ENER-CORE

RAVEN RIDGE RESOURCES INCORPORATED

New Economic Solution for Abating VAM Emissions at Gassy Coal Mines Ener-Core and Raven Ridge Resources

OTCQB: ENCR

Coal Mine Methane Outreach Program Conference

November 2014

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The Problem:

U.S. Coal Mine Emissions (2012)

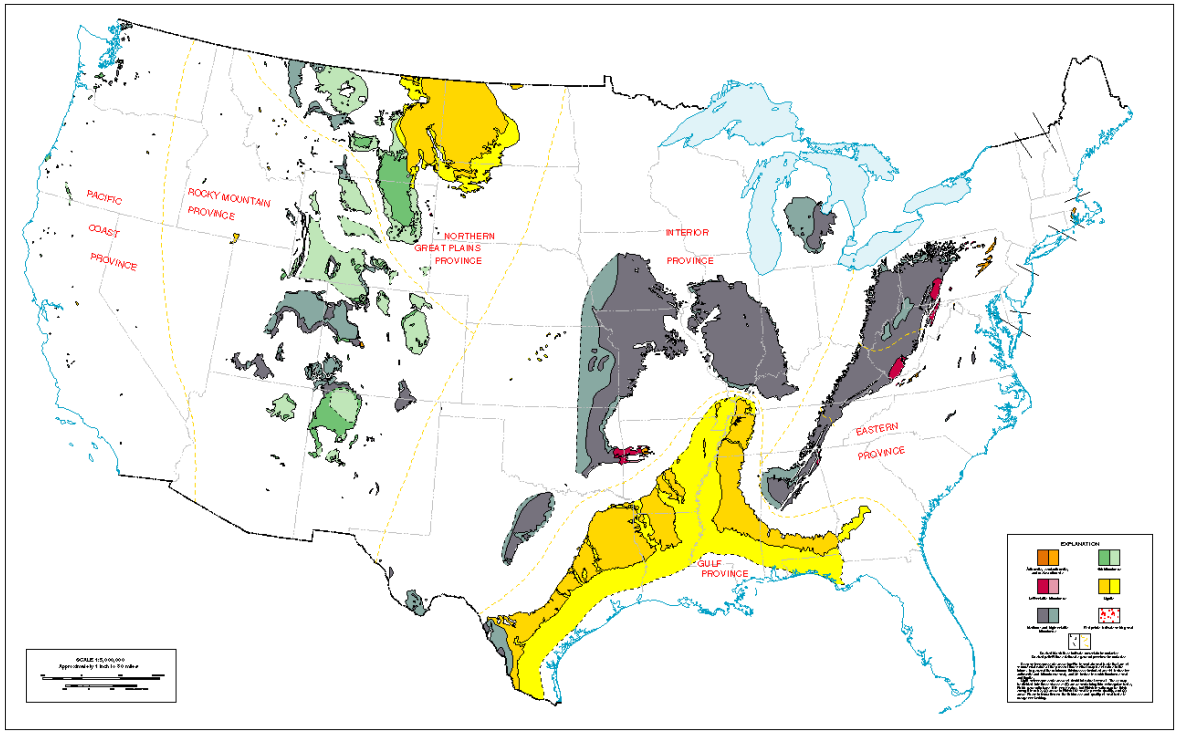
Liberated – 137 tcf

91 tcf was vented

46 tcf was drained

38 tcf was drained and either used or destroyed

8 tcf was drained and vented



Largest source of methane emissions is VAM.

Existing solutions destroy gases. They do not use them productively

Thermal Oxidation

Open Flare

Regenerative

Direct-Fired

Scrubbers

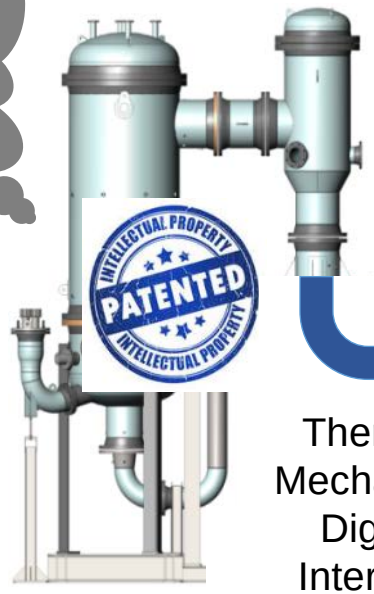
Packed Bed

Acids Gas

Ener-Core technology is an alternative, allows coal mines to economically abate emissions of VAM by using it along with CMM as fuel for power generation.

Major Components of the Ener-Core Solution

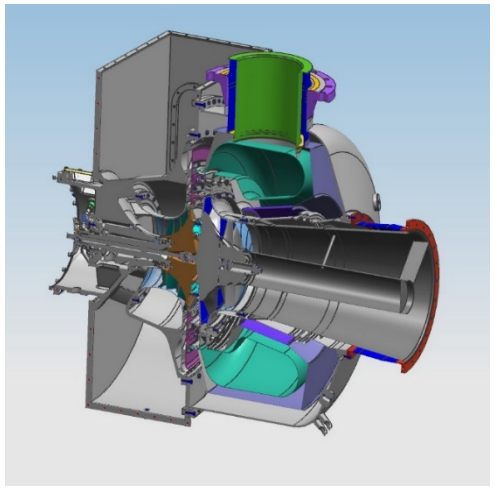
Source of Low-Quality or Off-Spec Gas



Thermal
Mechanical
Digital
Interface

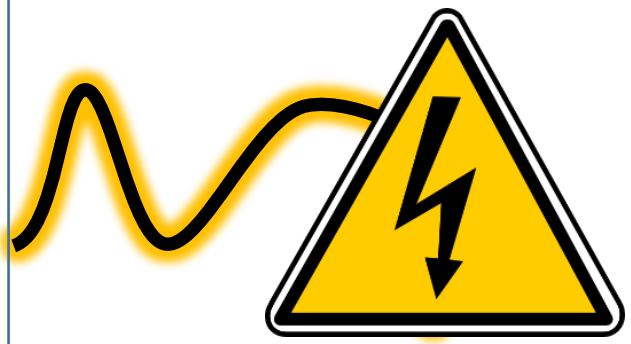
Ener-Core's Thermal Oxidizer

Turbine Package



Conventional Gas Turbine (modified for external combustion)

AC Generator

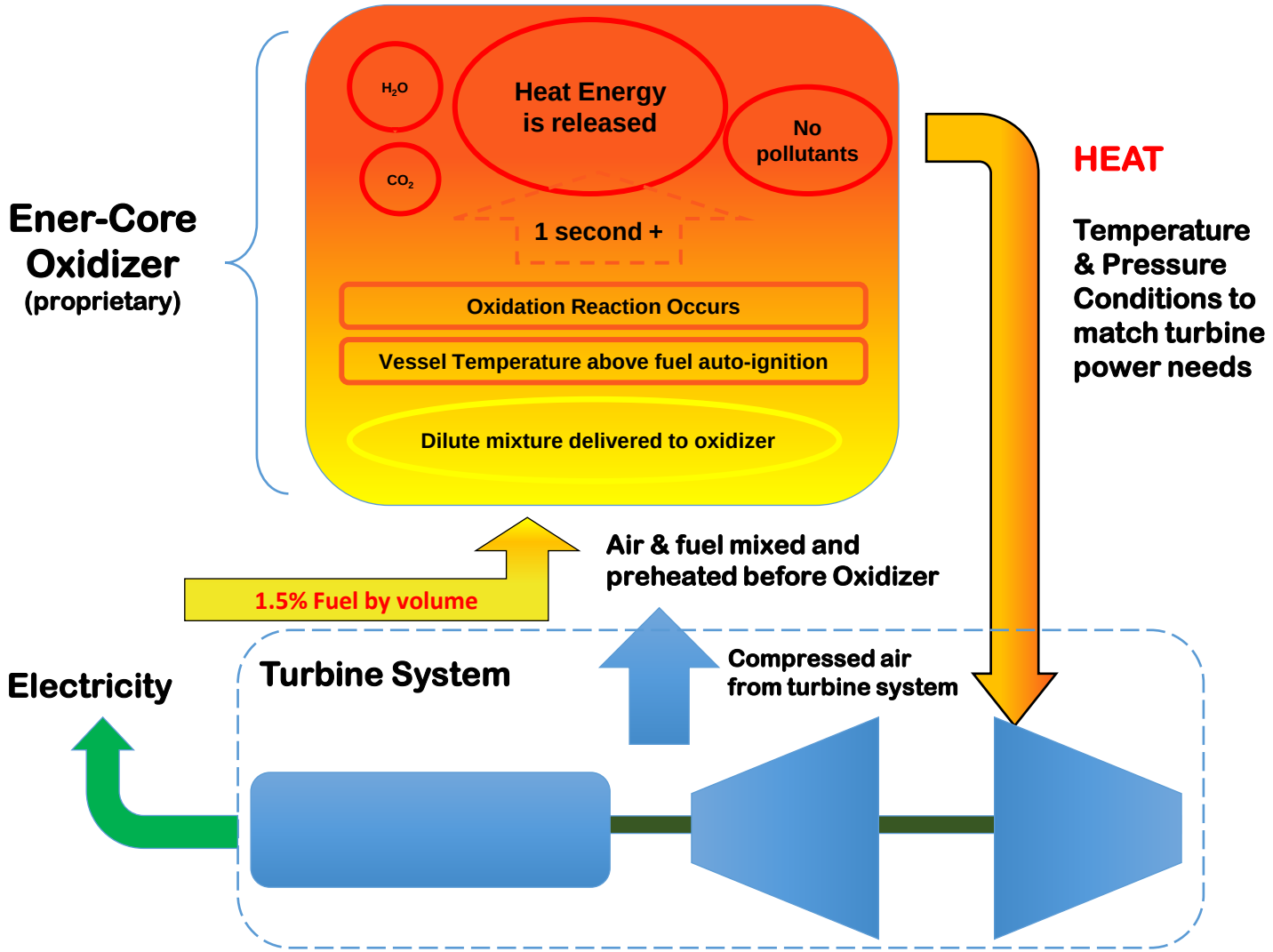


How the Technology Works

The dilute gas (input) does not have a high enough energy content for combustion.

Combustion is a rapid reaction that happens in milliseconds and produces pollutants as part of output.

Ener-Core Oxidation is an exothermic chemical reaction. It has no flame, resulting in temperature that avoids the NOx formation temperature. It happens in seconds, it produces heat, and it removes the pollutants in the Incoming gas.



Attero Landfill – Schinnen, Netherlands

- Closed landfill with below 30% methane; past problems with reciprocating engines running inconsistently and unable to run on gas
- First Commercially sold unit
- 250kW oxidizer powerstation was successfully installed and is currently operating continuously
- 250 kW oxidizer powerstation generates about 50% more electricity (kWhs) per week than reciprocating engine it replaced
- Has accrued over 1500 hours since commissioning in 2014

FP250 at Schinnen Landfill

Ultra-Low Btu Phase 1 Pilot for Oil & Gas Customer

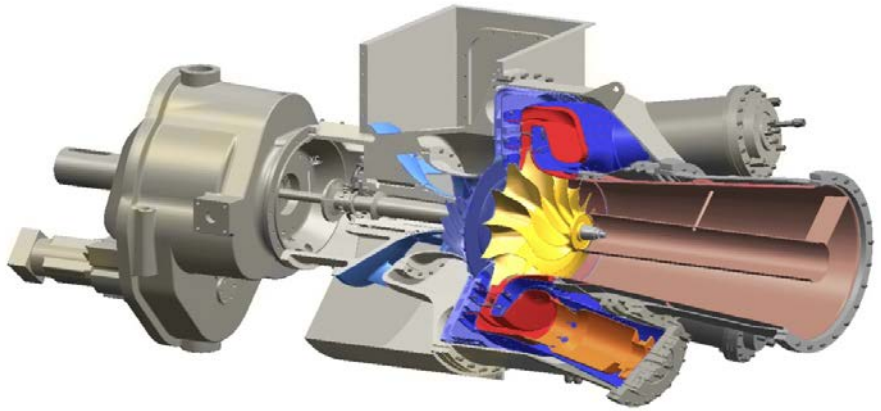
- Customer is interested in utilizing Ener-Core's Oxidation technology
  - Generate clean power from a casing gas emitted during a proprietary oil extraction process
  - Reduce CO2 footprint of process
    - Preventing methane venting
    - Avoiding gas blending for destruction (adding natural gas just to destroy methane vent)
  - Maintain air emissions below regulations with Low NOx exhaust (< 1 ppmv @ 15% O2)
  - Results used to permit Phase 2 Field Demonstration

	1st Condition	2nd Condition
Methane (CH4)	7.75%	5.80%
Nitrogen (N2)	84.20%	91.15%
Carbon Dioxide (CO2)	8.00%	3.00%
LHV (Btu/scf)	71	53
Steady run time (hr)	5.5	3

Ener-Core Powerstation at UC Irvine Campus

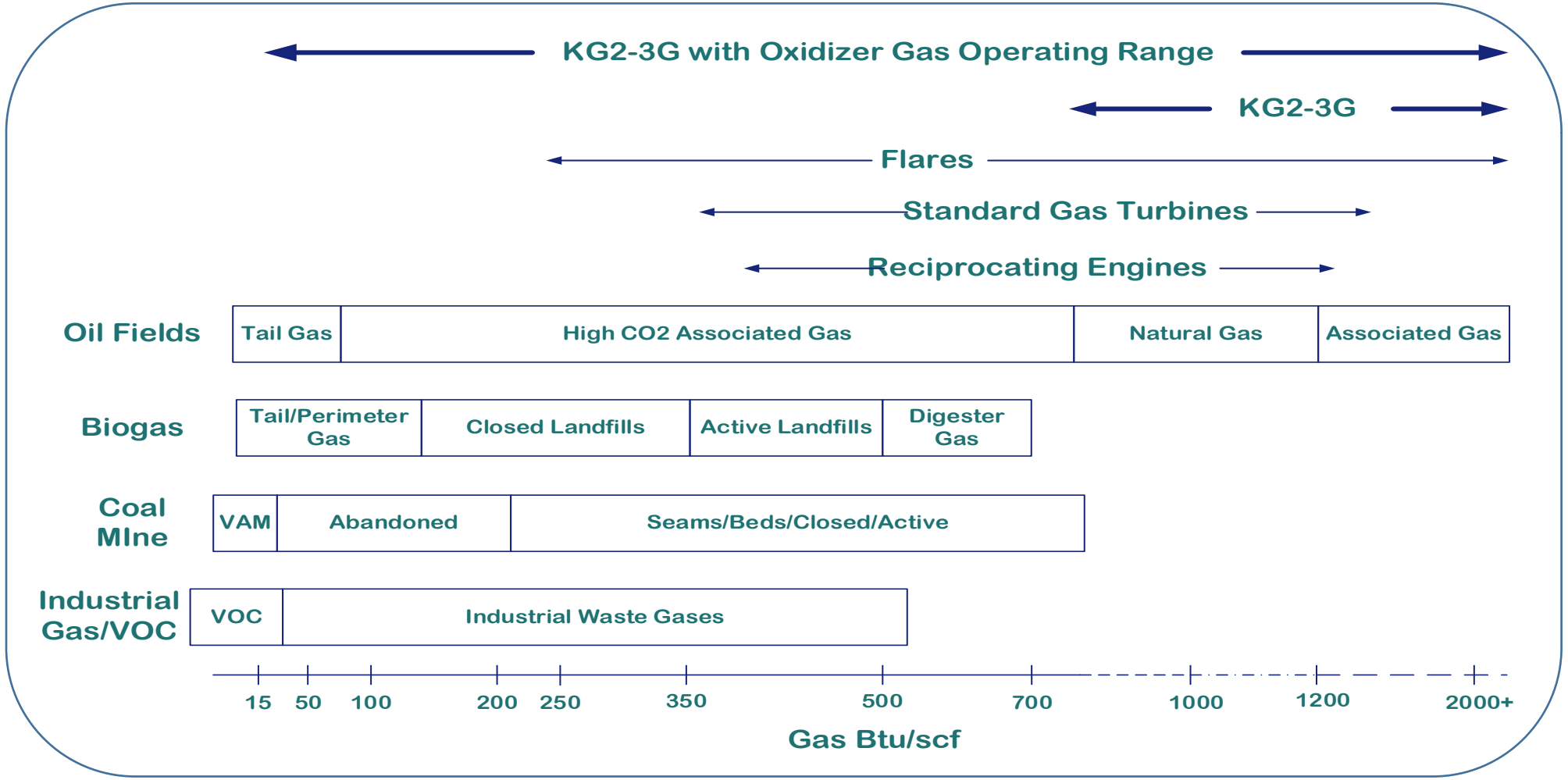
Robust Reliable Dresser-Rand KG2-3G Gas Turbine

- All Radial; Single Shaft
- Cold End Drive
- Capacity: 2 MW ISO Shaft
- Efficiency : 25%



- KG2-3GEF Off Base Combustor
- Standard Configuration
- Flanges for Oxidizer Interface

Ener-Core Oxidation Expands the Generation Opportunity to Previously Unusable Gases



KG2-3GEF/GO Configurations: Simple Cycle and Recuperated

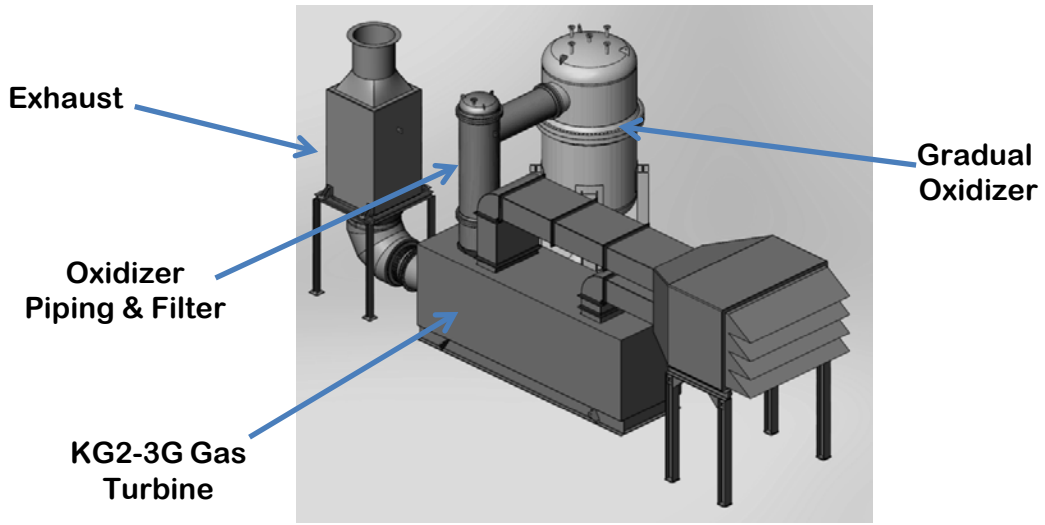
Simple cycle KG2-3GEF/GO (High Exhaust Heat)

Gas Energy Input: 25 MMBtu/hr (7300 kW)

Electric Output: 1750 kW

Steam Output: 12,667 lb/hr (3804 kW)

Overall efficiency: 76% (LHV)



Simple Cycle KG2-3GEF/GO (w/o Recuperator)

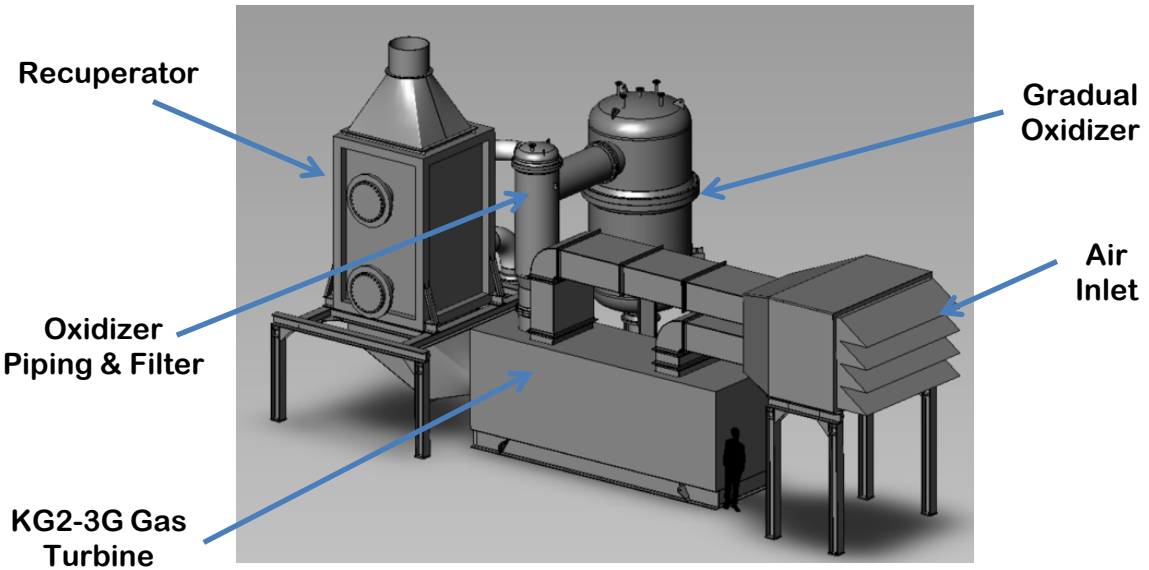
Recuperated KG2-3GEF/GO (High Electrical Efficiency)

Gas Energy Input: 17 MMBtu/hr (5000 kW)

Electric Output: 1750 kW

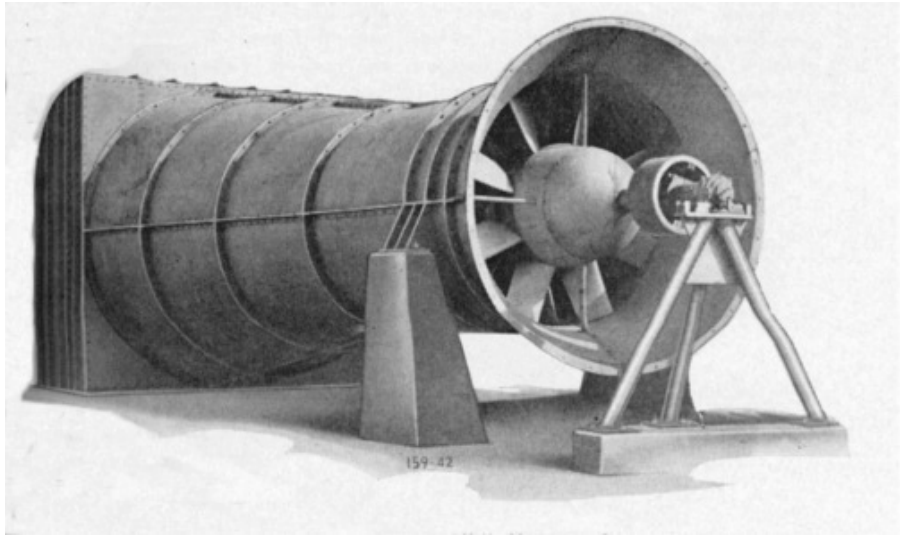
Electrical efficiency: 35% (LHV)

Overall efficiency: 70% (LHV)
(with 6 MMBtu/hr of hot water)

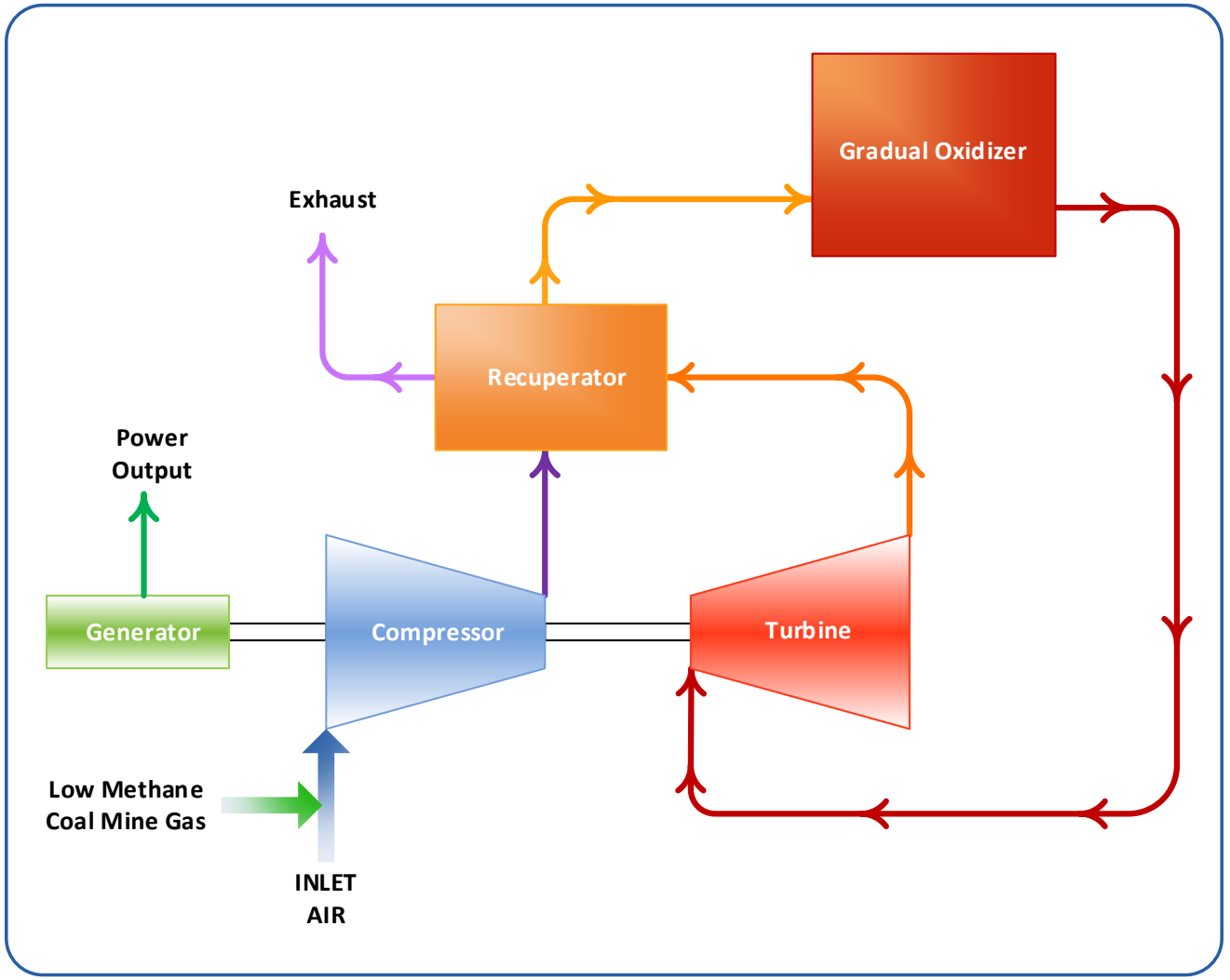


KG2-3GEF/GO with Recuperator

AMM Power Cycle

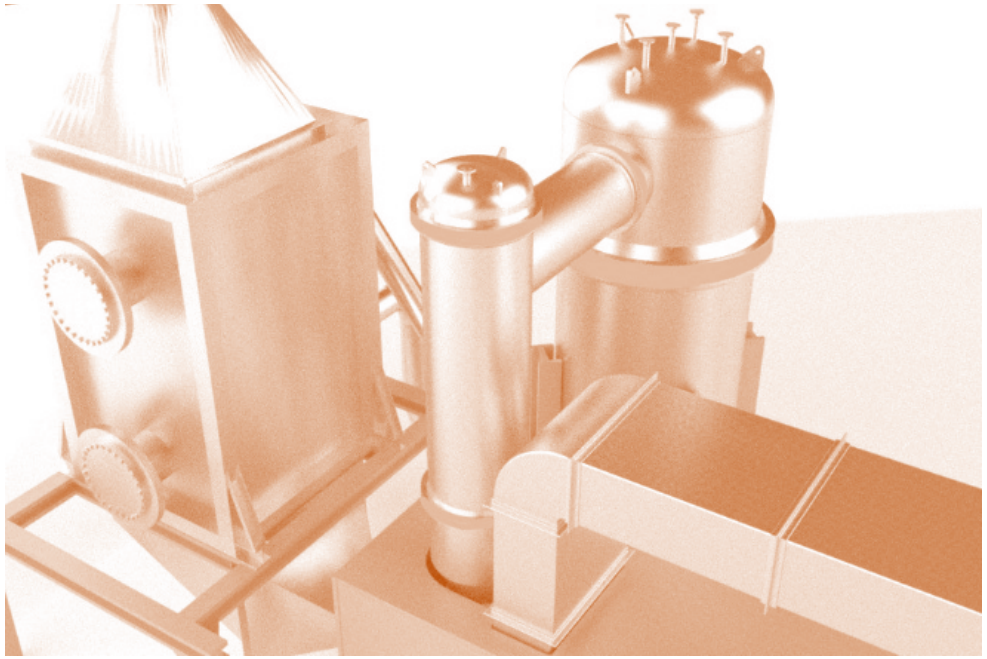


Abandoned Mine Methane (AMM) gas can be used as the primary fuel to operate the powerstation



AMM Fuel Input Requirements

As the AMM composition fluctuates, the flow required to operate the machine varies



KG2-3G w/GO

10% CH4

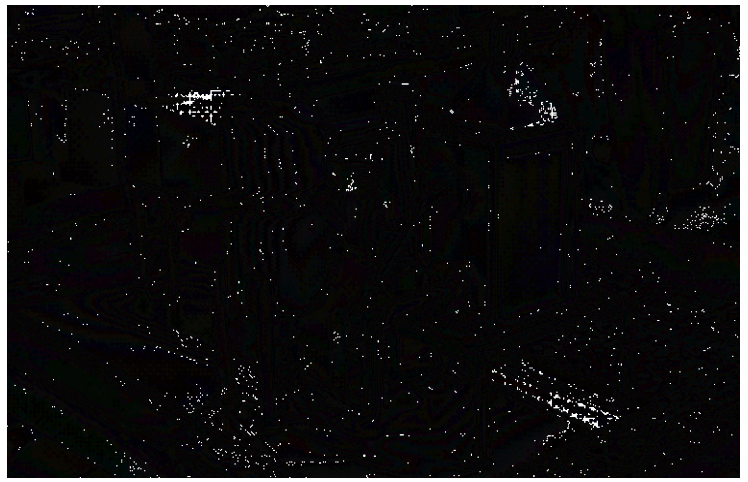
Energy Content – 3,91 MJ/Nm3
Flowrate – 4.600 to 6.400 NM3/hr

18.3% CH4

Energy Content – 7,21 MJ/Nm3
Flowrate – 2.500 to 3.500 NM3/hr

KG2-3G w/GO Energy Balance

Coal Mine Gas Energy Input 5000 kW

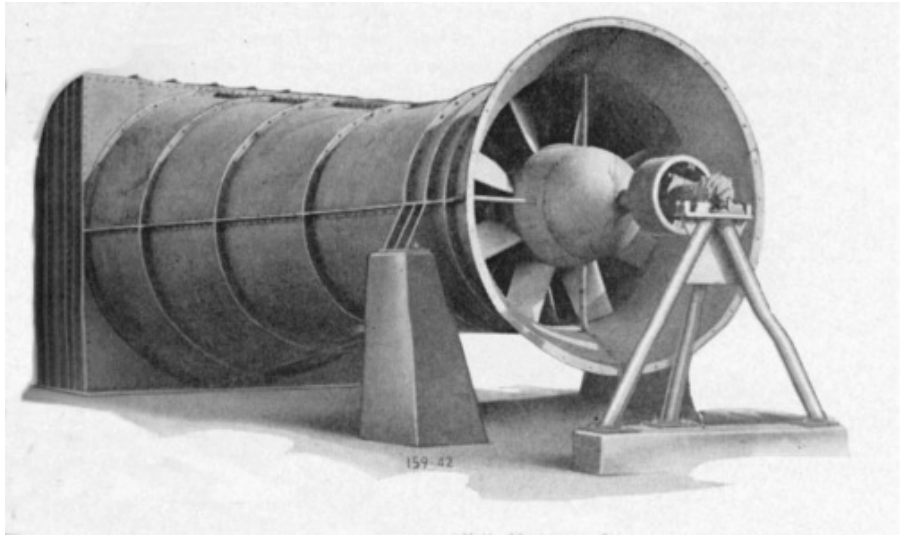


Electrical Output 1,750 kW

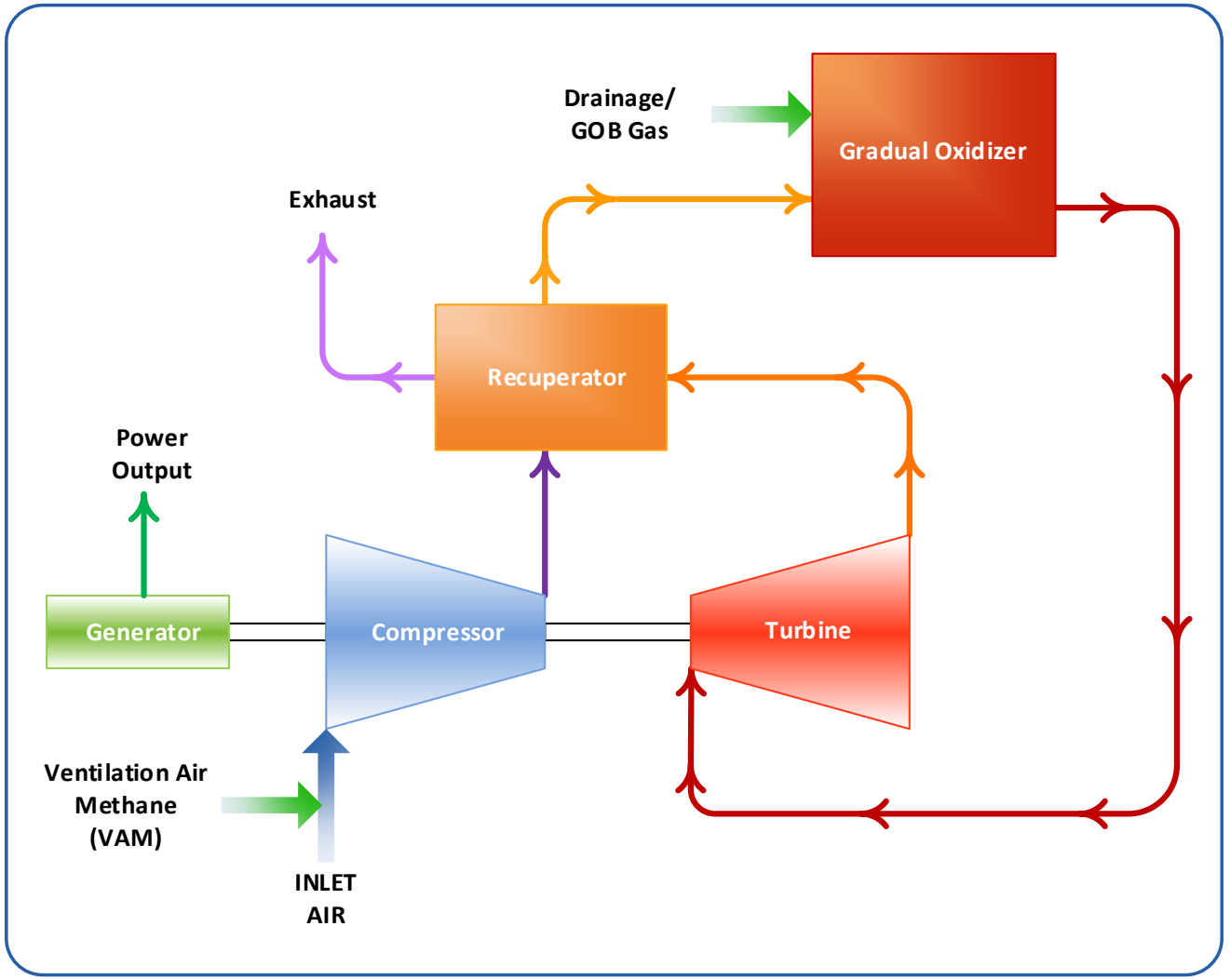
Exhaust Heat 2,700 kW

*Energy content of fuel * Flowrate*

VAM Power Cycle



Ventilation Air Methane (VAM) gas destroyed and GOB gas used to supplement powerstation operation



VAM Fuel Input Requirements

FP250

VAM

Flowrate – 6130 NM^3/hr(3615 scfm)
5206 MCFD
Pressure – Atmospheric

GOB gas

Flowrate - 75 NM3/hr (44 scfm)
63 MCFD
Pressure – 517 kPa (75 psig)

Assuming:

- 0.8% CH4 VAM
- 70.0% CH4 GOB Gas

KG2-3G w/GO

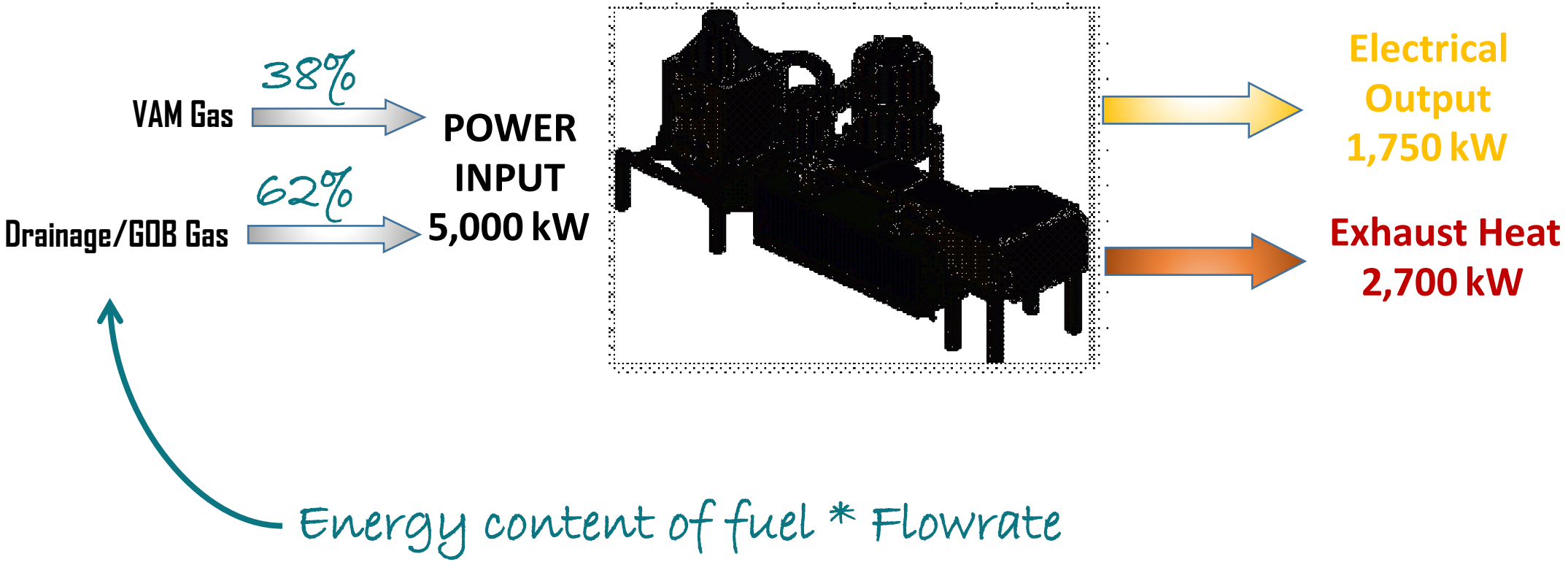
VAM

Flowrate- 27001 NM3/hr (15923 scfm)
22,929 MCFD
Pressure – Atmospheric

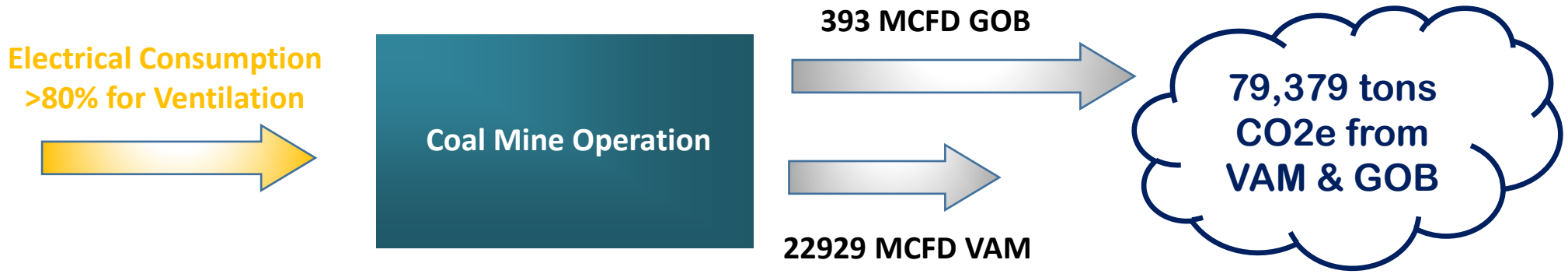
GOB gas

Flowrate - 463 NM3/hr (273 scfm)
393 MCFD
Pressure –1103 kPa (160 psig)

KG2-3GEF w/GO CO2 Balance

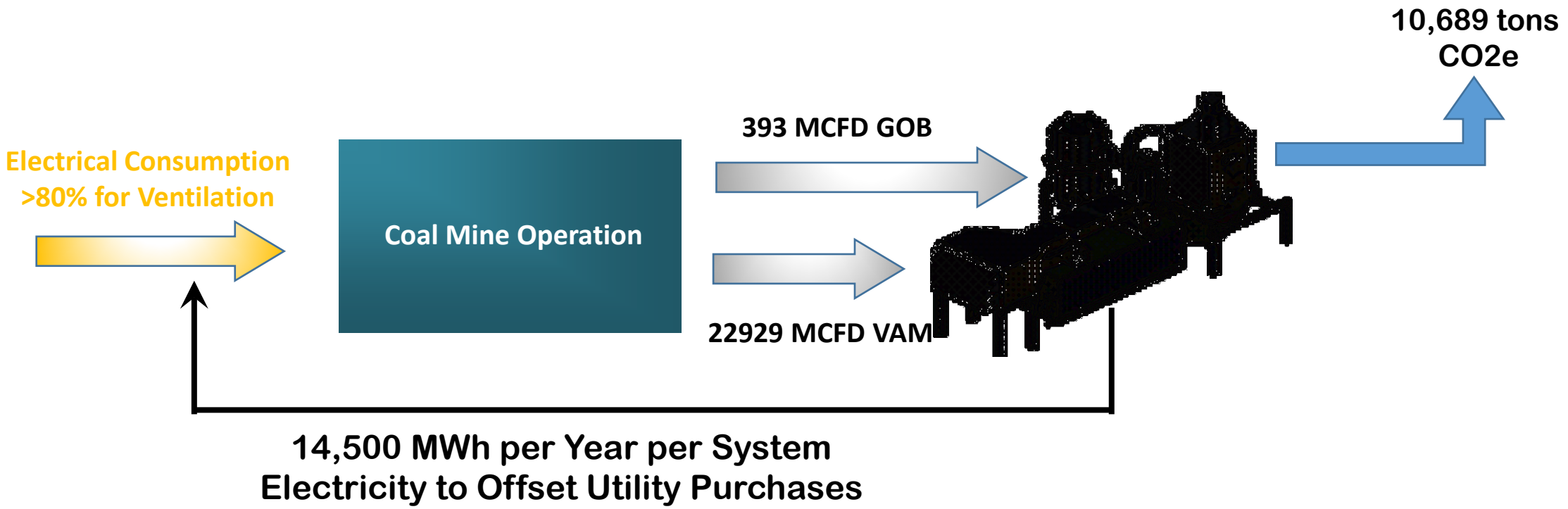


Coal Mine Operations
Costs & Emissions



Source: http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

Integration into Coal Mine Operations Offsetting Costs & Emissions



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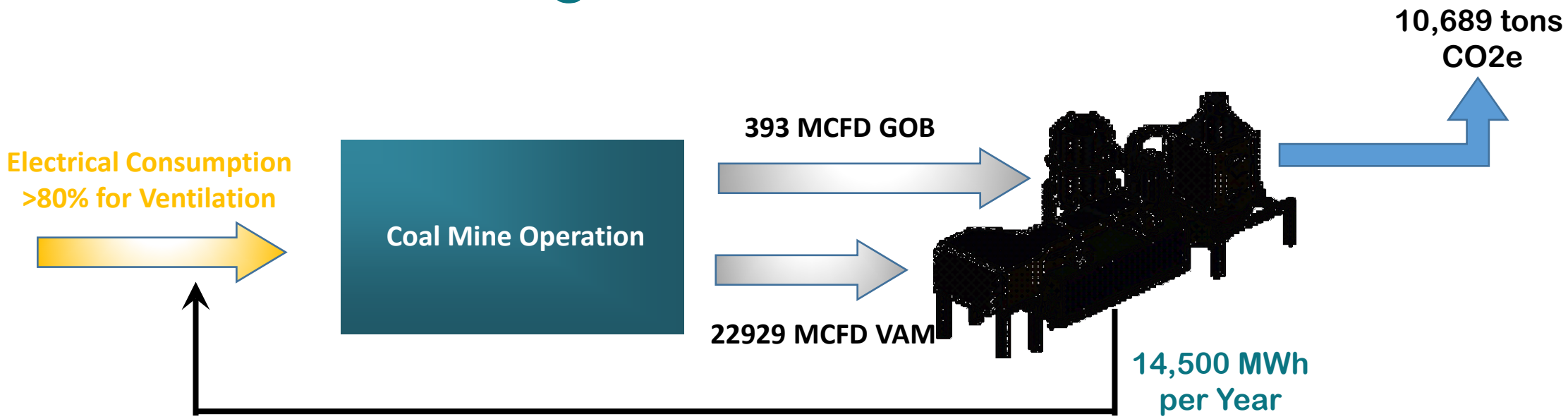
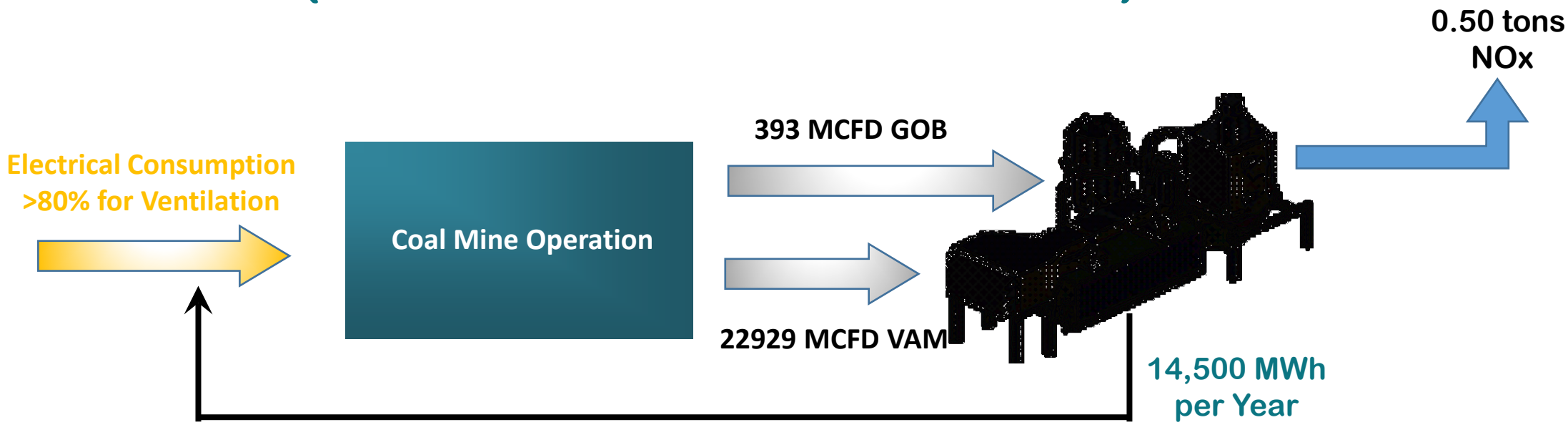


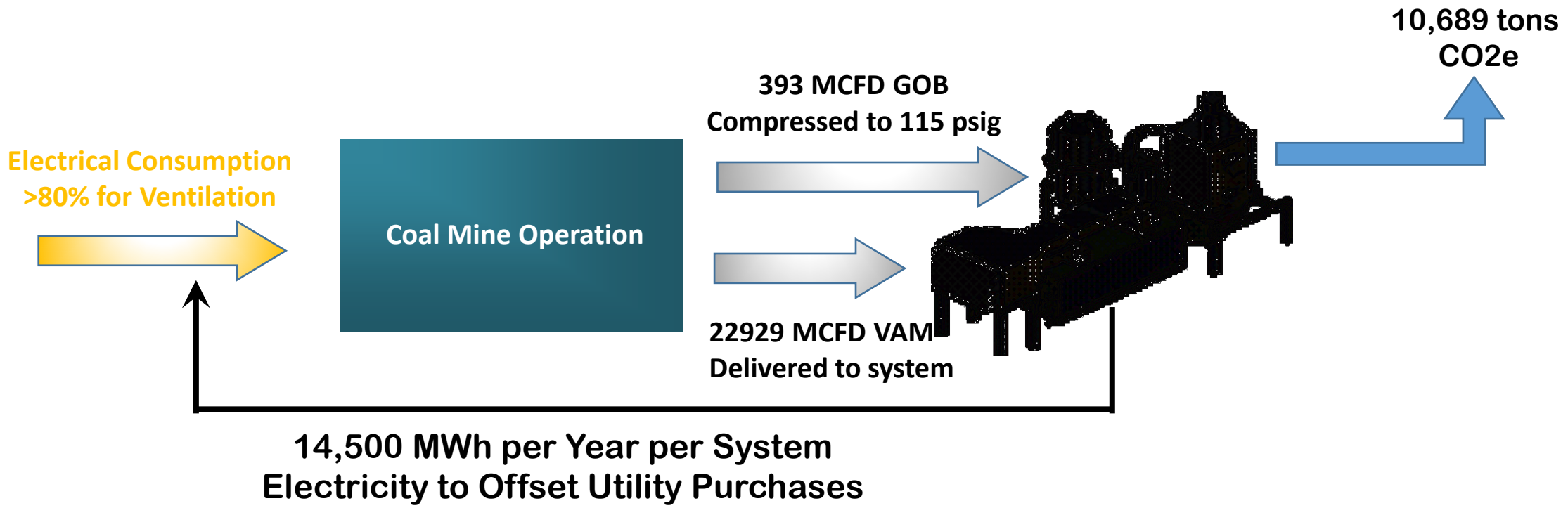
Annual Grid Electricity CO2 Savings from 1.75 MW Powerstation:	+10000 to 13800 tons (depends on region)
Annual Avoided CO2 from VAM & GOB Utilization:	+68690 tons
Annual Avoided CO2 Emissions from VAM Powerstation:	+78690 to 82490 tons

Benefit of Low NOx (Minor NOx Emissions Source)



Grid Electricity NOx Emissions Rate :	+1.38 to 2.3 lb/MWh (depends on region)
Grid Electricity NOx Associated Tons:	+10 to 17 tons (depends on region)
Annual Avoided NOx VAM Powerstation:	+9.5 to 16.5 tons (depends on region)

Economics of KG2-3GEF/GO at a Coal Mine Offsetting Electricity & Emissions



Source: http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

Installation of Ener-Core technology at XYZ Mine

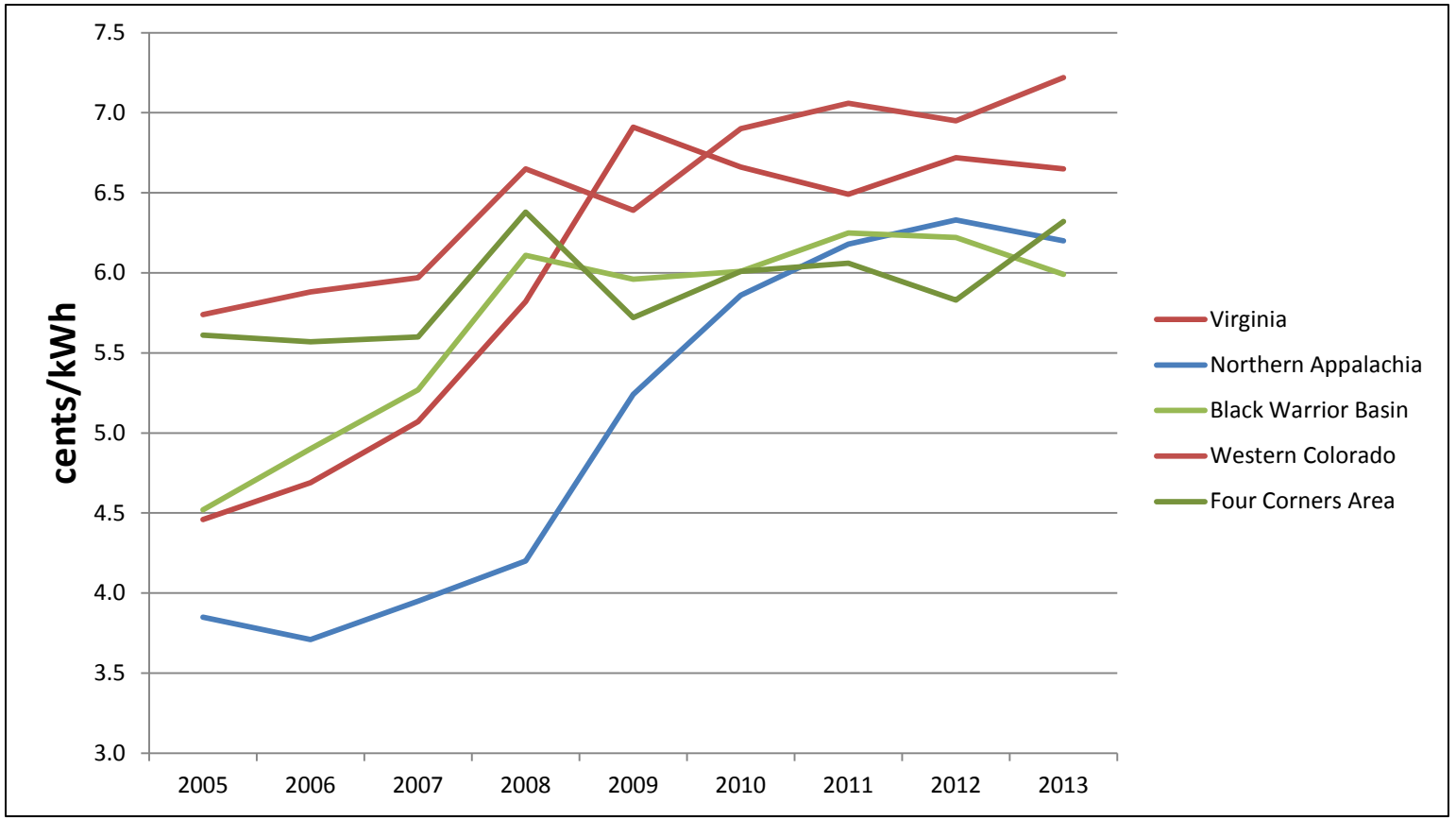
- ***Mine parameters***
  - 6 MT of coal mined annually
  - Annual ventilation emissions:
    - 1050 mmcf (or 2.8 mmcfd), 420,000 cfm
    - Concentration ranges from 0.35 to 0.7 percent
  - Annual gob gas drainage:
    - 525 mmcf (or 1.4 mmcfd)
    - Concentration averages 85 percent

Source: U.S.EPA's Envirofacts Tool - http://www.epa.gov/enviro/facts/ghg/search.html

Recent CMM Carbon Credit Prices

Emission Reduction	Price ($/tonne)	Credit Type	Includes CMM?
CRT	$1.00 - $3.00	Voluntary	Yes
VCU	$1.00	Voluntary	Yes
ARB Offset	$3.00 – 25.00	Compliance	Yes
Source: Cote (2013, 2014)			

Average Industrial Electricity Prices by Region



Source: www.eia.gov

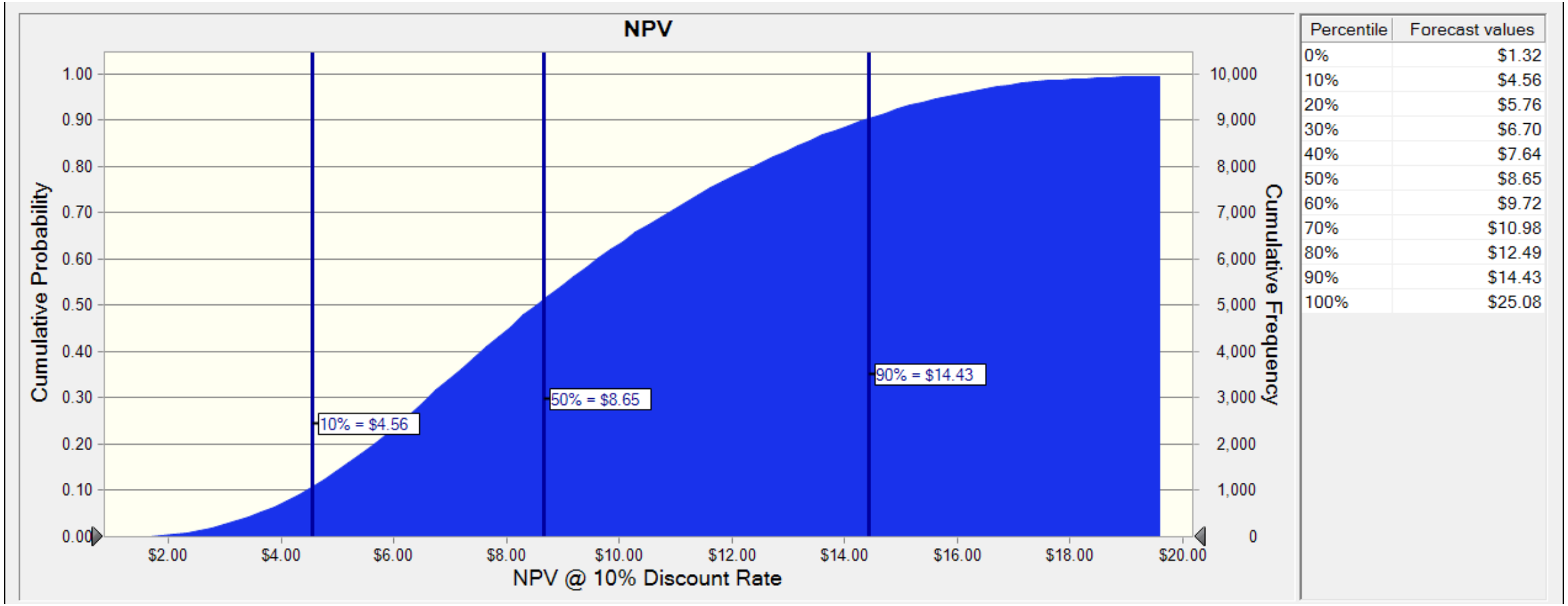
Inputs and assumptions

- Ener-Core KG2-3G w/GO units installed at mine site -
- All electricity generated will be used by the mine to supplant power purchased from the grid
- All gob gas is available for use by project at no cost to project
- Drilling costs are not included in economics
- Gas gathering and compression are included

Economic Analysis

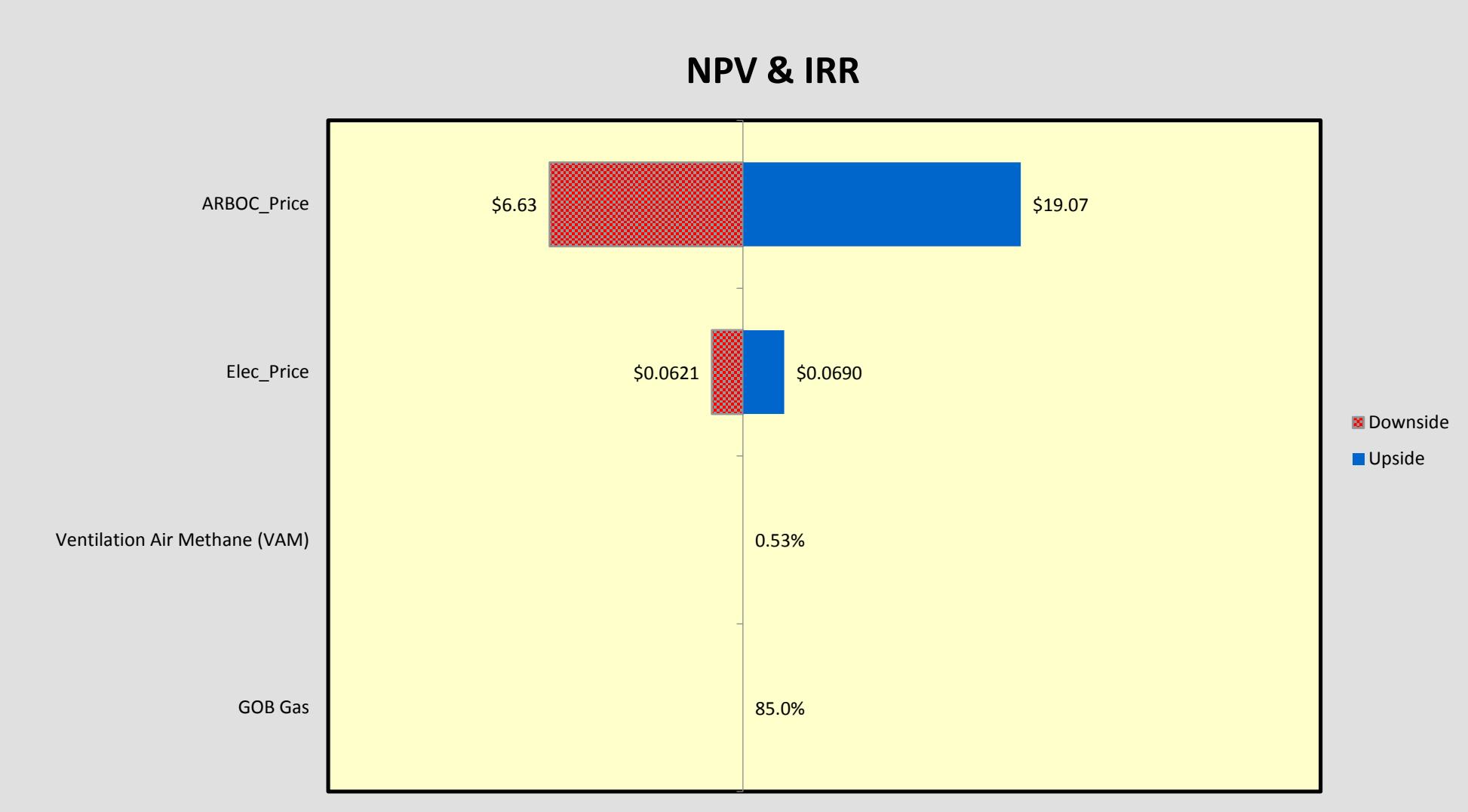
Parameter		Scenarios			
Assumptions	electricity price (¢)	5.99	7.22	6.40	6.40
	VAM concentration	0.70%	0.70%	0.70%	0.35%
	GOB concentration	85%	85%	85%	85%
Inputs	GOB production (mcfd)	1.40	1.40	1.40	1.33
	Installed capacity (MW)	7	7	7	5.25
	CAPEX ($ x 1,000)	21,592	21,592	21,592	16,194
	OPEX ($ x 1,000)	1,120.8	1,120.8	1,120.8	840.6
Results	ARBOCs	220,951	220,951	220,951	165,714
	IRR (%)	23.08	29.84	25.31	25.31
	NPV ($ x 1,000)	6,891	10,366	8,049	6,039
	Time to Payout (yrs)	4.6	3.9	4.3	4.3

Probability Distribution Plot - NPV



Percentile	Forecast values
0%	$1.32
10%	$4.56
20%	$5.76
30%	$6.70
40%	$7.64
50%	$8.65
60%	$9.72
70%	$10.98
80%	$12.49
90%	$14.43
100%	$25.08

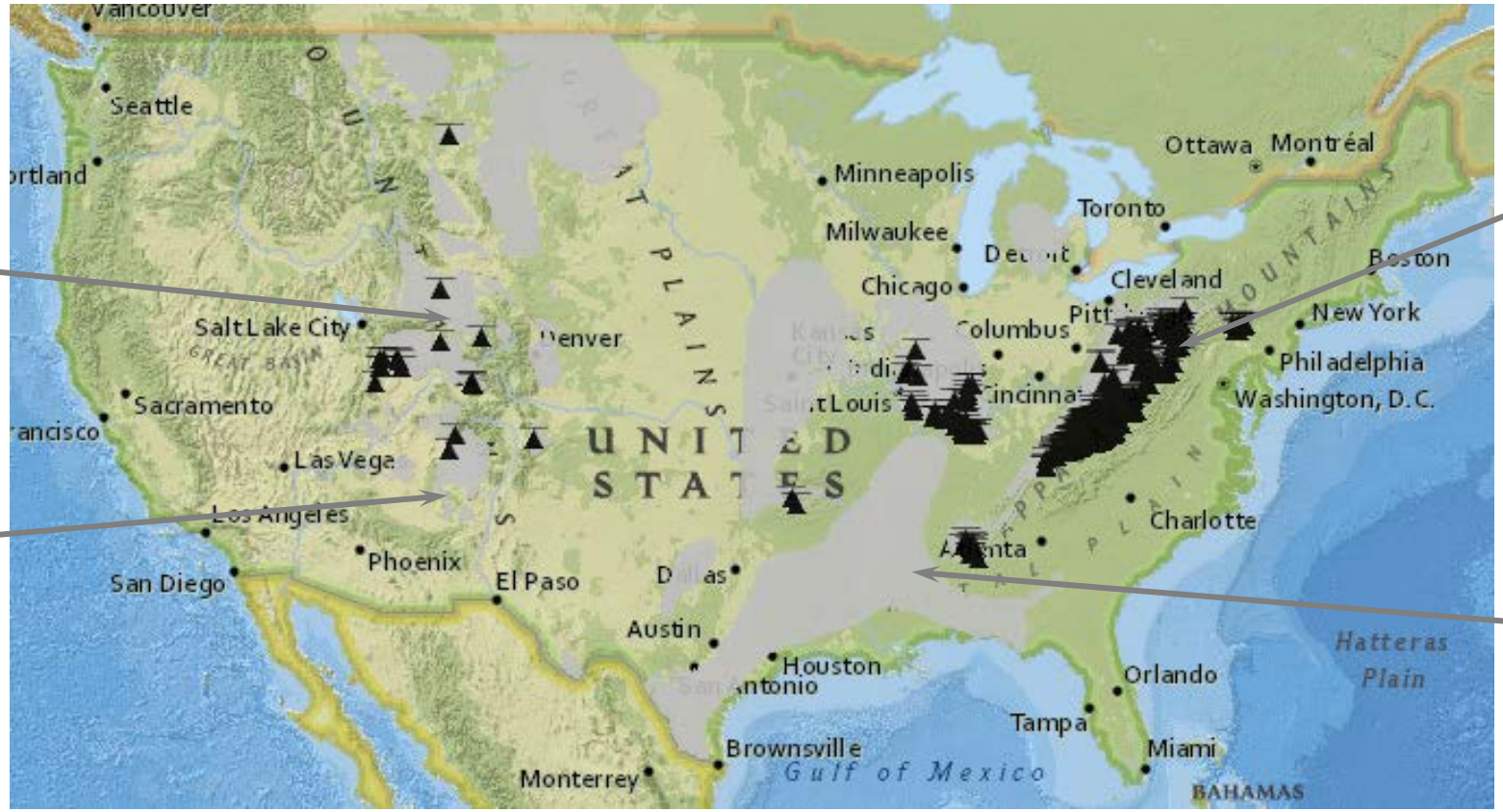
Sensitivity Analysis Tornado Plot



Raven Ridge Case Study Shows Environmental and Economic Solution Even with $60/MWh (6¢/kWh) Electricity

Western Colorado
$72.2/MWh
IRR 28%
3.9 yr payback

Four Corners
$63.2/MWh
IRR 25%
4.3 yr payback



Northern Applachia / Virginia
$62/MWh to $66.5/MWh
4.3 to 4.6 yr payback

Black Warrior Basin
$59.9/MWh
IRR 23%
4.6 yr payback

Watch our Whiteboard video explaining the gradual oxidation process and its applications

https://www.youtube.com/watch?v=YIwJNOF-SQU