

Supporting Sustainability: Organic Patient Food Waste Digester for Destination Grand (Under NDA)

Eliza Ajro, Josh Hirschenberger, Defne Karalar, Connor Moritz, and Maria Sufyan Abbasi

Client: Henry Ford Health Faculty Advisor: Dr. Wei Liao

Background

- HFH developing new patient care facility: Destination Grand, 2029
- Implement organic patient food waste digester
- Current landfill methods: extensive manual labor, costly, no return benefits
- Anaerobic digestion: organic waste → biogas
- Biogas use: electricity, heat, fuel
- Byproducts: digestate (N, Ph rich fertilizer)
- Benefits: improve soil health, less synthetic fertilizer use, reusable energy
- Co-digestion: higher biogas yield + better nutrient quality
- Scalable design, meets MI regulations supports sustainability



Figure 1: 3D Rendering of Henry Ford Health Destination Grand building

Objectives

- Compare technology options at 32 kWh/d
- Develop costs: ≤ \$750,000 capital, \$50,000/yr operating
- Estimate environmental benefits; 98% CO₂ reduction/yr
- Monitor organic waste: 615.5 lb/d (± 5%)
- Determine capacity to treat 700 kg/d at 90% efficiency

Constraints

- Space availability restricted to 58 ft x 57 ft
- Minimize waste transportation distance ≤ 423 ft
- Includes only organic patient food waste
- Prepare meals for approx. 600 to 700 patients/d
- Account for 100 to 170 of isolation patients

Safety & Compliance

- ISO standards: design, operation, safety (24252, 19388)
- OSHA: confined space safety (maintenance, inspection)
- Risks: methane buildup, explosion hazard, gas toxicity
- Controls: ventilation, gas monitoring
- Safety systems: monitoring, emergency shutdown

Design Alternatives

2-Stage CSTR AD [1]:

- Acidogenic thermophilic + mesophilic methanogenic operation
- Higher loading, smaller tanks, short HRT
- Optimized VFA + methane; biogas output
- Integrated odor control
- Higher energy recovery, safer digestate

1-Stage CSTR AD [2]:

- All digestion in 1 tank
- Uniform conditions
- Mesophilic/thermophilic operation (long HRT)
- Simple, low-cost, low-maintenance
- Biogas + digestate product

Plug-flow vertical in-vessel composter [3]:

- Enclosed aerobic composting tank
- Waste moves top to bottom
- Air supply supports microbial decomposition
- Vertical design for indoor use
- Produces compost only (no biogas)

Selected Design

Table 1: Decision Matrix

Criteria	Weight (%)	2-stage	1-stage	Compost
Space	30	9	6	2
Odor Control	30	8	5	2
Operational Complexity	15	3	5	7
Waste Reduction	15	7	5	3
Cost	10	2	5	7
Weighted Total	100	6.8	5.3	3.4

* Rating: 1-10 (where 1- Poor, 3- Fair, 5- Average, 7- Good, and 10- Excellent)

Design Parameters

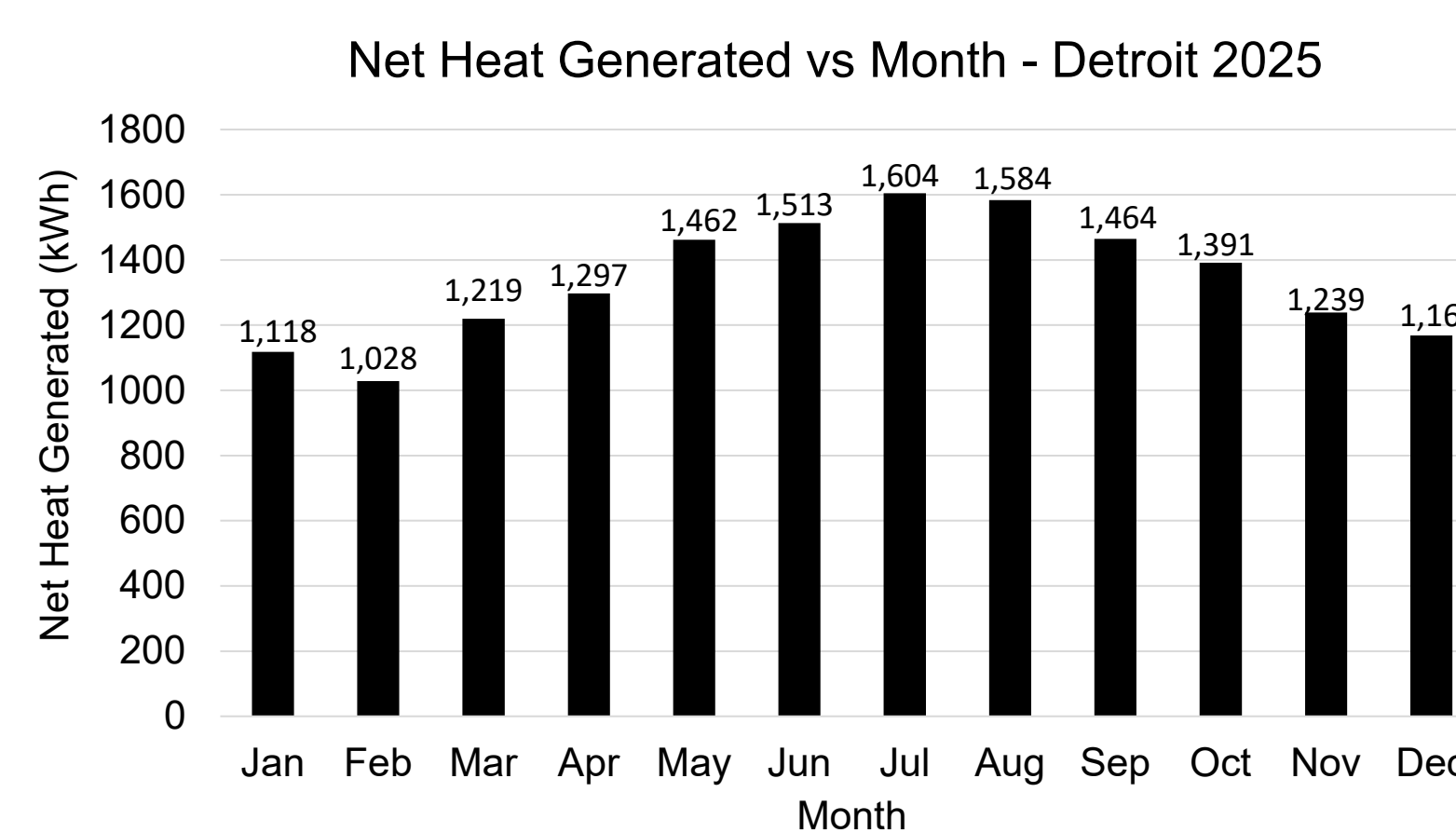


Figure 2: Digester Monthly Net Heat Gen (Detroit, 2025)

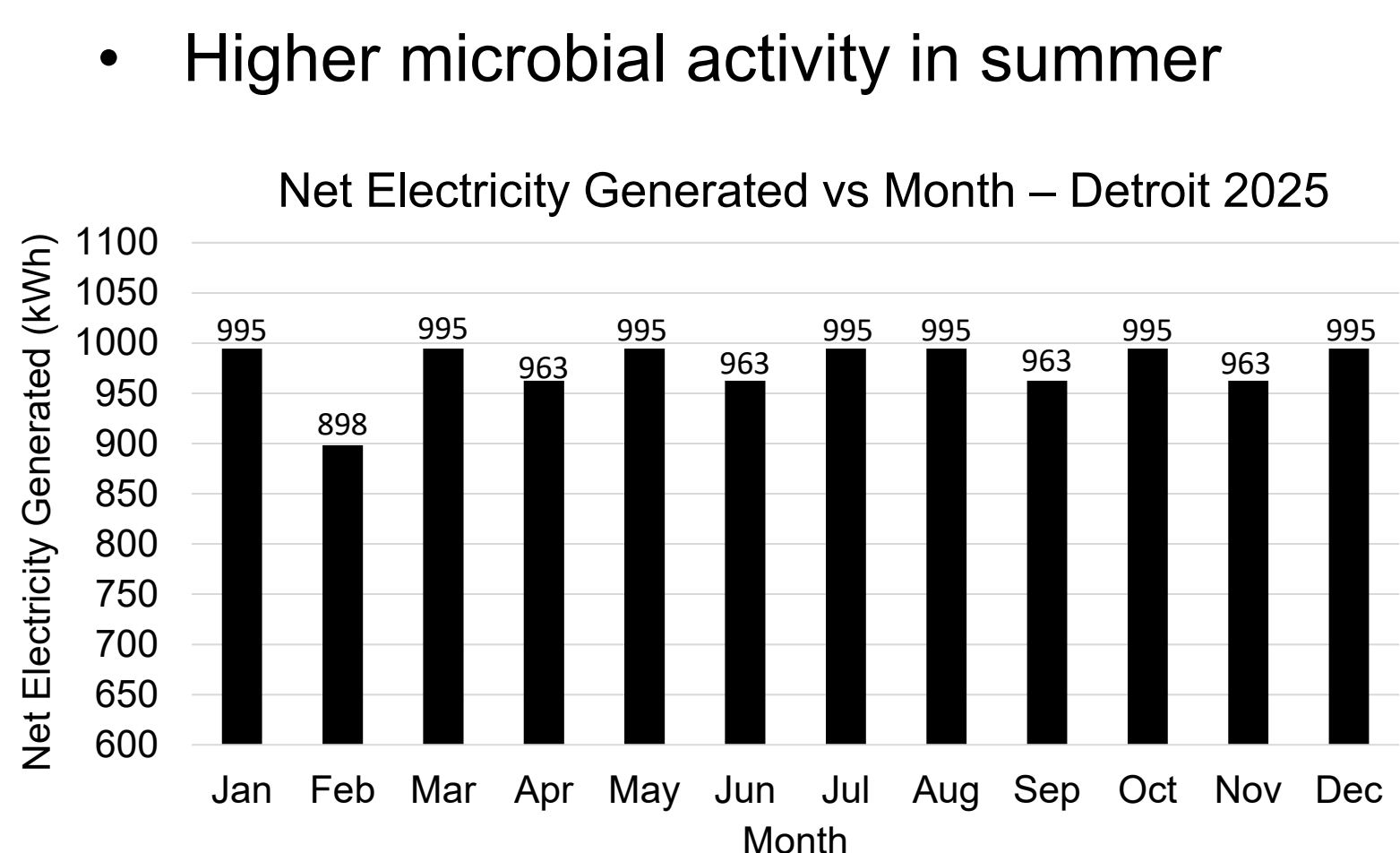


Figure 3: Digester Monthly Net Electricity Gen (Detroit, 2025)

- Stable electricity (~970-1000 kWh)
- Slight winter dip, overall reliable

Design Parameters (cont.)

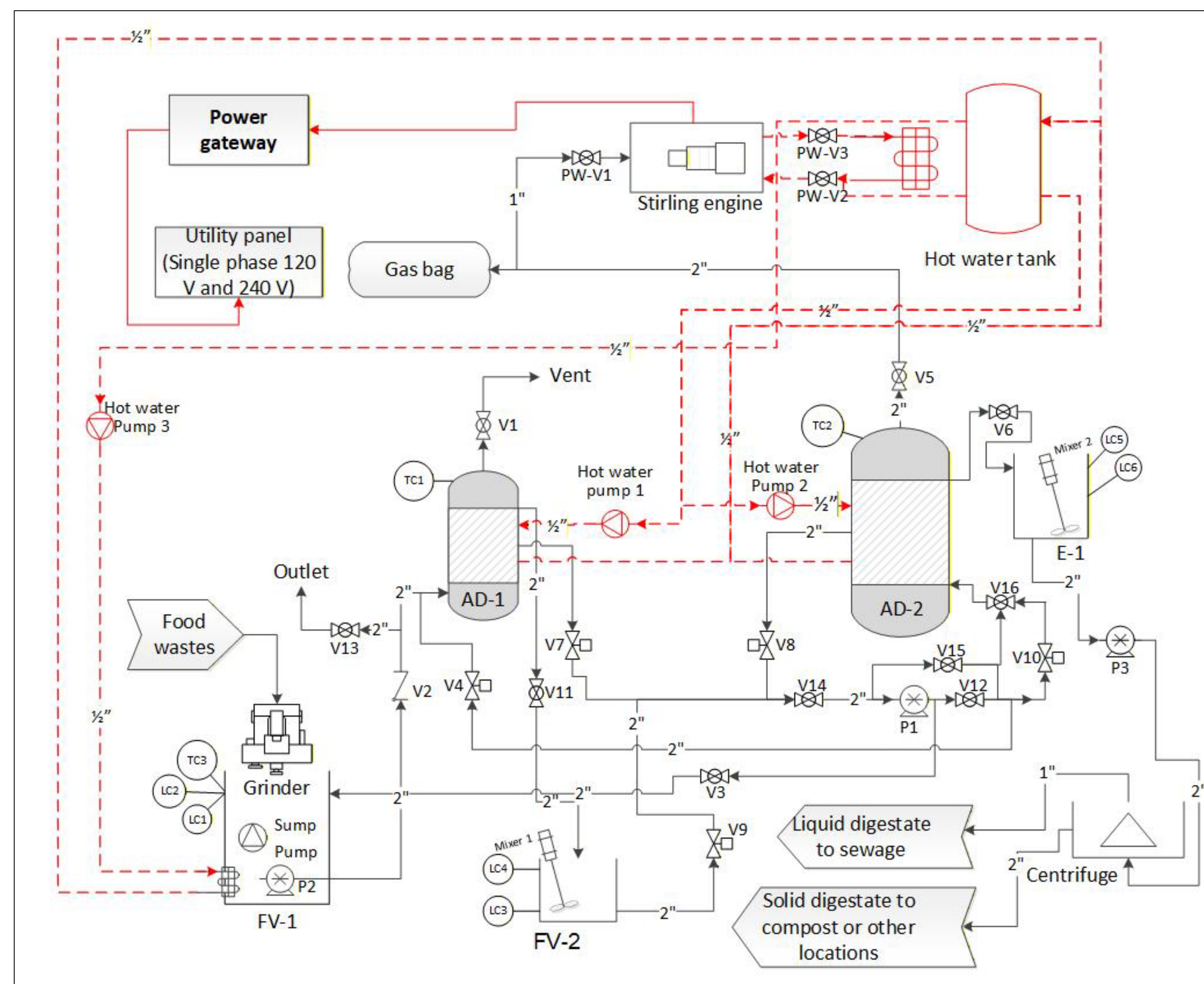


Figure 4: Piping and Instrumentation Diagram (P&ID) for 2-stage CSTR

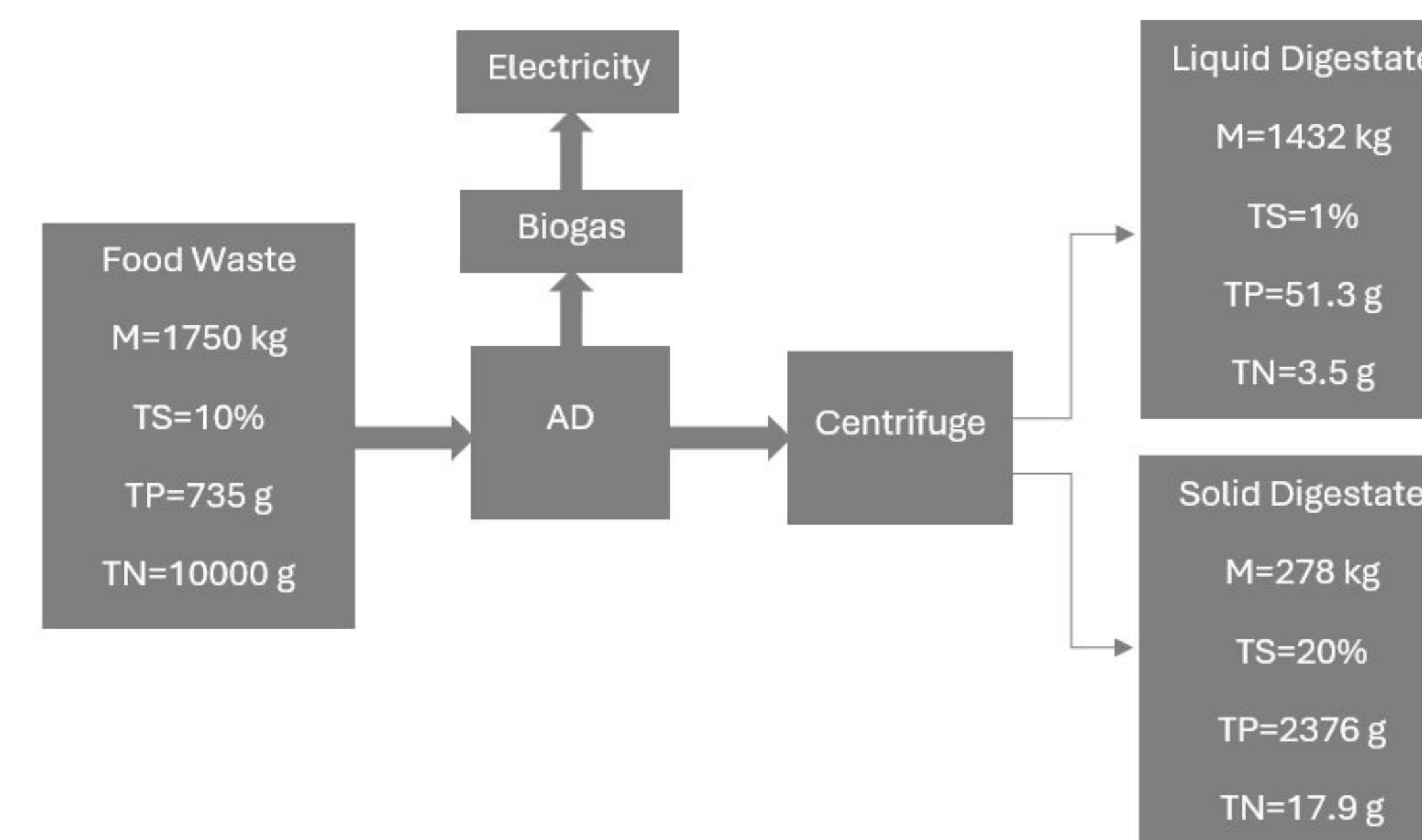


Figure 5: Process Flow Schematic & Digestate Composition

Key Equations

Table 2: Mass, Energy, & Digestate Equations

Variable	Equation
Daily Feed	$\frac{\text{Wet food waste} \cdot \text{TS content}}{\text{Diluted TS content}} = \text{Daily feed amount to digester}$
1 st Reactor Vol.	$\text{Daily feed amount to digester} \cdot \frac{1 \text{ L}}{\text{kg}} \cdot 10 \text{ d} \cdot 1.3 = \text{Reactor vol for 1st AD}$
2 nd Reactor Vol.	$\text{Daily feed amount to digester} \cdot \frac{1 \text{ L}}{\text{kg}} \cdot 30 \text{ d} \cdot 1.3 = \text{Reactor vol for 2nd AD}$
Biogas Vol.	$\frac{\text{Methane}}{\text{d}} \cdot \frac{1}{\text{Methane composition in Biogas}} = \text{Total Vol of Biogas}$
Net Heat Generated per Month	$\text{Heat Generated from Biogas} - \text{Heat Required} \times \# \text{ days for that month} = \text{Net monthly heat generated}$
Net Electricity Generated per Month	$\text{Electricity generated from biogas} \times \# \text{ days for that month} = \text{Net monthly electricity generated}$
Ph/N in Liquid Digestate	$\frac{\text{Total Ph/N in food waste} \times \text{TP/TN liquid digestate}}{\text{amount of liquid digestate}} = \text{Ph/N in liquid digestate}$
Ph/N in Solid Digestate	$\frac{\text{Total Ph/N in food waste} \times \text{TP/TN solid digestate}}{\text{amount of solid digestate}} = \text{Ph/N in solid digestate}$

Economics

Table 3: Total Cost for all Equipment component

Equipment	Cost
Valves	\$8,587
Pumps	\$21,985
Vessels	\$20,879
General	\$183,324
Total cost	\$234,775

*Note: More detailed information about specific equipment items are provided in project report

Table 4: Calculated Cost Analysis

Category	Value	Units
Total Saving Over Lifetime	62,906	\$
Annual Savings	3,145	\$/year
Capital Annual Distribution Cost	0.12	\$/gal
Lifetime Economic Value	2.4	\$/gal

- Focuses more on operational savings over profit metrics
- Reduces waste and recovers energy for on site use
- External funding options from both federal and state (EPA, DOE, USDA, EGLE), along with incentives and carbon credits, improve financial feasibility
- Supports long term economic and environmental sustainability

Future Steps

Future expansion include adding EV charging stations, installing solar panels and extending the digester system implementation to all HFH communities as well as surrounding communities in Detroit.

Acknowledgements

The team would like to thank Philip Guster, James Adams, and Vikas Relan from Henry Ford Health as well as Dr. Wei Liao, Dr. Luke Reese, and Dr. Sanghyup Jeong from the Biosystems Engineering Department.

Select References

- Ohdoi, K., Okamoto, Y., Koga, T., Takahashi, H., Oshiro, M., Morimitsu, T., Muraoka, H., Tashiro, Y., & Sakai, K. (2024). Efficient two-stage meso- and thermophilic anaerobic digestion of food waste from a microbial perspective. *Fermentation*, 10(12), 607. <https://doi.org/10.3390/fermentation10120607>
- Aminzadeh, M., Bardi, M. J., & Aminirad, H. (2021). A new approach to enhance the conventional two-phase anaerobic co-digestion of food waste and sewage sludge. *Journal of Environmental Health Science and Engineering*. <https://doi.org/10.1007/s40201-020-00603-8>
- United States Environmental Protection Agency. (2000). *Biosolids Technology Fact Sheet: In-Vessel Composting of Biosolids*. <https://www.epa.gov/sites/default/files/2018-11/documents/in-vessel-composting-biosolids-factsheet.pdf>