



Ventilation Air Methane: An Analysis of the Global Market for Methane Oxidation

Karl H. Schultz, U.S. Environmental Protection Agency,
H. Lee Schultz, F. Peter Carothers, Robert A. Watts, Alternative
Energy Development

16 May 2001

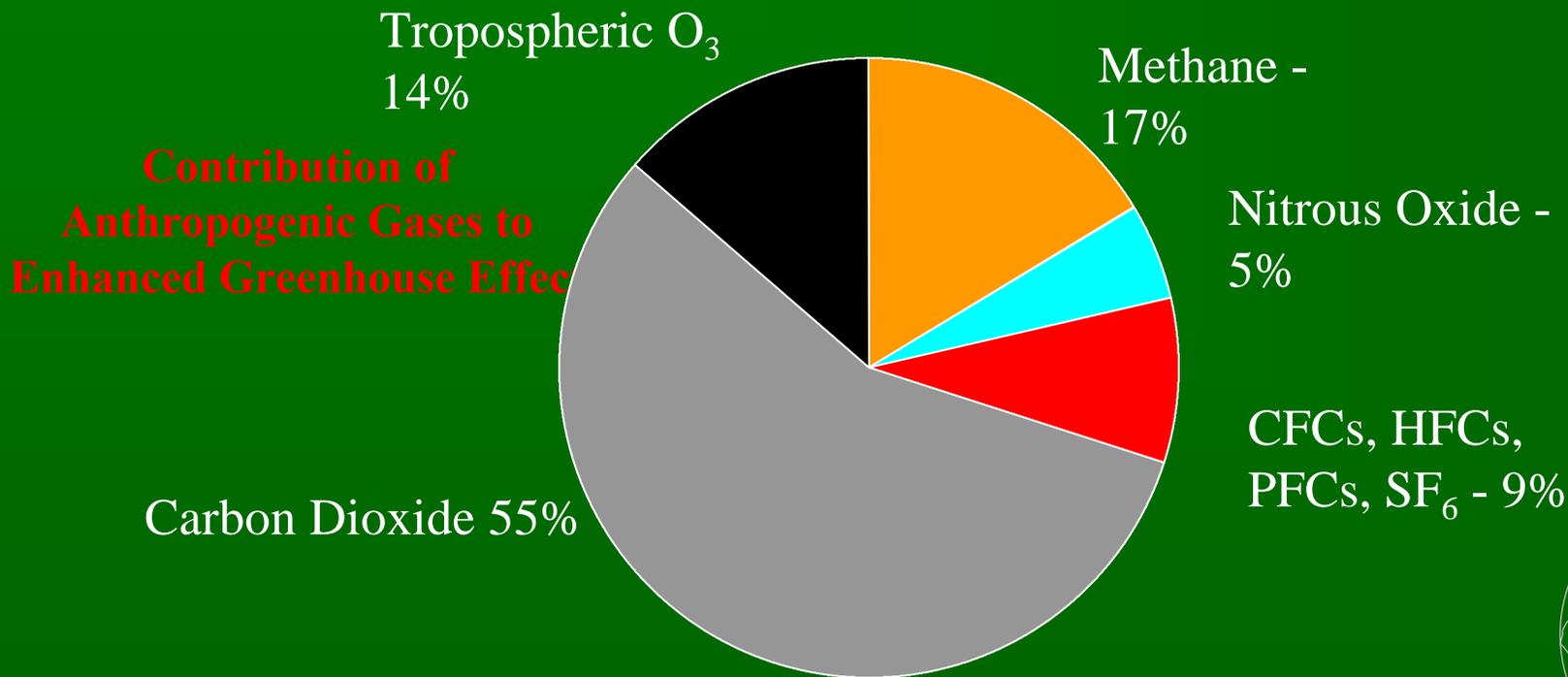
International Coalbed Methane Symposium
Tuscaloosa, Alabama

Overview:

- ✦ Coal Mine Methane Emissions and the Global Environment
- ✦ Ventilation Air Methane (VAM)
- ✦ Flow Reversal Reactor Commercial Status and Economics
- ✦ U.S. and Select International Markets
- ✦ Prospects for the Future

Methane is a Potent Greenhouse Gas

- ◆ 21 Times More Potent Than Carbon Dioxide
- ◆ 2nd Only to Carbon Dioxide as a Contributor to Global Warming



Source: IPCC, 1996.

Total = 2.85 Watts/m²

U.S. Environmental Protection Agency

6/5/2001

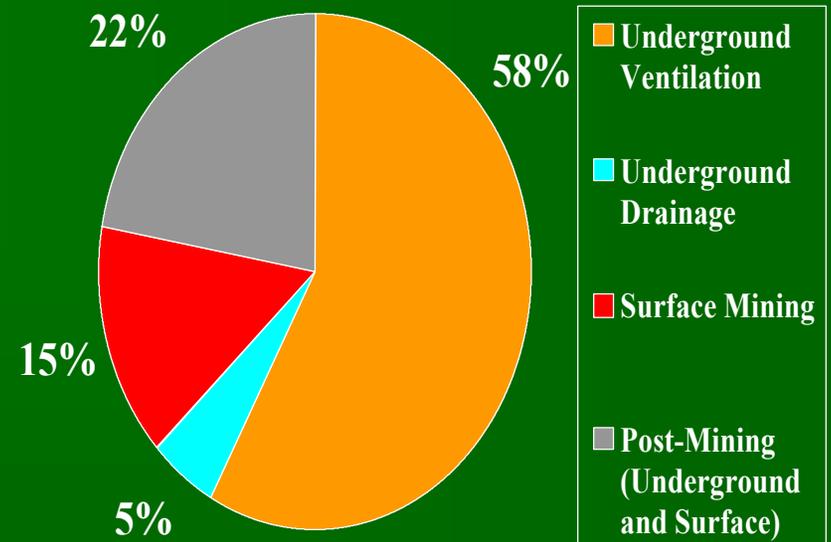


CMM Emissions By Source

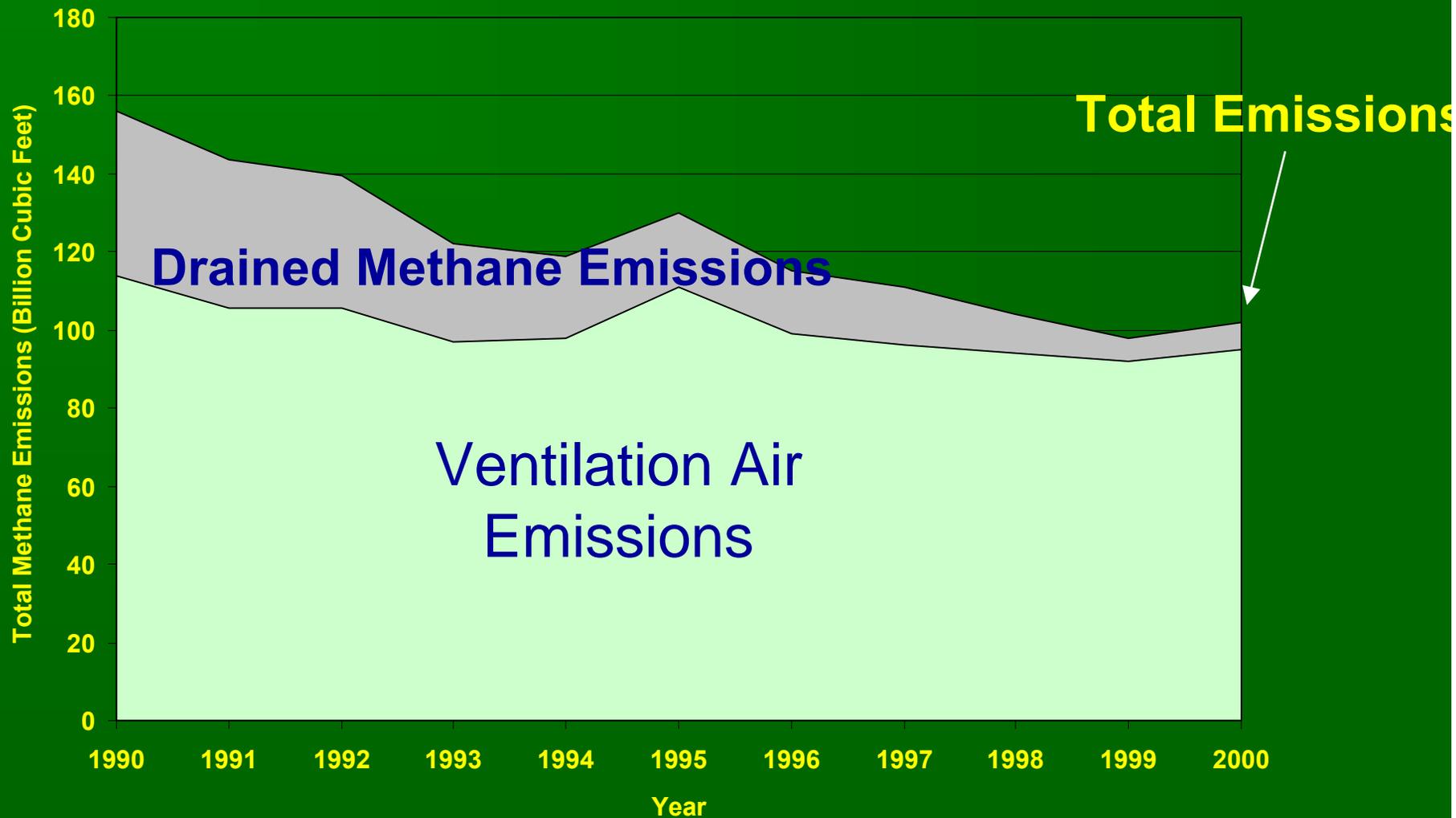
Sources of CMM:

- ✦ **Underground Mining**
 - Ventilation Systems (Largest Source)
 - Degasification Systems
- ✦ **Surface Mining**
- ✦ **Post-Mining**

Example: U.S. CMM Emissions (1998)



Remaining U.S. Underground Emissions



Ventilation Air Methane Emissions

- ✦ Ventilation Air Oxidation Technologies Ready for Commercialization
- ✦ Potential for Revenue from Emissions Reductions
- ✦ Large Untapped Market
 - No VAM Use in U.S.
 - Good Experience Internationally

Characterization of VAM: Gassiest U.S. Shafts



CH₄ Concentration:

Range = 0.3 - ~1.0%

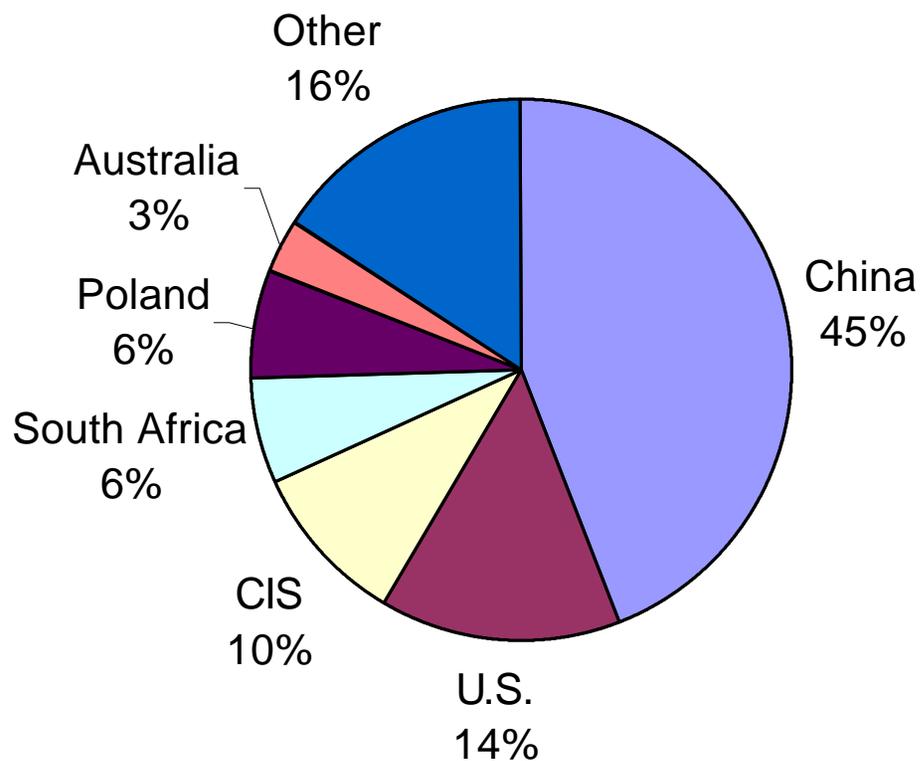
Average = 0.7%

Ventilation Air Flow:

Range = ~50 - 400 m³/s (2 - 15 mcf/s)

Average = 185 m³/s (6.5 mcf/s)

VAM: World Wide Characteristics



VAM: Global Characteristics

- ✦ China, U.S. and Former Soviet Union > 75% of Global Total
- ✦ Significant Range in Air Flow, Concentration
- ✦ Greatest Opportunities at Larger, Modern Mines



Uses for VAM:

- ✦ Supplemental Fuel Source for:
 - Turbines (Gas and Steam)
 - Engines
- ✦ Primary Fuel for Flow Reversal Reactors:
 - Simple Oxidation
 - Oxidation Plus Heat Recovery



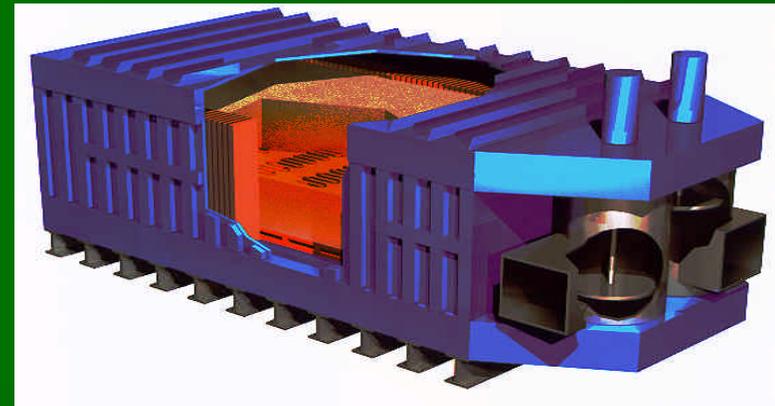
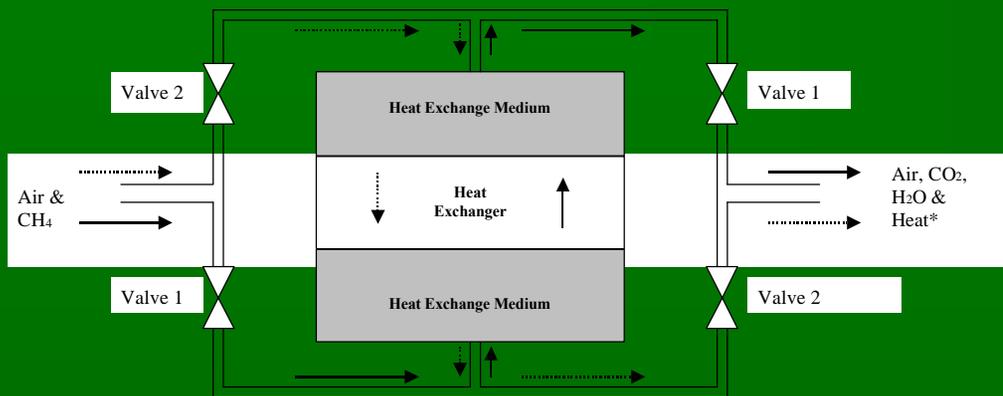
Supplemental Fuel Example: Appin Colliery, Australia

- ✦ Installed in 1995
- ✦ 54 x 1 MW IC Engines Produce Power from Gob Gas
- ✦ VAM Used as Feed Air, Supplies 7% of Energy

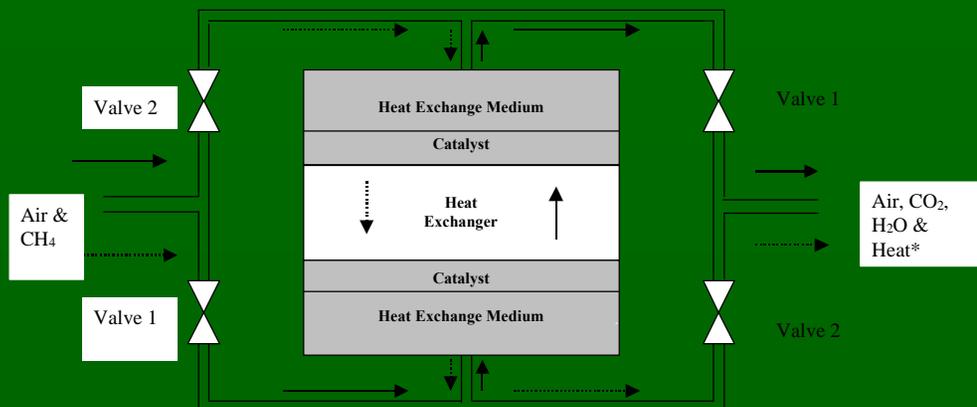


Uses: Primary Fuel For Flow Reversal Reactors

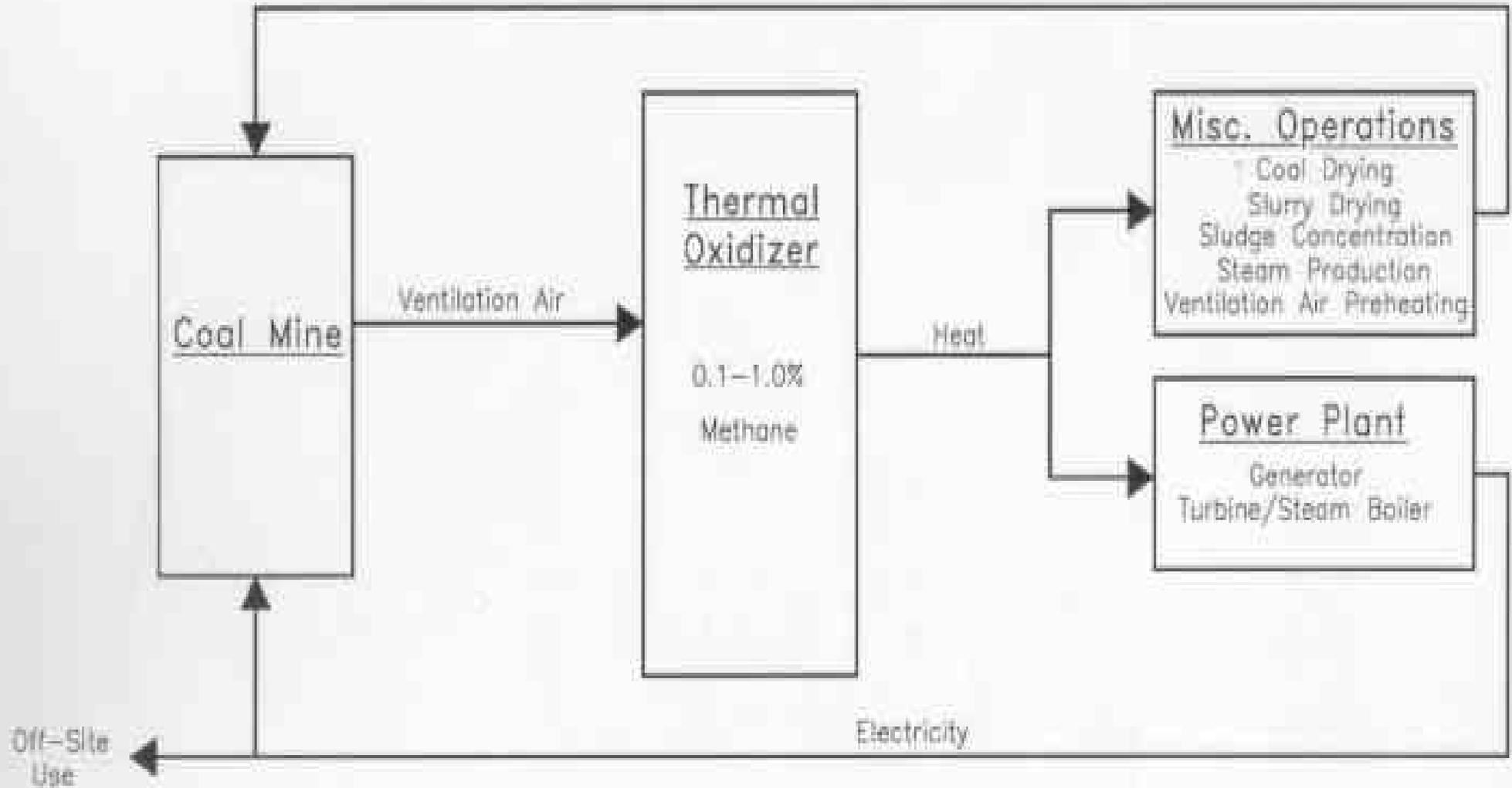
Thermal Flow Reversal Reactor



Catalytic Flow Reversal Reactor



Heat Recovery Options:



Factors Affecting Project Revenues

Electric sales

- In U.S.: typically US\$0.03 to \$0.04/kWh
- In other coal producing countries: \$0.05 to 0.06 per kWh

Thermal energy sales

- In U.S.: markets are niche markets, seasonal (e.g., coal drying, domestic hot water)
- In other countries: more district heating systems

Value of carbon reductions

- Emerging private market
- Current prices: US\$1 to \$2 per tonne (t) of CO₂
- Current premium: US\$0.40 to \$0.60 per t CO₂

Characteristics of Viable Projects

- ◆ For Oxidation of VAM and No Heat Recovery:
 - Dependent on Value of Emission Reductions
 - ◆ Breakeven Price from \$1.25/tonne CO₂e to \$6.00, Depending on VAM Concentrations and Flow
- ◆ For VAM Oxidation With Heat Recovery
 - Need Combination of CH₄ Concentration, Power Price, Heat Value, and Value to Emission Reductions; Site Specifics are Important



Project 1: VAM Use Example Project: No Heat Recovery

Combustion: 7.3 MMcf/d
Units: 6 -11
Capital Costs: \$6 - 8 million
O&M Costs: \$1-2 million per Yr
Annual Offsets: 1.1 million Tons CO₂e

Values of Emission Offsets at Different CO₂ Prices:

at \$1.50 TCO₂ = \$1.65 million per Yr

at \$3.00 TCO₂ = \$3.3 million per Yr

Project 1: VAM Oxidation, No Heat Recovery

Assumptions



Results

- ◆ Vent Air: 7.3 MMcfd
- ◆ Units: 6-11
- ◆ Project Life: 12 Years
- ◆ Interest Rate: 10%
- ◆ Value of Emission Offset in Yr 1: \$2.70/ton
- ◆ Offset Escalator: 6%/yr
- ◆ Inflation: 4%/yr

Cash Flow: \$6.1 mil
IRR: 16.5%
Cap. Costs: \$8 mil
O&M Costs: \$1.7 mil

Project 2: VAM Use: Heat Recovery for Power

Oxidation:	6.9 MMcf/d
Gas Gas:	2.0 MMcf/d
Units:	6 -11
Capital Costs:	\$25 million
O&M Costs:	\$2 -3 million per Yr
Annual Offsets:	1.3 million Tons CO ₂ e

Value of Assumed Revenue Streams:
at \$1.50 TCO₂ = \$1.9 million per Yr
at \$.035/kWh=\$5.5 million per Yr

VAM Heat Recovery for Power

Assumptions



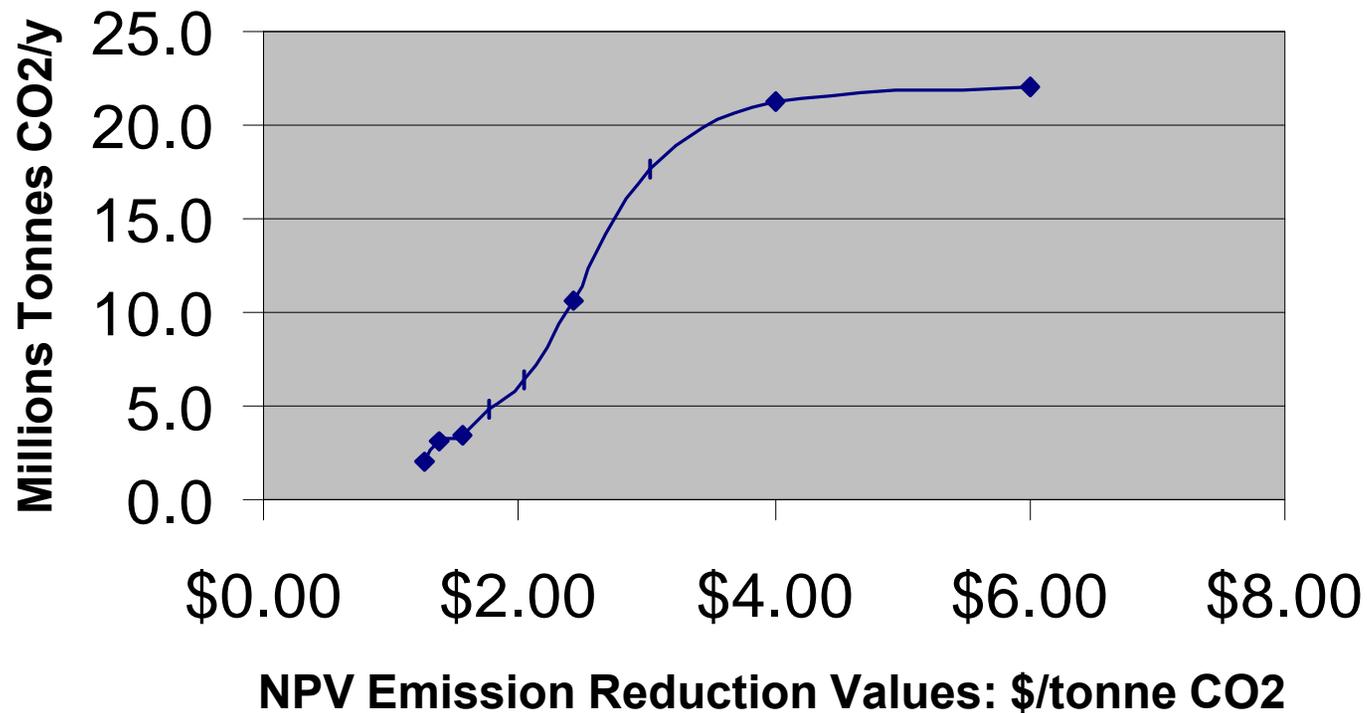
Results

- ◆ Vent Air: 6.9 MMcfd
- ◆ Gob Gas: 2.0 MMcfd
- ◆ FRR Units: 6-11
- ◆ Power Produced: 22.5 Mw
- ◆ Project Life: 12 Years
- ◆ Interest Rate: 10%
- ◆ Value of Emission Offset in Yr 1: \$1.50/ton
- ◆ Escalator: 6%/yr
- ◆ Inflation: 4%/yr

NPV: \$24.6 mil
IRR: 25.3%
Cap. Costs: \$26 mil
O&M Costs: \$2.3 mil

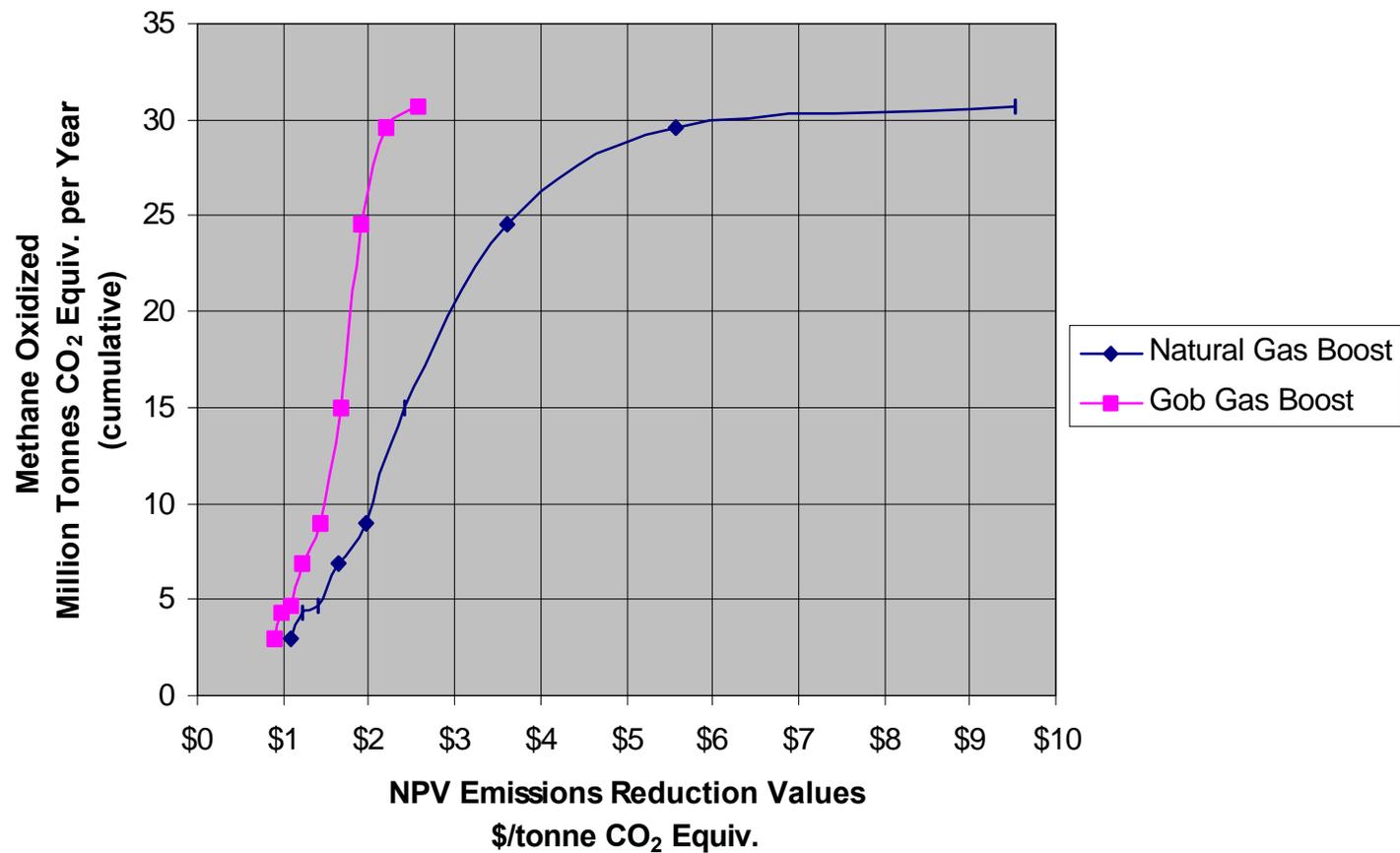
U.S. “Marginal Abatement Costs” (MAC): Oxidation Only

MAC for VAM at US Coal Mines



U.S. MAC: Power Generation

MAC Curve with Power Sales at \$0.04/kWh.



Substantial Market Potential

- ◆ U.S. Potential:

 - >30 Million Tons CO₂ Equivalent Emissions

 - \$343 million in Oxidizer Sales

 - Up to \$1 billion in Power Plant Sales

- ◆ Global Market:

 - Up To Six Times U.S. Market

Market Potential: China



- ✦ Largest Potential Market: >90 Millions Tons CO₂ Equivalent Emissions
- ✦ VAM Concentrations Good for Projects (Typically .3 - .75%)
- ✦ Large Market for Direct Thermal Use and Power

Contact: China CBM Clearinghouse, Beijing
cbmc@public.bta.net.cn



Market Potential: Russia



- ✦ >10 Million Tons CO₂ Equivalent VAM Emissions
- ✦ Average VAM Concentrations (.7%) Excellent for Projects
- ✦ Significant Seasonal Demand for Thermal Energy

Contact: Russia CBM Center
tailakov@mail.stanet.ru

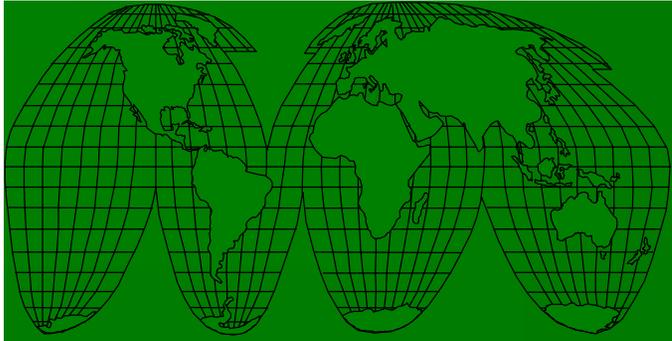


Market Potential: Ukraine

- ✦ >20 Million Tonnes CO₂ Equivalent VAM Emissions
- ✦ Typical VAM Concentrations Low (.2 - .3%)
- ✦ Significant Energy Demand

Contact: Partners in Economic and
Environmental Reform
aef@public.ua.net





Other Potential Markets

- ✦ Czech Republic: Coal Operator Considering VAM Project
- ✦ Australia: Commercial Supplemental Fuel Project, Oxidizer Pilot Project Underway
- ✦ Germany: >10 MMTCO₂e VAM, Government Incentives Available
- ✦ Poland: >5 MMTCO₂e VAM, Good Market for Heat





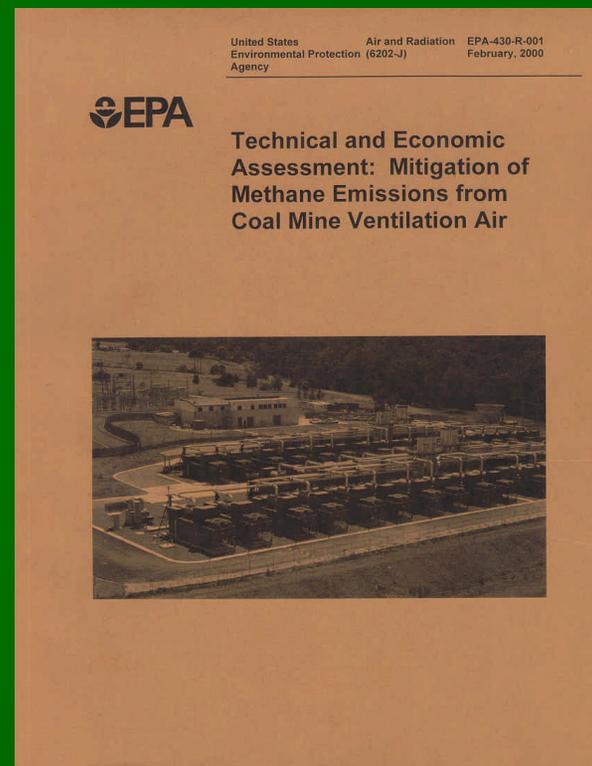
EPA's VAM Initiative

- ◆ Confirmed Technical Feasibility
- ◆ Helping to Deploy First Commercial Scale Unit
- ◆ VAM Website:

*www.epa.gov/coalbed
(go to "Ventilation Air")*

- ◆ Starting VAM Listserver:

*To Subscribe to Listserver, send an email to:
ventairuse-request@listserve.com
with the words "subscribe ventairuse" in the text box.*



Conclusions

- ✦ VAM Projects Offer Significant Environmental Benefits and Energy
- ✦ Project Economics Can Be Attractive with Value to Emission Reductions and/or Revenue for Energy
- ✦ The Market for VAM Technologies is Significant
- ✦ EPA is Working to Help Commercialize Technologies



Contact CMOP:

www.epa.gov/coalbed

Karl Schultz

schultz.karl@epa.gov

(202) 564 9468

Clark Talkington

talkington.clark@epa.gov

(202) 564 8969

