

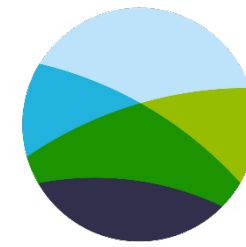
**AMERICAN
BIOGAS
COUNCIL**

Medium and High Biogas Projects

Biogas Processing Options

February 2019

Presented by Daniel Waineo, P.E.



**AMERICAN
BIOGAS
COUNCIL**

Medium and High Biogas Projects

Biogas Processing Options

February 2019

Presented by Daniel Waineo, P.E.

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



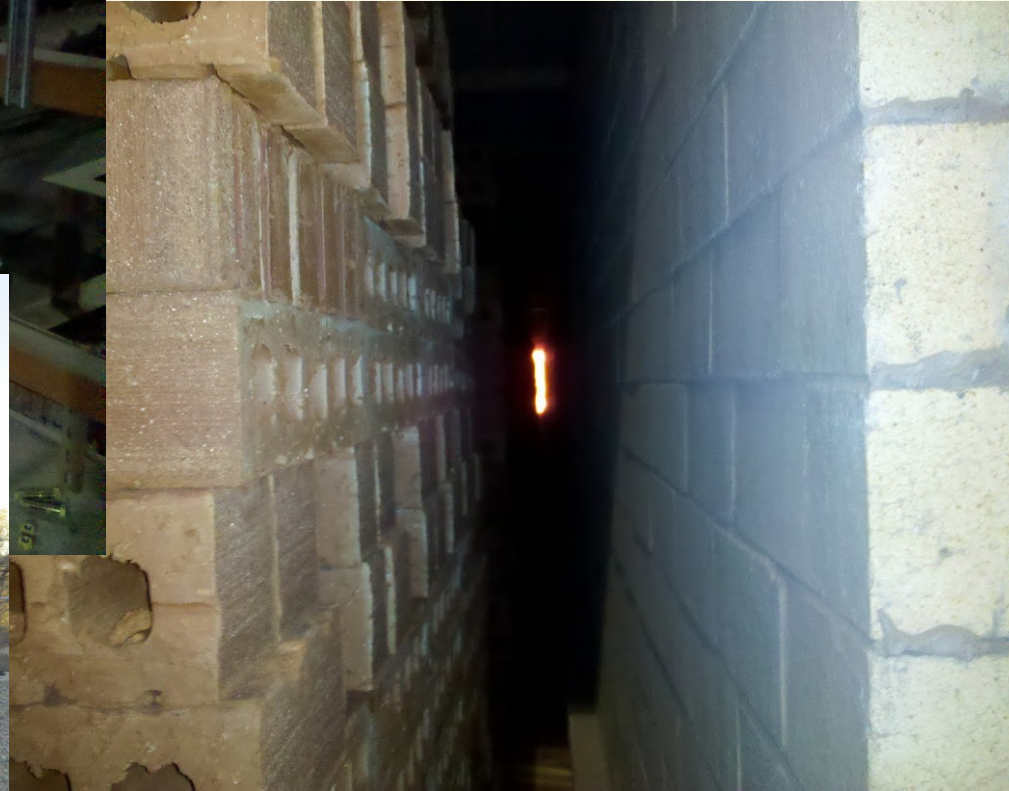
**AMERICAN
BIOGAS
COUNCIL**

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

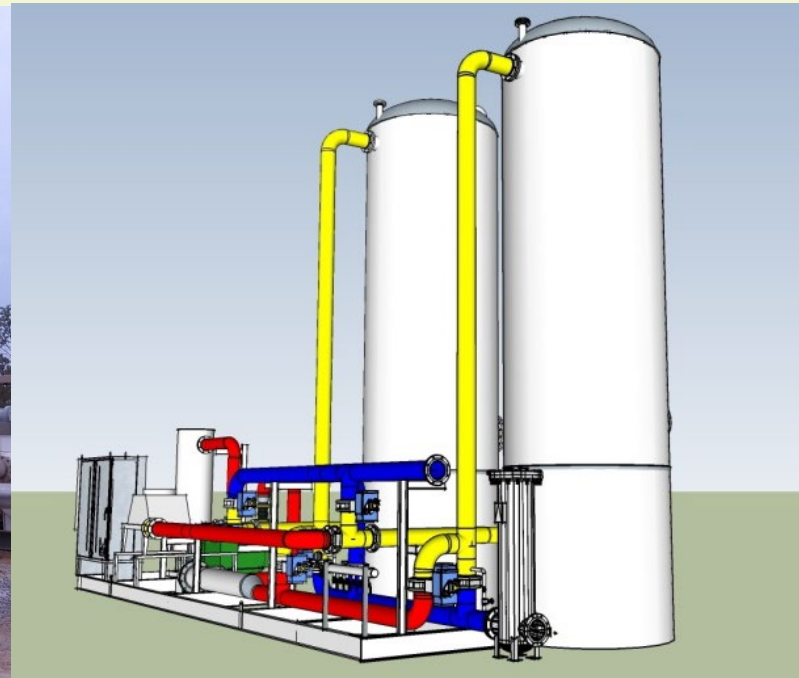
- 1. Blower
- 2. H₂S Treatment
- 3. Compressor
- 4. Dehydration
- 5. NMOC removal
- 6. CO₂ Removal
- 7. O₂ Removal (if necessary)
- 8. Dehydration (if necessary)
- 8. N₂ Removal (if necessary)
- 9. Compression to Pipeline Pressure

HiBTU NMOC/VOC

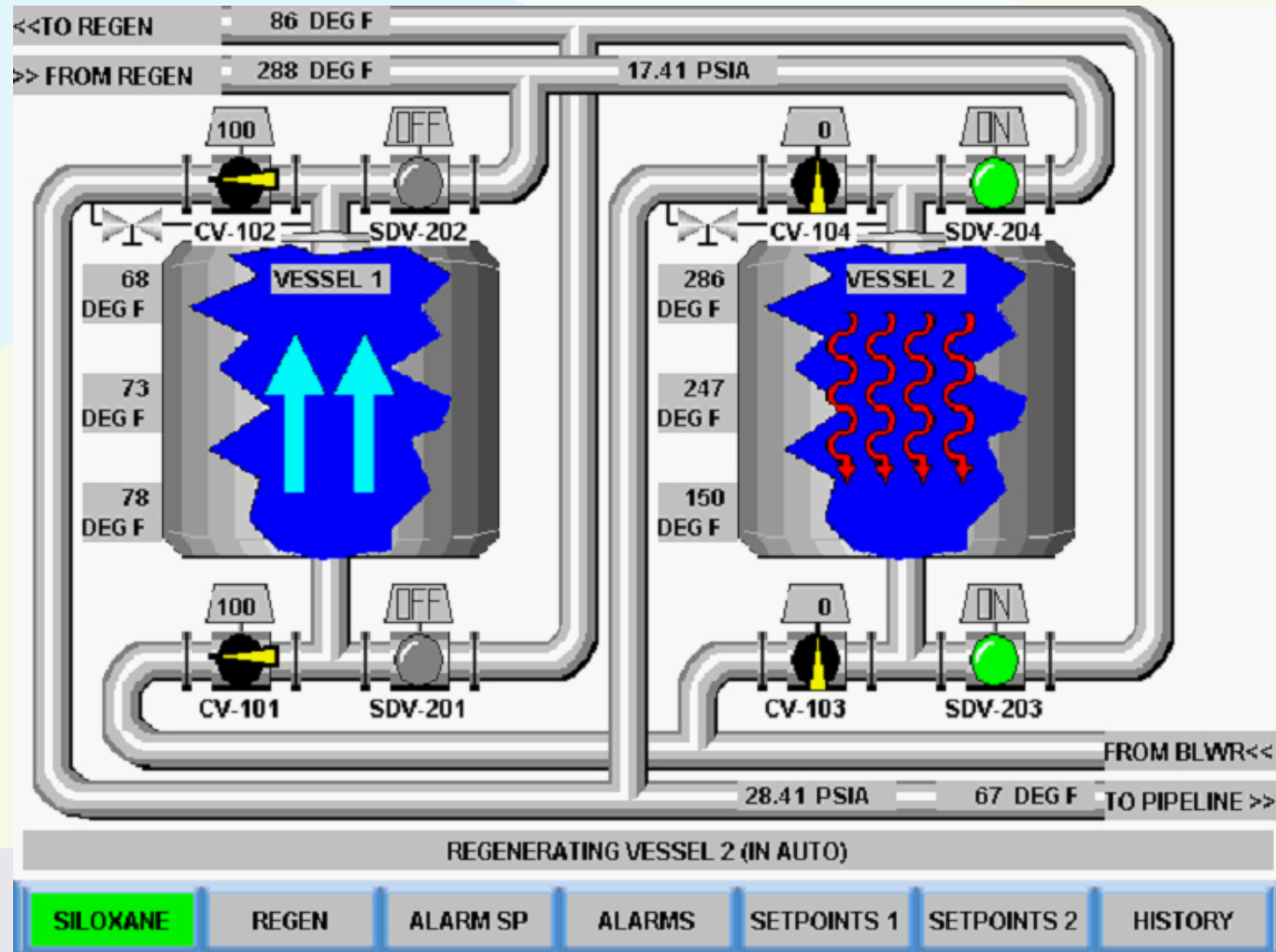
- Usually some pretreatment to remove Nonmethane Organic Compounds (NMOCs) and Volatile Organics (VOCs)
 - The Pretreatment protects membranes and/or PSAs installed down stream.
 - Pretreatment systems usually consist of:
 - Carbon Beds
 - Temperature Swing Adsorption Systems
 - Pressure Swing Adsorption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

Temperature Swing Adsorption

- One bed treats while the second bed regenerates



Temperature Swing Adsorption



CO2 Removal Options

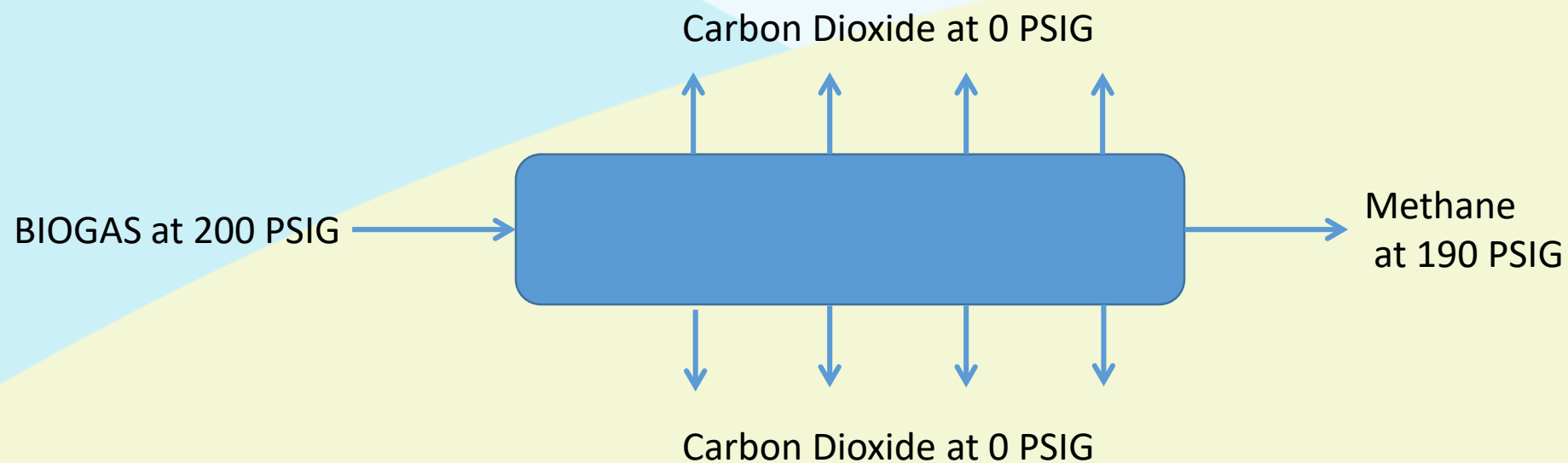
- 1. Membranes
- 2. PSA
- 3. Waterwash
- 4. Selexol/Methanol
- 5. Amine

CO2 with Membranes



**AMERICAN
BIOGAS
COUNCIL**

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

- CO₂ is adsorbed onto media at high pressure and is released at low pressure
- Six bed system:



PSA (CO₂) 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)

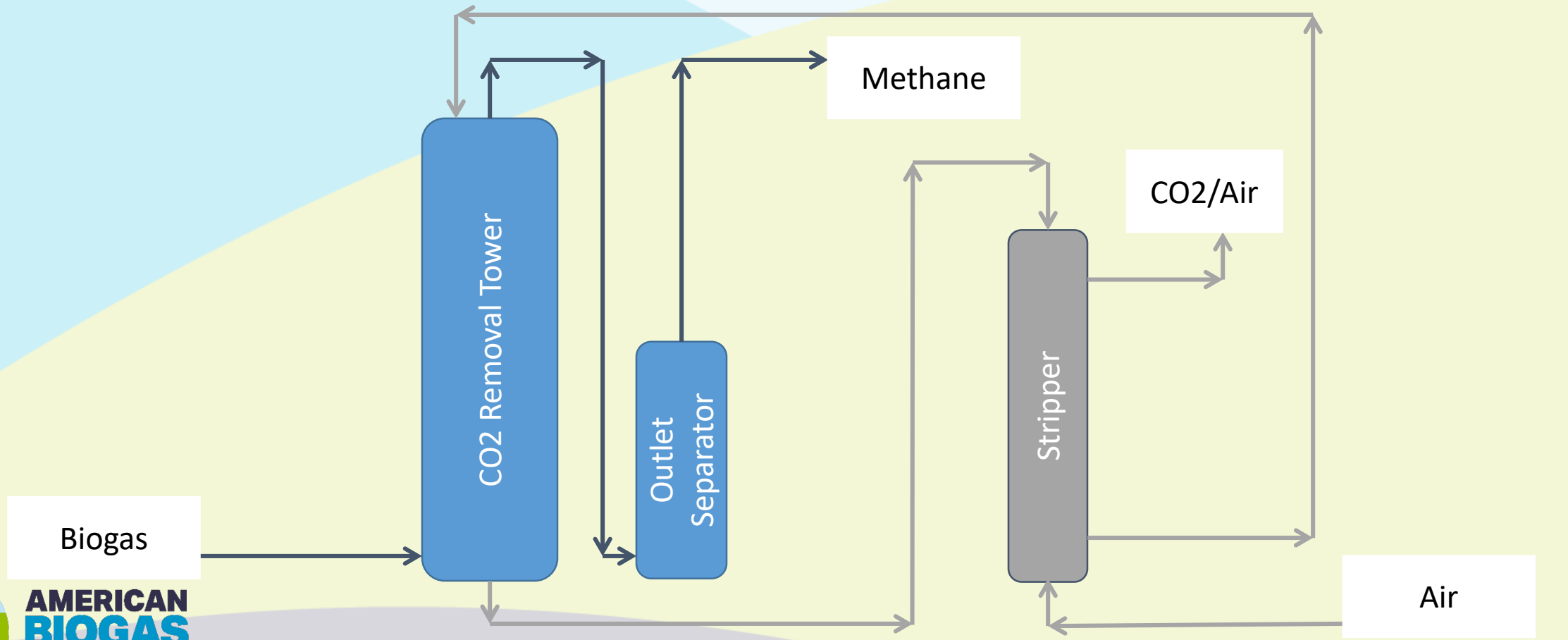
CO2 Absorption

- Processes
 - Water wash
 - Selexol
 - Methanol
- How it works
 - CO2 is adsorbed at high pressure into the liquid
 - CO2 flashes out of the liquid at low pressure
 - Additional CO2 is removed by stripping

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



Selexol



**AMERICAN
BIOGAS
COUNCIL**

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



**AMERICAN
BIOGAS
COUNCIL**

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
- Disadvantages
 - 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
- Mol Sieve
- Cryogenic Separation

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

