



Greenlane Biogas Gas Cleanup Technology. Developments and Key Considerations.

Cash Cow. RNG for Transportation in Washington.
University Place, July 16th, 2013





Our Company

- Greenlane started as Flotech, which was founded 1986 in New Zealand to provide machinery installation services to the compressed natural gas industry.
- Greenlane is the global leader in the biogas upgrading market, with ~70 installations in 15 countries. The company uses a water scrubbing and pressure / temperature adsorption gas cleaning process to produce renewable natural gas (RNG) from biogas and landfill gas.
- The organization operates internationally, offering solutions for:

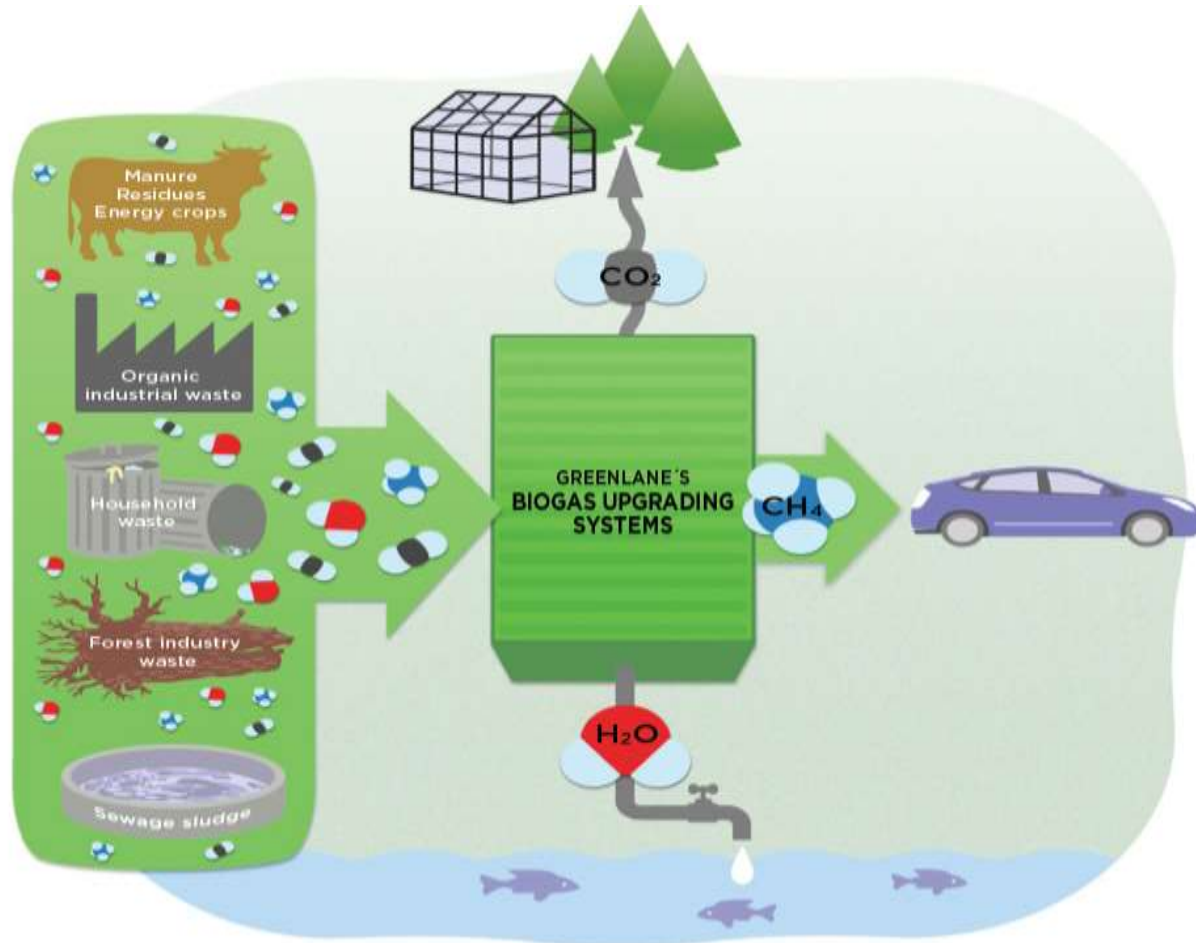
- Gas Purification, Drying and Conditioning
- Industrial Heat Exchange
- Gas Compression
- Technical Support, Field Services and Spare Parts





Biogas to Renewable Natural Gas

Biogas to RNG



BIOGAS requires upgrading to be used as CNG or LNG Vehicle Fuel

Raw Biogas Characteristics



- Pressure:
 - Common: 2 – 8 inches of water column
 - Municipal applications: up to 15 inches
- Major Constituents:

Constituent	Concentration
Methane (CH ₄)	55-60%
Carbon Dioxide (CO ₂)	40-45%
Nitrogen (N ₂)	0.4-1.2%
Oxygen (O ₂)	0.0-0.4%
Hydrogen Sulfide (H ₂ S)	0.02-0.4%
Water (H ₂ O)	Saturated

Biogas Use Options



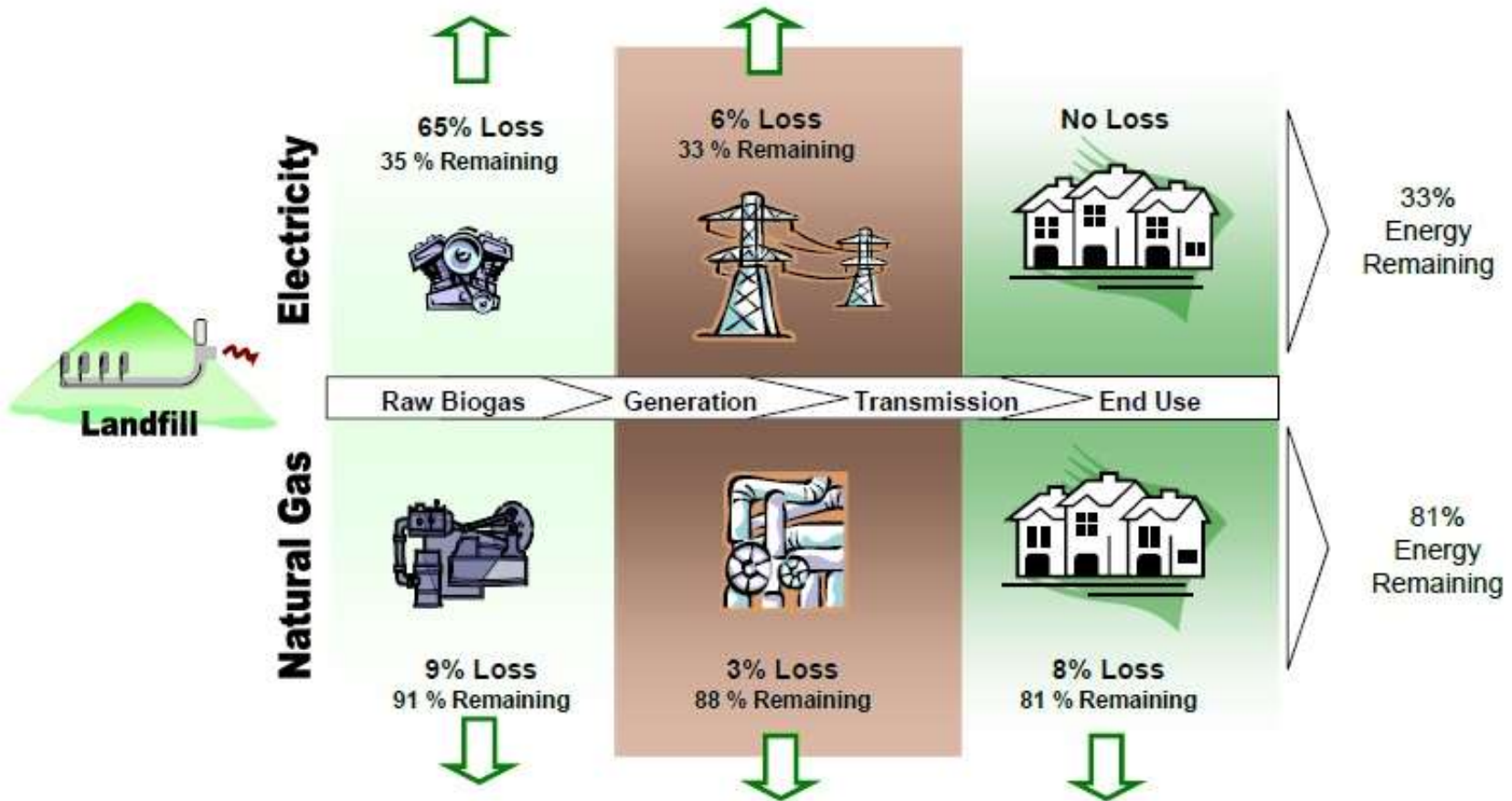
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- Heat Only: ~92% Heat Recovery Efficiency
- Power Only: ~38% Electrical Efficiency
- Renewable Natural Gas: ~99% Energy Available to Pipeline
- Combined Heat and Power (CHP): ~65% Electrical and Heat Recovery Efficiency
- CNG Vehicle Fuel: ~99% Energy Available to Vehicle

Increasing
Capital Costs



Vehicle Fuel vs Other Uses



Biogas to Vehicle Fuel Examples



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Greenlane® Totara+
Fair Oaks, Indiana



Greenlane® Rimu
Hamilton, Ontario

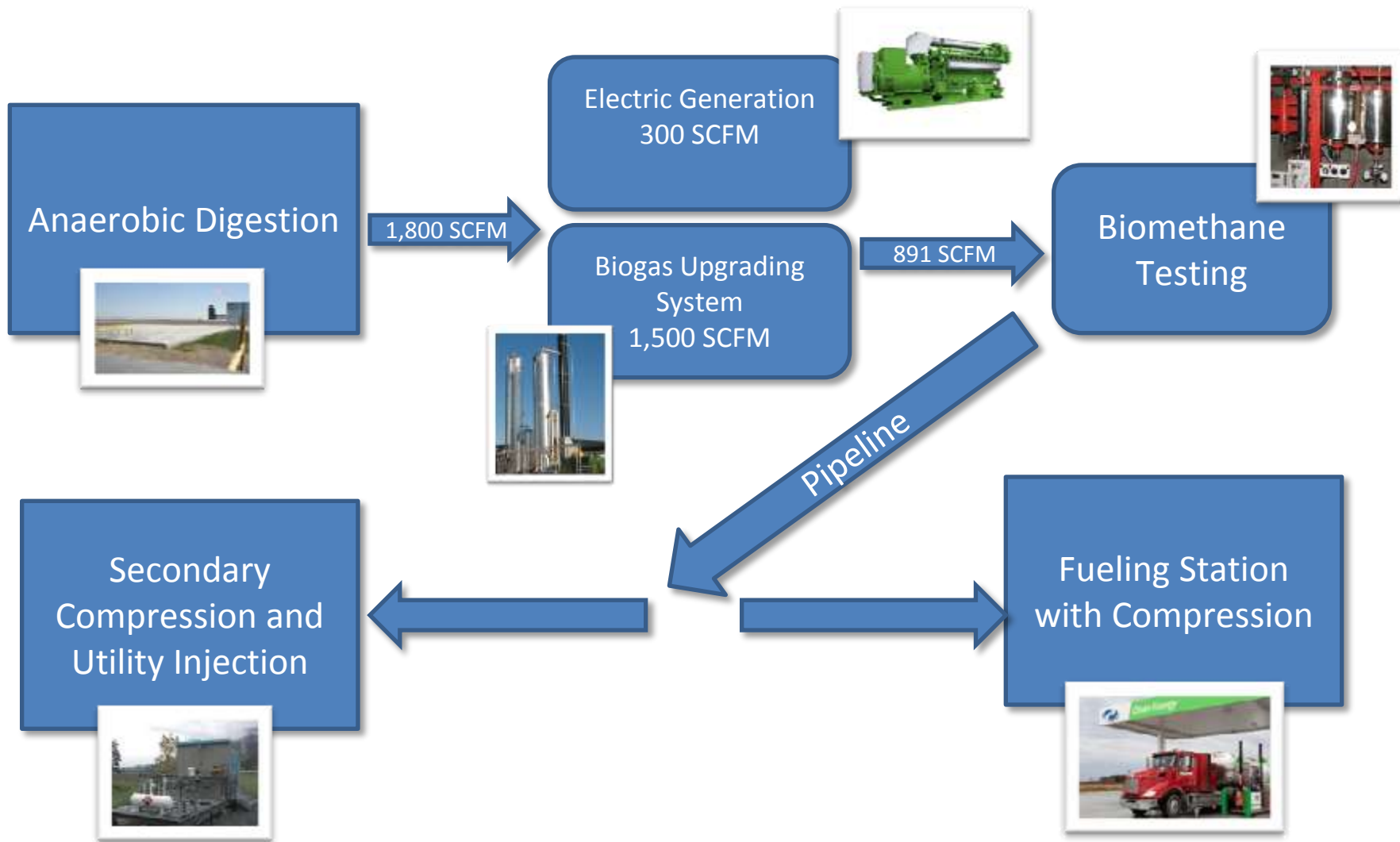


Greenlane® Manuka
Motala, Sweden



Greenlane® 2 x Totara
Madrid, Spain

Fair Oaks – Process Overview



Fair Oaks, IN

- A Greenlane Totara+ system upgrades up to 1500 scfm of biogas to both vehicle fuel and pipeline injection
- The installation is at a large dairy farm in NW Indiana. Anaergia integrated and operates the overall system and the renewable natural gas (RNG) station was installed and operated by Clean Energy Fuels
- The biomethane is used to fuel the dairy trucks delivering the milk, though the fuelling station is open to the public
- The plant was commissioned in 2012



Fair Oaks, Indiana
Totara+ System Installation



Greenlane® Totara Compression System
Fair Oaks, Indiana



- Low Avoided Price for Electricity
- High Gas Output
- Location Close to Fuelling Station
- Dedicated Routes
- Dedicated Fleets
- RIN's
- Tax Credits and Incentives
- Industry Commitment to Sustainability



Digester to Biogas Upgrading



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Technical Considerations

RNG Interchangeability



- Upgraded biogas can be interchangeable with natural gas

Selected standard requirements for grid injection or for utilization as vehicle fuel.

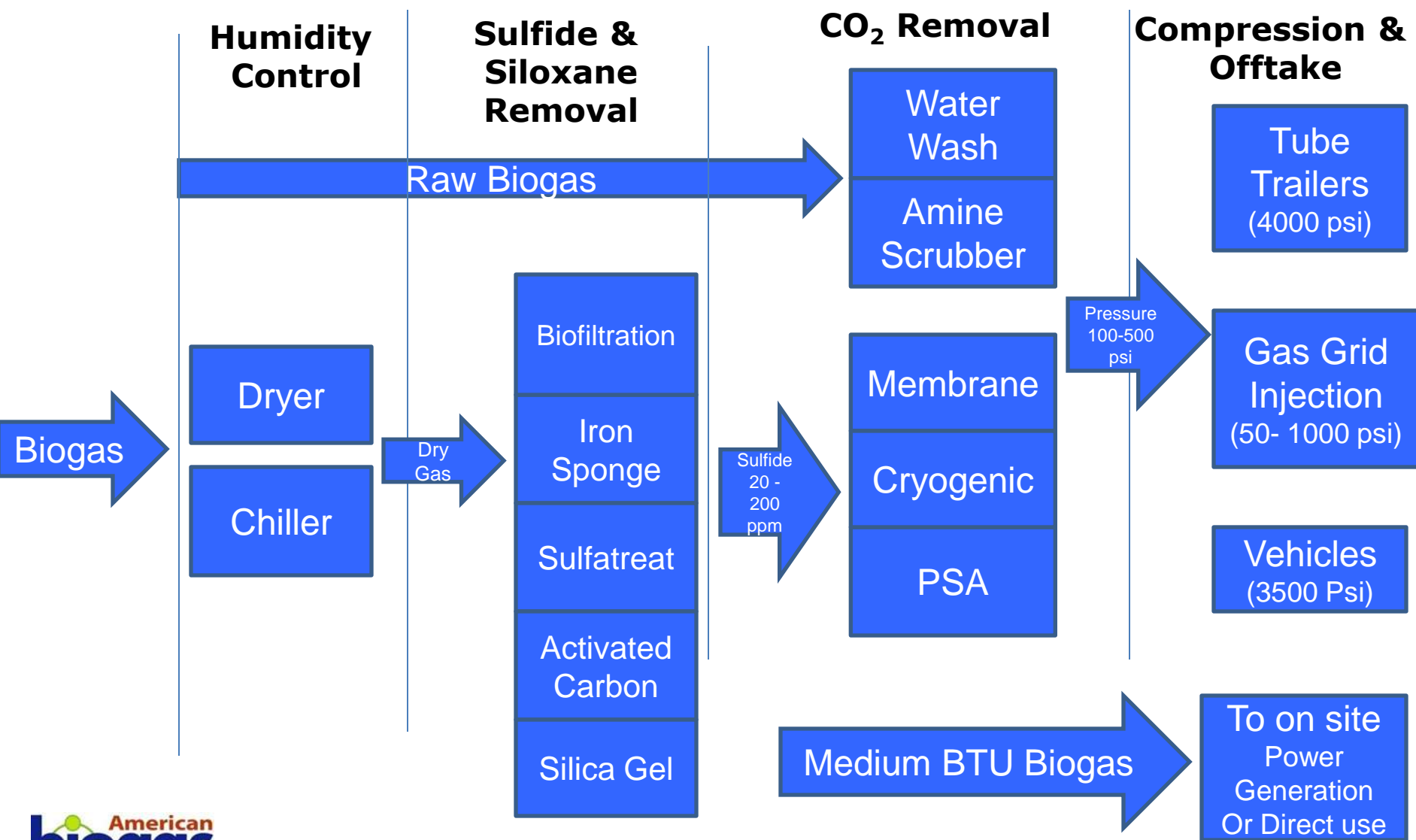
Compound	Units	Reported Tariff Range
Heating Value	Btu/scf	950 - 1000 (min) 1075 - 1200 (max)
Carbon Dioxide	% volume	1 - 3
Nitrogen	% volume	1 - 4
Oxygen	% volume	0.001 - 1
Hydrogen Sulfide	grains of H ₂ S/100scf	0.25 - 1
Water Content	lb/MMscf	4 - 7

Source: AGA Report No. 4A - Natural Gas Contract Measurement and Quality Clauses (DRAFT update, 2009)

Upgrading Steps



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- Biogas is primarily methane (CH_4) and carbon dioxide (CO_2)
- Water under pressure can be used to separate these two gases through their different solubility in H_2O



- Water from the scrubber is sent to flash tank to depressurize, so the small amount of absorbed methane can be removed from the water
- The water is then sent to a stripper that removes the gases absorbed in the water
- The water can now be reused to clean biogas





How Water Scrubbing Works

- The raw biogas is compressed, then fed to a 'scrubbing' vessel where it is contacted with water. CO₂, H₂S, siloxanes and other trace contaminants are preferentially absorbed by the water
- Absorbed methane is 'flushed' off, in a vessel at a lower pressure and recovered by returning it to the start of the process
- Product gas is further purified by a proprietary TSA, before being analyzed and delivered





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Thank You for Your Attention!

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