Waste Gas Treatment Systems

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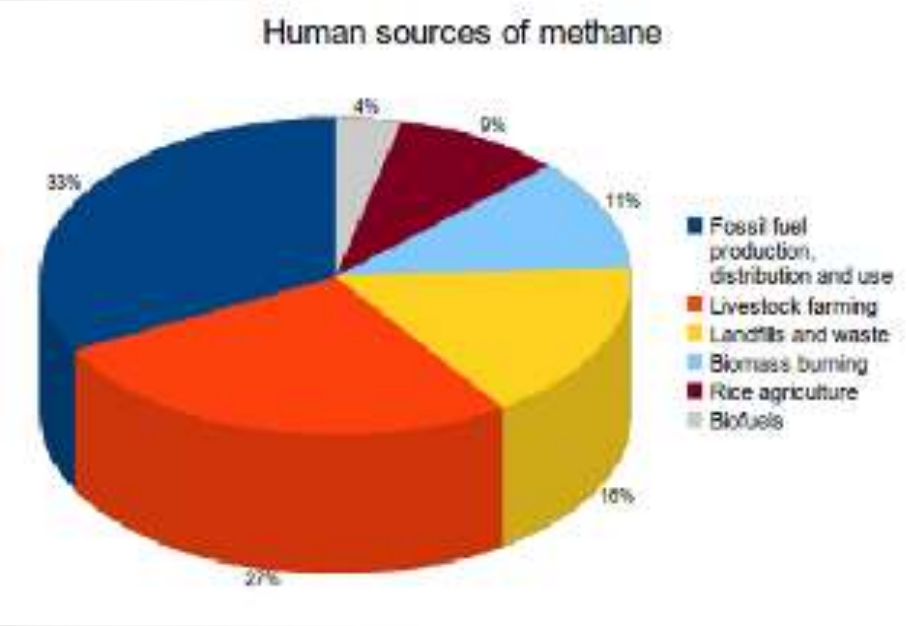
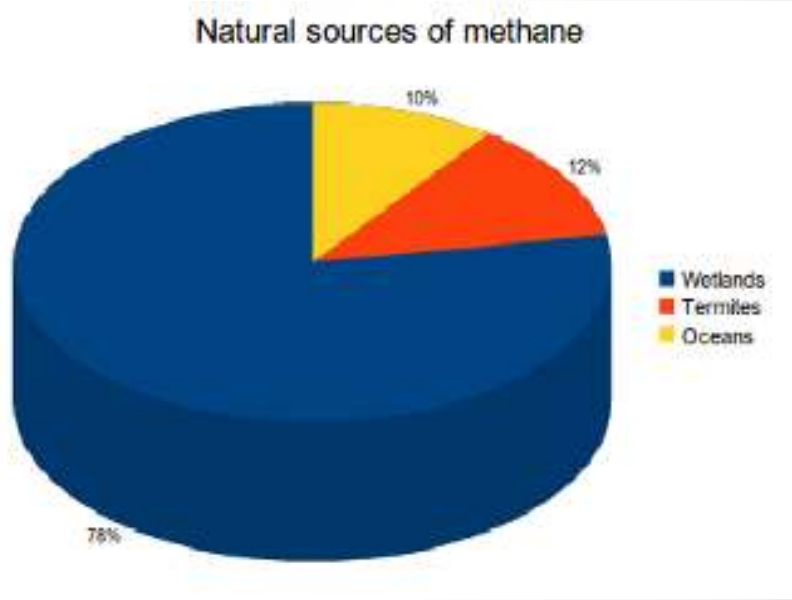
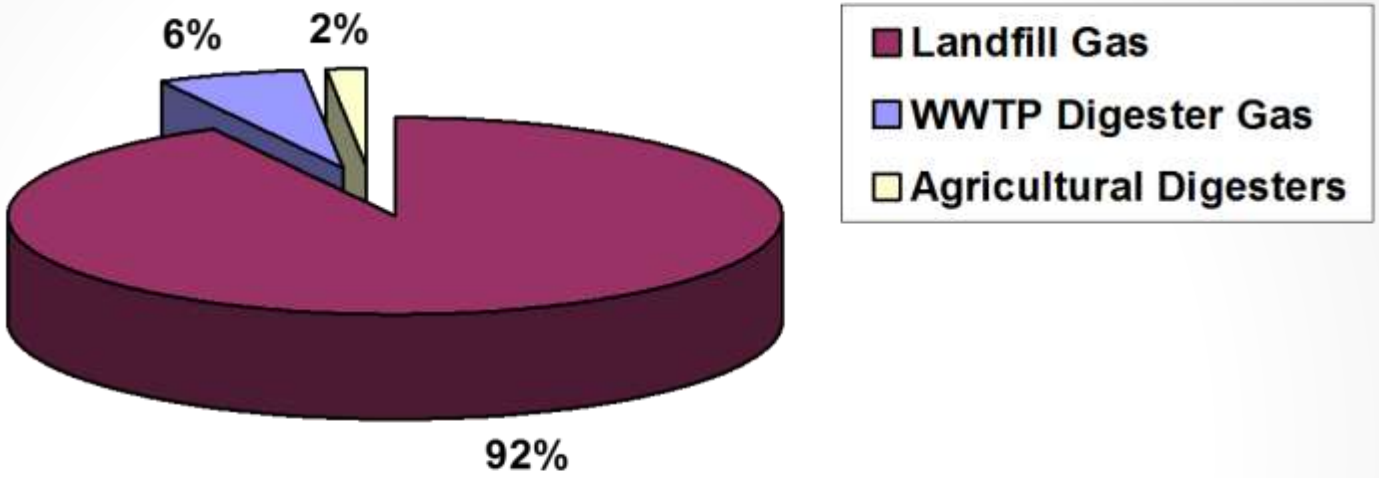
Methane Sources



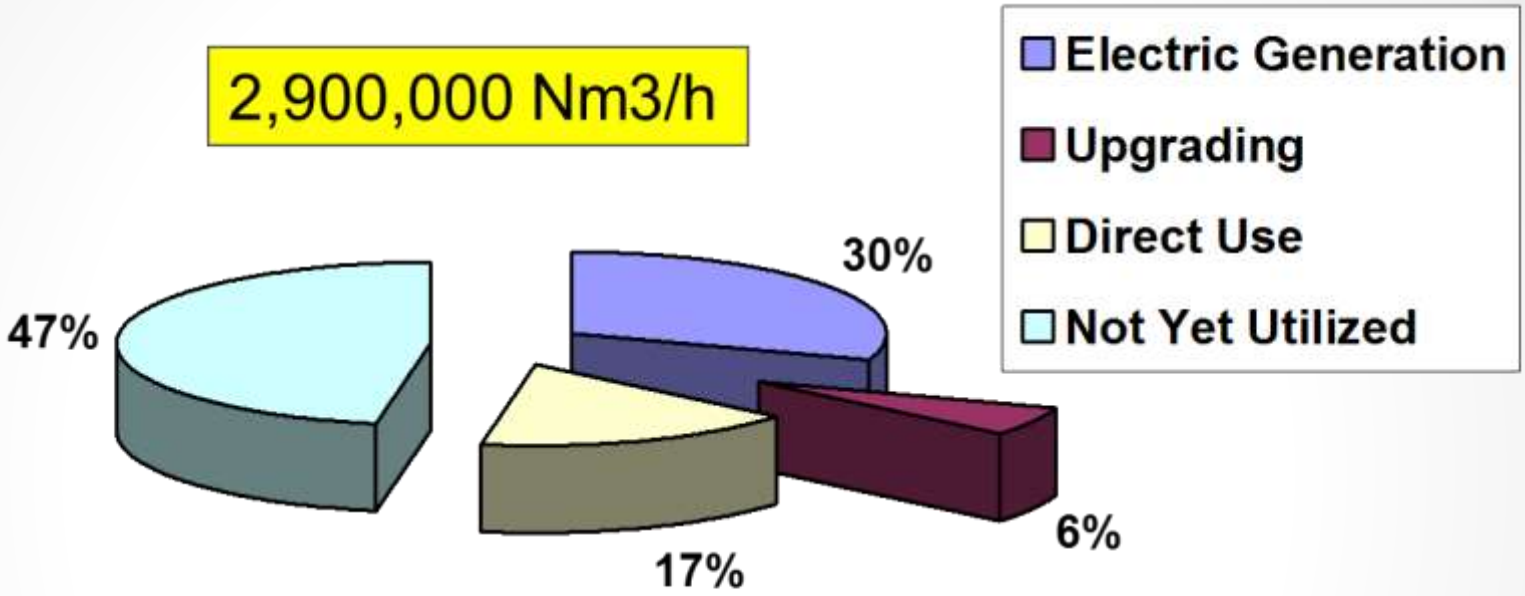


Biogas Sources in the US



- Landfill gas dominates (~4,000 Nm3/h typical)
- WWTP digester gas (~1,500 Nm3/h typical)
  - Easier to process
- Agricultural Digesters (~300 Nm3/h typical)
  - Added cost of digester
  - Rarely upgraded.

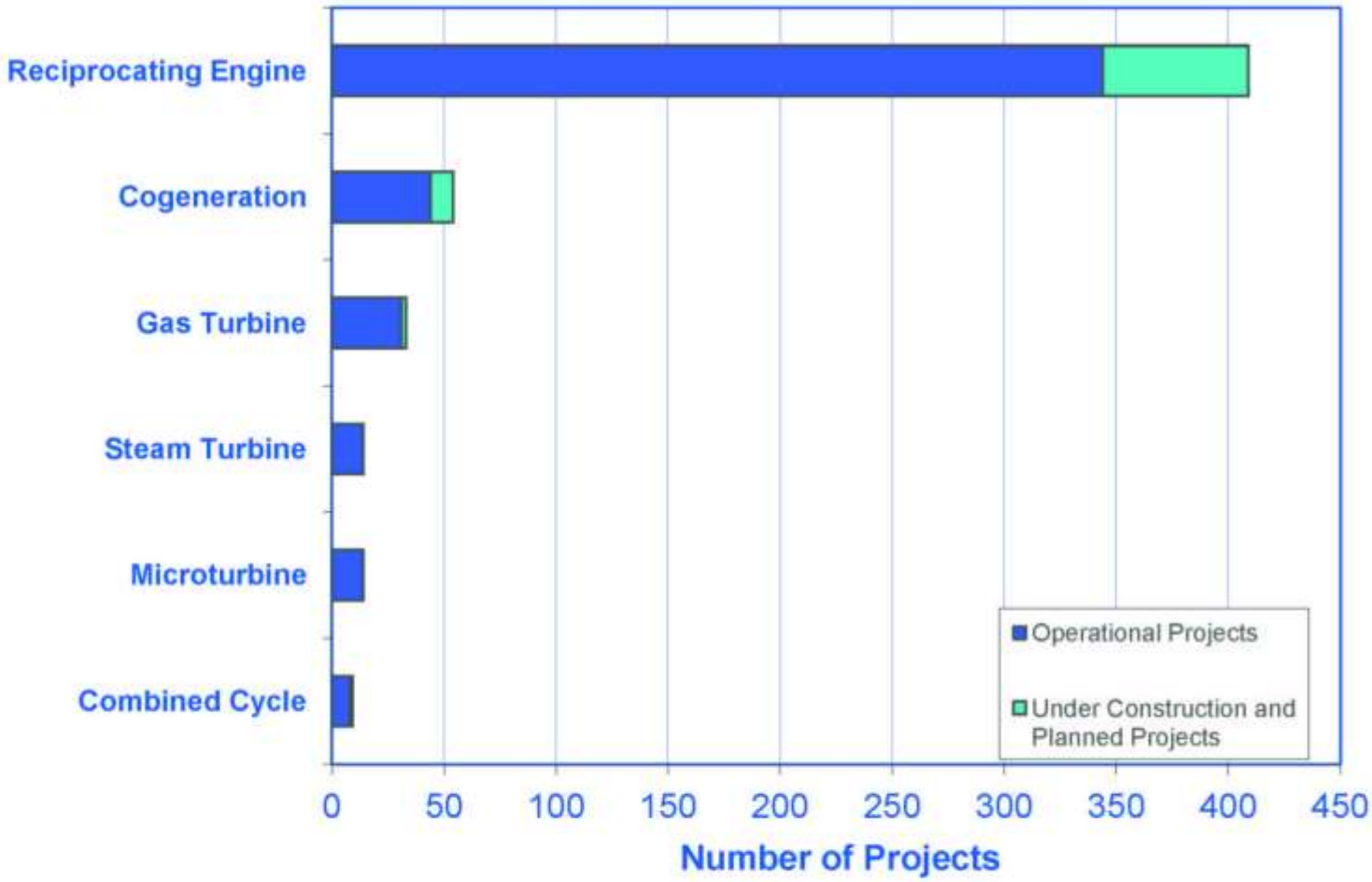
Landfill Gas (LFG) Utilization in the US



- Electric generation is most common
  - Incentives for electric (fed gov't grants, tax credits)
- Upgrading
  - Typically to pipeline quality
  - Zero US federal government incentives
  - Some states (California) offer added "renewable value"
- Almost ½ the US LFG is still not utilized

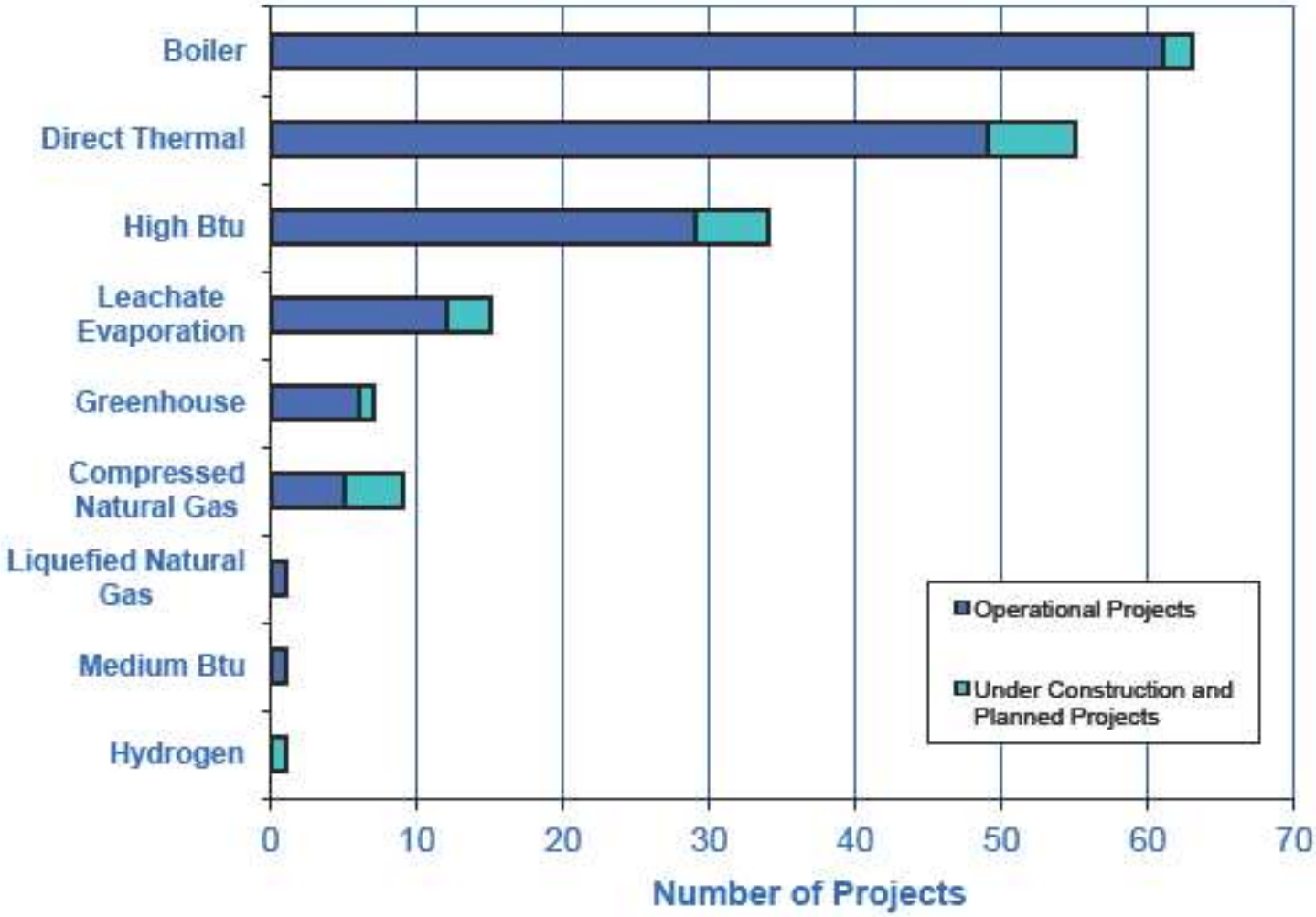
LANDFILL METHANE OUTREACH PROGRAM

Technology Trends
Electricity Projects



LANDFILL METHANE OUTREACH PROGRAM

Technology Trends
Direct-Use Projects



Concerns with LFG Emissions

- Landfills were the 3rd largest human-made source of methane (CH_4) in the U.S. in 2010
- LFG contains app. 50% CH_4
- CH_4 is a greenhouse gas (GHG), i.e. absorbs infrared radiation that would otherwise escape to space
- CH_4 as a GHG is over 20x more potent by weight than CO_2

Producing High BTU Gas: The Technologies

Three main technologies currently used:

- Pressure Swing Adsorption (PSA)
- Selexol Solvent – Oldest Technology
- Membrane – Currently Most Commonly Used

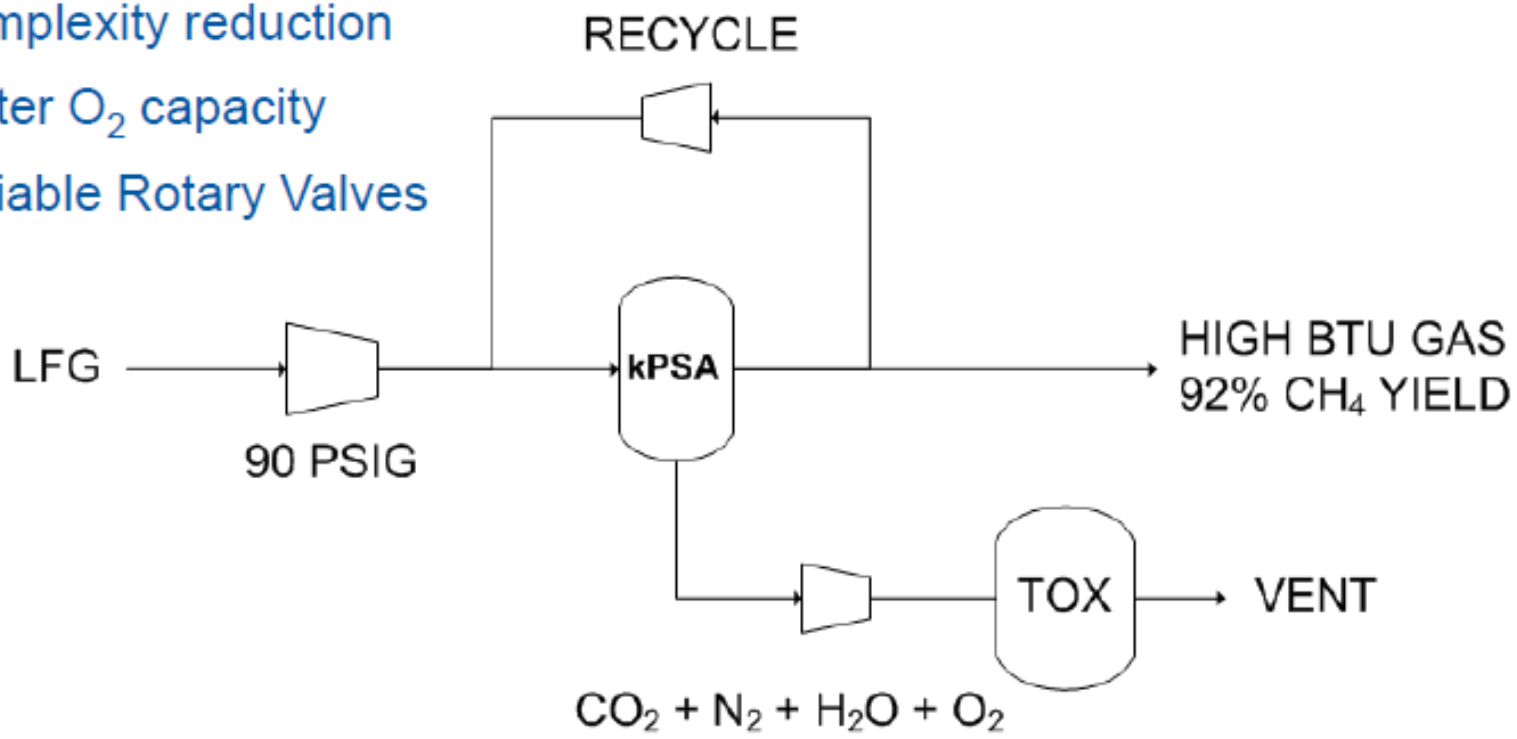
Pressure Swing Absorption (PSA) Technology

Uses Solid Porous Media with 3.7 Angstrom Pore Size

Methane	3.8 Angstroms
Nitrogen	3.6 Angstroms
Oxygen	3.5 Angstroms
Carbon Dioxide	3.4 Angstroms

Typical One Line of a PSA High BTU Project:

- Higher yield 92%
- Complexity reduction
- Better O_2 capacity
- Reliable Rotary Valves

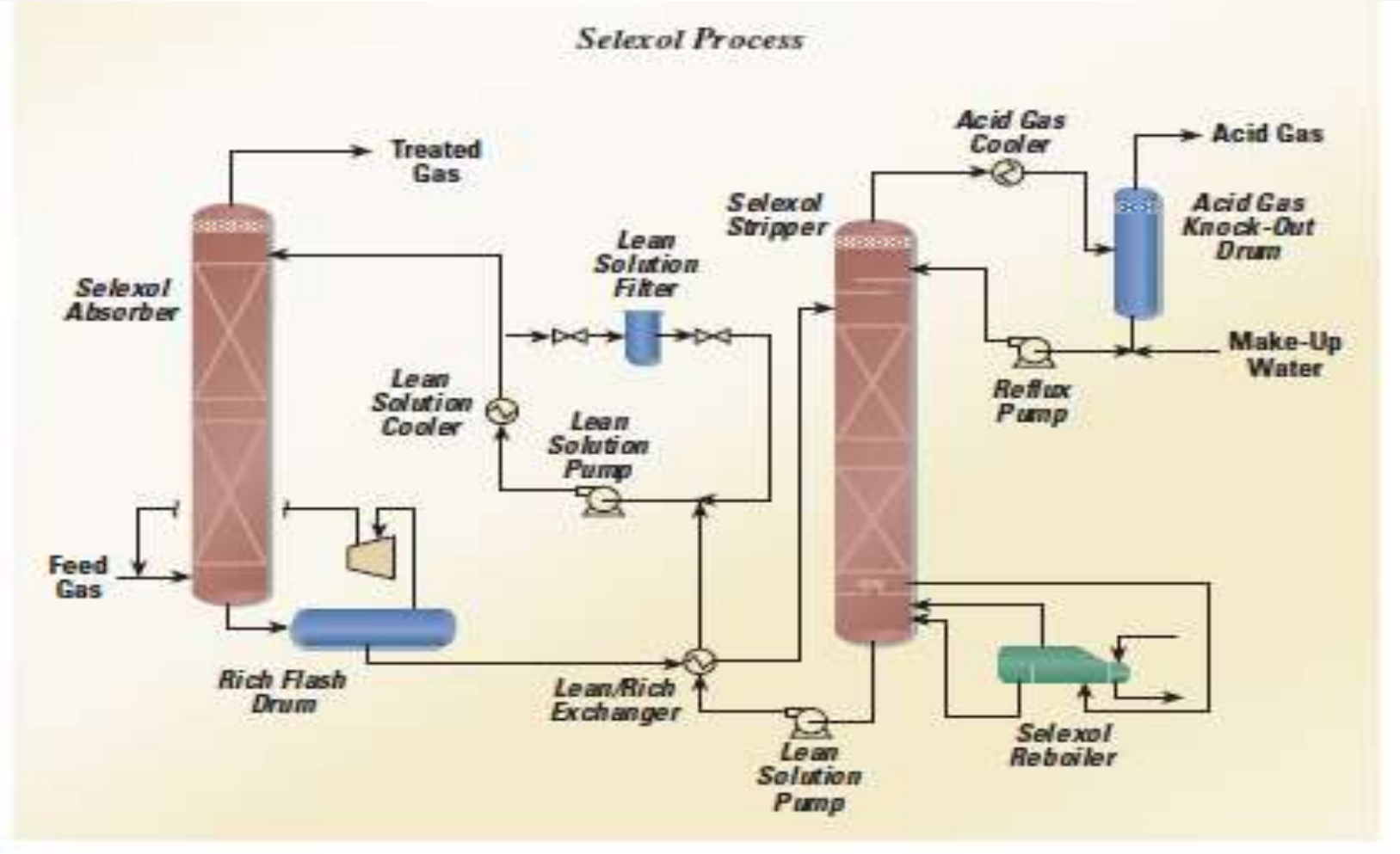


2010 PSA Plant (5200 scfm design)

Selexol Technology

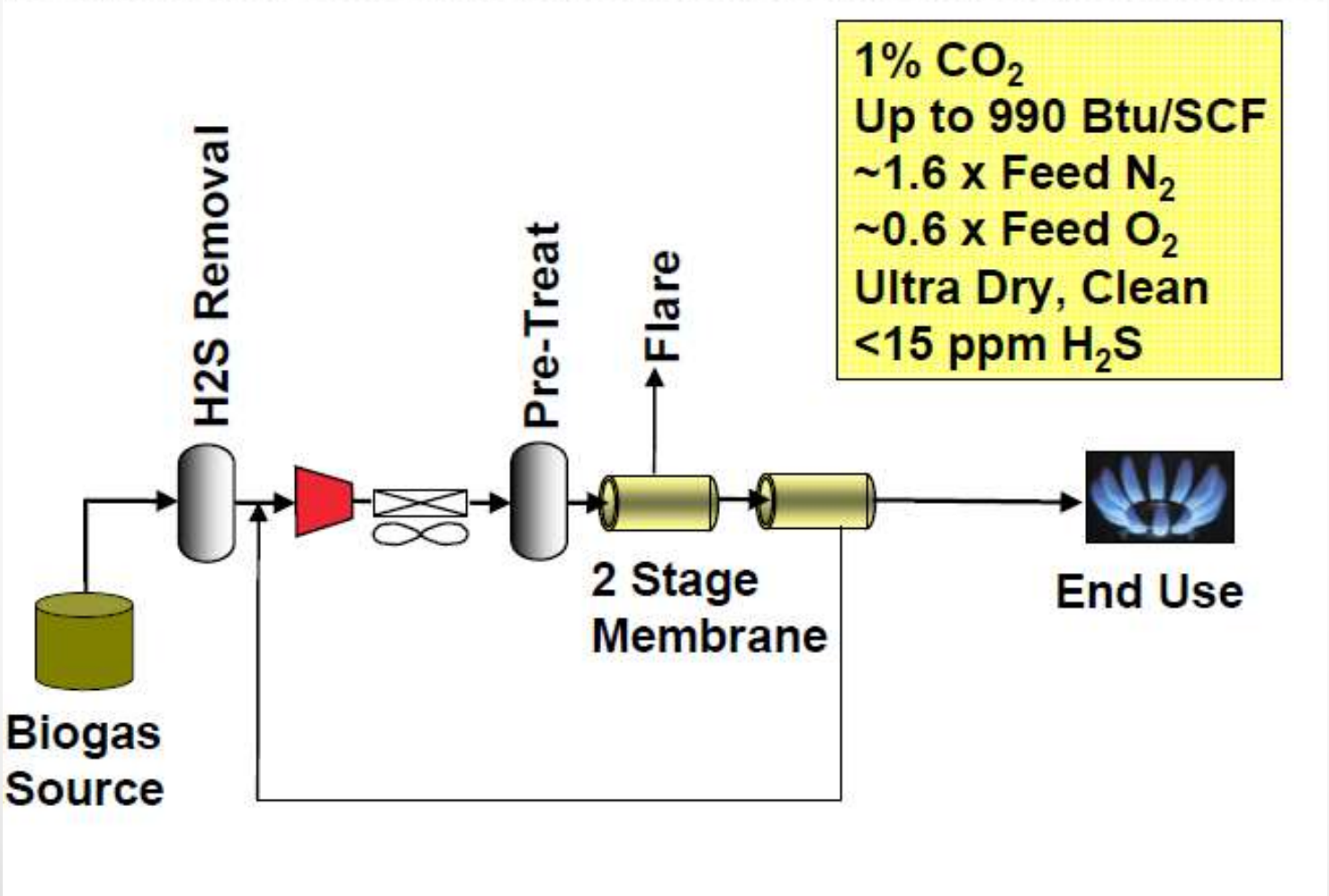
- Selexol is a blend of dimethyl ethers of polyethylene glycol
- Selexol absorption is a physical reaction vs a chemical reaction
- Acid Gases, i.e. CO_2 and H_2S are stripped and the lean solution is returned to the absorber unit

Typical One Line of a Selexol BTU Project:



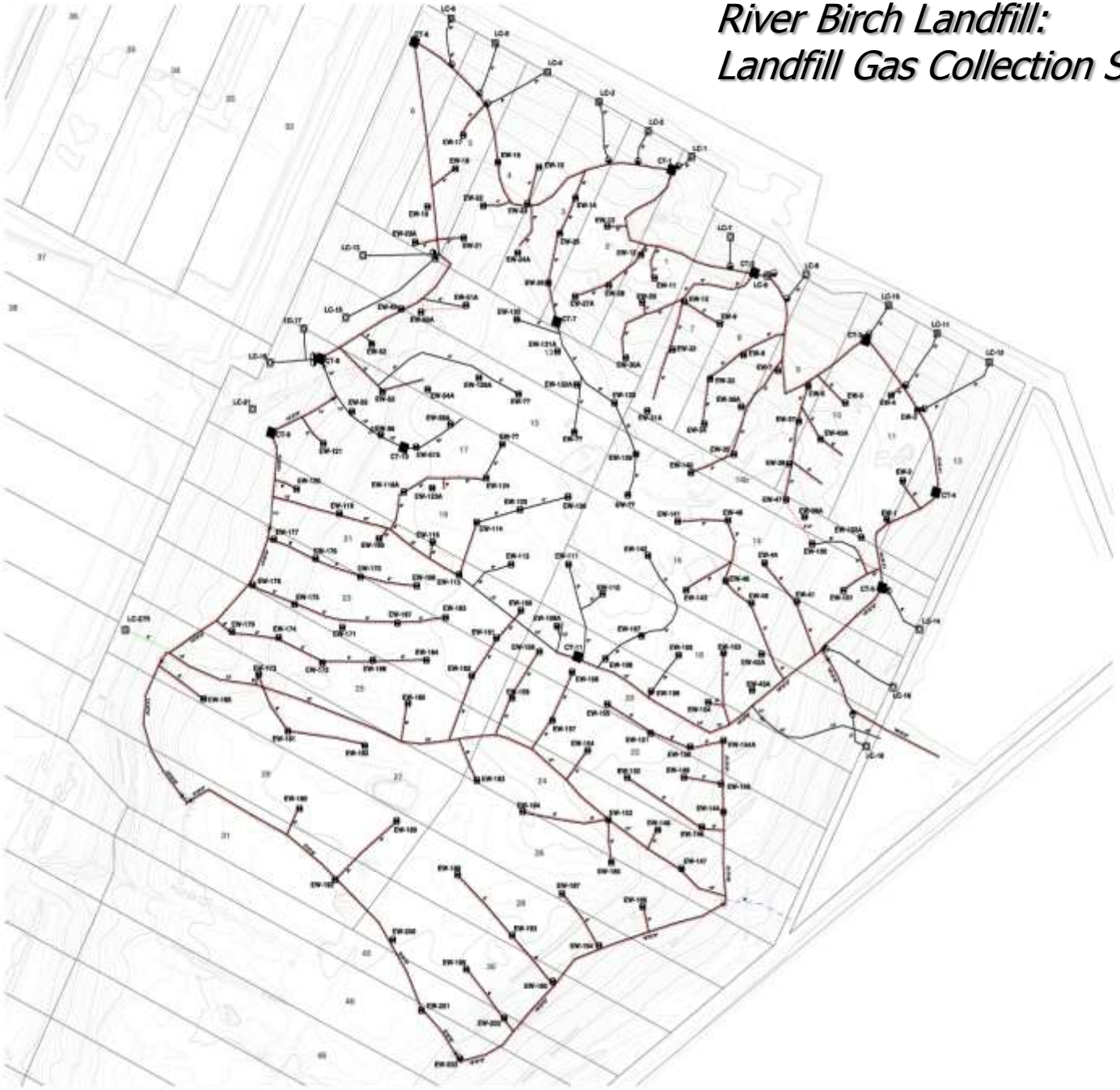
2009 Selexol Plant (2750 scfm design)

Typical One Line of a Membrane High BTU Project:



River Birch Landfill

River Birch Landfill:
Landfill Gas Collection System



NOTES:

1. AERIAL TOPOGRAPHY COMPILED BY AERO-DATA CORPORATION FROM AERIAL PHOTOGRAPHY DATED JUNE 12, 2013.

2. THE EXISTING LFG COLLECTION SYSTEM, CELL LIMITS, PROPERTY BOUNDARY, AND OTHER EXISTING SITE FEATURES SHOWN HERE WERE COMPILED FROM VARIOUS SOURCES, ASBUILT INFORMATION, AND AVAILABLE SITE DRAWINGS PROVIDED TO CEC BY THE OWNER.

3. NOTE THAT SOME LFG SYSTEM FEATURES MAY BE DIFFERENT THAN SHOWN HERE DUE TO MODIFICATIONS MADE BY THE OWNER OR THEIR CONTRACTORS TO ACCOMODATE LANDFILL OPERATIONS AND/OR CODE REGULATIONS.

LFG SYSTEM ASBUILT

DRAWING TITLE:	SITE PLAN (1" = 150')
PROJECT:	LANDFILL GAS COLLECTION AND CONTROL SYSTEM - 2013 ASBUILT RIVER BIRCH LANDFILL AVONDALE, LOUISIANA
CLIENT:	RIVER BIRCH INCORPORATED
	CARLSON ENVIRONMENTAL CONSULTANTS, PC
CEC PROJECT NO:	DATE: REVISED 2013 REV: 0
SCALE: 1" = 150'	SHEET 1 OF 1
DATE: SEPTEMBER 2013	

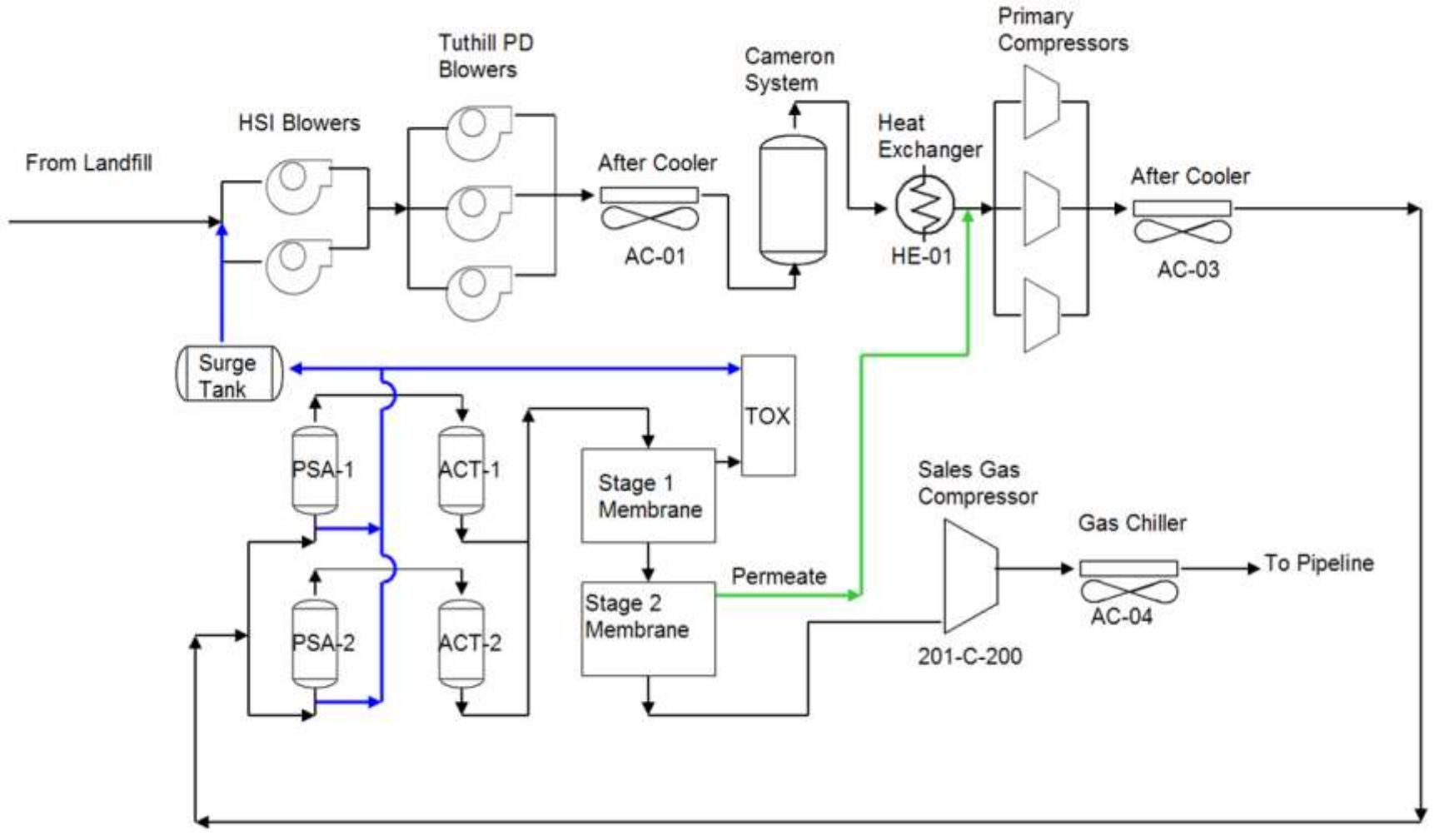
Landfill Gas Collection Wells

River Birch Landfill Gas

CONSTITUENT	CONCENTRATION
Methane	53-58%
Carbon Dioxide	40-45%
Nitrogen	1-4%
Oxygen	0-1%
Hydrogen Sulfide	120-150 ppmv
Non-Methane Organic Cpds (NMOCs)	1500-2500 ppmv

River Birch LGTE Plant (June 2010)

Single Line Diagram of River Birch Landfill Gas Plant

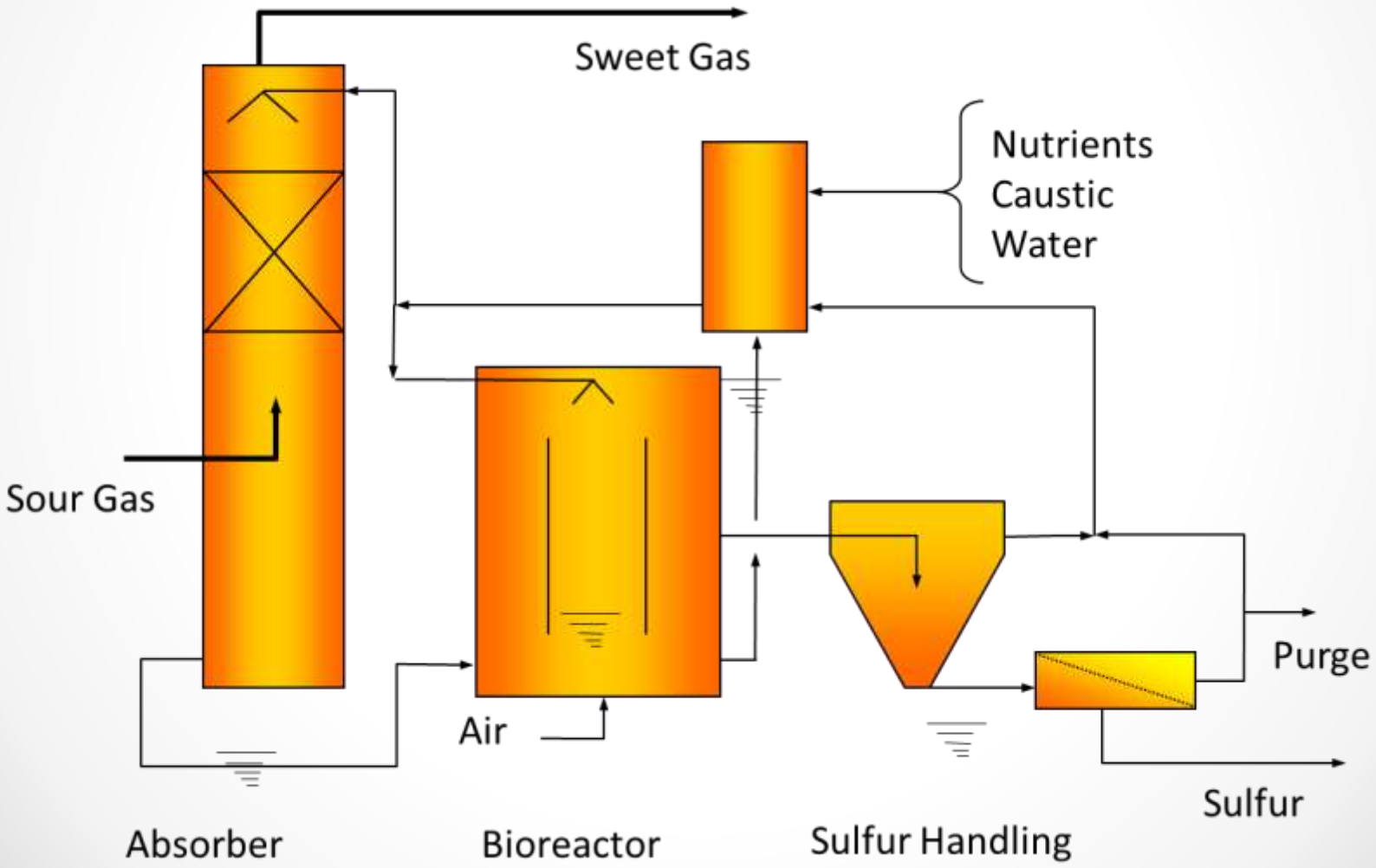


Landfill Gas Blowers

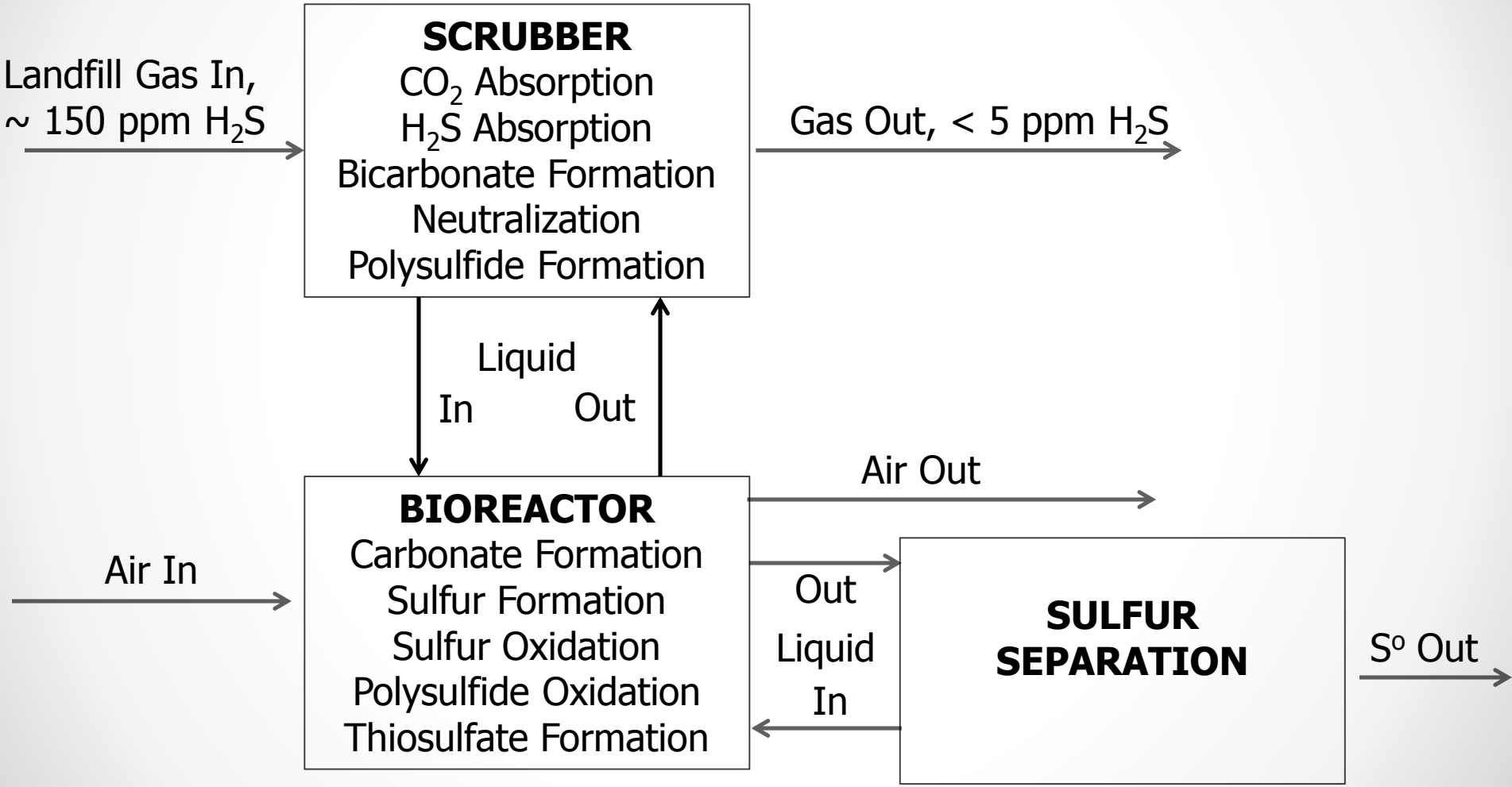
PD Blowers /Aftercooler

Cameron™ Biological Sulfide Treatment System

Thiopaq® Process Flow Diagram



General Process Chemistry



Anoxic Biological Conversion of Sulfide to Sulfur

Absorption

Caustic treating at gas pressure

$$H_2S + OH^- \qquad HS^- + H_2O$$

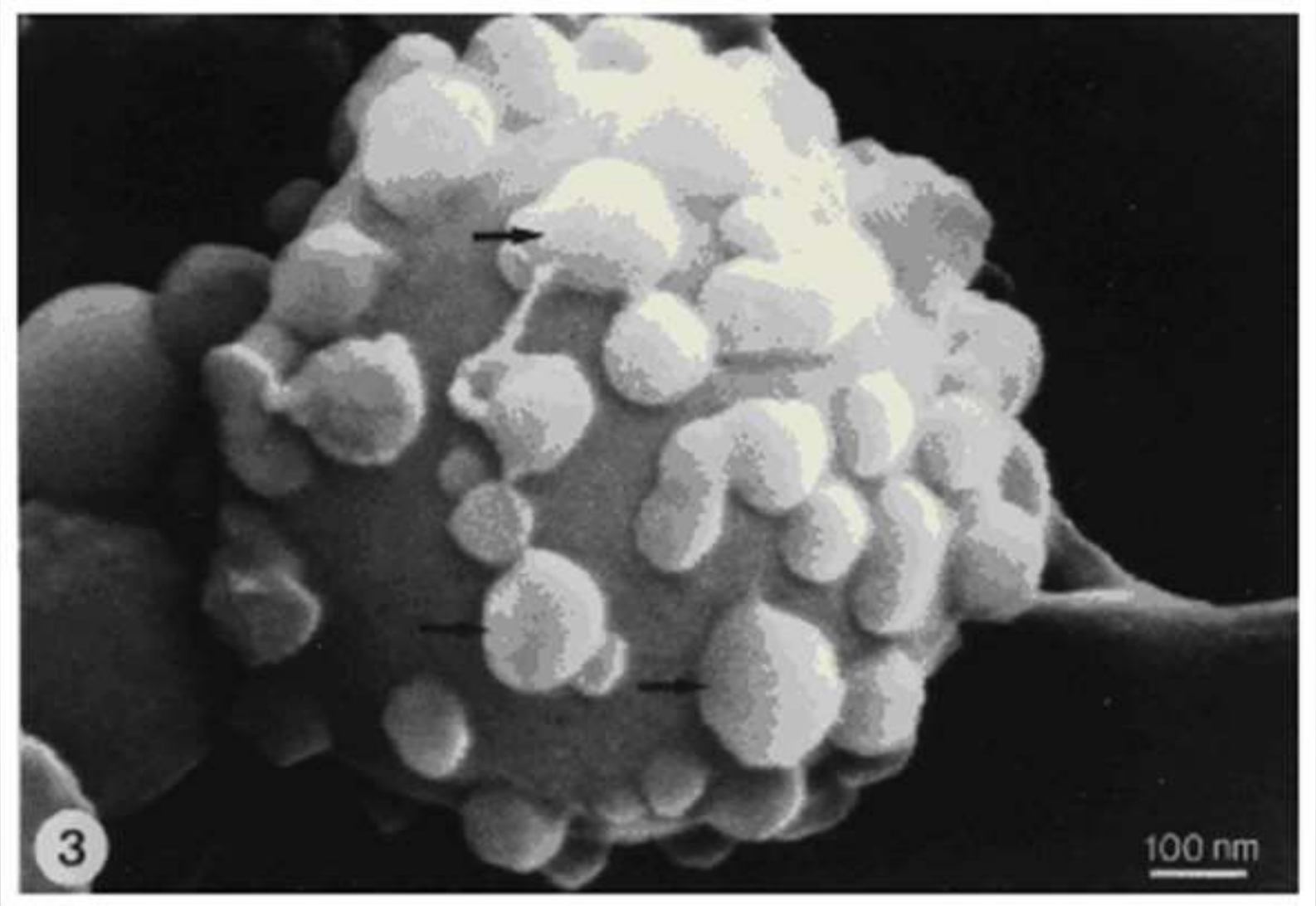
Bio-regeneration

Selective oxidation – caustic regeneration

$$HS^- + 0.5\ O_2 \qquad S^o + OH^-$$

Anoxic Conditions Important!!!!
Redox Potential Around -340 mV

Thiobacillus Bacteria Excreting Sulfur



Ammonia Chiller

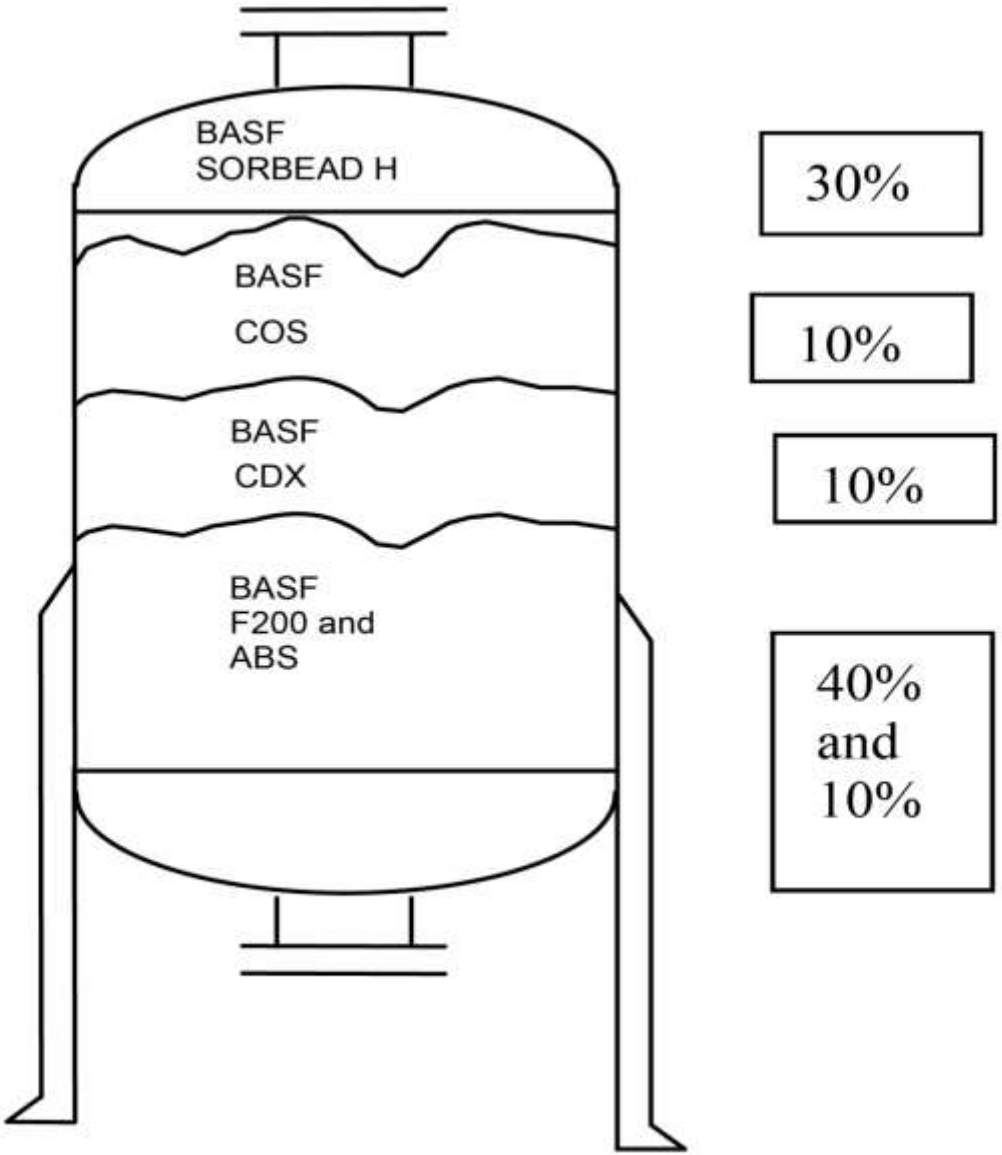
Inlet Gas 100°F
Outlet Gas 45°F

Primary Compressors

Inlet Gas	45°F
Outlet Gas	225°F
Compressor Aftercoolers	105°F

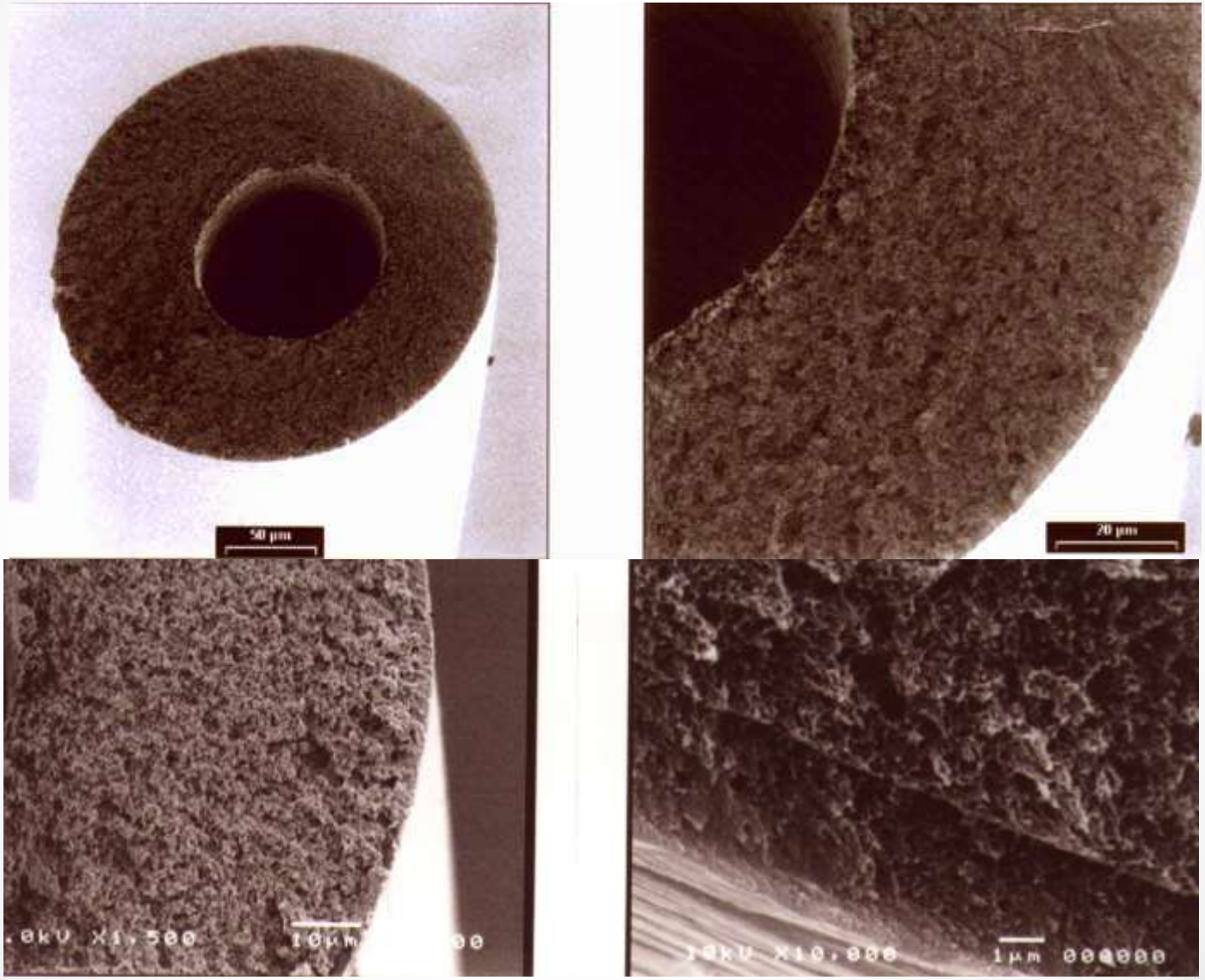
PSA Units

PSA Beds

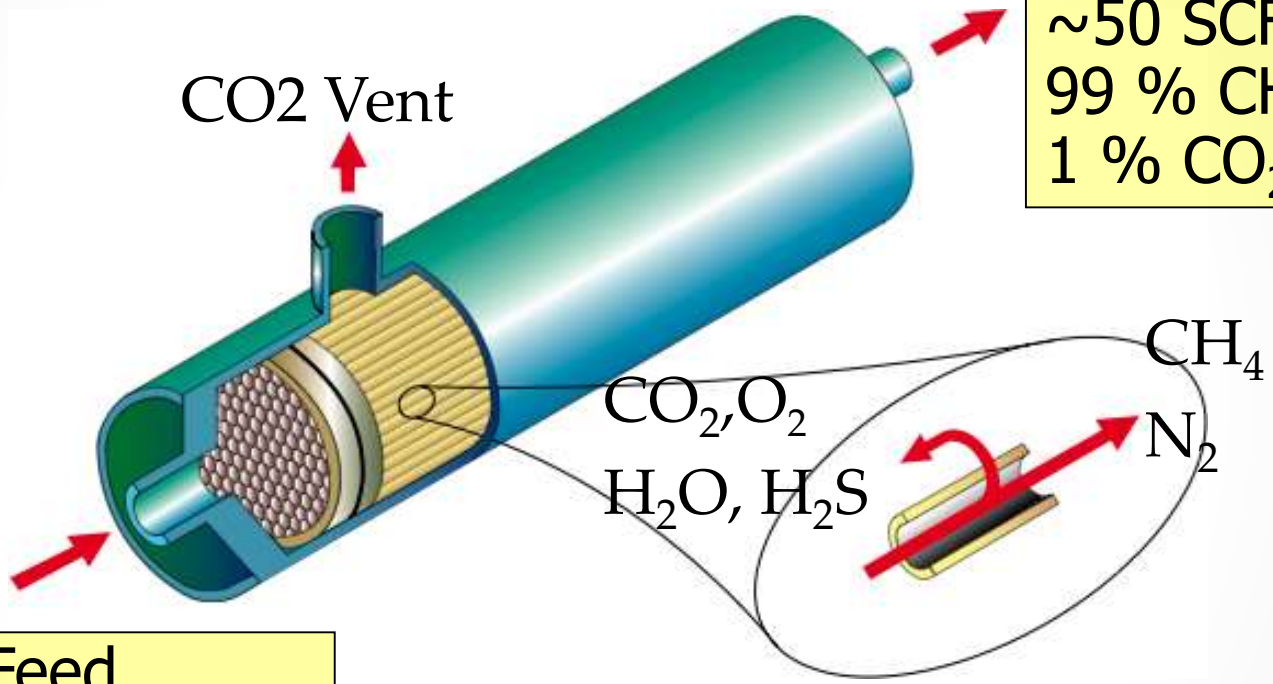

BASF
SORBEAD H
30%
BASF
COS
10%
BASF
CDX
10%
BASF
F200 and
ABS
40%
and
10%

Biogas Membranes

Membrane Hollow Fiber



How the Biogas Membrane Works



Product
~50 SCFM
99 % CH_4
1 % CO_2

Biogas Feed
100 SCFM
100-200 PSIG
55/45% CH_4 /CO_2

Stage 1 Membranes

- "First Pass" as separating CO_2 and CH_4
- Permeate Stream ~90% CO_2 and 10% CH_4
  - Regenerates PSA Beds then goes to the Thermal Oxidizer
- Residue Stream ~80% CH_4, 20% CO_2
  - Feed for the Stage 2 Membranes

Stage 2 Membranes

- Polishes the Stage 1 Residue Stream
- Permeate Stream ~50% CH_4 50% CO_2
  - Recycled to capture the CH_4
- Residue Stream ~ 95+% CH_4
  - Transported to Gas Pipeline

Sales Gas Compressor

Sales Gas Skid

LFGTE Membrane Plant

Landfill Gas Blowers

PD Blowers /Aftercooler

Cameron™ Biological Sulfide Treatment System

Ammonia Chiller

Primary Compressors

PSA Units

Biogas Membranes

Sales Gas Compressor

Sales Gas Skid

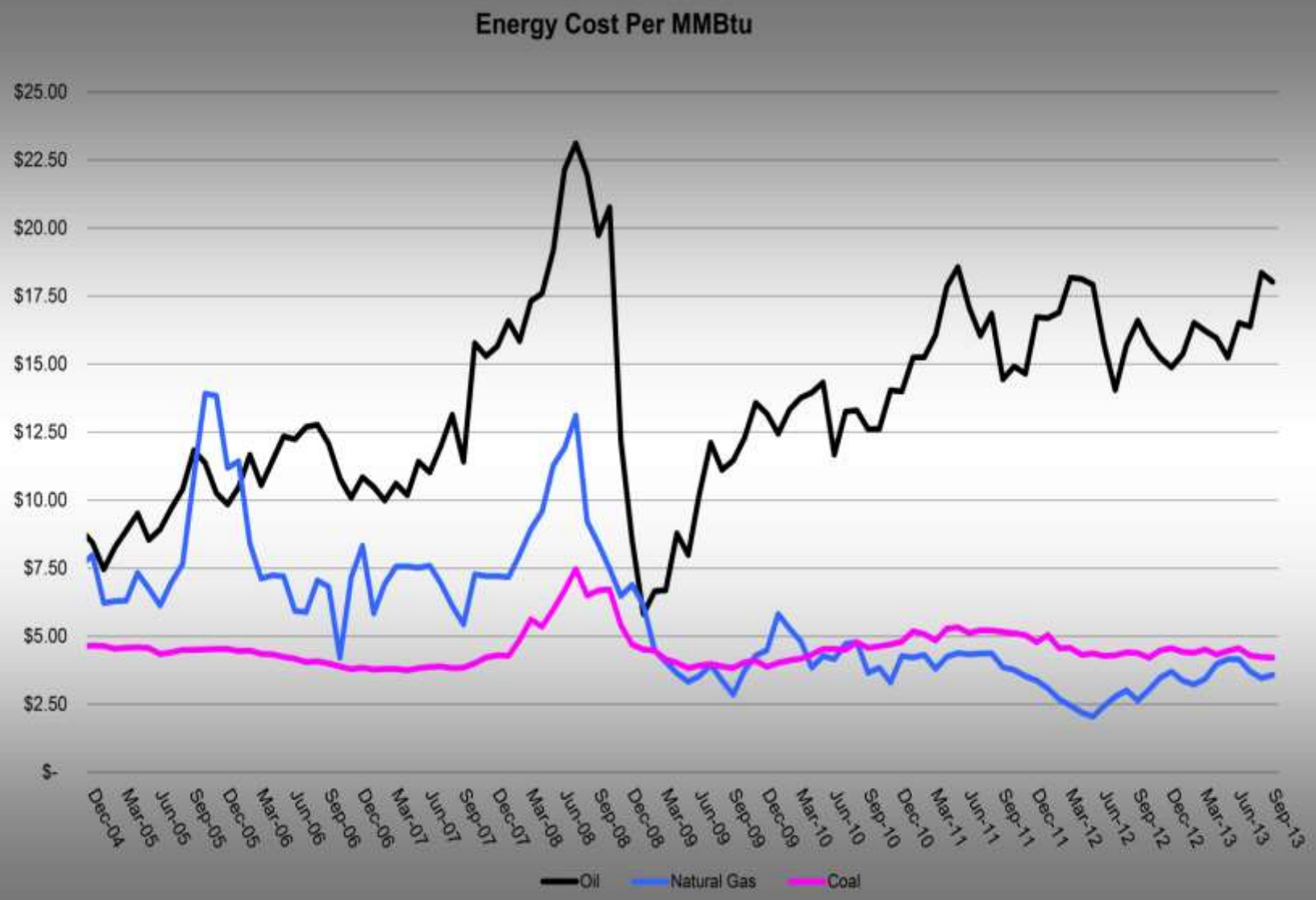
Pipeline Quality Gas Production

- Current Production is App. 2500 MMBTU/Day (4000 SCFM of LG)
- 1 MMBTU = 1 Decatherm = 8 GGE
- In Energy Equivalents, the Plant is Producing ~20,000 gallons of gasoline/day
- The Purified Gas is Sold to Atmos Energy

LFGTE Capital and Operating Costs

- Capital Costs for 6000 scfm Plant $14M
- Monthly Operating Costs = $86,900/Mo
- Monthly Electricity Costs Average $100K/Mo
- Revenue per Day at Current NYMEX Price ($3.68) + $1.00/MMBTU REN Credit = $4.68/MMBTU

Historical Energy Costs



QUESTIONS??

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