Medium and High Biogas Projects

Biogas Processing Options

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Medium BTU Processes

Typical end users:

1. Boilers for Heat

2. Direct Heating Applications

Medium BTU Gas Processing

Typical Processing Requirements:

1. Dehydration to 32 deg F using cold water dehydration

2. H2S removal to a level allowed by the permitting authority for combustion

3. Compression to lower levels (3 to 100 PSIG)

Gas is suitable for injection into a low pressure pipeline (typically HDPE)

Medium BTU Gas Makeup

	Before	After
Methane	40-70%	40-70%
Carbon Dioxide	30%-50%	30-50%
Oxygen	0-4%	0-4%
Nitrogen	0-20%	0-20%
H2S	0-1%	0-50 ppmv
Water	Saturated	35 deg dew point
Pressure	-50”-10”	3-100 PSIG

Medium BTU H2S

Typically Dry media H2S removal

Carbon

Sulfatreat

Sulfatrap

Medium BTU Dehydration

Medium BTU Users

Boilers for building heat or process heat

Medium BTU Direct Fire Applications

Nozzle Size Notes For Medium BTU projects

Nozzles will need to be changed in NG Burner equipment

- Prevents Flameouts due to high gas velocities
- Allows sufficient BTUs to burner

Typical HiBTU Processing to meet Pipeline Tarriff

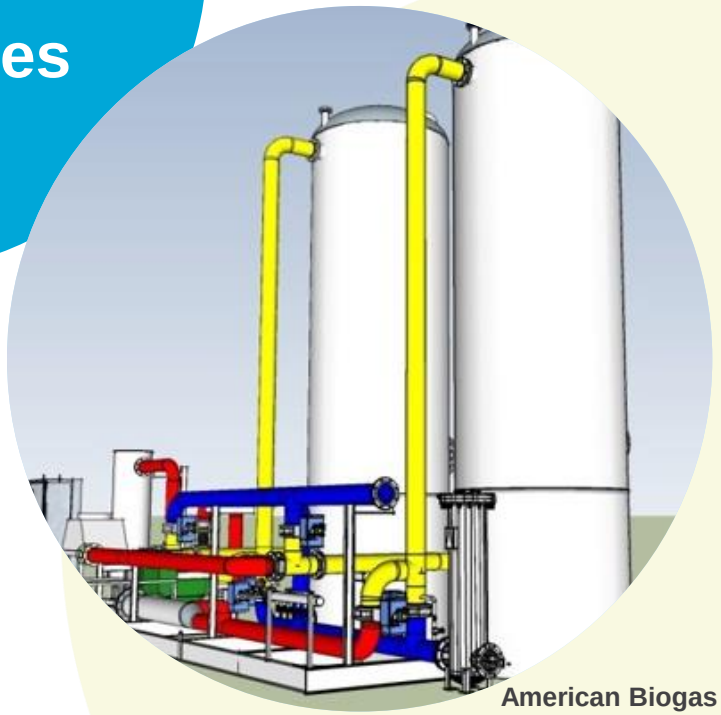
- 1. Blower
- 2. H2S Treatment
- 3. Compressor
- 4. Dehydration
- 5. NMOC removal
- 6. CO2 Removal
- 7. O2 Removal (if necessary)
- 8. Dehydration (if necessary
- 8. N2 Removal (if necessary)
- 9. Compression to Pipeline Pressure

HiBTU NMOC/VOC

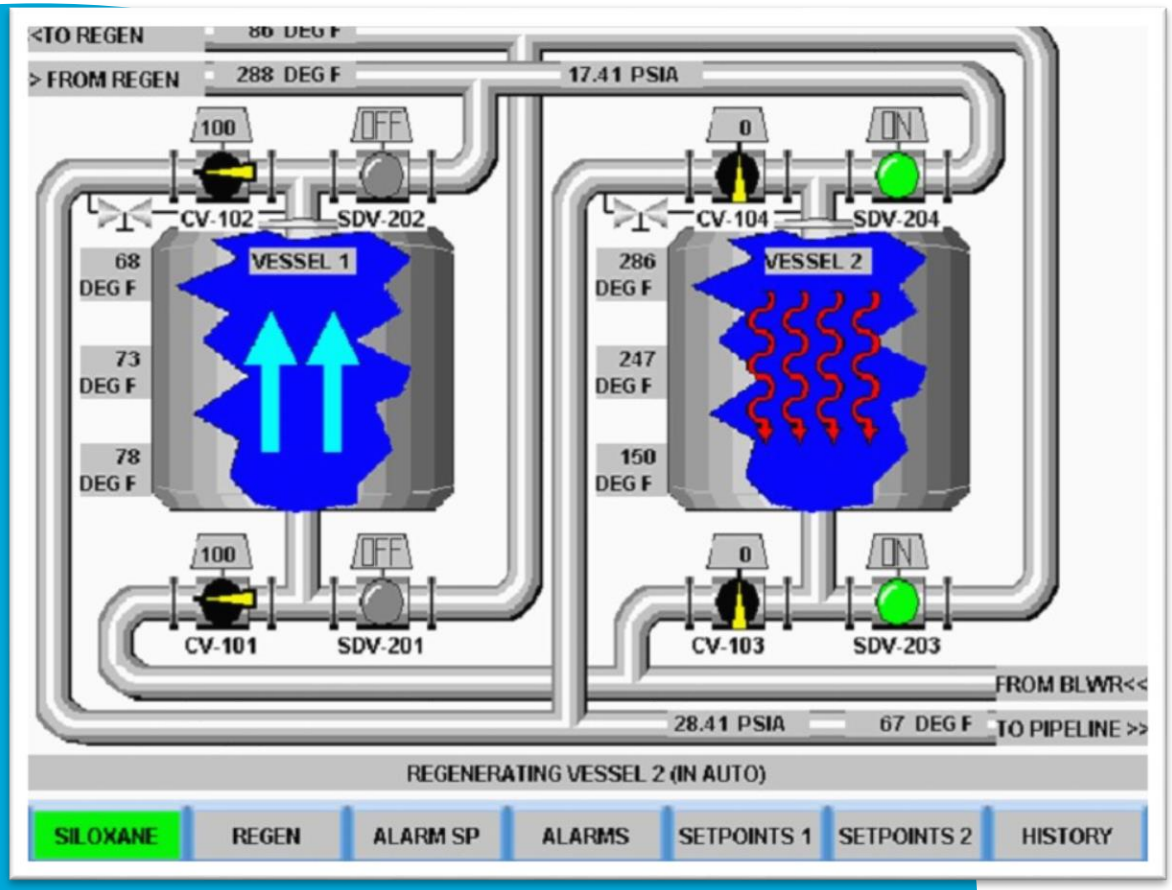
- Usually some pretreatment to remove Nonmethane Organic Compounds (NMOCs) and Volatile Organics (VOCs)
  - The Pretreatment protects membranes and/or PSAs installed down stream.
  - Pretreatment systems usually consist of:
    - Carbon Beds
    - Temperature Swing Adsorption Systems
    - Pressure Swing Adsorption Systems
  - Treatment selection depends on concentrations

Temperature Swing Adsorption

One bed treats while the second bed regenerates



Temperature Swing Adsorption

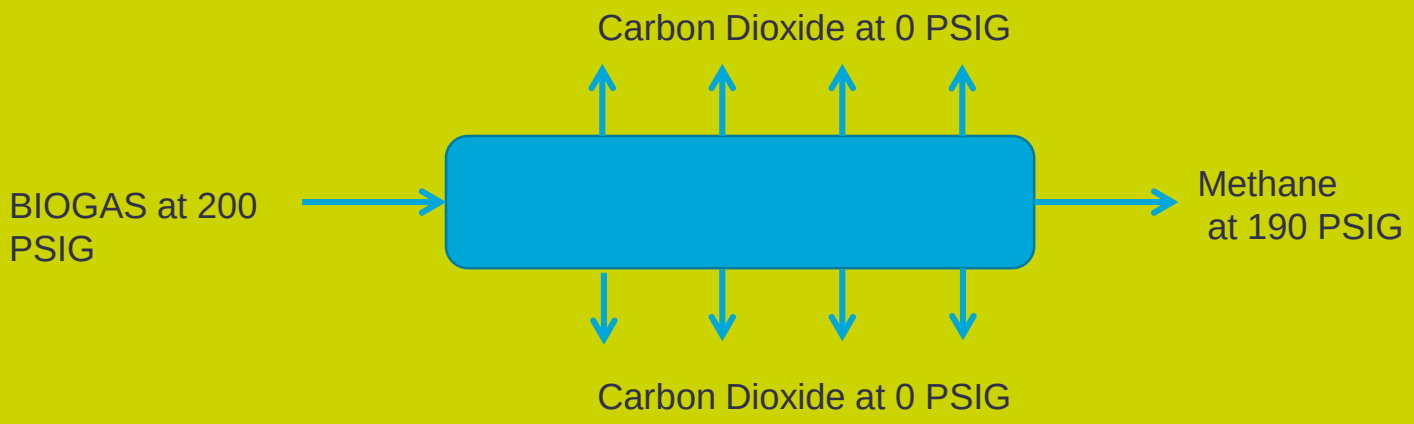


CO2 Removal Options

1. Membranes
2. PSA
3. Waterwash
4. Selexol/Methanol
5. Amine

CO2 with Membranes

Membrane operation



Membranes Evaluation

Advantages

- **Most common treatment method**
- **Very Simple**
- **Cost effective especially for small sites**
- **Also removes water and some O2 and N2.**

Disadvantages

- Gas Recycle requires addition compressor horsepower
- Pretreatment generally required before membranes

PSA for CO2 Removal

Six bed system:

CO2 is adsorbed onto media at high pressure and is released at low pressure

PSA (CO_2) Evaluation

Advantages:

- Relatively Low Cost

Disadvantages:

- Higher Complexity
- Gas Recycle required for higher efficiencies
- Valves potential wear out due to cycling on and off every minute
- Vacuum pumps are typically required (Maintenance and HP)

CO_2 Absorption

How it works

- CO_2 is adsorbed at high pressure into the liquid
- CO_2 flashes out of the liquid at low pressure
- Additional CO_2 is removed by stripping

Processes

- Water wash
- Selexol
- Methanol

CO2 Water Wash

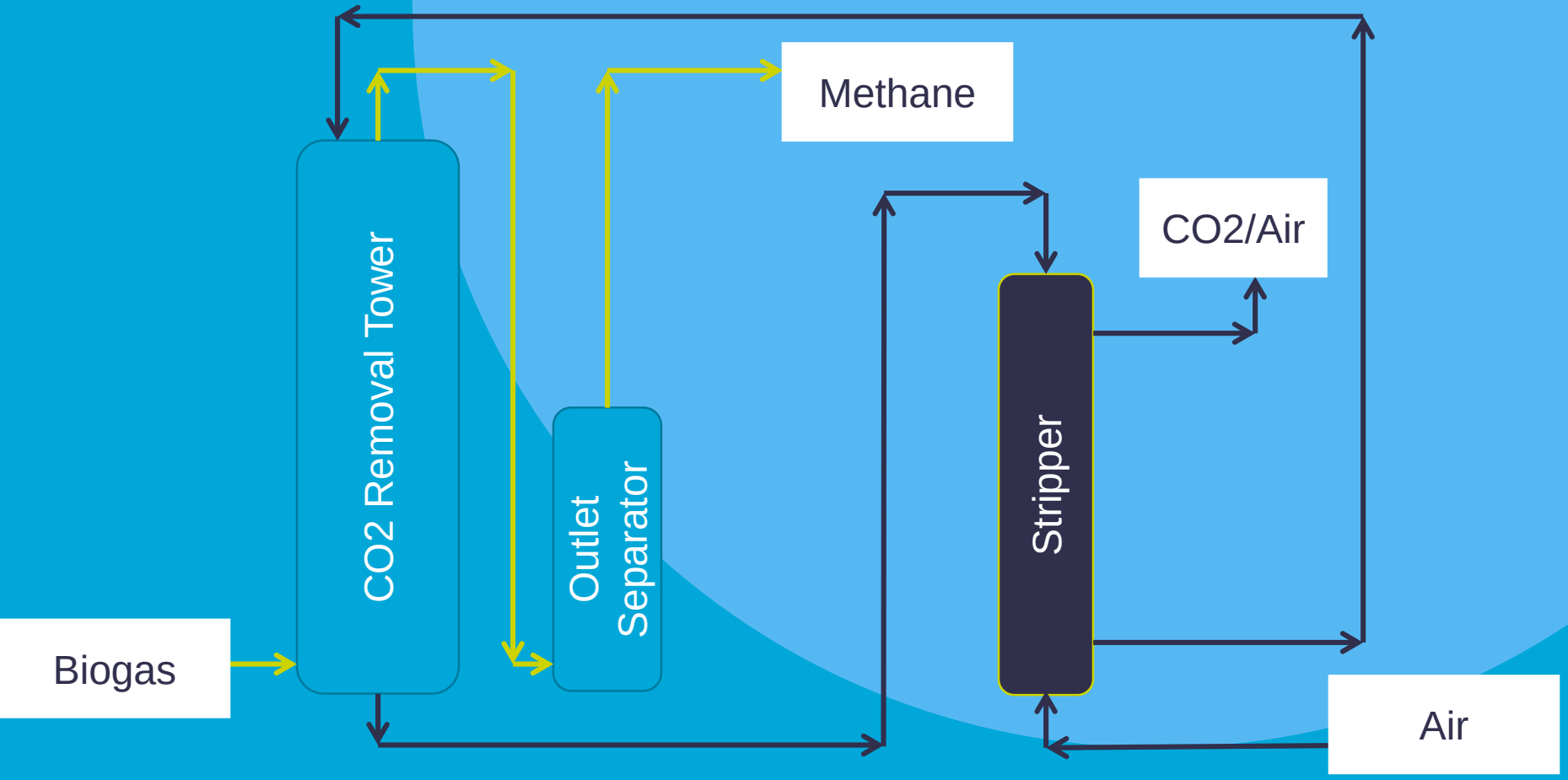
Advantages:

- No chemical usage
- Continuous process

Disadvantages:

- High electricity usage for water flows and chillers
- Biological contamination
- Potential Freezing of the water
- Venting of contaminants in the air stripper
- Gas will require dehydration post CO2 processing

Water Wash


Methane
CO2/Air
CO2 Removal Tower
Outlet Separator
Stripper
Biogas
Air

Selexol

CO2 Selexol

Advantages

- **Lower liquid recycle rates than water wash**
- **Lower recycle rates than most processes**

Disadvantages

- Chemical Use (initial fill and makeup)
- Fairly high pressure (400 psig)

CO2 Amine

Process: CO2 is absorbed into the amine.
Amine is regenerated by heating in a reboiler

Advantages:

- **Can remove CO2 to very low levels**
- **No gas recycle**

Disadvantages:

- Reboiler heat use is high
- Amine does not work well with Oxygen

Amine

Reboiler Picture:

O2 Catalyst

- Catalysts “burn” Oxygen in the gas using methane or other BTU containing molecules
  - Process is typically kicked off with an electric heater
  - Heat is maintained using heat exchangers
  - Process is typically at 550 deg F

O2 Catalyst

O2 Catalyst

Advantages

- Simple process
- Uses little energy after the process kicks off

Disadvantages

- High O2 can cause the process to overheat
- Condensate generated can be corrosive

Dehydration

Not typically needed after Membranes, Selexol or PSAs

Cold water dehydration

Glycol

Molecular Sieve

Cold Water Dehydration

Cold Water Dehydration

- Simple process uses chillers to chill water. Cold water dehydrates biogas using heat exchangers.
- 32 deg F dewpoint does not meet pipeline tariff requirements.

Glycol Dehydration

Glycol adsorbs water and is regenerated using a boiler

Glycol Dehydration

Advantages

- Removes water to pipeline specification

Disadvanges

- Uses a small amount of gas for the reboiler

Mol Sieve Dehydration

Mol Sieve Dehydration

- Uses a temperature swing adsorption process to remove water in the biogas

Advantages

- **Meets pipeline specifications**

Disadvantages

- Heat required for regeneration

Nitrogen Removal

PSA

Cryogenic Seperation

Mol Sieve

N2 and O2 VPSA

- Media is used to adsorb Methane. Pressure swing releases the methane. The methane is removed by vacuum pumps and recompressed to pipeline pressures.

Advantages

- **Higher methane recovery than Mol Sieve NRU**

Disadvantages

- Electricity use is high with gas recycle, vacuum pumps and gas requiring compression from -10 psig to pipeline pressures
- Valves wear out from cycling every minute
- Batch process

N2 Mol Sieve

- Pressure swing process that traps Nitrogen and Oxygen

Advantages:

- **Lower Electrical use because Methane does not require recompression**

Disadvantages:

- Methane recovery is not very high
- Valves wear out from fast cycles
- Batch process

N2 Cryogenic Separation

Process liquefies Methane and Nitrogen at very low temperatures. Nitrogen is distilled out of solution.

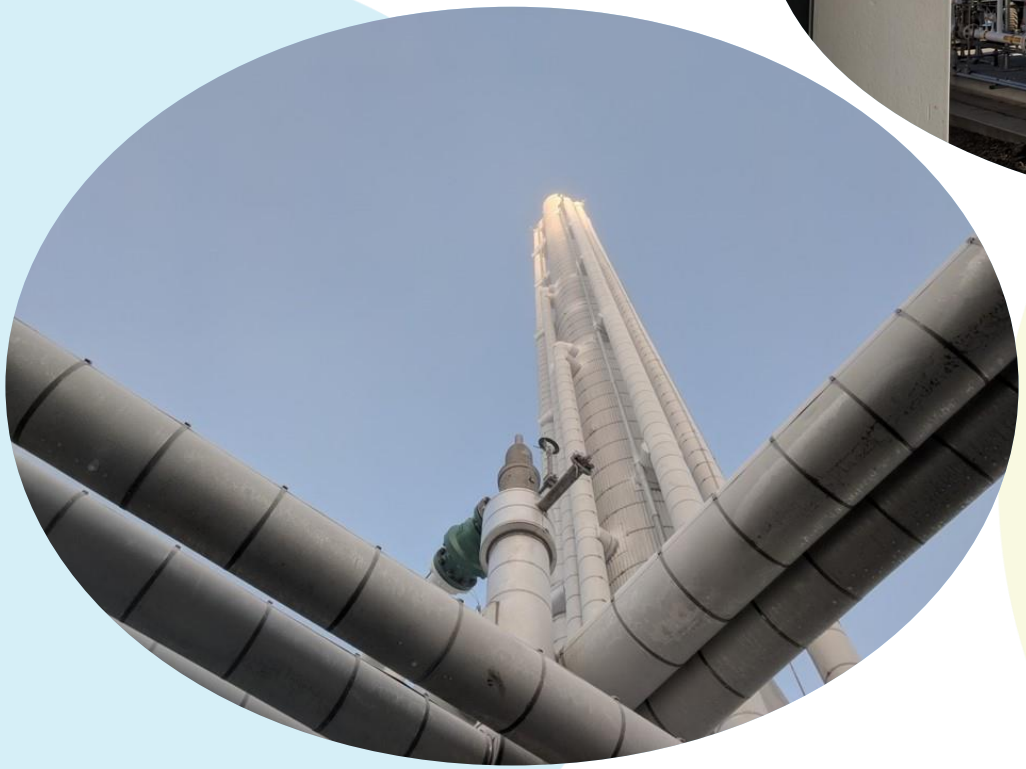
Advantages:

- **Very high Methane recovery**
- **Simple process with few moving parts**
- **Fairly low energy requirements**

Disadvantages

- Process takes a while to start when it is warm
- All CO2 and water must be removed from the gas before the Cryogenic process

N2 Cryogenic Separation



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