

VAM TECHNOLOGY AND IMPLEMENTATIONS

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INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

“The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options.” (1988)

A greenhouse gas (GHG) is any gas that absorbs and re-emits heat when in the atmosphere

Water vapor, CO₂, CH₄, N₂O and O₃ are the main GHGs

CO₂ is considered the base GHG, all other GHG's global warming potential (GWP) is baselined on CO₂ equivalence or CO₂e

Methane's GWP in the IPCC's 5th assessment is 28

1 ton CH₄ = 28 tons of CO₂ or 28 tons of CO₂e = 1 ton CH₄

Sulfur hexafluoride's (SF₆) GWP is 23,500

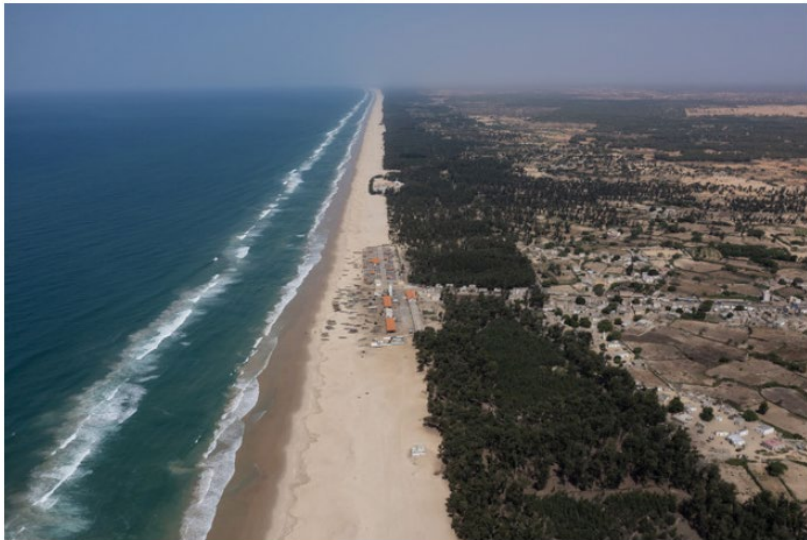
CARBON CREDITS

POLITICO

ENERGY & ENVIRONMENT

Kerry pitches climate finance plan. Other countries say it's 'not enough.'

Under the proposal from the U.S. climate envoy, companies would buy carbon credits that fund the greening of power grids in developing countries. It comes as rich nations face pressure at COP 27 to make good on their promise to mobilize \$100 billion a year in climate finance for poorer nations.



Filao trees form a curtain to slow coastal erosion along the Atlantic coast of Senegal. U.S. climate envoy John Kerry is announcing a carbon market program that could allow nations to offset their climate-changing emissions. | Leo Correa/AP Photos

There are two kinds of markets: compliance and voluntary

Voluntary markets, such as those used by many corporations, are based on the “good will” of participants

Compliance markets, such as the California Cap and Trade Scheme, are administered by government entities with strong compliance on the part of buyers and sellers of credit

Each market has it's own rules and exchange rates, but all will have some form of CO₂e for both sides of the market

EXAMPLE

A methane emission source has 20kcfm at 1% Methane by mass

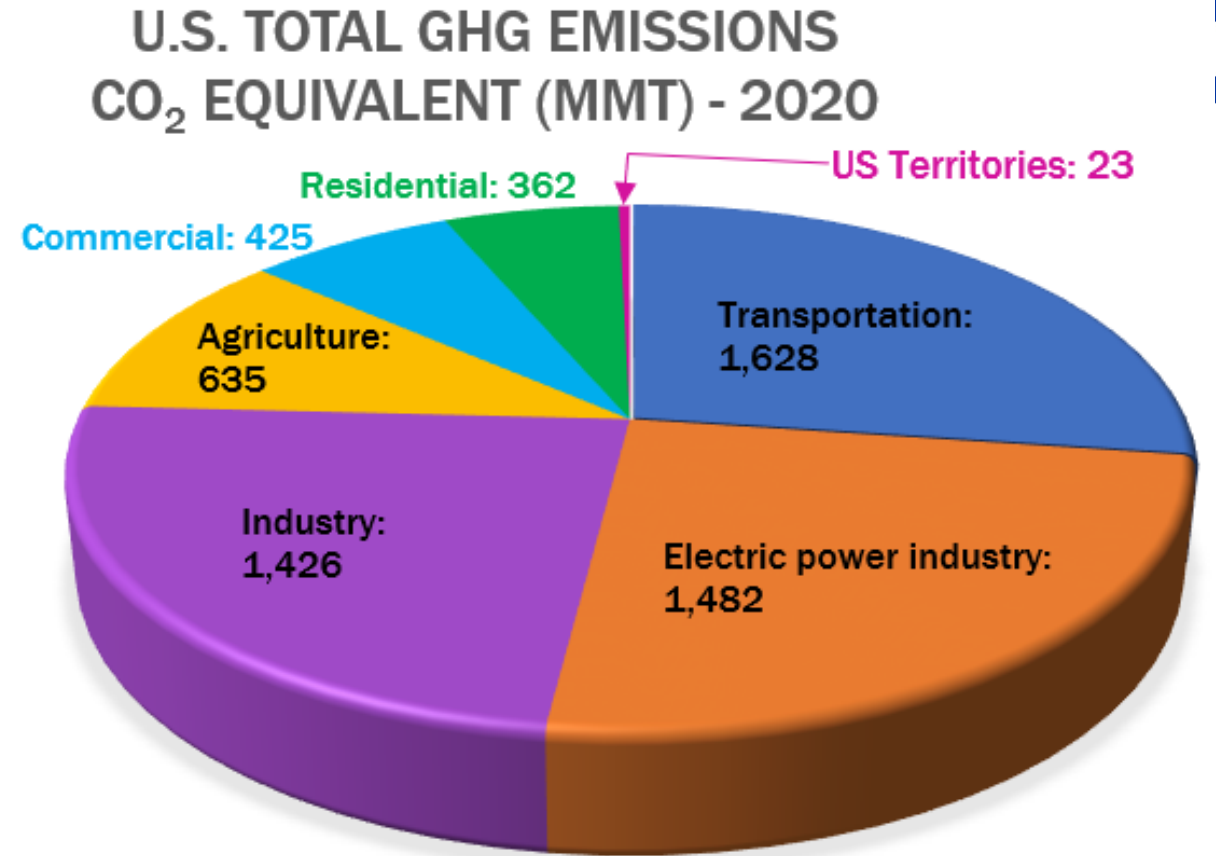
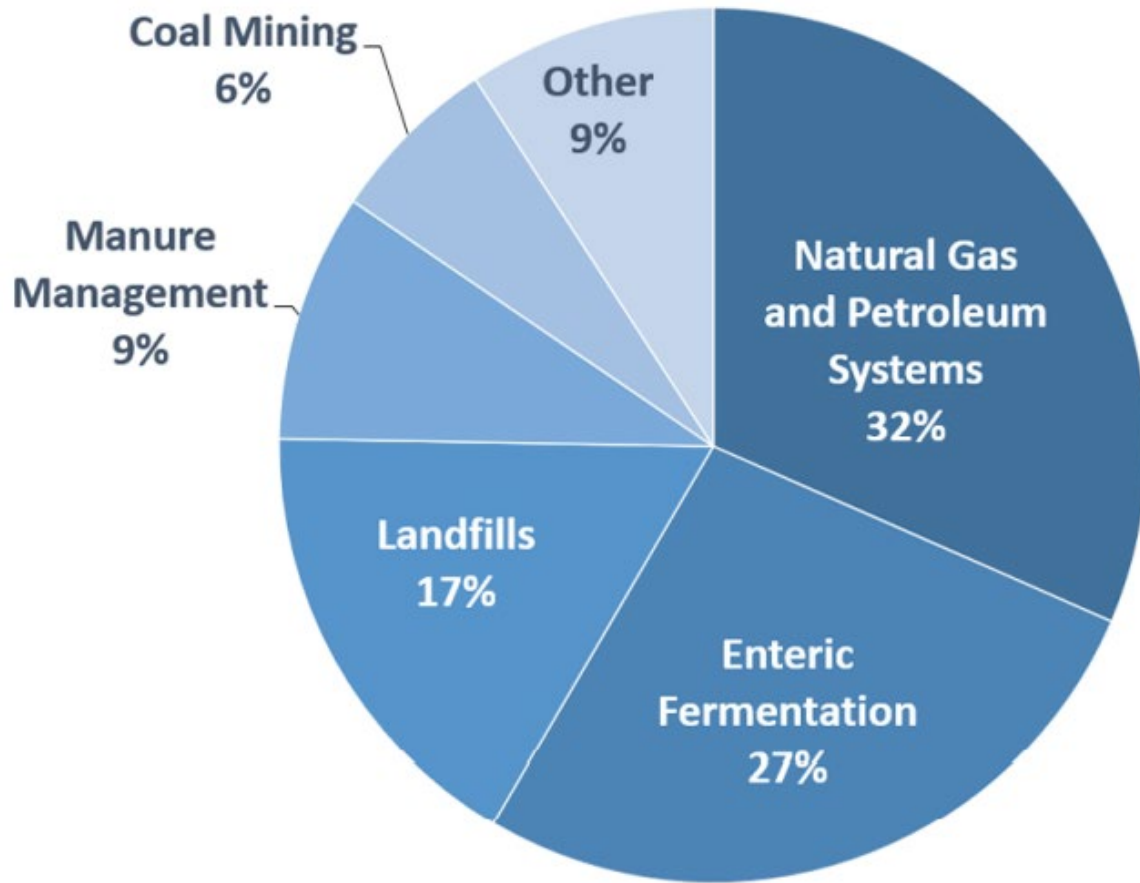
At 0.03 pounds/cu. ft. of methane, this source emits 6 pounds per minute or 8,640 per day, or 4.32 tons of CH₄

A market gives 26.5 CO₂e for CH₄, meaning this is 114.48 tons CO₂e per day

The current market (or auction prices) for that same market is \$29.33, this source could be worth \$3,357.70 per day

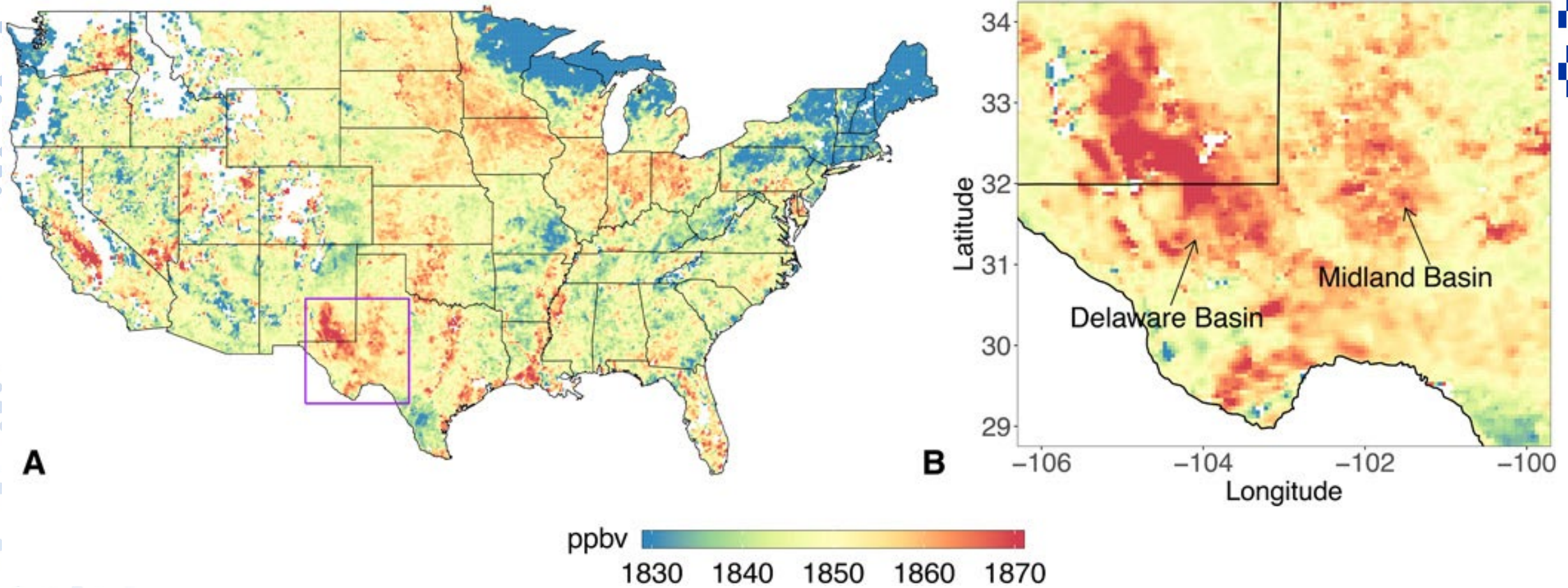
See: <https://carboncredits.com/carbon-prices-today/>

ESTIMATED METHANE EMISSIONS



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

METHANE EMISSIONS MEASUREMENTS FROM SPACE



<https://www.science.org/doi/10.1126/sciadv.aaz5120>
<https://www.methanesat.org/>

HOW TO CONVERT CH₄ INTO CO₂E

Destruction of the CH₄ constitutes conversion and is preferential to emission

Destruction of CH₄ is commonly carried out in flares

- CO₂e that is traded needs rigorous measurements of the flare's inputs and outputs to qualify
- CH₄ needs to be a consequence of human activity that is ongoing for purposes other than the production of CH₄

More efficient, lower quantity methane technologies are commonly called Ventilation Air Methane (VAM) projects or technologies



VAM TECHNOLOGIES

These have two major categories*:

- Thermal destruction
 - Variation on flares, but at different temperatures
 - Currently deployed
 - Can be thermally inefficient and need a feedstock gas
- Catalytic destruction
 - Similar to a catalytic converter on a car
 - In the development/test deployment stages
 - Can run very hot
 - May be overwhelmed when methane concentration is too high

* The information on this slide is a generalization and does not apply to your VAM technology

ARPA FUNDING TO DEPLOY VAM

ARPA-E program DE-FOA-00002505

Reducing Emissions of Methane Every Day of the Year SBIR/STTR
(REMEDY SBIR/STTR) Methane Emissions Abatement Program

Precision Combustion, Inc. (PCI) partners with SRK Consulting and the University of Kentucky with MegaHighwall Mining to help mitigate ventilation air methane by conversion to CO₂ from U.S. coal mines

PRECISION COMBUSTION, INC.

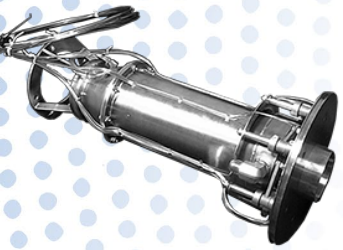


Microlith® Adsorbers For Carbon Dioxide And Water

RCL® Catalytic Combustion Technology

Oxy-Autothermal Reformer (Oxy-atr)

Sabatier Methanation Reactor



Initial cut on open bench, width is twice length of MHM ADDCAR miner

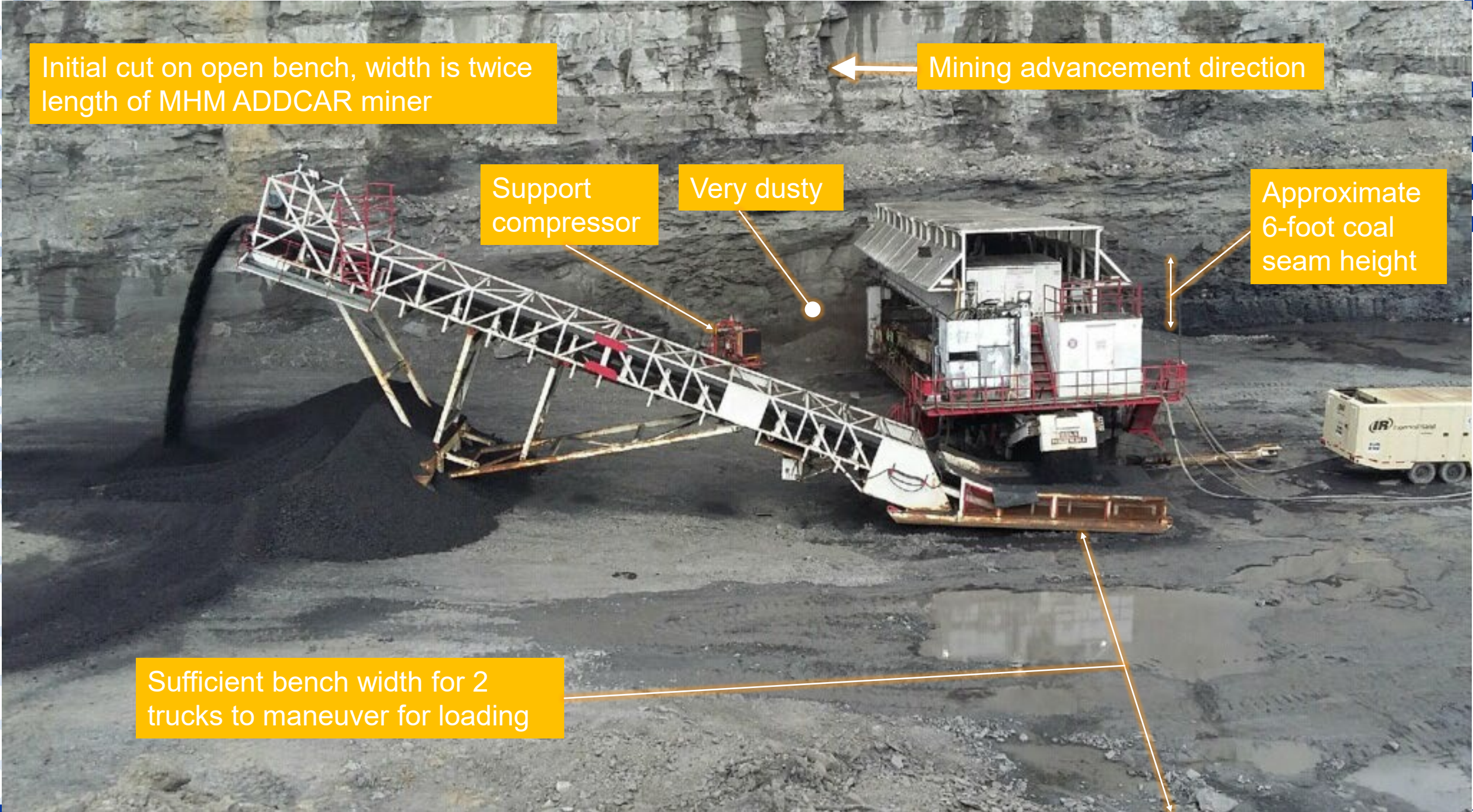
Mining advancement direction

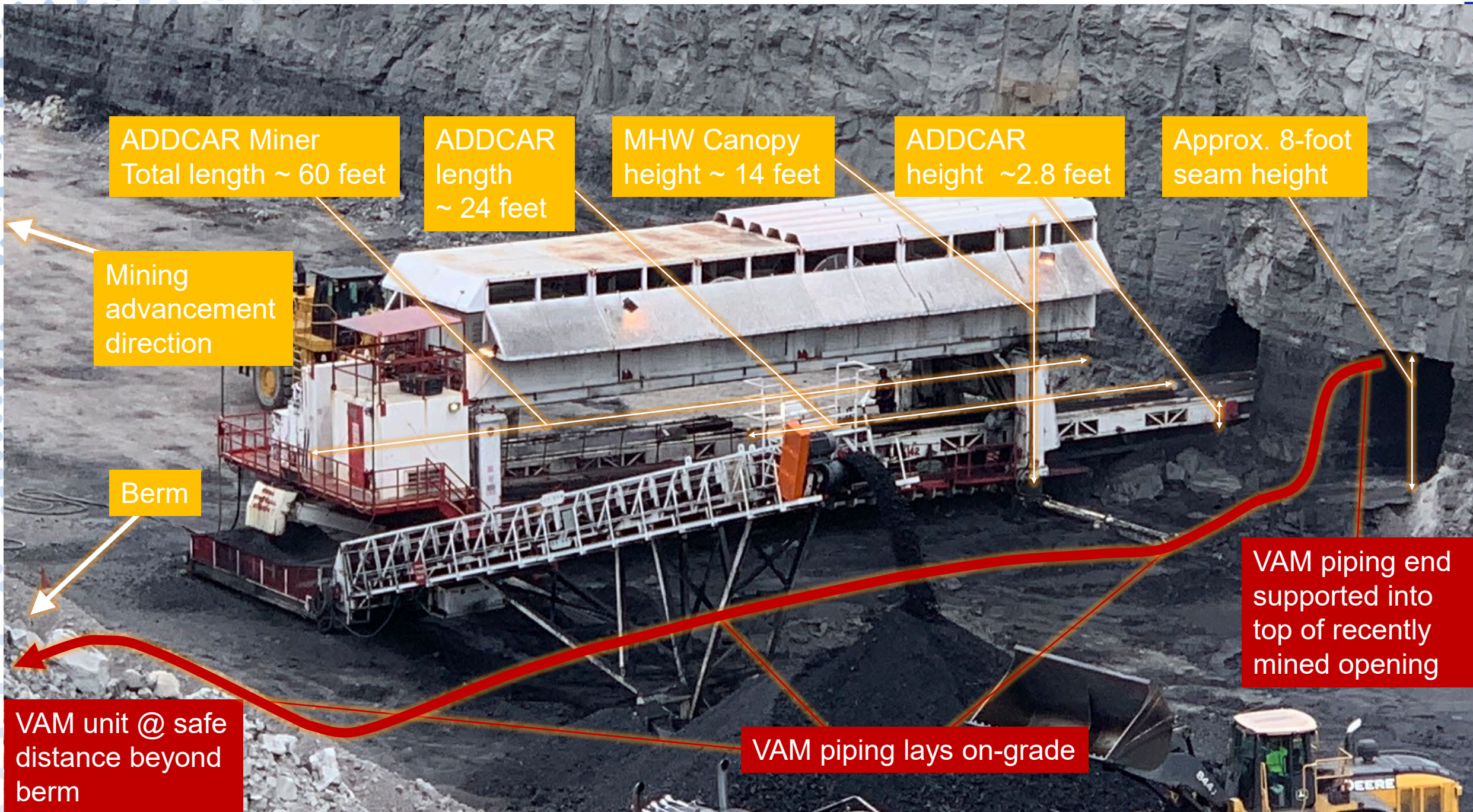
Support compressor

Very dusty

Approximate 6-foot coal seam height

Sufficient bench width for 2 trucks to maneuver for loading





ADDCAR Miner
Total length ~ 60 feet

ADDCAR
length
~ 24 feet

MHW Canopy
height ~ 14 feet

ADDCAR
height ~2.8 feet

Approx. 8-foot
seam height

Mining
advancement
direction

Berm

VAM piping end
supported into
top of recently
mined opening

VAM unit @ safe
distance beyond
berm

VAM piping lays on-grade

CONCLUSIONS

If you are a coal operator, you have been approached by a VAM project

If this is the first you are hearing about it, *they* approached someone else at your operation, I'm happy to talk with you about it in more detail

Several sites, using a variety of technologies are in the approval pipeline, with some under construction and others operating

The economics of the projects work, especially where the technology development is done with research grants

There is a manageable safety concern for operating mines

Our highwall approach is the only approach targeting surface mines

Coming soon to a highwall operation near you