Medium and High Biogas Projects

Biogas Processing Options

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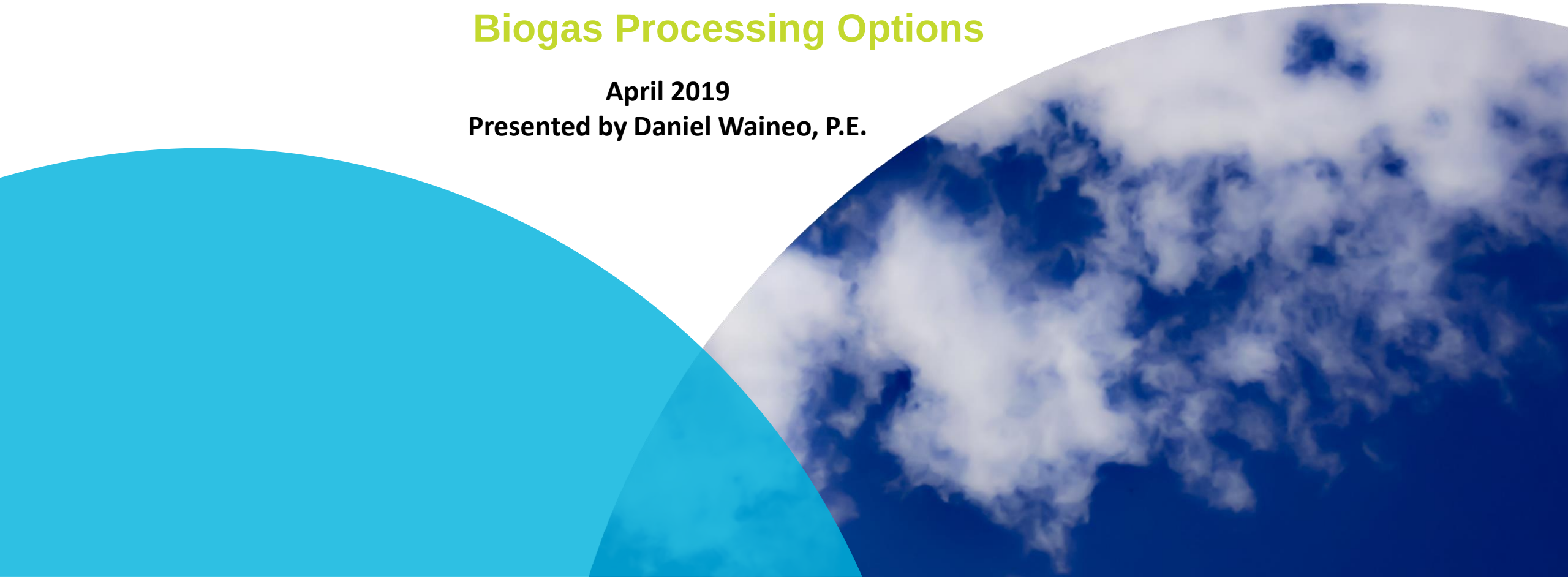

Medium BTU Processes

- Typical end users:
- 1. Boilers for Heat
- 2. Direct Heating Applications

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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)

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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

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Medium BTU H2S

- Typically Dry media H2S removal
  - Carbon
  - Sulfatreat
  - Sulfatrap

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Medium BTU Dehydration

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Medium BTU Users

- Boilers for building heat or process heat

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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

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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

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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

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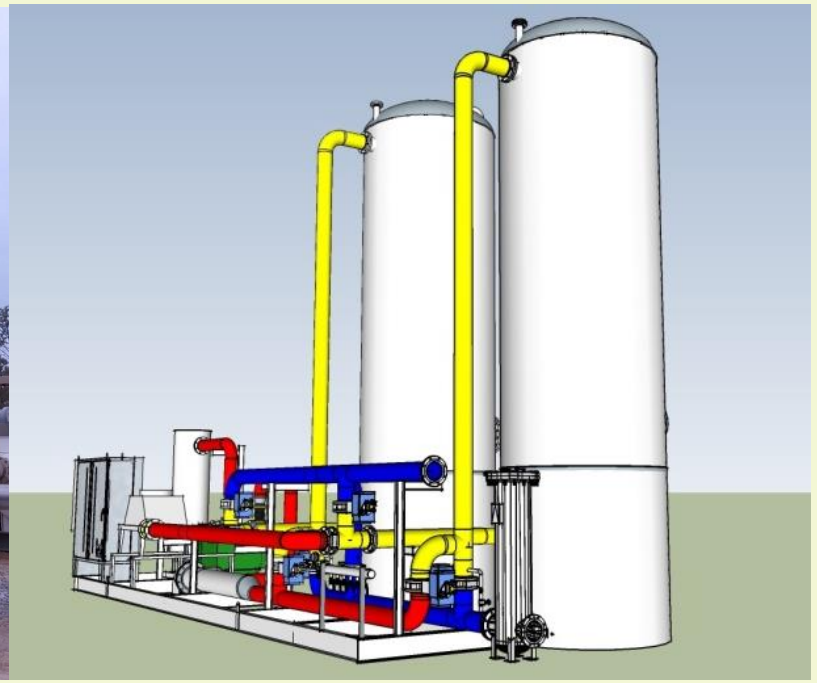
Temperature Swing Adsorption

- One bed treats while the second bed regenerates



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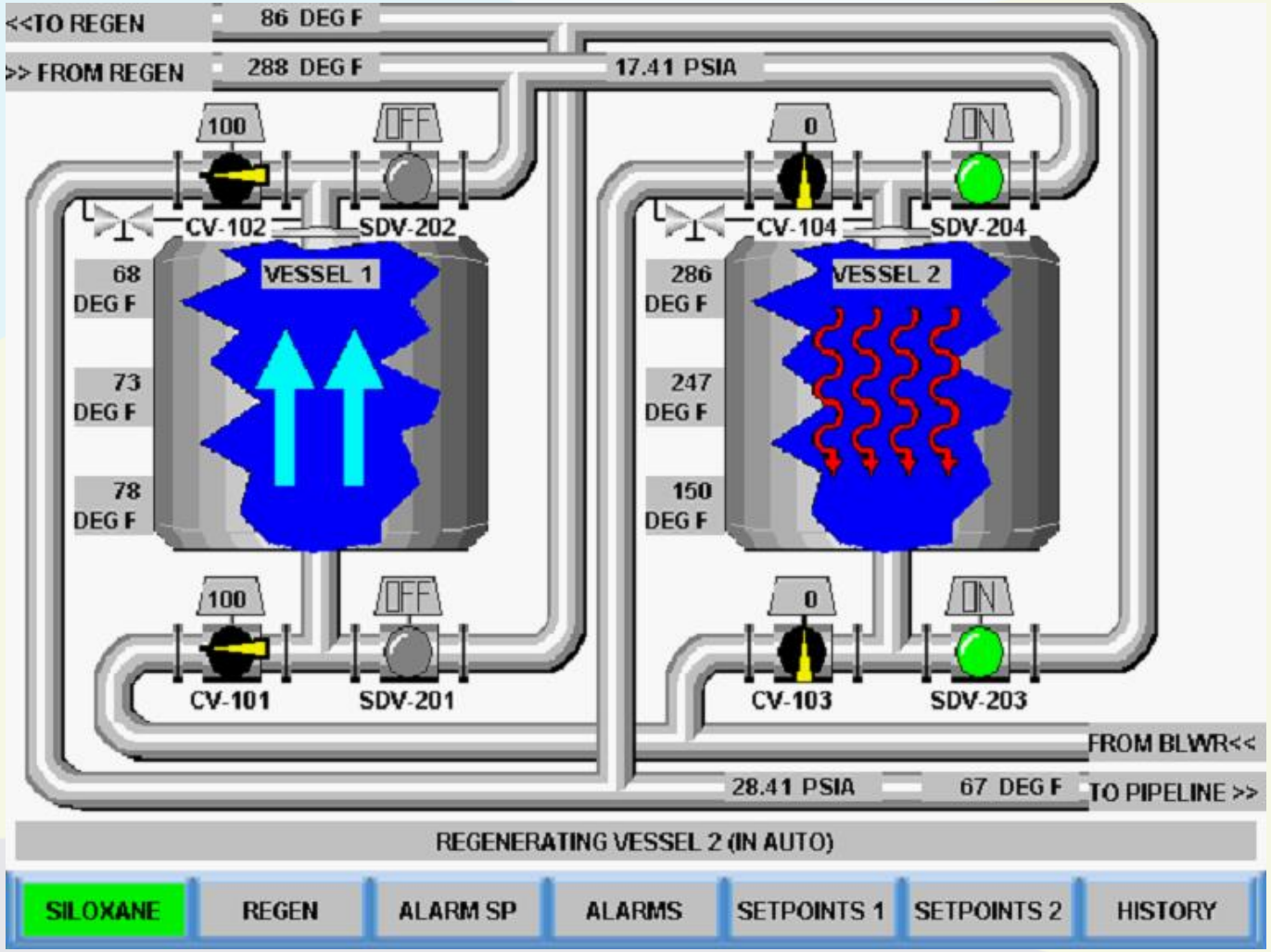
Temperature Swing Adsorption



CO_2 Removal Options

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

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CO2 with Membranes

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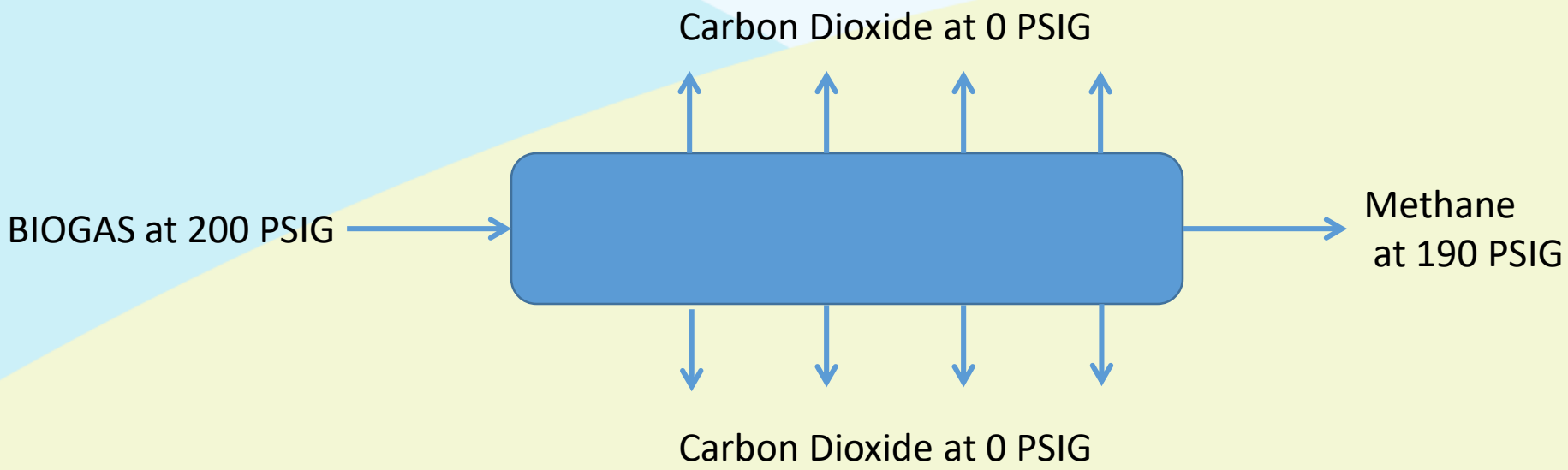
Membrane operation



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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

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PSA for CO2 Removal

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

- Six bed system:

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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)

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CO_2 Absorption

- Processes
  - Water wash
  - Selexol
  - Methanol
- 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

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CO_2 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 CO_2 processing

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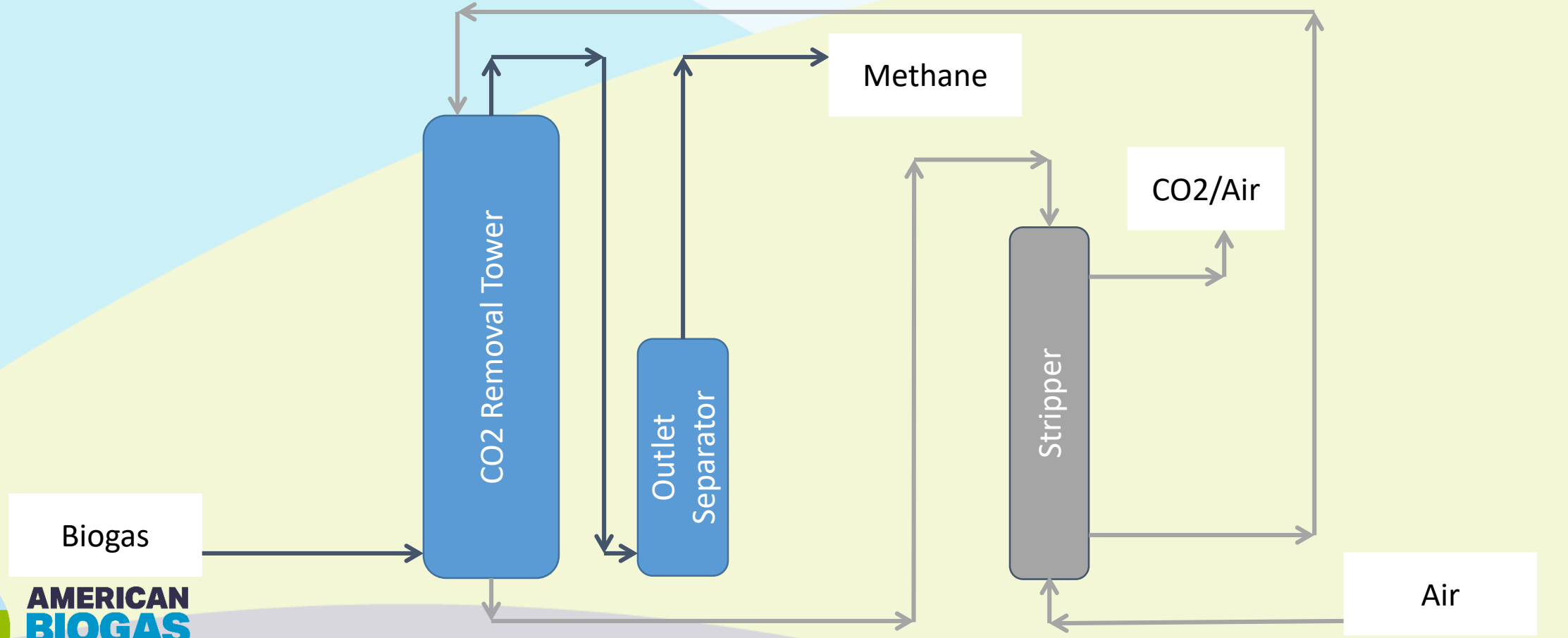
Water Wash



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Selexol

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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)

CO_2 Amine

- Process: CO_2 is absorbed into the amine. Amine is regenerated by heating in a reboiler

- Advantages:
  - Can remove CO_2 to very low levels
  - No gas recycle
- Disadvantages:
  - Reboiler heat use is high
  - Amine does not work well with Oxygen

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Amine

- Reboiler Picture

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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

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O2 Catalyst

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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

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Dehydration

- Not typically needed after Membranes, Selexol or PSAs
  - Cold water dehydration
  - Glycol
  - Molecular Sieve

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Cold water Dehydration

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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.

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Glycol Dehydration

- Glycol adsorbs water and is regenerated using a boiler

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Glycol Dehydration

- Advantages
  - Removes water to pipeline specification
- Disadvanges
  - Uses a small amount of gas for the reboiler

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Mol Sieve Dehydration

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Mol Sieve Dehydration

- Uses a temperature swing adsorption process to remove water in the biogas
- Advantages
  - Meets pipeline specifications
- Disadvantages
  - Heat required for regeneration

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Nitrogen Removal

- PSA
- Mol Sieve
- Cryogenic Separation

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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

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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

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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

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N2 Cryogenic Separation

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