Energy recovery from composting as a strategy to process food waste and generate heat for winter crop production

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Food Recovery & Donation: Opportunities & Challenges in the Lakes Region

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How heat is generated during composing

- Heat is produced by microbes as a byproduct of their metabolic activity
- High-heat composting requires creating an environment that microbes (primarily bacteria) can survive and reproduce
- Larger microbial population = more heat (Epstein 2011, Rynk et al. 1992)

Temperature Probe at UNH Organic Dairy Composting Facility

Temperature Limit

- Maintain pile temperatures under 160°F through aeration and/or turning
- The amount of aeration needed for heat removal can be 10 x the amount of aeration needed for microbial oxygen demand (Rynk et al. 1992).

UNH Aeration Fan

UNH Composting Facility

- UNH decided to build an Aerated Static Pile (ASP) composting facility with Agrilab Technologies Heat Transfer System in 2013
- Facility processes 2,000 yd^3 of agricultural wastes but has a 8,000 yd^3 composting capacity
- This type of facility could process food waste

UNH Heat-Recovery Composting Facility 10/2013

Background: How the System Works

1. Blower pulls air through compost

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

3. Heat transferred to water in a 295 gallon tank.

4. Hot water in milk house

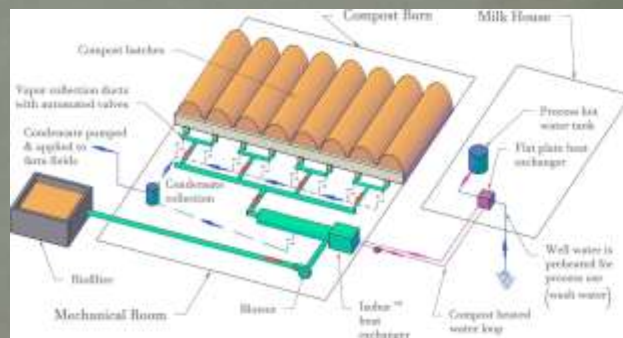


Diagram of UNH Joshua Nelson Energy Recovery Composting Facility
Published in Smith and Aber (2018)

Step 1: Store Compost Feedstocks

Feedstock Mixing Area at UNH Facility

Step 2: Mix Compost Feedstocks with Optimal Recipe (Crucial for Heat Production)

Mixing Compost Feedstocks at the UNH Facility

Step 3: Prepare the Aeration Floor

Woodchips over Cover Plates at the UNH Facility

Step 4: Unload Materials into Facility

Unloading feedstocks into the UNH Facility

Step 5: Pile Material Higher with a Hi-Dump Bucket

Unloaded Compost Prior to Pile Smoothing in UNH Facility

Step 6: Turn on Aeration System

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 through biofilter

Revenue Streams from UNH System

- Hot water for domestic needs offsetting fuel costs
- Compost – cost $4.95/yd^3 and can sell for $35-$40/yd^3 in the seacoast NH area
- Total facility cost was $538,000, but could be replicated for under $300,000 (Smith and Aber 2016)

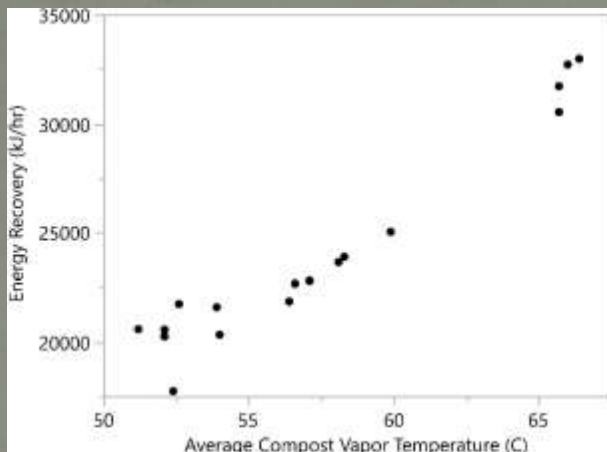
UNH Compost Batch 1 being Spread 11/2014

Compost Studies

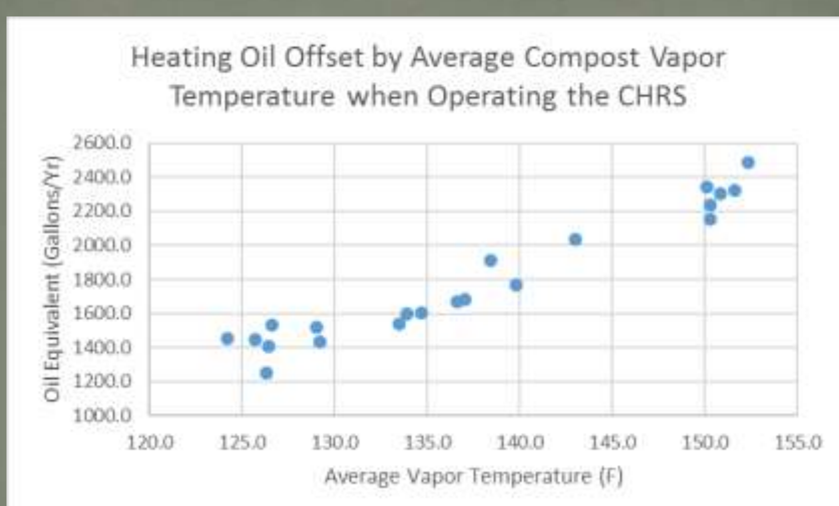
Temperature Probe at UNH Facility

UNH Composting Facility 4/2018

Energy recovery vs. compost vapor temperature

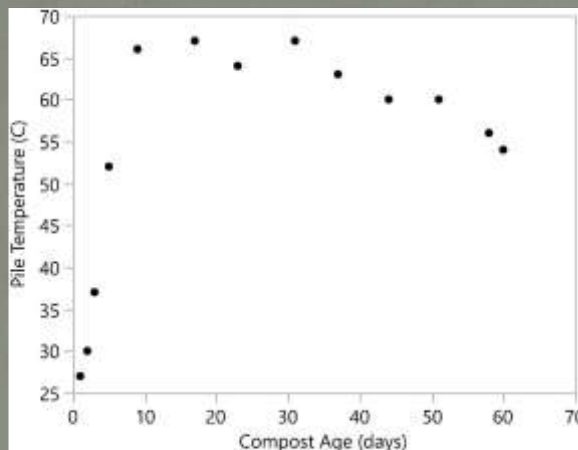


Smith and Aber (2018)



Smith and Aber (2018)

Compost pile temperature vs age



Smith and Aber (2018)

Energy Efficiency Study

- Research Goals
- 1) Determine the net energy efficiency (NEE) of the compost heat recovery system.
  - Aeration system, lighting, water pumps, etc.
- 2)Determine NEE of the entire composting operation
  - Diesel from equipment used for mixing, loading, unloading, etc.
- 3) Use NEE for calculations on carbon offsetting for points 1 & 2.

Energy Efficiency Study: Initial Results

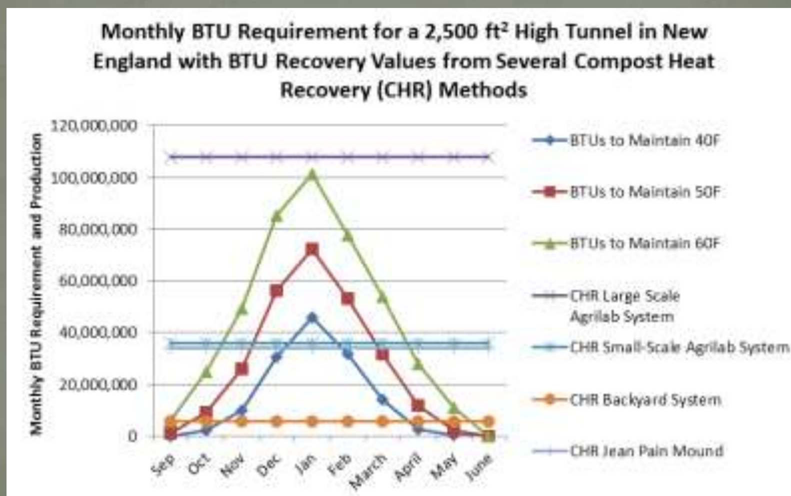
Electrical Component	Total Energy Cost/Day	Total Energy Cost/Year
Water Pump (Grundfos UPS 26-150)	$ 0.67	$ 243.09
Main Composting Floor Lights (8 T8 Fluorescent Lights, 2 Exit Signs)	$ 0.10	$ 35.65
Aeration Fan (NY Blower 126 1HP Fan)	$ 1.01	$ 370.31
Mechanical Room Lights (8 T8 Fluorescent Lights, 2 Exit Signs)	$ 0.08	$ 29.98
Aeration Control System & Panel (California Air Tools 4620 Air Compressor, Verizon Wireless Router, Direct Logic 205 Modular Programmable Logic Controller, GS2 Variable Frequency Drive, Web Energy Logger Temperature Sensors)	$ 0.12	$ 45.38
	$ 1.98	$ 724

Future Research – Attach High Tunnel to Facility

- Free heat from facility could be used to heat a winter greenhouse or high tunnel for free.
- Compost from facility could be used in the high tunnel for continual supply of new growing media.
- Ammonia in vapor stream could be used as supplemental N nutrient.
- CO_2 in vapor stream could be used for increased plant productivity/potentially quality for carbon credits

UNH High Tunnel at the Fairchild Dairy

Future Work: To what Degree can we Support Winter Crop Production in a High Tunnel?



Questions

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