Biogas Cleaning and Optimization of Biomethane Transportation in the Commonwealth of Pennsylvania

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Abstract

Anaerobic digestion is the process in which biological material is naturally broken down by bacteria in an oxygen deprived vessel to produce a biogas of 55%-70% methane and 30%-45% carbon dioxide.[7] After a cleaning process, the methane can be extracted to produce a renewable to natural gas(RNG); also referred to as biomethane. Infrastructure to deploy this renewable solution already exists as it can be injected into public gas utility pipelines or fuel natural gas vehicles. The separated CO_2 can be sequestered in geological formations. **A feasibility analysis was conducted for the state of Pennsylvania to examine optimal transportation and injection of biomethane into the natural gas pipeline. The model predicated a total of 4.433 trillion MJ/year and 11 of 23 anaerobic digestion farming sites may be economically viable. In addition, 135 thousand tons of CO_2 would be available for geological sequestration.** Pennsylvania is the 5th largest user of natural gas in the US and 4th largest producer of CO_2 emissions, investment in renewable energy production for a sustainable future is necessary.[11,12]

Biogas to Biomethane Cleaning

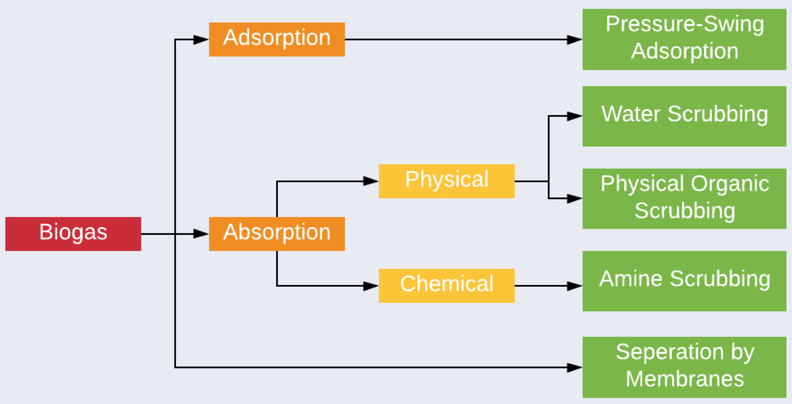


Figure 1 Biogas to Biomethane Cleaning Options[4]

- **Farm size, capital investment, resource availability, and desired end product influence the choice of biogas cleaning system.**
- Cleaning systems are utilized to remove impurities of nitrogen, oxygen, hydrogen, hydrogen sulfide, and ammonia.
- Each cleaning technology will also produce different methane levels, with water scrubbing producing the most pure methane gas with 96.1% purity.
- Water scrubbing and pressure-swing absorption make up 68% of the market.[14]

Research Methods

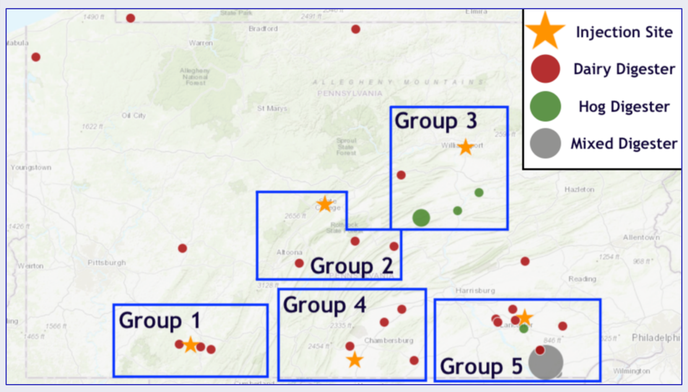


Figure 2 Groupings of Anaerobic Digesters in Pennsylvania[3]

Assumption	Cost
Biogas Cleaning Cost	$0*
Biogas Cleaning	1,250 m³/h
Driver Salary	$1,283 a week
Trucking MPG	6 MPG
Trucking Fuel	$2 per gallon
LNG Trucking Capacity	12,000 Gallons
Biomethane Injection	$0.61 per m³
Natural Gas Price	$105.84 per 1000 m³
RIN Natural Gas Price	$356.33 per 1000 m³
CO2 Trucking Capacity	6274 Gallons
California CO2 Capture	$193 per ton
45 Q CO2 Capture Price	$33.60 per ton

Figure 3 Pricing Assumptions

- Using information located on AgSTAR, an EPA and USDA program, feedstock, biogas output, electricity generation was gathered.
- The produced liquid biomethane (LBM) is moved to a centralized point located on the natural gas grid.
- LBM is transported by standard liquid gas tanker trucks
- Model inputs included biogas generated, injection site distance, biomethane produced, trucking wages and fuel costs.
- Sites were assumed to have water scrubbing system, LBM conversion/storage, and gas loading labor.

Results

Of 23 digestion sites, 11 were found to have a yearly positive revenue stream. 3 additional were within $30,000 of breaking even. Bulk of cost comes from the transportation, as trucking wages and fuel costs equate to $41.72 a mile. CO_2 income potential is $30.7 million. Total yearly Injection cost is $122,000.[10] Each truck carries 4.68 billion MJ of energy. A total production of 4.433 trillion MJ/year is possible.

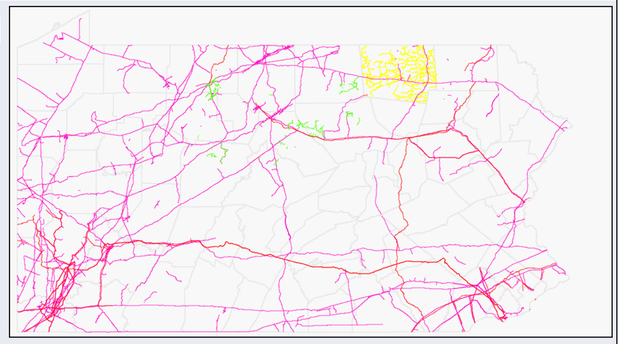


Figure 4 Natural Gas Pipelines in Pennsylvania[6]

Future Research

- Profile each farm's anaerobic digestion technology outputs
- Evaluate future cryogenic liquid transportation technology
- **Incorporate government credits/grants for Renewable Natural Gas electricity, and for CO_2 sequestration in revenue streams**

End Uses of Renewable Natural Gas

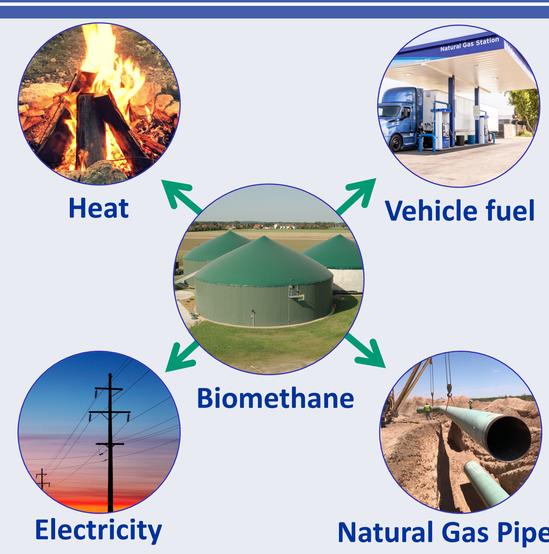


Figure 5 Uses of Biomethane

- **Biomethane can be used to feed into the natural gas pipeline or burned to provide electricity to the grid to consumers.**
- It can be used to power compressed or liquid natural gas vehicles, which currently have annual growth rates of 15%-20% and 5%-10% a year respectively.[4]

Carbon Dioxide Extraction and Sequestration

- **With the removal of CO_2 during the biogas cleaning process, pure CO_2 can be extracted and trucked for geological sequestration.**
- Through government incentives, $226 per ton of CO_2 can be paid for its sequestration, and the value per ton will continue to increase.[4,10]
- There are currently no carbon sequestration facilities in PA. However plentiful saline aquifers and other favorable geology in PA provide opportunities for investment in this carbon negative technology.

Conclusion

Anaerobic digestion provides a source of renewable natural gas for a state greatly dependent on it. Infrastructure to deploy this technology largely exists. Currently, farms with close injection site and favorable amount of biomethane production succeed. **However, with government assistance and refined optimization, this technology can be deployed and utilized to its full potential in creating a more sustainable state.**

Acknowledgments

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Scan the QR code for references & further methodology