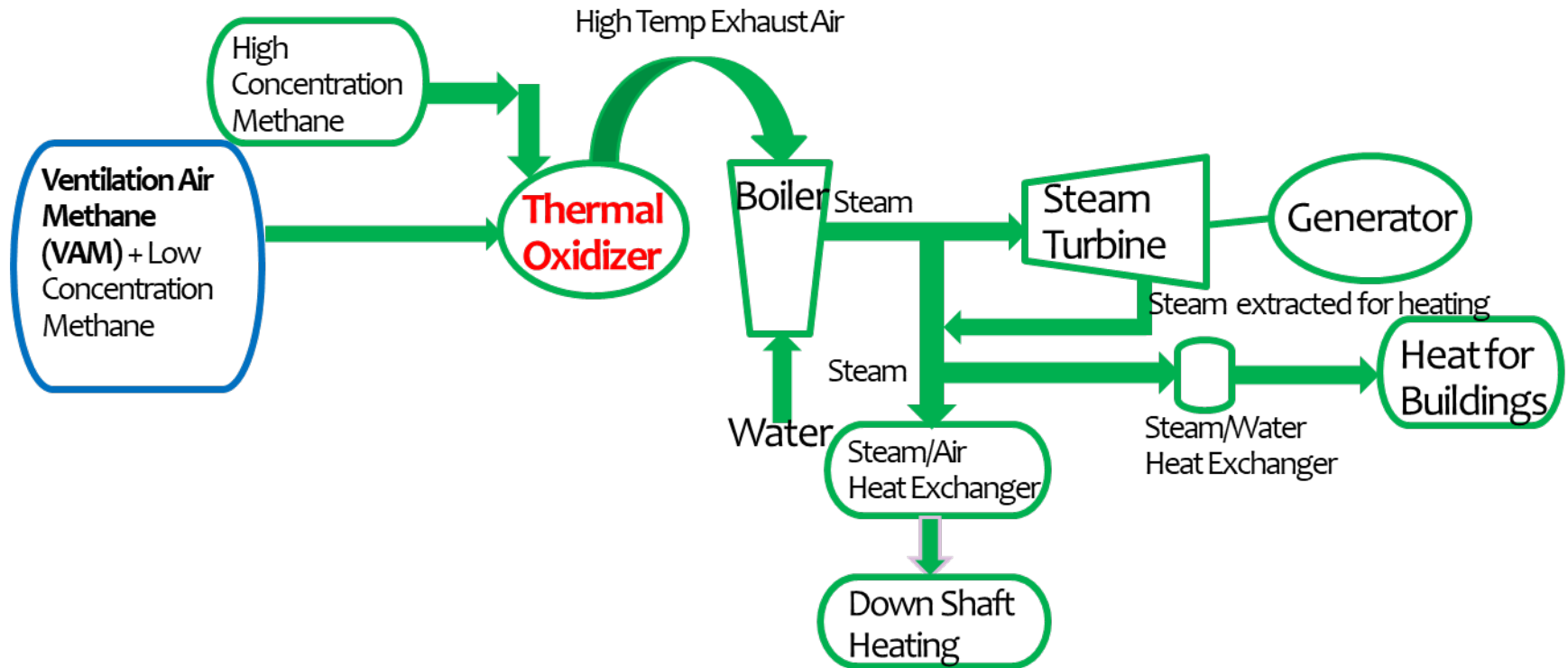
Such a large quantity presents huge opportunity



CMM/VAM Potential Uses

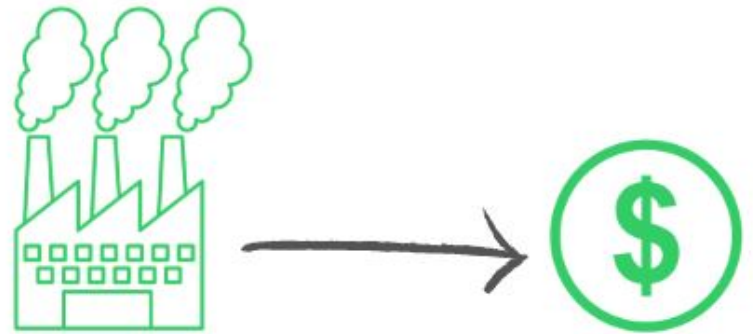


CMM/VAM Oxidation & Electricity/Heat Co-generation



Barrier: Electric Generation Doesn't Make Sense...

Many locations around the United States have such low electrical costs that the return on investment for power generation does not make sense.



Electricity sales at U.S. \$0.10 per kilowatt hour (kWh) and above starts to bring money to the table.

Barrier: Inconsistencies in Carbon Markets

The inconsistencies in carbon pricing and regulations on a regional and global level often lead to a lack of faith and interest in CCM abatement projects.

Carbon Market Pricing Instruments

- **Carbon Tax:** Puts a direct price on emissions and requires payment for every carbon ton of pollution emitted.
- **Emissions Trading Systems:** Also called a cap and trade system, sets a limit (cap) of total emissions allowed in a region or sector. This design sets up a market where the rights to emit are traded.
- **Results-Based Climate Finance:** This setup allows organizations and facilities to receive funds when they meet pre-defined goals related to climate action, like a reduction in emissions over a certain time period.
- **Credit Mechanism:** Under this framework, reductions in emissions that occur as the result of a project completed by a business or government entity, are assigned credits, which can be sold or purchased.
- **Internal Carbon Pricing:** allows governments, businesses, and other entities to assign their own price to carbon, and factor it as part of their investment and business strategy.

Incentive: Funding Opportunity Adoption of State Participation

States with Carbon Taxes or Market Participation

1. California
2. Connecticut
3. Delaware
4. Maryland
5. Maine
6. Massachusetts
7. New York
8. New Hampshire
9. New Jersey
10. Vermont
11. Rhode Island
12. California
13. Washington



Source: priceoncarbon.org

*** Many markets, like California's, present an Incentive, but with very specific challenges and limitations

Incentive: Funding Opportunity: 45Q Tax Incentive

- 45Q is a section of the U.S. tax code that provides a performance-based tax credit for carbon capture projects. The credits can be claimed when an eligible project has:
 - Securely kept the captured CO₂ in geologic formations (i.e., oil fields and saline formations)
- **OR**
- Used captured CO₂ or its precursor carbon monoxide (CO) as a feedstock to produce fuels, chemicals, and products such as concrete, in a way that results in emissions reductions as defined by federal requirements.
- The method and technology in which pollution control equipment treats CMM can create a recoverable CO₂ that can be repurposed in multiple ways, like:
 - Enhanced oil recovery
 - Food and beverage grade CO₂

Finding the right partner

Due to the varying emissions regulations and market conditions, the idea of taking on a CMM project can be daunting. Understanding the options available, and the strengths each brings, can make this process easier. The best way to do this is to find a partner that is capable of managing every part of the project.



A CMM/VAM project partner should:

1. Provide a cost-analysis on the project
2. Counsel on potential funding opportunities
3. Advise on local, state, regional, and federal regulations and incentives
4. Be knowledgeable on available markets
5. Provide the equipment and technologies
6. Purchase or advise on buyers of potential recovered materials, such as food and beverage grade CO₂



Question and Answer Session



To learn more about CMOP, visit:

www.epa.gov/cmop

To connect with CMOP, visit:

www.epa.gov/cmop/forms/contact-us-about-coal-methane-outreach-program

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