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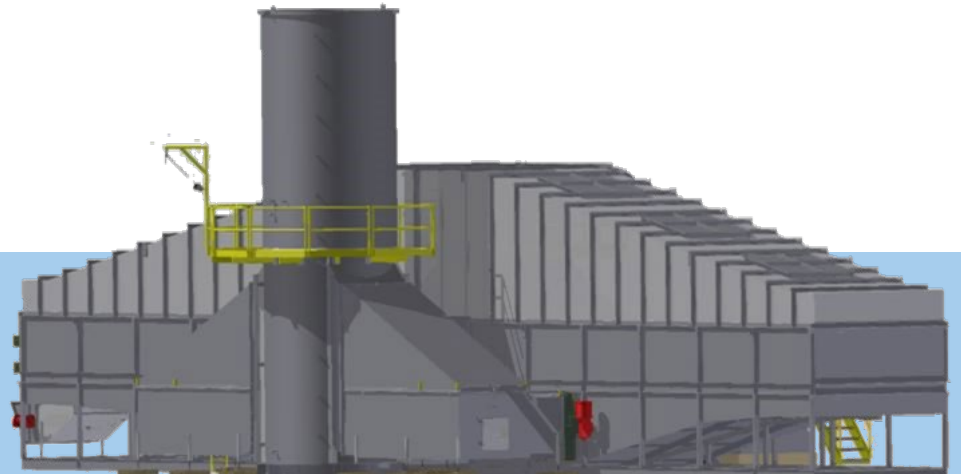
VAMOX® RTO System For The Abatement of VAM Emissions

Challenges, Projects Implementation and Expansion around the World



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- Private company founded in 1987
- 3 main lines of business
  - Air pollution control technologies (VAMOX®/BIOTOX®)
  - Landfill gas evaluation, capture and valorization services
  - Climate mitigation infrastructures – landfill gas/coal mine methane
- Developer of landfill/coal mine methane abatement/valorization projects




Mission
We build a carbon neutral world

Vamox® RTO coal mine methane (Virginia, USA)

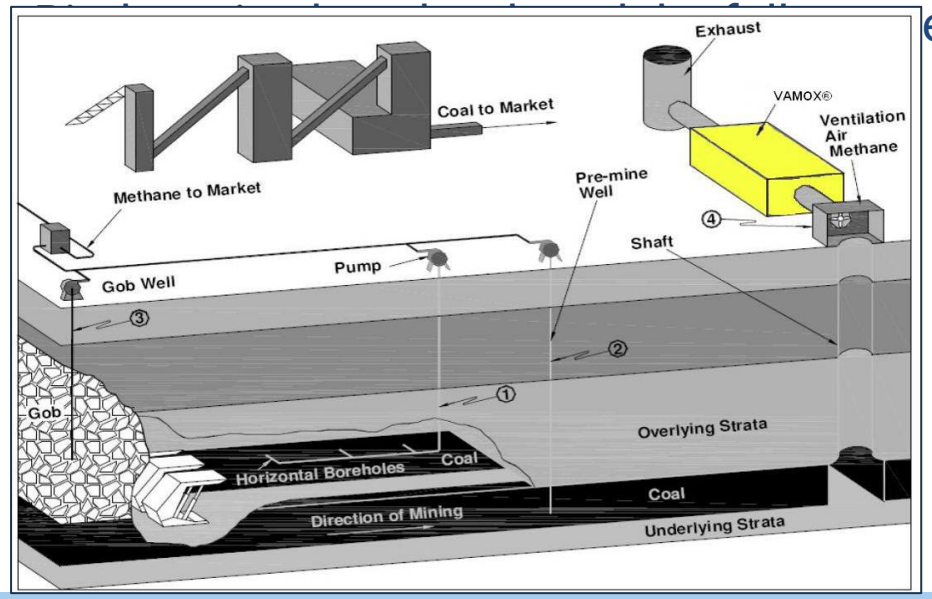
25 MW LFG valorization (Quebec, Canada)

LFG valorization (Nejapa, El Salvador)

Vamox® RTO coal mine methane (Alabama, USA)

VAM Emissions
Key facts

- Underground coal mining activities generate methane gas that must be vented for safety purposes
- Global VAM emissions are estimated at 1.2 $GtCO_2e/y$, 2.5 % of world GHG emissions
- VAM represents 65 % of total CMM emissions (low concentration, high volume)
- Drainage gas represents some 35 % of CMM emissions (high concentration, low volume)
- [illegible] en VAMOX® technology to abate GHG emitted from VAM



From Pilot to Full Scale VAMOX® VAM Abatement Unit 2009-2024

Vamox #1:
14 m^3/s
30k acfm*
2009

Vamox #2:
72 m^3/sec
152k acfm*
2022

Vamox#3:
85 m^3/sec
180k acfm*
2024

*at 20°C/0.95atm

1st VAMOX® RTO unit – 14 m^3/sec (30k cfm) ALABAMA (2009-2013)

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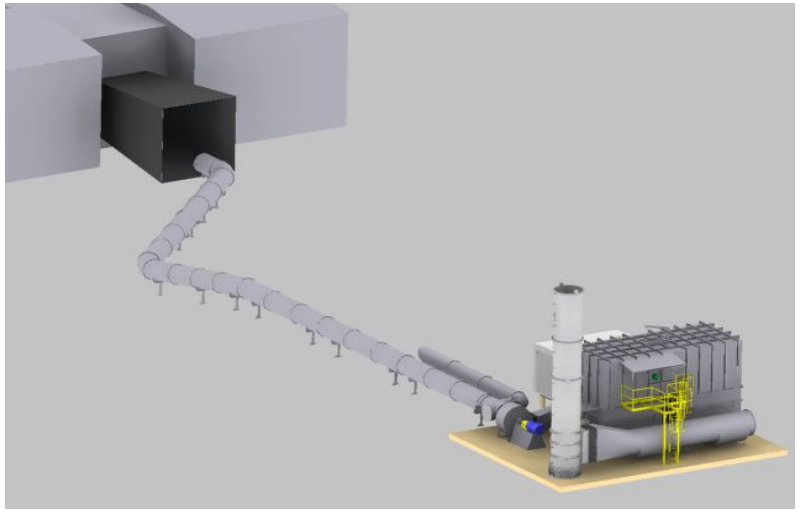
- Walter Energy, No. 4 Mine (shaft 4-9), Brookwood, AL
- 1st VAM oxidation project at an active U.S. Coal mine
- No physical connection to vent shaft – 10 % of the flow
- Registered with the Climate Action Reserve and CARB
- 81,000 carbon credits sold
- Capacity→ 30,000 scfm
- CH_4 Range→ 0,3% - 1.2%
- 93% availability
- MSHA approval



Main Project Outcome: Process Simulator

- The simulator has become a **reliable tool** used to…

Guide large scale's design

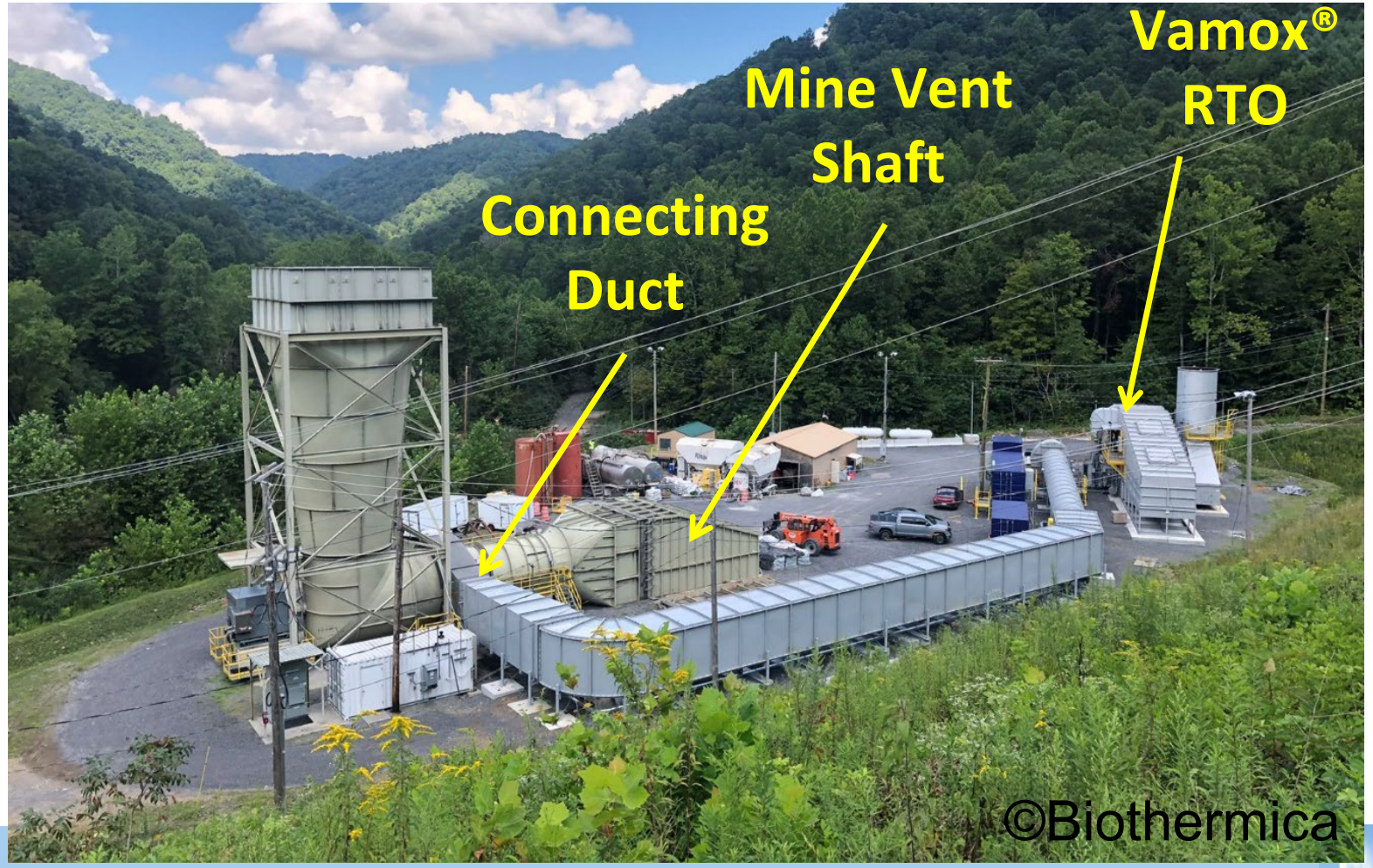
Develop control strategies

Predict performance

VAM Challenges which have been overcome

- Highly variable methane concentration (2500 ppm up to18000 ppm)
  - Overheat issues and loss of oxidation reaction – Process safety – Hazop review
- Process simulator for optimal RTO design for VAM abatement (carbon credits)
  - Drainage gas to increase inlet VAM concentration
  - Sacrifice some gas capture to slightly enrich VAM concentration → allow feasibility of a VAM project to value a resource that would otherwise be wasted to the atmosphere?
- Bleeder shaft in USA typically operational 3-7 years – Units should be movable
- System should be approved by Health and Safety Agency (MSHA)
- System should be designed to prevent VAM exceeding 2 % to reach RTO
- Dust may clog the ceramic bed – not an issue in USA
- Complete automation of the system

2nd VAMOX® RTO unit – 72 m³/sec (152k cfm) Virginia – 2022...



2nd VAMOX® RTO unit – 72 m^3/sec (152k cfm) Virginia – 2022...

- Coronado/Buchanan Mine (VS-16), Virginia(USA)
- Project owner – large US renewable energy Cie
- Commissioned in July 2022
- Flow capacity → 72 m^3/sec (152,000 cfm)*
- % CH_4 Range→ "0.3% - 1.2%
- 97,4 % availability
- Power Consumption: ~550 kW (740 hp) on average
- Credits production → ~260,000 tCO_2e/year
- Modular section for easy relocation
- Fully automated and remotely monitored operation

*at 20°C/0.95atm

3rd VAMOX® RTO - 85 m^3/sec (180k cfm) 2024

- In Construction..
- Location: U.S Coal mine
- Capacity: 180,000 cfm*
- Footprint: ~16 m X 36 m
- Carbon offsets ~ 300,000 tCO_2e/yr
- Start-up date: May 2024

*at 20°C/0.95atm

VAM Abatement Expansion Around the World
What we need

What we need to expand VAM abatement projects

- Regulatory obligations – ex : Safeguard mechanism Act (Australia), EU methane regulation - provisional agreement of Nov 15, 2023 to curb methane emissions

  or

- Carbon pricing mechanism
  - California cap-and-trade market (USA/Quebec) – a success story for VAM abatement in North America
  - Voluntary carbon market – in fast expansion – Potential VAM projects in many countries (India, South Africa etc..)
  - Paris Agreement Art 6,4 – Not yet effective - Complex application for a developer and a banker
- Five (5) Conditions for a successful VAM project financing closing
  - 1-Accurate forecast of methane emissions from a vent shaft - basis for cash flow forecast and ROI
  - 2- Carbon Price guarantee and proven technology
  - 3- Previsible Health and Safety regulations
  - 4- Long-term (20 years) VAM right agreement with mine owner in line with the debt amortization period
  - 5-Methane abatement/valorization strategy based on optimal ventilation/degas strategy
    - High methane , low volume drainage gas – A portion can be used to increase average VAM concentration and decrease CAPEX/OPEX of a VAM abatement unit
    - Low methane, high volume – VAM abatement

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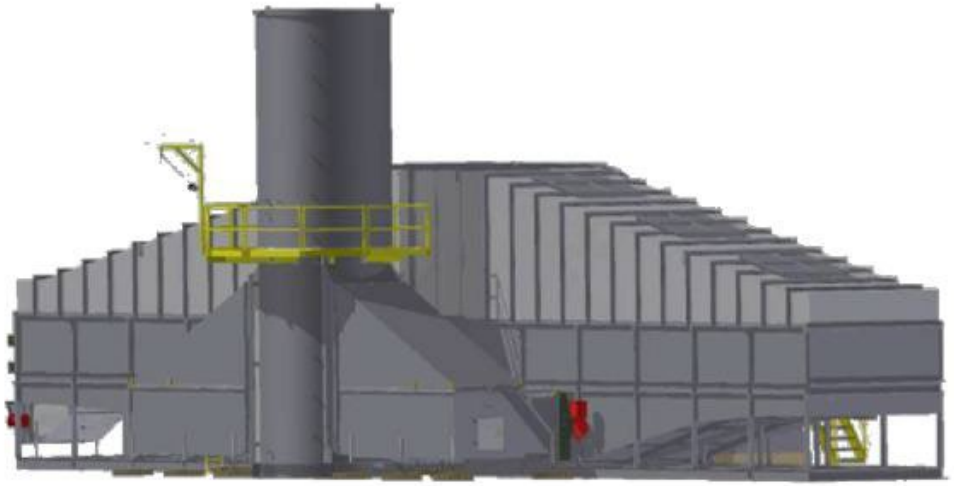

VAMOX® RTO Technology

Creating value from VAM

Thank you

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