



Biogas Engine Application

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Company Information

- Since 1960, CEC has been specializing in energy systems for business, homes and municipalities.
- Wide range of applications include: landfill gas to energy, skyscrapers, hospitals, airports, schools and universities, sewage, wastewater treatment facilities, police and fire stations, and communication centers.
- Everything you need in one place.
- With you throughout the project.





Products

- Generator Sets
- Controls
- Heat Recovery
- Cooling
- Exhaust
- Fuel Compression and Processing



Service Offering

- Engineering
 - Assess customer needs.
 - Provide complete turn-key package for any application.
- Training
- Maintenance Programs
 - From oil changes to major overhauls. CEC can tailor programs for monthly, quarterly or semi-annual depending upon the application.
- Emergency Service
 - CEC provides 24-hour emergency service for engines, driven components and generators, not just those we sell.



Waukesha Biogas Experience

- Since 1985 there are 400 Waukesha engines producing 280,000 kWe with bio-gas fuels worldwide.



DRESSER

Waukesha



Wisconsin Biogas Projects

- Burlington WWTP
- Eau Claire 7-Mile Landfill
- Five Star Dairy
- Glacier Ridge Landfill
- Janesville WWTP
- Janesville Landfill





Wisconsin Biogas Projects

- Kenosha WWTP
- Kenosha Water Utility
- Madison WWTP
- Outagamie County
Landfill
- Racine WWTP
- Wild Rose Dairy





Power Generation Equipment Cost vs. Size

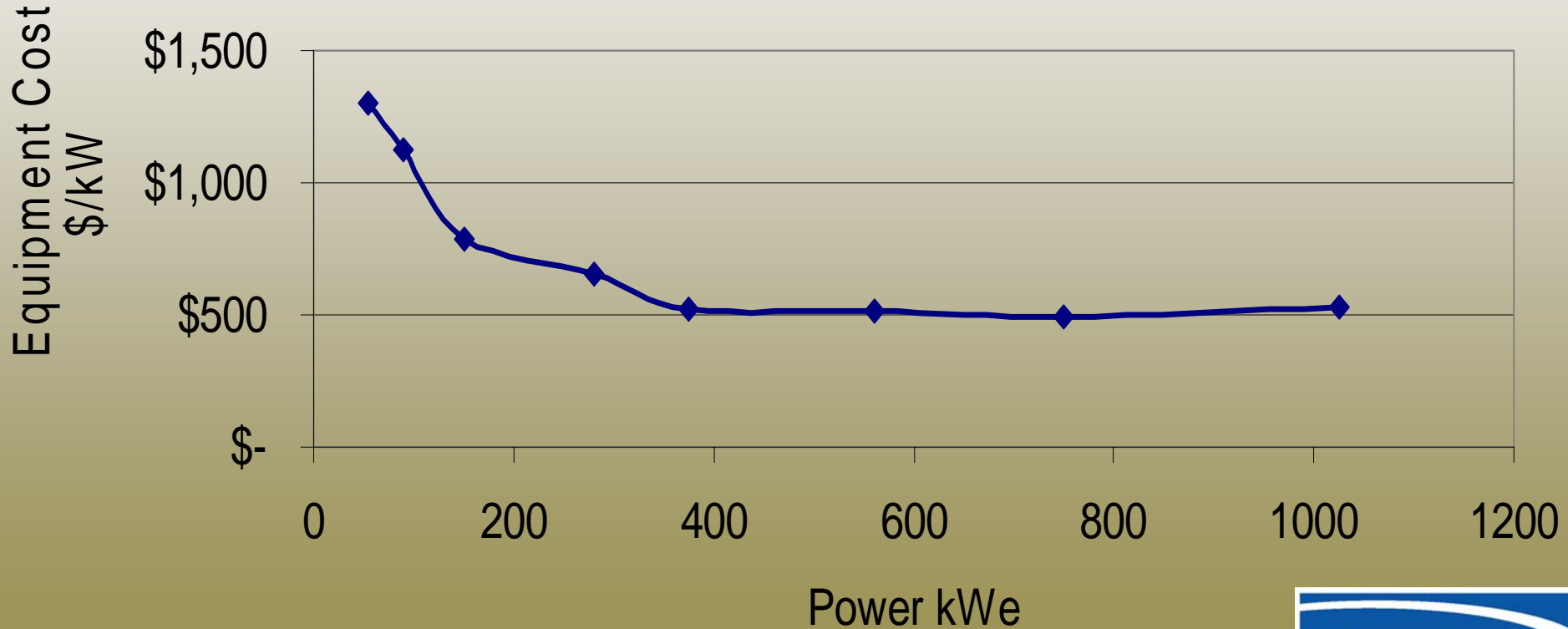
- Power generation equipment that is operated connected to utility power has certain fixed costs that are irrespective of size. This includes generator controls and utility protective relays.
- These fixed costs and economics of scale of the generation equipment result in higher costs per kW in smaller units.



Power vs Equipment Costs

Generator Set, Controls, Heat Recovery,
Fuel Drying and Compression

Not including enclosure, construction and installation





Maintenance Affected by Biogas Operation

- Oil Change Intervals
- Valve Adjustment Intervals
- Fuel System Adjustment Intervals
- Valve Overhaul Intervals
- Major Overhaul Intervals
- Fuel System Repair Intervals



Agricultural Digester Fuel Contaminants

- Hydrogen Sulfide
- Water
- Solid Debris



Hydrogen Sulfide In Digester Gas

- Produced in the digestion process.
- Absorbs in water forming a weak acid corrosive to piping and equipment.
- Burns in combustion to SO₂ then combines with water forming a very strong acid: sulfuric acid (H₂SO₄)
- Sulfuric Acid is corrosive to engine and heat recovery equipment.



Tolerance to H₂S and H₂SO₄

- Minimize use of yellow metals such as brass, bronze, and copper in engine components that contact combustion gas or lube oil.
- Use high TBN (Total Base Number or alkalinity reserve) lube oils to prevent oil from becoming acidic.
- Raise coolant temperature to reduce condensation of H₂SO₄.



Sulfuric Acid Boiling Point

- Biogas engines operate at high temperatures to avoid condensation of acids.



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- What temperature does pure sulfuric acid boil at?



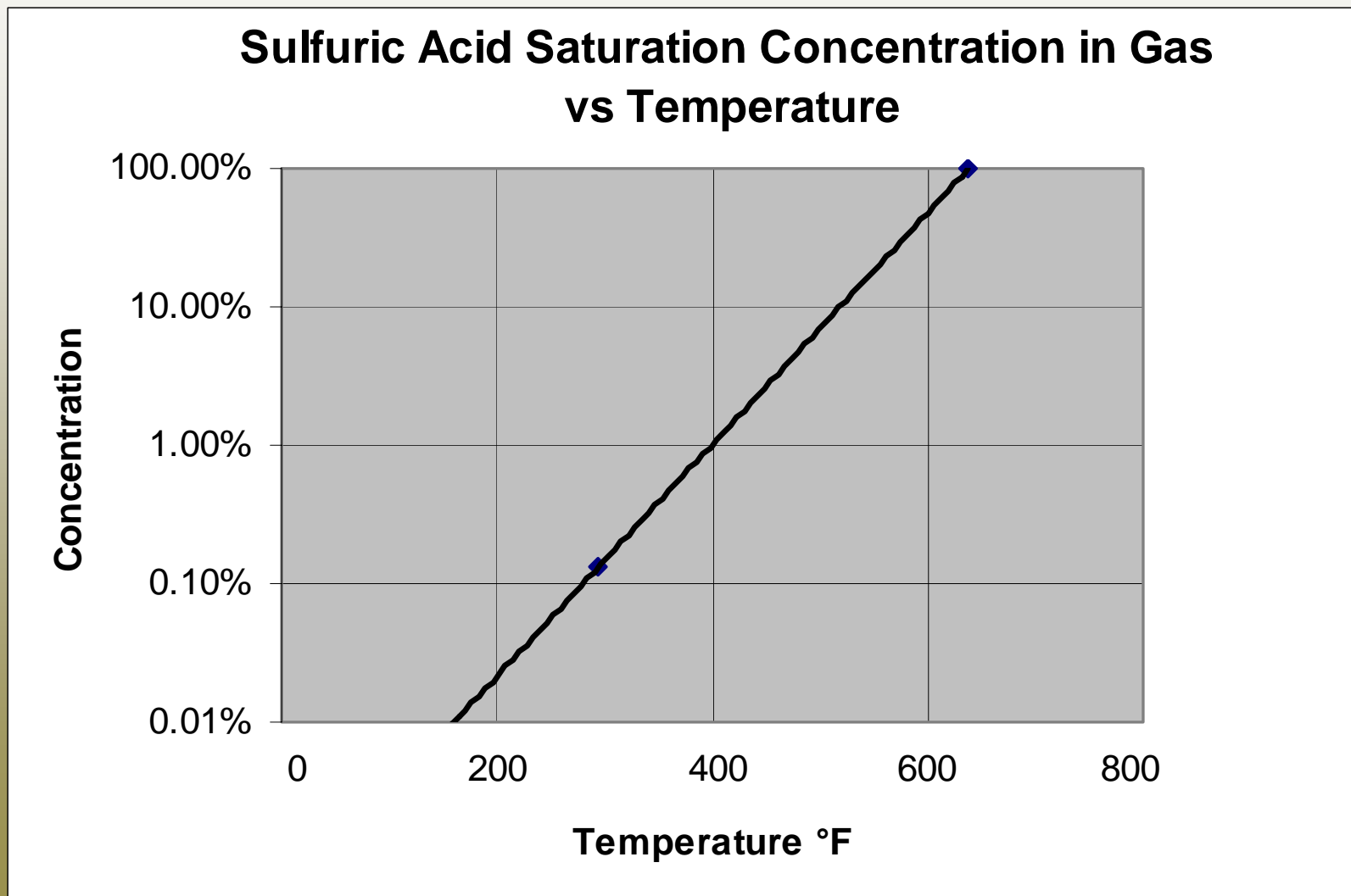
Sulfuric Acid Boiling Point

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638°F

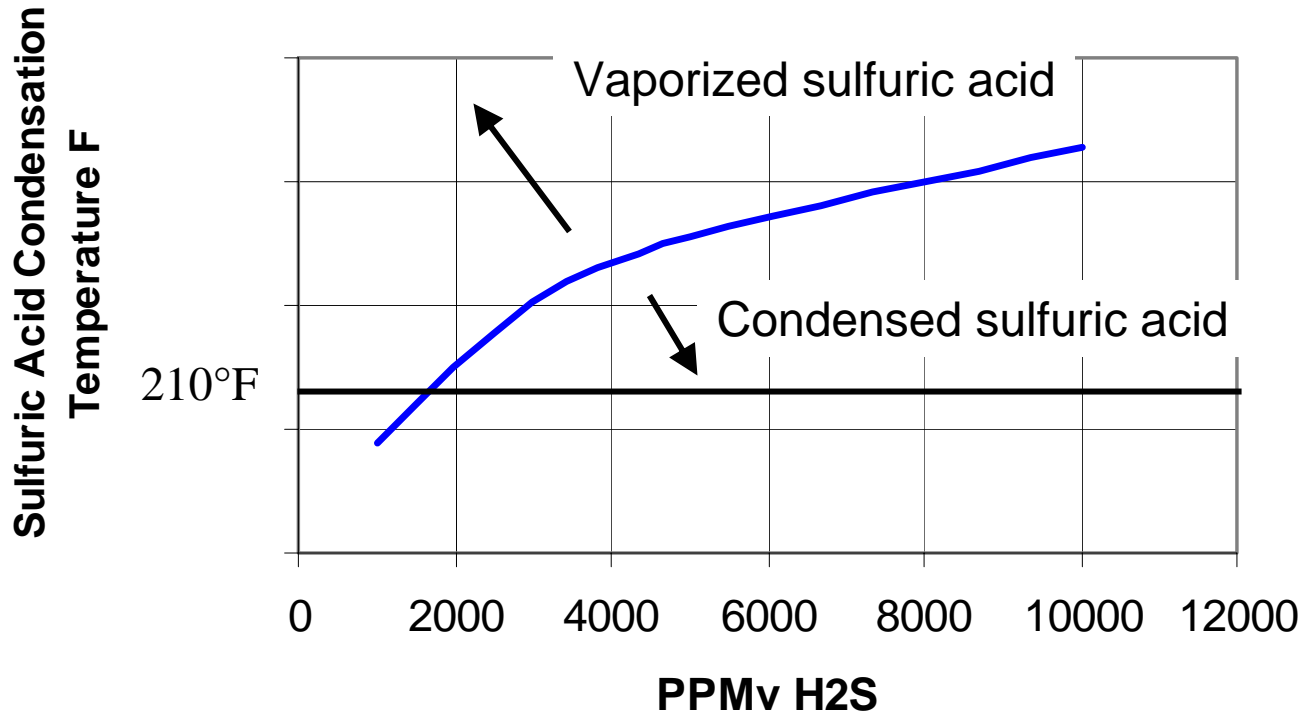


Sulfuric Acid Concentration vs. Boiling Point





H₂S Concentration in Fuel vs. H₂SO₄ Condensation Temp. in Exhaust





Water in Biogas

- Water is formed in the digestion process resulting in saturated gas at the digestion temperature.
- Saturated gas at 95 F is 5.5% water vapor.
- Saturated gas at 140 F is 20% water vapor.
- Condensed water from the fuel for a 100 kW generator is 0.5 to 2 gallons/hour, 4400 to 18,000 gallons/year.



Water's Impact on Engine Operation

- Water condensation in fuel piping causes corrosion, and builds up on carburetor and regulator diaphragms taking fuel system components out of calibration.
- Water condensation in the combustion chamber washes lubricating oil off cylinder walls resulting in higher wear.



Debris in Digester Gas

- Debris can result from digester influent, digester additives for H₂S control, fabrication of fuel piping, and from corrosion of piping and fuel handling equipment.
- Debris in the combustion chamber causes abrasive wear.
- Debris is easily removed by filtration.
- The coalescing filter used for water removal will also remove debris.
- A particulate filter may be desired to reduce the cost of replacing coalescing filter elements.



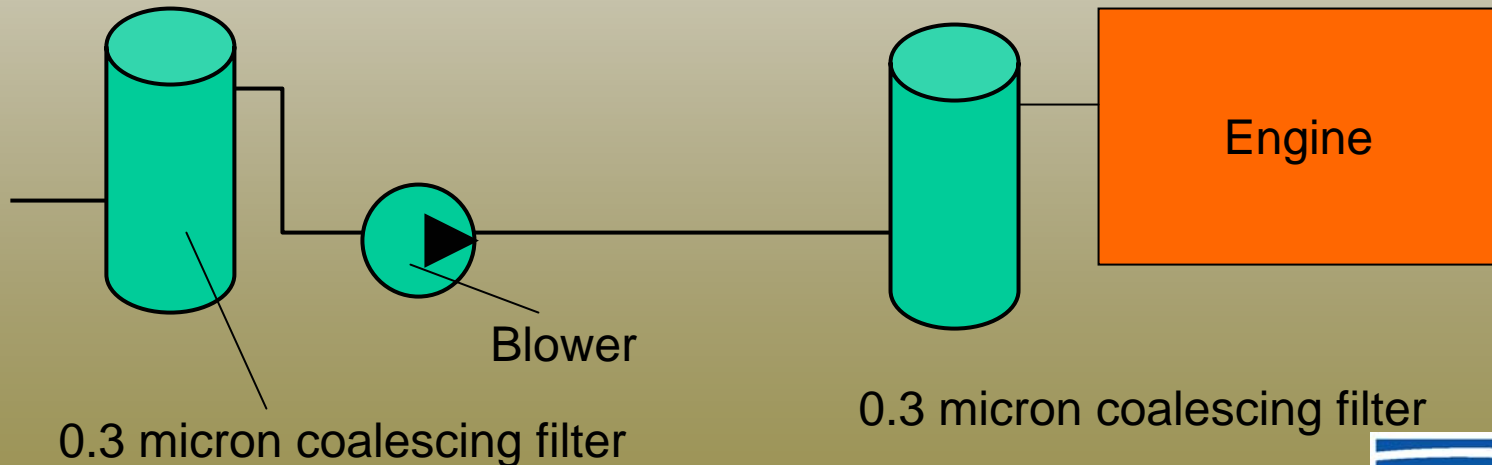
Biogas Processing

- Costs for removing H₂S, water, and debris vary widely and can become prohibitive when pursuing complete removal.
- H₂S is soluble in water (0.5 g H₂S /100 ml water @ 67 F) and a portion of it can be removed by condensing water. Reducing water vapor from 5.5% to 1% by chilling to 40 F and coalescing, could remove approximately 200 ppm H₂S.



Biogas Processing

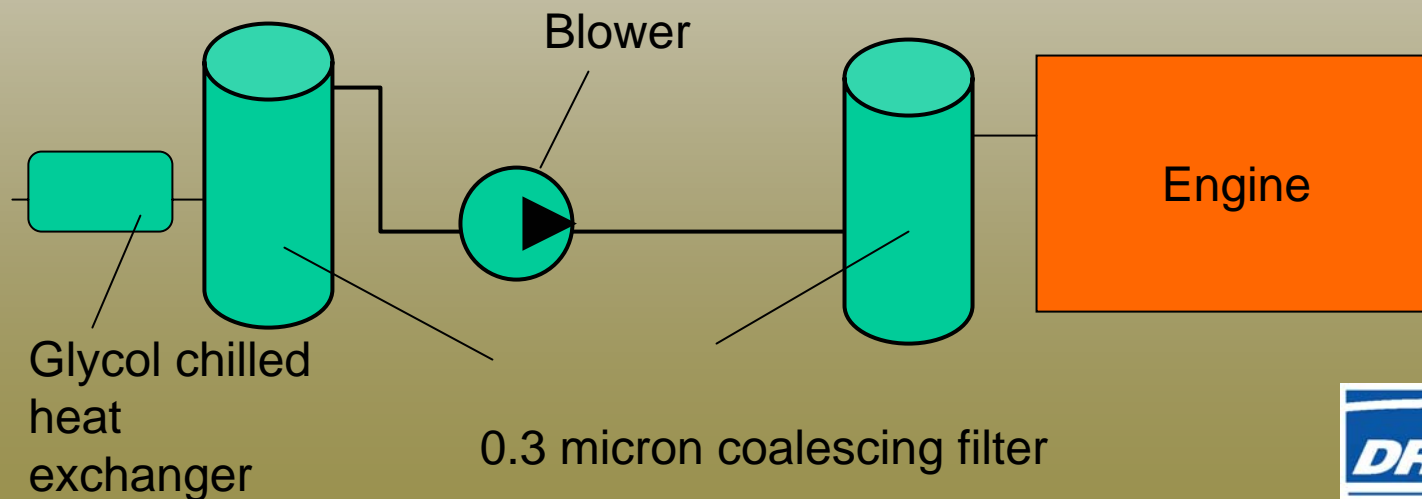
- **Minimum System:** Condensed water, dissolved H₂S, and debris are removed prior to entering the blower. Water vapor content in the gas is 5.5% for a 95 F gas temperature. The blower pressurizes and heats the gas resulting in dry gas (<60% RH). Final coalescing filter removes piping debris and condensed water if engine is far from blower.





Biogas Processing

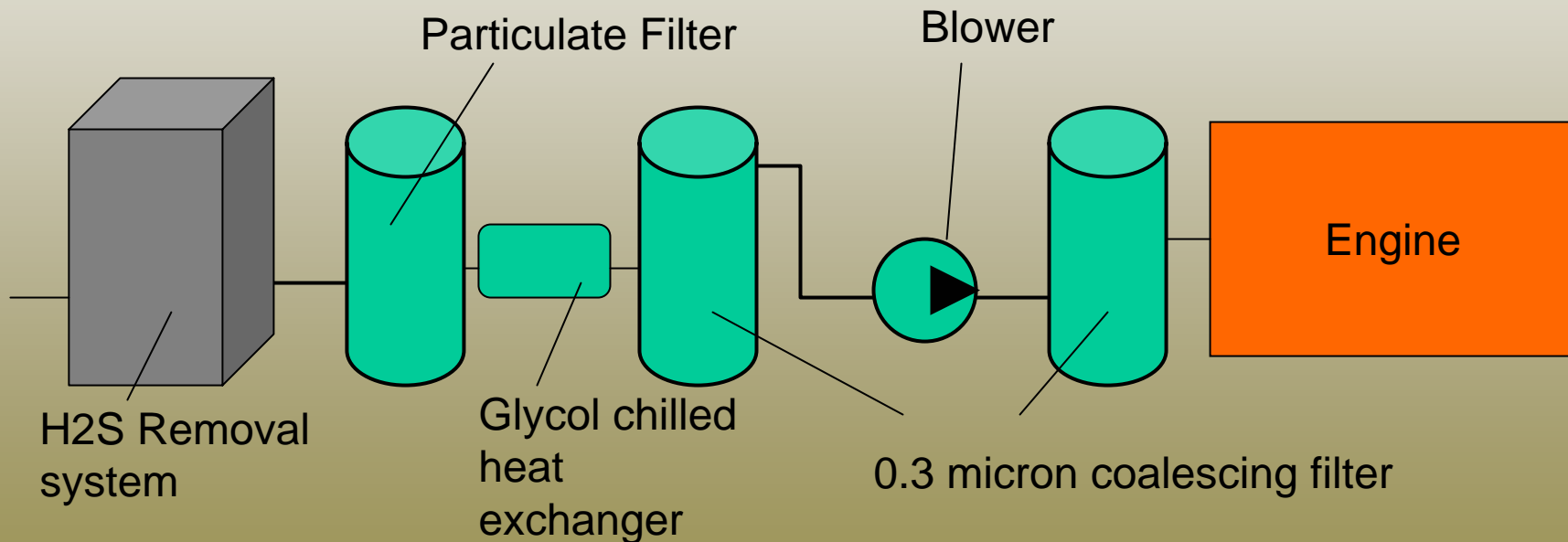
- Improved System: Gas is chilled to 40F then passes through a coalescing filter for removal of condensed water and dissolved H₂S. Gas is then pressurized and heated in a blower before entering the engine. Cooling to 40F reduces water vapor content in the gas to <1%.





Biogas Processing

- Ideal System: Gas passes through an H₂S removal system, particulate filter, then is cooled to 40F, liquid removed in a coalescing filter, then pressurized and heated in a blower.





Summary

- Operation with biogas reduces service intervals compared to natural gas operation.
- Water, H₂S, and debris removal are important for minimizing operating and maintenance costs.
- 3 levels of gas processing were presented and discussed.