System Design to Produce RNG From Anaerobic Digestion (Under NDA)

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Background

Introduction:
Consumers Energy (CMS) is a Michigan energy provider with goals to achieve net zero carbon emissions and meet 90% of Michigan’s energy needs with clean resources by 2040. MSU’s SCAD produces 46 million standard cubic feet of biogas every year. Refinement of this biogas into a RNG has potential to remove 14,500 tons of CO₂ annually, while increasing and diversifying CMS’ energy supply.

Justification:
• In the US, nearly 31 trillion ft³ of natural gas is consumed annually³
• RNG can be used to displace fossil fuel-based consumption, while capturing harmful methane emissions
• Diverting CH₄ emissions into energy consumption releases CO₂ instead—this equates to a 27-fold reduction in global warming potential²

Problem Statement:
To determine the system requirements to refine biogas produced from anaerobic digestion into RNG that meets CMS’ gas specifications.
- CH₄ >97% by volume
- CO₂ <2% by volume
- O₂ <5ppm
- H₂S <0.25 grains/100ft³

Objectives & Constraints

Objectives:
• To minimize the costs of the cleaning and compressing facility
• Allow the design to be used as a model for alternative sites
• To minimize the design’s potential emissions and environmental damage
• To minimize the cost per MMBtu of RNG produced
• To maintain a CH₄ recovery rate of at least 95%

Constraints:
• To meet CMS’ pipeline natural gas specifications
• The additional RNG volume must remain under CMS’ pipeline capacity
• Team must complete project by April 21, 2021

Selected Design

Membrane permeation technology utilizes porous membranes to separate the CH₄ stream from the CO₂ stream. The advantages include low capital cost, low energy demand, small footprint, and ease of operation.

Design Alternatives

<table>
<thead>
<tr>
<th>Pressure Swing Adsorption</th>
<th>Water Scrubbing</th>
<th>Amine Gas Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pros</td>
<td>Cons</td>
<td>Pros</td>
</tr>
<tr>
<td>Low energy</td>
<td>Unable to remove all impurities; requires pretreatment</td>
<td>Low CAPEX</td>
</tr>
<tr>
<td>Low CAPEX</td>
<td>Simple and compact</td>
<td>Simple operation</td>
</tr>
<tr>
<td>Simple and compact</td>
<td></td>
<td>No added chemicals</td>
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</tbody>
</table>

Economics

Project Costs:

<table>
<thead>
<tr>
<th>Capital Expenditure (CAPEX)</th>
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<tbody>
<tr>
<td>MSU SCAD</td>
</tr>
<tr>
<td>Biogas Upgrading System</td>
</tr>
<tr>
<td>System Enclosure with Electrical Room</td>
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<tr>
<td>DeOxo System</td>
</tr>
<tr>
<td>Shipping</td>
</tr>
<tr>
<td>Start-Up</td>
</tr>
<tr>
<td>Pipeline to Interconnection Point</td>
</tr>
<tr>
<td>Regulator Stand</td>
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<tr>
<td>Total</td>
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</tbody>
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Project Revenue:

- The revenue for this project is based on the selling price of RNG, which is determined based on the commodity value of NG, as well as the market price of government subsidies such as Renewable Identification Number (RIN) and Low-Carbon Fuel Standard (LCFS) credits²
- RIN credits are determined based on the quality of gas; this project is producing D5 gas, which is sold at $1.05/RIN
- The system has decided to price RNG at $15/MMBTU per MMBTU; from this evaluation, the project generates $412,590 annually

Conclusion

Client Future Steps:
Based on the current feedstock, which produces D5 gas, the project will never make a profit. To address this, the team recommends that the client reevaluate how RNG is to be priced. Legislation like the LCFS program in California is likely to be passed in Michigan in the future, which would increase the selling price of RNG. Currently, access to distribution channels for RNG producers can be difficult to obtain, which has been factored into the $15/MMBTU price for RNG.

- At this price, the team recommends that only D3 RNG producers should be considered for implementation
- If implemented, SCAD could adjust the feedstock to entirely dairy manure resulting in D3 RNG that is sold for $60-80/MMBTU
- If this project could sell its RNG at the D3 price, the annual revenue would be nearly $2M

Key Takeaways:

- A biogas-to-RNG project of this scale has potential to remove 14,500 tons of CO₂ emissions annually
- Membrane permeation is an adaptable technology which is useful for various gas flows, and is simple to operate
- Implementation on dairy farms will make the project financially feasible, as transportation and piping costs can be significantly reduced

References


References