Recovering Heat from Composting for Hot Water Heating and Greenhouse Gas Mitigation

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Project Origins

- UNH met with the major organic dairy producers in 2009 to ask what research would be most helpful to their stakeholders.
  - Conclusion of meeting: develop new approaches to reduce costs associated with feed, energy, bedding, and waste management
  - My focus → Energy and waste management
Research Site – UNH Organic Dairy Farm in Lee, NH

- 100 head in the herd (50 cows and 50 calves, heifers and dry cows)
- 40 acres pasture, 140 acres forage, and 120 acres in woodlot

UNH Organic Dairy 2014
Pre-Study Baseline Manure/Nutrient Management at the UNH Organic Dairy

Anaerobic Manure Piles Stored in the Back Field

Manure Holding Pit Full of Water
Problems Associated with Past Manure/Nutrient Management

- Manure pile and pit were always saturated
- Difficult to remove manure after stored in lower field
- Loss of nitrogen through:
  - Leaching to a nearby stream ($\text{NO}_3^-$)
  - Denitrification ($\text{Nr} - \text{N}_2$)
- High $\text{CH}_4$ emissions
- Foul odors
- Source of weed seeds
Solution - Composting with Thermal Energy Capture

Steaming Pile of Compost at UNH ODRF
Background

- UNH built an aerated static pile (ASP) composting facility with Agrilab Technologies Heat Transfer System
- ASP is a type of composting where material is not turned – aerated by fan system instead
- Heat is produced by metabolic activity from aerobic microbes
- Larger microbial population = more heat
- Research facility cost = $500,000
- Can process up to 10,000 yd³/yr
1. Blower pulls air through compost

2. Hot, moist air passes over isobars, flashing refrigerant inside them

3. Heat transferred to 295 gallon water tank as refrigerant condenses back to liquid

4. Hot water used for all hot water needs in milk house

Background: How the UNH System Works
1) Turn on aeration blower
2) Pull vapor from composting piles
3) Pull vapor through bay headers
4) Send vapor into heat exchanger
5) Send vapor through biofilter
Research Questions

- What is the heat extraction & utilization rate from a commercial-scale heat recovery composting facility?
- What is the fossil-fuel equivalent of the captured heat?
- To what degree does the heat recovery system offset GHG emissions for the purpose of carbon pricing?
Typical Compost Temperature Curve at UNH facility

Average Compost Vapor and Pile Temperatures by Compost Age

Average Temperature (°F)

Compost Age (Days)

- Compost Pile
- Compost Vapor
Recovery Rate by Incoming Vapor Temperature

Compost Heat Recovery Rate per Day by Average Vapor Temperature when Managing for 90°F Water

$y = 42378x - 5 \times 10^6$

$R^2 = 0.9189$
Fossil Fuel Equivalent

Energy Saving Equivalent in Oil and Propane by Average Compost Vapor Temperature if Managing for 90°F Water

Gallon Equivalent

Vapor Temperature (°F)

Oil
Propane
Greenhouse Gas Implications

Greenhouse Gas Emission Avoidance for Oil and Propane by Average Vapor Temperature if Managing for 90°F Water

![Graph showing greenhouse gas emission avoidance for oil and propane by average vapor temperature if managing for 90°F water. The graph shows the relationship between vapor temperature (°F) and lbs CO₂E/day, with data points indicating differences in emission avoidance between oil and propane.]
Revenue Streams from UNH System

- Hot water for domestic needs
- Sale of compost (cost $3.95/yard$^3$ to make – sells for $35)
Questions