Background
Renewable Natural Gas (RNG) is a form of renewable energy that replaces natural gas from non-renewable sources like fracking. The RNG market is experiencing rapid growth and is expected to grow its market share nine-fold by 2028. This growth demands improvements in RNG processes that will increase profitability and sustainability.

Existing RNG facilities use a series of steps to upgrade raw biogas to useable methane (CH4) gas that is sent to pipelines. This includes removal of carbon dioxide (CO2), which forms a waste stream called tailgas. Tailgas is vented to the atmosphere, causing greenhouse gas emissions.

Quantalux is a company based in Ann Arbor, Michigan that develops renewable energy technologies. They are seeking to develop a system that will utilize the waste tailgas and hydrogen (H2) produced by electrolysis to produce additional methane. Using a catalyst, CO2 and H2 can be converted to CH4 via the process of methanation.

Objectives
- Characterize tailgas found in operating RNG facilities
- Develop a bench-scale model sulfur removal system
- Achieve complete removal of hydrogen sulfide from test gas stream
- Develop a mass balance model for the sulfur removal system

Constraints
- Under 20ppb of sulfur compounds going to catalysts
- Removal media requirements: 1:1 ratio or greater of oxygen to sulfur compounds in gas
- Minimum of 60% relative humidity

Design Alternatives

**Alternative 1- DARCO® BG 1**
- Sulfur irreversibly bound to carbon
- Tested to lower H2S levels to undetectable levels
- Cost estimated at $3.85 per pound H2S removed
- Nonhazardous
- Client’s electrolysis system will produce required oxygen

**Alternative 2- Ferrosorp®**
- Lowest recommended concentration 20 ppm H2S
- Cost estimated at $7.5 per pound H2S removed
- PPE required for handling
- Can be regenerated for longevity

**Alternative 3- SulfurTrap® EX**
- Iron-based sorbent
- Typically, disposable in landfills
- Does not require oxygen or moisture
- $8.11 per pound of H2S removed
- PPE required for handling

**Alternative 4- SulfurTrap® HT8**
- Alkanolamine liquid treatment
- Will remove CO2 as well
- Cost estimated at $20.21 per pound H2S removed
- Requires adequate ventilation and PPE

Selected Design
To select the best design alternative, a decision matrix was employed. The main consideration was selectivity for H2S to CO2, to ensure it would remove H2S and not CO2. Compatibility measures the impact that using the removal media would have on the existing system. Maintenance is a measure of how often the media needs to be swapped out, and how hazardous or difficult it is to dispose of or work with. Cost is how much the material costs.

Our selected design alternative was DARCO BG-1 activated carbon. This media scored an 8.6 on our decision matrix, beating out all three other options.

Advantages:
- Low removal cost at $3.85 per pound H2S
- Nonhazardous and stable after used up
- Effective at removing other volatile organic compounds (VOCs)
- Utilizes oxygen generated during hydrolysis

Disadvantages:
- Cannot be regenerated
- Dry gas requires added moisture

Design Parameters
Once the removal media had been selected, the team constructed a bench-scale sulfur removal system. The activated carbon beds are made of 3-inch diameter schedule 40 PVC pipe. The removal media was surplus from EDL in Lansing.

To get proper removal, the bed contact time needed to be at least 4 seconds. To verify the flow rate was low enough, we used a wet tip bucket. The actual operation of the design was below the theoretical maximum flow, due to the limitations of the wet tip bucket.

Economics
- Purchasing the materials would cost $589.
- Majority of the cost is for new wet tip buckets.
- Excluding wet tip buckets, other materials cost $129.

In a real system, the health of the methanation catalyst has a large impact on economics. Methanation catalysts have been measured to work at 88% efficiency but drop to 10% when poisoned. This represents a large loss in potential methane revenue.

References

Acknowledgements

References

Table 1. Decision Matrix

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<th>Maintenance</th>
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Table 1. Decision Matrix

Figure 1. DARCO BG1 Removal Media

Figure 3: Process Flow Diagram

Figure 4: H2S Concentration in Raw vs. Clean Gas