Team 11: Anaerobic Digestion Process for Methane Production (ADPMP)

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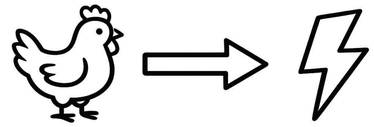
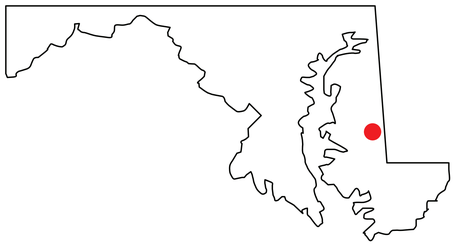
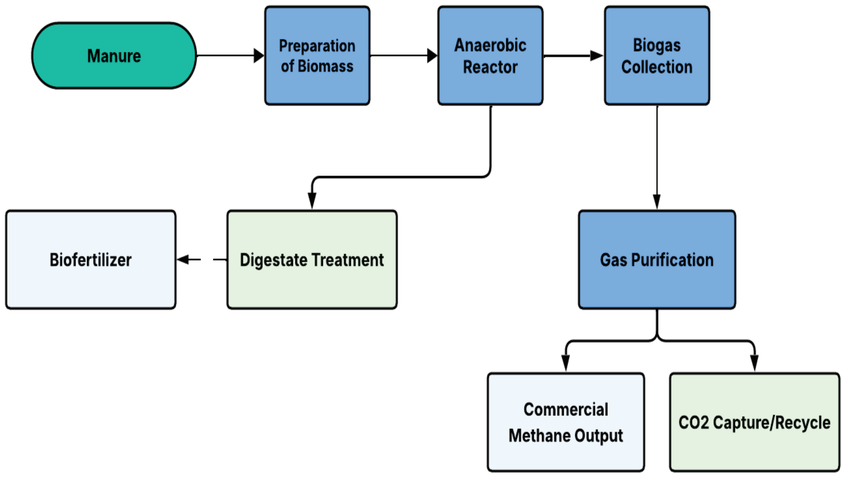




The Concept: Converting Chicken Manure to Methane

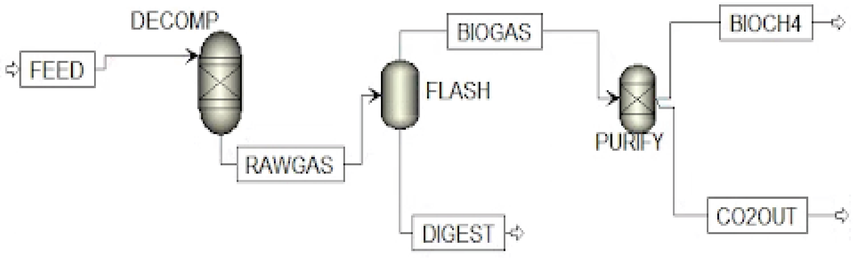
The eastern shore of Maryland produces around 500,000 tons of chicken manure every year, far exceeding the land's ability to absorb it. This leads to nutrient over-saturation, which runs off into our Chesapeake Bay, contaminates water, causes air pollution from ammonia emissions, and creates other detrimental impacts on our environment. This project proposes a sustainable concept to improve waste management by converting manure into methane and digestate, which could eventually be used as fertilizer.



Baseline Design:

- Manure enters the facility through feed pumps and enters a mixer with liquid to prepare for anaerobic digestion
- The mixture enters an anaerobic digester vessel and breaks down into biogas and digestate
- The digestate exits the facility, with the ability to be turned into fertilizer
- The biogas is purified through scrubbing and adsorption with methane as a final product

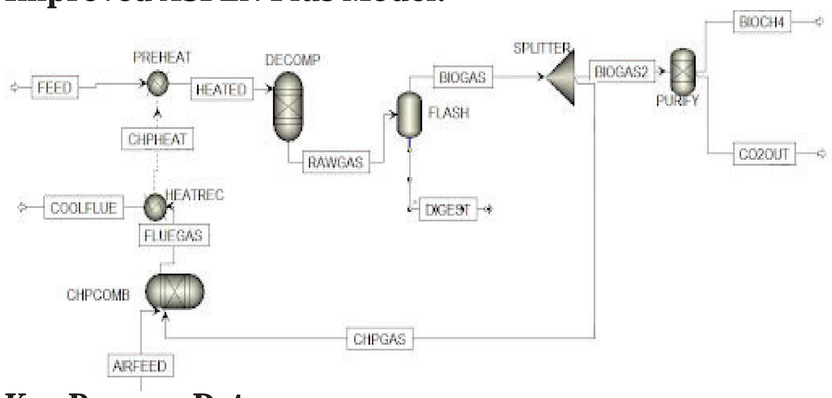
ASPEN Plus Model:



Sustainability Improvements: CHP and Solar Power

After modeling our baseline process, we found that its exothermic nature, combined with the production of combustible biogas, enabled us to use combined heat and power (CHP) to power the entire process. The entire process was modeled to run at a constant 37 °C; thus, in our "ideal" simulation, using CHP to preheat the feed stream was sufficient. Additionally, to power factory pumps, lighting, and other standard utilities, we found that solar power would be sufficient.

Improved ASPEN Plus Model:



Key Process Data:

Process	Manure Processed (tons/day)	CH4 Output (tons/day)	CO2 Output (tons/day)	CO2 Emissions (tons/day)
Baseline	100	2.11	17.6	78
Improved with CHP (15% biogas)	100	1.59	13.2	65

Annual Parasitic Loads:

System	Consumption (kWh/day)
Pumps (feed, discharge, circulation, etc.)	60-100
Agitators	50-80
Biogas Compressor	30-60
H2S Scrubber	18-25
Facility Lighting	36-50
SCADA, HVAC, etc.	70-154
Total Parasitic Load	264-469

Solar Requirements (JinkSolar 700W Panels):

Target kWh/d	$/Panel	Dimensions (ft^2)	Avg. Peak Sun Hours / Day	Avg. kWh/d per panel
300	70-110	33.54	4.5	3

Utilizing JinkoSolar's 700W industrial panels as a baseline would require roughly 100 panels to power most of our system. This would be around $17k-$28k with standard costs and installation.

Overall Sustainability:

Utilizing CHP and solar power can cover nearly all of the energy requirements of this process. Simultaneously, the predicted carbon emissions of this process also significantly decrease by almost 20%. As this process is modeled to handle 100 tons of manure a day, this equates to roughly 7% of the chicken manure produced each year in the eastern shore of Maryland. Sustainability is a key metric for establishing a repeatable, continuous process in a government waste management system, and we are proud to find that this process is plausible.

One major concern is the occurrence of rainy or snowy days, as well as continuously cloudy weather. In cases like this, the facility likely will not have solar power, and more methane will have to be used to run the facility on CHP, or it will have to use electricity from a utility grid.

Conclusive Statements and Recommendations:

This project gives excellent insight into the potential of incorporating ADPMP into our Eastern Shore's waste management program.

The CHP unit generates enough electricity to cover most operational energy costs, and by directing a portion of the methane output to power internal processes directly, the facility reduces grid dependence even further while improving overall energy efficiency. Parasitic loads remain minimal relative to total output, and the solar array provides reliable backup, making the system largely self-sustaining.

This initiative is a commitment to prevent manure from decomposing uncontrolled in the environment and releasing methane, ammonia, and nitrous oxide into the atmosphere, and from leaching nitrogen and phosphorus into lakes, rivers, and the Chesapeake Bay/Eastern Shore of Maryland.

Regarding byproduct recovery, our recommendation for future improvements to this plant is to implement treated wastewater from the digestion process for return to agricultural use as nutrient-rich irrigation water, closing the loop between waste and crop production. Carbon dioxide and other gaseous byproducts can be captured and processed into usable products such as compressed CO_2 for food-grade or industrial applications, creating additional revenue streams.