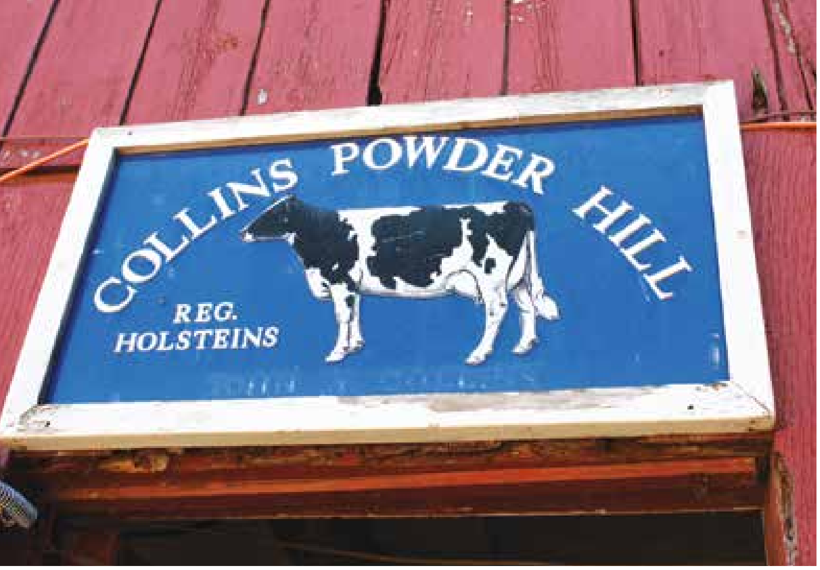
Compost Aeration and Heat Recovery Project

Agrilab Technologies Hot Skid 250R at Collins Powder Hill Farm

A Look at Connecticut's First On-farm Compost Aeration and Heat Recovery System



Project Goal:

to demonstrate an alternative to large anaerobic digesters for smaller dairy farm operations that could produce value added energy and compost.

Contents

Introduction

Connecticut Resource Conservation and Development (CTRC&D), through its Connecticut Farm Energy Program, implemented Connecticut's first on-farm Compost Aeration and Heat Recovery System in 2017.

This project was made possible with supporting funds from the Connecticut Department of Energy and Environmental Protection (DEEP) and U.S. Department of Energy. The USDA Natural Resources Conservation Service (NRCS) provided technical assistance in site selection and design criteria.

CTRC&D went through an application process for interested farms to apply. A selection process with a committee, compiled of agency partners and professionals ranked and scored the applications. The competitively selected farm, Collins Powder Hill Farm in Enfield, CT, was provided the core equipment from CTRC&D that was purchased from Agrilab Technologies Inc. Additionally, Collins Powder Hill Farm was expected to cover installation costs such as site preparation, concrete push and side walls, insulated piping and ductwork, contractor installation costs, as well in-kind time to maintain and assist with monitoring the system for the first year of installation. CT RC&D also provided contractor consulting services and paid for monitoring costs.

The goal of this project was to demonstrate an alternative to large anaerobic digesters for smaller dairy farm operations that could produce value added energy and compost. The Compost Aeration and Heat Recovery system recovers heat from compost for agricultural use as an energy source and produce a compost product that is reduced in volume by 50%, making it more nutrient stable with regards to nitrogen (N) and phosphorus (P). The compost product after cycling through the process should conserve N while reducing trucking costs and can be spread on fields with currently used industry equipment. Alternatively, the compost product could be sold off-farm thus reducing nutrient management load on- farm and creating a value-added income.

This final report with results of this pilot program along with research and recommendations is for education and assisting in the deployment of future systems on other Connecticut farms. This report summarizes energy implications and other operating observations through July 2018 and includes 12 months of operational data.

The Compost Aeration and Heat Recovery system recovers heat from compost for agricultural use as an energy source and produce a compost product that is reduced in volume by 50%, making it more nutrient stable with regards to nitrogen and phosphorus.

John Collins preparing wood chips for aeration plenum around pipes before loading fresh manure compost.

Compost mixtures that previously took two years to achieve maturity were processed for sale or on-farm land application in three to six months. This accelerated compost sales revenues in spring of 2018 by approximately $21,600.

Key findings to date

- Rapid achievement of thermophilic conditions (131+ F temperatures and up to 165F) have been observed which accelerate the composting process of farm manure, animal bedding and other carbon-rich biomass amendments.
- Compost mixtures that previously took two years to achieve maturity were processed for sale or on-farm land application in three to six months. This accelerated compost sales revenues in spring of 2018 by approximately $21,600.
- The changes in operating practices have saved the farm 1400 gallons of diesel fuel consumption and 400 labor and equipment hours in the first year. With a 12-month average of $2.40/gallon, the diesel savings total $3360. At $50/hour (separate from diesel costs) labor and equipment savings total $20,000.
- Preheating wash water in the dairy barn with CAHR over 12 months off set heating oil consumption by 760 gallons @ $3/gal average or $2280 annually. Savings increased with the January installation of a hydronic heater in the milk room.
- Additional heating capacity is available and there are plans for a heater in the equipment shop and/or use of heat for drying compost, straw or grain. This will increase the value of recovered thermal energy from the compost in future years.
- Improvements to the site infrastructure including a receiving/mixing pad adjacent to the aerated composting pad and a roof (hoop barn) for the composting area and mixing pad would further improve efficiency while managing moisture from heavy precipitation events that have become more frequent. The farm is working through the USDA NRCS EQIP process to obtain cost-share funding.

How it Works

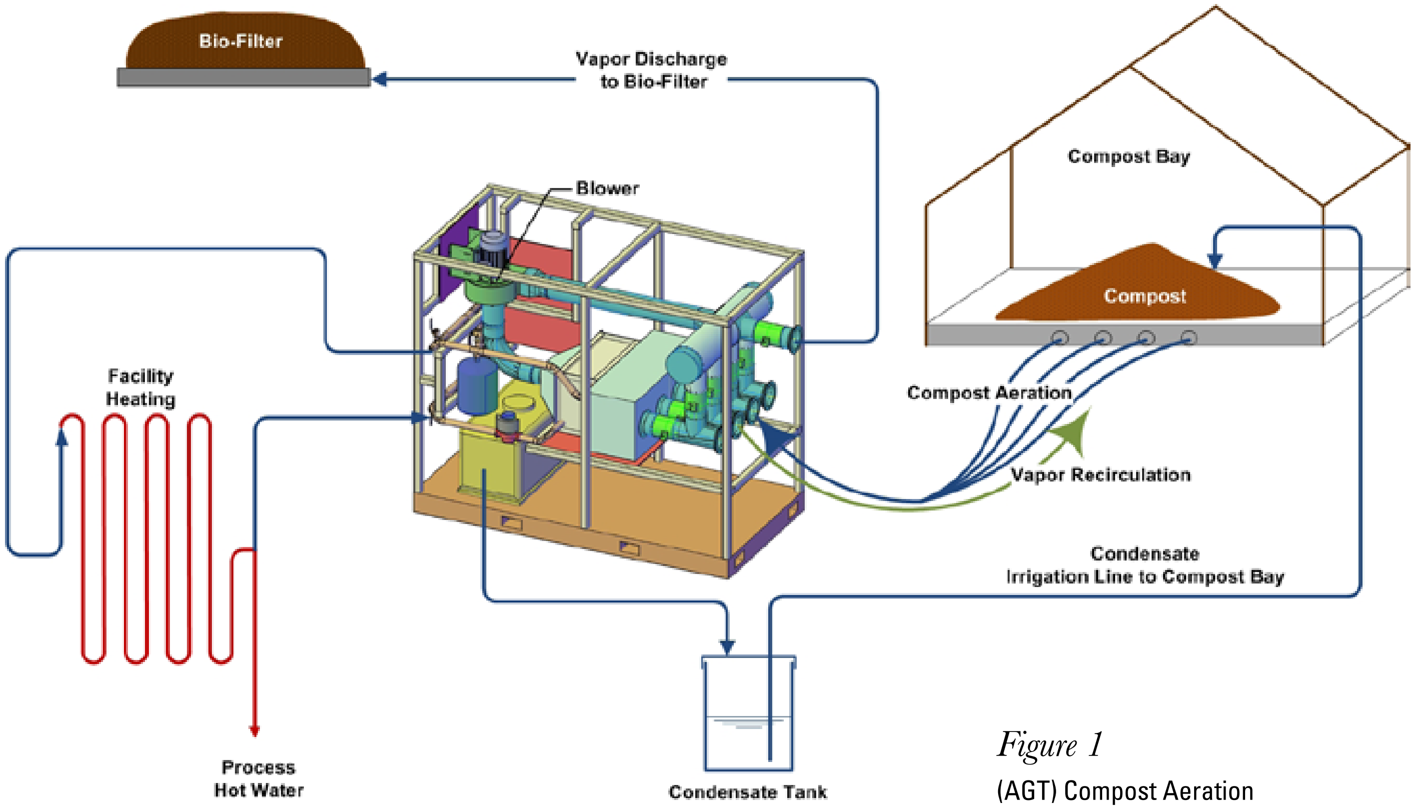


Figure 1

(AGT) Compost Aeration and Heat Recovery (CAHR) Process Flow Diagram

The Agrilab Technologies Hot Skid 250-R is a plug and play unit consisting of the mechanical aeration, heat recovery, plumbing, monitoring and control components.

The CAHR process begins with an active batch of composting materials loaded on to perforated pipes in an aeration bay. Negative aeration draws vapor through pipes into the Hot Skid 250-R equipment using a blower fan, while pulling fresh air and oxygen into the decomposing biomass.

Hot vapor runs through a specialized heat exchanger to heat a water/glycol loop, condensing some vapor into liquid form. Condensate at Collins Powder Hill Farm is pumped into vegetated drainage. Other systems can irrigate condensate back on to active compost piles.

Compost vapor can be exhausted outdoors or other aeration bays can be positively recirculated into other bays, to boost temperatures and humidity of active compost batches. If negative odors are created, a biofilter may be used. This has not been needed at Collins Powder Hill Farm.

Heated water/glycol fluid is moved via a circulator pump to points of heating demand for hot wash water and space heating in the dairy barn milk house. Cooled return water/glycol returns to the Hot Skid 250-R for reheating in a closed loop system.

Four batches (110-120 cubic yards each) of manure compost loaded into aeration bays at Collins Powder Hill Farm. Hot vapor is pulled to Hot Skid 250R unit inside shed for energy capture.

PHOTO CREDIT BRIAN JEROSE

Thermal Performance & Data Figures

This installation is the first in Connecticut and site-specific performance data was captured to provide an assessment of energy outputs and utilization.

The intent was to guide optimal operation of the system from compost mixing and handling methods, to control settings of the CAHR equipment. Further the economic value of the renewable thermal energy and operational efficiency could be quantified to better inform other farmers, funding and technical agencies and other stakeholders.

The Hot Skid 250-R captures operational data including temperatures and flows of the compost aeration and water/glycol loop before and after the heat exchanger. As the system cycles between zones, the temperatures and energy (BTU) flow from each compost batch is interpreted from these temperatures. This is used to track the performance of individual batches, and the energy production of the system as a whole.

Every time the compost zone is switched, or water in the milk house is used, the temperatures change quickly resulting in a series of waves (pulses) in the output data, which typically happen every 15 to 60 minutes. When you look at the data over a weekly or monthly resolution, this creates a lot of fuzzy / zig-zag lines that cross over each other and are hard to interpret (Figures 2 & 3).

The relative outgoing water/glycol temperature from the CAHR system is high, especially with fresh batches of compost. Lowering the return temperature from the dairy barn and other locations (more thermal load) will improve the overall energy capture (as measured in BTU's) and performance of the system.

The performance data is summarized in four sets of figures on the following pages, which are described here; more general interpretation is given in the introduction and conclusion sections. These figures show operation from September through December 2017 and then January 2018 through July 2018.

➔ *Figures 2 & 3*

The graphs show the windrow batches of composting manure aeration temperatures by zone (TA1 – TA4), and the air flow as DCFM (cubic feet per minute /10). Since the system cycles between zones approximately four times per hour, while the water use in the milk house cycles a couple times per day, this creates a series of pulses that is hard to interpret at the month resolution.

At left: John Collins unloading compost around aeration pipes.

Aeration Temperatures and CFM

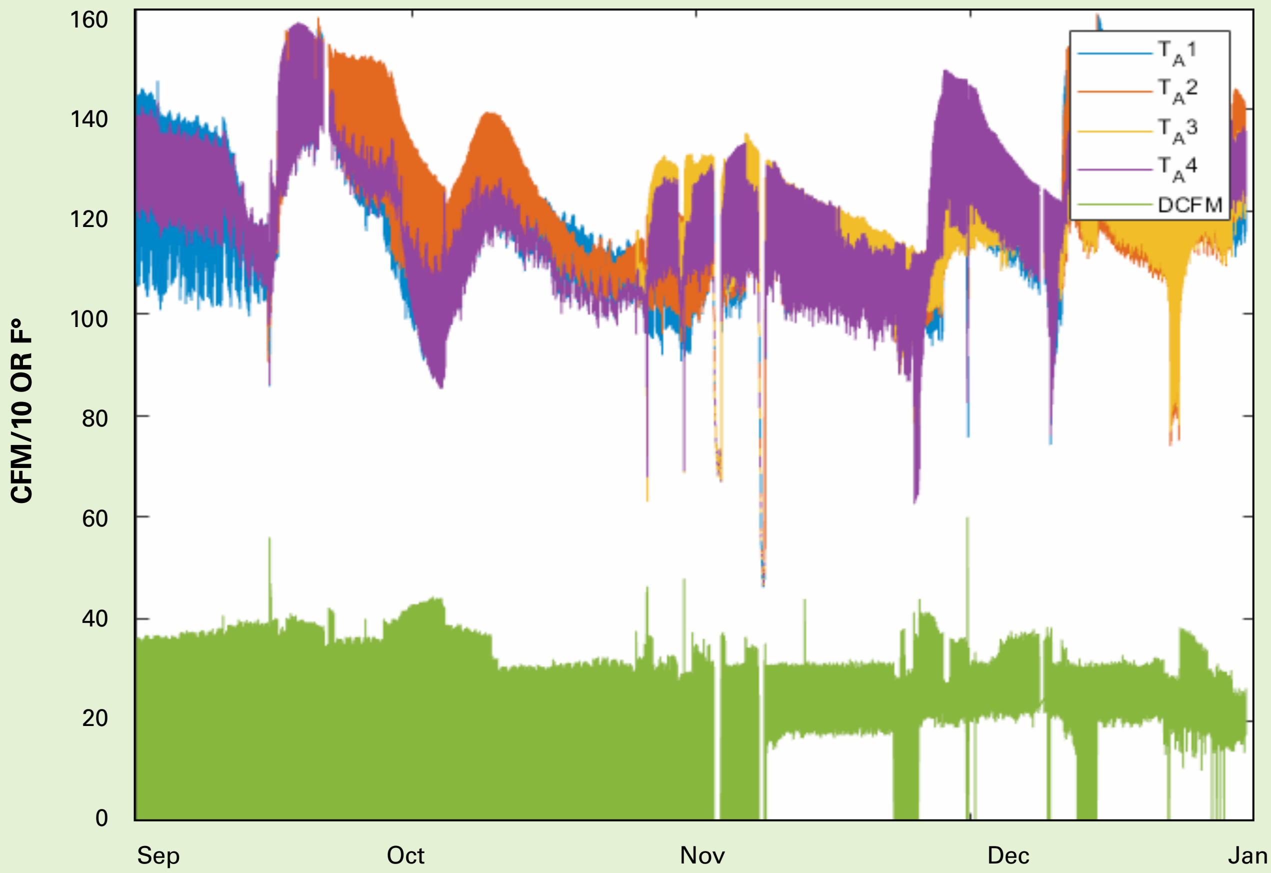


Figure 2

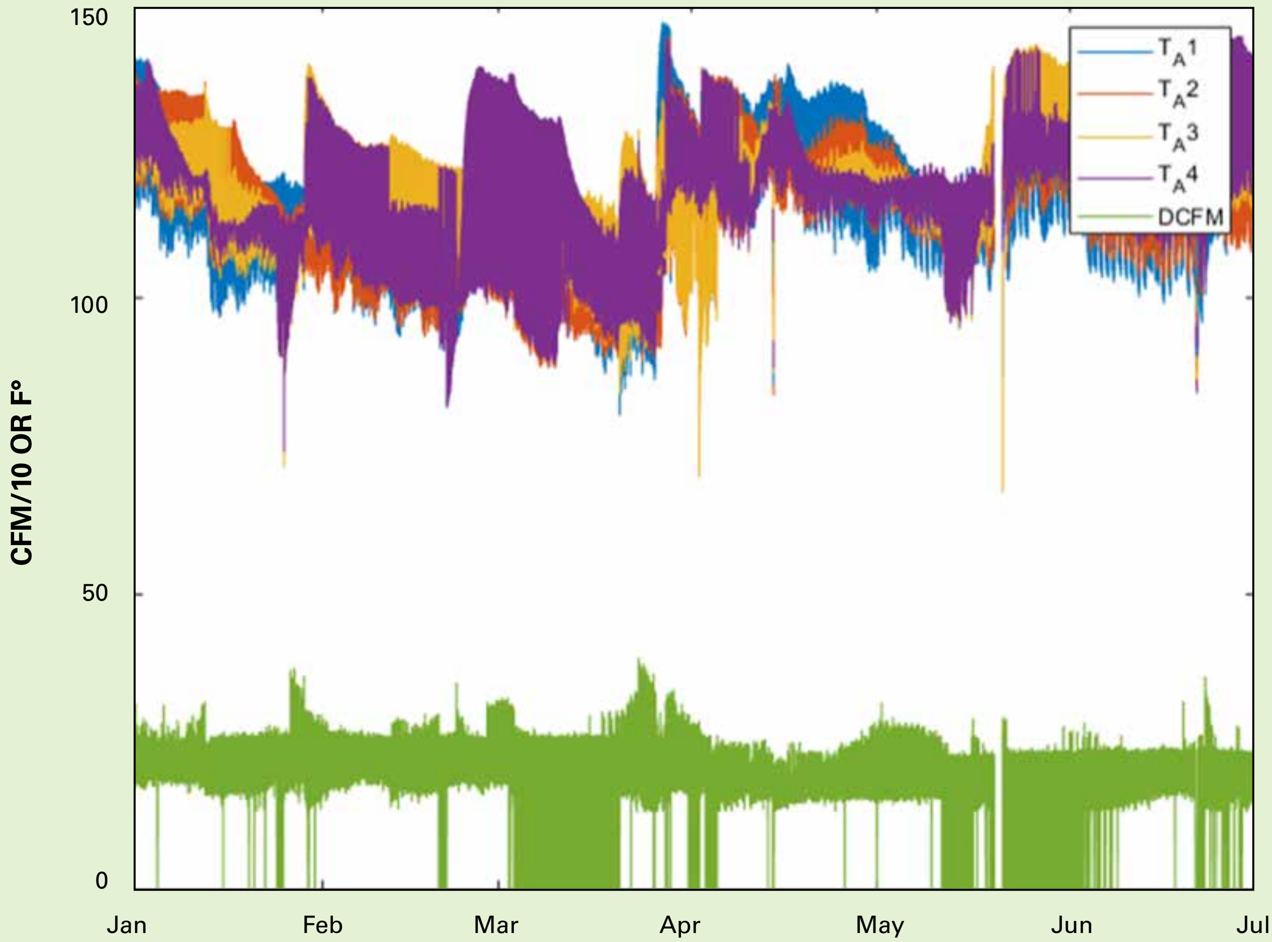
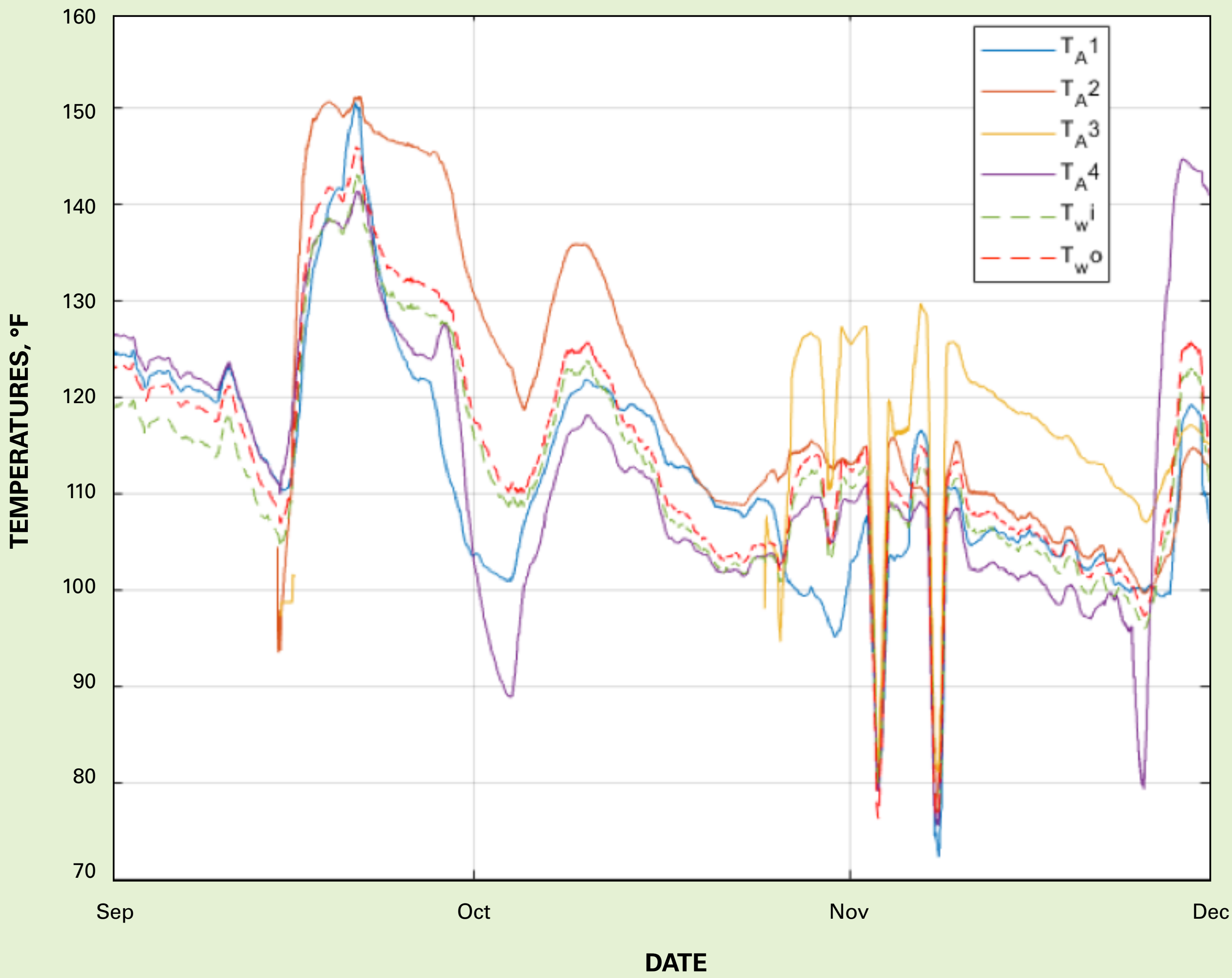


Figure 3

Figure 4

Average Compost Zone Temps & Water Temps
Moving mean of 24 hours

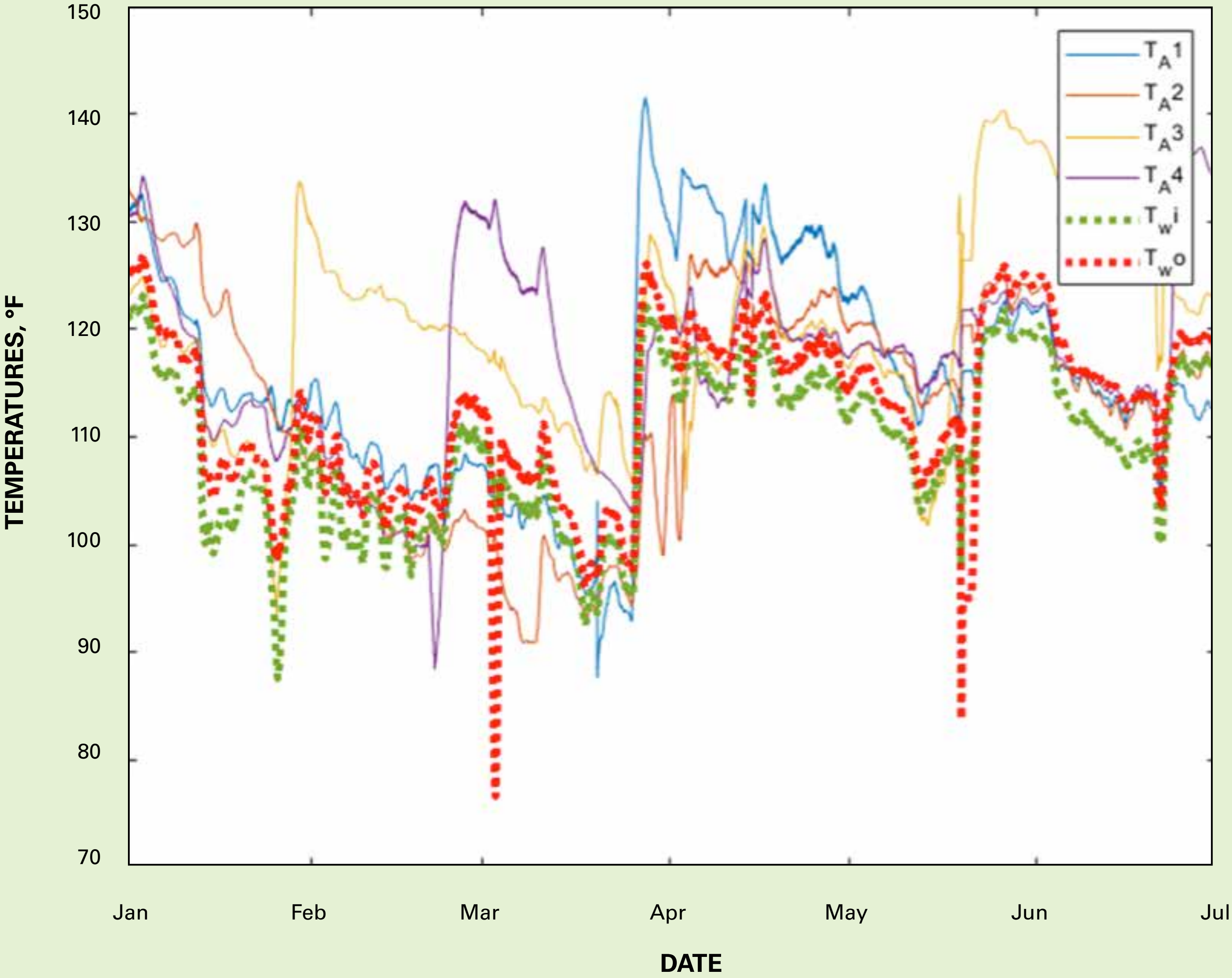


Figures 4 & 5

Figures 4 and 5 show the zone temperatures and water temperatures, smoothed by a moving mean of 24 hours. This allows us to see the average temperature trends of each zone over time. The peaks observed correspond with the loading of new compost batches. Typically a brief lag of 1-3 days from loading to the spike in temperatures into the 131F up to 160F shown. Batches typically sustained temperatures in this range for three to six weeks, following a moderate decay curve on the graphs.

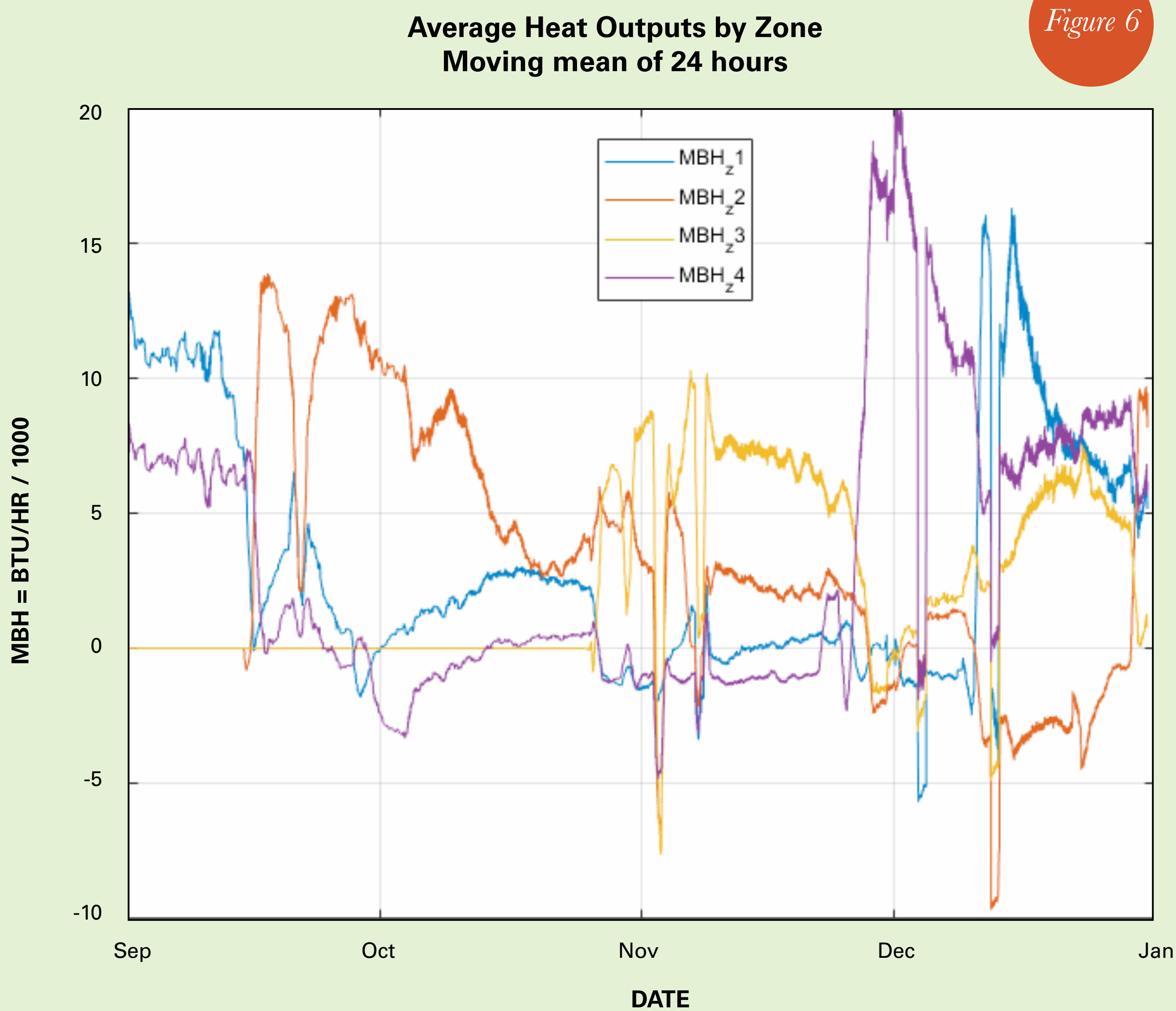
Figure 5

Average Compost Zone Temps & Water Temps
Moving mean of 24 hours



Seasonal variations are shown in the water temperatures returning to the Hot Skid 250R from the heating location in the dairy barn milk room. Not surprisingly, return water temperature was lower during the winter. Note that during the extreme cold of early January (repeated subzero temperatures), hot batches of compost were able to provide ample energy to maintain useful thermal support of wash water and space heating loads.

Figure 6

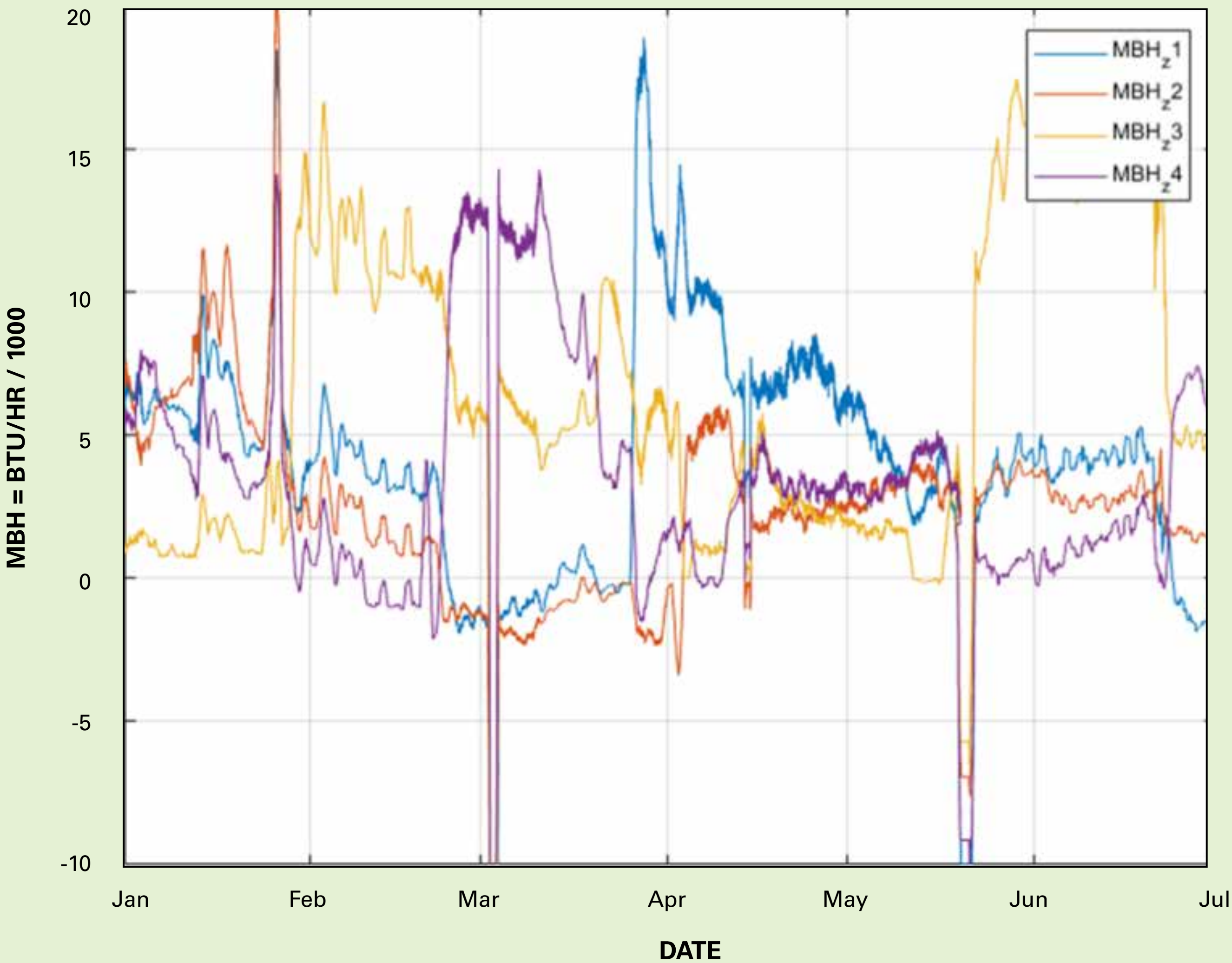


Figures 6 & 7

Figures 6 and 7 show the average heat output of the system by zone, also smoothed by a 24-hour moving mean. BTU figures show what is actually used by heating water and the space heater, not what is generated. Note that peak outputs correlate with the age of the compost batch, typically in the first few days and weeks with a gradual decay curve.

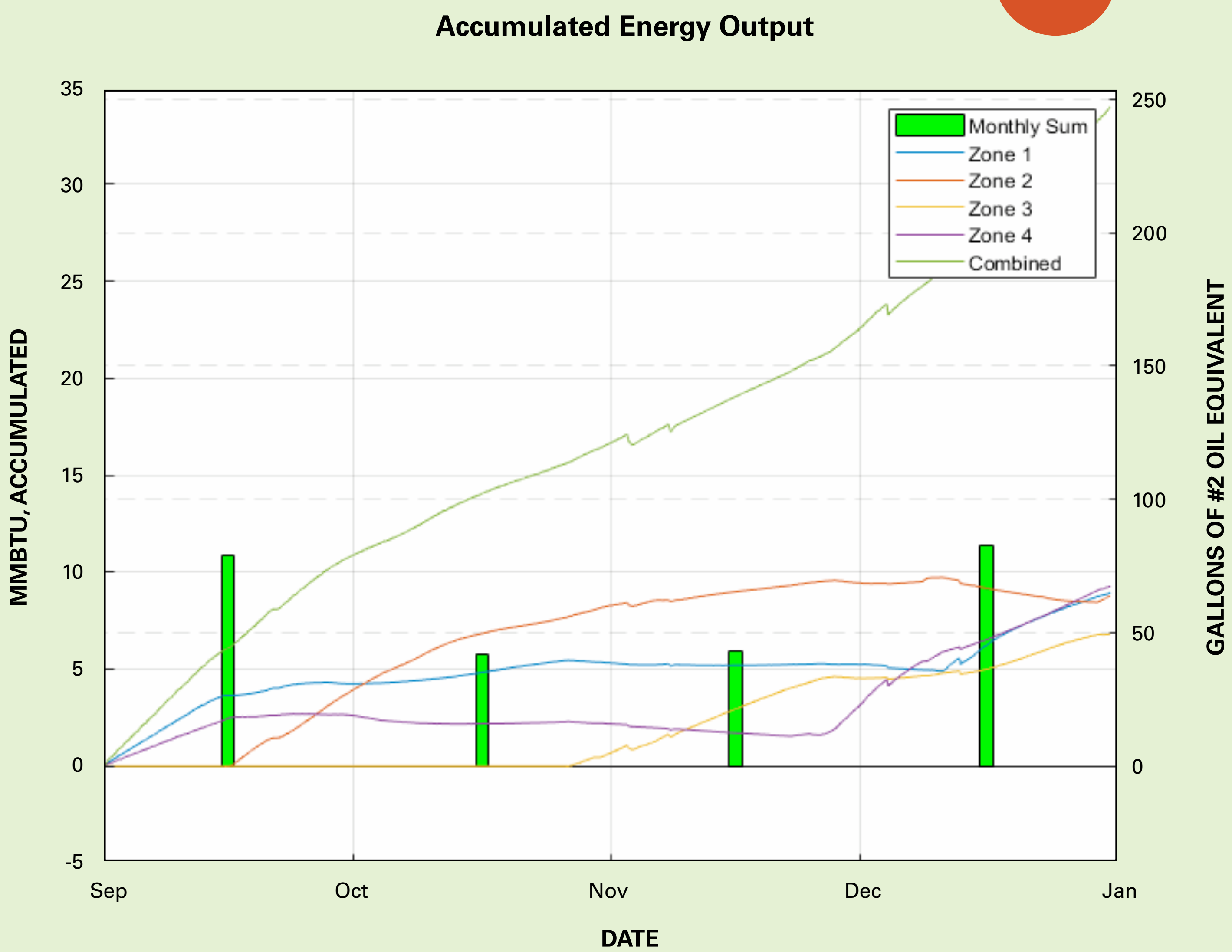
Figure 7

Average Heat Outputs by Zone
Moving mean of 24 hours



At left: the Agrilab Technologies Hot Skid 250-R consists of the mechanical aeration, heat recovery, plumbing, monitoring and control components.

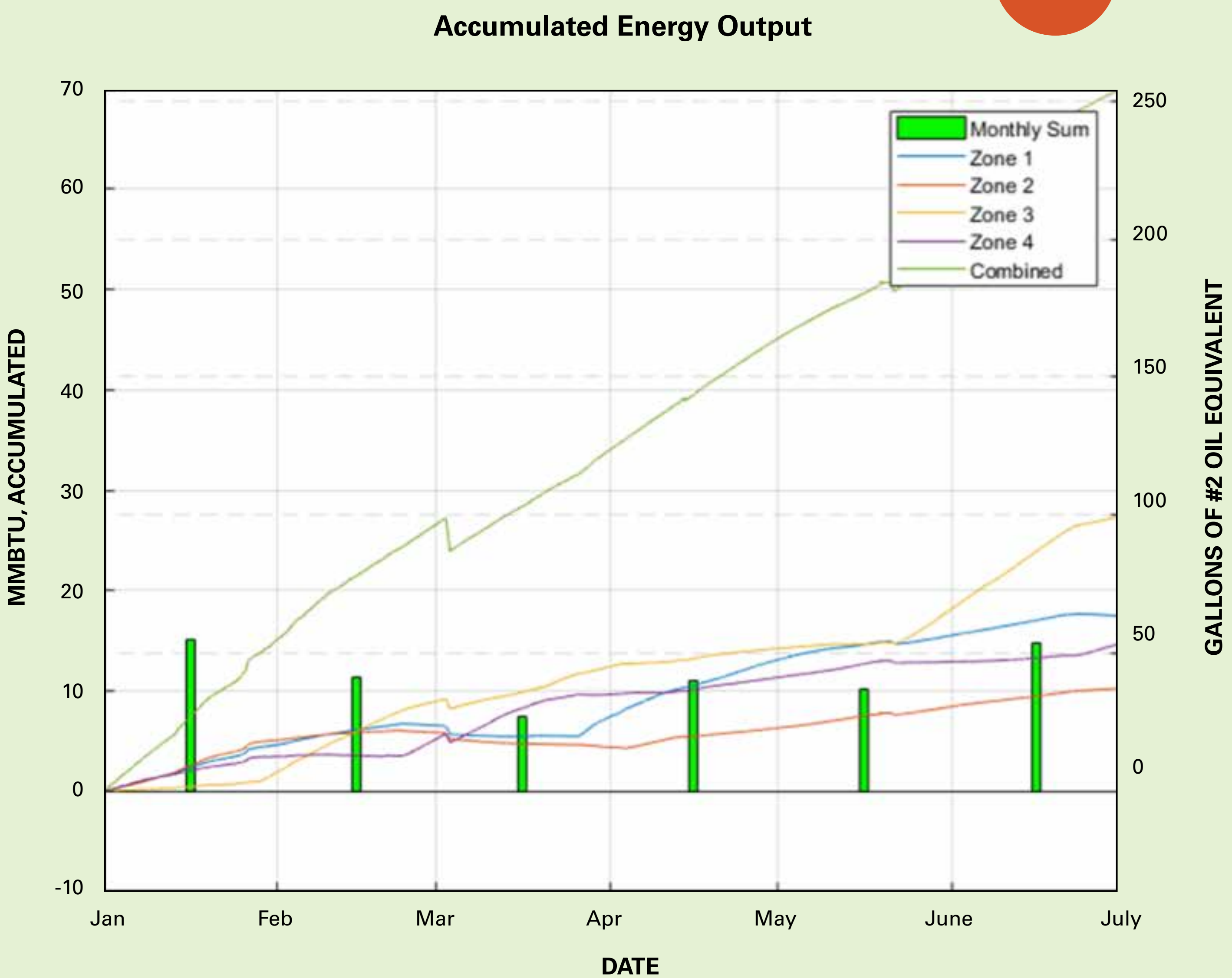
Figure 8



Figures 8 & 9

Figures 8 and 9 show the estimated total heat output of the system, discretized by zones and the combined output. This is calculated by integrating the instantaneous heat output (figure 3) by the time steps between measurements (15 seconds on average) to produce the total energy output shown in MMBTU (millions of BTU) and the equivalent gallons of #2 heating oil.

Figure 9



Note a savings of 760 gallons of heating oil is calculated by this approach. This is supported by the Collins reporting average daily consumption of heating oil for water heating dropping from a pre-project 3 gallons per day to 1.9 gallons per day. The additional energy consumption for wintertime space heating explains the additional gallons saved.

Table 1

Compost Batch Tracking

Batch	Zone	Date	lbs/ 5 gal	lbs minus bucket	lbs/ gal	gal/ cubic ft	cf/cy	gal/cy	lbs/cy	CY loaded	Tons loaded
1	3	7/18/17	47.2	45.2	9.04	0.1337	27	202.0	**1825.8**	110	100.42
2	4	7/29/17	35.6	33.6	6.72	0.1337	27	202.0	**1357.2**	105	71.26
3	1	8/22/17	37	35	7	0.1337	27	202.0	**1413.8**	105	74.22
4	2	9/15/17	35.2	33.2	6.64	0.1337	27	202.0	**1341.1**	110	73.76
5	3	10/25/17	34.4	32.4	6.48	0.1337	27	202.0	**1308.8**	110	71.98
6	4	11/22/17	27	25	5	0.1337	27	202.0	**1009.9**	110	55.54
7	1	12/8/17	24	22	4.4	0.1337	27	202.0	**888.7**	120	53.32
8	2	12/22/17	25	23	4.6	0.1337	27	202.0	**929.1**	120	55.74
9	3	1/25/18	27	25	5	0.1337	27	202.0	**1009.9**	120	60.59
10	4	2/20/18	25	23	4.6	0.1337	27	202.0	**929.1**	120	55.74
11	1	3/20/18	27	25	5	0.1337	27	202.0	**1009.9**	115	58.07
12	2	4/2/18	31	29	5.8	0.1337	27	202.0	**1171.4**	125	73.21
13	3	5/15/18	36	34	6.8	0.1337	27	202.0	**1373.4**	120	82.40
14	4	6/22/18	29.5	27.6	5.52	0.1337	27	202.0	**1114.9**	130	72.47
15	1	7/24/18	36	34	6.8	0.1337	27	202.0	**1373.4**	120	82.40
Total										**1740**	**1041.14**

A heavy use area southwest of the composting working pad gets lots of traffic between loading and unloading bays. Improving this driveway and stacking/mixing pad would make equipment operations more efficient, and ideally be placed under cover of an improved facility.

PHOTO CREDIT BRIAN JEROSE

Table 1 shows the date, volume, weight and bulk density of the compost batches loaded in to the Aerated Static Pile (ASP) composting system since installation and start-up. 1,740 cubic yards (cy) equaling 1,041 tons of manure, bedding and other mixed feedstocks have been loaded in the first year of operation.

As these batches become mature and are unloaded for sale or on-farm use, their volume is reduced in half to 870 cubic yards. The weight is calculated to be reduced to 653 tons of finished product. The reductions are attributed to both loss of moisture to evaporation and loss of mass due to respiration, primarily as carbon dioxide. The resulting finished bulk density is estimated at 1,500 lbs/cy. This is higher than typical finished compost weights that range from 750-1,250 lbs/cy, often dependent on how dry the material is and affected by if it is processed and/or stored under cover.

The Collins Powder Hill Farm compost has a higher bulk density and this is attributed to the inclusion of the fine bedding sand used in the dairy barn. It imparts a beneficial sandy texture to the finished compost but is a factor for both aeration during the active composting phase as well as the weight of the finished product.

A correlation of compost batch thermal energy generation performance to its mixed bulk density was made via general observations rather than using data analysis due to the variability of the compost during the decomposition process. What was observed was higher initial temperatures for batches with the lowest bulk density. Batch numbers 6 to 11 included a higher proportion of leaves brought in from fall collection and had a lower bulk density when loaded, and a more rapid rise in temperatures. Improved use of the vapor recirculation feature also helps boost the initial rise in temperatures. The batches with more leaves however did not sustain elevated temperatures as long as mixes with more shavings and sawdust, and were observed to shrink in height and volume more rapidly. It is likely the carbon in leaves is more available and degrades more rapidly than the lignin in wood shavings and sawdust, resulting in less structural support of the mix and more rapid shrinkage.

Other factors such as rain or snow during the loading can impact batch performance by increasing the material weight and bulk density, and making it more difficult to fully aerate the batch. This occurred during several loading events, including batches 12, 13 and 15.

Farm owners noted that an additional 560 cubic yards of product were ready for Spring sales than would have been available using the previous windrow method.

Discussion

Major energy impacts of the compost aeration and heat recovery (CAHR) system are the improved processing efficiency, and the generation of useful heat. Process efficiency is improved by reduced compost pile turning and reduced trucking of manure and biomass around the farm.

Decreased diesel fuel consumption was observed, with minor increase in electrical energy consumption due to the CAHR motors and controls. The actual increased electrical cost for operating the new equipment was calculated to be $300-$350 per year, or $500 per year if the fan was operated at maximum power. As compost batches could be overcooled if continuously operated at maximum fan speed, lower settings are typically used as oxygen demand diminishes during the decomposition cycle. The variable speed drive (VFD) on the blower fan is an efficiency component that aids in reducing power consumption.

The renewable thermal energy is recovered from the compost by a water/glycol heating loop. The heated vapor drawn from the actively composting batches is pulled through the specialized heat exchanger containing the heating loop. This loop preheats water used for washing and heating in the milk room and other areas in the dairy barn, reducing the consumption of heating oil.

Process Efficiency

The Collins estimated 160 fewer hours of loader operation for composting activities between mid-July and December 2017, compared to the previous year. An additional 240 hours of loader operation were tracked from January through July 2018, totaling 400 hours saved for the year. At an estimated 3.5 gallons/hour of fuel consumption for the payloader this totals 1,400 gallons of diesel fuel saved. Using $2.40/gallon for the 12-month average off-road diesel price, the cost savings total $3360.

Pre-project loader operation was tracked at 1,500 hours per year, including all aspects of material handling and windrow turning. Those 400 hours saved represent a 27% reduction in loader operating hours. Using a conservative loader operation cost of $50/hour (excludes $8.40/hour of diesel costs), the farm saved $20,000 in year one in this area. Combined the process efficiency savings total $23,360.

The saved labor hours do not include a value for the opportunity to work on other farm tasks. The Collins shared that due to being down one farm hand from December 2017 on, the increased availability of Jack Collins for other non-composting farm chores during winter and spring was particularly valuable the past few months. Spring composting operations require significantly more hours of pay loader use preparing and loading product for deliveries.

An October 2018 tour of the operation, with U.S. Rep. Joe Courtney (second from left), Jack Collins (center), and staff members from the U.S. Department of Energy and Connecticut Department of Energy and Environmental Protection.

Process efficiency also positively impacted the ability to increase spring 2018 compost sales revenues. The Collins described the breakdown of wood shavings in the compost as achieving in 3 to 6 months what has previously taken about 2 years. This could be further tested through product analyses prior, but customer feedback on product quality from spring sales was positive. This reduction in compost cycle length generally conforms with the expectation that increased aeration introduces more oxygen and speeds decomposition compared to traditional turned windrow composting practices.

Jack Collins tracked that an additional 560 cubic yards of product were ready for the spring sales season than would have been using the previous turned windrow method. Using the average price (a mix of bulk and blend prices), this yielded $21,600 in additional farm revenue. In the climate of low commodity milk prices, diversifying sources and amounts of revenue was very timely. These increased revenues should be viewed as largely a one-time event, as the acceleration of these sales can only be achieved once before it becomes the standard operating conditions. Some increases in total throughput and resulting sales are possible with more frequent compost batch loading, but are not assumed for economic reporting at this time. Instead using a five year timeframe (the warrantied period of the Hot Skid 250R unit), the value of the increased sales revenue is spread over five years, or $4,320/year. This is reflected in the simple payback table in the "Overall Performance" section below.

The Collins used a temporary propane heater in the milk room through the Dec 24-January 15 period due to extreme low temperatures. This added $180 to their heating costs and is a practice they have only used on rare occasions in recent years. On January 14, 2018, a new hydronic heating unit was installed in the milk room. This unit connects to the glycol loop from the Hot Skid 250-R unit and replaces the temporary propane heater. This applies another thermal load to the overall system and it increased the total avoided fossil fuel consumption on the farm. The data collection does not allow for a precise break-out of the cost-savings for space heating vs. wash water heating. However, the farm reports a drop of heating oil consumption for wash water from an average 3.1 gallons/day to 1.9 gallons per day. Using this average it can be projected that the value of wash water heating was equivalent to saving 438 gallons or 58%, and space heating savings 322 gallons or 42% of the heating savings. Together the 760 gallons saved total $3,360 of value at an average of $3/gallon heating oil cost.

It is recommended the farm add a similar heating unit to the equipment shop adjacent to the Hot Skid 250-R shed to further reduce fossil fuel consumption in heating. It will also improve the overall energy ROI for the system by adding to the thermal load and increasing energy consumption from the glycol loop. The Collins have deferred this installation due to challenging revenues from current depressed milk prices but are seeking to install this in the future.

The water/glycol loop heated by the compost energy via the Hot Skid 250-R unit is used in the dairy barn for hot water preheating and space heating.

PHOTOS BY JACK COLLINS

For aerated composting, the bulk density needs to be low enough to leave adequate pore space in the compost pile for air, water vapor, CO2 and other gasses to be moved through the pile through the fan on the Hot Skid 250-R pulling or pushing air through the piles.

Thermal Energy

The heat output (thermal power) from the CAHR system is calculated by multiplying the flow rate and temperature difference across the heat exchanger:

$$P_{th}\left(\frac{btu}{hr}\right) = 500*Q\left(\frac{gal}{min.}\right)*\Delta T\ (°F)$$

The above formula is based on water flow of 10 gallons per minute (average flow rate observed), with a slight correction applied to a water/glycol mixture. The temperate difference across the heat exchanger (ΔT) depends on the compost vapor temperatures and flow rate (CFM) and the temperature of the incoming water (GPM). The heat load as well as the compost system are major drivers of the energy output; this is discussed in more detail in the first report.

Figures 4 and 5 (on pages 8 and 9) show the temperatures of each zone smoothed by the same moving average. **Figures 6 and 7** (on pages 10 and 11) show the average (24-hour period) thermal power output of each zone in MBH, or thousands of BTU per hour. By comparing these figures, it is seen how each zone's temperature affects its heat output. The vapor flow rate (cfm) also affects heat output, with higher flow rates increasing heat output.

Composting and Compost Use Parameters

There are several factors in a compost feedstock mix that affect the rate of decomposition and temperatures achieved, and thus potential renewable energy available for capture and utilization. They include but are not limited to the carbon to nitrogen (C:N) ratio, moisture content, oxygen levels and bulk density. The factors need to be within acceptable ranges to achieve good composting conditions and can be simply confirmed through observing temperatures above 131F for a period of two or more weeks.

For aerated composting, the bulk density needs to be low enough to leave adequate pore space in the compost pile for air, water vapor, CO2 and other gasses to be moved through the pile through the fan (blower) on the Hot Skid 250-R pulling or pushing (primarily pulling through negative aeration) air through the piles. Higher bulk densities will make it more difficult for vapor to move through the entire mass of compost.

The first five batches loaded consisted of scraped dairy manure (bedded with sand) and wood shavings bedded manure from the Big E exposition barns in nearby W. Springfield, MA. Note the higher bulk densities on initial batches that were reduced as the proportions were modified each time. The sixth and seventh batches consisted of the same scraped dairy manure but then mixed with leaves delivered from local landscapers. The resulting bulk densities measured were significantly lower, thus improving aeration and oxygenation of feedstocks.

Only Batch 1 proved to be too dense (bulk density too high) to effectively move air and vapor through the compost, only partial composting was achieved. All other batches achieved good composting temperatures and vapor flow rates. The leaf and manure compost mixtures had the lowest bulk densities and were observed to have the highest initial vapor flow rates (as indicated by cfm) and rapidly came up to thermophilic (131F+) temperatures. The highest vapor temperature observed was 165F and highest water/glycol mix

Aeration pipes that feed hot air from the compost windrows to the Hotskid.

temperature observed was 160F.

The farm uses 80+ cubic yards of sand for bedding in the dairy barn each month. The fine local sand has been valuable for maintaining sanitary conditions for many years on the farm, as evidenced by Collins Powder Hill Farm achieving a Top 25 milk quality award among the 1,400 member AgriMark Cooperative. Changing to a new bedding source would present some risk to herd health to the farm. A bedded pack facility for lactating cows and young stock has been considered but is not in immediate plans.

The impact of the sand is that scraped manure from the barn is relatively dense and needs not only carbon-rich materials to balance its nitrogen and moisture content, but also materials with some structure to impart more porosity in the compost pile, and reduce the mixture's bulk density. Observations include that the show sawdust and wood shavings bedding from Big E blended with manure had higher bulk densities initially, but tended to collapse less and maintain porous conditions suitable for aeration longer than the leaf based mixtures and matured faster as well.

Fifteen batches have been loaded in the first year of operating the CAHR system. As shown in Table 1, 1740 cubic yards (cy) equaling 1041 tons have gone into the four aerated composting bays. Typical shrinkage was 50% by the time the compost was removed.

Finished compost was used for both on-farm application to cropland, hay fields and for sale to customers. Compared to the previous practices of exclusively field-based windrow turning, the compost from the CAHR system was more homogeneous and spread more evenly. Further, some batches were pulled directly from aerated bays into sales bunks. This meant more compost was available for retail and sale with less hours into field turning.

The farm applied approximately 1,700 cy of compost to 70 acres of corn fields and another 150 cy to hay fields over the last year. The compost was from both the existing field site of turned windrows as well as the CAHR system. The majority of compost land applied was from existing stockpiles from the field windrows. Only two aerated batches, or approximately 120 cy, (19%) were applied on-farm. 540 cy or 81% of the finished aerated compost was sold. As noted in the "Process Efficiency" section above, this facilitated an increase of $21,600 in compost sales revenues beyond what would have been possible with the previous turned windrow composting practices.

The quality of finished compost also varied based on its source feedstocks, whether it was managed in the field windrow or the CAHR system, and how rapidly it was cycled through the CAHR system. Generally the bedded manure with sawdust and shavings composted most readily, had the most consistent texture and the least weed seeds. Bedded manure with straw was largely segregated and composted in the field windrows. Mixtures with leaves tended to have the most weed growth, likely due to containing higher levels of weed seeds, and then the static process did not destroy weed seeds on the outer layer. This was most evident during summer months and was not a factor during winter months, and more rapid cycling of batches.

Identifying multiple source of carbon-rich feedstocks is important to be capable of handling scraped dairy barn manure as a solid on a year-round basis. Leaves are delivered seasonally with peaks in the fall and some additional volumes received during spring clean-up. The bedding from animal shows is received seasonally but has occasional interruptions if there are infection outbreaks.

Overall Performance

While the energy savings in heating oil and diesel consumption are noteworthy and beneficial, the process efficiency value in terms of labor savings and increased compost sales revenue is the largest component for the calculated 4.1 year simple payback.

The Collins have demonstrated their ability to make suitable mixtures of their own dairy manure, leaves and bedded manure from the expo shows. Agrilab Technologies has recommended operators of aerated composting systems to load batches with bulk densities of 1,000 lbs/cubic yard (cy) or less. The Collins have been able to achieve effective composting with batch bulk densities up to 1,400 lbs/cy but observed higher vapor flow rates and rapid increase in temperatures with batches mixed to lower bulk densities (889 to 1,340 lbs/cy).

Total energy potential and yield as shown in other figures is influenced by multiple variables beyond the compost batch mixture recipe and bulk density. These include the ambient temperature and weather conditions, insulation of the ductwork (completed partially in September then completely in early December 2017), the load/demand for hot water and specific operation of the aeration and recirculating vapor cycles.

Installation of the system in late Spring 2017

Generally performance has improved with experience in mixing and loading batches, as well as timing of aeration and recirculation intervals. Continued tracking of the performance should yield additional insights with subsequent batch loading, winter weather conditions and when additional loads such as a hydronic heating loop to the adjacent equipment shed are installed.

Economic performance has been calculated in a simple payback table to project a return on investment (ROI) without cost of financing. While the energy savings in heating oil and diesel consumption are noteworthy and beneficial, the process efficiency value in terms of labor savings and increased compost sales revenue is the largest component for the calculated 4.1 year simple payback. As noted elsewhere in the report, adding additional thermal loads as well as loading the compost zones more frequently would further improve the energy value and economic return. See details in **Table 2: Simple Payback Analysis**.

Jack Collins shared in observations that $50,000 may need to be budgeted for additional site improvements in Phase 2 including an improved mixing pad area and a cover for the working pad. While interest rates have increased over the past year, the bigger factor is still the limited free working capital due to depressed milk prices. If financing can be obtained for the facility for longer terms, 7, 10 or even 20 year periods, there should be ample cash flow to net savings on an annual basis after servicing debt.

Table 2

Simple Payback Analysis

Capital Cost Item	Budget Cost
AGT Hot Skid 250R	$55,000
Aeration Ductwork	$7,000
Insulation	$600
Aeration Pad Gravel	$2,000
Water Line - Insulated Loop	$2,550
Plumbing - Tank and Fittings	$2,500
Fusion Welder Rental	$900
Collins site work - estimate	$18,000
Plumbing Labor	$1,500
Electric	$1,300
Subcontractor Labor (Design, Installation, Start-up)	$17,700
Data and Internet Service	$1,050
Total	**$110,100**

Projected Annual Savings and Revenues	
Heating Oil	$2,280
Diesel	$3,360
Operating Labor Savings	$20,000
Increased Compost Sales Revenue	$4,360
New Operating and Maintenance Labor	($3,000)
New Electrical Cost	($300)
Total	**$26,700**

Simple Payback - total cost (years)	**4.1**
Collins Payback - with cost sharing (years)	**1.7**

NOTES:

- Increased compost sales revenue is $21,600 divided over 5 years.
- Savings and revenues assume same frequency of batch loading as Year One.
- Increased savings and revenues are possible with greater loading frequency.

Cost Sharing Via CT Farm Energy Program

Equipment Cost Value **$55,000**

Technical Services **$10,000**

Net Collins Cost **$45,100**

Spring Open House

CT RC&D/CT Farm Energy Program hosted an open house at the Collins Powder Hill Farm in conjunction with the Collins Family, Agrilab Technologies Inc., and other project stakeholders on March 29, 2018.

Roughly 60 attendees came to the event including farmers, local, state and federal officials and staff, community members and technical contractors. Remarks from the CT Resource Conservation and Development President, CT Farm Energy Program staff, the CT Department of Energy and Environment Protection Commissioner, CT Department of Agriculture Commissioner, the farm owners Jack and John Collins, Brian Jerose from Agrilab Technologies, and partner agency USDA Natural Resource Conservation Service staff, were followed by tours of the composting facility and dairy barn. An informational handout from the open house, attached as an educational resource, has been updated and is found at the end of this report.

Lessons Learned and Recommendations

The construction stage was led by the Collins Powder Hill Farm owners and employees with equipment installation and technical support from Agrilab Technologies Inc. and other local plumbing and carpentry contractors. John Collins reflection was that while total cash outlays were reduced by their work on site preparation, pad and wall construction, vapor pipe assembly and other details, it was a significant time commitment that had to be conducted around other farm tasks. The farm also had greater insight into the system operation and maintenance, being intimately involved in construction and assembly.

The Collins wished to share their insights for other potential farm installations. While it is possible to have the host farm act as the general contractor and lead many construction tasks in order to reduce total expenditures, there can be an impact on availability of farm staff for other farm tasks. If the farm does have the financial capacity, hiring more elements of the site work and installation would put less time stress on the farm and permit more focus on herd management and field work.

Location and Siting

The physical layout and selected location for the new aerated composting pad was economical and functional for successful accelerated composting. Part of the improved efficiency was locating the composting pad closer to the farm to reduce material transfer times and to facilitate the transfer of hot water to nearby loads (barn and shop). The farm identified that this efficiency is partial to this point as the total volume of compost feedstocks is more than can be stored, mixed and processed by composting at the new site. The old feed bunk pad was a good hard surface for mixing but still involved some transfer time. It is recommended that a receiving and mixing area be also installed in closer proximity to the aeration pad. The reduced labor and diesel consumption benefits would

John and Jack Collins work with Ryan Koloski during construction and installation.
PHOTO CREDIT BRIAN JEROSE

Amanda Fargo-Johnson of CT Farm Energy Program and Jack Collins of Collins Powder Hill Farm speak at the March 2018 Open House.

improve further beyond what has been observed from this initial phase.

The new aerated composting pad also has the effect of freeing up field space in the existing field composting area. Presently eight acres are used for compost feedstock storage, compost windrows and screening operations. Some field composting area will still be needed to handle seasonal surges of leaves, wood chips and other feedstocks. Jack Collins believes this field composting area can be reduced to two acres and therefore return six acres of land to active crop production. An economic value has not been assigned to this benefit.

Four bays of loaded compost at Collins Powder Hill Farm – note fresh batch with darker color on left and shed with AGT Hot Skid 250R behind compost bays (March 2018)

PHOTO CREDIT BRIAN JEROSE

Next Steps

As a result of this project, the Collins are currently engaged with the USDA Natural Resources Conservation Service (NRCS) and working on a comprehensive nutrient management plan (CNMP).

Working through this process, the Collins should become eligible for cost-sharing funds for various improvements around the farmstead. Relevant to this project, a covered composting facility may be designed and funded to provide better process control as well as conserve nutrients lost to leaching.

Precipitation not only affects the density of the compost batches and ability to effectively aerate the material, but can transport nitrogen and phosphorus via leaching and runoff.

The site used at the Collins is fortunate to have ample vegetated area downslope from the composting pad, over 1,000 feet from any mapped surface waters. Other sites may need to install a covered facility if they do not have sufficient vegetated filtration area downslope from the working pad or have inadequate separation from surface waters.

Jack Collins loading compost zone 2 on April 3, 2018. Snow or rain during mixing and loading can increase the batch density and limit proper aeration and heat recovery potential, as well as lose nutrients to leaching. Another motivation to acquire a cover for the working pad.

PHOTO CREDIT JACK COLLINS

From July 2017 to July 2018, the farm realized a savings of 400 hours of labor and loader hours compared to previous years. This represents a 27% reduction in operating hours for compost production.

The Compost Heat Recovery Report was created in partnership by: Brian Jerose and Jason McCune-Sanders, Agrilab Technologies Inc. Amanda Fargo-Johnson, CT RC&D/CT Farm Energy Program and Jack and John Collins, Collins Powder Hill Farm. September 30, 2018.

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