ANALYSIS OF ORGANICS DIVERSION ALTERNATIVES

REPORT TO THE DELAWARE SOLID WASTE AUTHORITY

PREPARED BY

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I. INTRODUCTION

The 2015 Delaware Senate concurrent resolution number 35 recognized that a significant amount of waste going to Delaware landfills is organic, and that closure of the Wilmington Organics facility eliminated the primary method for diverting food waste (the largest component of organic waste). Therefore, the Senate, with the concurrence of the House of Representatives created a task force to "*evaluate the best possible way to recycle organic waste in the State of Delaware in an odor free manner."*

The Delaware Solid Waste Authority (DSWA), as the co-chair of the Task Force contracted with DSM Environmental Services, Inc. (DSM) to prepare a holistic analysis of food waste generation, reduction and recycling to serve as a guide for moving forward with diverting organic waste from landfilling, over and above the ban on yard waste disposal already in place.

Recognizing that three competent private companies had constructed, operated, and closed food waste composting facilities over the past several years, the goal of DSM's research and analysis was to first look up-stream toward strategies to reduce food waste generation and disposal, and then downstream at methods to recover the energy value of the remaining food waste before it reached the landfill.

This report begins by reviewing national literature on food waste generation and diversion, and then proceeds to a review of food waste generation in Delaware, followed by measures that could be taken in Delaware (but not necessarily by DSWA) to reduce generation and increase diversion. Finally, it posits ways that DSWA could intervene to manage the food waste destined for its landfills.

II. OVERVIEW OF FOOD WASTE GENERATION

INTRODUCTION

Food waste has become an important topic throughout the United States based on recent reports presenting estimates of quantities of food loss and waste[1], and its economic value, including potential greenhouse gas (GHG) emissions savings from reducing food waste. For example, a recent USDA report estimated 30 to 40 percent of food produced in the United States is lost during harvesting and transport, and wasted during retailing and consumption.

It is important to first place United States and global estimates of food loss and waste in context, comparing these estimates with recent data on food waste disposal in Delaware, so that decision makers can direct efforts to reduce and recycle food waste with the greatest benefit to Delaware.

Annual generation of food "waste" in the United States and world-wide has been estimated by several entities including:

- The *Food and Agriculture Organization of the United Nations (FOA*), which estimates food waste at 105 kilograms (47.7 pounds) per capita, and food loss at 290 kilograms (131.8 pounds) per capita[2]-for a total of 179.5 pounds per capita, world-wide[3];

- The *USDA Economic Research Service,* which estimates food waste at 133 billion pounds (or 66.5 million tons in 2010) in the United States – or about 431 pounds per capita; and,

- The *US EPA* that last estimated that 38.4 million tons of food waste was generated and 36.5 million tons disposed in 2014 – or 229 pounds per capita, disposed.

Because measurement is at different points in the cycle of food use – at the retail/consumer level, during food manufacturing, or a byproduct of crop production - losses or "wastage" figures can be quite different. They can also vary significantly between developing countries and developed countries, with

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[1] https://www.usda.gov/oce/foodwaste/faqs.htm
[2] FAO. 2011. Global food losses and food waste – Extent, causes and prevention. Rome.
[3] Food *loss* refers to the food lost during production and harvesting, and postharvest and processing stages in the food supply chain, while food *waste* refers to the end of the food chain, at the retail and final consumption stages.

significant losses in developing countries occurring during food production and transport, and significant losses occurring in developed countries during the retail stage and consumption.

Table 1 places these estimates in context comparing per capita data from each of the above sources. As illustrated by Table 1, the US EPA data look at food waste destined for disposal, while the USDA and the FAO look at total food losses, which include food plowed back into the ground after harvesting, and by-products of food production that are typically utilized as animal feed or fertilizer, as opposed to being disposed in a landfill (e.g., poultry production in Delaware, with by-products utilized for fertilizer and feed).

It is interesting to note that the US EPA and FAO data presented in Table 1 for per capita food waste, or disposal are quite similar, with the primary discrepancies in terms of estimates of food loss.

TABLE 1 – Per Capita Food Waste Estimates for the United States

Source	Tons	Population	Lbs/Cap	Year
USDA	66,500,000	308,700,000	431	2010
US EPA	38,400,000	318,857,000	241	2014
Disposed	36,460,000	318,857,000	229	2014
FAO				
Losses			638	2011
Waste			231	2011

In 2015, in alignment with UN Sustainable Development Goals, the USDA and EPA announced the first ever goal to cut food waste in half by the year 2030. Called the 2030 Food Loss and Waste Reduction goal (2030 FLW reduction goal), two separate measurements will be used as the baselines against which food waste and loss reduction will be measured.

- To measure *food waste* EPA's "*Advancing Sustainable Materials Management: Facts and Figures*" would be used, focusing on food disposed from the residential, commercial and institutional sectors but excluding pre-consumer food waste generated during manufacturing and packaging. A 2010 baseline of 218.9 pounds per capita was used to set a goal of reducing disposal to 109.4 pounds per person by 2030.

- USDA's Economic Research Service estimated total food loss, and then calculated that the uneaten portion of the US food supply at the retail and consumer levels was 31 percent of supply, or 66.5 million tons of food *wasted*, and set a goal to cut losses (at the retail and consumer level) by approximately 33 million tons.

Some of the differences between USDA and EPA food waste estimates are that food fed to animals, liquids going down the drain, and fats, oils and grease are not included in EPA's figures – which measures food waste at the final point of disposal – but are included in the USDA estimates.

To further complicate the data, the recent ReFED report analyzed available data and estimated that 52.4 million tons of food waste is generated per year in the U.S., with an additional 10.1 million tons lost on farms. ReFED's non-residential food waste estimates were developed by applying population and employment data to food waste generation coefficients from the literature. For residential food waste, a study from the United Kingdom's WRAP program was referenced to be 238 lbs. per capita with 30% of food wastes disposed down the drain.[4] Table 2 illustrates ReFED's per capita estimates based on their data.

TABLE 2 – ReFED's Estimated Tons and Per Capita Food Waste Generation in the US

Sector	Tons	Population	Lbs/Cap	Year
Residential (1)	26,560,793	321,400,000	165	2015
ICI (2)	24,817,855	321,400,000	154	2015
Industrial / Manufacturing	1,065,000	321,400,000	7	2015
Total:	52,443,648	321,400,000	326	2015

(1) The residential ReFED estimate, is based on the 2012 WRAP study findings that generation fell to 260 kg's of food waste per household (or 238 lbs. per capita), but says that 30% was disposed via the drain with the balance (an estimated 165 lbs. per capita) left to manage. WRAP estimates roughly 20% was disposed down the drain, with additional material fed to pets and composted on-site. [5]
(2) ICI includes the following sectors: Restaurants (22% of total), Supermarket, Distribution and Grocery Stores (15%), Institutional (9%) and Government (1%). In total, 47% of food waste is estimated to be ICI.

Finally, Table 3 compares food waste disposal in Delaware (based on the FY 2016 Statewide waste characterization study) with recent waste

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[4] ReFED. *A Roadmap to Reduce US Food Waste by 20%.* Technical Appendix, March 2016.

[5] WRAP. Household Food and Drink Waste in the United Kingdom 2012. Project code: CFP102 ISBN: 978-1-84405-458-9. November 2013. WRAP. The Food We Waste. Project code: RBC405-0010 ISBN: 1-84405-383-0 (version 2).
April 2008 (revised July 2008).

characterization studies for Connecticut, Vermont and Rhode Island, all of which were measured at the point of disposal. Comparing these four waste characterization studies, which were all managed by DSM and therefore followed similar sampling methodology, show estimated per capita disposed food waste was roughly equivalent in Connecticut and Delaware at 290 and 279 pounds, respectively.

Of the total, Connecticut's residential per capita disposal was 152 pounds and Delaware's 137 pounds. Vermont and Rhode Island were lower at under 200 lbs. per capita in total, and 132 and 115 lbs. respectively of residential waste. New York City, which conducted a major residential waste characterization study in 2013 is also shown in Table 3 and found residential food waste was roughly 134 pounds per capita. All of these are lower than the ReFED estimates for residential and ICI food waste, but all show Delaware per capita food waste disposal to be in the same range as other northeastern states.

TABLE 3 – Municipal Solid Waste Characterization Results – Food Waste Disposal Per Capita

States	Tons	Population	Lbs./Cap	Year
Delaware (Total)	131,998	945,934	*279*	2016
Residential	64,912	945,934	*137*	2016
Connecticut (Total)	519,832	3,591,000	*290*	2015
Residential	272,655	3,591,000	*152*	2015
Vermont (Total)	60,078	626,687	*192*	2011
Residential	41,486	626,687	*132*	2011
Rhode Island	100,009	1,056,423	*189*	2015
Residential	60,577	1,056,423	*115*	2015
New York City				
Residential			*134*	2013

In general, results from State waste characterizations studies indicate that residential food waste is roughly half of the total food waste disposed.

These results are compared against national estimates, as shown on the next page in Table 4.

TABLE 4 – Comparison of Per Capita Food Waste Generation and Disposal Estimates

Source/State	Total *(Lbs/Cap)*	Total Disposed *(Lbs/Cap)*	Residential Disposed *(Lbs/Cap)*
FAO (USA)	638	231	
USDA (USA)	431		
US EPA (USA)	241	229	
ReFED (USA)		326	165
Connecticut		290	152
Delaware		279	137
Vermont		192	132
Rhode Island		189	115
New York City			115

(1) Note that ReFED includes 7 pounds/capita of Industrial/Manufacturing food waste typically excluded from MSW, but does exclude any food waste disposed down the drain.
(2) EPA does not separately estimate residential waste.

IMPACTS FROM FOOD LOSSES AND WASTE

There have been numerous studies documenting the benefits of reducing food loss and waste. Reducing food loss reduces the amount of cropland, water, and fertilizer required which has significant environmental benefits. Reducing food loss and waste also reduces food insecurity, given that one in eight U.S. households (15.7 million) reportedly experienced food insecurity in 2016.[6]

Another benefit of reducing food loss and waste is a reduction in greenhouse gas (GHG) emissions. Energy consumed in food production results in GHG emissions created during three stages - agricultural production and processing, post-harvest handling and storage, and distribution and consumption – and are responsible for an estimated eight percent of global GHG emissions (Food and Agriculture Organization, 2015). While the FAO estimates that agricultural production creates the highest percentage of food loss, distribution and consumption create the largest impact to GHG emissions because of the increased energy used during distribution and retailing.

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[6] Hunger in America: 2016 United States Hunger and Poverty Facts. http://www.worldhunger.org/hunger-in-america-2016-united-states-hunger-poverty-facts/

According to the US EPA Warm Model, reducing the *generation* of 1,000 tons of food waste reduces the equivalent of 1,085 metric tons of carbon emissions. This compares against diverting food waste generated from landfill disposal to composting or AD facilities, which would reduce carbon emissions the equivalent of 136 and 103 metric tons respectively for each 1,000 tons of mixed food waste. More information on how this is calculated is found in Section 4 of this report.

The economic benefits of reducing food loss are also huge. Agriculture encompasses 37.5% of earth's land surface and 44.6% of the United States land. Reducing, or maintaining this percent (of land use) as the population grows makes economic, as well as environmental, sense.

In addition, reducing food waste at the commercial or consumer level saves money. Strategies to reduce food waste result in immediate monetary savings. The USDA estimates Americans spend 6.4 percent of our budgets on food. This can be compared to Germans, and French at 10.3 and 13.2 percent, respectively, and up at 14.1 percent in China.[7] Citizens in the poorest countries of the world spend around half of their budgets on food: 41.9 percent in the Philippines; 43 percent in Kazakhstan and 56.4 percent in Nigeria.

The USDA estimates that the average American loses $371 a year to wasted food. Although, because Americans spend such a small percent of their total budget on food; according to a recent Johns Hopkins study, $371 is not enough to motivate most people to reduce waste and "might not be sufficient to motivate even most non-low-income consumers." This is clearly one of the issues confronting efforts in the U.S., and in Delaware to reduce food waste.

HIERARCHY OF MANAGEMENT APPROACHES

Similar to the hierarchy for solid waste management, which ranks management strategies from most to least environmentally preferred, EPA's food recovery hierarchy emphases reducing and reusing food waste before composting as key to sustainable materials management.

Figure 1 below illustrates EPA's hierarchy for food waste management and shows source reduction at the top followed by donation/redistribution of food to feed people and then to feed animals. This is followed by use of foods for

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[7] Calculations based on Euromonitor International data from August 2016.

rendering, fuel conversion or digestion and finally management through composting before landfilling.

FIGURE 1 – EPA's Food Recovery Hierarchy

The USDA and EPA launched the U.S. Food Waste Challenge in 2013 to begin to assess and disseminate information about the best practices to reduce, recover, and recycle food loss and waste. Some of the techniques emphasized include:

- Just in time ordering, inventory control;
- Adjusting menus to reduce frequently uneaten or wasted items;
- Clearer label information on food expiration date, including differentiation in best by and use by labeling; and,
- Avoiding spoilage by making changes to packaging, storage and transportation, and supply chain management.

A discussion of how some of these techniques might apply to Delaware is included in Section 4.

III. DELAWARE ORGANIC WASTE GENERATION AND DISPOSAL

As illustrated in Table 3, above, Delaware has recent data on the quantity of food waste disposal by the residential and the ICI sectors. These data are the result of the most recent waste characterization study carried out at DSWA facilities in 2015 and 2016 (FY 2016).

Table 5, below presents the overall results of the *Delaware Solid Waste Authority Statewide Waste Characterization Study, FY 2016 (Table 7)*, which include data on food and yard waste disposed.

The green highlighted rows in Table 5 represent total food and yard waste disposed at DSWA facilities in FY 2016. Total food and yard waste equals 159,569 tons of the total of 626,914 tons disposed, or 25 percent of mixed solid waste (exclusive of Construction and Demolition waste)[8]; while food waste equals 132,000 tons, or 21 percent of mixed solid waste. Of this food waste, roughly 40 percent was contaminated with packaging when disposed.

While there are other sources of food loss and waste in Delaware, Table 5 illustrates the total amount of food and yard waste managed by DSWA. As discussed in Section 4, significant quantities of food loss/waste are generated by food processing facilities in Delaware, but the vast majority of it is already beneficially reused, and is therefore beyond the scope of this analysis.

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[8] *Construction and Demolition waste accounted for in the waste characterization results are residential and ICI loads delivered to landfills and transfer stations that are mixed waste that include some C&D wastes. Separate C&D loads are not included in these totals.*

TABLE 5 - State-wide Waste Characterization, Delaware, FY 2016

Material	Est. Tons	Mean	+/-	Stnd. Dev.	Material	Est. Tons	Mean	+/-	Stnd. Dev.
Paper	**148,030**	**23.6%**			***Metal***	**19,557**	**3.1%**		
Newspaper and Inserts	10,317	1.6%	0.4%	0.3%	Tin/Steel Containers	5,333	0.9%	0.1%	0.1%
Corrugated Cardboard/Kraft Paper	36,907	5.9%	1.2%	0.7%	Other Ferrous	6,829	1.1%	0.4%	0.2%
High Grade Office Paper	5,809	0.9%	0.3%	0.2%	Aluminum Beverage & Cat Food Containers	2,720	0.4%	0.1%	0.0%
Mixed Recyclable Paper	22,731	3.6%	0.7%	0.4%	Other Aluminum	1,757	0.3%	0.1%	0.0%
Compostable Paper	62,258	9.9%	1.6%	1.0%	Other Non-Ferrous	2,919	0.5%	0.3%	0.2%
Aseptic Boxes and Gable Top Cartons	1,441	0.2%	0.1%	0.1%					
Remainder/Composite Paper	8,567	1.4%	0.4%	0.2%	***Glass***	**16,612**	**2.6%**		
					Glass Bottles and Jars	13,437	2.1%	0.4%	0.2%
Plastic	**93,369**	**14.9%**			Remainder/Composite Glass	3,176	0.5%	0.3%	0.2%
PET #1 Bottles, Jars, or Containers	10,993	1.8%	0.3%	0.2%					
HDPE #2 Natural and Colored Bottles	5,352	0.9%	0.1%	0.1%	***C&D***	**66,131**	**10.5%**		
Rigid HDPE #2 Containers	510	0.1%	0.0%	0.0%	Pallets/Crates	2,161	0.3%	0.2%	0.1%
#3 to #7 Bottles or Jars	523	0.1%	0.0%	0.0%	Clean Lumber	9,554	1.5%	0.5%	0.3%
Injection Molded Tubs #2, #4, #5, #6, & #7	1,728	0.3%	0.1%	0.0%	Painted and Stained Wood	2,428	0.4%	0.2%	0.1%
All Other Rigid Plastic Packaging	668	0.1%	0.1%	0.0%	Other Engineered Wood	10,679	1.7%	0.8%	0.5%
White Expanded Polystyrene (Styrofoam)	4,346	0.7%	0.2%	0.1%	Wood Furniture	11,515	1.8%	1.0%	0.6%
Recoverable Film	5,196	0.8%	0.2%	0.1%	Other Wood	5,233	0.8%	0.4%	0.2%
All Other Film	35,565	5.7%	0.6%	0.4%	Asphalt Roofing	780	0.1%	0.1%	0.1%
Agricultural Film & Marine Shrink Wrap	508	0.1%	0.1%	0.1%	Asphalt, Brick, Concrete, and Rocks	11,667	1.9%	2.7%	1.7%
Large Plastic Items	3,134	0.5%	0.3%	0.2%	Drywall/Gypsum Board	3,046	0.5%	0.5%	0.3%
Remainder/Composite Plastic	24,848	4.0%	0.7%	0.4%	Remainder/Composite C&D	9,069	1.4%	0.9%	0.6%
Organic	**252,039**	**40.2%**			***Other***	**31,175**	**5.0%**		
Vegetative Food Waste, Unpackaged	57,704	9.2%	1.9%	1.2%	Tires	2,132	0.3%	0.5%	0.3%
Protein Food Waste, Unpackaged	21,125	3.4%	0.8%	0.5%	Small Appliances	474	0.1%	0.1%	0.0%
Food Waste in Plastic Packaging	43,749	7.0%	1.0%	0.6%	Large Electronics	6,154	1.0%	0.6%	0.4%
Food Waste in Other Packaging	9,421	1.5%	0.6%	0.4%	Other Small Consumer Electronics	1,566	0.2%	0.2%	0.1%
Leaves, Grass, and Brush	25,690	4.1%	1.4%	0.9%	Items with CRTs	1,857	0.3%	0.4%	0.2%
Branches and Stumps	1,881	0.3%	0.2%	0.1%	Other Larger Electronics	14	0.0%	0.0%	0.0%
Textiles	32,323	5.2%	2.1%	1.2%	Other Haz. or Household Haz. Waste (HHW)	3,168	0.5%	0.3%	0.2%
Rubber/Leather	3,842	0.6%	0.2%	0.1%	All Other Wastes	15,809	2.5%	0.6%	0.4%
Diapers and Sanitary Products	18,705	3.0%	0.5%	0.3%					
Carpet and Carpet Padding	20,072	3.2%	2.2%	1.3%	***Hauler Collected MSW Tons***	**601,326**			
Remainder/Composite Organic	17,526	2.8%	0.6%	0.4%	***Tons of Non C&D Materials from Self-haul Customers***	**25,588**			
					Totals	**626,914**	**100%**		
					Sample Count		**152**		

Confidence intervals calculated at a 90% confidence level.

Table 6 provides more detail on where food waste is disposed, and by which type of generator. State-wide data from Table 5 are divided into residential and Industrial/Commercial/Institutional (ICI) categories, and reported geographically by county. Table 6 is useful in deciding where to target food waste reduction and recycling opportunities, and where any centralized food waste processing facility might be located.

TABLE 6 - Delaware Food Waste Disposal by Generator Category and Site of Disposal

Facility/County	Res *(tons/year)*	ICI *(tons/year)*	Total *(tons/year)*
New Castle County			
Food Waste	39,406	44,357	83,763
Tons/Day (312 days/year)	*126*	*142*	*268*
Yard Waste	6,943	10,166	17,108
Subtotal, Food and Yard Waste:	46,475	54,664	101,139
Kent County, Including Pine Tree			
Food Waste	17,660	18,315	35,975
Tons/Day (312 days/year)	*57*	*59*	*115*
Yard Waste	7,610	1,356	8,966
Subtotal, Food and Yard Waste:	25,327	19,729	45,056
Kent County Without Pine Tree			
Food Waste	11,756	11,759	23,515
Tons/Day (312 days/year)	*38*	*38*	*75*
Yard Waste	3,752	1,043	4,795
Subtotal, Food and Yard Waste:	15,546	12,840	28,385
Sussex County			
Food Waste	13,750	10,970	24,720
Tons/Day (312 days/year)	*44*	*35*	*79*
Yard Waste	5,070	598	5,668
Subtotal, Food and Yard Waste:	18,864	11,603	30,467
Total, Statewide			
Food Waste	64,912	67,086	131,998
Tons/Day (312 days/year)	*208*	*215*	*423*
Yard Waste	15,765	11,807	27,571
Total, Food and Yard Waste:	**80,677**	**78,892**	**159,569**

As illustrated by Table 6, 63 percent of food and yard waste disposed at DSWA facilities is generated in New Castle County and disposed at either Cherry Island or Pine Tree. However, because Pine Tree waste is transferred to Sandtown for disposal, Table 6 has allocated food and yard waste disposal to Kent County with and without waste from the Pine Tree transfer station to allow for review of different management options.

Food and yard waste collected and disposed in Kent County and Sussex County represents 18 and 19 percent respectively, of total food and yard waste disposed state-wide at DSWA facilities.

ORGANIC WASTES GENERATED IN DELAWARE BUT NOT MANAGED BY DSWA

The majority of organic waste generated in Delaware is currently not disposed at DSWA facilities, but is instead already beneficially reused. Table 7 presents the most current data on organics diversion for Delaware, CY 2015.

TABLE 7 - Current Estimated Diversion of Organic Waste Generated in Delaware by Material Type

Organic Waste by Category		Tons
Organic Wastes Categorized as Mixed Solid Waste (1)		
	Fats,Oils, Grease	3,565
	Food Waste	8,509
	Leaf and Yard Waste	110,690
	Trees and Branches	83,383
	Clean Wood	1,318
	Sub-Total	***207,465***
Other Organic Wastes (2)		
	Poultry Waste	363,200
	Poultry Litter	57,900
	Biosolids (Includes Ag)	147,700
	Food Processing Wastes	39,200
	Sub-Total	***608,000***
	Total Beneficially Reused & Recycled	**815,465**
Disposed (Waste Characterization, FY 2016)		
	Food and Yard Waste	159,570
	Other Organics (Excluding Recyclable Paper)	110,204
	Sludges, Sweepings, Biosolids and Carcasses	6,312
	Total Disposed at DSWA Landfills	**276,086**
	Diversion Rate	***75%***

1) Source: State of Delaware Assessment of Municipal Solid Waste Recycling for Calendar Year 2015.
2) Source: All Materials Recycling Study, October 2015.

As illustrated by Table 7, 75 percent of all organic waste generated in Delaware is already being recycled or beneficially reused. Organic wastes currently disposed at DSWA landfills essentially represent the remaining harder to recycle or reuse organic materials.

IV. MEASURES THE STATE OF DELAWARE MIGHT TAKE TO INCREASE FOOD WASTE DIVERSION FROM LANDFILL

INTRODUCTION

As illustrated in Table 7, above, food and yard waste represent 58 percent of the total organic waste disposed at DSWA landfills. The second largest type of organic waste disposed is “compostable paper”, at 62,000 tons (Table 5, rounded). While compostable paper can be mixed with food waste for composting, the difficulties of composting materials other than yard wastes in Delaware have refocused efforts on non-centralized composting solutions. As such, the focus here is on food waste, as opposed to other organics.

As concluded in the ReFED report[9] “*Solutions that prevent (food) waste in businesses and homes have the greatest economic value per ton and net environmental benefit*.” On a national scale, ReFED estimates the potential exists to reduce food waste by 6 million tons of waste annually, or 16 pounds per capita.

The ReFED report outlines strategies with the potential to achieve a 20% reduction in food waste in 5-10 years. These strategies are reviewed below as they may fit into Delaware’s approach to reducing food waste disposal. They are laid out following EPA’s hierarchy for food waste recovery, as shown in Figure 1 of this report.

FOOD WASTE REDUCTION

Because food waste generated on farms is not landfilled (but for the most part handled on-site) and food manufacturers typically take measures to address food waste at the plant to minimize costs, the greatest opportunities to intervene at the State level are more likely to be found by working with businesses and institutions and educating consumers.

However, there are critical measures that must be taken at the manufacturing level to help consumers achieve food waste reductions.

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[9] http://www.refed.com/analysis?sort=economic-value-per-ton

The ***first***, which two of the biggest trade groups in the grocery industry have promoted, encourages manufacturers to voluntarily standardize food labeling. The Food Marketing Institute and Grocery Manufacturers Association are asking retailers and manufacturers to label food with a "Use By" date if it's highly perishable and there is a food-safety concern and with a "Best If Used By" date to describe best product quality, but not safety. These standardized terms would replace the many different labels used including *Sell By, Use By, Expires On, Best Before, Better if Used By or Best By* which have confused consumers and led to wasting usable food products. Widespread adoption is urged by the summer of 2018.[10]

The ***second*** would be to work on changes in both transport and consumer packaging to minimize food waste. Manufacturers create product lines to meet consumer choice for taste, convenience, portion size, and nutrition as well as to ensure food quality and security. Working with manufacturers to design packaging to not only meet customer and safety demands but also extend product shelf life at the store and with the customer is critical to minimize waste.[11]

Post manufacturing - at businesses and institutions - food waste reduction requires changes in practices specific to each operation. The ReFED project performed research and consulted with a broad range of stakeholders including food producers, retailers (grocers), restaurants and food service institutions to identify practical measures with high potential for food waste reduction. Table 8 summarizes eight strategies to reduce food waste generation from the ReFED project research.

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[10] Grocery Manufacturers' Association. *Grocery Industry Launches New Initiative to Reduce Consumer Confusion on Product Date Labels*. February 15, 2017.

[11] In creating new types of packaging to extend shelf life, the life cycle analysis of the packaging must also be a consideration including whether it is recyclable or biodegradable after its' useful life.

TABLE 8 – Food Waste Prevention and Reduction Measures (1)

PRODUCERS, RETAILERS	
Change in Specifications for Resale or Purchase	Allow for off-grade produce (cosmetic imperfections, short shelf life, discoloration) to be used in foodservice and restaurant preparation, and allowed for retail sale
FOODSERVICE AND RESTAURTANTS	
Use Smaller Plates	Provide consumers with smaller plates in self-serve, all-you-can-eat dining settings to reduce consumer waste
Use Trayless Dining	Eliminate tray dining in all-you-can-eat dining establishments to reduce consumer waste
Eliminate Refilling the Buffet	Minimize the need to keep large serving containers full for all buffet diners - do not refill containers toward the end of dining hours
Utilize Waste Tracking & Analytics	Provide restaurants and prepared-food providers with tools to measure wasteful practices and with data to inform behavior and operational changes
RETAILERS	
Change Cold Chain Management	Reduce product loss during shipment to retail distribution centers by using direct shipments and cold-chain-certified carriers
Improve Inventory Management	Improvements in the ability of retail inventory management systems to track an average product's remaining shelf-life (time left to sell an item) and inform efforts to reduce days on hand (how long an item has gone unsold)
Utilize Secondary Resellers	Identify businesses to purchase unwanted processed food and produce direct from manufacturers/ distributors for discounted retail sale to consumers

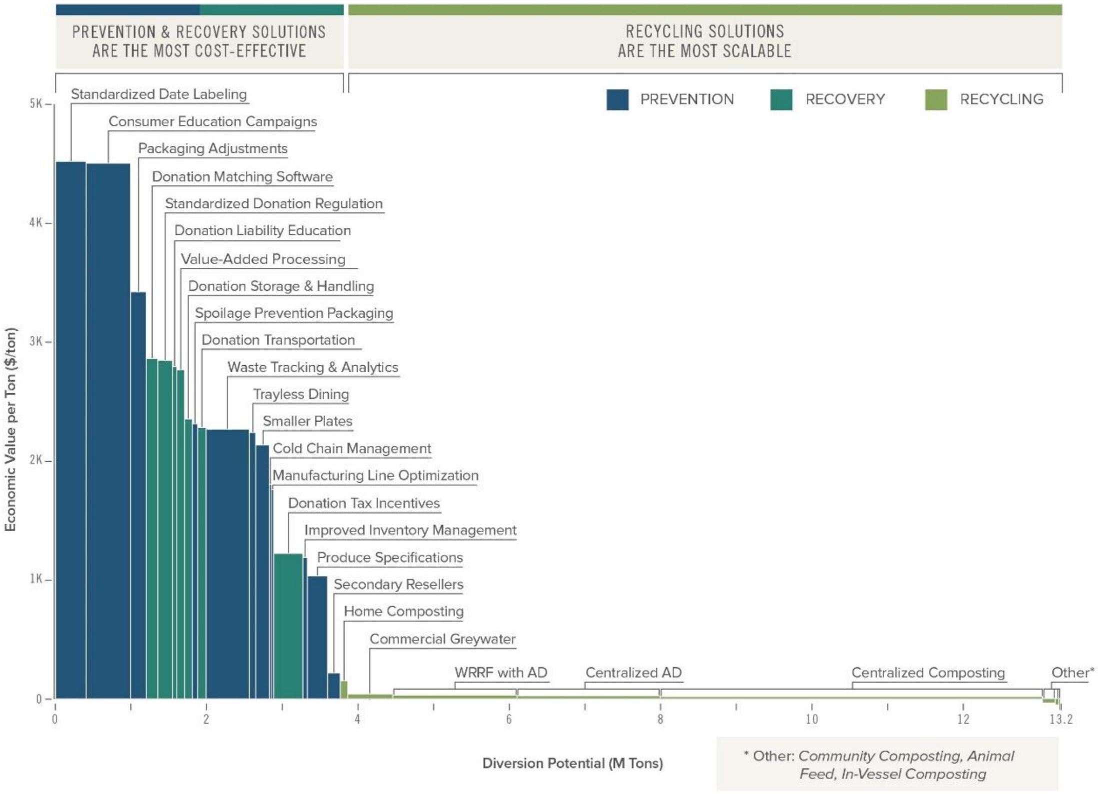
(1) Most of these strategies listed are from ReFED's Economic Analysis, The Business and Societal Case for Reducing Food, Solutions Evaluation, page 17.

In Delaware, technical assistance programs - jointly administered by appropriate State agencies – that are designed to implement the strategies listed in Table 8 (and others) could be developed. In doing so, they should work closely with, or be managed through, organizations that serve the grocery, restaurant and foodservice industries as well as food manufacturers and distributers. For example, the Office of Food Protection, within the Delaware Health and Social Services Department, could be tasked with integrating food waste reduction strategies into best practices for food handling and preparation, as well as designing educational campaigns and outreach programs targeting those trained in food handling and preparation.

At the consumer level, education is key to reducing food waste. While the *Use By* and *Best By* standardized labeling (and associated education) will help consumers make better choices about wasting safe food, the WRAP study (2008) found the five main reasons food that could have been eaten was thrown away were: left on the plate after a meal; passed its' date; smelled or looked bad; went moldy; and, left over from cooking. Unless the food was purchased this way, all of these could be avoided, at least at the consumer level.[12]

The ReFED project performed an analysis of 27 viable solutions to reducing food waste, ranking them based on cost effectiveness. Figure 2 (taken directly from the ReFED report) illustrates ReFED's findings.

FIGURE 2 – Marginal Food Waste Abatement Cost Curve (1)



(1) Source: FeFED, *A Roadmap To Reduce Food Waste By 20 Percent*, Page 20.

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[12] WRAP. The Food We Waste. Project code: RBC405-0010 ISBN: 1-84405-383-0 (version 2) April 2008 (revised July 2008).

The analysis pointed to consumer education (along with standardized labeling and packaging adjustments) as having the highest economic value per ton of food waste diverted. The analysis also concluded that food waste prevention and food recovery solutions generally result in greater economic value per ton of food waste reduced, even though recycling/composting solutions have significantly larger diversion potential.[13] For example, the WRAP analysis found that only 61% of consumer food waste was avoidable as the balance includes inedible food that would never be consumed, such as tea bags, coffee ground, and banana skins and other food waste that some consumers will never eat, such as potato peels. Some of these items would never be source reduced, but could be recycled to animal feed or fuel/energy (anaerobic digestion) or composting.

There are many toolkits and technical assistance materials available to help in any state-wide food waste reduction campaign focused at consumers. A partial list is included in Appendix B to this report.

FOOD WASTE REUSE (DONATION AND REDISTRIBUTION)

At the State level incentivizing food waste recovery not only helps reduce food waste but helps to address food insecurity.

The *Bill Emerson Good Samaritan Act* (PL 104-210) provides liability protection in all states for food donors and nonprofit food recovery organizations that distribute food to needy individuals. Donors must meet requirements to receive protection, including that any food donated must: be done with the belief that it is safe to eat; meet certain quality and labeling requirements; and, be distributed to needy individuals without a fee. Protection also extends to premises to allow gleaners or food recovery personnel onto their property.

While the *Good Samaritan Act* provides liability protection in all states for food donors and nonprofit food recovery organizations, and states cannot reduce these protections, additional protections could help to increase donation and redistribution of food. For example, many states have enacted laws to strengthen these liability protections. Delaware has added state law to reinforce

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[13] ReFED. Fink Family Foundation. A Roadmap To Reduce U.S. Food Waste By 20 Percent. ReThink Food Waste Through Economic and Data. 2016. Pgs. 19 – 21.

this protection[14] (See Appendix C), but Delaware's law still requires the donor to go through a charitable organization to receive liability protection. Protections for donors that bypass a charitable organization could therefore be added to Delaware law to expand opportunities for food redistribution.

DELAWARE FOOD DONATIONS

The Delaware Food Bank received 8.5 million pounds of food in 2016, of which 66% was donated. Many Delaware grocers lead the list of food donations, donating from 100,000 to 500,000 pounds each last year. The Food Bank operates a number of nutrition and hunger abatement programs including a mobile pantry that brought food to nearly 3,800 households last year.

The Society of St. Andrew operates *The Potato and Produce Project* (established in 1983) which salvages and distributes about 10 million pounds of potatoes and other fresh fruits and vegetables each year; and the Gleaning Network saves and distributes another 15-20 million pounds per year. The Gleaning Network operates in the 48 contiguous states, and as of 2015 distributed 319,321 pounds of food in Delaware.

Despite these efforts, food donation and redistribution is still potentially a significant opportunity in Delaware based on the amount of food disposed by large food waste generators in Delaware. Table 9, below, presents results from the FY 2016 *DSWA Waste Characterization Study* which included sampling of targeted business sectors, which demonstrated that groceries, restaurants and convenience stores had the highest percentage by weight of organic waste disposed based on the sectors including in the Study.

While the *Waste Characterization Study* did not quantify total tons by business sector, it provides a useful guide for targeting technical assistance to reduce or redistribute food waste. For example, based on the data in Table 9, there may be opportunities to reduce and even redistribute food waste from convenience stores, particularly those with large delis. Without this study, convenience stores would not have been identified as a target to redistribute food.

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[14] 61 Del. Laws, c. 439, § 1.;. § 8130 Exemption from liability for donation of prepared food.

TABLE 9 – Percentage of Food Waste Found in Total Solid Waste Disposed by Commercial Sector, by weight (FY 2016)

ORGANIC MATERIAL	Large Retail (%)	Office (%)	Small Retail (%)	Grocery (%)	Restaurant (%)	Convenience Stores (%)
Vegetative Food Waste, Unpackaged	0.8%	4.8%	13.6%	12.4%	28.3%	26.4%
Protein Food Waste, Unpackaged	0.7%	2.0%	2.0%	2.7%	13.3%	4.4%
Food Waste in Plastic Packaging	3.3%	3.6%	3.7%	10.6%	5.1%	18.1%
Food Waste in Other Packaging	2.7%	0.8%	0.7%	3.0%	1.9%	6.3%
Total:	**7.5%**	**11.3%**	**20.1%**	**28.7%**	**48.7%**	**55.1%**

ANIMAL FEED

Farms can redistribute imperfect or blemished foodstuff directly to animal food. Restaurants and grocers can as well without treatment provided it is pre-plate vegetative food waste. Small hog farmers, especially could benefit from a more robust system identifying generators of pre-plate waste willing to divert this waste to the farmers, in some cases "closing the loop" by purchasing the finished hogs for use in the institutional kitchen or restaurant.[15]

In some cases, post-plate food waste can also be directly fed to animals after it is heat treated and dehydrated. This practice already occurs in many part of the US where farmers substitute treated food waste for commercial feeds to reduce costs, although in Delaware hog farmers are prohibited from feeding post plate waste to hogs, even if it is heat treated.[16]

ON-SITE DIVERSION

There are many on-site food waste processing systems available for large and medium size food waste generators that reduce off-site disposal, falling into four major categories:

- Pulpers/grinders which pulverize the food waste for discharge to the sewer system;
- Biological/liquification systems that first liquify and then decompose the food waste using microbial activity before discharge to sewer systems;

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[15] A hog farmer in Bethel, Maine has successfully implemented this arrangement with restaurants in this tourist area of Maine

[16] The law appears to be silent on feeding heat treated food waste to other farm animals.

- Grinders/dewatering systems that grind and dewater (or de-hydrate) to create a dry waste for composting (or disposal) with discharge of liquids to the sewer system; and,
- In-vessel dry waste systems that compost the food waste on-site.

Multiple companies manufacture, sell, and in some cases lease/maintain these in-house systems. Numerous articles and guidance documents describe and categorize these systems[17], often as a response to proposed or implemented state bans on disposal of organics.

In general, there are three primary reasons to install one of these systems:

- To comply with an organics landfill ban – which often apply only to large generators (e.g., Connecticut, Massachusetts, Vermont, and, proposed in New Jersey);
- To save money through reducing costs of dumpster rental(s) and either collection and disposal (at a landfill or waste-to-energy facility) or, in a landfill ban state, delivery to an off-site composting or anaerobic digester facility; or,
- To bolster sustainability goals of the generator which are often based on high waste diversion rates or "zero waste to landfill" policies.

Because Delaware does not currently ban disposal of organics at landfills (other than yard waste), DSM's analysis concentrated on the cost and environmental sustainability of on-site options when compared to collection as solid waste disposed at a landfill, or separate collection with diversion to a composting or AD facility.

GRINDING WITH DISCHARGE TO WASTE WATER TREATMENT FACILITY

Grinding of food waste with discharge to the sewer system is a common method for disposing of food waste in many areas. In-home garbage disposal systems are often installed in household kitchen sinks, and larger, commercial units can

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[17] See for example: *On-Site Systems for Processing Food Waste,* A Report to the Massachusetts Department of Environmental Protection, Isaac Griffith-Owen, Zak Patten, and Jennifer Wong, Northeastern University, 4/26/2013; *An Analysis of New and Emerging Food Waste Recycling Technologies and Opportunities for Application,* P. Richard M. Cook, Sustainability Consultant, Great Forest, undated; and, *Analysis of Biodigesters and Dehydrators To Manage Organics On-Site,* Zoe Neale, BioCycle, October, 2013.

be purchased and installed in commercial kitchens. Some municipalities specifically encourage installation of food waste grinders[18], while others discourage use of food waste grinders, depending on the capacity of the waste water treatment plant to treat additional materials with a high biological oxygen demand.

The potential to divert food waste via grinding and discharge to waste water treatment plants (WWTP's) is typically limited by the following factors:

- Whether the WWTP uses anaerobic digestion to capture energy inherent in the sludge;
- Whether the sewer system and WWTP capacity can manage increased BOD flows and fats/oils/grease; and/or,
- How the effluent is disposed.

In the case of Delaware, each county is different. Waste water from New Castle County goes to the Wilmington WWTP, which anaerobically digests its sludge. As such, it may be feasible for large food waste generators in New Castle County to use on-site treatment of food waste and discharge the resulting liquid to the treatment plant. It also might be feasible in the long run to deliver food waste that has been slurried in a food depackaging machine to the facility.

Kent County has a single WWTP in Frederica, DE serving all of the major municipalities in the County. Effluent is discharged to a stream flowing into Delaware Bay, and sludge is dewatered, dried, and land applied on farm fields. According to Jim Newton[19], Manager of the WWTP, grinding food waste for discharge to the sewer system is not prohibited, but is restricted under the Kent County Codes for two primary reasons.

First, the addition of food waste and potentially fats oils and grease increases clogging of the sewer lines, and as such is restricted under Kent County Code 180-10. Section B(1)(b)(1) which prohibits "*any waters or waste which contain grease or oil or other substances that will solidify or become discernibly viscous at temperatures between 32 F and 150 F.*"

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[18] Philadelphia recently implemented a requirement to install food waste grinders in new residential construction. See http://www.wastedive.com/news/philadelphia-mandates-garbage-disposals-to-tackle-food-waste/412026/

[19] Telephone conversation, June 22, 2017.

Second, land application of dried sludge is restricted by nitrogen and phosphorous limitations. Section (B)(1)(b)(13) states, in part "*In no case shall a substance discharged to the POTW cause the POTW to be in noncompliance with sludge use or disposal criteria…"*. While the WWTP is designed to remove nitrogen and phosphorous, increasing delivery of ground food waste may increase treatment costs and/or increase the risk of exceeding, especially, phosphorous limitations for land application of sludge.

However, recently Kent County has been in discussions with a private vendor about the potential for construction of an anaerobic digester to further process the sludge and produce energy for use at the treatment plant. Development of an AD facility at the treatment plant might provide an opportunity for diversion of some percent of food waste from DSWA facilities to this digester if it were to move forward because typically the addition of food waste to a sludge digester increases energy output. And, there are methods for reducing the phosphorous in the resulting digestate that could alleviate concerns about land application of the resulting digestate in Kent County.

In Sussex County the majority of effluent, with the exception of Rehoboth City is disposed of via spray irrigation to land. Given nitrogen and phosphorous concerns for Delaware Bay, it may be that significant increases in discharge of food waste to Sussex County WWTPs would negatively impact nitrogen and phosphorous loads, and would therefore not be environmentally preferred over continued landfilling.[20]

In conclusion, with the possible exception of New Castle County (where sewer clogging could remain a problem), or in the future, Kent County if it were to move forward with an AD facility, increased food grinding with discharge to the sewer systems as currently designed is not likely to be an acceptable option for reducing food waste deliveries to DSWA landfills.

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[20] According to a Life Cycle Assessment of food waste alternatives published in the Journal of Cleaner Production, food waste grinding with discharge to the Sydney, Australia WWTP increased eutrophication of surface water by 2 percent when compared to landfill of food waste and treatment of leachate, with much of the nitrogen and phosphorous sequestered in the landfill. See, *Life cycle assessment of food waste management options,* Sven Lundie and Gregory M. Peters, Journal of Clean Production 13 (2005) p. 275 – 286.

BIOLOGICAL/LIQUIFICATION SYSTEMS

According to a report prepared for Massachusetts Department of Environmental Protection, "*Biological liquification systems grind food waste and mix it with water and patented micro-organisms or nutrient mixes. This accelerates the decomposition process, causing most of the food waste to turn into liquid effluent that is discharged into the municipal waste water treatment system. While manufacturers claim that this effluent is safe for discharge, some sewer districts are reluctant to allow their use. Independent tests have indicated levels of biological oxygen demand that exceed most municipal wastewater standards.*[21]"

Because the potential to clog sewer lines is reduced with degraded food waste and fats/oils/grease (FOG), this is potentially a viable solution for on-site diversion of food waste from some large generators, depending on the BOD limitations of the WWTP they discharge to. The primary factor then would be the cost to install, operate and maintain these systems, including the cost to purchase the proprietary micro-organisms or nutrient mixes.

GRINDING/DEWATERING SYSTEMS

These systems essentially grind/pulp food waste and then use either mechanical dewatering or heat systems to remove the water, producing a relatively dry waste that can be landfilled or potentially composted. Typically, these systems provide an 8-to-1 reduction in volume.[22]

There are several important considerations, in addition to costs, associated with these systems:

- Heat drying of the ground food waste eliminates, or significantly reduces waste water discharges, but comes at a high energy cost;
- Systems that mechanically remove the water result in discharges to WWTPs that may have similar BOD restrictions to the wet systems discussed above, except for systems that re-circulate waste water to pulp additional food waste (such as the Somat Company, Lancaster, PA which produces machines that re-circulate waste water);

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[21] *On-Site Systems for Processing Food Waste,* Report to Massachusetts Department of Environmental Protection, Isaac Griffith-Onnen, Zak Patten, and Jennifer Wong, Northeastern University, 4/26/2013, p. 1.

[22] IBID, p.6

- When these systems grind the waste, some also grind plastics and other contaminants found in food waste, resulting in a dry material that must be landfilled, rather than composted. Although lower in weight, the organic material must still be delivered to a landfill, albeit without 90 – 95 percent of the water. The primary savings in this case go to the generator who can reduce pull and tipping fee costs significantly. Reducing pull costs also reduces the environmental impacts of trucking.

IN-VESSEL DRY WASTE COMPOSTING SYSTEMS

These systems offer the greatest potential to reduce food waste from large generators in the most environmentally sound manner. In-vessel systems are offered in a range of sizes, from small bins to larger tub-grinders and even larger vertical or horizontal containers that grind, mix and aerate (and sometimes heat) food waste to produce a relatively stable compost in a short amount of time compared to conventional, centralized systems. And, because the generator controls the food waste fed into the system, and the output is relatively small, the potential to find viable uses or markets should be relatively easy. However, because these systems do much more than simply grind and pump or dehydrate the food waste, they are also significantly more complex to operate, which can add to costs.

REPRESENTATIVE COSTS OF ON-SITE SYSTEMS

Costs for all of the systems described above are site-specific, and therefore beyond the scope of this project. However, the 2015 report prepared for Massachusetts Department of Environmental Protection (MassDEP)[23] did provide estimated capital costs for a wide range of systems.

Table 10, on the next page, is excerpted from the MassDEP report to provide examples of the potential capital cost for different sized on-site systems. These costs have not been verified by DSM, but are included for illustrative purposes only.

Other costs may include special electrical hookups, and site-specific modifications to accommodate the equipment. In addition, most systems have

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[23] *On-Site Systems for Processing Food Waste,* Report to Massachusetts Department of Environmental Protection, Isaac Griffith-Onnen, Zak Patten, and Jennifer Wong, Northeaster University, 4/26/2013.

on-going operational water and power requirements that may exceed the amortized capital costs.

A financial assistance program covering the capital cost of these types of on-site systems might be provided by DNREC or DSWA, assuming that the county sewer system and treatment plants could handle any associated increase in the discharge of waste water. However, before a program of this type is developed, and/or as part of the funding agreement, case studies should be put together that document the potential operating and maintenance costs of these systems to provide specific information on the potential total system costs.

TABLE 10 - Reported Range of Capital Costs, On-Site Systems (1)

System Type and Manufacturer	Model	Pounds	Capital Cost	Notes
Food Waste Pulping/Grinding				
Somat	SPC-60S	1000/hr	$53,000	
InSinkErator	WX 300	700/hr	$24,000	
Dewaterer				
Somat	HE-6S-3	1600/hr	$30,500	
Dehydrator				
GaiaRecycle	G-30H	66/day	$20,000	
	G-300H	660/day	$65,000	
EcoVim	Eco-66	65/cycle	$18,500	
	Eco-250	250/cycle	$28,500	
	Eco-2200	2200/cycle		
Biological/Liqification				
EnviroPure (1)	EPW 120	120/day	$17,000	low point of range
EnviroPure (1)	EPW-2000	2000/day	$45,000	high point of range
BioHiTech America	Eco-Safe 400	400/day	$23,000	
BioHiTech America	Eco-Safe 1200	1200/day	$42,000	
Totally Green	OG 600	600/day	$1,500	Rental/Month
Dry Compost				
Biogreen 360	250	250/day	NA	Depends on system configuration
Biogreen 360	1500	1500/day	NA	
Hot Rot	1206	700/day	$125,000	One example of installed system

(1) Source: On-Site Systems for Processing Food Waste, Report to Massachusetts Department of Environmental Protection, Isaac Griffith-Onnen, Zak Patten, and Jennifer Wong.

OFF-SITE DIVERSION OF ORGANICS

INTRODUCTION

There are multiple types of technologies that can be used to process organics. Typically, processing is used to recover the energy value of the food waste or the soil improving characteristics of processed food and yard wastes. This report focuses on three primary types:

- Conversion of food waste to animal feed;
- Anaerobic Digestion (AD); and,

- Composting

A brief overview of each technology is provided below, followed by DSM's assessment of the applicability to development by DSWA – or by a private company contracting with DSWA.

CONVERSION OF FOOD WASTE TO ANIMAL FEED

One processing technology that is of interest to DSWA would be to convert the energy value inherent in food waste to animal feed. This could potentially be attractive in Delaware because of the large poultry production activity in the southern part of the state.

There are at least two facilities in the demonstration/operational stage in the U.S.; one located in Florida (Nutritious Foods, Inc.) and another in California (Sustainable Alternative Feed Enterprises). In both cases, the incoming food waste is inspected by sorters to remove large contaminants, and then ground/slurried, run through screens to remove additional contaminants, dehydrated and pelletized or milled, for mixing with other nutrients for industrialized agricultural enterprises.

There are, however, several limitations associated with this technology.

First, to protect against the threat of bovine spongiform encephalopathy (BSE) only non-meat food waste can be converted to animal feed if the feed is to be fed to ruminant animals.[24] While this does not apply to poultry, it does reduce the potential market for the resulting animal feed. However, according to Louie Pellegrini, Sustainable Alternative Feed Enterprises, the protein in meat wastes is an important source of protein in the animal feed and therefore it is necessary to forego the ruminant market.[25]

The second significant limitation to the use of post-consumer food waste to produce animal feed is contaminants. While contaminants are of concern to both composting and anaerobic digestion, they are a much greater concern with respect to the production of animal feed. Glass, especially, would be considered a significant contaminant. For this reason, it is essential to employ significant

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[24] See for example, *Leftovers For Livestock: A Legal Guide for Using Food Scraps as Animal Feed,* Harvard Food Law and Policy Clinic and University of Arkansas School of Law, August, 2016.

[25] Telephone conversation, March 30, 2017

processing steps to assure that removal of glass and other contaminants occurs during the conversion process.[26]

ANAEROBIC DIGESTION

According to a National Renewable Energy Laboratory (NREL) *Feasibility Study of Anaerobic Digestion of Food Waste in St. Bernard, Louisiana* (January 2013), *"Food wastes are an excellent candidate for Anaerobic Digestion (AD) due to high moisture and organic content. AD is the natural, biological degradation of organic matter in absence of oxygen yielding biogas. Biogas is comprised of 60-70% methane and 30-40% carbon dioxide and other trace gasses. Biogas is capable of operating in nearly all devices intended for natural gas."*

The NREL report goes on to state, "*AD technologies are typically optimized for either low solids or high solids content. Alternatively, these technologies are referred to as wet or dry even though the feedstock generally has moisture content above 70%. Low solids (wet) refers to wastes with a solid content of 3% - 10%, and high solids (dry) refers to solid content of 15% or more. Wet systems (low solids) … are the most common and often deployed at WWTPs. Wet systems slowly mix feedstocks with microbes to increase the speed of degradation."* For this reason, most wet systems are continuous feed systems, when compared to dry systems, which are often batch feed systems.

Finally, the NREL report states, "*There are few examples of food waste digestion in the United States. Existing or planned stand-alone systems are increasingly evaluating high solids/dry digester technologies. Dry digestion is common for food wastes in Europe. Dry systems can be built to scale-up as more wastes become available."*

For purposes of this analysis DSM has assumed that development of an anaerobic digester to manage food waste currently being disposed at DSWA landfill would most likely be a dry (high solids) digester. This could change if DSWA were to identify one or more large generators of wet, homogeneous waste that could be mixed with the food waste, in which case a wet system (low solids) might make more sense. This would be the case, for example if either the Wilmington or Kent County WWTP's decided to accept food waste to increase energy output from their sludge digesters.

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[26] Depackaging equipment is employed in many settings that recover post-consumer food waste, however extra steps to address specific contaminants of concern to animal feed are required.

Further, because DSWA primarily uses diesel fuel to run its landfill equipment, DSM has assumed that the gas produced by an anaerobic digester would be used to power an electric generator set selling electricity to the grid. This assumption has economic implications, because roughly 60 percent of the energy available from the digester is lost as heat during the production of electricity.

COMPOSTING

Composting is a biological waste management option which uses the natural process of biological decomposition under controlled conditions to produce a stable end-product. The resulting compost is not necessarily high in fertilizer value, but if it is fully composted it can improve the soil aeration and water-holding capacity and allow better utilization of fertilizers. The key to successful composting is to make sure that contaminants such as metals, plastics and other non-organic wastes are kept out of the compost, and that the organic materials are *stable,* which means the decomposition process is complete before the material is applied to areas where crops are grown.

Decomposition is conducted primarily by microorganisms naturally present in nature, such as bacteria, fungi, and actinomycetes that can exist across a range of compost pile temperatures. These organisms reproduce rapidly on the organic material, using it as a source of food. It is the growth of these micro-organism populations which result in the rapid degradation of organic material in the compost mass. Heat, carbon dioxide, water vapor, and compost are produced when the process is managed correctly.

Composting is an aerobic process, which means it occurs in the presence of oxygen. When oxygen is present, organisms release carbon dioxide and water vapor. If the oxygen content falls below a level of about five percent, these organisms begin to die off and the composting process is taken over by anaerobes, organisms which do not require oxygen.

Anaerobes operate much less efficiently and create bad odors. Odorless methane can also be produced in the absence of oxygen. Since anaerobic degradation is less efficient, it takes longer to achieve a stable product, which results in materials staying on-site much longer further challenging a site constrained operation.

Compost organisms need a moist environment. The amounts of air and water in a composting pile are related, so rapid decomposition requires a proper balance. For most composting methods, the optimal moisture content is 40 to 60 percent, by weight. Moisture is required to transport the nutrients utilized by composting organisms as well as to provide a suitable environment for microbial population growth.

A moisture content below 40 percent limits the availability of nutrients and limits this microbial population expansion. When the moisture content exceeds 60 percent, the flow of oxygen into a composting pile is slowed and anaerobic conditions begin to develop.

An understanding of the concept of the carbon to nitrogen (C/N) ratio is also necessary to manage a compost operation. Carbon and nitrogen are the primary elements that organisms need for food. Compost organisms get their energy from carbon found in carbohydrates, such as the cellulose in the organic matter. Nitrogen is necessary for the population growth of micro-organisms which decompose the organic material.

The description above is included in this report because it is often assumed that composting is easy, and that it is the only way to manage organic waste. However, Delaware has had three recent examples of competent owner/operators who have had to close, or significantly curtail their operations – these include Blessing’s, Blue Hen, and Wilmington Organics.

Because three reputable firms have recently tried to implement composting systems in Delaware that incorporated food waste, and all three have either shut down or significantly reduced operations, DSM does not consider construction of a large-scale composting facility by DSWA to be a logical way to divert large quantities of food waste from DSWA landfills. Instead, DSM has concentrated our analysis on anaerobic digestion and animal feed production.

ESTIMATED DIVERSION FOR OFF-SITE PROCESSING

As illustrated in Table 5, above, a total of 159,569 tons of food and yard waste was disposed at DSWA landfills in FY 2016; with food waste representing 83 percent, or 132,000 tons (rounded).

Like recycling, not all food waste generation can be assumed to be source separated and delivered to an organics processing facility. For purposes of this analysis DSM has assumed that food waste diversion would be voluntary – as there is no mandate in Delaware for generators to separate and divert food waste from disposal, and there is no ban on disposal of food waste at DSWA landfills. The drivers to participate may include corporate sustainability goals, environmental benchmarks, or even the potential to save costs.

Tables 11 and 12 build off the county level data presented in Table 6, above, and present estimates of the amount of organic waste diversion by county based on the assumption diversion is voluntary. Table 11 reflects potential start-up quantities, and Table 12 presents what DSM would consider to be reasonable recovery rates for a mature organics processing facility charging a tipping fee that is lower than DSWA landfill tipping fees.

Table 11 assumes a 20 percent capture rate of ICI generated food waste and a 2 percent capture rate of residential food waste. Table 12 assumes a 40 percent capture rate for ICI generated food waste and a 10 percent capture rate for residential food waste. These rates are what DSM believes are reasonably achievable in the short term (3-10 years) given the current economics of separate food waste collection and processing, and the factors understood to motivate both ICI and residential generators to separately manage organics.

For example, peak deliveries of Delaware generated food waste to separate processing facilities for composting represented less than 25 percent of total food waste disposed at Delaware facilities in 2013 - 2014 when the Wilmington Organics Recycling facility (WORC) was still in operation, and the Blue Hen composting facility still accepted food wastes.

To achieve overall ICI food waste recovery rates of 20 and 40 percent, it is necessary to capture 35 and 60 percent respectively of food wastes from four major ICI food waste generator categories – restaurants, groceries, convenience stores and institutions.

Tables 11 and 12 illustrate annual throughput and daily throughput of food waste only, assuming 312 operating days per year at each potential site. While it is possible to add yard wastes to an anaerobic digester, the impact on energy production is quite limited, and there is no benefit to adding yard waste to a facility producing animal feed. Therefore, DSM has concentrated our analysis on food waste only.

As illustrated in Table 12, even with relatively aggressive assumptions about recovery rates, daily throughput is still quite low, except for a single facility drawing food waste from the entire State. These low throughput rates impact costs for full scale implementation, as discussed below.

TABLE 11 - Start-up Capture Rates for Food Waste, ICI and Residential (FY 2016)

Facility/County	**FY 2016 Res**	**FY 2016 ICI**	**FY 2016 Total**
	2%	20%	
New Castle County			
Food Waste Only	788	8,871	9,659
Tons/Day (312 days/year)	3	28	31
Kent County Without Pine Tree			
Food Waste Only	235	2,352	2,587
Tons/Day (312 days/year)	1	8	8
Sussex County			
Food Waste Only	275	2,194	2,469
Tons/Day (312 days/year)	1	7	8
Total, Statewide			
Food Waste Only	1,298	13,417	14,715
Tons/Day (312 days/year)	4	43	47

TABLE 12 - Reasonably Achievable Capture Rates for Food Waste, ICI and Residential (FY 2016)

Facility/County	**FY 2016 Res**	**FY 2016 ICI**	**FY 2016 Total**
	10%	40%	
New Castle County			
Food Waste	3,941	17,743	21,683
Tons/Day (312 days/year)	13	57	69
Kent County Without Pine Tree			
Food Waste	1,176	4,704	5,879
Tons/Day (312 days/year)	4	15	19
Sussex County			
Food Waste	1,375	4,388	5,763
Tons/Day (312 days/year)	4	14	18
Total, Statewide			
Food Waste	6,491	26,834	33,325
Tons/Day (312 days/year)	21	86	107

Cost Analysis For Off-site Processing

There are essentially two primary costs associated with off-site processing – whether an anaerobic digestion facility or an animal feed production facility. These are the costs to separately collect and transport the food waste to the facility, and the cost to construct and operate the facility.

A detailed feasibility level analysis is presented in Appendix A to this report. A summary is presented below.

COLLECTION COSTS

DSM modeled the cost of separate collection assuming the use of dedicated trucks to collect food waste on a weekly basis. Separate containers to store food waste were included in these costs based on estimated quantities, with smaller generators assumed to use rolling carts, and larger generators using one or more 3 cubic yard dumpsters dedicated to food wastes. All residential participants were assumed to be provided with either a 15 gallon or 32-gallon cart, depending on whether yard waste was co-collected or not.

The number of carts and dumpsters required for ICI food waste were calculated assuming weekly collection and densities of 150 and 225 lbs. per 32- and 64-gallon cart respectively, and 450 pounds per cubic yard for dumpsters.

In the case of residential collection, it was assumed that each household choosing to participate would be provided a cart, with food waste collected once per week from each participating household, no matter how much food waste was set out.[27]

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[27] Reported per household weekly quantities range from 4.5 to 7.5 pounds of food waste per week.

With the number of carts and dumpsters calculated, the hours of truck time necessary to serve the carts and dumpsters weekly could be estimated. Carts were assumed to be served by a leak proof side loading truck, and dumpsters by a conventional front or rear loader.

Part of the problem with determining the cost of collection is that generators are scattered throughout each county. As a consequence, collection costs are typically high, just as they were initially for recyclables collection when DSWA offered recyclables collection throughout each county irrespective of where the generator lived. Rolling out collection by zip code helped to limit costs, but eventually under a voluntary program, long distances between customers will and did drive up costs.

Alternative collection programs could be pursued based on new models being developed in municipalities and states where separate food waste collection is required. For example, if all residential generators are required to separate food waste, then split trucks could be used collecting, for example food waste and recyclables one week and food waste and the remaining refuse the second week.

Another option being promoted in some municipalities is for the food waste to be stored in separate colored heavy-duty plastic bags, and placed in with the refuse. The bags are then sorted out, either manually or optically at the transfer station or MRF. However, this is difficult in the case of Delaware because the most economically feasible size for an AD facility is to construct a single facility (see below). Separating out food waste by colored bag would therefore only work if all refuse was going to a single location in Delaware which is not the case; and it would not be feasible to construct and operate organic bag sorting equipment at each DSWA facility.

Finally, one option being implemented in Vermont, where source separation of food waste is supposed to be mandatory by 2020; and in the Ecomaine area of Maine (Portland area) is for transfer stations to provide containers for drop-off of food waste. Because DSWA has one or more manned drop-offs in each county, it would be possible, assuming a processing facility were available for the source separated food waste, for DSWA to provide one or more drop-off locations in each county where residents and small commercial generators could drop off their food waste.

This option has not been costed out in this report but could potentially be used if a location for processing of food waste were identified by DSWA in the future. It should be noted that a significant amount of the cost for a drop-off system will be incurred by the user driving to the drop-off location; and, participation rates will be relatively low for households receiving curbside collection of refuse and recyclables.

Table 13, on the next page, summarizes the number of rolling carts and dumpsters required, truck hours, total cost, and cost per ton for both the low and high recovery scenarios.

As illustrated by Table 13 per ton collection costs are quite high, especially for residential food waste collection. There are several reasons for this.

First, separate collection of residential food waste is inherently costly because it must be collected weekly and represents relatively small quantities per household.

Second, and most importantly, voluntary programs do not allow for optimization of the collection system because households choosing to participate may be geographically dispersed making it impossible for collection companies to co-collect MSW and food waste. This is illustrated especially under the higher participation estimates for residential food waste in the bottom half of Table 13. Under this case, the number of truck hours required to separately collect food waste throughout each county are significant, but there are no real savings in MSW or recycling collection costs.

These costs would only come down significantly if all households participated, and MSW, recycling and food waste collection could be optimized.

TABLE 13 - Summary of Source Separated Food Waste Collection Costs, Low and High Recovery

Scenario	COUNTY			State-Wide
	NCC	Kent	Sussex	
Low - 20% Recovery ICI, 2% Recovery Residential				
ICI				
Carts (Number)	1,091	272	195	1,558
Dumpsters (Number)	132	37	41	209
Truck Hours/Week (1)	113	41	42	191
Total Cost (2)	$ 1,028,104	$ 357,280	$ 371,223	$ 1,719,197
Savings in MSW Collection	*$ (308,431)*	*$ (107,184)*	*$ (111,367)*	*$ (515,759)*
Net Cost	***$ 719,673***	***$ 250,096***	***$ 259,856***	***$ 1,203,438***
Cost Per Ton	$ 81	$ 106	$ 118	$ 90
Residential				
Carts (Number)	4,045	1,211	1,624	6,880
Truck Hours (1)	162	55	87	304
Total Cost (2)	***$ 1,247,307***	***$ 423,913***	***$ 658,227***	***$ 2,329,447***
Cost Per Ton	$ 1,583	$ 1,803	$ 2,394	$ 1,794
Total Collection System Cost	**$ 1,966,980**	**$ 674,009**	**$ 918,083**	**$ 3,532,885**
Cost Per Ton	***$ 204***	***$ 261***	***$ 372***	***$ 240***
High - 40% Recovery ICI, 10% Recovery Residential				
ICI				
Carts (Number)	2,275	528	389	3,192
Dumpsters (Number)	253	75	82	410
Truck Hours (1)	171	56	59	257
Total Cost (2)	$ 1,620,683	$ 522,864	$ 548,801	$ 2,477,761
Savings in MSW Collection	*$ (486,205)*	*$ (156,859)*	*$ (164,640)*	*$ (743,328)*
Net Cost	***$ 1,134,478***	***$ 366,005***	***$ 384,161***	***$ 1,734,433***
Cost Per Ton	$ 64	$ 78	$ 88	$ 65
Residential				
Carts (Number)	20,227	6,057	8,118	34,402
Truck Hours (1)	360	129	200	551
Total Cost (2)	***$ 2,964,290***	***$ 1,044,469***	***$ 1,593,869***	***$ 4,599,967***
Cost Per Ton	$ 752	$ 888	$ 1,159	$ 709
Total Collection System Cost	**$ 4,098,768**	**$ 1,410,473**	**$ 1,978,030**	**$ 6,334,400**
Cost Per Ton	***$ 189***	***$ 240***	***$ 343***	***$ 190***

1) *Truck hours do not sum across because of economies of scale and facility location*
2) *Costs do not sum across because truck hours change with single facility.*

PROCESSING COSTS

Construction and operating costs for either an anaerobic digester or an animal feed production facility have been estimated based on average costs per ton of installed capacity (AD facilities)[28] coupled with data available to DSM from other analyses carried out by DSM; and reported costs (Louie Pellegrini – for animal feed production). Additional capital costs which DSM has incorporated into our analysis include: site preparation costs; up-front food depackaging machines; the acquisition of rolling equipment (front loaders); purchase of a generator set in the case of a single AD facility located at Pine Tree[29] , engineering costs, and for an AD facility, digestate composting space and equipment. Amortization of these capital costs has been assumed at a borrowing cost of 3.5% spread over the lifetime of the capital – with buildings, site and engineering costs at 20 years, and rolling equipment spread over seven years.

Operating costs are assumed to be 4.5 percent of capital costs. While this is a very rough estimate, it can be considered sufficient for a preliminary economic analysis where there is no facility design.

In the case of an AD facility, DSM has assumed that the facility will process both food wastes as well as yard wastes – primarily grass clippings and small, chipped brush. While yard waste has a much lower energy production value than food waste, it can be processed in an AD facility.

Finally, energy or food recovery rates are based on literature reports (for AD facilities producing electricity), and conversations with Louie Pellegrini for feed production. For purposes of this analysis DSM has assumed that an AD facility will produce 200 kW hours of electricity per input ton, which will be sold at the average commercial retail electric rate of 3.5 cents per kW hour.

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[28] While DSM has assumed that an AD facility would be a high solids digester, the level of economic analysis is probably insufficient to distinguish between high or low solids digestion. In addition, the difference is blurred by the ability to construct high solids digesters that are continuous feed, by introducing holding tanks between the incoming food waste and the digester tank – which is the case for the proposed Trenton Bio-Gas Facility being proposed in Trenton, NJ.

[29] While it would be possible to tie into the existing generator sets at the DSWA landfills, because Pine Tree is not a landfill it does not have the gas collection system in place.

Animal feed output is based on: (1) an assumed loss rate of 35 percent for contaminant removal[30]; and, (2) moisture loss through dehydration from an assumed 85 percent moisture of the input food waste slurry, to a 10 percent allowable moisture content of the resulting animal feed. Sales are based on the mid-range of bulk animal feed reported by Sustainable Alternative Feed Enterprises of $275 per ton.

Tipping fees for the production facility are based on dividing net costs, after deducting energy or animal feed sales revenues, by the total input tons. At an AD facility accepting yard waste, this probably distorts the true tipping fee because yard waste typically can be recycled in Delaware at relatively low cost, and therefore the AD facility may have to lower the tip fee for this material.

DSM estimated facility costs for AD facilities located in each county, and accepting food waste and yard waste only from that county, as well as for a central facility assumed to be located at the Pine Tree transfer station. For an animal feed production facility, DSM estimated costs for a single central facility located at Pine Tree but accepting food waste from generators throughout Delaware.

Finally, DSM assumed that the digestate from any AD facilities would be composted, and then either used at DSWA landfills, or sold at zero dollars. This is primarily because DSM assumed food depackaging machines would be used to create an input slurry that was relatively contaminant free- but that the slurry would contain broken glass which would significantly reduce the value of the resulting composted digestate.

Tables 14 presents the detailed cost analysis for an AD facility located at Pine Tree, but accepting food waste state-wide. This is the lowest cost AD facility. Table 15 presents a detailed cost estimate for a single animal feed processing facility located at Pine Tree but accepting food waste from generators throughout Delaware.

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[30] This does not imply 35 percent contamination, it just means that a significant amount of food waste is lost to create a food slurry for dehydration that is clean enough for animal feed.

TABLE 14 – Cost Analysis, Single, State-Wide Anaerobic Digester

Pine Tree, Statewide Facility	**Low**	**High**
Anaerobic Digestion	**Input/Output/Cost**	**Input/Output/Cost**
Throughput		
Total Food Waste (tons/yr)	14,715	33,325
Yard Waste (tons/yr)	5,514	11,028
Total	20,230	44,354
Days of Operation	312	312
Daily Throughput	65	142
Energy Output		
kWh/ton	200	200
Total Output (kWh/yr)	4,045,918	8,870,782
Net assuming 20 % in plant use	3,236,735	7,096,626
Cost		
Cost/Ton installed capacity	$ 449	$ 449
Total Capital (including building)	$ 9,079,041	$ 19,906,035
Amortized Capital	$ (610,254)	$ (1,337,998)
Food Depacking Machine	$ 500,000	$ 500,000
Amortized Capital	$ (58,615)	$ (58,615)
Site Work and Pad Area (1)	$ 3,000,000	$ 4,000,000
Amortized Capital	$ (201,647)	$ (268,863)
Mobile Equipment	$ 250,000	$ 350,000
Amortized Capital	$ (40,127)	$ (56,177)
Total Capital	$ 12,829,041	$ 24,756,035
Engineering	$ 1,924,356	$ 3,713,405
Amortized	$ (129,347)	$ (249,599)
Total Amortized Capital	$ (1,039,990)	$ (1,971,253)
Operating Cost		
4.5 % of CAPEX	$ (577,306)	$ (1,114,021)
Annual Cost	*$ (1,617,296)*	*$ (3,085,273)*
Annual Cost/Ton	*$ (80)*	*$ (70)*
Revenues		
Electric Rate	$ 0.035	$ 0.035
Electric Revenue	$ 113,286	$ 248,382
Required Tip Fee	***$ (74)***	***$ (64)***

1) Includes digestate windrow composting area

TABLE 15 – Cost Analysis, Single, State-Wide Animal Feed Production Facility

State Wide - Pine Tree	**Low**	**High**
Animal Feed Production	**Input/Output/Cost**	**Input/Output/Cost**
Throughput		
Total Food Waste (tons/yr)	14,715	33,325
Days of Operation	312	312
Daily Throughput	47	107
Energy Output		
Mass Output (wet tons)	9,565	21,662
Feed Output (10% moisture)	1,578	3,574
Cost		
Total Capital (including building)	$ 6,000,000	$ 10,000,000
Amortized Capital	$ (403,294)	$ (672,157)
Site Work and Pad Area	$ 2,000,000	$ 3,000,000
Amortized Capital	$ (134,431)	$ (201,647)
Mobile Equipment	$ 250,000	$ 350,000
Amortized Capital	$ (40,127)	$ (56,177)
Total Capital	$ 8,250,000	$ 13,350,000
Engineering	$ 1,237,500	$ 2,002,500
Amortized	$ (83,179)	$ (134,599)
Total Amortized Capital	$ (661,032)	$ (1,064,581)
Operating Cost		
4.5 % of CAPEX	$ (371,249)	$ (600,749)
Annual Cost	*$ (1,032,281)*	*$ (1,665,330)*
Annual Cost/Ton	*$ (70)*	*$ (50)*
Revenues		
Feed Sales/Ton	$ 275.00	$ 275.00
Total Feed Sales	$ 434,011	$ 982,892
Net Cost	$ (598,270)	$ (682,438)
Required Tip Fee	***$ (41)***	***$ (20)***

COMBINING SOURCE SEPARATED FOOD WASTE COLLECTION COSTS AND PROCESSING COSTS

Table 16 combines the collection costs presented in Table 13 with organics processing costs presented in Tables 14 and 15 to provide total cost per ton estimates to separately collect and process food waste (either in an AD or animal feed processing facility) at the three DSWA locations.

As illustrated by Table 16, source separate food waste collection and processing is significantly more costly than continued disposal of food waste at a DSWA facility. This is a combination (except in the case of an animal feed facility) of the high cost per ton for organics processing and (especially) the high cost of source separate organics collection. This is especially the case of for AD processing at the county/landfill level.

TABLE 16 - Summary of Collection and Processing Costs for Source Separated Food Waste

Summary	New Castle County		Kent County		Sussex County		Statewide/Pine Tree	
	Low	High	Low	High	Low	High	Low	High
Throughput								
Food Waste (tons)	9,659	21,683	2,587	5,879	2,469	5,763	14,715	33,325
Yard Waste (tons)	2,588	5,175	1,793	3,586	1,134	2,267	5,514	11,028
Net Tip Fee/Ton								
AD Facility	$ (99)	$ (68)	$ (162)	$ (107)	$ (187)	$ (119)	$ (74)	$ (64)
Animal Feed							$ (41)	$ (20)
Collection Cost/Ton	$ (204)	$ (189)	$ (260)	$ (240)	$ (372)	$ (343)	$ (240)	$ (190)
Total Per Ton Cost								
AD Facility	***$ (303)***	***$ (257)***	***$ (423)***	***$ (347)***	***$ (558)***	***$ (462)***	***$ (314)***	***$ (254)***
Animal Feed							***$ (281)***	***$ (210)***

OBSERVATIONS CONCERNING DEVELOPMENT OF OFF-SITE PROCESSING FACILITIES FOR ORGANICS

It is clear from the above analysis that development of a stand-alone facility at a DSWA facility to process organic waste is cost prohibitive given both processing costs (especially for an AD facility) and the costs associated with separate collection of food waste for delivery to a facility.

One way to reduce the cost of an AD facility would be to deliver food waste to an AD facility that has been constructed to digest another homogeneous organic waste. The two logical examples are manure digesters and sludge digesters located at waste water treatment plants (WWTP).

There are no large-scale manure digesters in Delaware potentially available for DSWA food waste. However, the Wilmington WWTP digests sludge prior to dewatering, and has developed generator sets to recover the gas generated from the digesters to produce electricity for in-house use[31].

Similarly, while Kent County currently land applies sludge from their WWTP they are considering development of an AD facility to produce power for the WWTP from the sludge. Since this would be a new facility, it may be easier for DSWA and Kent County to investigate the potential to deliver slurried food waste from one or more DSWA facilities to a new sludge digester at the Kent County WWTP.

One potential way to co-develop a facility with Kent County (or for the Wilmington WWTP) would be for DSWA to explore acquisition of a food depackaging machine at one of DSWA's landfills or transfer stations that would accept high food waste content loads from specific ICI generators. The food depackaging machine could be used to separate out the contaminants, with the resulting slurried food waste then trucked to the AD facility, increasing the energy output of the facility.

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[31] Telephone conversation with Alec Reznick, August 3, 2017.

V. ENVIRONMENTAL IMPACTS OF OPTIONS

INTRODUCTION

When comparing diversion of recyclables from landfilling, the environmental impacts are typically measured based on avoided impacts from mining and manufacturing of materials and the greenhouse gas (GHG) emissions associated with the lower energy use to produce materials from recycled versus virgin materials.

In all cases, source reduction nets the greatest benefits because all of the mining and manufacturing impacts and associated GHG emissions are avoided.

A similar comparison for food waste is also possible. As illustrated in Figure 2 (found in Section IV), reducing food waste and loss, and re-purposing food waste has significantly greater environmental benefits than diverting food waste for composting or anaerobic digestion.

There are also micro-nutrient and soil tilth benefits associated with applying compost produced from food wastes to the soil. Unfortunately, these benefits are not easily quantifiable in economic terms, and are much more farming-specific, and site and soil specific, than simply comparing national data. And, to the extent that composted digestate from an AD facility is contaminated with broken glass and other contaminants, the soil benefits are significantly reduced because the resulting compost will have to be applied to low value uses such as shaping and grading at landfills, or mulch along highways.

There are also GHG emission benefits associated with diverting food waste from landfill. However, these benefits are not as significant as for recycling of anthropogenic (man-made) materials such as plastic or aluminum, when compared to biogenic materials such as paper or food waste. That is because to the extent that some portion of the biogenic materials disposed in a landfill do not degrade and produce methane over the assumed lifetime of the landfill, the EPA Waste Reduction Model (WARM) model assumes that this carbon is sequestered and therefore not released as a GHG.

There is some disagreement about this broad assumption, and while there is another US EPA funded model (Municipal Solid Waste Decision Support Tool, or MSW-DST) that allows one to vary this assumption[32] the WARM model remains

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[32] See for example recent work produced for Portland (OR) Metro by HDR comparing the WARM and MSW-DST model results from waste-to-energy versus landfilling of mixed solid waste from

the default model for evaluating GHG emissions from waste management alternatives, and was used in this analysis.

According to the Environmental and Energy Study Institute, "Landfills are the third largest source of anthropogenic (human caused) methane in the United States. According to the U.S. EPA, landfill gas comprises 17.7 percent of all U.S. methane emissions."[33]

There continues to be some disagreement about the global warming potential (GWP) of methane when compared to carbon because of the difference in the lifetime of methane when compared to carbon dioxide in the atmosphere. The current version of the WARM model (2016) assumes that the 100-year time horizon of methane has a GWP of 25 when compared to carbon dioxide, which is based on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. The more recent Fifth Assessment Report has increased the GWP to 28 when compared to carbon dioxide (with a GWP of 1), but the 2016 WARM model continues to use a GWP of 25.[34]

Because of the high GWP of methane, best management practices for landfills include installation of methane recovery wells in landfills, with the resulting methane (and other gases) either flared – turning the methane into carbon dioxide - or converted to energy. In Delaware, DSWA has installed collection systems with gas recovery at all three landfills, with the majority of the collected methane converted to energy – either as gas or burned in a generator set to produce electricity.

One potential method to reduce methane emissions from landfills is to divert organic matter to a composting or AD facility, preventing it from anaerobically breaking down in the landfill. This can be especially important in the operating cell because fully efficient gas collection typically does not begin until the cell is capped.[35] At an organics processing facility, either the organic waste is composted aerobically, producing carbon dioxide (and some methane under

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the Portland metro area. *Technical Memorandum, Thursday, July 06, 2017, Expansion of the Existing Covanta Waste to Energy Facility, Comparative Greenhouse Gas Analysis*

[33] http://www.eesi.org/files/FactSheet_Landfill-Methane_042613.pdf

[34] The IPCC Fourth Assessment Report was published in 2007, while the Fifth Assessment report, which assumes a 100-year time horizon GWP of Methane of 28, was published in 2013.

[35] *It takes typically 3 - 6 months from waste placement to full landfill gas generation. During the early stages of filling a cell, gas volume and methane content are typically low and operational factors limit effective gas collection. For example, operators can easily damage collection systems and daily (intermediate) cover with higher permeability reduces the efficiency of gas extraction. Source: Management of Low Levels of Landfill Gas Prepared by Golder Associates Ireland Limited on behalf of the Environmental Protection Agency, (Office of Environmental Enforcement).*

upset conditions), or is anaerobically digested in an enclosed vessel with the resulting methane captured and converted to energy.

There has been a significant amount of work over the past decade by U.S. EPA and other researchers to determine just how much methane is released from a well-managed landfill. This research can be used to compare DSWA methane emissions from its’ three landfills against the impact of diverting some portion of food waste and grass clippings to an organics processing facility, as described in Section IV, above.

DSM reviewed reported emissions from each DSWA facility and then ran the most recent version of the EPA WARM Model (2016) to examine the potential emissions impacts from employing different alternative management methods for food wastes and yard wastes currently landfilled.

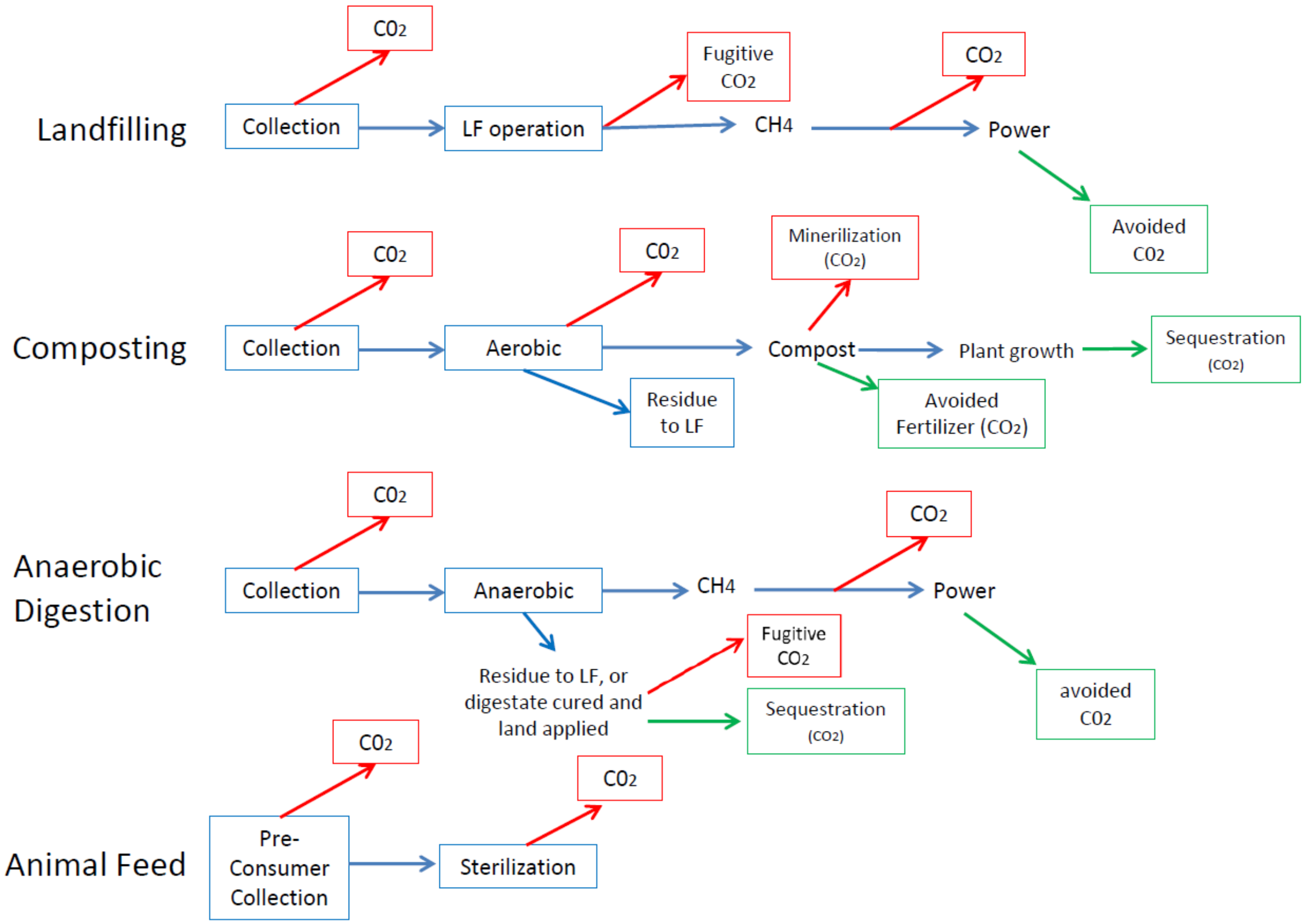
BACKGROUND

When organic waste breaks down - whether in a landfill or organics processing facility - gas byproducts are emitted. Uncontrolled emissions can occur before material is contained in a capped cell in the landfill; during mixing, screening or curing at a composting facility; and, during pre-processing before loading into a digester or curing of the digestate created. In addition, GHG emissions are generated from collection (combustion of diesel fuel by the collection truck).

Figure 3 (on the next page) illustrates where carbon equivalent emissions occur during different solid waste management practices, and also shows where carbon is stored and sequestered or emissions are avoided as a result of waste management and emissions control processes. Figure 3 also illustrates the potential emissions and offsets from managing recyclables.

As Figure 3 illustrates, emissions *reductions* also may be accounted for through different waste management practices. At landfills, gas recovery systems can be installed to capture gas for on-site use or when coupled with generator sets, to produce electricity that can be sold back into the grid (as is the case with DSWA). At composting facilities, controlled composting can produce soil amendments and/or compost products that can store carbon and replace nitrogen and phosphorus fertilizers. Finally, at anaerobic digestion facilities, gas can be captured and used as heat or fuel or converted to electricity. The resulting digestate can be cured/composted and land applied replacing nutrients and storing carbon.

Figure 3. GHG (Carbon Equivalent) Emissions from Organic Waste Management Options and Recyclables



EMISSIONS FROM LANDFILLING VS ANAEROBIC DIGESTION

Depending on the characteristics of the organic material handled and the environment in which it decomposes, gas byproducts may differ. While methane is a potent GHG, it also has high energy content. In an anaerobic digester, decomposition occurs in a closed, controlled setting, allowing for more efficient gas capture and unlike a landfill, occurs relatively quickly. Batch times may fall between 14 – 30 days depending on the system.

Depending on the system, digestate removed from the reactor can be dewatered and aerobically cured. The resulting compost is typically land applied and is assumed to store carbon and may offset nitrogen and phosphorus fertilizer use.

During landfilling, initial decomposition occurs in a relatively uncontrolled environment. Typically, once organic wastes are dumped on the landfill face, aerobic bacteria start to decompose the waste until oxygen is consumed, which typically lasts less than a week. Next, an anaerobic acid state further breaks down materials and finally, during the “methanogenic state”, bacteria decompose biodegradable materials into methane and carbon dioxide.

Depending on how long the organic waste remains in the operating cell, some methane from the anaerobic decomposition will be released to the atmosphere, but once the cell height reaches a certain stage, gas wells are installed and begin to capture methane. And, once the cell is capped, the vast majority of the methane is captured and either flared or utilized to produce energy.

While there has been disagreement in the literature as to the percent of methane released while organic waste is in the operating cell, versus capped, the most recent data would indicate that roughly 70 to 75 percent of the total methane is captured from well operated landfills – such as the three landfills operated by DSWA. This is not the case in all landfills and makes comparison of organics processing to landfilling site specific.

In essence, the closed cells in a well operated landfill act like anaerobic digesters – albeit inefficient ones because of the variable rate of moisture entering the cell, and the discontinuous nature of the organic waste when mixed with inorganic wastes.

In general, the decomposition rate in a landfill is affected by these factors:

- the composition of the waste stream;
- moisture content, pH, temperature and available nutrients which impact microbial growth; and,
- landfill operations (which can enhance or retard the rate of waste decomposition).[36]

The moisture content of the waste is critical in the rate of decomposition and tends to vary widely in landfills.[37] In addition, climate plays a factor with locations with higher rainfall totals, such as Delaware, enhancing decomposition in active cells.

APPLICATION OF THE EPA WARM MODEL

Because of the importance of GHG emissions to climate change, the U.S. EPA has developed the Waste Reduction Model (WARM) to model emissions from different methods of waste management and materials recovery systems. There are other models available, however, the long period of time that the WARM model has been available, coupled with continued vetting by environmental and waste management professionals, and periodic up-dates of the model as new data are developed, makes the WARM model the preferred method for comparing GHG emissions from applying alternative solid waste management systems.

The WARM model can be used to compare GHG emissions from a continuous single-stage, wet, mesophilic anaerobic digester, or from a single-stage, dry, mesophilic digester. While wet digestion is the most widely-used (when considering the number of facilities that co-digest food waste with wastewater sludge or with manure), dry digesters designed to accept food waste, yard trimmings and mixed organics process the majority of organics from mixed solid waste, and are projected to represent the majority of growth in the United States[38]. For this reason, DSM assumed the use of a dry digestion process/technology in running the WARM model.

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[36] ICF International for the U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)
Management Practices Chapters. February 2016.
[37] Ibid.
[38] *Anaerobic Digestion of Municipal Solid Waste, Report on the State of Practice,* Environmental Research & Education Foundation, August 2015, Revised February 2016.

The WARM model also assumes the biogas produced by the digester is used to heat the reactor and to generate electricity on-site, which is assumed to power the facility and sell excess to the grid.

In comparing GHG emissions from different solid waste management systems, collection emissions are accounted for, but typically are a minor component of total GHG emission. For purpose of this analysis, DSM has assumed that the collection miles would be *70 percent higher* with the addition of source separated collection of food wastes. This is because generators typically cannot eliminate refuse collection services when they separate organics. Instead, organics diversion typically adds another collection to accommodate management of source separated organics. The WARM model accounts for these additional collection emissions.

The WARM model also allows for identification of specific organic inputs. Four were used by DSM to best match data available in the recent waste characterization study:

- "Food waste (meat only)", which is a weighted average of the two meat-food type emission factors developed for WARM - beef and poultry. The weighting is based on the relative shares of these two categories in the U.S. food waste stream according to USDA (2012b) and therefore not meant to be representative of emissions from other types of meat.
- "Food waste (non-meat)", which is a weighted average of the three non-meat food type emission factors developed for WARM -grains, fruits and vegetables, and dairy products. The weighting is based on the relative shares of these three categories in the U.S. food waste stream according to USDA (2012b).
- "Fruits and vegetables" energy and emission factors consist of a weighted average mix of materials that reflects the relative contribution of different fruits and vegetables to the total U.S. waste stream based on the USDA Economic Research Service (ERS) loss-adjusted food availability data from 2010.
- Yard trimmings, which are assumed to be 50% grass, 25% leaves, and 25% tree and brush trimmings from residential, institutional and commercial sources.[39]

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[39] This is the default for yard waste in the WARM Model. Delaware has a much lower percentage of grass in the yard waste composition.

Emissions (and offsets) related to diverting organic materials to a digester include:

- Collection and transport of food waste to the digester (DSM accounted for a 70% increase in collection activity from separate organics collection);
- Equipment use and any biogas leakage at the digester vessel;
- Offsets such as an increase in soil carbon storage from application of digestate to soils (if applicable);
- CH4 and N2O emissions during digestate curing or the N2O emissions from land application of digestate;
- Avoided utility emissions from the production of gas or electricity from the facility; and,
- Avoided synthetic fertilizer use due to land application of digestate.

Emissions modeled in the WARM model related to landfilling include the following:

- Collection and transport of food waste in mixed solid waste to landfill;
- Operation of machinery at the landfill;
- Landfill methane offsets occurring because aerobic and anaerobic bacteria degrade material, producing CH4 (methane) and CO2 (carbon dioxide) although the WARM model counts only CH4 (methane) emissions, assuming CO2 (considered biogenic) is offset by CO2 captured by regrowth of the plant sources of the material;
- Avoided utility emissions due to landfill gas production of heat or electricity; and,

Landfill carbon storage is also included - food waste is not completely decomposed in the landfill, resulting in some carbon stored in the landfill -this stored carbon constitutes a sink (i.e., negative emissions) in the net emission factor calculation.

As discussed above, methane emissions vary across landfills depending on operations, the length of time operating cells remain open, and whether gas recovery occurs, and if it is flared (therefore producing CO2) or used for power generation.

For purposes of this analysis, DSM assumed that landfill gas recovery at DSWA facilities is aggressive (reducing emissions), and that the landfill is a relatively wet environment, consistent with Delaware's annual precipitation data (increasing emissions).

Further, as discussed above, DSM assumed that collection emissions were 70 percent higher for source separated collection of food waste when compared to straight landfilling. Finally, DSM assumed that the digestate from an anaerobic digester was composted before it was land applied (which increases emissions).

Applying these assumptions for managing 1,000 tons of each type of material in a digester compared to a landfill yield the results shown in Table 17. Table 17 illustrates that landfilling 1,000 tons of each of these four material streams (for a total of 4,000 tons) result in estimated emissions of 959 metric tons of C02 equivalent (MTC02E) from a DSWA modeled landfill, compared with diverting them to an AD facility where estimated emissions yield *reductions* of 247 MTCO2E for a *net change* (or reduction) of 1,207 MTCO2E.

In other words, landfilling the 4,000 tons at a DSWA modeled landfill (which includes gas collection and energy production) generates a net total release to the atmosphere of 959 MTCO2E, while digestion of these same source separated organics, with production of energy from the captured methane *reduces* discharge of GHG emissions by 247 MTCO2E because of the replacement of energy produced by burning a mix of coal, natural gas and oil and the sequestration of carbon. Eliminating these releases from the landfill *and* achieving savings from anaerobic digestion off-setting other power production yields a total improvement of 1,207 MTCO2E emissions per 4,000 tons of organic waste (1,000 of each of the four streams modeled).

TABLE 17 - Estimated GHG Emissions from Current Landfill Disposal in Delaware Compared with Anaerobic Digestion of the Same 1000 Tons

Organic Stream	*Tons*	**Landfilling** *(MTC02E)*	**Using AD Instead (with Curing)** *(MTC02E)*	**Change from Landfilling to AD** *(MTC02E)*
Food Waste (non-meat)	1,000	400	(52)	(452)
Food Waste (meat only)	1,000	400	(52)	(452)
Fruits and Vegetables	1,000	400	(52)	(452)
Yard Trimmings	1,000	(241)	(91)	151
Total:		**959**	**(247)**	**(1,207)**

Note that landfilling of yard trimmings is assumed to sequester carbon and thus has a positive impact on GHG emissions.

These emission factors are then applied to each DSWA facility based on annual tonnages that might be diverted to an AD facility under the most aggressive scenario (from Table 12, above). Using estimated diverted food waste tonnages from Table 12, and adding yard waste diversion (40% of ICI food and yard waste and 10% of residential food and yard waste), Table 18 shows the estimated emission reductions from each facility.

TABLE 18 - Estimated GHG Emissions (Reductions) Associated with 40% ICI and 10% Residential Diversion of Food Wastes and Yard Trimmings at each DSWA Landfill to Anaerobic Digestion, and Statewide Change in Emissions

	CHERRY ISLAND		**SANDTOWN**		**JONES CROSSROADS**		**STATEWIDE**	
Organic Stream	*(tons)*	*(MTC02E)*	*(tons)*	*(MTC02E)*	*(tons)*	*(MTC02E)*	*(tons)*	*(MTC02E)*
Food Waste (non-meat)	9,235	(4,179)	2,715	(1,228)	1,548	(700)	13,498	(6,108)
Food Waste (meat only)	3,181	(1,439)	958	(433)	1,166	(528)	5,305	(2,400)
Fruits and Vegetables	9,267	(4,193)	2,206	(998)	3,049	(1,380)	14,522	(6,571)
Yard Trimmings (1)	5,175	781	3,586	541	2,267	342	11,028	1,665
Total:	**26,858**	**(9,030)**	**9,465**	**(2,119)**	**8,030**	**(2,265)**	**44,353**	**(13,414)**

(1) Includes a small quantity of branches and stumps.

It is interesting to note, as discussed above, that anaerobic digestion of yard waste does not produce savings in GHG emissions over landfilling of the yard waste. This is primarily because the WARM model assumes that the woody waste does not break down rapidly, and therefore does not produce methane or carbon dioxide while in the operating cell, even though grass clippings do. Instead, the woody waste essentially is assumed to be part of the carbon sink in the capped landfill cells. In addition, the yard waste produces very little methane, compared to food waste, when anaerobically digested.

Finally, these reductions can be compared to total current emissions at each landfill to illustrate the hypothetical change in emissions at each facility. As illustrated by Table 19, diversion of 40 percent of ICI food and yard waste and 10% of residential food and yard waste from landfilling to anaerobic digestion (or 33,325 tons of food waste and 11,028 tons of yard waste) results in a net reduction in GHG emissions, statewide, of roughly 13,400 MTCO2 equivalent or 5 percent of current total emissions.

TABLE 19 - Estimated Potential Change in Emissions, By DSWA Facility and Statewide

	Cherry Island (MTC02E)	Sandtown (MTC02E)	Jones Crossroad (MTC02E)	All (MTC02E)
Current Eimissions (2016)	188,399	56,843	27,988	273,230
Reductions (Table 11)	(9,030)	(2,265)	(2,119)	(13,414)
Net Emissions:	179,369	54,578	25,869	259,816

(1) Reductions are from Table 18 and are calculated assuming the food waste diversion shown in Table 12, and detailed in Table 18, along with yard waste diversion shown in Table 18.

DSM also looked at emissions reductions from source reduction and composting, as compared to AD, as calculated in the WARM Model. Shown below (Table 20) are the results from source reducing, composting or using AD for managing 1,000 tons of each of the material streams. Note that for mixed paper, the results of source reduction compared with recycling 1,000 tons are shown for comparison.

TABLE 20 - Estimated Emissions from Source Reduction, Composting and AD by Material Type (Per 1,000 tons) (1)

Organic Stream	*Tons*	**Source Reduction** *(MTC02E)*	**Composting / Recycling** *(MTC02E)*	**AD / Recycling** *(MTC02E)*
Food Waste (non-meat)	1,000	(758)	(179)	(52)
Food Waste (meat only)	1,000	(15,098)	(179)	(52)
Fruits and Vegetables	1,000	(440)	(179)	(52)
Mixed Paper (Residential) (2), (3)	1,000	(6,647)	(3,529)	(3,529)

(1) Emissions shown are calculated from each management method per 1,000 tons of each organic stream and do not include emissions reductions (or savings) from disposal this material, which vary by disposal method and conditions.
(2) For Mixed Paper, the results other than Source Reduction come from Recycling as the Warm model does not model composting or AD emissions from mixed paper.
(3) Mixed Paper (primarily residential) = Corrugated Containers 53%, Magazines/Third-class Mail 10%, Newspaper 23%, Office Paper 14%

As shown in Table 20, there is a huge benefit from source reduction of most organics and of mixed paper, but less so for composting and AD of organics. This reinforces the findings that source reduction has significant environmental benefits as well as economic value per ton.

There is also a relatively high benefit from recycling newspaper (especially), as well as from recycling mixed recyclables, including cardboard, aluminum and steel cans, and to a lesser degree, plastic and glass. The estimated reduction in GHG emissions from managing organic streams can be compared against the impact on GHG emissions from increasing recovery of conventional mixed recyclables by looking at the impact of GHG emissions reductions at DSWA facilities, as illustrated by Table 21.

TABLE 21 - Comparison of the Change in GHG Emissions Associated with Equivalent Tons of Organic Waste When Compared to Mixed Recyclables (1)

	CHERRY ISLAND		**SANDTOWN**		**JONES CROSSROADS**		**STATEWIDE**	
Stream	*(tons)*	*(MTC02E)*	*(tons)*	*(MTC02E)*	*(tons)*	*(MTC02E)*	*(tons)*	*(MTC02E)*
Organics, All	25,912	(9,173)	6,869	(2,511)	7,021	(2,418)	39,802	(14,102)
Mixed Recyclables, Total	25,912	(66,524)	6,869	(17,636)	7,021	(18,025)	39,802	(102,185)
Difference in Emissions Reductions		**725%**		**702%**		**746%**		**725%**

(1) Mixed Recyclables in the WARM Model are: Aluminum Cans 1.4%, Steel Cans 2.7%, Glass 6.4%, HDPE 1.2%, PET 1.9%, Corrugated Containers 54.1%, Magazines/Third-class Mail 7.6%, Newspaper 10.6%, Office Paper 8.1%, Phonebooks 0.4%, Textbooks 0.7%, and Dimensional Lumber 5.0%.

The conclusion that can be drawn from Table 21 is that while there are soil productivity reasons for diverting food waste from landfills, the GHG emission impacts associated with capturing the energy inherent in the food waste through a dedicated anaerobic digester, compared to landfilling the same organic materials with capture of the majority of methane generated by the landfill are relatively minor, based on the emission factors and assumptions applied within the WARM model.[40] They are also relatively minor for composting, as shown in Table 20.

This compares against food waste source reduction, where understandably they are high due to upstream impacts. This also compares against recycling of mixed recyclables, which the WARM model estimates results in more than 7 times the emissions reductions on a per ton basis. In other words, from a GHG emissions reductions standpoint, investing in increasing recycling of mixed recyclables provides significantly greater GHG emission benefits than organics diversion.

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[40] The default value for methane capture from well managed landfills like the DSWA landfills range from 50 percent in years 2-4 one 75 percent by year 5.

VI. POTENTIAL NEXT STEPS

This analysis clearly shows that developing a central organics processing facility to divert food waste from DSWA landfills will result in significantly higher costs than continued landfilling, and with relatively minor GHG emission reductions. However, much higher GHG emissions reduction benefits lie in focusing on food waste reduction and even redistribution and at lower costs.

There are many other steps that Delaware can take, as described below, to continue to move forward with increasing diversion of food waste, other than through development of a central organics processing facility.

First, Delaware state agencies involved in food handling and preparation should begin assessing the potential to integrate food waste reduction training into their food safety programs, as well as teaming with trade organizations involved in food preparation. Grants might be made available to help achieve this.

Second, the Delaware State Legislature can consider expanding the already existing liability protection for edible food waste generators to be able to donate their food without having to go through the existing institutions, but under guidelines specified in the legislation and subsequent rule making.

Third, the Delaware Department of Agriculture could work with DSWA and DNREC to try to expand efforts to assist hog farmers, especially with sourcing pre-plate food waste. A logical way to start would be to develop an exchange where hog (and cattle) farmers as well as generators of pre-plate food waste could list on a free exchange organized by the Department of Agriculture.

Fourth, DNREC and DSWA should work with County and Municipal waste water treatment authorities to identify the most appropriate on-site treatment systems for food waste that will not negatively impact sewer line clogging or BOD, nitrogen and phosphorous limits. To the extent these systems can be identified, it may make sense to create grant funding that might help large food waste generators justify the cost of installation, given the potential savings in container rental, pull charges and tipping fees for heavy food waste.

Fifth, DSWA should meet with the Kent County Public Works Department to explore collaboration on the potential development of an anaerobic digester for production of energy from their sludge. It is DSM’s observation that co-digestion of waste water sludge and food waste is one way to lower the cost of AD facilities to the point where it is cost-effective when compared to landfilling of food waste.

Sixth, and similarly, DSWA should continue to discuss with the City of Wilmington the potential for delivery of slurried food waste to the Wilmington WWTP digesters of ICI food waste delivered to the Cherry Island Landfill and processed through a food depackaging machine.

Seventh, DSWA should continue working with the University of Delaware to research and develop on-site digestion options for food waste. The University currently has a small on-site digestion project at the Caesar Rodney Dining Hall. This program is diverting pre-plate and post-plate food waste to a small unit which breaks down food with enzymes and releases the digestate into the waste water treatment system. DSWA and the University should continue research of this technology and closely track the results. This research should include looking at diversion potential but also O&M issues, contamination levels and tolerance, emissions reductions, and digestate quality and applications.

Finally, DSWA should expand its education program to the public on the benefits of backyard composting and food waste disposal systems. DSWA should also consider developing a food waste diversion grant program which could provide funding to individuals or businesses that wish to engage in the practice of food waste diversion. DSWA could collaborate with the Delaware Recycling Public Advisory Council (RPAC) on the best practices to administer the grant application and review process.

APPENDIX A: DETAILED ANALYSIS OF ORGANICS PROCESSING ALTERNATIVES | REPORT TO THE DELAWARE SOLID WASTE AUTHORITY

FINAL REPORT | SEPTEMBER 2017

DSM ENVIRONMENTAL SERVICES, INC.
Resource Economists
Environmental Scientists

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SERVICES, INC.
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Environmental Scientists

Detailed Analysis of Organics Processing Alternatives

FINAL REPORT | SEPTEMBER 2017

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Introduction

This Appendix is designed to provide detailed background data and analysis on the potential to construct and operate an organics processing facility at one or more DSWA facility locations.

This analysis is intended to help meet the objectives of 2015 Delaware Senate concurrent resolution number 35 which recognized that a significant amount of waste disposed at DSWA landfills is organic, and that closure of the Wilmington Organics facility eliminated the primary method for diverting food waste (the largest component of organic waste) from landfills. Therefore, the Senate, with the concurrence of the House of Representatives created a task force to "*evaluate the best possible way to recycle organic waste in the State of Delaware in an odor free manner.*"

The Delaware Solid Waste Authority (DSWA), as the co-chair of the Task Force contracted with DSM Environmental Services, Inc. (DSM) to prepare a holistic analysis of food waste generation, reduction and recycling to serve as a guide for moving forward with diverting organic waste from landfilling, over and above the ban on yard waste disposal already in place.

Recognizing that three competent private companies had constructed, operated, and closed food waste composting facilities over the past several years, the primary goal of DSM's research into organics processing facilities was to analyze the costs and benefits associated with constructing a facility to recover the energy value of some portion of disposed food waste before it reached the landfill.

The push to increase diversion of organics is driven by both the assumption that overall diversion rates can increase significantly because of the weight of organics present in the waste stream, and, that methane emissions from DSWA landfills would be reduced by removing organics from disposal. However, because DSWA captures much of the methane generated in its' landfills, and produces power from some of it, the question is whether food waste diversion to an organics processing facility would be more effective (in terms of reducing greenhouse gas emissions) in comparison, and at what cost. The other question is what types of technologies could best utilize these materials, and at what cost?

This analysis is an economic analysis, not an engineering analysis, and is intended to be a feasibility level evaluation of the economic and environmental costs and benefits of diverting some portion of food waste (primarily) from DSWA landfills to an organics processing facility.

Analysis

DSM has undertaken the following tasks as part of this analysis.

Task 1: Manipulate the 2015 – 2016 Waste Characterization Data to determine quantities of food waste, by type, potentially available by DSWA facility location and by county

Task 2: Compile data on commercial food waste generators in Delaware to develop estimates of potential participation and capture rates by geographic region, and the estimated change in costs associated with separate collection of this food waste

Task 3: Compile preliminary capital and operating cost data on alternative food waste processing technologies

Task 4: Conduct a preliminary economic analysis of the identified processing facilities based on throughput by DSWA facility location

Task 5: Utilize the EPA WARM model to estimate greenhouse gas emissions (reductions) associated with organics processing technologies when compared to landfilling of the organic material with landfill gas capture

TASK 1: Estimation of Organic Waste Disposition by Facility and County

DSM has assumed that development of an organic processing facility would require siting at an existing DSWA facility. After discussions with DSWA, it was determined that there is inadequate site capacity at the Cherry Island landfill and at the Milford and Route 5 transfer stations. Therefore, facility data on waste disposal was aggregated to estimate organic waste deliveries to the other three DSWA facilities: Pine Tree transfer station; the Sandtown landfill; and, the Jones Crossroads landfill.

Currently waste delivered to the Pine Tree transfer station is transferred to the Sandtown landfill, even though the Pine Tree facility is located in New Castle County. Therefore, organics from Pine Tree are reported twice in this analysis. First, siting a facility at the Pine Tree transfer station would mean that organic waste currently delivered to the Cherry Island landfill would be delivered to Pine Tree along with organic waste currently delivered directly to Pine Tree. Second, an organics processing facility at the Sandtown landfill would rely on waste organic waste currently delivered to the Milton transfer station and organic waste delivered directly to Sandtown.

Finally, organic wastes from the Route 5 transfer station and waste delivered directly to the Jones Crossroads landfill were aggregated to represent organic waste generated and disposed in Sussex County.

These three scenarios represent the approximate throughput of an organics processing facility located at one of these three sites. DSM then also assessed the cost associated with construction of a central facility, probably located at the Pine Tree transfer station, that would be capable of handling organics from all three counties. Table 1 presents the data for the three potential facility locations. Note that this represents ***total organic waste disposed*** which is significantly greater than what would actually be delivered to an organics processing facility relying on source separation of organics.

TABLE 1. TOTAL DISPOSED FOOD WASTE BY COUNTY, FY 2016

Facility/County	Res *(tons/year)*	ICI *(tons/year)*	Total *(tons/year)*
New Castle County			
Food Waste	39,406	44,357	83,763
Tons/Day (312 days/year)	*126*	*142*	*268*
Yard Waste	6,943	10,166	17,108
Subtotal, Food and Yard Waste:	46,475	54,664	101,139
Kent County, Including Pine Tree			
Food Waste	17,660	18,315	35,975
Tons/Day (312 days/year)	*57*	*59*	*115*
Yard Waste	7,610	1,356	8,966
Subtotal, Food and Yard Waste:	25,327	19,729	45,056
Kent County Without Pine Tree			
Food Waste	11,756	11,759	23,515
Tons/Day (312 days/year)	*38*	*38*	*75*
Yard Waste	3,752	1,043	4,795
Subtotal, Food and Yard Waste:	15,546	12,840	28,385
Sussex County			
Food Waste	13,750	10,970	24,720
Tons/Day (312 days/year)	*44*	*35*	*79*
Yard Waste	5,070	598	5,668
Subtotal, Food and Yard Waste:	18,864	11,603	30,467
Total, Statewide			
Food Waste	64,912	67,086	131,998
Tons/Day (312 days/year)	*208*	*215*	*423*
Yard Waste	15,765	11,807	27,571
Total, Food and Yard Waste:	**80,677**	**78,892**	**159,569**

As illustrated Table 1, 63 percent of industrial/commercial/institutional (ICI) food waste disposed at DSWA facilities, and 56 percent of residential food waste, is from New Castle County. Given that food waste transport is relatively expensive (see discussion below), and capital costs for these types of facilities are high, the logical place to site an organics processing facility would be in New Castle County based on economies of scale. And given the site constraints at the Cherry Island landfill, the Pine Tree transfer station would be the preferred site for organics processing in New Castle County. However, it should also be noted that unlike the three DSWA landfill sites, there is no landfill gas recovery system at Pine Tree landfill, and therefore no electric generator set available to tie into. In addition, waste water from Pine Tree is trucked off-site, as opposed to piped off site at the three landfills. Construction of this infrastructure at Pine Tree adds to the capital cost of a facility located there.

The decision to site a full- scale organics processing facility in Kent or Sussex Counties instead would depend on whether organic waste generated in central or southern Delaware, but not currently going to a DSWA facility were identified and combined with food waste delivered to these DSWA facilities. The most logical source of significant quantities of organic waste generated in Delaware is the poultry growing and processing industry, which is primarily located in Sussex County. While DSM considered these organic waste streams, and reviewed their potential to be delivered to a DSWA facility, it was determined that attracting much of this organic material for processing at a DSWA facility is unlikely because most of it is already being beneficially used at relatively low cost. In addition, it is DSWA's desire to focus on materials that are currently being landfilled at DSWA facilities. Therefore, for the purposes of this analysis, DSM focused on organic waste that is currently delivered to DSWA facilities.

While ICI generated food waste is the logical point of diversion (because higher volumes are generated in single locations, and because some generators produce fairly homogenous organic streams), it represents only 51 percent (67,000 tons, rounded) of total food waste disposed at DSWA facilities (or 132,000 tons, rounded) as shown in Table 1. The percentage of ICI food waste is slightly higher in New Castle County but still only 53 percent. This is an important consideration in facility planning since ICI waste is typically much easier to source than residential waste.

Like recycling, not all food waste generation can be assumed to be source separated and delivered to an organics processing facility. For purposes of this analysis DSM has assumed that food waste diversion would be voluntary – as there is no mandate in Delaware for generators to separate and divert food waste from disposal, and there is no ban on disposal of food waste at DSWA landfills.

Tables 2 and 3 present estimates of the amount of organic waste diversion based on the assumption diversion is voluntary. Table 2 reflects potential start-up quantities, and Table 3 presents what DSM would consider to be reasonable recovery rates for a mature organics processing facility charging a tipping fee that is lower than DSWA landfill tipping fees.

Table 2 assumes a 20 percent capture rate of ICI generated food waste and a 2 percent capture rate of residential food waste. Table 3 assumes a 40 percent capture rate for ICI generated food waste and a 10 percent capture rate for residential food waste. These rates are what DSM believes are reasonably achievable in the short term (3-10 years) given the current economics of separate food waste collection and processing, and the factors motivating both ICI and residential generators to separately manage organics.

For example, peak deliveries of Delaware generated food waste to separate processing facilities for composting represented less than 20 percent of total food waste disposed at Delaware facilities in 2013 - 2014 when the Wilmington Organics Recycling facility (WORC) was still in operation, and the Blue Hen composting facility still accepted food wastes.

To achieve overall food waste recovery rates of 20 to 40 percent, it is necessary to capture 35 and 60 percent respectively of food wastes from the four major ICI food waste generator categories (as discussed under Task 2 and illustrated in Tables 5 and 6).

Tables 2 and 3 illustrate annual throughput and daily throughput of food waste only, assuming 312 operating days per year at each potential site. While it is possible to add yard wastes to an anaerobic digester, the impact on energy production is quite limited. Therefore, while DSM assumes that some portion of yard waste would be utilized in our cost analysis in Task 3, the key to collection costs will be diversion of food waste. As such, DSM has concentrated our collection analysis on food waste only.

As illustrated in Table 3, even with relatively aggressive assumptions about recovery rates, daily throughput is still quite low, except for a single facility drawing food waste from the entire State. These low throughput rates will impact costs for full scale implementation, as discussed in Task 4.

TABLE 2. START-UP CAPTURE RATES FOR FOOD WASTE, ICI AND RESIDENTIAL (FY 2016)

Facility/County	**FY 2016 Res** 2%	**FY 2016 ICI** 20%	**FY 2016 Total**
New Castle County			
Food Waste Only	788	8,871	9,659
Tons/Day (312 days/year)	3	28	31
Kent County Without Pine Tree			
Food Waste Only	235	2,352	2,587
Tons/Day (312 days/year)	1	8	8
Sussex County			
Food Waste Only	275	2,194	2,469
Tons/Day (312 days/year)	1	7	8
Total, Statewide			
Food Waste Only	1,298	13,417	14,715
Tons/Day (312 days/year)	4	43	47

TABLE 3: REASONABLY ACHIEVABLE CAPTURE RATES FOR FOOD WASTE, ICI AND RESIDENTIAL (FY 2016)

Facility/County	**FY 2016 Res**	**FY 2016 ICI**	**FY 2016 Total**
	10%	40%	
New Castle County			
Food Waste	3,941	17,743	21,683
Tons/Day (312 days/year)	13	57	69
Kent County Without Pine Tree			
Food Waste	1,176	4,704	5,879
Tons/Day (312 days/year)	4	15	19
Sussex County			
Food Waste	1,375	4,388	5,763
Tons/Day (312 days/year)	4	14	18
Total, Statewide			
Food Waste	6,491	26,834	33,325
Tons/Day (312 days/year)	21	86	107

TASK 2: Compile Data on Commercial Food Waste Generators

While it is possible to run mixed solid waste through a depackaging machine, produce a slurry and process it in an organics processing facility, the cost to operate the depackager and the high levels of contamination in the resulting slurry typically make processing mixed solid waste both economically and technically, from an engineering point of view, unfeasible.

Currently, most organics processing facilities target source separated organic waste, which still contains some contamination but is primarily high nitrogen food waste. As illustrated by Tables 2 and 3, DSM has assumed that the majority of source separated food waste would come from ICI sources. This is because these generators tend to generate larger quantities of more homogeneous organic wastes than households, and have a greater incentive to source separate this material to reduce their waste disposal costs and/or attain sustainability goals.

DSM has concentrated this analysis on potential large generators of organic waste (primarily food waste) that currently dispose of their waste at DSWA facilities. As stated above, while DSM has made a limited effort to identify food processor waste that is not currently going to a DSWA facility, to date no single facility stands out as a potential contributor.

Organics Generation by County and Commercial Sector

As illustrate by Table 4, while many different types of businesses generate some food waste, the largest generator types analyzed during the FY 2016 Waste Characterization are grocery stores, convenience stores, and restaurants. Table 4 shows the percentage of food and yard waste found in each of these generator categories, when compared to small and large retail generators and office generators.

Institutions - such as hospitals and schools – also tend to generate large quantities of food waste, but were not targeted during the waste characterization study.

TABLE 4. PERCENT OF ICI WASTE DISPOSED BY GENERATOR CATEGORY, FY 2016 WASTE CHARACTERIZATION

Material Type	**Small Retail**	**Large Retail**	**Office**	**Restaurant**	**Convenience Store**	**Grocery Store**
	Percent of Total Waste	Percent of Total Waste	Percent of Total Waste	Percent of Total Waste	Percent of Total Waste	Percent of Total Waste
Food Waste	20.0%	7.5%	11.2%	48.6%	55.2%	28.7%
Yard Waste	0.5%	1.8%	1.0%	0.6%	2.0%	1.3%
Total	20.5%	9.3%	12.2%	49.2%	57.2%	30.0%

To estimate food waste potentially available in each county (for processing at Pine Tree, Sandtown, and Jones Crossroads) by the large food waste generator categories shown in Table 4, plus institutional generators, two steps were taken. First, the number of businesses and employees per business were estimated for each generator type in order to apply a food waste generation coefficient. DSM relied on county level data compiled by the U.S. census, and reported by North American Industry Classification System (NAICS) code, and compared this against data compiled by trade associations in Delaware to estimate the number of establishments and total employment by county.

Second, DSM conducted a literature search to find per employee food waste generation coefficients that could be applied to each generator category. Unfortunately, there are not a lot of data points available to choose from, and few that are recent. Ultimately DSM decided to utilize the generation coefficients compiled by Recycling Works Massachusetts for their Food Waste Estimation Guide for Massachusetts.[1] The Recycling Works data provided generation coefficients for restaurants, hospitals, grocery stores and K-12 schools. These generation coefficients were supplemented by DSM, using the Annual Delaware Recycling Report (and employment per location) for food waste generation by category, when the data were available.

Total estimated generation by sector was then compared against the FY 2016 Waste Characterization Study to confirm that the estimates were reasonable in the context of quantities disposed at DSWA facilities by county, and were adjusted where necessary based on DSM's best professional judgement.

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[1] Recycling Works Massachusetts. Food Waste Estimation Guide. Retrieved from: http://recyclingworksma.com/food-waste-estimation-guide/#Jump06

Estimated Organic Waste Generation by Category and County

Restaurants

A total of 1,889 restaurants are reported to be operating in Delaware employing a total of 35,000 full time employees.[2] Using County Business Pattern (CBP) data by NAICS code, it is estimated that roughly 55 percent of restaurants are operating in New Castle County, 32 percent in Sussex County, and the remaining 13 percent in Kent County.

The total number of full time restaurant employees per county was also obtained from CBP data. Food waste originating from restaurants was calculated using a generation coefficient of 1,500 pounds per employee per year. In the case of Sussex county, it was assumed that the majority of restaurants are highly seasonal, and therefore many employees are not full time. In this case a generation coefficient of 600 pounds per employee per year was used, which aligned closely with the available data on total ICI food waste disposed at the Rt. 5 Transfer Station and Jones Crossroads Landfill.

Grocery

One hundred and sixty-one grocery stores are reported to be operating in Delaware according to CBP data. Using data reported to DSM for the Annual Delaware Recycling Report, Delaware grocery stores are estimated to divert roughly 52 tons of food waste per year on average. Using this reported diversion rate, Delaware grocery stores are estimated to be capable of diverting 8,300 tons of food waste in 2016 (rounded), with New Castle grocers capable of diverting 4,538 tons, Kent County 1,186 tons, and Sussex County 2,578 tons.

Convenience Stores

The Association for Convenience and Refueling reported a total of 348 convenience stores operating in Delaware.[3] Using percentages determined from CBP data, it is estimated that roughly 69 percent of convenience stores are located in New Castle County, 12 percent are located in Kent County, and 19 percent in Sussex County. As reported in the FY 2016 Waste Characterization Study, 57 percent of the total waste produced by convenience stores is organic waste.

No generation coefficients for convenience stores were found in the literature, but given an estimated waste composition of 57% (Table 4), an assumption was made that each store was one tenth the size of a grocery store but produced twice as much food waste per location. This resulted in an estimated food waste generation coefficient of 10 tons per convenience store.

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[2] National Restaurant Association. State Statistics: Delaware Restaurant Industry at a Glance. Retrieved from: http://www.restaurant.org/Downloads/PDFs/State-Statistics/2016/DE_Restaurants2016.pdf

[3] The Association for Convenience & Refueling Retailing: U.S. Convenience Store Count. Retrieved from: http://www.nacsonline.com/Research/FactSheets/ScopeofIndustry/Pages/IndustryStoreCount.aspx

Institutions

Hospitals:

Hospital food waste was estimated using a generation coefficient of 3.42 pounds per hospital bed per day, with Delaware reported to have a total of 2,934 hospital beds.[4] Therefore, total estimated food waste generation by Delaware hospitals is 1,831 tons, with 1,306 tons generated in New Castle County, 262 tons originating in Kent County, and 263 tons originating in Sussex County.

Universities, Colleges and Vocational Schools:

Seventeen universities and colleges with significant student populations operate in Delaware, with an estimated population of 11,002 on-campus and 46,927 off-campus (which include students taking classes part time). Using a generation coefficient of 141.75 pounds of food waste per on-campus student per year, and 37.8 pounds per off-campus student, DSM estimated that 1,667 tons (rounded) of food waste are generated from these universities and colleges annually.

K-12 Public Schools:

Using data obtained from the Delaware Department of Education, there are 220 K-12 Public Schools operating in Delaware, with a total of 136,027 students.[5] Using a generation coefficient of 0.5 pounds of food waste per student per week, it was estimated that a total of 884 tons of food waste are produced from Delaware K-12 Public Schools. By county, New Castle generates 511 tons, Kent, 198 tons and Sussex, 175 tons.

Summary

Table 5 summarizes estimated 2016 generation by commercial generators of large quantities of food waste. Table 5 also compares estimated generation by these four generator categories against the total amount of commercial food waste disposed at DSWA facilities in each county. As illustrated by Table 5, these four generator categories are estimated to dispose, on average, 57 percent of total ICI food waste disposed in Delaware. The remaining ICI food waste is assumed to be generated by all of the other ICI activities – for example office buildings (cafeterias), retail establishments (Walmart has food service located in many of their stores), bakeries, and hotels.

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[4] U.S. News & World Report. Best Regional Hospitals Rankings. Retrieved from: http://health.usnews.com/best-hospitals/area/de

[5] State of Delaware Department of Education: School Profiles. Retrieved from: http://profiles.doe.k12.de.us/SchoolProfiles/State/Default.aspx

TABLE 5. ESTIMATED FOOD WASTE GENERATION BY COMMERCIAL GENERATOR AND BY COUNTY, 2016

County	Institutions	Restaurant	Grocery	Convenience Stores	Total Food Waste, Four Generator Categories	Total Food Waste Disposed, FY 2016 Waste Characterization	Percent Represented by Four Generators Categories
	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)
New Castle	3,680	14,383	4,538	2,404	25,005	44,357	56%
Kent	925	3,426	1,186	431	5,968	11,759	51%
Sussex	671	3,376	2,578	646	7,272	10,970	66%
Total	5,276	21,185	8,303	3,480	38,244	67,086	57%

Tables 6 and 7 then illustrate recovery rates that would be necessary from these four generator categories to come close to achieving the overall recovery rates assumed in Tables 2 and 3. As illustrated by Tables 6 and 7, targeting these four generator categories would yield roughly 85 percent of the total food waste necessary to achieve the overall ICI recovery rates with the remaining coming from other ICI generator sources.

It should be noted here that achieving a 60 percent recovery rate would, in DSM's professional opinion, be a significant achievement.

TABLE 6. PERCENT SHARE OF TOTAL ICI FOOD WASTE DELIVERED FROM FOUR GENERATOR CATEGORIES AT 30 PERCENT RECOVERY RATE FROM THOSE GENERATORS (2016 TONS)

County	Institutions	Restaurant	Grocery	Convenience Stores	Total Food Waste, Four Generator Categories	Total Estimated ICI Food Waste @ 20% Recovery (Table 2)	Percent of Available ICI Food Waste
New Castle County	1,104	4,315	1,361	721	7,501	8,871	85%
Kent	278	1,028	356	129	1,790	2,352	76%
Sussex	201	844	774	194	2,013	2,194	92%
Total	1,583	6,187	2,491	1,044	11,304	13,417	84%

TABLE 7. PERCENT SHARE OF TOTAL ICI FOOD WASTE DELIVERED FROM FOUR GENERATOR CATEGORIES AT 60 PERCENT RECOVERY RATE FROM THOSE GENERATORS (2016 TONS)

County	Institutions	Restaurant	Grocery	Convenience Stores	Total Estimated Food Waste	Total Estimated ICI Food Waste @ 40% Recovery (Table 3)	Percent of Available ICI Food Waste
New Castle County	2,208	8,630	2,723	1,442	15,003	17,743	85%
Kent	555	2,056	712	258	3,581	4,704	76%
Sussex	403	1,857	1,547	387	4,194	4,388	96%
Total	3,166	12,542	4,982	2,088	22,778	26,834	85%

TASK 3: Compile Preliminary Capital and Operating Cost Data on Alternative Food Waste Processing Technologies

There are multiple types of technologies that can be used to process organics. Typically, processing is used to recover the energy value of the food waste or the soil improving characteristics of processed food and yard wastes. This report focuses on three primary types:

- Composting
- Anaerobic Digestion
- Conversion of food waste to animal feed

A brief over-view of each technology is provided below, followed by DSM's assessment of the applicability to development by DSWA – or by a private company contracting with DSWA.

Composting

Composting is a biological waste management option which uses the natural process of biological decomposition under controlled conditions to produce a stable end-product. The resulting compost is not high in fertilizer value, but if it is fully composted it can improve the soil water-holding capacity and allow better utilization of fertilizers. The key to successful composting is to make sure that contaminants such as metals, plastics and other non-organic wastes are kept out of the compost, and that the organic materials are *stable,* which means the decomposition process is complete before the material is applied to areas where crops are grown.

Decomposition is conducted primarily by organisms naturally present in nature, including beetles, ants and worms, and microscopic organisms such as bacteria and fungi. These organisms reproduce rapidly on the organic material, using it as a source of food. It is the growth of these micro-organism populations which result in the rapid degradation of organic material in the compost mass. Heat, carbon dioxide, water vapor, and compost are produced when the process is managed correctly.

Two categories of micro-organisms are active in composting. At temperatures above freezing, insects, worms and microscopic organisms become active. As a result of their activity, the temperature within the compost pile increases. At temperatures in excess of 110°F, bacteria and fungi become active, increasing the rate of decomposition. As the temperature approaches 150°F, the rate of decomposition begins to decline rapidly as organisms begin to die off or assume dormant forms.

Composting is an aerobic process, which means it occurs in the presence of oxygen. When oxygen is present, organisms release carbon dioxide and water vapor. If the oxygen content falls below a level of about five percent, these organisms begin to die off and the composting process is taken over by anaerobes, organisms which do not require oxygen.

Anaerobes operate much less efficiently and create bad odors. Odorless methane is also produced in the absence of oxygen. Since anaerobic degradation is less efficient, it takes longer to achieve a stable product. Conditions leading to anaerobic decomposition, and bad odors include:

- Piles of organic material that are too large or tightly packed; and,
- Piles that are too wet.

Compost organisms need a moist environment. The amounts of air and water in a composting pile are related, so rapid decomposition requires a proper balance. For most composting methods, the optimal moisture content is 40 to 60 percent, by weight. Moisture is required to dissolve the nutrients utilized by composting organisms as well as to provide a suitable environment for microbial population growth.

A moisture content below 40 percent limits the availability of nutrients and limits this microbial population expansion. When the moisture content exceeds 60 percent, the flow of oxygen is slowed and anaerobic conditions begin to develop.

An understanding of the concept of the carbon to nitrogen (C:N) ratio is also necessary to manage a compost operation. Carbon and nitrogen are the primary elements that organisms need for food. Compost organisms get their energy from carbon found in carbohydrates, such as the cellulose in the organic matter. Nitrogen is necessary for the population growth of micro-organisms which decompose the organic material. A simple way to think about it is brown and green waste streams. The brown is high in carbon, the green is high in nitrogen.

The description above is included in this report because it is often assumed that composting is easy, and that it is the only way to manage organic waste. However, Delaware has had three recent examples of competent owner/operators who have had to close, or significantly curtail their operations – these include Blessing's, Blue Hen, and Wilmington Organics. As such, it is not a given that the most logical organic processing facility would be a composting facility.

Because three reputable firms have recently tried to implement composting systems in Delaware that incorporated food waste, and all three have either shut down or significantly reduced operations, DSM does not consider construction of a large-scale composting facility by DSWA to be a logical way to divert large quantities of food waste from DSWA landfills. Instead, DSM has concentrated our analysis on anaerobic digestion and animal feed production, with the assumption that if neither of these alternatives proves economically feasible, DSWA could always experiment with accepting small quantities of food waste for mixing with yard waste in low technology windrow composting operations at one or more of their landfills or transfer stations.

Anaerobic Digestion

According to a National Renewable Energy Laboratory (NREL) *Feasibility Study of Anaerobic Digestion of Food Waste in St. Bernard, Louisiana* (January, 2013), *"Food wastes are an excellent candidate for Anaerobic Digestion (AD) due to high moisture and organic content. AD is the natural, biological degradation of organic matter in absence of oxygen yielding biogas. Biogas is comprised of 60-70% methane and 30-40% carbon dioxide and other trace gasses. Biogas is capable of operating in nearly all devices intended for natural gas."*

The NREL report goes on to state, "*AD technologies are typically optimized for either low solids or high solids content. Alternatively, these technologies are referred to as wet or dry even though the feedstock generally has moisture content above 70%. Low solids refers to wastes with a solid content of 3% - 10%, and high solids refers to solid content of 15% or more. Wet systems (low solids) … are the most common and often deployed at WWTPs. Wet systems slowly mix feedstocks with microbes to increase the speed of degradation.*" For this reason, most wet systems are continuous feed systems, when compared to dry systems, which are often batch feed systems.

Finally, the NREL report states, "*There are few examples of food waste digestion in the United States. Existing or planned stand-alone systems are increasingly evaluating high solids/dry digester technologies. Dry digestion is common for food wastes in Europe. Dry systems can be built to scale-up as more wastes become available.*"

For purposes of this analysis DSM has assumed that development of an anaerobic digester to manage food waste currently being disposed at DSWA landfill would most likely be a dry (high solids) digester. This could change if DSWA were to identify one or more large generators of wet, homogeneous waste that could be mixed with the food waste, in which case a wet system (low solids) might make more sense. Further, because DSWA primarily uses diesel fuel to run its landfill equipment, DSM has assumed that the gas produced by an anaerobic digester would be used to power an electric generator set selling electricity to the grid. This assumption has economic implications, because roughly 60 percent of the energy available from the digester is lost as heat during the production of electricity. Pine Tree does not have a generator set already (unlike the landfills) so costs to construct an AD facility at Pine Tree need to include a generator set. In addition, unlike Sandtown and Jones Crossroads which are relatively isolated sites, Pine Tree is located nearer residential and commercial development so odor issues would also have to be closely monitored and controlled.

It should be noted that there is a demonstration project reported in the literature which uses the methane generated by the AD facility to produce power, but then converts the carbon dioxide to fuel using algae. This demonstration project is being conducted by University of Cincinnati in conjunction with Rumpke.

Conversion of Food Waste to Animal Feed

An alternative processing technology that is of interest to DSWA would be to convert the energy value inherent in food waste to animal feed. This could potentially be attractive in Delaware because of the large poultry production activity in the southern part of the state.

There are at least two facilities in the demonstration/operational stage in the U.S. One if Florida (Nutritious Foods, Inc.) and one in California (Sustainable Alternative Feed Enterprises). In both cases, the incoming food waste is inspected by sorters to remove large contaminants, and then ground/slurried, run through screens to remove additional contaminants, dehydrated and pelletized or milled, for mixing with other nutrients for industrialized agricultural enterprises.

There are, however, several limitations associated with this technology.

First, to protect against the threat of bovine spongiform encephalopathy (BSE) only non-meat food waste can be converted to animal feed if the feed is to be fed to ruminant animals.[6] While this does not apply to poultry, it does reduce the potential marked for the resulting animal feed. However, according to Louie Pellegrini, Sustainable Alternative Feed Enterprises, the protein in meat wastes is an important source of protein in the animal feed and therefore it is necessary to forego the ruminant market.[7]

The second significant limitation to the use of ICI food waste to produce animal feed is contaminants. While contaminants are of concern to both composting and anaerobic digestion, they are a much greater concern with respect to the production of animal feed. Glass, especially, would be considered a significant contaminant. For this reason, it is essential to employ significant processing steps to assure that removal of glass and other contaminants during the conversion process.

Processing Costs

Construction and operating costs for either an anaerobic digester or an animal feed production facility have been estimated based on average costs per ton of installed capacity (AD facilities)[8] coupled with data available to DSM from other analyses carried out by DSM; and reported costs (Louie Pellegrini – for animal feed production). Additional capital costs which DSM has incorporated into our analysis include: site preparation costs; up-front food depackaging machines; the acquisition of rolling equipment (front loaders); and, engineering costs. Amortization of these capital costs has been assumed at a borrowing cost of 3.5% spread over the lifetime of the capital – in the case of buildings, site and engineering costs – 20 years, with rolling equipment spread over seven years.

Operating costs are assumed to be 4.5 percent of capital costs. This is obviously a very rough estimate, but considered sufficient for a preliminary economic analysis where no design of the facility has been prepared and costed out.

In the case of an AD facility DSM has assumed that the facility will process both food wastes as well as yard wastes – primarily grass clippings and small, chipped brush. This material has a much lower energy production value than food waste, but can be processed in an AD facility.

Finally, energy or food recovery rates are based on literature reports (for AD facilities producing electricity), and conversations with Louie Pellegrini for feed production. For purposes of this analysis DSM has assumed that an AD facility will produce 200 kW hours of electricity per input ton, which will be sold at the average commercial retail electric rate of 3.5 cents per kW hour.

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[6] See for example, *Leftovers For Livestock: A Legal Guide for Using Food Scraps as Animal Feed*, Harvard Food Law and Policy Clinic and University of Arkansas School of Law, August, 2016.

[7] Telephone conversation, March 30, 2017

[8] While DSM has assumed that an AD facility would be a high solids digester, the level of economic analysis is probably insufficient to distinguish between high or low solids digestion. In addition, the difference is blurred by the ability to construct high solids digesters that are continuous feed, by introducing holding tanks between the incoming food waste and the digester tank – which is the case for the proposed Trenton Bio-Gas Facility being proposed in Trenton, NJ.

Animal feed output is based on an assumed loss rate of 35 percent for contaminant removal[9], and moisture loss through dehydration from an assumed 85 percent input percent moisture of the food waste slurry, to a 10 percent allowable moisture content of the resulting animal feed. Sales are based on the mid-range of bulk animal feed reported by Sustainable Alternative Feed Enterprises of $275 per ton.

Tipping fees for the production facility are based on dividing net costs, after deducting energy or animal feed sales, by the total input tons. In the case of an AD facility this includes yard waste, which probably distorts the true tipping fee because yard waste can typically be recycled of it in Delaware at relatively low cost.

DSM estimated facility costs for AD facilities located in each county, and accepting food waste and yard waste only from that county, as well as a central facility assumed to be located at Pine Tree. DSM only estimated facility costs for a single animal feed production facility assumed to be located at Pine Tree but accepting food waste from generators throughout Delaware.

Finally, DSM assumed that the digestate from an AD facility would be composted and then either used on-site at the landfill, or sold at zero dollars. This is primarily because of DSM's assumption that food depackaging machines would be used to create an input slurry that was relatively contaminant free- but that the slurry would contain broken glass which would significantly reduce the value of the resulting composted digestate.

Tables 8 presents the detailed cost analysis for an AD facility located at Pine Tree, but accepting food waste state-wide. This is the lowest cost AD facility. Table 9 summarizes costs for AD facilities located in each county and accepting food waste and yard waste only from generators within that county.

Table 10 presents a detailed cost estimate for a single animal feed processing facility located at Pine Tree but accepting food waste from generators throughout Delaware.

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[9] Note that this does not assume that food waste delivered to the facility is non-food contaminants, instead that to assure a very low level of contaminants in the outgoing dried feedd

TABLE 8. ESTIMATED FACILITY COST, ANAEROBIC DIGESTION, SINGLE FACILITY LOCATED AT PINE TREE TRANSFER STATION

Pine Tree, Statewide Facility	**Low**	**High**
Anaerobic Digestion	**Input/Output/Cost**	**Input/Output/Cost**
Throughput		
Total Food Waste (tons/yr)	14,715	33,325
Yard Waste (tons/yr)	5,514	11,028
Total	20,230	44,354
Days of Operation	312	312
Daily Throughput	65	142
Energy Output		
kWh/ton	200	200
Total Output (kWh/yr)	4,045,918	8,870,782
Net assuming 20 % in plant use	3,236,735	7,096,626
Cost		
Cost/Ton installed capacity	$ 449	$ 449
Total Capital (including building)	$ 9,079,041	$ 19,906,035
Amortized Capital	$ (610,254)	$ (1,337,998)
Food Depacking Machine	$ 500,000	$ 500,000
Amortized Capital	$ (58,615)	$ (58,615)
Site Work and Pad Area (1)	$ 3,000,000	$ 4,000,000
Amortized Capital	$ (201,647)	$ (268,863)
Mobile Equipment	$ 250,000	$ 350,000
Amortized Capital	$ (40,127)	$ (56,177)
Total Capital	$ 12,829,041	$ 24,756,035
Engineering	$ 1,924,356	$ 3,713,405
Amortized	$ (129,347)	$ (249,599)
Total Amortized Capital	$ (1,039,990)	$ (1,971,253)
Operating Cost		
4.5 % of CAPEX	$ (577,306)	$ (1,114,021)
Annual Cost	*$ (1,617,296)*	*$ (3,085,273)*
Annual Cost/Ton	*$ (80)*	*$ (70)*
Revenues		
Electric Rate	$ 0.035	$ 0.035
Electric Revenue	$ 113,286	$ 248,382
Required Tip Fee	***$ (74)***	***$ (64)***
(1) Includes digestate windrow compost area		

TABLE 9. COMPARISON OF AD FACILITY COSTS FOR FACILITIES LOCATED AT PINE TREE, SANDTOWN, AND JONES CROSSROADS

Summary	New Castle County		Kent County		Sussex County		Statewide/Pine Tree	
Anaerobic Digestion	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Throughput								
Total Food Waste (tons/yr)	9,659	21,683	2,587	5,879	2,469	5,763	14,715	33,325
Yard Waste (tons/yr)	2,588	5,175	1,793	3,586	1,134	2,267	5,514	11,028
Total	12,247	26,858	4,380	9,465	3,603	8,030	20,230	44,354
Days of Operation	312	312	312	312	312	312	312	312
Daily Throughput	39	86	14	30	12	26	65	142
Cost								
Amortized Capital	$ (830,628)	$ (1,269,947)	$ (494,607)	$ (735,614)	$ (455,773)	$ (647,772)	$ (1,039,990)	$ (1,114,021)
Operating	$ (455,423)	$ (711,178)	$ (259,804)	$ (400,110)	$ (237,197)	$ (348,971)	$ (577,306)	$ (3,085,273)
Total Cost	$ (1,286,051)	$ (1,981,126)	$ (754,411)	$ (1,135,723)	$ (692,969)	$ (996,743)	$ (1,617,296)	$ (3,085,273)
Revenues								
Electric Revenue	$ 68,583	$ 150,406	$ 25,190	$ 56,313	$ 20,175	$ 44,969	$ 113,286	$ 248,382
Required Tip Fee	$ (99)	$ (68)	$ (162)	$ (107)	$ (187)	$ (119)	$ (74)	$ (64)

TABLE 10. ESTIMATED FACILITY COST, ANIMAL FEED PRODUCTION FACILITY LOCATED AT PINE TREE TRANSFER STATION

State Wide - Pine Tree	**Low**	**High**
Animal Feed Production	**Input/Output/Cost**	**Input/Output/Cost**
Throughput		
Total Food Waste (tons/yr)	14,715	33,325
Days of Operation	312	312
Daily Throughput	47	107
Energy Output		
Mass Output (wet tons)	9,565	21,662
Feed Output (10% moisture)	1,578	3,574
Cost		
Total Capital (including building)	$ 6,000,000	$ 10,000,000
Amortized Capital	$ (403,294)	$ (672,157)
Site Work and Pad Area	$ 2,000,000	$ 3,000,000
Amortized Capital	$ (134,431)	$ (201,647)
Mobile Equipment	$ 250,000	$ 350,000
Amortized Capital	$ (40,127)	$ (56,177)
Total Capital	$ 8,250,000	$ 13,350,000
Engineering	$ 1,237,500	$ 2,002,500
Amortized	$ (83,179)	$ (134,599)
Total Amortized Capital	$ (661,032)	$ (1,064,581)
Operating Cost		
4.5 % of CAPEX	$ (371,249)	$ (600,749)
Annual Cost	*$ (1,032,281)*	*$ (1,665,330)*
Annual Cost/Ton	*$ (70)*	*$ (50)*
Revenues		
Feed Sales/Ton	$ 275.00	$ 275.00
Total Feed Sales	$ 434,011	$ 982,892
Net Cost	$ (598,270)	$ (682,438)
Required Tip Fee	***$ (41)***	***$ (20)***

TASK 4: Economic Analysis

As illustrate in Task 3, preliminary estimates of tipping fees necessary to sustain an AD facility are equal to, or higher than tipping fees for disposal at DSWA facilities. This does not appear to be the case for construction of a food waste to animal feed facility, although there is significantly greater uncertainty associated with an animal feed production facility given the lack of long term operational experience.

There is, however, an additional cost associated with organics processing, which is the cost to separately store, collect and haul the source separated food waste to the organics processing facility. This cost is presented below, followed by an analysis of the combined system cost associated with development of an organics processing facility.

Separate Collection and Transport Cost

While DSM has broken out the primary sources of food waste by generator category and county (Task 2), there are no data available on the exact locations of these generators within each county. As such, DSM has modeled separate collection assuming dedicated trucks to collect this food waste. Separate containers are also included based on quantities, with smaller generators assumed to use rolling carts with larger generators using one or more 3 cubic yard dumpsters dedicated to food wastes.

Tables 6 and 7 (above) form the basis for the analysis of collection costs. Tons per generator category were converted to the need for carts and dumpsters based on the following assumptions by generator category:

- Institutions – 50% carts, 50% dumpsters
- Restaurants – 50% cars, 50% dumpsters
- Grocery – 100% dumpsters
- Convenience Stores – 75% carts, 25% dumpsters
- All Other Commercial Generators – 50% carts, 50% dumpsters
- Residential – 100% carts

The number of carts and dumpsters were then calculated based on an assumption of weekly collection and a density of 225 pounds per 64-gallon cart (150 pounds for a 32-gallon residential cart) and 450 pounds per cubic yard for dumpsters (assuming 3 cubic yard dumpsters). Each participating household was assumed to be given either a 15 or 32 gallon cart depending on whether yard waste was co-collected with the food waste.

Once the number of carts and dumpsters had been calculated, then DSM calculated the number of hours of truck time that would be necessary to serve the carts and dumpsters. Carts were assumed to be served by a leak proof, side loading truck, and dumpsters by a conventional front or rear loader.

Part of the problem with collection is that generators are scattered throughout each county. As a consequence, collection costs will be high, just as they were initially for recyclables collection when DSWA offered recyclables collection throughout each county irrespective of where the generator lived.

Because of the dispersed nature of collection DSM used our best judgement to estimate many hours it would take to collect all of the carts and dumpsters by county based on dividing the total number of carts and dumpsters requiring collection during a week by 5 working days. Table 11 summarizes the number of rolling carts and dumpsters required, truck hours, total cost, and cost per ton for both the low and high recovery scenarios. Total collection costs in Table 11 have been adjusted down by 30 percent to reflect potential savings for mixed solid waste container rental and collection costs due to the impact of food waste diversion. While a 30 percent reduction may seem low given the high percentage of food waste in refuse for some generators, DSM recognizes that it is often difficult for generators to achieve significant reductions in their hauling charges when they divert some (but not all) of their waste to separate recycling or organics collection.

TABLE 11. SUMMARY OF SOURCE SEPARATED FOOD WASTE COLLECTION COSTS, LOW AND HIGH RECOVERY

Scenario	COUNTY			State-Wide
	NCC	Kent	Sussex	
Low - 20% Recovery ICI, 2% Recovery Residential				
ICI				
Carts (Number)	1,091	272	195	1,558
Dumpsters (Number)	132	37	41	209
Truck Hours/Week (1)	113	41	42	191
Total Cost (2)	$ 1,028,104	$ 357,280	$ 371,223	$ 1,719,197
Savings in MSW Collection	*$ (308,431)*	*$ (107,184)*	*$ (111,367)*	*$ (515,759)*
Net Cost	***$ 719,673***	***$ 250,096***	***$ 259,856***	***$ 1,203,438***
Cost Per Ton	$ 81	$ 106	$ 118	$ 90
Residential				
Carts (Number)	4,045	1,211	1,624	6,880
Truck Hours (1)	162	55	87	304
Total Cost (2)	***$ 1,247,307***	***$ 423,913***	***$ 658,227***	***$ 2,329,447***
Cost Per Ton	$ 1,583	$ 1,803	$ 2,394	$ 1,794
Total Collection System Cost	**$ 1,966,980**	**$ 674,009**	**$ 918,083**	**$ 3,532,885**
Cost Per Ton	***$ 204***	***$ 261***	***$ 372***	***$ 240***
High - 40% Recovery ICI, 10% Recovery Residential				
ICI				
Carts (Number)	2,275	528	389	3,192
Dumpsters (Number)	253	75	82	410
Truck Hours (1)	171	56	59	257
Total Cost (2)	$ 1,620,683	$ 522,864	$ 548,801	$ 2,477,761
Savings in MSW Collection	*$ (486,205)*	*$ (156,859)*	*$ (164,640)*	*$ (743,328)*
Net Cost	***$ 1,134,478***	***$ 366,005***	***$ 384,161***	***$ 1,734,433***
Cost Per Ton	$ 64	$ 78	$ 88	$ 65
Residential				
Carts (Number)	20,227	6,057	8,118	34,402
Truck Hours (1)	360	129	200	551
Total Cost (2)	***$ 2,964,290***	***$ 1,044,469***	***$ 1,593,869***	***$ 4,599,967***
Cost Per Ton	$ 752	$ 888	$ 1,159	$ 709
Total Collection System Cost	**$ 4,098,768**	**$ 1,410,473**	**$ 1,978,030**	**$ 6,334,400**
Cost Per Ton	***$ 189***	***$ 240***	***$ 343***	***$ 190***
Tons	**9,659**	**2,587**	**2,469**	**14,715**
Tons	**21,683**	**5,879**	**5,763**	**33,325**
Additional Tonnage	**124%**	**127%**	**133%**	**126%**
(1) Truck Hours do not sum across because of economies of scale and facility location				
(2) Costs do not sum across because truck hours change with single facility				

As shown in Table 11, a 30 percent reduction associated with the separate collection of food wastes, and the concomitant reduction in MSW collection and transport have been taken into account in the collection model. Therefore, the net costs reflected in Table 11 represent costs over and above the cost to the generator of managing the food waste as mixed solid waste. This is likely a reasonable assumption, at least in the early years of any Delaware program.

It is difficult to find examples in the literature of increased collection costs associated with separate organics collection of ICI generators because collection costs are typically negotiated between the hauler and each individual business. However, because of the amount of activity in organics processing occurring in certain areas of California, Waste Management's posted prices for Castro Valley, CA provide an example of current pricing.[10] While commercial prices in Delaware are probably different, the *relative impact* is likely to be fairly representative of what would occur in Delaware if an organics processing facility was operating.

Using these published monthly rates for commercial MSW collection for a six and four cubic yard MSW dumpster and for a two yard organics dumpster, it is possible to calculate the impact of a business reducing their overall MSW dumpster size by approximately 30 percent (from six to four yards) and adding a two cubic yard dumpster for organics in Castro Valley. As illustrated by Table 12, the business will pay roughly $182 per ton more to have their food waste collected separately when compared to having the food waste collected as part of MSW.

TABLE 12. ILLUSTRATION OF INCREASED COST OF SEPARATE FOOD WASTE COLLECTION USING POSTED WASTE MANAGEMENT RATES FOR CASTRO VALLEY, CA

Description	Monthly Charge
6 Cubic Yard MSW Dumpster	$837.39
4 Cubic Yard MSW Dumpster	$569.68
MSW Collection Cost Savings	$267.71
Cost Of 2 Cubic Yard Organics Dumpster	$349.54
Additional Cost of Adding Organics	$81.83
Calculating Cost Per Ton	
Pounds/Cubic Yard, Food Waste	450
2 Cubic Yard (pounds)	900
Cost Per Pound	$0.09
Cost Per Ton	$181.84

One other important observations associated with Table 11 is that there appear to be significant economies of scale associated with separate food waste collection. That is, low density food waste generation in Sussex and Kent Counties significantly increase the estimated per ton collection cost when compared to either a facility located at Pine Tree Transfer Station serving only New Castle County generators.

Combining Collection and Processing Costs

Table 13 combines the collection costs presented in Table 11 with organics processing costs presented in Tables 8 -10 to provide total cost per ton estimates to separately collect and process food waste (either in an AD or animal feed processing facility) at the three DSWA locations.

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[10] https://www.wm.com/location/california/bay_area/castrovalley/commercial/rates.jsp

TABLE 13. SUMMARY OF COLLECTION AND PROCESSING COSTS FOR SOURCE SEPARATED FOOD WASTE

Summary	New Castle County		Kent County		Sussex County		Statewide/Pine Tree	
	Low	High	Low	High	Low	High	Low	High
Throughput								
Food Waste (tons)	9,659	21,683	2,587	5,879	2,469	5,763	14,715	33,325
Yard Waste (tons)	2,588	5,175	1,793	3,586	1,134	2,267	5,514	11,028
Net Tip Fee/Ton								
AD Facility	$ (99)	$ (68)	$ (162)	$ (107)	$ (187)	$ (119)	$ (74)	$ (64)
Animal Feed							$ (41)	$ (20)
Collection Cost/Ton	$ (204)	$ (189)	$ (260)	$ (240)	$ (372)	$ (343)	$ (240)	$ (190)
Total Per Ton Cost								
AD Facility	***$ (303)***	***$ (257)***	***$ (423)***	***$ (347)***	***$ (558)***	***$ (462)***	***$ (314)***	***$ (254)***
Animal Feed							***$ (281)***	***$ (210)***

As illustrated by Table 13, development of a stand-alone anaerobic digester would not be economically feasible in Delaware at this time. This is not surprising given the difficulty experienced in most states in moving forward with stand-alone AD facilities for food waste only. Typically, they are only economically viable if: (1) favorable energy rates are available in the state for AD facilities – which do not currently exist in Delaware; (2) there are significant economies of scale associated with facilities larger then could be supported by food waste disposed in Delaware; and/or, (3) food waste can be added to an existing digester – either manure or waste water treatment plant.

There are no large-scale manure digesters in Delaware. The Wilmington Waste Water Treatment Plant (WWTP) is digesting sludge prior to de-watering, and could potentially take some food waste. In addition, recent discussions with Kent County indicate that they are considering construction of a digester for sludge at their Frederica WWTP. Because this would be a new facility, it could be designed to include food waste, and therefore may be something DSWA wants to discuss with Kent County as a potential way to divert food waste in the future.

The economics of animal feed production appear to be better than for development of a stand-alone AD facility. However, it should be cautioned that the cost data are based on a new start-up facility. Typically, costs for these facilities increase as all of the issues that were not anticipated are addressed. As such, if DSWA were to decide to pursue this type of technology, they should consider partnering with a private vendor who was responsible for the technological risks.

Conclusions

This analysis clearly shows that developing a stand-alone central organics processing facility to divert food waste from DSWA landfills will result in significantly higher costs than continued landfilling, and with relatively minor GHG emission reductions.

As such, if DSWA wants to continue to pursue food waste diversion, DSWA should meet with the Kent County Public Works Department to explore collaboration on the potential development of an anaerobic digester for production of energy from their sludge. It is DSM's observation that co-digestion of waste water sludge and food waste is one way to lower the cost of AD facilities to the point where it is cost-effective when compared to landfilling of food waste.

Similarly, DSWA should continue to discuss with the City of Wilmington the potential for delivery of slurried food waste to the Wilmington WWTP digesters of ICI food waste delivered to the Cherry Island Landfill and processed through a food depackaging machine.

DSWA should also continue working with the University of Delaware with research and developing of on-site digestion options for food waste. The University currently has a small on-site digestion project at the Caesar Rodney Dinning Hall. This program is diverting pre-plate and post-plate food waste to a small unit which breaks down food with enzymes and releases the digestate into the waste water treatment system. DSWA and the University should continue research of this technology and closely track the results. This research should include looking at diversion potential but also O&M issues, contamination levels and tolerance, emissions reductions, and digestate quality and applications.

Finally, DSWA should expand its education program to the public on the benefits of backyard composting and food waste disposal systems. DSWA should also consider developing a food waste diversion grant program which could provide funding to individuals or businesses that wish to engage in the practice of food waste diversion. DSWA could collaborate with RPAC on the best practices to administer the grant application and review process.

APPENDIX B

FOOD WASTE REDUCTION AND REDISTRIBUTION RESOURCES

Below is a partial list of links to tools, educational materials and other resources that may help in local, regional or statewide food waste reduction and redistribution initiatives.

Food Waste Reduction Resources

How to Reduce Food Waste - A Guide for Businesses and Institutions in Massachusetts, RecycleWorks
(The Center for EcoTechnology)
This guidance introduces several actions you can take to reduce food waste at your facility and highlights successful examples in place at several businesses and institutions.
http://recyclingworksma.com/wp-content/uploads/2015/11/How-to-Reduce-Food-Waste.pdf

Food: Too Good to Waste Implementation Guide and Toolkit (US EPA)
https://www.epa.gov/sustainable-management-food/food-too-good-waste-implementation-guide-and-toolkit

The Food Waste Innovator Database (ReFED)
Interactive map with examples of food waste reduction initiatives and tools found across the United States: http://www.refed.com/tools/innovator-database

Save The Food
On-line educational resource to help reduce food waste from purchasing to preparation and storage. Includes ads and outreach materials.
https://www.savethefood.com/share-it

Reuse – Food Donation and Redistribution

Food Recovery Network
Founded as a national student movement against food waste and hunger in America, which now has several partners. Delaware's chapter can be found at:
https://www.foodrecoverynetwork.org/delaware

USDA. Let's Glean! United We Serve Toolkit
https://recyclingworksma.com/wp-content/uploads/2015/07/Legal_Fact_Sheet_-MA_Liability_Protections-FINAL_RWF.pdf

The National Gleaning Project. Models for Success:
Laurie J. Beyranevand, Amber Leasure-Earnhardt, and Carrie Scrufari, Models for Success: A Set of Case Studies Examining Gleaning Efforts Across the United States. Center for Agriculture and Food Systems, Vermont Law School. South Royalton, VT. January 2017
http://forms.vermontlaw.edu/farmgleaning/GleaningReport2017_forprint.pdf

Creating a Gleaning Program in Your State – Guides from St. Andrews
http://endhunger.org/other/

Gleaning Organization Examples:
http://www.bostonareagleaners.org/

Legal Fact Sheet for Food Donation (Massachusetts Specific, but include Federal Guidelines)
https://recyclingworksma.com/wp-content/uploads/2015/07/Legal_Fact_Sheet_-MA_Liability_Protections-FINAL_RWF.pdf

FoodKeeper App
The FoodKeeper helps the user understand proper food and beverage storage to maximize the freshness and quality of food items. Developed by the USDA's Food Safety and Inspection Service, with Cornell University and the Food Marketing Institute, it is available as a mobile application for Android and Apple devices. https://www.foodsafety.gov/keep/foodkeeperapp/

Other Resources:

Harvard Food Law and Policy Center http://www.chlpi.org/food-law-and-policy/about/

Natural Resources Defense Council https://www.nrdc.org/issues/food-waste

Food Waste Reduction Alliance - An initiative of the Grocery Manufacturers Association, (representing food and beverage companies), the Food Marketing Institute (representing food retailers), and the National Restaurant Association (representing the foodservice industry, the FWRA was established in 2011 and seeks to: reduce the amount of food waste generated; increase the amount of safe, nutritious food donated to those in need; and, recycle unavoidable food waste, diverting it from landfills. Resources can be found at: http://www.foodwastealliance.org/full-width/

APPENDIX C

SUMMARY OF REGULATIONS

FOOD DONATION

The Emerson Act offers an excellent federal baseline for providing liability protection for food donation.

Donors must meet four requirements to receive protection:

(1) The food must be donated in good faith (belief that the food is safe to eat).

(2) The food must meet all quality and labeling requirements, even if it is not “readily marketable due to appearance, age, freshness, grade, size, surplus, or other conditions.” Examples of federal labeling standards include the name of the food, the manufacturer, and the net quantity of contents. Donors and distributers can recondition the food to comply by informing the organization of the defective condition of the food, and the organization must agree to recondition the food.

(3) The nonprofit organization that receives the donated food must distribute it to needy individuals.

(4) Recipients must not pay for donated food, however a donor can charge the distributing nonprofit a nominal fee to cover their handling and processing costs but cannot charge for the food itself.

Protection also extends to premises owned by donors who allow gleaners or food recovery personnel onto their property, protecting property owners from liability if injury or death arises due to donation or collection activities on their premises.

While the Emerson Act’s protections are intended to provide blanket protection across the nation in order to encourage food donations, there are no court cases that involve food donation liability, nor agency attempts to interpret the protections offered by the Act. Thus, some potential food donors are confused about certain terms in the Act. Further, the Act’s protections work extremely well when food is being donated to a nonprofit food bank, but there are some instances where additional or clearer protection could increase donation of foods in situations that are unclear or unprotected under the current federal law.

The Emerson Act also has limitations:

1. Donated food must be distributed to final recipients for free in order for the protections to apply;

2. No liability protection is given when donors donate directly to final recipients without going through a nonprofit food recovery intermediary;

3. Donated food must comply with all federal, state, and local quality and labeling standards, even when such standards are not linked to safety risks;

4. The Emerson Act does not explicitly state that donations of past-date foods are protected from liability; and

5. Food businesses lack awareness and education about the Act, which stems from the absence of direction and oversight over the Act by a federal agency.

DELAWARE DONATION LAWS - 61 Del. Laws, c. 439, § 1.;

§ 8130 Exemption from liability for donation of prepared food.

(a) Any person, business or institution who makes a good faith donation of prepared or left-over perishable food which appears to be fit for human consumption at the time it is donated to a charitable organization serving free meals to the needy public shall not be liable for damages in any civil action or subject to criminal prosecution for any illness, injury or death due to the condition of such food.

(b) A charitable organization which receives, prepares and serves to the needy public free food which appears to be fit for human consumption at the time it is served shall not be liable for damages in any civil action or subject to criminal prosecution for any illness, injury or death due to the condition of such food unless the condition is a direct result of the gross negligence, recklessness or intentional misconduct of employees of the organization.

FEEDING ANIMALS

Fifteen states, including Delaware, have exceeded the federal approach to feeding food scraps to animals by flatly prohibiting individuals and facilities from feeding animal derived food scraps to swine.

DELAWARE LAW Del. Code Ann. 3. 71, §§ 7101, 7108 (2015)

Delaware prohibits the feeding of animal-derived waste and vegetable waste that has been mixed with animal-derived waste to swine. Food waste that consists of only vegetable matter may be fed to swine. Individuals may feed household garbage to their own swine ("garbage" is defined as putrescible animal and vegetable waste resulting from the handling, preparation, cooking and consumption of foods, swine carcasses and parts thereof, but not waste exclusively vegetable in nature). § 7108 (2015).

No feeding garbage to swine. Exception for individuals feeding household garbage. §7108 (2015).

Enforcement - Any individual or facility that willfully violates the garbage-feeding ban shall be fined not less than $200 and not more than $500. Each day's violation will be considered a separate offense. § 7108 (2015).

Relevant state regulatory body Delaware Department of Agriculture (§ 7101 (2015)), http://dda.delaware.gov/

Source*: Leftovers for Livestock: A Legal Guide for Using Food Scraps as Animal Feed. Harvard Food Law and Policy Clinic and the Food Recovery Project at University of Arkansas School of Law. August 2016.*