ARPA-E
Ventilation Air Methane (VAM) Mitigation

ARPA-E program DE-FOA-00002505
Reducing Emissions of Methane Every Day of the Year SBIR/STTR (REMEDY SBIR/STTR) Methane Emissions Abatement Program

SRK Consulting (US), Inc. (SRK) partners with Precision Combustion, Inc. (PCI) to help mitigate ventilation air methane by conversion to CO_2 from U.S. coal mines

arpa·e CHANGING WHAT'S POSSIBLE

PCI Precision Combustion, Inc.

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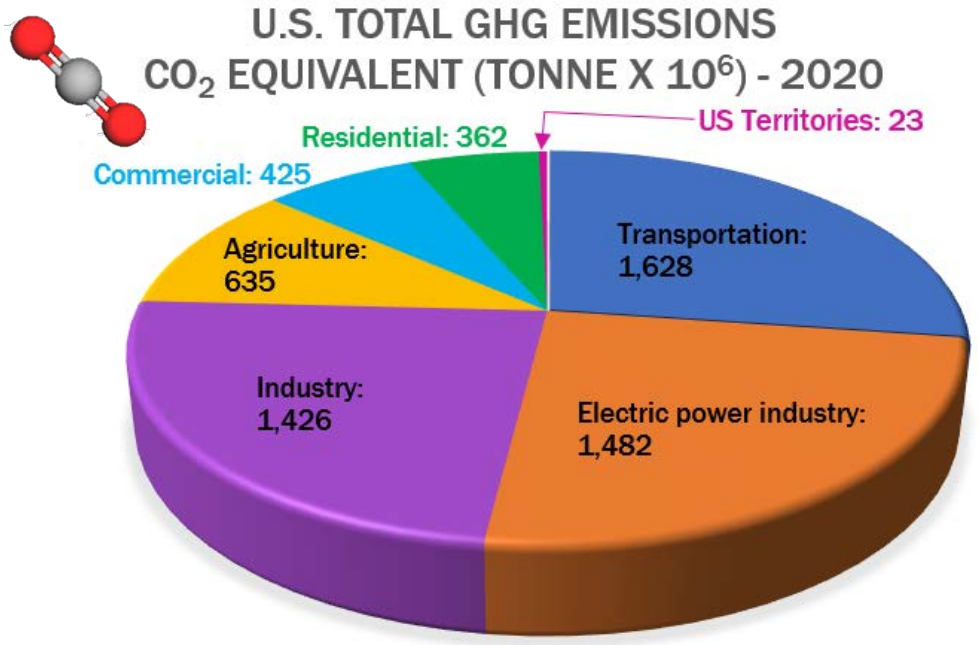
Total Greenhouse Gas Emissions (2020)

- By sector:
  - Transportation | 27.2%
  - Electric power industry | 24.8%
  - Industry | 23.8%
  - Agriculture | 10.6%
  - Commercial | 7.1%
  - Residential | 6.1%
  - US Territories | 0.4%



Source: U.S. E.P.A. (2022), Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020

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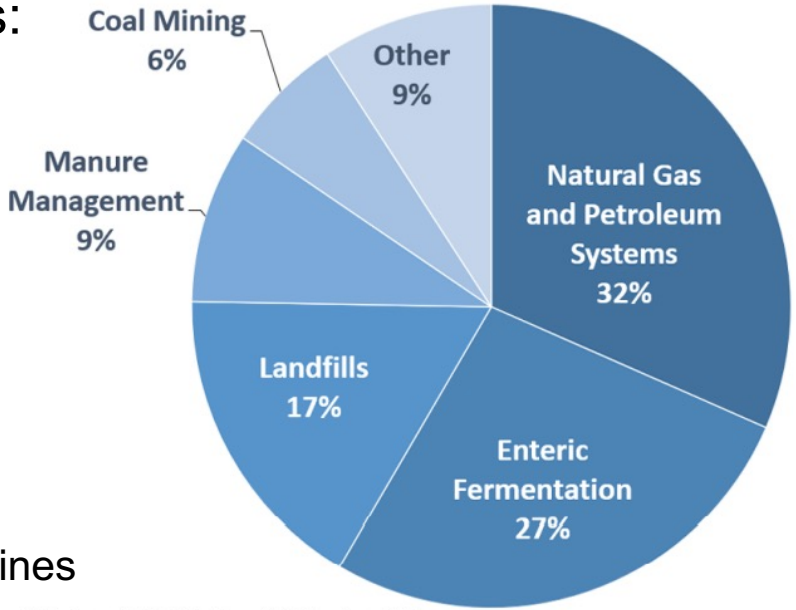
Estimated Methane (CH_4) Emissions

- Annual compilation from U.S. sectors:
  - Engines

    Engine exhaust emissions and crankcase CH_4 from lean-burn LNG engines
  - Flares

    Landfills, oil & gas supply stream
    Enclosed flares are only accounted for
    Bleeder wells
  - VAM

    Low concentration CH4 from active coal mines



- Lofty goal of 99.5% CH_4 reduction for <u>all</u> exhaust streams

Source: U.S. E.P.A. (2022), Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020

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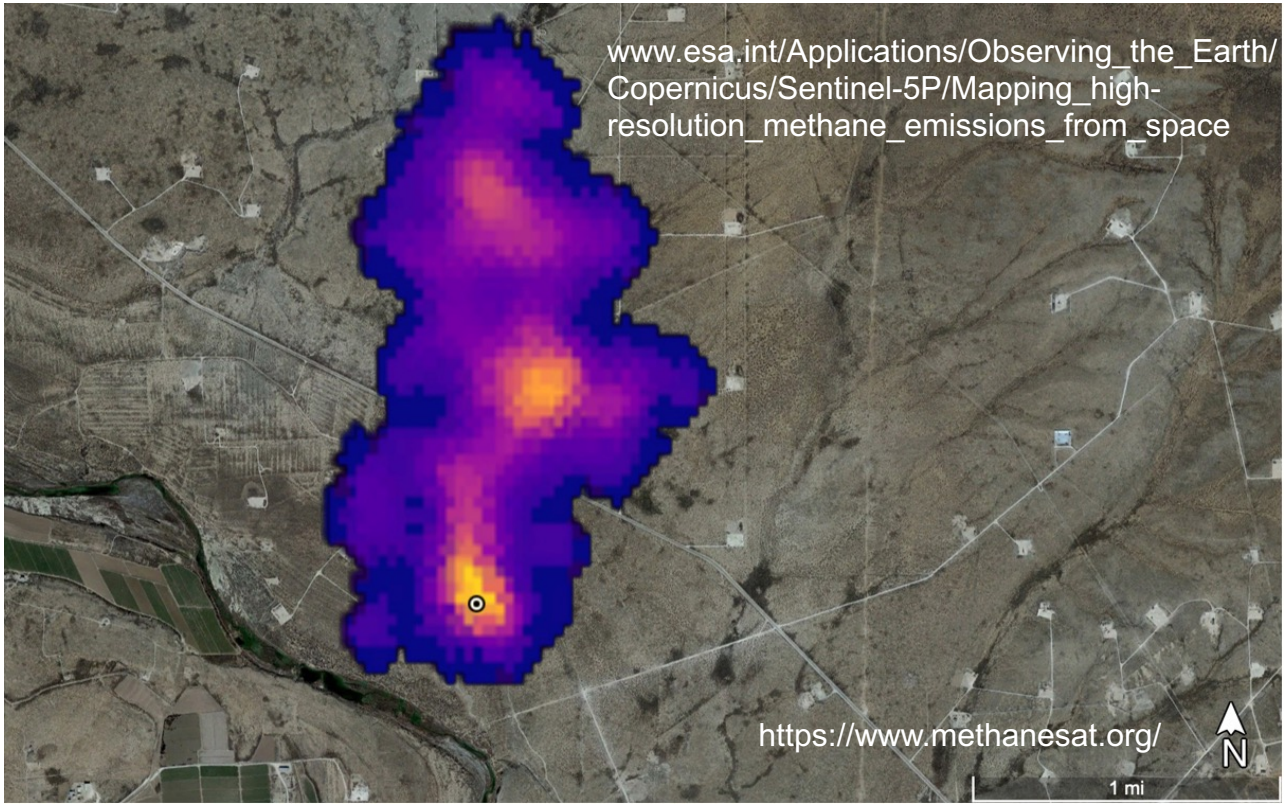
Satellite Methane Observations



Source: www.nasa.gov/sites/default/files/thumbnails/image/1-pia25592_emit_methane_permian.jpg | accessed Feb.27-23

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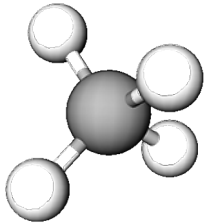
Potential CH_4 Utilization



- REMEDY CH_4 utilization programs:
  - Engines

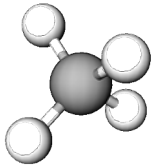
    Engine exhaust emissions and crankcase CH_4 from lean-burn LNG engines
  - Flares

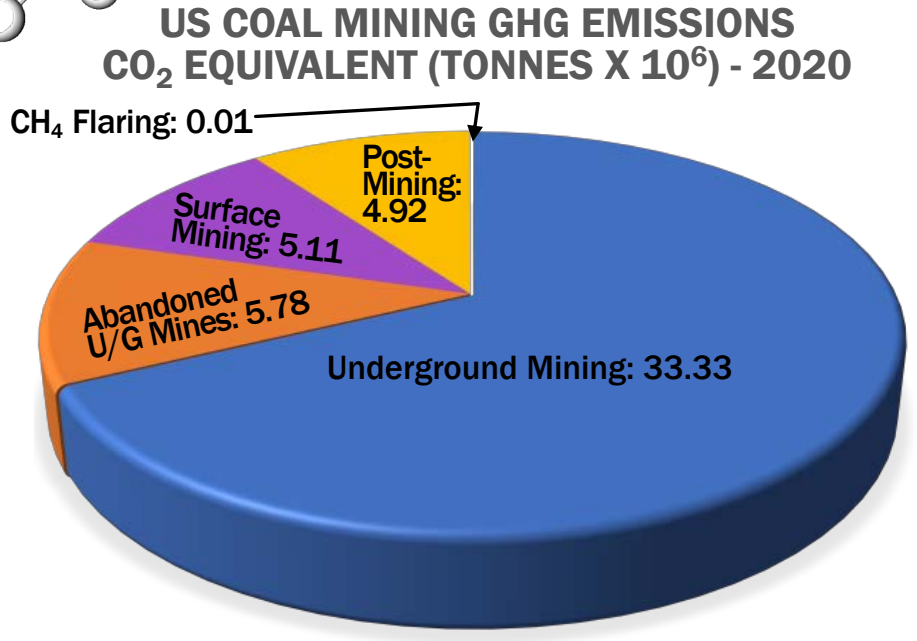
    Estimated 300,000 flares required for safe operation of oil and gas facilities – enclosed flares are encouraged
  - VAM

    CH_4 concentrations below 2% for operating mines
    Gob and bleeder systems are natural candidates
    Room for innovations, if new regulations are implemented

VAM Opportunities

- UNDERGROUND COAL MINES & BLEEDER SYSTEMS
- ABANDONED UNDERGROUND MINES
- HIGHWALL MINING OPERATIONS (HWM)
- BULK TRANSFER





Source: U.S. E.P.A. (2022), Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020

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Coalbed Methane Outreach Program (CMOP – EPA)
Abandoned Mine Methane Opportunities

- US: 514 abandoned gassy mines (2015)
  - 42% - West Virginia & Pennsylvania
  - 17% - Colorado & Utah
- Top 79 candidate mines in 2017 would have removed 308.6e^6 m^3/year
  - 35 currently in use for REMEDY projects
- CO_2 capture needs to be incorporated

Global Methane Initiative (GMI)
International Coal Mine Methane Projects Database (2021)

- Includes current US methane utilization projects & opportunities

REMEDY (ARPA-E)
Abandoned Mine Methane Opportunities

- Open Flares: *Not* included in REMEDY program (unknown quantity)
- Gas Sales to Pipeline: 32
- Enclosed Flare: 20
- Direct Thermal, Heaters: 3 (1 trona mine)
- Power Generation: 2
- VAM : 2
  - One actual airflow from mine workings, decommission 2013
  - One borehole gob drainage

- Abandoned mines are perfectly suited for VAM site - *safety's sake*

Pilot Plant

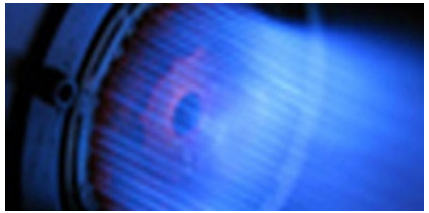
- New pilot plant will generate carbon credits from catalyzed CH_4
- Plans for CO_2 capture from VAM destruction exhaust stream
- Pilot plant sites to be evaluated in Q2 2023
  - Currently producing Highwall Mining (HWM) operations
  - VAM extracted to aid remote mining procedure
    - Operator's camera visual quality improvement
- Seeking MSHA approval for explosion proof systems integration
  - Allowing CH_4 concentrations beyond MSHA limits!
- Pursuing abandoned underground mines for full production model
- Focus innovation to replace coal mine CH_4 flare-off systems!

Pilot Plant

- Remote, modular system destroys methane during normal HWM production, while remaining stationary during miner relocation
  - Pre-conditioning removes dust and moisture from exhaust airflow stream
  - Location helps eliminate possibility for catastrophic explosion
  - Explosion proof systems already approved for use in natural gas production can be readily approved by MSHA

Precision Combustion, Inc.

- **MICROLITH® ADSORBERS FOR CARBON DIOXIDE AND WATER**



- **RCL® CATALYTIC COMBUSTION TECHNOLOGY**

- **OXY-AUTOTHERMAL REFORMER (OXY-ATR)**

- **SABATIER METHANATION REACTOR**

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Thanks for being a great audience!

We hope our legacy includes a cleaner atmosphere!

PCI
Precision Combustion, Inc.

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