pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

PENNSYLVANIA FOOD WASTE TO RENEWABLE ENERGY ASSESSMENT

Prepared for the Pennsylvania Department of Environmental Protection

June 2021

FINAL REPORT

MSW CONSULTANTS

COKER COMPOSTING AND CONSULTING

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E. EXECUTIVE SUMMARY

E 1. OVERVIEW

Food waste has seen a recent increase in attention across the nation as more states begin to prioritize its diversion from disposal. In its *2018 Wasted Food Report*, the U.S. EPA estimated that about 103 million tons of food waste and excess food are generated each year – 76 percent of which is estimated to originate from industrial, commercial, and institutional (ICI) sources.[1] Food waste diversion from landfills to other management pathways, such as anaerobic digestion (AD) and composting, yields numerous benefits including a reduction in greenhouse gas (GHG) emissions, the production of useful soil amendments, and, in the case of anaerobic digestion, the generation of biogas that can be used to heat buildings, generate electricity, or be converted into renewable natural gas. Despite these benefits, the same EPA study estimated that over 35 million tons of food waste are disposed of in landfills each year with nearly 19 million of those tons originating from the ICI sector.

In support of furthering the goals outlined in the *2018 Pennsylvania Climate Action Plan*, the Pennsylvania Department of Environmental Protection (DEP) retained MSW Consultants to perform an inventory of ICI food waste generated within the Commonwealth, as well as the AD and composting capacity for processing this food waste. The specific objectives of this study were to:

- Quantify current ICI food waste generation and diversion within Pennsylvania (the Commonwealth),
- Compile a comprehensive inventory of AD and compost facilities accepting ICI food waste and the current quantities of food waste being processed,
- Identify any additional food waste processing capacity available within these existing AD and compost facilities,
- Estimate the reduction in GHG emissions resulting from the current level of diversion of ICI food waste from landfill,
- Estimate the amount of biogas currently produced from processing ICI food waste via AD and estimate how much additional biogas could be produced by increasing ICI food waste diversion using existing infrastructure, and
- Identify best practices for expanding existing AD/compost processing capacity and encouraging additional diversion programs in order to further increase the diversion of food waste, reduce the amount of emissions occurring from landfilling food waste, and increase renewable energy generation.

The scope of this study was limited to ICI food waste generation and diversion. The residential and agricultural sectors were not within the scope of this assessment in order to focus on identifying diversion potential and best practices from the largest generators of food waste.

To estimate food waste generation, a comprehensive database of over 52,000 food-related ICI establishments in the Commonwealth was assembled from a variety of public and private data sources. ICI establishments were grouped into sectors, such as "Food Manufacturers and Processors" or "Food Wholesale and Retailers," as defined by the U.S. EPA.[2] Waste generation factors (e.g., full-service restaurants are estimated to generate an annual 3,000 lbs of food waste per employee) were compiled from existing studies and used to extrapolate the food waste generation of each ICI establishment. The type of waste generation factor varied by the establishment type and available data. For instance, annual sales

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[1] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *2018 Wasted Food Report.*

[2] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (April 2020). *Excess Food Opportunities Map.*

revenue was used to estimate food waste generation for food manufacturers, the number of beds was used to estimate food waste generation for healthcare facilities, and the number of students was used for educational institutions.

Quantifying processing capacities and related attributes from AD and compost facilities required a more direct measurement approach. The research approach included a direct survey of every AD and compost facility that currently accepts food waste in the Commonwealth using a combination of postal mail and telephone follow-up. This direct research approach was also applied to every AD facility in Pennsylvania that does not currently accept food waste, for the purpose of evaluating the potential for increasing co-digestion within this installed base of facilities. A summary of the direct research and survey methodology is shown in Table E-1.

Table E-1 Processing Facilities Identified and Surveyed

Type of Processing Facility	# of Facilities Identified	# of Survey Responses	Response Rate
AD Processing ICI Food Waste	26	16	62%
Compost Processing ICI Food Waste	25	20	80%
AD Not Processing ICI Food Waste	83	28	34%
Total	**134**	**64**	**48%**

Responses from these surveys were used quantity the amount of ICI food waste currently being diverted, the GHG emissions reductions from avoiding landfilling, the biogas generation from anaerobic digestion, and the additional processing capacity available to increase ICI food waste diversion further.

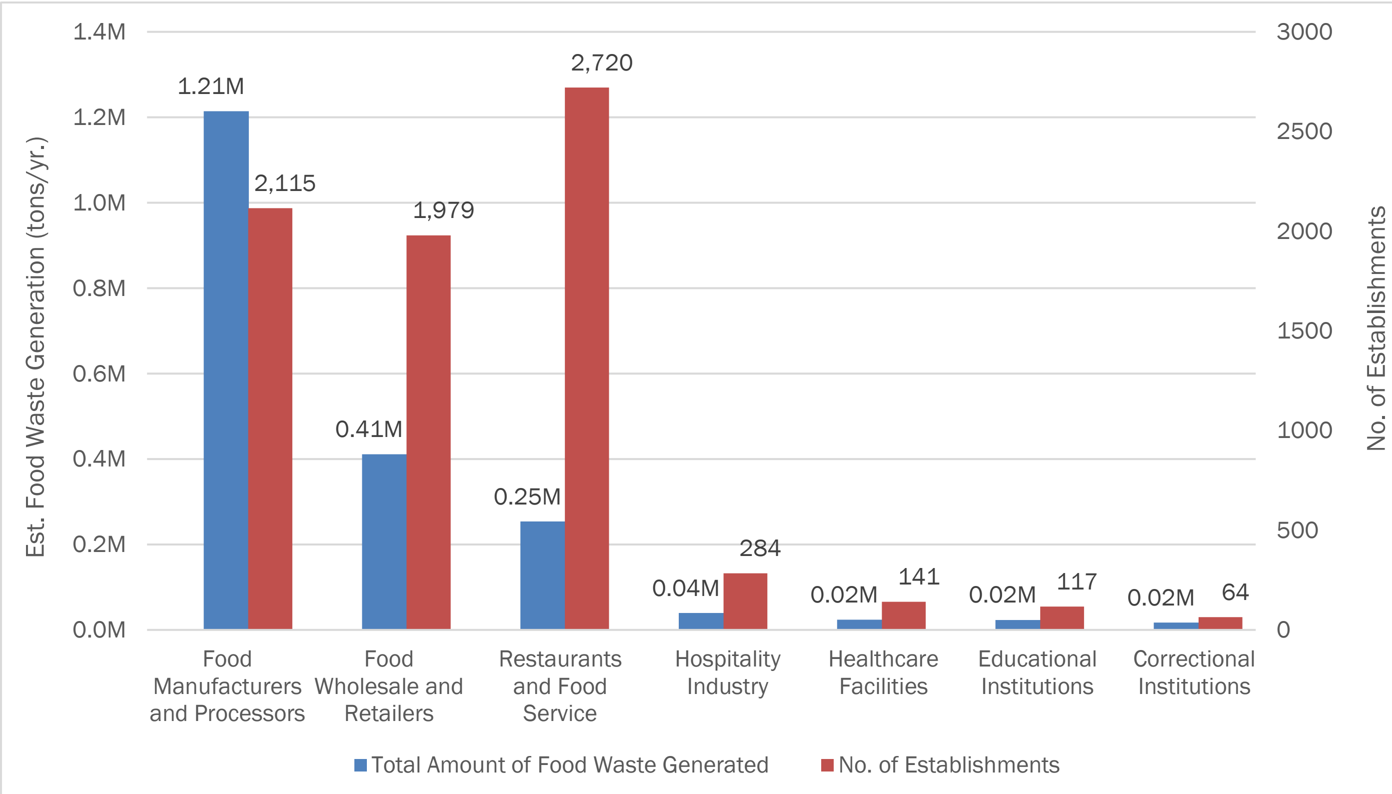
It is important to note that this analysis relied on a number of simplifying assumptions and estimation methods. For example, food waste is not always delivered to the processing facilities in a solid form. The food waste received at AD facilities is often already liquified and diluted, resulting in much of its weight consisting of water. Additionally, the majority of processing facilities do not have weigh scales on-site, and the food waste is instead recorded in volumetric units, such as cubic yards or gallons. In these cases, assumptions of the organics content and densities of food wastes were necessary to estimate the weight of food waste processed. Furthermore, the U.S. EPA's Waste Reduction Model (WARM) and Co-digestion Economic Analysis Tool (Co-EAT) that were used to estimate the reduction in GHG emissions and a facility's potential of beginning co-digestion, respectively, both describe a host of simplifying assumptions in their documentation. Therefore, the results of this study should be used in the aggregate for planning purposes only.

E 2. KEY RESULTS

The analysis of food waste generation focused on ICI establishments estimated to generate at least 52 tons per year (or one ton per week) of food waste. This threshold was chosen to focus on identifying diversion potential for generators where it is more likely to be economically feasible to implement food waste reduction strategies. The 52 tons per year threshold is used in other states, such as Massachusetts and Connecticut, that have policies and regulations governing the disposal of excess food waste.

Nearly two million tons of food waste are estimated to be generated annually at Pennsylvania ICI establishments producing more than 52 tons per year. As shown in Figure E-1, food manufacturers and processors are estimated to generate over half of this food waste at approximately 1.2 million tons annually.

Figure E-1 ICI Food Waste Generation by Generator Type



Note: Includes only establishments estimated to exceed 52 tons per year in food waste generation.

A key finding from this analysis is that the majority of total food waste generation occurs at the largest of establishments. Only 14 percent of ICI establishments are estimated to exceed the 52 tons per year threshold, yet these establishments are estimated to generate approximately 73 percent of total statewide ICI food waste (2.7 million tons total when including food waste from establishments estimated to generate less than 52 tons per year).

It is important to note that although nearly two million tons of food waste are estimated to be generated annually from establishments exceeding the threshold, that does not suggest that two million tons of food waste are disposed in landfills or waste-to-energy facilities. A significant portion of this food waste is likely diverted to animal feed, food donation, and direct land application; however, this study focused only on quantifying the amounts diverted to AD and composting.

Based on the surveys of AD and compost facilities, an estimated 145,000 tons of ICI food waste are currently diverted each year via AD and composting. Additionally, survey respondents reported that an estimated 111,000 additional tons of processing capacity is either immediately available or could be made available through changes in their permit limits and/or a shift in the current economics of organics recycling. "Processing capacity" refers collectively to the amount of capacity currently utilized ("current food waste throughput") and the additional amount of food waste that could be processed using current infrastructure (i.e., "unused available capacity"). Figure E-2 shows the aggregate processing capacities of AD and compost facilities. The AD capacity is further broken down based on whether the digester is located on a farm, a wastewater treatment plant (WWTP), or at a food manufacturing or other industrial-type site (stand-alone).

Figure E-2 ICI Food Waste Processing Capacity by Facility Type

[1] "Unused available capacity" includes capacity that is: 1) immediately available and not in-use due to lack of feedstock, or 2) that is physically available but is currently limited by economics or permits. It does not include capacity that could potentially be created through significant capital improvements, such as installing a new anaerobic digester reactor or enabling co-digestion at an AD facility not currently accepting food waste.

Collectively, AD facilities currently process about 107,000 tons of food waste per year and have the potential to process over an additional 40,000 tons of food waste per year using existing infrastructure. However, compost facilities offer the greatest potential for processing additional food waste, with about 70,000 tons of available capacity yet to be utilized. Many of the compost facilities who responded to the survey reported that the underutilization of their physical capacity is the result of their permitted limit[3] or a lack of motivated feedstock due to the current economics of organics recycling. Figure E-3 shows these and other commonly reported barriers to increase food waste throughputs through utilization of unused available capacity, as reported by facilities physically capable of accepting additional ICI food waste.

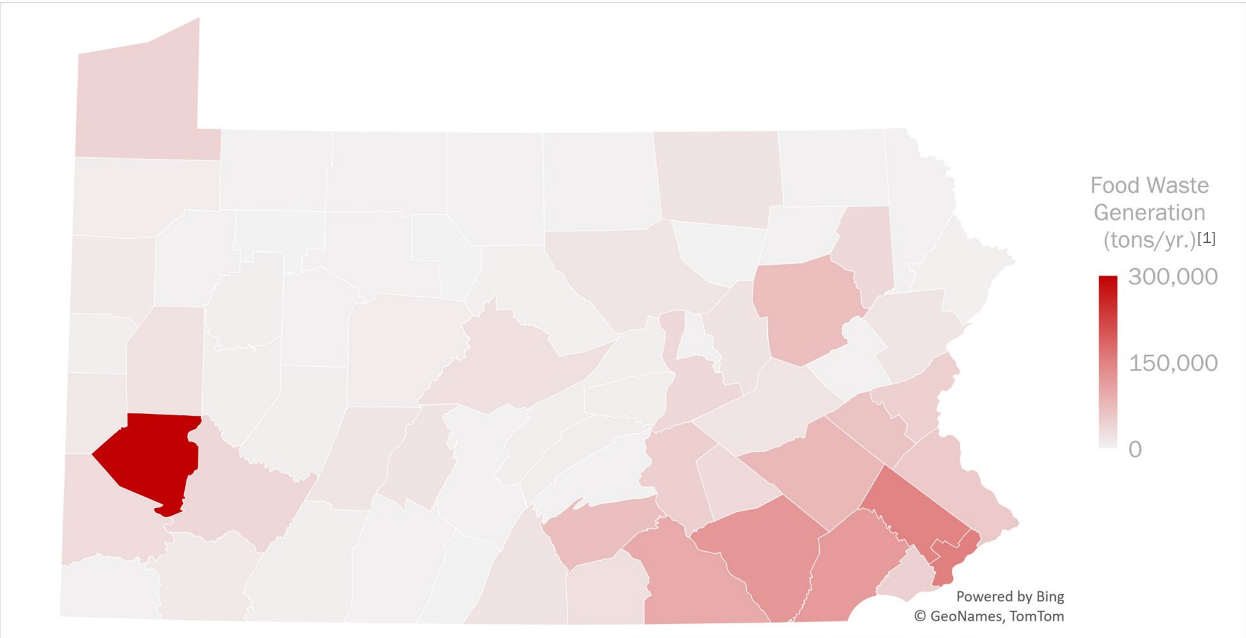
Figure E-3 Reported Barriers to Utilizing Unused Available Capacity

[1] Does not include survey respondents that indicated they have no interest in accepting external food waste or that they are at the maximum physical capacity of their facility without significant capital improvements.

[3] Due to the "5-acre footprint rule." Detailed further in Section 4.4.8.

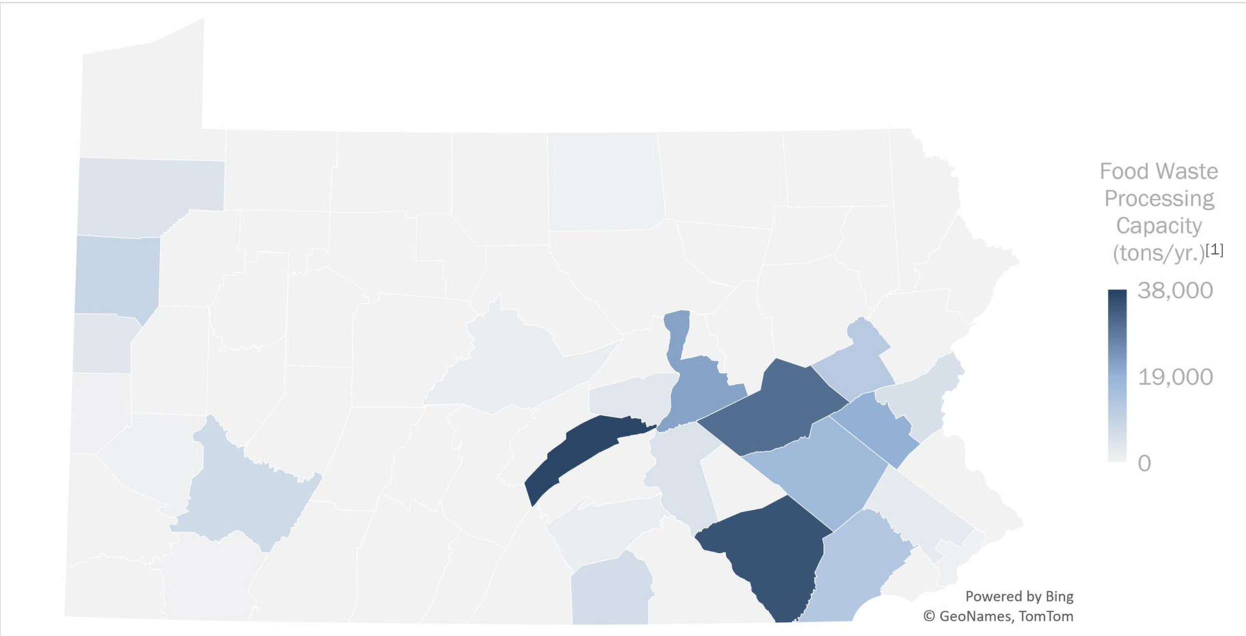
Figure E-4 highlights the counties in which ICI food waste generation is estimated to be most prevalent. By contrast, Figure E-5 highlights the counties where food waste processing capacity exists. Comparison of these figures suggests that the southeast and southwest regions are currently underserved in organics processing capacity.

Figure E-4 Map of ICI Food Waste Generation by County (≥52 Tons/Yr.)



[1] From ICI establishments estimated to produce more than 52 tons per year.

Figure E-5 Map of ICI Food Waste Processing Capacity by County



[1] Includes current food waste throughput and unused available capacity from survey respondents processing ICI food waste, as well as estimated throughput of nonrespondents processing ICI food waste.

E. EXECUTIVE SUMMARY

This study quantified the beneficial impacts of AD and composting in terms of 1) tons diverted, 2) GHG emissions reduced, and 3) biogas generated. Table E-2 summarizes the beneficial impacts of current diversion efforts and projects the increase in these impacts if diversion were to increase further through the utilization of unused available capacity. Additionally, the final scenario presented in Table E-2 presents the impacts if diversion via AD and composting was yet further increased to account for 35 percent of total ICI food waste generation from establishments exceeding 52 tons per year. This percentage was chosen to emulate the food waste diversion goal of Massachusetts, which in 2014 implemented a disposal ban on food waste from establishments exceeding one ton per week in generation. (It should be noted that Massachusetts also counts food donation and animal feed towards this goal. The prevalence of food donation and animal feed in Pennsylvania is currently unknown and is not considered in the table below.)

Table E-2 ICI Food Waste Diversion Summary and Scenarios

Parameter	Scenarios: Current Diversion via AD and Composting	Scenarios: Potential Diversion Using All Unused Available Capacity	Scenarios: Potential Diversion at 35% Diversion Rate via AD and Composting[1]
ICI Food Waste Tons Diverted[2]	145,000	255,000	731,000
ICI Food Waste Diversion Rate[2][3]	7%	13%	35%
GHG Emissions Reduction (MTCO2e/yr.)[2][4]	99,000	176,000	508,000
Biogas Generation (million ft^3/yr.)	363	561	1,605

[2] Under this scenario, processing capacity at AD and compost facilities would be increased until sufficient capacity exists to achieve a diversion rate of 35% for ICI food waste. The current ratio of AD capacity to composting capacity (roughly 1.2:1) would be maintained, resulting in an additional 361,000 tons of food waste diverted through AD and 300,000 tons diverted through composting.

[3] Does not account for food waste diverted from disposal via direct land application, animal feed, or food donation.

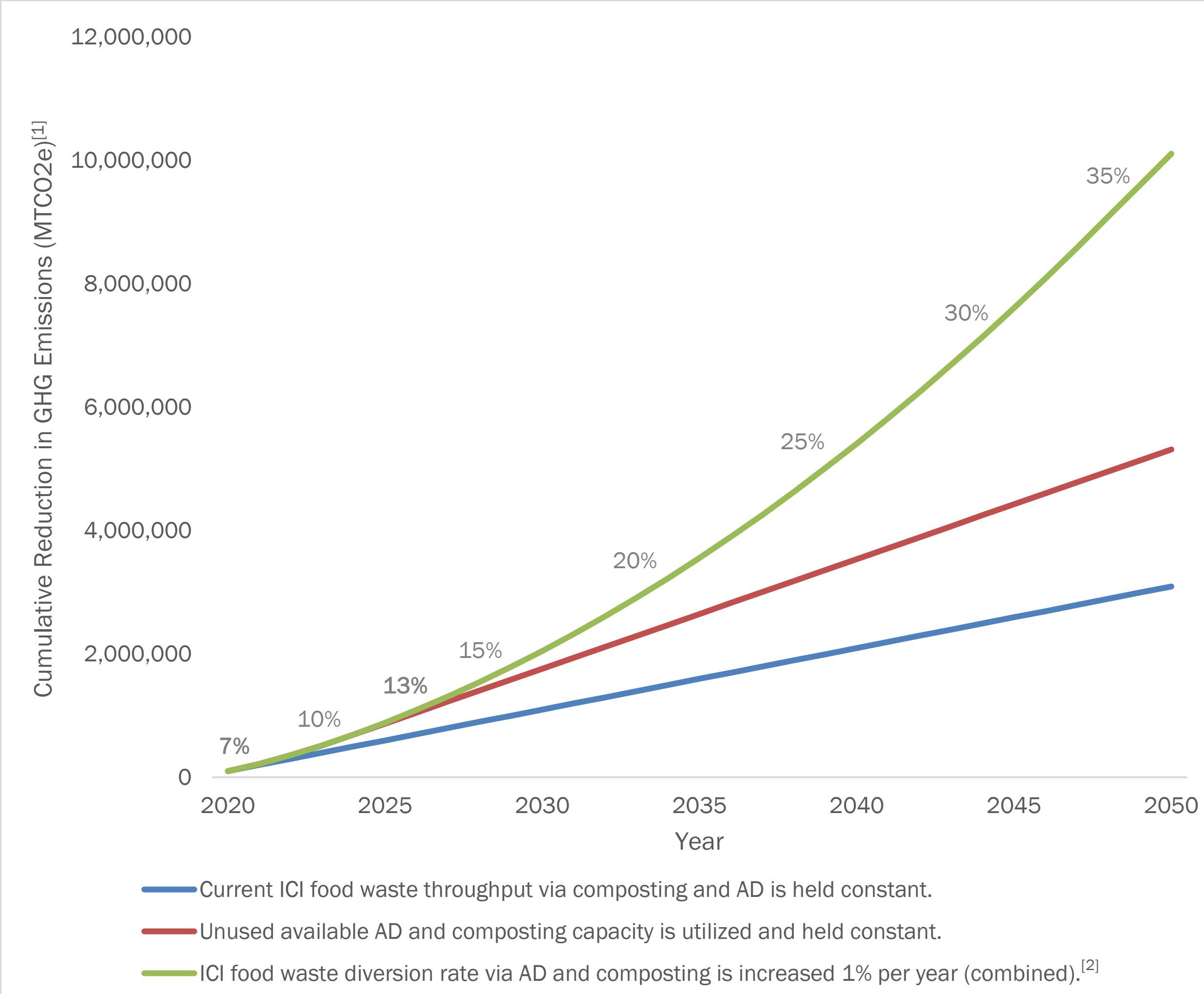
[4] The total estimated amount of food waste generation from ICI establishments exceeding 52 tons per year in generation (2 million tons) is used as the denominator for calculating the diversion rate.

[5] Assumes diverted food waste would have been disposed of via landfill.

The three scenarios presented in Table E-2 are further examined in the context of their cumulative reduction in GHG emissions in Figure E-6. For the third scenario, in which the food waste diversion rate via AD and composting is projected as increasing to 35 percent, the diversion rate is increased one percent each year, beginning at the current rate of 7 percent in 2020 and reaching 35 percent in 2048 after which it is held constant. The figure shows these estimates through 2050 to correspond with the Commonwealth's goal to reduce GHG emissions by 80 percent by 2050 (relative to 2005 emission levels).[4]

[4] Pennsylvania Exec. Order No. 2019-1 (January 2019). *Commonwealth Leadership in Addressing Climate Change and Promoting Energy Conservation and Sustainable Governance*

Figure E-6 Comparison of GHG Emissions Reduction by Diversion Scenario



[1] Assumes diverted food waste would have been disposed of via landfill.
[2] The total estimated amount of food waste generation from ICI establishments exceeding 52 tons per year in generation (2 million tons) is used as the denominator for calculating the percentage.

This study also examined the potential of beginning co-digestion of food waste at Pennsylvania anaerobic digesters which do not currently accept food waste. Of the 28 facilities that responded to the survey, seven were found to be potentially capable of co-digestion, as shown in Table E-3.

Table E-3 Co-digestion Potential of Anaerobic Digesters Not Currently Accepting Food Waste

Survey Outcome	Count of Facilities	Percent of Facilities
Potentially Capable of Co-digestion Based on Co-EAT Modeling	4	14%
Potentially Capable of Co-digestion Based on Reported Feasibility Study	3	11%
Not Likely Capable of Co-digestion	21	75%

Five of the facilities that responded to the survey had already conducted feasibility studies to assess the feasibility of co-digestion of food waste; three of these facilities were planning to, or were still considering, moving forward with co-digestion. Another five facilities self-reported that that they were not capable of co-digestion due to a lack of interest or physical digester capacity. For the remaining 18 facilities that responded to the survey, the U.S. EPA's Co-EAT model was used to assess their potential for co-digestion of food wastes. Based on the Co-EAT model, the two variables that appeared most indicative of the feasibility of initiating food waste co-digestion were: 1) the current effective operating capacity percentage, and 2) targeted hydraulic retention time (HRT). Facilities that were already operating at high effective operating capacities of over 90 percent and at low HRTs of about 20 days, are likely not capable of accepting substantial quantities of food waste while continuing to digest their current feedstock. These limitations effectively excluded most of the existing AD facilities from feasibly initiating co-digestion.

To enable co-digestion of food waste at the seven facilities potentially capable of doing so, it is estimated to require about $20.1 million of capital investments (average $2.9 million per facility) which would result in the creation of about 77,000 tons of new food waste processing capacity (average 11,000 tons per facility). However, more rigorous feasibility studies of each facility are necessary to verify these estimates.

E 3. STRATEGIES TO INCREASE FOOD WASTE DIVERSION

Based on the survey responses, interviews with stakeholders, and the preceding analysis, 19 potential strategies for increasing food waste diversion were identified. Figure E-7 summarizes the strategies and denotes the approximate timeframe in which they could be implemented. Note that the ordering of the potential strategies does not in any way indicate the priority or otherwise estimate the potential impact of a strategy. Full descriptions of the potential strategies are provided in Section 4.4.

Figure E-7 Timeline of Potential Strategies to Increase Food Waste Diversion

Potential Strategies	Near-term (0-2 yrs.)	Mid-term (2-5 yrs.)	Long-term (5+ yrs.)
Overall Economics of Food Waste Diversion			
1. Mandate that food waste from generators meeting certain criteria is banned from disposal.			
2. Monetize GHG emissions reductions.			
General Administration			
3. Create a state organics recycling coordinator position or task force.			
4. Set a diversion goal and establish methodology to benchmark progress.			
Permitting Process and Regulations			
5. Establish clear, consistent, and comprehensive processes for permitting organics processing facilities.			
6. Develop permit tools for small-scale and developing facilities.			
Food Waste Generators			
7. Offer food waste generators technical assistance.			
8. Establish or join a coalition of organizations successful in food waste diversion.			

Potential Strategies	Near-term (0-2 yrs.)	Mid-term (2-5 yrs.)	Long-term (5+ yrs.)
9. Provide online resources to suggest best practices and help food waste generators connect with haulers and processors.			
Food Donation			
10. Standardize date labels to clearly distinguish between food safety and food quality.			
Contamination and Depackaging			
11. Develop permits and regulations for depackaging.			
12. Monitor and offer assistance in the development of organic transfer stations.			
Anaerobic Digestion Facilities			
13. Offer technical assistance for anaerobic digestion.			
14. Make capital improvement grants available for existing anaerobic digestion facilities.			
15. Develop a food waste-to-renewable-energy siting database.			
Compost Facilities			
16. Revisit composting permit limits.			
17. Facilitate public-private partnerships for composting food waste.			
18. Centrally manage and publicize grant-funded equipment.			
19. Encourage the use of finished compost in public capital projects where possible.			

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1. INTRODUCTION

1.1 OVERVIEW

In response to the Pennsylvania Climate Change Act (Act 70 of 2008), the Pennsylvania Department of Environmental Protection (DEP) is required to inventory greenhouse gas (GHG) emissions and maintain a Climate Change Action Plan that is updated every three years. In its 2018 update, the *Pennsylvania Climate Action Plan* (the Plan)[1] took a more comprehensive and pragmatic approach to addressing climate change by offering recommended strategies to adapt to climate change impacts and reduce GHG emissions across eight sectors. Additionally, through *Executive Order 2019-1*, Pennsylvania set its first ever statewide goals to reduce GHG emissions: a 26 percent reduction by 2025 and an 80 percent reduction by 2050 (relative to 2005 emission levels).[2]

Included in the Plan's recommendations were leadership actions to:

- "Implement programs to encourage citizens and business to reduce waste (including food waste) and use recycling and composting programs through reduce, reuse, and recycle actions," and
- "Encourage the use of digesters for methane capture and recovery."

To continue advancing its progress in line with these actions, DEP retained MSW Consultants to complete this food waste to renewable energy assessment. The overall objective of this study was to identify the potential renewable energy generation and GHG emissions reduction from the diversion of institutional, commercial, and industrial (ICI) sources of food waste from the solid waste stream. Specific objectives of this study included:

- Quantify current ICI food waste generation and diversion within the Commonwealth,
- Compile a comprehensive inventory of anaerobic digestion (AD) and compost facilities accepting ICI food waste and the current quantities of food waste being processed,
- Identify any additional food waste processing capacity available within these AD and compost facilities already accepting food waste,
- Estimate the reduction in GHG emissions resulting from the current level of diversion of ICI food waste from landfill,
- Estimate the amount of biogas currently produced from processing ICI food waste via AD and estimate how much additional biogas could be produced by increasing ICI food waste diversion using existing infrastructure,
- Evaluate the potential for AD facilities not currently accepting food waste to begin co-digestion, and
- Identify best practices for expanding existing AD/compost processing capacity and encouraging additional diversion programs in order to further increase the diversion of food waste, reduce the amount of emissions occurring from landfilling food waste, and increase renewable energy generation.

This study placed particular emphasis on food waste diversion via AD and composting as they represent the greatest opportunities to increase renewable energy generation and reduce GHG emissions while being widely accessible to all types and sources of food waste. However, these food waste diversion strategies

[1] Pennsylvania Department of Environmental Protection. (April 2019). *Pennsylvania Climate Action Plan 2018*.

[2] Pennsylvania Exec. Order No. 2019-1 (January 2019). *Commonwealth Leadership in Addressing Climate Change and Promoting Energy Conservation and Sustainable Governance*

should only take place after other food management methods including source reduction, food donation, and use as animal feed occur. These other strategies are taken into consideration in the potential strategies to increase food waste diversion.

The scope of this study was limited to ICI food waste generation and diversion. The residential and agricultural sectors were not within the scope of this assessment in order to focus on identifying diversion potential and best practices from the largest generators of food waste. Additionally, fats, oils, and grease (FOG), such as from restaurant grease traps, were not considered food waste and were not examined in this study.

The results of this study are intended to provide the Commonwealth and its partners with the foundation to participate in larger, cross-functional, food waste reduction strategies involving Commonwealth agencies, non-profits, and the private sector.

1.2 BACKGROUND

1.2.1 FOOD WASTE OVERVIEW

Food waste has gained increasing attention as more states, local governments, corporations, institutions, and individuals become aware of the risks of climate change. The U.S. EPA has stated that "more food reaches landfills than any other material in our municipal solid waste (MSW), making up over 24 percent of MSW sent to landfills."[3] When food waste is exposed to anaerobic conditions, as is often found in landfills, it creates methane – a greenhouse gas (GHG) that is "28 to 36 times more effective than carbon dioxide at trapping heat in the atmosphere over a 100-year period."[4] Due to the food waste and other organics disposed, landfills are the third-largest contributor to methane generation from human activity in the United States, accounting for about 15 percent of these emissions.[5]

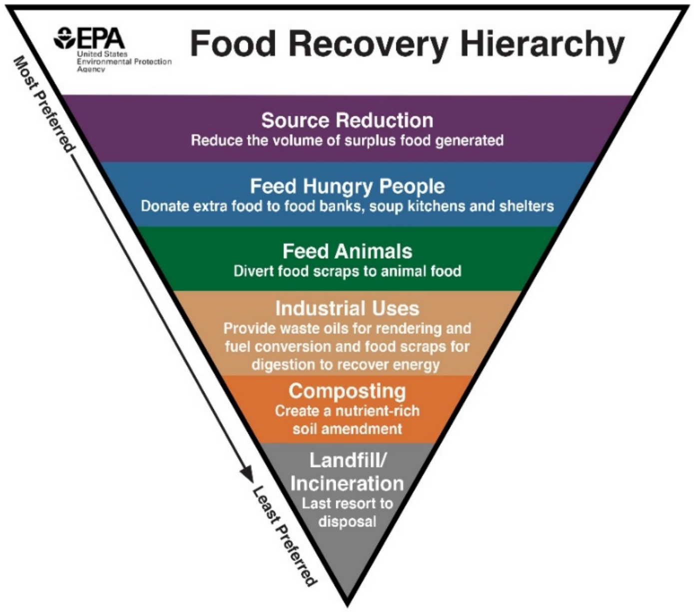
Fortunately, there are numerous alternative management pathways available to food waste in lieu of landfilling. The U.S. EPA has described and ranked these management pathways in its Food Recovery Hierarchy, as shown in Figure 1-1. Although the Commonwealth maintains its own waste management hierarchy, this hierarchy applies to the municipal waste stream as a whole, whereas the U.S. EPA's Food Recovery Hierarchy focuses exclusively on food and food waste. Thus, the U.S. EPA's hierarchy is used in this study for ordering the preference of food recovery and food waste diversion options.

[3] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *2018 Wasted Food Report.*

[4] U.S. Environmental Protection Agency Landfill Methane Outreach Program. (n.d.). *Basic Information about Landfill Gas.*

[5] Same source as previous.

Figure 1-1 U.S. EPA Food Recovery Hierarchy



Source: U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (n.d.). *Food Recovery Hierarchy.*

According to the U.S. EPA, "the top levels of the hierarchy are the best ways to prevent and divert wasted food because they create the most benefits for the environment, society and the economy."[6] In addition to reducing GHG emissions from landfilling, other benefits of diverting food waste include:

- Conserving landfill space,
- Reducing the energy usage, pollution, and overall costs from manufacturing, transporting, storing, and preparing wasted food,
- Assisting some of the 1.4 million food-insecure Pennsylvania residents[7] through food donation,
- Creating jobs at food banks and organics processing facilities,
- When anaerobically digested, creating methane-rich biogas that can heat buildings, fuel electrical generators, or be converted into renewable natural gas for transmission via pipeline or use as vehicle fuel, and
- When anaerobically digested or composted, producing nutrient-rich soil amendment for farmland or land restoration: reducing the need for chemical fertilizers, promoting higher crop yield, and enhancing water retention.

Though the Food Recovery Hierarchy does offer a prioritization of the various food management pathways, the best approach to managing excess food and food waste will be unique to each generator based on the specifics of their geographic location, type of food (e.g., pre-consumer packaged food versus post-consumer food scraps), and logistical capabilities.

[6] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (n.d.). *Food Recovery Hierarchy.*

[7] Feeding America. (n.d.). *Hunger in Pennsylvania.*

1.2.2 FOOD WASTE DYNAMICS IN PENNSYLVANIA

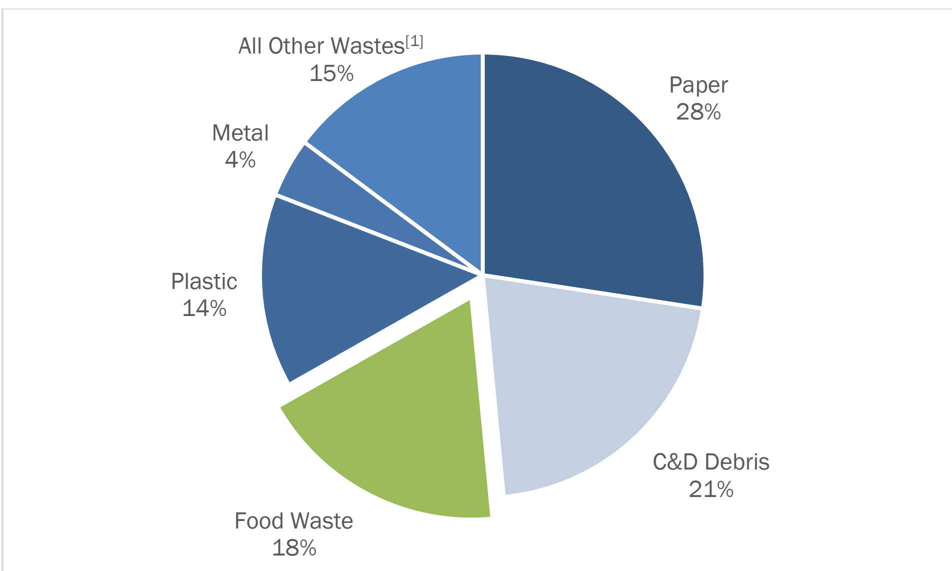
In 1988, Pennsylvania legislators passed Act 101 which led to the creation of modern recycling programs within the Commonwealth. Among other things, Act 101:

1) Requires municipalities beyond a specified population threshold to establish recycling collection programs for certain materials.
2) Imposes a $2-per-ton recycling fee on all waste (except ash) disposed at landfills and resource recovery facilities (RRFs). A portion of the fees collected go to the PA Recycling Fund which is used assist counties and municipalities in solid waste planning, technical assistance, and recycling program implementation, as well as other DEP programming such as household hazardous waste management and markets development.

Unlike paper, plastic/metal/glass containers, and yard/leaf waste, there are no mandates for food waste recycling from residential or commercial sources, nor are there currently any specific diversion goals for food waste.

In 2001, a Pennsylvania statewide waste composition study found that food waste made up about 12 percent of waste from commercial and institutional sources (although this figure does not include food waste from industrial sources, such as large-scale food manufacturers). An update to this composition study is currently underway that will both update the 2001 estimate and also quantify the proportions of disposed food waste that are still packaged and edible, nonpackaged and edible, or inedible. Because the updated composition study was not yet available at the time of this report, Maryland's 2016 statewide waste composition study was researched as a proxy to gauge current food waste disposal in the Commonwealth. The Maryland study's results are shown in Figure 1-2.

Figure 1-2 Maryland Statewide Disposed Commercial/Institutional MSW Composition (2016)



[1] Includes glass, non-food organics, electronics, household hazardous waste, textiles, and "other MSW."
Source: Maryland Department of the Environment. (July 2017). *2016 Maryland Statewide Waste Characterization Study.*

Economics are an important factor to food waste diversion. In the absence of regulatory or legislated bans on organics landfilling, organics processing facilities accepting solid food waste are competing with the convenience and disposal costs of landfills and RRFs. Though landfill capacity is somewhat limited in eastern Pennsylvania, the Commonwealth as a whole has significant landfill capacity, resulting in low-to-mid-range disposal tip fees in central and western Pennsylvania. Although there are currently no Commonwealth-level incentives for the processing of food waste through AD or composting, DEP's Food Recovery Infrastructure Grant Program provided funding in 2020 to assist non-profit entities in strengthening food donation programs and recovering food that might otherwise be wasted. This program awarded more than $9 million to 145 projects to allow food banks, shelters, and soup kitchens to cover the costs of equipment purchases necessary to prepare, transport, and store food acquired from retailers, wholesalers, farms, processors, and cooperatives.

1.2.3 Food Waste Management Outside of Pennsylvania

As of 2020, eight states[8] as well as some cities have set specific diversion goals for food waste and/or have mandated that food waste from generators meeting certain criteria (typically ICI generators producing more than one to two tons of food waste per week) is banned from landfill disposal. Food waste diversion has seen particular prominence in New England where municipal solid waste disposal capacity is already constrained, resulting in disposal tip fees in excess of $100 per ton.

1.3 METHODOLOGY

This study was designed to combine the most current and up-to-date data sources with direct surveying of food waste processing facilities. In cases where certain data sets were incomplete, this study applied basic estimation techniques to fill in the gaps. Additionally, this study relied on the U.S. EPA's Waste Reduction Model (WARM) to estimate the reduction in GHG emissions from diverting food waste, as well as the U.S. EPA's Co-digestion Economic Analysis Tool (Co-EAT) to evaluate AD facilities' potential of beginning co-digestion. Detailed methodology is provided in the relevant chapters of this report.

It is important to note that even through the direct surveying of facilities, exact quantities of food waste, biogas generation, and reduction in GHG emissions at the individual facility-level cannot be guaranteed due to the various simplifying assumptions inherent to researching so many unique processing facilities. Furthermore, the WARM and Co-EAT both describe a host of simplifying assumptions in their own documentations. Every attempt has been made to document these assumptions in the relevant chapters of this report, and alternative estimates of the key results from other sources are offered for comparison purposes where available. While the results of this study are believed to be reasonably accurate to the order of magnitude, the results are geared towards statewide planning considerations and should not be used to represent the operations or performance of any individual facility, region of the state, or food waste processing technology in use.

1.4 REPORT ORGANIZATION

This report is organized into the following chapters:

- **Chapter 2: ICI Food Waste Generation.** This chapter presents the methodology and results of inventorying Pennsylvania ICI food waste generators and estimating their food waste generation. This chapter also tabulates the resulting statewide generation of food wastes originating from ICI sources believed to be generating more than 52 tons of food waste per year.[9]
- **Chapter 3: Organics Processors.** This chapter presents the methodology and results of the inventorying, direct surveying, and subsequent analysis of AD and compost facilities currently processing food waste, as well as that for AD facilities not currently processing food waste, but that were evaluated for the potential of initiating the co-digestion of food wastes with their existing infeed

[8] CA, CT, MA, NJ, NY, RI, VT, and WA.

[9] The basis for this threshold is also explained within the chapter.

(e.g., wastewater treatment). Additionally, an overview of the WARM and Co-EAT used in this analysis are given in this chapter.

- **Chapter 4: Strategies to Increase Food Waste Diversion.** This chapter combines the results of the preceeding two chapters and insights gained from interviews with stakeholders across the Commonwealth to descibe the various potential strategies available to increase food waste diversion. This chapter also presents a synopsis of six case studies that highlight successful food waste diversion initiatives in the Commonwelath, as well as an overview of food waste diversion initiatives in other states.
- **Chapter 5: Conclusions.** This chapter summarizes the key findings of the study.
- **Appendices.** This report contains a number of appendices containing supporting and ancillary information, including:
  - Appendix A – Food Waste Generation by NAICS Code
  - Appendix B – Survey Questionnaires
  - Appendix C – Food Waste Diversion Success Stories

2. ICI FOOD WASTE GENERATION

2.1 OVERVIEW

Food waste was broadly defined in this study as surplus organic material (excluding FOG) created during the production, distribution, or consumption of food and beverages within the industrial, commercial, and institutional (ICI) sectors. Although the residential and agricultural (unharvested crops) sectors are significant generators of food waste, they were not examined in this study in order to provide greater detail on potential food waste diversion strategies in the ICI sector. Some examples of food waste generation examined in this study include expired food at retailers, post-consumer food scraps at restaurants and cafeterias, unused ingredients at food manufacturers, and organic by-products from food and beverage manufacturing such as brewer's spent grain or whey from dairy processing. The focus of this study was ICI food waste generators with sufficient quantities of food waste to potentially warrant separate collection and delivery to a central food waste processing facility.

In order to baseline statewide food waste generation and identify major sources of food waste generation (both geographically and by establishment-type), this study estimated ICI food waste generation at the establishment level. In general, each establishment's food waste generation was extrapolated from location-specific, commonly-available data that indicates the scale of the establishment, such as the number of employees.

Similar analyses have been performed at the national level by the U.S. EPA[1] and at the state level in Massachusetts,[2] Connecticut,[3] and Vermont.[4] These studies relied on similar methodologies to those used in this study, and a summary of their results are compared with those of this study.

The U.S. EPA's *Excess Food Opportunities Map*[1] methodology was followed for defining the strata of food-waste-generating establishments (hereinafter referred to as "sectors"). These sectors included:

- Industrial
  - Food Manufacturers and Processors
- Commercial
  - Food Wholesale and Retailers
  - Restaurants and Food Service
  - Hospitality Industry
- Institutional
  - Healthcare Facilities
  - Educational Institutions
  - Correctional Institutions

[1] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (April 2020). *Excess Food Opportunities Map.*

[2] Massachusetts Department of Environmental Protection. (2011). *Summary Analysis of Massachusetts Commercial/Institutional Food Waste Generation Data.*

[3] Connecticut Department of Energy and Environmental Protection. (2012). *Updated Mapping of Food Residual Generation in Connecticut.*

[4] Vermont Agency of Natural Resources. (February 2021). *Food Scrap Generators.*

2. ICI FOOD WASTE GENERATION

Though the U.S. EPA's study included food banks as potential generators of food waste (due to spoilage of donated goods before they can be distributed), these establishments were not examined in this study.

Establishments were assigned to sectors based on their primary North American Industry Classification System (NAICS) code. NAICS is the Federal standard for classifying businesses for use in statistical data. Appendix A provides a complete list of the NAICS codes included in each sector, as well as a further breakdown of results by NAICS code.

As a final note, this analysis focused on ICI establishments estimated to generate at least 52 tons per year (or one ton per week) of food waste. This threshold was chosen to focus on identifying diversion potential for generators where it is more likely to be economically feasible to implement food waste reduction strategies. The 52 tons per year threshold is used in other states, such as Massachusetts and Connecticut, that have policies and regulations governing the disposal of excess food waste.

2.2 METHODOLOGY

In line with the similar state-level assessments aimed at estimating food waste generation from potentially tens of thousands of establishments, this study estimated food waste generation at the establishment level by applying **generation factors** to **establishment data** such as the number of employees or annual sales revenue. For example, one source provided a generation factor for full-service restaurants equal to 3,000 lbs of annual food waste per employee. Therefore, a hypothetical full-service restaurant with 10 employees would be estimated to generate 30,000 lbs, or 15 tons, of food waste per year.

Therefore, this study's methodology can be broadly summarized as:

1. Compile food waste generation factors for each sector,
2. Compile a statewide database of ICI establishments grouped by sector,
3. Apply generation factors to the statewide database to estimate food waste generation by establishment.

Although this methodology does result in individual food waste generation estimates at an establishment level, true food waste generation will vary from establishment to establishment. Therefore, it is recommended that these results only be used in aggregate forms, such as by county or sector, and for statewide planning purposes.

The following subsections detail the methodologies followed in identifying, compiling, and applying the **generation factors** and **establishment data** to estimate food waste generation.

2.2.1 FOOD WASTE GENERATION FACTORS

Generation factors were first researched to identify the type of establishment data that should be gathered. In general, generation factors were obtained from existing studies that correlated food waste estimates derived from surveying, economic analysis, and expert interviews with commonly-tracked establishment data, such as number of employees or annual sales revenue. Some generation factors were correlated with more sector-specific establishment data, such as number of inmates for correctional institutions or number of beds for healthcare facilities.

Table 2-1 shows the publications reviewed in researching generation factors.

Table 2-1 Identified Sources of Generation Factors

Author/Publisher	Publication Name	Year Published
CalRecycle	*2014 Generator-based Characterization of Commercial Sector Disposal and Diversion in California*	2015
Food Waste Reduction Alliance	*Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Wholesalers*	2013
Food Waste Reduction Alliance	*Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Restaurants*	2014
Food Waste Reduction Alliance	*Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Restaurants*	2016
Metro Vancouver	*2014 ICI Waste Characterization Program*	2015
Natural Resources Defense Council	*Estimating Quantities and Types of Food Waste at the City Level*	2017
RecyclingWorks in Massachusetts	*Food Waste Estimation Guide*	2020
U.S. Environmental Protection Agency Office of Resource Conservation and Recovery	*Excess Food Opportunities Map*	2020
U.S. Environmental Protection Agency Office of Resource Conservation and Recovery	*2018 Waste Food Report*	2020

Note that many of these sources are themselves aggregates of other direct research and as a result there is significant overlap between some sources (for instance, the Natural Resources Defense Council study cites the RecyclingWorks in Massachusetts study, which in turn cites CalRecycle and BSR data).

The U.S. EPA's *Excess Food Opportunities Map*, which simultaneously applied all available generation factors to its establishment data in order to provide a range of food waste generation estimates for each establishment, demonstrates the variety of generation factors available and the subsequent variability in food waste estimates based on the factor used. For example, for the Food Manufacturers and Processors sector, the U.S. EPA identified three independent studies (though all authored by or prepared for the Food Waste Reduction Alliance) that provided generation factors for food manufacturers based on direct surveying. Between these three studies, the generation factors ranged from 0.053 lbs/dollar of annual revenue/year up to 0.17 lbs/dollar of annual revenue/year – a 220 percent difference. This singular choice of generation factor could result in potentially millions of additional tons of estimated food waste generation when applied to the tens of billions of dollars of annual revenue from Pennsylvania food manufacturers.

While it was not within the scope of this study to critically evaluate the methodologies of each individual source of generation factors, this analysis did attempt to qualitatively assess the best generation factors available based on metrics such as the geographic boundary analyzed, the age of the publishing study, and the comprehensiveness of the direct research. For example, of the three aforementioned generation factors available for estimating the Food Manufacturing and Processing sector, the percentage of national food manufacturers that provided survey data varied from 6.2 percent in the 2016 study to 17 percent in the 2013 study. This study selected the 2013 generation factor for estimating the Food Manufacturing and Processing sector due to the larger percentage of food manufacturers represented in its survey. Additionally, when multiple generation factors were available for the same sector that utilized differing establishment data types (i.e., "basis units"), this study defined an order of preference for each generation factor based on the reasonableness of correlating the sector's food waste generation with the respective basis unit. The order of preference of basis units for each sector is shown in Table 2-2.

Table 2-2 Basis Units Used for Estimating Food Waste, Ordered by Preference

Sector ↳ Subsector	Generation Factor Basis Units		
	First Preference	Second Preference	Third Preference
Food Manufacturers and Processors[1]	Annual Sales Revenue	Employees	EPA Excess Food Map Upper Bound
Food Wholesale and Retailers ↳ Food Wholesalers	Annual Sales Revenue	Employees	EPA Excess Food Map Lower Bound
Food Wholesale and Retailers ↳ Supermarkets and Other Retail	Employees	EPA Excess Food Map Upper Bound	-
Restaurants and Food Service	Employees	EPA Excess Food Map Upper Bound	-
Hospitality Industry	Employees	EPA Excess Food Map Upper Bound	-
Healthcare Facilities	Beds	-	-
Educational Institutions	Students	-	-
Correctional Institutions	Inmates	Employees	-

[1] Direct tonnage data on food waste was available for 109 food manufacturers and processors from the DEP *Residual Waste Reports*. This data was used in place of estimation via generation factors where possible.

As an example, generation factors that utilized annual sales revenue as their basis units were preferred for estimating food waste generation at establishments in the Food Manufacturers and Processors sector. However, when annual sales revenue was not available for an establishment in this sector, a generation factor based on the number of employees would instead be used, if possible. In some cases, such as for the Healthcare Facilities sector, establishment data was complete enough that generation factors using alternative basis units were not needed.

In cases where some establishment data was available, but a corresponding generation factor which could utilize it as a basis unit was unavailable, "quasi-generation factors" were calculated from other available data. For example, many of the establishments included in this study were identified through the U.S. EPA's *Excess Food Opportunities Map*. Though the U.S. EPA's study provides a range with upper and lower bounds of estimated food waste generation for each establishment, point estimates (i.e., "best guesses") from within these ranges are not provided. Furthermore, the establishment data on which the U.S. EPA based their estimates is not provided in the available source files. Therefore, in cases where establishment data from other sources was not available, this study calculated quasi-generation factors that could be applied to the U.S. EPA's given range in order to determine a point estimate for an establishment's food waste generation. The exact methods to calculating and applying these quasi-generation factors varied based on the number of data points available to use as reference and the skewness of the data, but generally followed this approach:

1) Calculate food waste generation estimates using sourced generation factors for establishments where it is possible to do so.
2) Select only establishments that have both: a) a food waste generation estimate calculated in Step 1, and b) alternative data to serve as the basis units for the quasi-generation factor, such as the upper bound of the U.S. EPA's range (e.g., a restaurant that a) food waste generation has been estimated at 6 tons per year based on its number of employees, and b) was given an upper bound of 8 tons per year on its

food waste generation by the U.S. EPA).

3) Calculate the ratio of food waste generation estimate to alternative basis unit for each establishment (e.g., in the previous example, the restaurant's ratio would be 6:8, meaning its food waste estimate was 0.75 of its upper bound from the U.S. EPA).
4) For each sector, calculate either the average or median of the ratios from the previous step to get the quasi-generation factor. (e.g., the average ratio of all restaurants is 0.74)
5) Apply this quasi-generation factor to other establishments in the sector that lack establishment data necessary for sourced generation factors, but have the alternative data used in the quasi-generation factor (e.g., another restaurant with an unknown number of employees but that was given an upper bound of 10 tons per year by the U.S. EPA would be estimated at 7.4 tons per year).

A complete list of the generation factors sourced directly from existing studies is shown in Table 2-3, while a complete list of the quasi-generation factors calculated by correlating food waste generation estimates with alternative data is shown in Table 2-4.

Table 2-3 Sourced Generation Factors

Sector ↳ Subsector	Generation Factor Basis Units	Generation Factor (lbs/basis unit/yr.)	Source
Food Manufacturers	Annual Sales Revenue	0.05	FWRA[5]
Food Manufacturers	Employees	1,400	CalRecycle[6]
Food Wholesale and Retail ↳ Wholesalers	Annual Sales Revenue	0.01	FWRA[7]
Food Wholesale and Retail ↳ Supermarkets and Other Retail	Employees	3,000	RecyclingWorks MA[8]
Restaurants and Food Service ↳ Full-Service Restaurants	Employees	3,000	RecyclingWorks MA
Restaurants and Food Service ↳ Limited-Service Restaurants	Employees	2,200	RecyclingWorks MA
Hospitality Industry	Employees	1,305	RecyclingWorks MA
Healthcare Facilities	Beds	1,248	RecyclingWorks MA
Educational Institutions ↳ Colleges and Universities	Students (Residential)	142	RecyclingWorks MA
Educational Institutions ↳ Colleges and Universities	Students (Non-residential)	38	RecyclingWorks MA
Educational Institutions ↳ Elementary Schools	Students	59	RecyclingWorks MA
Educational Institutions ↳ Middle Schools	Students	38	RecyclingWorks MA
Educational Institutions ↳ High Schools	Students	18	RecyclingWorks MA
Correctional Institutions	Inmates	365	RecyclingWorks MA

[5] Food Waste Reduction Alliance. (April 2013). *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Wholesalers.*
[6] CalRecycle. (2015). 2014 Generator-Based Characterization of Commercial Sector Disposal and Diversion in California.
[7] Food Waste Reduction Alliance. (2014). *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Wholesalers.*
[8] RecyclingWorks in Massachusetts. (June 2020). *Food Waste Estimation Guide.*

Table 2-4 Calculated Quasi-generation Factors

Sector ↳ Subsector	Generation Factor Basis Units	Quasi-generation Factor
Food Manufacturers	EPA Excess Food Map Upper Bound (tons)	58% of upper bound
Food Wholesale and Retail ↳ Wholesalers	Employees	12,650 lbs per employee
Food Wholesale and Retail ↳ Wholesalers	EPA Excess Food Map Lower Bound (tons)	100% of lower bound
Supermarkets and Other Retail	EPA Excess Food Map Upper Bound (tons)	35% of upper bound
Restaurants and Food Service	EPA Excess Food Map Upper Bound (tons)	74% of upper bound
Hospitality Industry	EPA Excess Food Map Upper Bound (tons)	55% of upper bound
Correctional Institutions	Employees	1,124 lbs per employee

It should be acknowledged that generation estimates can only be refined to the degree of specificity available in generation factors. For example, though the Food Manufacturers and Processors sector contains a wide variety of establishments, the same generation factor was applied to all establishments in the sector because more granular generation factors were not available. The results of this study should continue to be improved as more recent, comprehensive, and granular generation factors are identified through direct research.

2.2.2 Establishment Data

Generation factors are only useful if adequate establishment data, such as the number of employees or annual sales revenue, can be compiled. This establishment data provides a basis for which the generation factors can be applied to in order to calculate food waste generation estimates. The goals of this study required estimating food waste generation at the establishment level (as opposed to in aggregate), thus, it was necessary to compile a database of individual establishments and their respective data.

The database compiled in this study is believed to be the most complete inventory of food-waste-generating establishments in the Commonwealth as of the time of this report. Key features of this database include: a) an extensive effort to identify and prioritize primary sources of data wherever possible, b) the combination of two expansive business databases, and c) an innovative method to improving record matching and reducing the prevalence of double counting that typically arises from combining large amounts of location data from multiple datasets.

Primary sources of establishment data include organizations such as state and national agencies, trade associations, and non-profits that compile data directly from establishments. Primary data sources were identified largely through online research and were more commonly available for institutional-type sectors, such as Healthcare Facilities, Educational Institutions, and Correctional Institutions, than for industrial- and commercial-dominant sectors. Table 2-5 gives a full list of the primary sources incorporated into the database.

Table 2-5 Primary Sources of Establishment Data

Sector ↳ Subsector	Author/Publisher	Publication Name	Data Year
Food Manufacturers and Processors	PA Department of Environmental Protection	*Residual Waste Reports*	2018
Food Manufacturers and Processors	PA Department of Agriculture	*Pennsylvania Food Manufacturers Directory*	2020
Healthcare Facilities	PA Department of Health	*Hospital Reports*	2018
Educational Institutions ↳ Colleges and Universities	National Center for Education Statistics	*Integrated Postsecondary Education Data System*	2017-18
Educational Institutions ↳ Public Schools (K-12)	PA Department of Education	*Public School Enrollment Reports*	2018-19
Educational Institutions ↳ Private/Non-Public Schools (K-12)	PA Department of Education	*Private and Non-Public Schools Enrollment Reports*	2018-19
Correctional Institutions	PA Department of Corrections	*Monthly Population Report*	2020
Correctional Institutions	Bureau of Justice Statistics	*Census of State and Federal Correctional Facilities*	2012

In all cases, the most recent data as of the time of this study was used, resulting in an average baseline year of about 2018. Any temporal differences between datasets were assumed insignificant to the results of this study.

DEP's *Residual Waste Reports* were unique in that they were the only identified sources to provide direct tonnage data on food waste generation. DEP defines residual waste as "nonhazardous industrial waste. It includes waste material (solid, liquid or gas) produced by industrial, mining, and agricultural operations." Two relevant types of residual waste included "Food Waste (Excluding Wastewater Treatment Sludge)" and "Food Processing Sludge." In 2018, 109 of the industrial establishments that submitted their biennial report listed some quantity of these waste types, collectively totaling to 641,000 tons. However, the *Residual Waste Reports* also reveal that about 377,000 of these tons are liquids or sludges that are land applied or otherwise managed through "Other" methods outside of the typical waste management pathways. This study assumed that a large portion of the weight from this subset of tons was from water (such as from the cleaning of food manufacturing vessels), and therefore, they are not appropriate for representing food waste generation as it is defined in this study. After removing these excluded wastes, a total of 149,000 tons of "Food Waste (Excluding Wastewater Treatment Sludge)" and 115,000 tons of "Food Processing Sludge" remained and were included in the database.

After primary sources of establishment data were exhausted, the database was supplemented with data from two business databases:

- **InfoGroup**,[9] a business-to-business (B2B) marketing data provider that employs researchers to identify and survey businesses. Data collected includes establishment names, addresses, NAICS codes, number of employees, annual sales revenue, and other, less-relevant data. DEP holds a subscription to the state dataset and exported InfoGroup data for the NAICS codes included in the scope of this

[9] From the date that the data was accessed to the publication of this report, InfoGroup has since changed its name to Data Axle.

analysis, resulting in about 24,000 records in total.

- The **U.S. EPA's Excess Food Opportunities Map**, which itself is derived largely from D&B Hoovers datasets. D&B Hoovers is another B2B marketing data provider offering similar products to InfoGroup. Though the complete datasets from D&B Hoovers (which would contain attributes such as number of employees for each establishment) were not included in the U.S. EPA's database, using the quasi-generation factors described earlier is believed to yield similar results in estimated food waste generation to directly applying sourced generation factors. About 47,000 records were considered for inclusion from this source.

A common issue encountered when combining large amounts of locational data from multiple sources is the potential of double counting. Seldom is locational data from different sources collected in exactly the same formats (for instance, "100 S St" in one source might be recorded as "100 South Street" in another) preventing simple methods from matching the records. This issue is further exacerbated when establishments do businesses under multiple names or share addresses with other establishments.

To combat this issue, a proprietary methodology was used to join duplicative records based on the abilities of popular search engines for location lookup. This process allowed sufficiently similar records to be combined despite slight variations in names or addresses and also assisted in filtering out invalid addresses and establishments that are no longer operational. After applying this methodology, a total of 52,403 establishments remained in database.

Table 2-6 on the following page shows the breakdown of the food-waste-generating ICI establishments evaluated based on the establishment data and generation factors available.

After combining the establishment data with generation factors, the resulting estimates were inspected to reduce the prevalence of outliers from erroneous establishment data. One method used to gauge the reasonableness of estimates from restaurants and food retailers was to estimate the container size and collection frequency that would be needed to adequately service the estimated quantity of food waste (along with other wastes typical for such establishments). Food waste generation estimates that exceeded reasonable expectations were either reduced to a reasonable quantity or were eliminated. However, it should be acknowledged that some discrepancies in establishment data were likely not identified as such and remained within the database. Though the prevalence of these cases is unknown, it is presumed to be insignificant in the context of statewide food waste generation.

Table 2-6 Prevalence of Establishment Data/Generation Factors Used

Sector ↳ Subsector	Gen. Factor Priority	Generation Factor Basis Units	No. of Establishments Estimated Using Gen. Factor	No. of Establishments Estimated ≥52 Tons/Yr. of Food Waste
Food Manufacturers and Processors	1	Direct Tonnage Data	109	70
	2	Annual Sales Revenue	5,244	1,878
	3	Employees	43	23
	4	EPA Excess Food Map Upper Bound	1,210	144
	N/A	No Establishment Data Available	144	0
		Subtotal	*6,750*	*2,115*
Food Wholesale and Retailers ↳ Food Wholesalers	1	Annual Sales Revenue	2,470	757
	2	Employees	16	14
	3	EPA Excess Food Map Upper Bound	1,554	33
	N/A	No Establishment Data Available	2	0
		Subtotal	*4,042*	*804*
Food Wholesale and Retailers ↳ Supermarkets and Other Retail	1	Employees	1,410	1,044
	2	EPA Excess Food Map Upper Bound	5,856	131
	N/A	No Establishment Data Available	4	0
		Subtotal	*7,270*	*1,175*
Restaurants and Food Service	1	Employees	6,759	2,386
	2	EPA Excess Food Map Upper Bound	18,361	334
	N/A	No Establishment Data Available	344	0
		Subtotal	*25,464*	*2,720*
Hospitality Industry	1	Employees	875	222
	2	EPA Excess Food Map Upper Bound	1,416	62
	N/A	No Establishment Data Available	1	0
		Subtotal	*2,292*	*284*
Healthcare Facilities	1	Beds	239	141
	N/A	No Establishment Data Available	0	0
		Subtotal	*239*	*141*
Educational Institutions	1	Students	6,187	117
	N/A	No Establishment Data Available	0	0
		Subtotal	*6,187*	*117*
Correctional Institutions	1	Inmates	155	63
	2	Employees	3	0
	N/A	No Establishment Data Available	1	1
		Subtotal	*159*	*64*
		Grand Total	**52,403**	**7,420**

2.3 RESULTS

In order to focus on larger generators where economies of scale are more likely to be sufficient to accommodate food waste diversion, a 52 tons per year (i.e., one ton per week) threshold was applied to the results of this study. Additionally, a minimum of 52 tons per year is a common threshold for applying food waste policies and regulations governing the disposal of excess food waste in other states. Table 2-7 shows the percentage of establishments estimated to exceed this threshold in each sector.

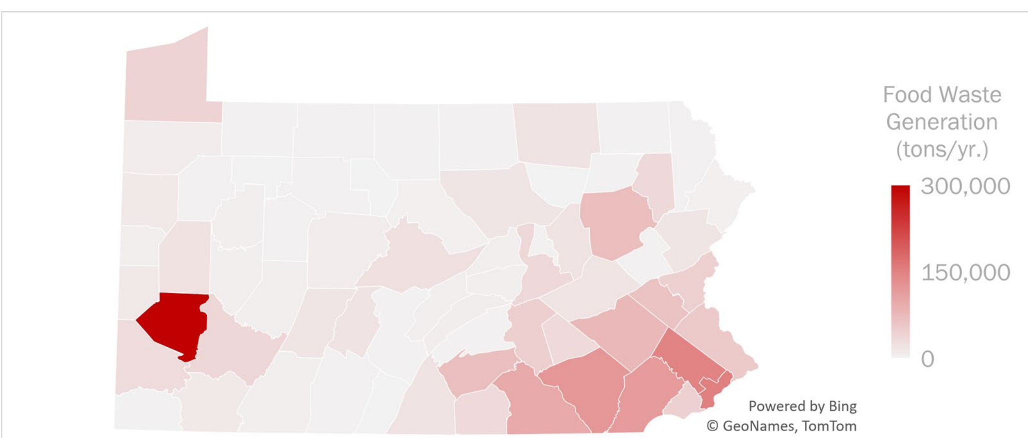
Table 2-7 Percent of Establishments Exceeding 52 Tons per Year by Sector

	No. of Establishments			Estimated Tons of Food Waste Generation		
Sector	≥52 Tons/Yr. of Food Waste	All Establishments (any size)	%	≥52 Tons/Yr. of Food Waste	All Establishments (any size)	%
Food Manufacturers and Processors	2,115	6,750	31%	1,214,000	1,265,000	96%
Food Wholesale and Retailers	1,979	11,312	17%	411,000	706,000	58%
Restaurants and Food Service	2,720	25,464	11%	254,000	574,000	44%
Hospitality Industry	284	2,292	12%	39,000	61,000	64%
Healthcare Facilities	141	239	59%	24,000	27,000	89%
Educational Institutions	117	6,187	2%	23,000	62,000	37%
Correctional Institutions	64	159	40%	17,000	19,000	89%
Total	**7,420**	**52,403**	**14%**	**1,982,000**	**2,714,000**	**73%**

Although only 14 percent of all identified establishments are estimated to exceed 52 tons per year, 73 percent of all ICI food waste generation was estimated to occur at establishments exceeding this threshold. Therefore, the total ICI food waste generation relevant to the scope of this study is approximately two million tons. **The remaining tables, figures, and analysis in this section refer only to establishments exceeding 52 tons of food waste generation per year.**

One goal of this study was to identify where in the Commonwealth food waste generation is most prevalent. Figure 2-1 shows a heatmap of total estimated food waste generation by county. Additional maps are included in Exhibit 2-1 which show the estimated county-level food waste generation by each sector.

Figure 2-1 Map of Food Waste Generation by County (≥52 Tons/Yr.)



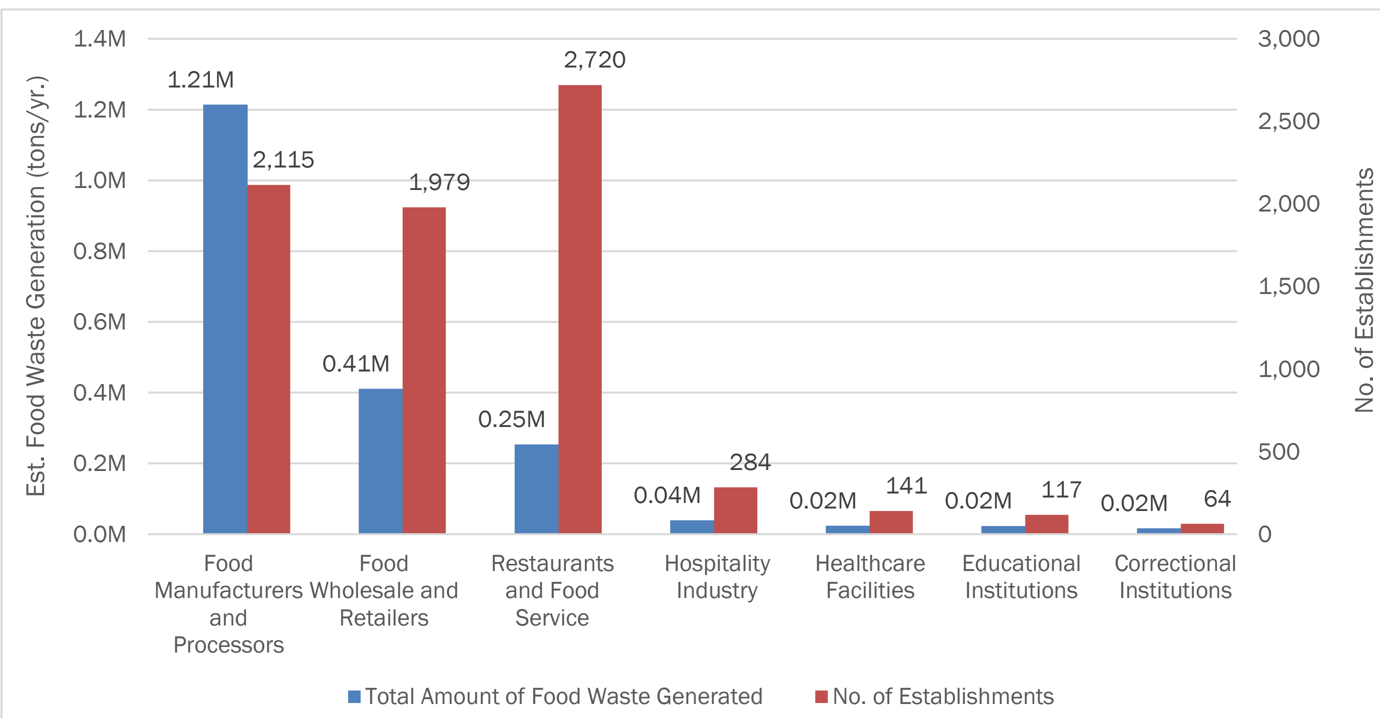
Allegheny County is believed to generate the most food waste in Pennsylvania, estimated at nearly 300,000 tons per year. The additional maps in Exhibit 2-1 clarify that over two-thirds of these tons are estimated to originate from the Food Manufacturing and Processing sector. Following Allegheny County is Philadelphia County at 152,000 tons and Montgomery County at 146,000 tons.

Allegheny County's substantial estimated food waste generation due to the Food Manufacturing and Processing sector is less surprising when given further context. As shown in Table 2-8, the Food Manufacturing and Processing sector is estimated to generate 61 percent of all ICI food waste, or over 1.2 million tons per year. Similar results are presented visually in Figure 2-2.

Table 2-8 Estimated Food Waste Generation Summary Statistics by Sector (≥52 Tons/Yr.)

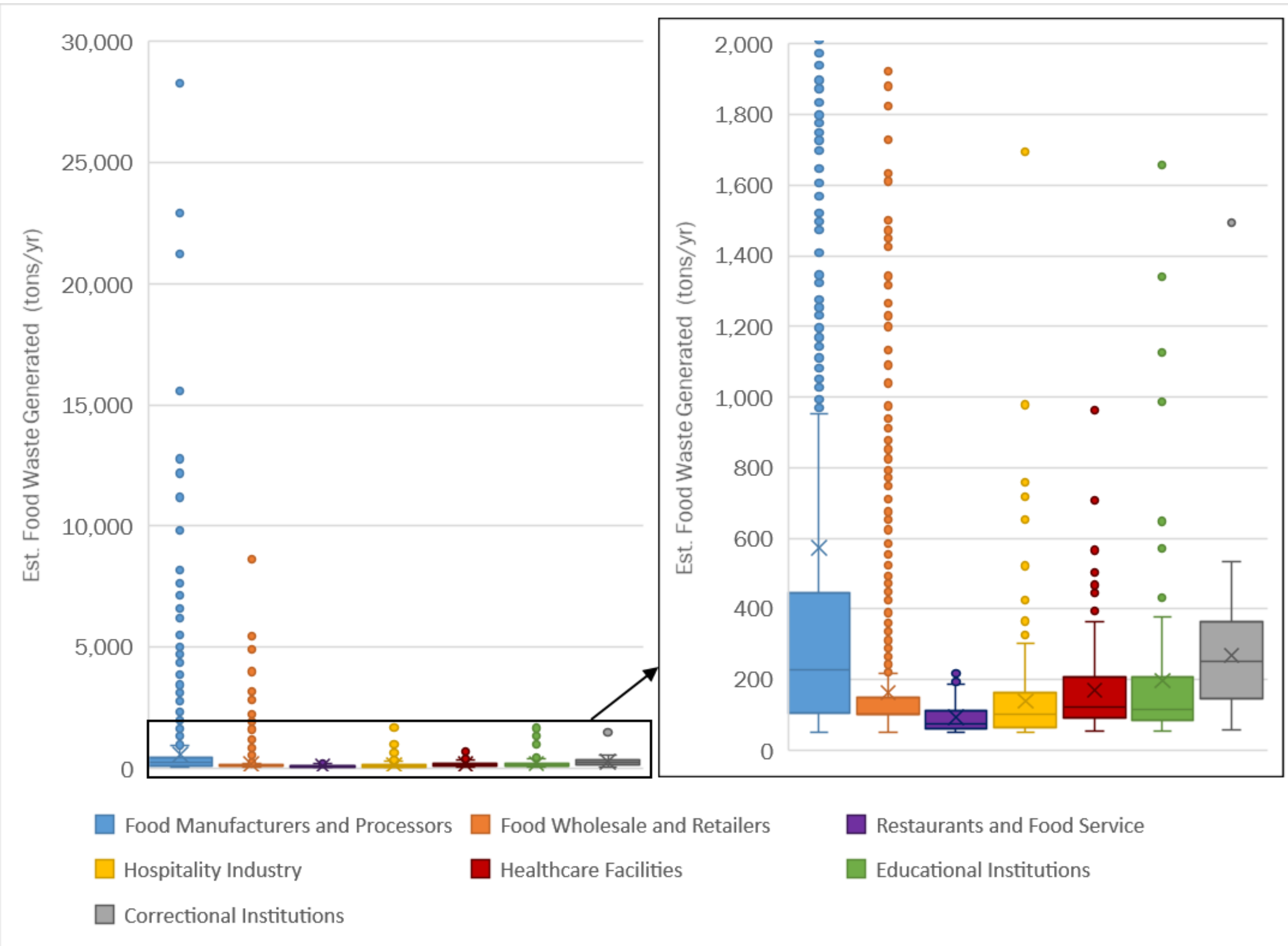
Sector	No. of Establish-ments	Median Food Waste Generation per Establishment (tons/yr.)	Avg. Food Waste Generation per Establishment (tons/yr.)	Total Food Waste Generation (tons/yr.)	% of Total Food Waste Generation
Food Manufacturers and Processors	2,115	227	574	1,214,000	61%
Food Wholesale and Retailers	1,979	126	208	411,000	21%
Restaurants and Food Service	2,720	75	93	254,000	13%
Hospitality Industry	284	103	139	39,000	2%
Healthcare Facilities	141	122	170	24,000	1%
Educational Institutions	117	115	198	23,000	1%
Correctional Institutions	64	253	268	17,000	1%
Total	**7,420**			**1,982,000**	**100%**

Figure 2-2 Estimated Food Waste Generation by Sector (≥52 Tons/Yr.)



Comparing the per-establishment averages with the per-establishment medians shown in Table 2-8 reveals that the food waste generation estimates for most sectors are moderately-to-heavily skewed towards the largest establishments. This skewness is visualized in Figure 2-3. The box plot on the left shows the food waste generation estimates of all ICI establishments exceeding the 52 ton per year threshold. Because the scale of the chart is so drastically influenced by the presence of extremely high food waste generation estimates from some food manufacturers and wholesalers/retailers, a zoomed-in depiction of the same chart is given on the right.

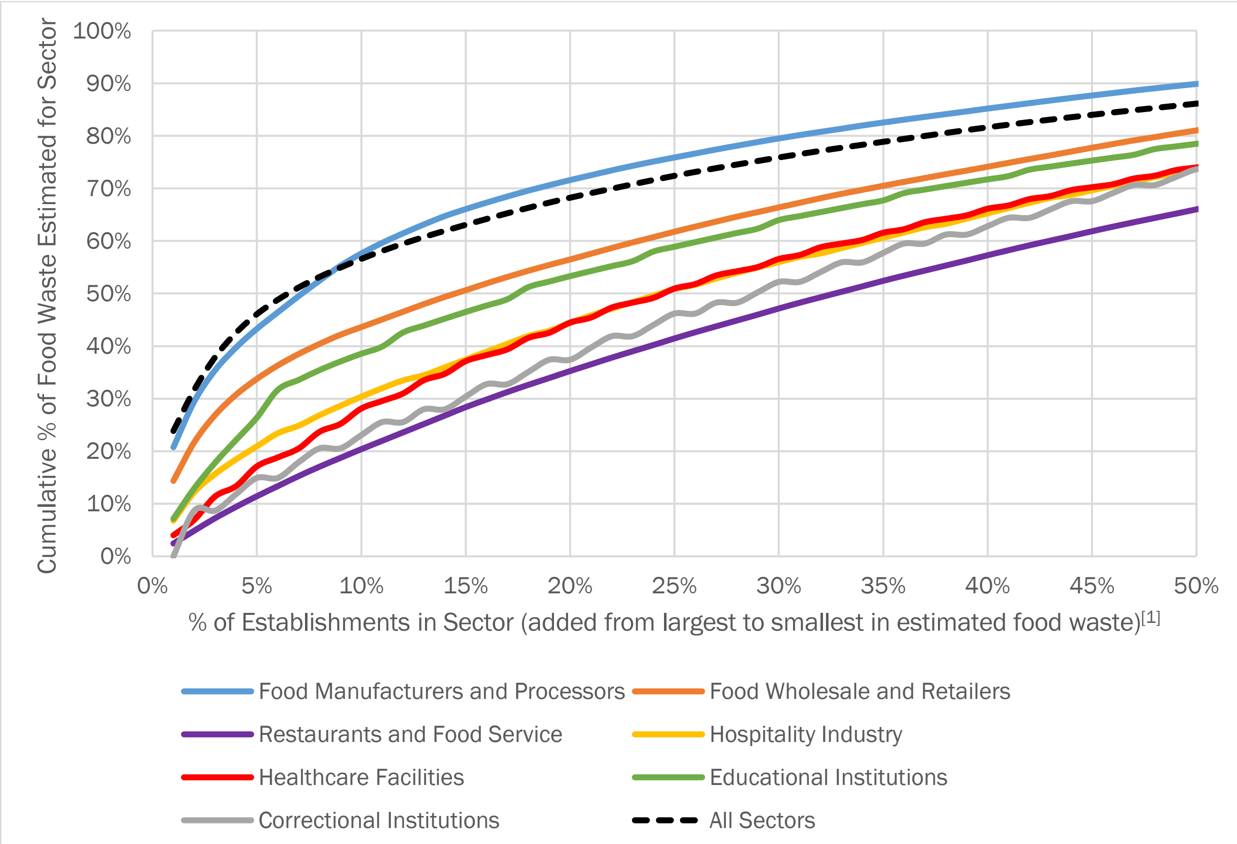
Figure 2-3 Distribution of Food Waste Generation Estimates by Sector (≥52 Tons/Yr.)



Box Plot Legend:
- ⊤ **4th Quartile Bin** contains the highest 25 percent of data points, excluding outliers.
- ⊟ **3rd Quartile Bin (top box), Median (middle line), and 2nd Quartile Bin (bottom box)** all excluding outliers.
- ⊥ **1st Quartile Bin** contains the lowest 25 percent of data points, excluding outliers.
- × **Average** the average value of all data points, including outliers.
- ○ **Outliers** data points that exceed the 3rd quartile by 1.5x the total length of the 2nd and 3rd quartile bins.

The box plots demonstrate that, even when controlling for sector, the total estimated food waste generation is heavily impacted by the largest of establishments. This is further illustrated in Figure 2-4.

Figure 2-4 Percent of Estimated Food Waste Generation at Largest Establishments (≥52 Tons/Yr.)



[1] Includes only establishments exceeding 52 tons per year of food waste generation. (e.g., since only 14 percent of all establishments are estimated to exceed 52 tons per year, the largest 1 percent of establishments depicted in this figure would translate to the largest 14% × 1% = 0.14% of all establishments)

Several interesting conclusions can be drawn from the above figure:

- Approximately 46 percent of total ICI food waste generation (about 912,000 tons) occurs at only 5 percent of the largest establishments (370 establishments) exceeding 52 tons per year of food waste generation.
- The largest one percent of Food Manufacturing and Processing establishments exceeding the threshold (21 establishments) is cumulatively estimated to generate about 21 percent (252,000 tons) of food waste from the entire sector.
- If 100 percent of food waste from the top 50 percent of food waste generators (equal to 3,710 establishments, the smallest of which generates about 106 tons per year or about 2 tons per week) was hypothetically diverted from disposal, that would have the effect of diverting approximately 86 percent of the total ICI food waste generation (1.7 million tons) from all establishments generating more than 52 tons per year.

2.4 COMPARISONS TO OTHER STUDIES

In order to benchmark the reasonableness of this study's food waste generation estimates, the results of this study were compared to those of similar studies. This study's results are shown with the 52 ton per year threshold, as well as without the threshold in order better align with the methodologies of other studies.

Table 2-8 compares the relative proportions of total ICI food waste generation as estimated by the U.S. EPA' *2018 Wasted Food Report* with that of this study. The U.S. EPA study followed a similar methodology to that of this study, however, rather than estimating food waste generation at the establishment level, the U.S. EPA study instead applied generation factors to aggregate, national-level data.

Table 2-9 Comparison of Food Waste Generation Results to U.S. EPA Study

Sector	U.S. EPA's Estimated Percentage of ICI Food Waste Generation[1][2]	This Study's Estimated Percentage of ICI Food Waste Generation (≥52 tons/yr.)	This Study's Estimated Percentage of ICI Food Waste Generation (any size)
Food Manufacturers and Processors	54%	61%	47%
Food Wholesale and Retailers	17%	21%	26%
Restaurants and Food Service	23%	13%	21%
Hospitality Industry	2%	2%	2%
Healthcare Facilities	1%	1%	1%
Educational Institutions	3%	1%	2%
Correctional Institutions	1%	1%	1%

[1] Source: U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *2018 Wasted Food Report*.

[2] The U.S. EPA's study includes food waste generation from office buildings, sports venues, and military installations, which cumulatively account for 5 percent of its total estimated ICI food waste generation. These quantities have been removed for better comparison with this study's estimates.

The U.S. EPA's estimates and this study's estimates appear to be within the same order of magnitude. The differences between the results of the two studies can likely be explained due to the differences in:

- **Geographic scope**. The U.S. EPA's study is supposed to be representative of the U.S. as a whole, whereas this study's scope was specific to the Commonwealth.
- **Establishment data**. The U.S. EPA's study used aggregate estimates of sector data (e.g., the U.S. Census Bureau's estimate of annual sales revenue of the Food Manufacturing and Processing sector), whereas this study used establishment-specific data.
- **Generation factors**. Both studies relied on estimated generation factors from existing research for extrapolating food waste generation, however the exact generation factors used varied between the two studies. For example, the U.S. EPA's study used the average of the three generation factors available for extrapolating annual sales revenue in the Food Manufacturing and Processing sector, whereas this study used the singular generation factor that was determined to be the most comprehensive.

The states of Massachusetts, Connecticut, and Vermont have undertaken similar studies of ICI food waste generation in their states. Each study applied a relatively similar methodology of combining generation factors with establishment data to estimate food waste generation at the establishment level. Of these three studies, only the Massachusetts study appeared to be a good fit for comparison with this study. The Connecticut study did not attempt to estimate food waste generation for food manufacturers, wholesalers, or the hospitality industry, which collectively makeup nearly 74 percent of the total food waste tons estimated in this study (after applying the 52 ton per year threshold). The Vermont study did attempt these estimates, however, food waste generation estimates were not available for about 45 percent of food manufacturers.

Table 2-9 compares the results of the Massachusetts study with this study's results. It should also be noted that the Massachusetts study applied various minimum size thresholds to the establishment data that likely eliminated many of the smaller establishments that would otherwise have been included in its database.

Table 2-10 Comparison of Food Waste Generation Results to Massachusetts Study by Sector

Sector	% of Total Food Waste Generation	
	MA Study[1]	This Study (≥52 tons/yr.)
Food Manufacturers and Processors	58%	61%
Food Wholesale and Retailers	19%	21%
Restaurants and Food Service	17%	13%
Hospitality Industry	1%	2%
Healthcare Facilities	3%	1%
Educational Institutions	2%	1%
Correctional Institutions	0%	1%

[1] Source: Massachusetts Department of Environmental Protection. (2011). *Summary Analysis of Massachusetts Commercial/Institutional Food Waste Generation Data.*

Similarly, the results of the two studies appear to be within the same order of magnitude. The differences in geographic scope (MA vs. PA) and generation factors are again likely reasons for the remaining differences between the two studies. Table 2-11 compares the same studies, but instead shows the distribution of total food waste generation by various sizes of food waste generators.

Table 2-11 Comparison of Food Waste Generation Results to Massachusetts Study by Generator Size

ICI Establishments Generating…	% of Total Food Waste Generation	
	MA Study[1]	This Study (≥52 tons/yr.)
≥ 400 ton/yr. of food waste	59%	58%
300-399 ton/yr. of food waste	4%	6%
200-299 ton/yr. of food waste	4%	9%
100-199 ton/yr. of food waste	14%	15%
50-99 ton/yr. of food waste	7%	12%
25-49 ton/yr. of food waste	7%	0%
< 25 ton/yr. of food waste	3%	0%

[1] Source: Massachusetts Department of Environmental Protection. (2011). *Summary Analysis of Massachusetts Commercial/Institutional Food Waste Generation Data.*

The Massachusetts study appears to find similar conclusions to this study: total food waste generation is heavily skewed towards the largest of establishments, and the Food Manufacturing and Processing sector is responsible for about 60 percent of all ICI food waste generation.

In February 2021, the non-profit organization ReFED launched a tool that, among other things, attempts to estimate food waste generation (referred to as "surplus food") at the state level for the manufacturing, foodservice, and retails sectors, as well as for the residential and agricultural sectors. The tool utilizes a relatively complex economic analysis methodology that is unique to the estimation of each sector. Broadly speaking, the tool uses sales data from each sector, estimates the quantity of food sold from the sales data, then applies percentage estimates from case studies and expert interviews to estimate the quantity of food created in surplus. The tool's estimates of food waste generation (as it is defined in this study) from the Pennsylvania manufacturing, retail, and restaurant sectors are shown in Table 2-12.

Table 2-12 Comparison of Food Waste Generation Results to ReFED Estimates

	Food Waste Generation Estimate (tons/yr.)		
Sector **↳ Subsector**	**ReFED[1]**	**This Study (≥52 tons/yr.)**	**This Study (any size)**
Food Manufacturers and Processors	394,899	1,213,853	1,264,833
Food Wholesale and Retailers ↳ Supermarkets and Other Retail	383,429	203,888	450,296
Restaurants and Food Service	467,986	253,635	573,553
	1,246,313	**1,671,376**	**2,288,682**

[1] Source: ReFED. Retrieved March 3, 2021. Insights Engine.

This study's estimates for the supermarkets and restaurants appear to bound the estimates provided by the ReFED tool, however, the ReFED tool's estimate for food manufacturers equaled only about 33 percent of this study's estimate. It is not clear what is responsible for this large discrepancy. It was beyond the scope of this study to investigate this discrepancy and further study may be necessary.

2.5 SUMMARY

This study's analysis of ICI food waste generation resulted in the most comprehensive, publicly-known database of food-waste-generating establishments in Pennsylvania. The methodology and sources utilized in this study have been thoroughly documented in this report for future reference as newer generation factors and other data are made available.

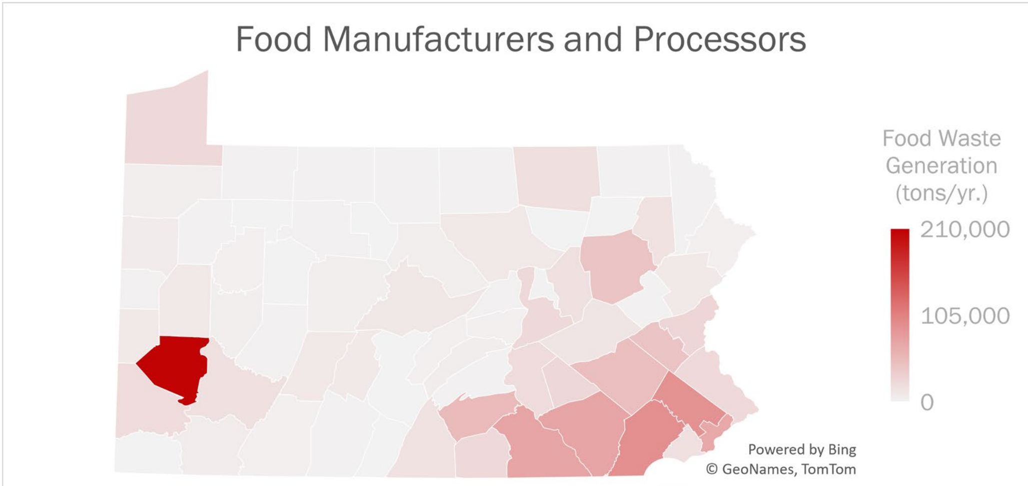
Key takeaways from the results of this analysis include:

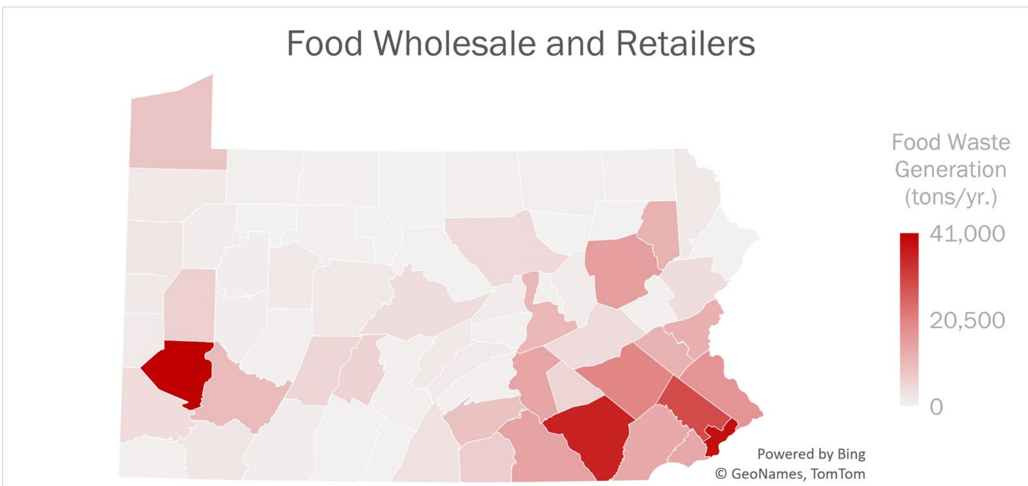
- ICI establishments that produce more than 52 tons per year of food waste are estimated to generate nearly two million tons per year in total.
- Though only 14 percent of ICI establishments are estimated to exceed the 52 ton per year threshold, these establishments are estimated to be responsible for approximately 73 percent of total statewide ICI food waste generation.
- The Food Manufacturers and Processors sector alone was estimated to generate 61 percent of the two million tons per year, followed by the Food Whole and Retail sector at 21 percent and the Restaurant and Foodservice sector at 13 percent (for a combined total of 95 percent).
- The 370 largest-generating establishments are estimated to generate over 46 percent of the total two million tons per year.

The results of this study were compared with those of similar studies and generally seem in line with their findings. Though it is not recommended that these results be interpreted to represent the food waste generation of any individual establishment, the results of this analysis should be useful for statewide planning purposes.

CHAPTER 2 EXHIBITS

Exhibit 2-1 Maps of Estimated Food Waste Generation by County and Sector (≥52 Tons/Yr.)





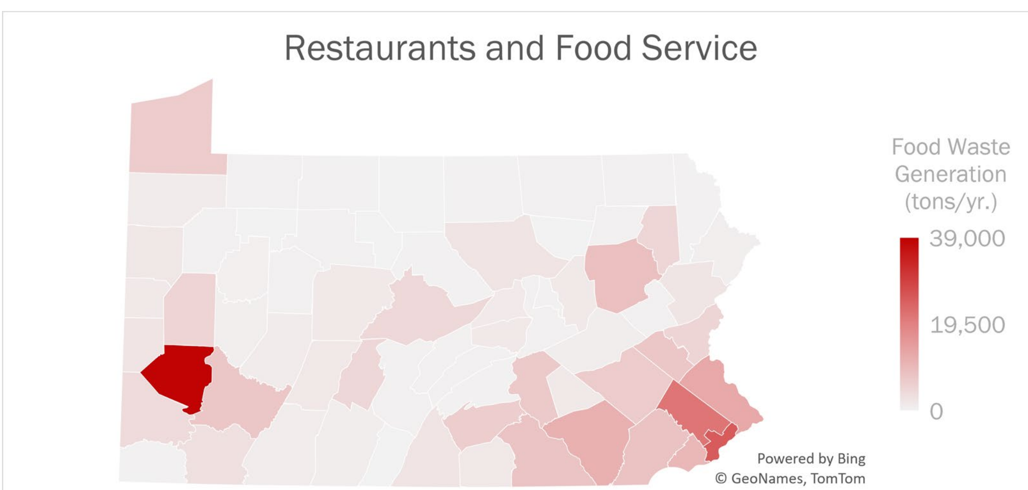
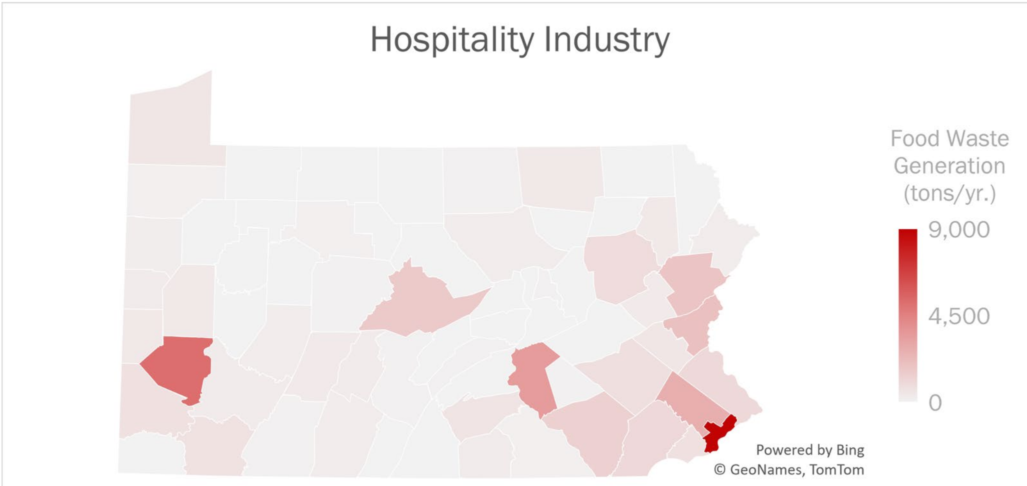
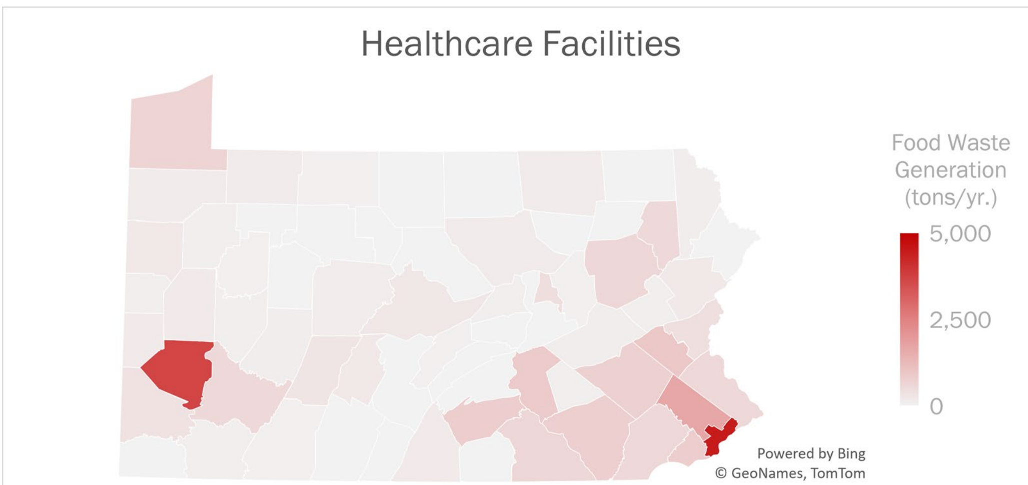


Exhibit 2-1 Continued





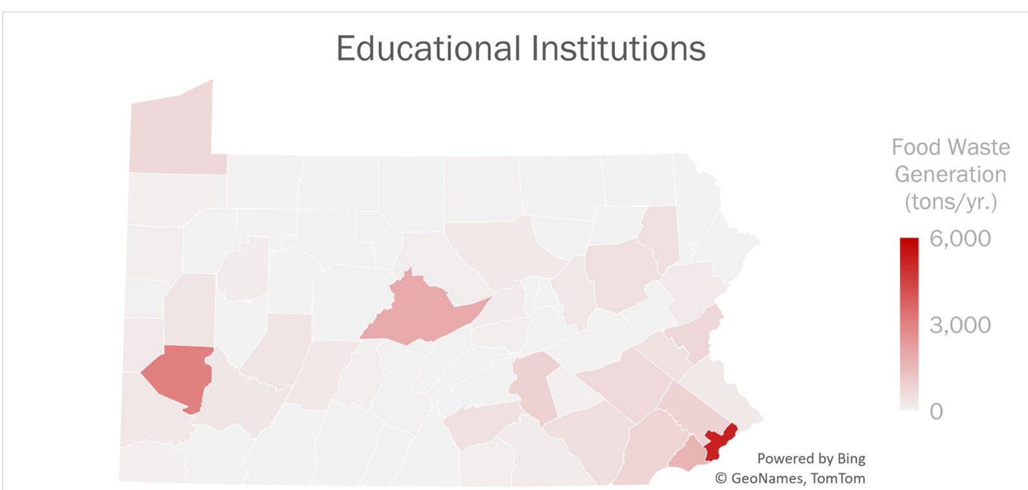
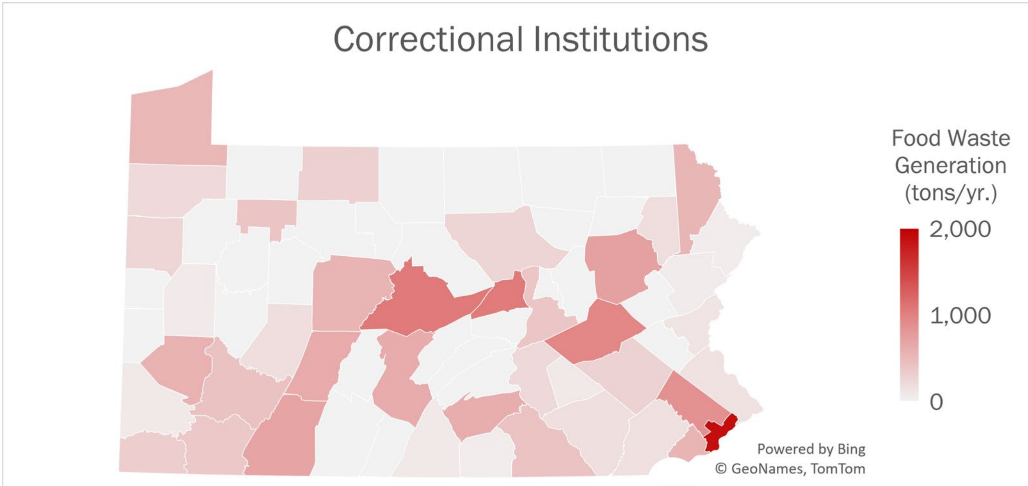


Exhibit 2-1 Continued



3. ORGANICS PROCESSORS

3.1 OVERVIEW

Prior to this assessment, understanding the amount of industrial, commercial, and institutional (ICI) food waste diverted via anaerobic digestion (AD) and composting in Pennsylvania was limited. No publicly-available dataset comprehensively identified all AD and compost facilities processing ICI food waste, much less documented the amounts accepted and the additional capacities available.

This study aimed to:

- Compile a comprehensive inventory of AD facilities and compost facilities accepting ICI food waste,
- Quantify the amount of food waste being processed at these facilities,
- Estimate the resulting reduction in greenhouse gas (GHG) emissions,
- For AD facilities, quantify the biogas generated from the anaerobic digestion of food waste, and
- Investigate the ability of AD and composting facilities to process additional food waste using existing infrastructure or with limited capital improvements.

To accomplish the above, this study utilized direct outreach to facilities via postal mail, telephone, and electronic mail. This approach allowed data to be gathered directly from facilities in a consistent methodology. This approach also allowed facility operators to qualitatively address the potential issues they foresee in accepting additional food waste and voice other challenges they have encountered related to food waste processing.

This analysis separated organics processing facilities into three categories:

1. AD facilities currently processing ICI food waste,
2. Compost facilities currently processing ICI food waste, and
3. AD facilities not currently processing ICI food waste.

Note from the above categorization that: a) unlike AD facilities, compost facilities not processing ICI food waste (including those that only process residential waste) were not examined in this study, and b) AD facilities already processing ICI food waste were examined separately from those that were not currently processing food waste. Analysis of facilities in the former category relied largely on the ability of facility operators to estimate the additional capacity available for processing food waste at their location. A different, modeling-based methodology was utilized for facilities in the latter category in order to estimate the amount of food waste (if any) that can be processed were the facility to begin co-digesting food waste.

Congruent with the U.S. EPA's survey of AD facilities processing food waste,[1] AD facilities were further categorized by their location as either:

- On-farm AD facilities,
- Wastewater treatment plant (WWTP) AD facilities, or
- Stand-alone AD facilities.

Some facilities, such as stand-alone anaerobic digesters utilized as part of a food manufacturing process, do not accept food waste from external sources. These facilities were included in the results of this study and were considered to not have additional capacity available. It is possible that additional facilities beyond

[1] U.S. Environmental Protection Agency. (January 2021). *Anaerobic Digestion Facilities Processing Food Waste in the United States.*

those identified in this study exist but were not captured in this study because they are not in DEP's permitting database and are not publicly known.

3.2 METHODOLOGY

The specific research objectives of this study required direct outreach to organics processing facilities. Before facilities could be contacted, it was first necessary to inventory potentially eligible facilities based on existing public and private datasets. Preliminary phone calls were then made to confirm each facility's eligibility for this study; those that were eligible were subsequently surveyed via a combination of postal mail, telephone, and electronic correspondence. Direct responses from facility operators were the primary data sources for this analysis. In cases where primary data was not available, such as when facility operators were unable to approximate a value, this study estimated values based on those observed at similar facilities or by applying reasonable standards based on the professional experience of the project team. Additionally, two U.S. EPA modeling tools, the Waste Reduction Model (WARM) and the Co-digestion Economic Analysis Tool (Co-EAT), were used to approximate data unlikely to be known by facility operators.

Therefore, this study's methodology can be broadly summarized as:

1. Research existing datasets and compile inventory of facilities.
2. Survey facilities.
3. Apply analytical tools and methods to survey responses.

The following subsections detail the methodologies followed in completing the above steps.

3.2.1 EXISTING DATASETS

The existing datasets identifying AD and compost facilities were an excellent starting point to the research. However, none were found to be entirely complete, nor did many of them denote if ICI food waste was being processed at each facility.

Many facilities were identified through their possession of general permits. Five general permit types were found to authorize the processing of food waste and are shown in Table 3-1. Of the five permit types, four authorized the composting of food waste (as well as other materials); the remaining permit type authorized the co-digestion of food waste with animal manure for on-farm AD facilities. As of Spring 2021, no general permits existed to authorize the anaerobic digestion of food waste at WWTP or stand-alone facilities, though a coordinated effort between the Bureau of Waste Management and Bureau of Wastewater had begun which could result in such general permits.

Table 3-1 General Permits Related to Food Waste Processing

Permit	No. of Facilities	Description
WMGM042	18	Processing by anaerobic digestion of animal manure generated on a farm to be blended with (a) grease trap waste and (b) **pre-and-post consumer food waste** from commercial and institutional establishments for beneficial use activity as follows: 1.) The methane gas produced by the anaerobic digestion as fuel, including in the production of electricity. 2.) The waste solids removed from the digester as animal bedding material at the farm; and 3.) The liquid waste and solids removed from the digester as a soil additive for agricultural purposes.
WMGM017	18	Processing and beneficial use of compost of manure, yard waste, **source separated food scraps from food markets, grocery stores, food banks, food distribution centers, school cafeterias and institutions**, source-separated newspaper, and source-separated corrugated paper (cardboard) as soil substitute, soil conditioner, fertilizer, mulch or soil amendment.
WMGM027	8	Processing of: 1. wood waste (clean and uncontaminated land clearing, grubbing and excavation waste, 2. yard waste, and residual and municipal wood scrap) to produce mulch for landscaping purposes, leaf and yard waste, **food processing residuals**, and spent mushroom substrate (SMS) to produce compost, 3. organic, non-organic residuals with a BTU value of at least 5,000 BTU/lb for use as alternative fuels, 4. compost, drinking water treatment plant sludge, waste gypsum, foundry sand and SMS with non-waste soils to produce topsoil for landscaping purposes, and 5. clean, uncontaminated rock, stone, gravel, brick, block, concrete and used asphalt) for use as a construction material at the processing facility only.
WMGM045	1	Processing and beneficial use activities performed by facilities that, at any one time, do not exceed (i) 5 acres and (ii) 6,000 cubic yards per acre of wastes as follows: 1. Processing by mixing or blending, screening and composting of (a) **source separated food processing waste**, (b) **source separated pre-and-post consumer food wastes**, (c) yard waste, (d) unpainted and untreated wood waste, (e) source segregated paper and cardboard, (f) land clearing and grubbing waste, and (g) agricultural waste on an active or abandoned mine site approved by the Department as part of a mine reclamation permit or project. 2. Beneficial use of the cured compost as (a) a soil additive, (b) a mulch for landscaping purposes, (c) a fertilizer in normal farming operations or mine reclamation activities, or (d) in the production of a manufactured topsoil.
WMGR025	15	Composting and beneficial use of the following source-separated wastes: agricultural waste other than mortalities, butcher waste other than whole carcass, **food processing waste**, **pre-consumer and post-consumer food residuals**, yard waste, land clearing and grubbing material, untreated wood waste, gypsum wallboard, paper, cardboard, waxed cardboard, virgin paper mill sludge and spent mushroom substrate. The beneficial uses of the finished compost approved in this permit are for use, marketing or distribution as a soil conditioner, soil amendment, fertilizer, mulch or for erosion control. The finished compost is not considered a waste when it has satisfied the conditions of this permit and is ready for use, marketing or distribution as a soil conditioner, soil amendment, fertilizer, mulch or for erosion control.

Source: Pennsylvania Department of Environmental Protection. Retrieved March 31, 2021. List of Municipal Waste Beneficial Use General Permits.

Although the general permits authorized facilities to process food waste, it was not initially clear which of the facilities were actively doing so.

Additional datasets were consulted in order to better gauge which facilities were accepting ICI food waste, identify the WWTP and stand-alone AD facilities not represented in the general permits, and gather secondary data that could be utilized for facilities that would not respond to the survey. Table 3-2 summarizes the supplemental datasets compiled in this research.

Table 3-2 Organics Processor Datasets Compiled

Processor Type	Author/Publisher	Publication Name	Data Year
AD	American Biogas Council	*Biogas Projects*	n.d.
AD	Penn State Extension	*On-farm Anaerobic Digestion Biogas Production in Pennsylvania - 30 Years*	2016
AD	U.S. Department of Agriculture	*Biogas Information System*	2016
AD	U.S. EPA	*Anaerobic Digestion Facilities Processing Food Waste in the United States*	2017-18
AD	U.S. EPA AgSTAR Program	*Livestock Anaerobic Digester Database*	2020
AD	Water Environment Federation	*Biogas Data*	2015
AD/Compost	U.S. EPA	*Excess Food Opportunities Map*	2019
Compost	Litterless.com	*Where to Compost*	n.d.
Compost	RecycleSearch.com	N/A	n.d.
Compost	U.S. Composting Council	*STA Certified Compost Participants*	n.d.

The combination of these datasets identified an initial list of 118 AD facilities and 83 compost facilities. Note that some of these facilities were later found to be ineligible for inclusion in this study, such as compost facilities not processing ICI food waste or facilities that were no longer operating. Though this list is believed to be the most comprehensive, publicly-available dataset of organics processors in Pennsylvania, it is possible that additional facilities exist that were not captured in this study. For example, food manufacturers that utilize AD to process food residuals may not publicize their operation nor require a general permit to do so, and thus may not have appeared in any of the compiled datasets.

3.2.2 Facility Surveys

Before surveying began, preliminary phone calls were made to each facility to confirm the facility's eligibility to participate and to identify the appropriate contact information for transmitting the survey. These preliminary calls revealed that a large proportion of organizations possessing a general permit that authorized the composting of food waste were not utilizing the permit for this purpose: some of these facilities were instead utilizing the permit for composting other authorized materials, while others reported only hauling food waste to other organizations for processing. These preliminary phone calls also filtered out facilities that were no longer operational.

A total of 26 AD facilities and 25 compost facilities were verified to process ICI food waste, and 83 AD facilities were identified as not processing ICI food waste. Conversely, 20 compost facilities were unable to be contacted and were presumed ineligible.

Facility surveys were conducted in three groups: 1) AD facilities processing ICI food waste, 2) compost facilities processing ICI food waste, and 3) AD facilities not processing ICI food waste. Most surveys for the first group took place in September 2020, followed by the second group in October and the third group in November-December. The survey questionnaires used for each group are included in Appendix C.

Two different methodologies were employed for surveying facilities:

- For facilities processing ICI food waste (first and second group), a letter was first sent on DEP letterhead to notify the facilities of the upcoming survey that was to be conducted primarily via telephone interview. The letter provided a brief introduction to the study, a summary of the questions to expect, a description of how the information would be used, and notice of when to expect the telephone interview. The letter also provided recipients with an email address to contact should they prefer to complete the survey via email as well as the contact information of DEP staff. Facilities were called via telephone on the dates specified in the letter – approximately one week after the letters were sent. Facility operators were asked to answer the questions to the best of their ability and were reminded that their participation was voluntary and that they may abstain from answering questions that could reveal confidential information. When a facility operator could not be reached, a voicemail was left and the facility would be recalled two business days after the previous call. After three attempted phone calls, a facility would be deemed nonresponsive.
- For AD facilities not processing ICI food waste (third group), the highly-technical nature of questions required that a different approach be followed. Similar to the above, facilities were sent a letter on DEP letterhead that introduced the study and how their information would be used; however, also included with this letter was a printed copy of the questionnaire and a prepaid envelope for facility operators to return their responses. Additionally, facilities were given the option to complete the questionnaire electronically through an online webform. As an added incentive to facilities for their participation in this study, the results of this analysis as they related to their facility were emailed to each responding facility operator at the conclusion of this study. One week after the letters were mailed, a follow-up phone call was made to each facility operator to confirm their receipt of the parcel and answer any potential questions related to the study or questionnaire. Facilities were given several months to submit their responses and were only deemed nonresponsive when the development of this report began.

Table 3-3 shows the response rate of each facility group. As shown, the overall response rate was 50 percent and was highest from compost facilities and AD facilities currently processing food waste.

Table 3-3 Survey Response Rate

Facility Type	# of Facilities Identified	# of Survey Responses	Response Rate
AD Processing ICI Food Waste	**26**	**16**	**62%**
On-farm AD	*17*	*9*	*53%*
WWTP AD	*3*	*3*	*100%*
Stand-alone AD	*6*	*4*	*67%*
Compost Processing ICI Food Waste	**25**	**20**	**80%**
AD Not Processing ICI Food Waste	**83**	**27**	**33%**
On-farm AD	*15*	*6*	*40%*
WWTP AD	*68*	*22*	*32%*
Stand-alone AD	*0*	*0*	*0%*
Total	**160**	**80**	**50%**

The lower overall response rate of the third group, AD facilities not processing ICI food waste, can likely be attributed to the effort required to address some of the technical questions of the survey. In conversations with survey respondents from this group, some respondents mentioned that it took upwards of 20 minutes to complete the survey, and in some cases, the facility's engineer had to be consulted. Though attempts were made to minimize the number of questions included in this survey, the need to accurately operate the Co-EAT increased the technical complexity of the survey. Data from the U.S. EPA's *Clean Watersheds Needs Survey*[2] was used to compare the flow rates of WWTPs that responded to the survey with the flow rates of those that did not respond to the survey. The flow rates between the two strata were similarly distributed, suggesting that the survey respondents are a fair representation of the larger population of AD facilities.

Additionally, some facilities reported difficulty in responding to the surveys due to the seasonality (particularly relevant to on-farm digesters preoccupied with the fall harvest) or due to labor shortages resulting from COVID-19.

3.2.3 Analytical Tools and Methods

In cases where a direct survey response was not obtained, estimation techniques were applied to complete the analysis. Estimation was used in:

- Standardizing food waste weights for water content,
- Converting food waste reported in volumetric units into weights,
- Estimating biogas produced from digesting food waste (when necessary), and
- Approximating food waste throughputs at nonresponsive facilities.

Additionally, two U.S. EPA tools were used in this analysis to produce estimates based on facility-provided data:

- the Waste Reduction Model (WARM), and
- the Co-digestion Economic Analysis Tool (Co-EAT).

A summary of estimation methods used in this study, as well as overviews of the WARM and Co-EAT, are provided in the following subsections.

3.2.3.1 Estimation Methods for Data Gaps

Standardizing food waste weights for water content. Many AD facilities that responded to the survey reported that the food waste they process is already liquified upon arriving at the processing facility and is naturally high in water content. Examples of this include whey wastewater from cheese manufacturing, sugar water, or wastewater from the cleaning of food-laden processing vessels. In these cases, a disproportionate amount of the recorded food waste is the result of excess water content. To avoid overreporting the amount of actual food waste processed, attempts were made to standardize high-water-content material to a moisture content of 72.2 percent, as is assumed for food waste in WARM.[3] These conversions were performed by first researching prior studies that examined the physical characteristics of waste material similar in description to the material described by the survey respondent. The total solids content of the analogous material was then used as a proxy for the dry food waste content of the material reported in the survey. The approximated dry weight value (which by definition has a moisture content of 0 percent) would then be increased until 72.2 percent of the weight of the material was the result of its water content, putting it in line with that of more traditional pre- and post-consumer food waste.

Estimating food waste weights from volumes. In order to relate the quantity of food waste processed via AD and composting to the estimated amount of food waste generated, all food waste in this study was

[2] U.S. Environmental Protection Agency. (2012). *Clean Watersheds Needs Survey.*

[3] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model.*

expressed in tons. However, many of the surveyed facilities record food waste amounts in volumetric units such as gallons or cubic yards rather than by weight. Thus, it was necessary to estimate conversion factors (i.e., densities) to translate recorded volumes into weights. In many cases, this was performed in conjunction with standardizing the food waste's water content. For example, if a facility reported processing 100,000 gallons of whey wastewater, it would be converted to approximately 165 tons of food waste using the process described previously. In other cases, volume-to-weight conversion factors reported by the U.S. EPA[4] were used. Finally, professional judgment and/or direct estimates from knowledgeable sources were used in some cases. For instance, to approximate the weight of food waste received in the form of a slurry from an external preprocessing site, the conversion factor of 10 lbs of food waste per gallon of slurry[5] was used.

Estimating biogas produced from digesting food waste. Approximating the amount of biogas resulting exclusively from the anaerobic digestion of food waste – separate from other co-digested wastes such as manure at on-farm AD facilities or municipal sludges at WWTP AD facilities – was challenging for many AD facility operators who responded to the survey. In most cases, AD operators provided their total biogas production amount and a general approximation of what percentage of it originates from food waste. However in some cases, AD facility operators did not feel confident in providing such an approximation. Biogas yield rates vary based on the composition of the food waste and the specific characteristics of the AD facility (e.g., hydraulic retention time, single-stage or two-stage digestion, etc.). Table 3-4 shows approximate biogas yield rates for various organic waste types in both their natural forms (which may be very high or very low moisture content), as well as standardized to the average food waste moisture content of 72.2 percent. As shown in the table, biogas generation from food wastes is estimated to vary between 2,200 and 7,200 cubic feet per moisture-standardized ton. Values from Table 3-4 were used to approximate the biogas generation from food waste for facilities where direct estimates from survey respondents were unavailable.

[4] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (April 2016). *Volume-to-Weight Conversion Factors.*

[5] Sourced from correspondence with an AD developer active in Pennsylvania.

Table 3-4 Approximate Biogas Yield Rates by Organic Waste Type

Waste Type	Natural Moisture Content		Standardized Moisture Content	
	% Moisture Content	Biogas Yield Rate (ft^3/ton)	% Moisture Content	Biogas Yield Rate (ft^3/ton)
Chip fat	5.0%	26,479	72.2%	7,748
Fat	5.0%	26,479	72.2%	7,748
Animal carcasses (homogenized)*	70.0%	7,785	72.2%	7,214
Animal fat	10.0%	22,057	72.2%	6,813
Grease trap	87.0%	3,165	72.2%	6,769
Silage effluent	98.6%	340	72.2%	6,743
Pure fat (rendering plants)	1.0%	23,787	72.2%	6,680
Fermentation slops*	98.2%	423	72.2%	6,531
Concentrated whey*	85.0%	3,460	72.2%	6,413
Glycerine*	0.0%	22,826	72.2%	6,346
Whey*	95.0%	1,083	72.2%	6,021
Old bread*	35.0%	13,850	72.2%	5,923
Rapeseed cake*	15.0%	17,220	72.2%	5,632
Maize silage*	68.0%	6,427	72.2%	5,583
Potatoes*	75.0%	5,011	72.2%	5,572
Cereals/grains*	15.0%	16,816	72.2%	5,500
Potato pulp*	85.0%	2,967	72.2%	5,498
Corn Cob maize (CCM) *	40.0%	10,957	72.2%	5,077
Canteen waste/food waste*	80.0%	3,524	72.2%	4,898
Food waste (disinfected) *	80.0%	3,524	72.2%	4,898
Blood	92.0%	1,384	72.2%	4,809
Fruit wastes*	85.0%	2,380	72.2%	4,412
Silage from grain (whole plant) *	72.0%	4,440	72.2%	4,409
Sugar beet chopped*	75.0%	3,950	72.2%	4,393
Fruit Pomace*	80.0%	2,999	72.2%	4,168
Grass silage	75.0%	3,745	72.2%	4,165
Clover	85.0%	2,198	72.2%	4,073
Cereal slop (alcohol production) *	94.0%	830	72.2%	3,845
Fruit slop*	98.0%	276	72.2%	3,830
Grass fresh	82.0%	2,335	72.2%	3,607
Rape seed-silage*	84.0%	2,050	72.2%	3,563
Draff from beer production*	80.0%	2,563	72.2%	3,563
Sewage sludge	88.0%	1,506	72.2%	3,488
Potato top*	87.2%	1,499	72.2%	3,256
Residuals from vegetables*	80.0%	2,307	72.2%	3,206
Sugar beet leaves*	78.0%	2,380	72.2%	3,008
Gut and Stomach/Intestines content	85.0%	1,538	72.2%	2,850
Chaff*	15.0%	8,579	72.2%	2,806
Chicken litter/dung	60.0%	4,037	72.2%	2,805
Beet top*	88.0%	1,131	72.2%	2,620
Municipal solid waste, MSW (brown bin)	65.0%	3,252	72.2%	2,583
Fruit residuals*	80.0%	1,794	72.2%	2,494
Cattle-slurry*	92.0%	657	72.2%	2,282
Pig slurry*	95.5%	368	72.2%	2,276
Cattle-dung	75.0%	1,922	72.2%	2,138
Horse manure	72.0%	1,794	72.2%	1,781
Hemp cake	12.0%	2,752	72.2%	869
Average	**66.4%**	**6,018**	**72.2%**	**4,487**
Median	**80.0%**	**2,967**	**72.2%**	**4,393**

Source: MSW Consultants' calculations based on approximated data compiled by the Sustainable Energy Authority of Ireland.
* Denotes food wastes.

Estimating food waste throughputs at nonresponsive facilities. To estimate the total quantity of ICI food waste diverted via AD and composting, the amount of ICI food waste processed at facilities that did not respond to the survey (ten AD facilities and five compost facilities) had to be estimated. Estimates were based on the median amount of food waste processed per facility as reported by survey respondents from similar facility types. For instance, the median amount of ICI food waste reported by on-farm AD survey respondents was 1,500 tons per facility. Thus, the eight on-farm AD facilities that did not respond to the survey were each estimated to process 1,500 tons of ICI food waste per year. This methodology was repeated for the two stand-alone AD facilities that did not respond (estimated at 7,355 tons per year each) and the five compost facilities that did not respond (estimated at 800 tons per year each). The total estimated capacity was therefore 30,710 tons (rounded to 31,000 tons) per year, which was not verified via direct survey. No additional unused capacity was estimated for nonresponsive facilities.

3.2.3.2 Waste Reduction Model (WARM)

This study used the U.S. EPA's WARM to estimate the reduction in GHG emissions resulting from the anaerobic digestion or composting of food waste. WARM allows users to input tonnage data into both a "current" and "future" scenario to estimate the impact of redirecting waste quantities from one management method (such as landfilling or incineration) to another (such as anaerobic digestion or composting). WARM also approximates the emissions impacts from transportation and allows users to set operating parameters such as how landfill gas is recovered (if at all) and whether or not digestate is cured before land application. An example output of WARM showing the GHG emissions reduction estimated from diverting 1,000 tons of food waste from landfilling to anaerobic digestion is shown in Figure 3-1.

Figure 3-1 Example WARM Output

Waste Reduction Model (WARM)

Summary Report (MTCO2E)

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **Example**
Prepared by:
Project Period for this Analysis: to

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Food Waste	N/A	1000.00	0.00	0.00	0.00	547.02
						547.02

Material	Alternative Scenario						
	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Food Waste	0.00	N/A	0.00	0.00	0.00	1000.00	-124.28
							-124.28

Total Change in GHG Emissions (MTCO2E): **-671.29**

This is equivalent to...
Removing annual emissions from **142** Passenger Vehicles
Conserving **75536** Gallons of Gasoline
Conserving **27970** Cylinders of Propane Used for Home Barbeques

While WARM is a commonly referenced tool within the waste industry, it is ultimately intended only for high-level analysis and relies on several simplifying assumptions. Some of WARM's assumptions[6] relevant to this study include:

- WARM assumes that biogas from AD is used for on-site electricity generation and to heat the digester (i.e., combined heat and power, or CHP), with excess electricity sold to the regional electrical grid. WARM models the recovery of biogas for electricity generation and assumes that this electricity offsets non-baseload electricity generation in the power sector. Electricity generation from combustion of biogas is assumed to be unavailable for 15 percent of operation time and the process is assumed to be 29 percent efficient. Though CHP is currently the most common use of biogas in the Commonwealth, two AD facilities that responded to the survey reported that some proportion of biogas is flared and one additional AD facility reported that biogas is used only for on-site electricity generation. Thus, WARM may overestimate the GHG emissions reductions for these facilities. Furthermore, WARM may not accurately calculate the GHG emissions reduction in cases where biogas is converted into

[6] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model.*

renewable natural gas (RNG) for pipeline transmission or use as vehicle fuel, though no AD facilities that responded to the survey reported this usage method.

- WARM assumes that digestate from AD is applied to agricultural lands. While many on-farm AD facilities do apply their digestate to land, not all AD facilities do so. WWTP AD facilities in particular, which co-digest food waste with primary sludge, waste activated sludge, or municipal wastewater, are less likely to be permitted to land-apply digestate. Digestate that cannot be land applied is usually disposed of via landfill. The GHG emissions resulting from the hauling and landfilling of digestate were not considered in this analysis, though are likely minor in comparison to the reduction in emissions from having digested the food waste.
- All food waste, regardless of its composition, is treated as the same material in WARM. The model's documentation presents the general life cycles and materials management pathways modeled in WARM for beef, poultry, grains, bread, fruits and vegetables, and dairy products.
- WARM assumes anaerobic digestion is conducted using a continuous, single-stage, mesophilic digester. Though this is the most common type of digester for food waste digestion, at least one AD facility processing food waste in the Commonwealth uses a two-stage digester, and an additional facility uses a thermophilic digester. Both two-stage and thermophilic digestion typically result in increased biogas yields, and therefore, decreased residual emissions in comparison to single-stage, mesophilic digestion. Thus, WARM may underestimate GHG emissions reductions in these cases.

Additional assumptions that this study made in operating WARM include:

- Landfilling was used as the management pathway in the "current" scenario (alternative to anaerobic digestion or composting) in all cases.
- The transportation distance to a landfill was assumed to be 20 miles in all cases.
- The default parameters for landfilling, including whether landfill gas is recovered, the landfill gas' recovery rate, and the moisture/decay rates of landfilled organic wastes, were all left as their default values resulting in national averages being used.

3.2.3.3 Co-Digestion Economic Analysis Tool (Co-EAT)

This study used the U.S. EPA's Co-EAT to conduct preliminary evaluations of the physical and economic feasibility of adding food waste co-digestion to AD facilities not currently processing food waste. Co-EAT's documentation,[7] lists the three primary objectives of the model:

1. To provide an **initial** economic feasibility assessment for co-digestion of organic wastes at a WWTP using AD to manage wastewater solids. The analysis can also be conducted to assess the feasibility of co-digestion at facilities that do not yet use, but are considering, anaerobic digestion, including dairies and stand-alone digesters.
2. To compare the relative merits of three uses of biogas: heating, electrical generation, and compressed natural gas for vehicle fuel.
3. To provide a clear comparison of the economic implications of co-digestion, given multiple performance assumptions, and unique physical and cost parameters provided by the tool-user.

Figure 3-2 shows an example output of Co-EAT in which a facility's parameters and results using its current feedstock (Current) are compared to other scenarios where food waste is added and:

- Biogas is used to heat the digester only (Future A), or

[7] U.S. Environmental Protection Agency Office of Research and Development. (May 2017). User's Manual: Co-digestion Economic Analysis Tool.

- Biogas is used in a CHP system to generate heat and power (Future B).

Co-EAT also models two additional scenarios (not shown) in which:

- Biogas is used to heat the digester and the excess is converted to compressed natural gas (CNG) for vehicle fuel (Future C), or
- All biogas is converted to CNG for vehicle fuel (Future D).

Figure 3-2 Example Co-EAT Output

	Current	Future A	Future B
Biogas Produced (cf/yr)	2,540,064	7,143,008	7,143,008
Total Biogas Heating Energy (MBTU/yr)	1,156	3,250	2,080
Total Energy Needed for Heating (MBTU/yr)	2,498	3,144	3,144
Max Capacity of Digester (gal)	273,618	273,618	273,618
Feedstock Feed Rate (gal/day)	4,942	7,501	7,501
% Solids of Feedstock Fed to Digester (%)	4.1%	6.3%	6.3%
Percent Volatile Solids Reduction (%)	40%	38%	38%
Actual Hyraulic Retention Time (days)	30.5	20.1	20.1
Target Hydraulic Retention Time (days)	29.7	20.0	20.0
Available Capacity (gal/day)	125	24	24
Additional Volume Needed to Treat Feedstock (gal)	0	0	0
Mass of Biosolids (Tons/yr)	1332	2691	2691
Biosolids Cost ($/yr)	($66,588)	($134,558)	($134,558)
Biosolids Revenue ($/yr)	$0.00	$0.00	$0.00
Tipping Fees ($/yr)	$0.00	$43,070.00	$43,070.00
Avoided Natural Gas Costs ($/yr)	$11,948	$1,093	($11,003)
Avoided Electricity Costs ($/yr)	$0	$0	$31,503
Avoided Vehicle Fuel ($/yr)	$0	$0	$0
Annualized Cost of Plant Upgrades ($/yr)	$0	($67,376)	($88,367)
Annual Operations and Maintenance ($/yr)	$0	$0	$0
Net Annualized Value ($/yr)	($54,640)	($157,771)	($159,356)

Operation of Co-EAT requires specific knowledge of facility parameters such as the dimensions of the digester(s), current targeted hydraulic retention time (HRT), and the current percent volatile solids (VS) reduction achieved, as well as the quantities and characteristics of facilities' current feedstocks. Additionally, details such as annual operation and maintenance (O&M) costs, digestate disposal costs, and electricity and natural gas rates are needed to project the economic impacts of co-digestion. The full list of details requested of survey respondents is shown in Appendix C.

Some submitted surveys were not completed in their entirety and others contained information requiring clarification. In these cases, the project team attempted to contact survey respondents to request additional information. When additional information was unavailable, this study approximated missing model inputs based on the values reported by similar facilities or through professional judgment.

Salient additional assumptions that this study made in operating Co-EAT include:

- **Current feedstocks could not be displaced to add food waste.** It was assumed that AD facilities rely on their digesters as an important part of treating and reducing the volume of current feedstocks. Though it is conceivable that some non-WTTP AD facilities may be willing and able to reduce the quantity of current feedstocks in order to increase revenue from food waste tip fees, this scenario was not modeled.

- **Total digester capacity would remain constant.** Though some AD facilities have previously added additional digester vessels in order increase their capacity to process food waste, this study assumed no additional digesters would be constructed.
- **Added food waste would not affect the digestion of current feedstocks.** Anaerobic digestion is a biochemical process that requires the balancing of feedstocks and avoidance of contaminants to maintain conducive conditions. The co-digestion of certain feedstocks can result in increased biogas generation that is greater than the sum of its parts, or conversely, can negatively impact biogas generation or potentially disrupt the digestion process. These possibilities are not considered by Co-EAT and were not considered in this study.
- **HRT could be lowered to a minimum of 20 days.** HRT reflects an AD facility's flow rate relative to its total digester volume. All else being equal, increasing the flow rate (adding more feedstock) or decreasing the total digester volume would result in a decreased HRT, and the converse would result in an increased HRT. Longer HRTs (which can in rare cases exceed 70 days) typically result in greater (albeit diminishing) VS destruction – increasing the total biogas recovered and decreasing the amount of solids which may require disposal. Additionally, some feedstocks (e.g., sewage sludge) require a minimum HRT duration to allow time for the inactivation of pathogens. This study elected to use 20 days as the minimum allowed HRT for modeling purposes. Thus, the amount of food that an AD facility was estimated to be physically capable of processing was determined by incrementally adding food waste until the facility's projected HRT was decreased to 20 days. Furthermore, facilities with an HRT already at or below 20 days were assumed to be incapable of co-digesting food waste.
- **Added food waste would be delivered to facilities in solid form.** This study modeled the scenario in which AD facilities would be capable of accepting food waste from sources such as food wholesalers and retailers. Food waste was assumed to arrive at the facility in solid form before being slurried down to a 10 percent total solids level. The amortized capital costs to purchase weigh scales, preprocessing (depackaging) equipment, buffer tanks, and transfer pumps were added to each facility if the equipment was not already possessed. In practice, some of these capital improvements may be avoided if food waste is instead only accepted in liquid or pre-slurried forms directly from food manufacturers or external preprocessing sites, however, this scenario was not modeled.
- **$35 per ton could be generated in revenue from food waste tip fees.** This number is based on the average food waste tip fee reported by compost facilities that responded to this study's survey. The average tip fee reported by AD facilities currently processing food waste was not used because the reporting facilities almost exclusively accept food waste in liquid form from food manufacturers. Because Co-EAT modeling was performed with the assumption that AD facilities would be capable of accepting food waste in solid form from a variety of sources, the tip fees charged by compost facilities were deemed more applicable.
- The average cost of electricity for AD facilities was assumed to be $0.061/kWh based on U.S. Energy Information Administration estimates for Pennsylvania.[8]
- The average cost of natural gas for AD facilities was assumed to be $0.784/CCF based on U.S. Energy Information Administration estimates for Pennsylvania.[9]

[8] Based on the January 2021 "Average Price of Electricity to Ultimate Customers" for Industrial sector customers in Pennsylvania, as listed by the U.S. Energy Information Administration.

[9] Based on the December 2020 "Industrial Price" in Pennsylvania, as listed by the U.S. Energy Information Administration.

Co-EAT's documentation also provides a disclaimer that "this model is not intended to be a final evaluation of a food waste co-digestion project" and recommends that AD facilities "perform community and situation specific analyses of project viability prior to implementation." Due to the inherent high-level scope of Co-EAT as well as the assumptions made in operating it, this study is not qualified to conclusively determine that any individual AD facility not already processing food waste is capable of adding co-digestion. For this reason, results from Co-EAT modeling are presented using qualified terms such as "potentially capable of processing food waste" and "not likely capable of processing food waste." Additionally, due to the imprecision of Co-EAT, facilities that were estimated to only be capable of processing less than 5 tons of food waste per day or whose net revenues were estimated to barely exceed current amounts were conservatively categorized as "not likely capable of processing food waste."

3.3 RESULTS

Results of the surveys and subsequent analyses are given in the following subsections. Some terms used throughout this section for brevity are defined here:

- "**current**" refers to the time period roughly in which the surveys were conducted (Sept. 2020–Feb. 2021),
- "**food waste**" refers exclusively to ICI food waste,
- "**co-digestion**" refers to the co-digestion of food waste, and
- "**processing capacity**" refers to the total amount of food waste that a facility (or facilities) can process annually. This includes both the current amount of food waste processed (i.e., "current food waste throughput") and the additional amount of food waste that could be processed using current infrastructure (i.e., "unused available capacity"). Facilities that do not accept external waste do contribute to overall processing capacity because they currently processing food waste; however, they are not shown as offering any additional unused available capacity.

3.3.1 Anaerobic Digesters Currently Processing ICI Food Waste

A total of 26 AD facilities were found to process ICI food waste, of which, 16 facilities responded to the survey. Table 3-5 summarizes the current amount of ICI food waste processed at these facilities ("current food waste throughput"), as well as the approximate biogas generation and GHG emissions reduction from the food waste's digestion. Current food waste throughputs and biogas generation were estimated for the 10 nonrespondent facilities based on the values observed from the responding facilities.

Table 3-5 Results Summary of Anaerobic Digesters Processing ICI Food Waste

	No. of Facilities	Current Food Waste Throughput (tons/yr.)	Biogas Generation from Food Waste (million ft^3/yr.)	GHG Emissions Reduction from Food Waste (MTCO2e/yr.)[1]
Subtotals for Respondents				
On-farm AD	9	21,000	114	14,000
WWTP AD	3	20,000	82	13,000
Stand-alone AD	4	39,000	76	26,000
Respondents Subtotal	*16*	*81,000*	*271*	*54,000*
Estimated Subtotals for Nonrespondents				
On-farm AD	8	12,000	64	8,000
WWTP AD	0	0	0	0
Stand-alone AD	2	15,000	28	10,000
Nonrespondents Subtotal	*10*	*27,000*	*92*	*18,000*
Grand Total	**26**	**107,000**	**363**	**72,000**

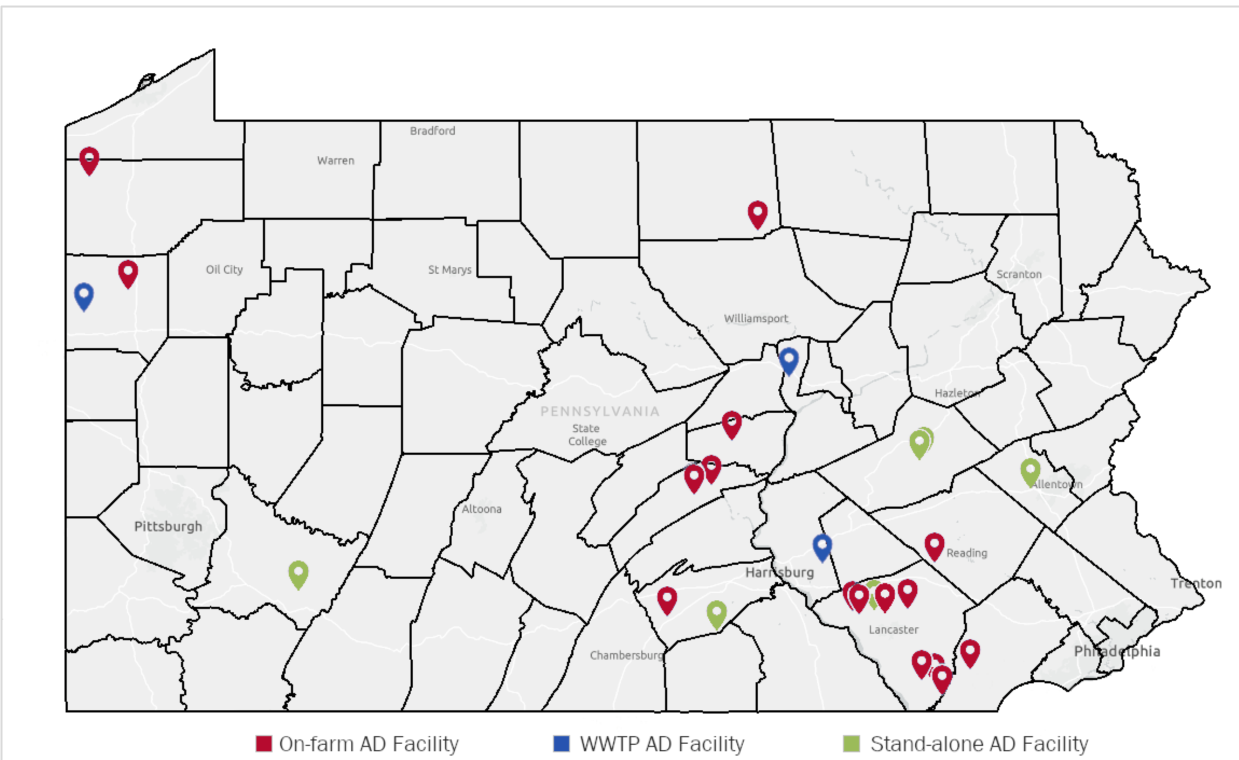
[1] Assumes diverted food waste would have been disposed of via landfill.

AD facilities were estimated to process about 107,000 tons of ICI food waste per year at the time of the study. From the digestion of this food waste, approximately 363 million cubic feet of biogas per year (or 691 SCFM) was generated – resulting in the generation of roughly 13.4 million kWh per year.[10,11] Additionally, the digestion of the food waste (as opposed to landfilling) was estimated to reduce GHG emissions by about 70,000 metric tons of carbon dioxide equivalents per year – equivalent to removing emissions from the energy usage of nearly 8,700 homes each year.

3.3.1.1 Geography

Figure 3-3 shows the physical locations of AD facilities processing ICI food waste and Figure 3-4 aggregates AD facilities' food waste capacity (inclusive of current amounts processed and additional unused capacity) by county. The juxtaposition of the two maps reveals that although there is a concentration of facilities in Lancaster County, overall AD capacity is greater in the more northern counties of Juniata, Schuylkill, and Northumberland.

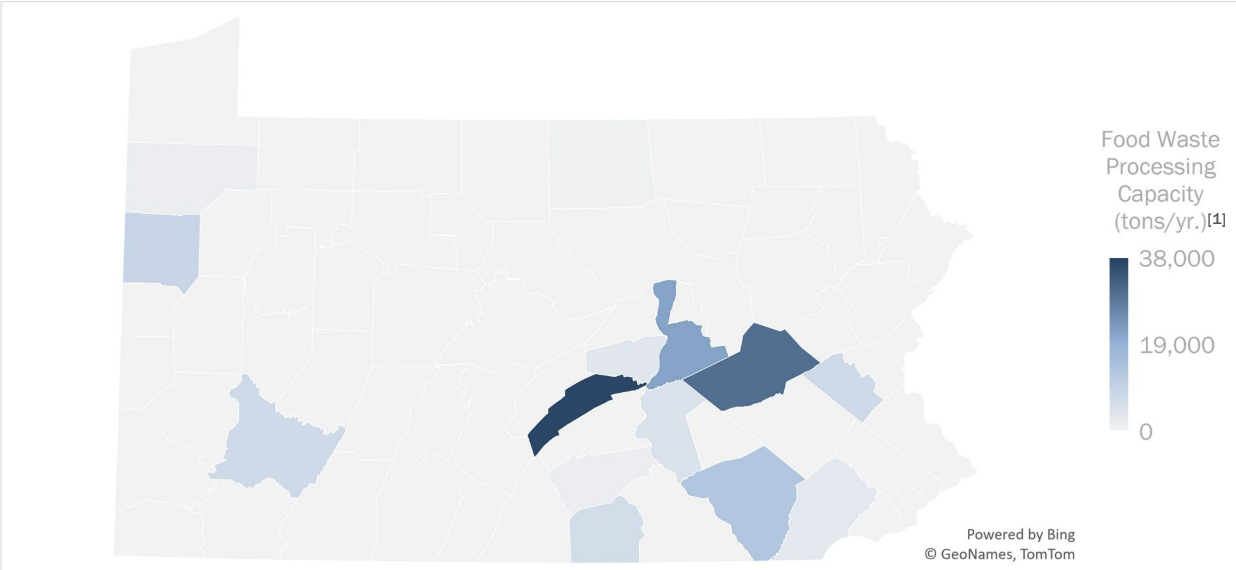
Figure 3-3 Map of AD Facilities Processing ICI Food Waste



[10] Note: kWh per year approximation is provided for reference as estimated by the U.S. EPA's LMOP Interactive Conversion Tool. No attempts were made to evaluate the reasonableness of these estimates. True energy generation is expected to vary based on factors unique to each facility such as the methane content of the biogas, the usage method of the biogas, the efficiency of the combustion engines, and the proportion of generated biogas able to be utilized.

[11] U.S. Environmental Protection Agency Landfill Methane Outreach Program. (April 2016). *Interactive Conversion Tool.*

Figure 3-4 Map of Current Food Waste AD Processing Capacity by County

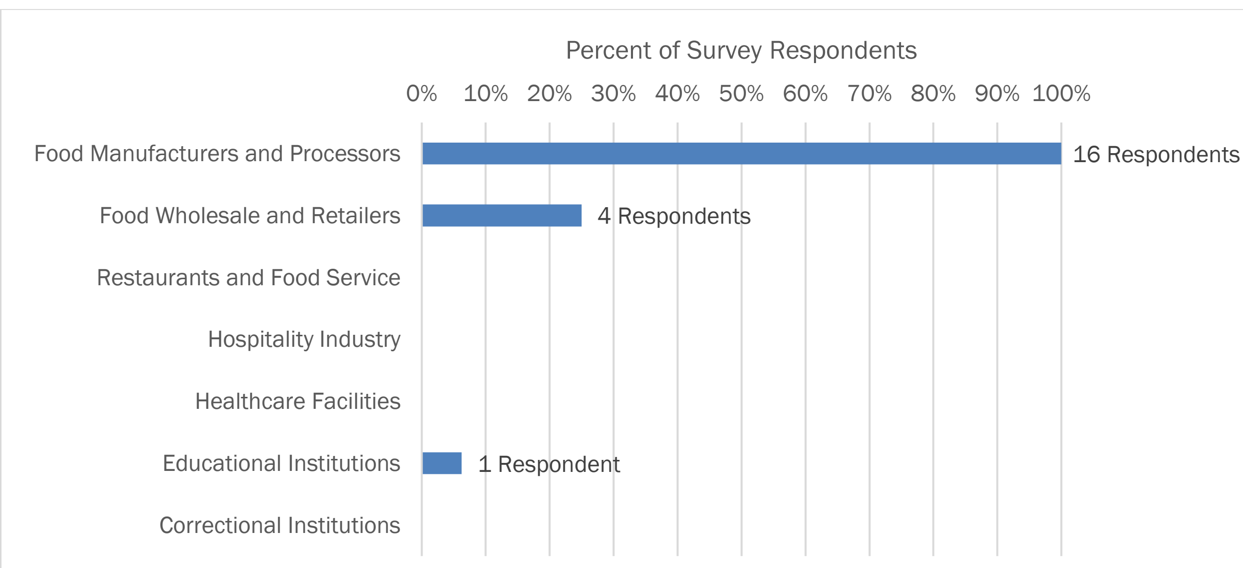


[1] Includes current throughput and additional unused available capacity from survey respondents, as well as estimated throughput of nonrespondents.

3.3.1.2 Food Waste Sources

Survey respondents were asked to report the generator sector(s) from which their processed food waste originated. Four survey respondents reported that all processed food waste originates from on-site food manufacturing and that no external wastes are accepted. Figure 3-5 shows the percent of respondents (including those not accepting external waste) that reported processing food waste from each generator sector.

Figure 3-5 Current Sources of Food Waste for AD Facilities



As shown, every AD facility that responded to the survey reported that at least some portion of its processed food waste originated from food manufacturers and processors. Only four facilities that responded to the survey (25 percent of respondents) reported processing pre-consumer food waste from wholesalers/retailers and only one facility reported processing post-consumer food waste originating from dining halls at universities and colleges. Note that some AD facilities did report accepting grease trap waste from restaurants; however fats, oils, and grease (FOG) were not considered food waste for the purposes of this analysis.

Residual food waste from food manufacturing and processing is the preferred source of feedstock for AD facilities: the food waste is typically source-separated with minimal contamination, the composition of the food waste is consistent, and food manufacturers and processors are more likely to generate substantial quantities of food waste to attain adequate economies of scale. By contrast, food waste from food wholesalers and retailers typically requires depackaging and slurrying, and its composition can vary based on the food discarded each day. These drawbacks are further amplified for food waste from post-consumer sources where contamination is a greater risk.

3.3.1.3 Unused Available Capacity

In addition to current food waste throughputs, survey respondents were asked to approximate the additional quantity of food waste that could be processed using existing infrastructure (or with limited capital improvements) if unlimited feedstock supply was available. This hypothetical scenario also assumes that food waste generators would be willing to pay a reasonable tip fee that justifies the cost of processing, and that facilities were not limited by permit constraints. Figure 3-6 shows the current food waste throughputs and the approximate unused available capacity as reported by each survey respondent. Survey respondents that do not accept external wastes or that have no interest in increasing the amount of food waste processed are shown as having no unused available capacity. Figure 3-7 shows the same results aggregated by AD facility type.

Figure 3-6 Food Waste Processing Capacity by AD Survey Respondent

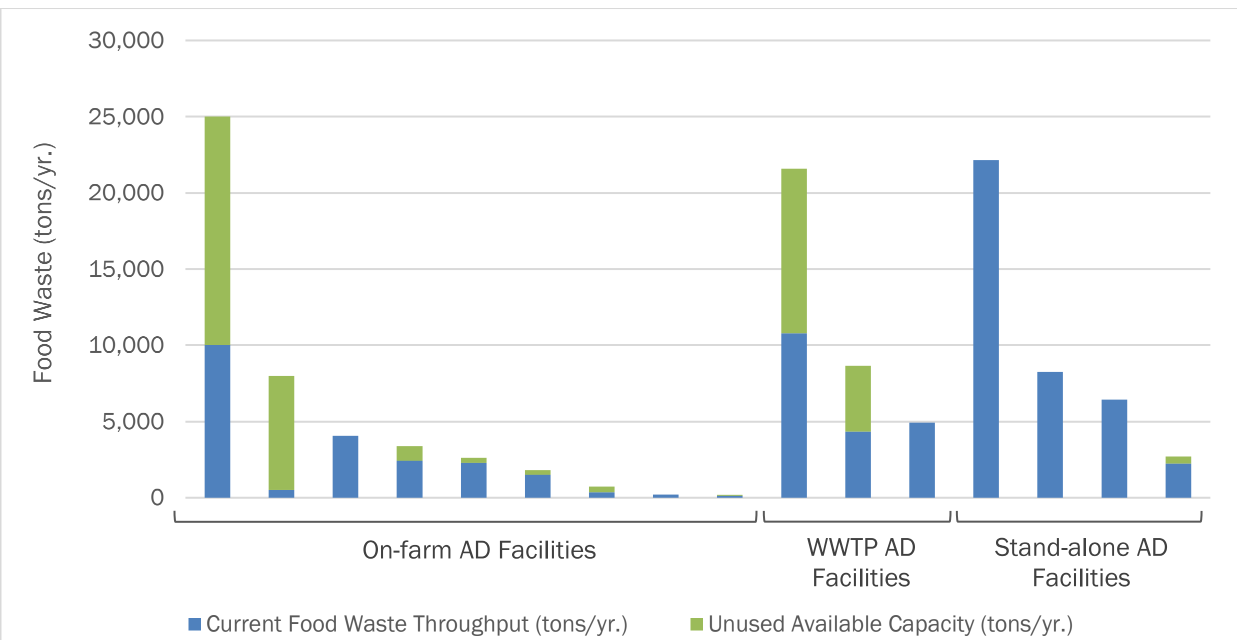
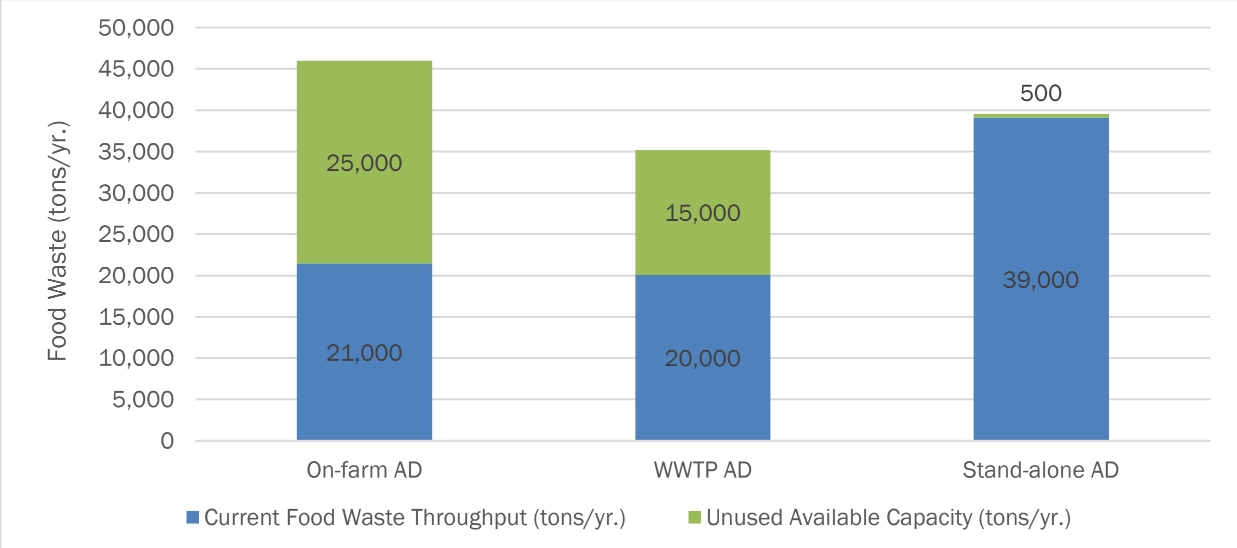


Figure 3-7 Food Waste Processing Capacity by AD Facility Type



Though only 25 percent of survey respondents were stand-alone AD facilities, nearly 50 percent of current food waste throughput is processed at these facilities. Of the four stand-alone AD facilities, three of them (including the largest one) were food manufacturers that utilize AD to process food waste residuals; the remaining stand-alone AD facility processes food manufacturing residuals, but itself is not owned by or located at a food manufacturer or processor.

About one-third (40,000 tons per year) of total AD food waste processing capacity is currently unused. Over 56 percent of the total unused available capacity exists at the largest two on-farm AD facilities and nearly an additional 38 percent exists at the largest two WWTP AD facilities. These four facilities all reported an interest and ability to increase the amount of food waste processed, and that capacity was currently unused due to a lack of high-quality feedstock supply with minimal contamination. The two largest on-farm AD facilities also reported that they had been limited by issues with permitting, which involved addressing concerns related to plastic contamination that could result after depackaging. The use of certain types of depackaging equipment can cause fragmentation of the packaging material that carries through the digestion process, leading to the land application of plastic in beneficial use material. Collaboration between DEP and the processing facilities eventually resulted in a draft amendment to the general permit. The amended permit implements permitting conditions and operational controls to alleviate the fragmentation of packaging, resulting in clean digestate for land application.

If the AD processing capacity was fully utilized to divert an additional 40,000 tons of food waste per year, it is estimated to result in the additional generation of 191 million cubic feet of biogas (roughly translating to 7.2 million kWh of electricity generation) and reduction of 26,000 MTCO2e in GHG emissions (equivalent to that from over 3,100 homes) each year.

3.3.1.4 Tip Fees

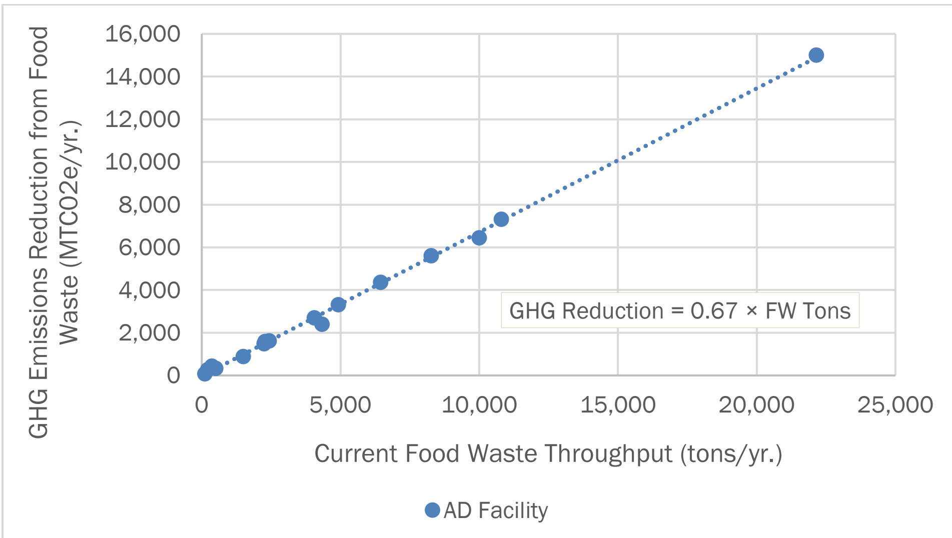
Survey respondents were asked about the tip fees they currently charge to accept food waste. Six survey respondents agreed to disclose their tip fees, all of which were reported (and charged) in terms of dollars per gallon of feedstock. Reported tip fees ranged from $0.01 per gallon to $0.10 per gallon with an average of about $0.05 per gallon. Several survey respondents noted that tip fees were variable depending on the type and quality of the food waste.

3.3.1.5 Food Waste Travel Distance and Emissions

Survey respondents were also asked to approximate the distance that external food waste travels before reaching their facility. Most survey respondents estimated that the majority of food waste travels less than 50 miles from its origin to their facility. Four AD facilities approximated that food waste may travel as much as 100 miles before reaching their facility, and one facility stated that some food waste is brought in from the PA-OH-MD tristate area and may travel as much as 200 miles.

The average distance food waste travels to each facility is factored into WARM's estimates of the net GHG emissions reduction from processing food waste. Figure 3-8 shows the relationship between the amount of food waste processed via AD and the reduction in GHG emissions (with the assumption that the food waste would have been otherwise been landfilled) using WARM.

Figure 3-8 GHG Emissions Reduction per Food Waste Ton Processed at AD Facilities

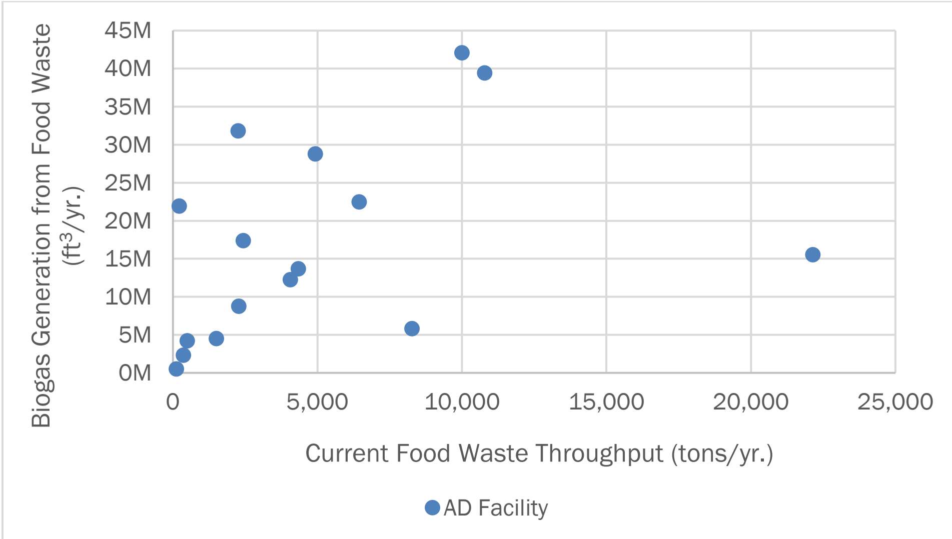


WARM estimates suggest that the reduction in GHG emissions is almost exclusively a function of the amount of food waste processed, and that differences in the distance traveled to each facility do not significantly impact the overall reduction in emissions. However, it should again be noted that in practice, the true reduction in GHG emissions will vary based on the composition of the food waste and the design and operating specifications of each facility.

3.3.1.6 Biogas Generation and Usage

The approximate biogas generation resulting from the processing of food waste at each AD facility that responded to the survey is shown in Figure 3-9.

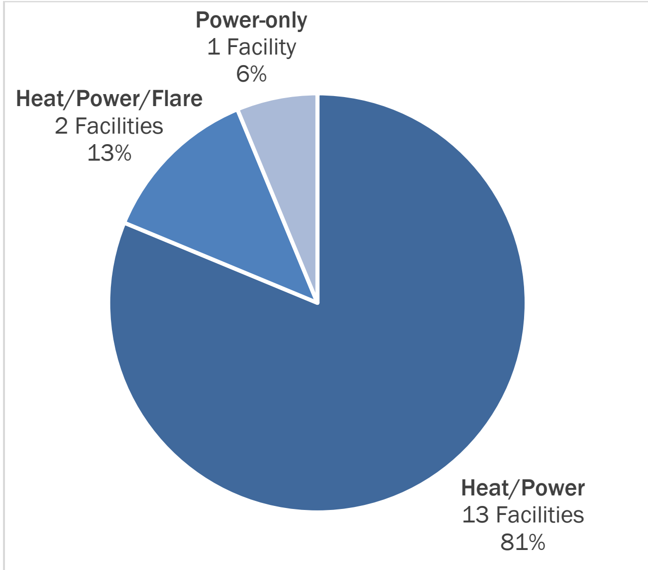
Figure 3-9 Biogas Generation per Food Waste Ton Anaerobically Digested



The average biogas generation rate was 4,800 cubic feet per ton of food waste and the median biogas generation rate was 3,800 cubic feet per ton of food waste. However, the above figure demonstrates that biogas generation cannot be easily predicted using only the amount of food waste digested. For example, high-fat and high-protein food wastes such as meats or whey will typically produce substantially greater amounts of biogas than high-carbohydrate food wastes such as vegetable scraps or spent grain. Facility design and operating specifications, such as digester temperature, hydraulic retention time, and whether the facility uses single-stage or two-stage digestion will also impact the rate of biogas generation. Furthermore, while it was not a focus of this study, the methane content of the biogas will also vary (usually between 50 and 70 percent of biogas volume) based on differences in these variables.

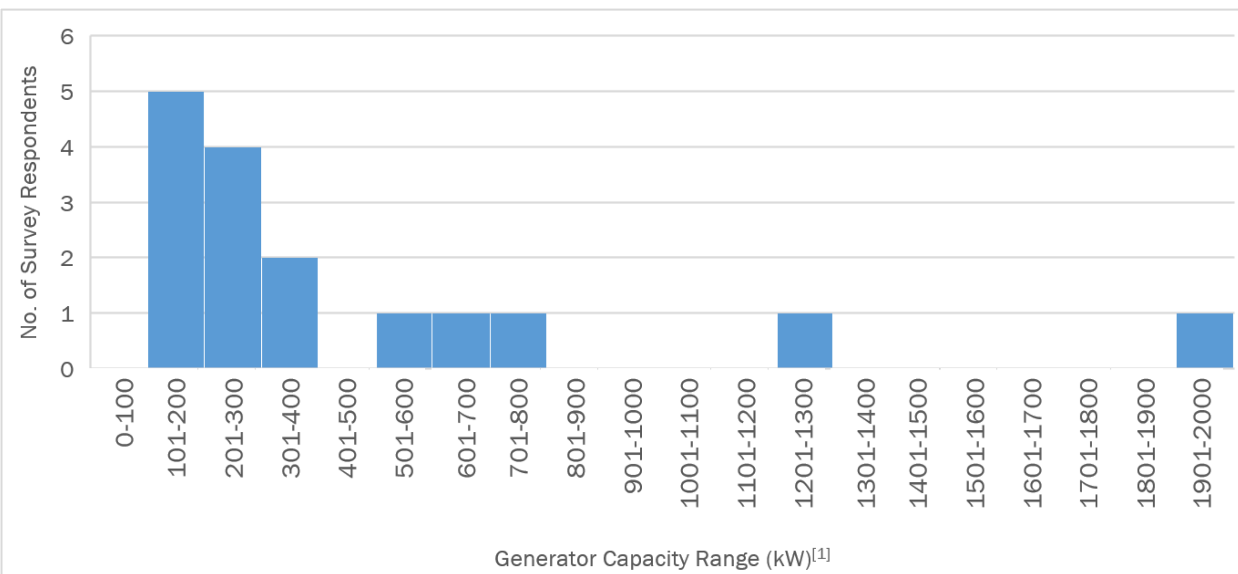
Finally, AD facilities that responded to the survey were also asked about their usage of biogas. As shown in Figure 3-10, almost all facilities that responded to the survey use CHP systems to generate both heat (which is used to heat the reactor and excess can be used to heat buildings) and electricity.

Figure 3-10 Biogas Usage Methods of AD Facilities Processing Food Waste



Two facilities reported that some amount of biogas is flared due to exceeding the capacities of the attached generators. As shown in Figure 3-11, the majority of facilities that responded to the survey (including the two facilities flaring biogas) have a total generator capacity of 200 kW or less.

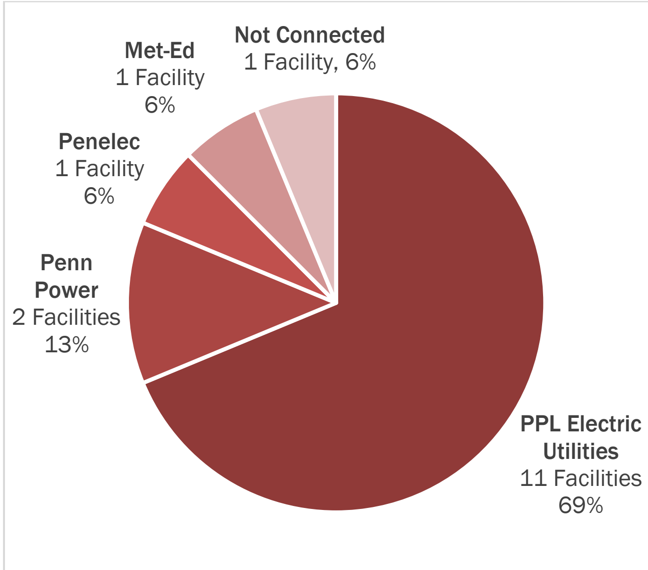
Figure 3-11 Generator Capacities of AD Facilities Processing Food Waste



[1] Generator capacities are summed for facilities with multiple generators.

Power-generating AD facilities are often connected to the regional power grid so that excess electricity can be sold to the respective energy companies. Figure 3-12 shows the prevalence of each energy company as reported by survey respondents.

Figure 3-12 Energy Companies Connected to Power-generating AD Facilities Processing Food Waste



Only one facility reported that they were not connected to the regional grid, but the facility also mentioned that they plan to connect to PPL in the future.

3.3.2 Compost Facilities Currently Processing ICI Food Waste

A total of 25 compost facilities were found to process ICI food waste and 20 of those responded to the survey. Table 3-5 summarizes the current food waste throughput and GHG emissions reduction from the composting the food waste. Current food waste throughputs were estimated for nonrespondent facilities based on the values observed from the responding facilities.

Table 3-6 Results Summary of Compost Facilities Processing ICI Food Waste

	No. of Facilities	Current Food Waste Throughput (tons/yr.)	GHG Emissions Reduction from Food Waste (MTCO2e/yr.)
Subtotals for Survey Respondents	20	35,000	25,000
Estimated Subtotals for Nonrespondents	5	3,000	2,000
Grand Total	**25**	**38,000**	**27,000**

Compost facilities were estimated to process about 38,000 tons of ICI food waste per year at the time of the study. Composting this food waste (as opposed to landfilling) was estimated to reduce GHG emissions by about 27,000 metric tons of carbon dioxide equivalents per year – equivalent to removing emissions from the energy usage of nearly 3,200 homes each year.

3.3.2.1 Geography

Figure 3-13 shows the physical locations of compost facilities processing ICI food waste and Figure 3-14 aggregates compost facilities' food waste capacity (inclusive of current amounts processed and additional unused capacity) by county. Lancaster County was found have the largest capacity for composting food waste, followed by Allegheny County and Berks County.

Figure 3-13 Map of Compost Facilities Currently Processing Food Waste

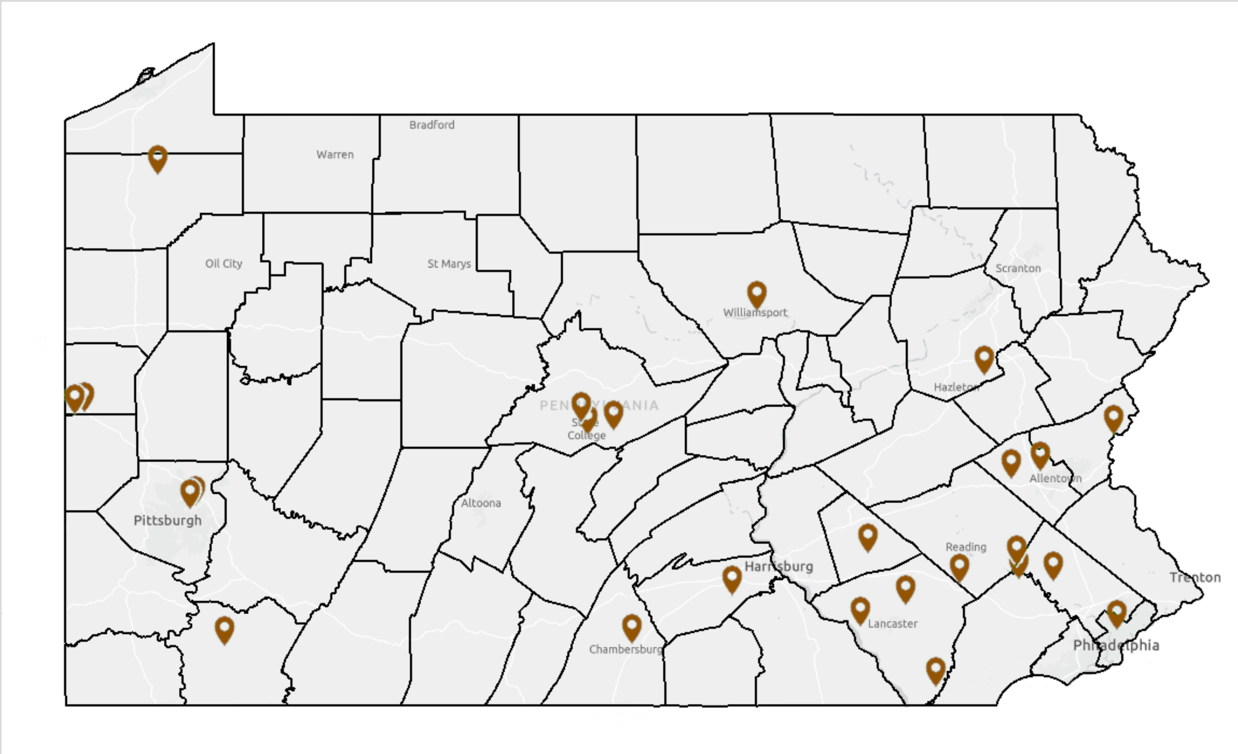
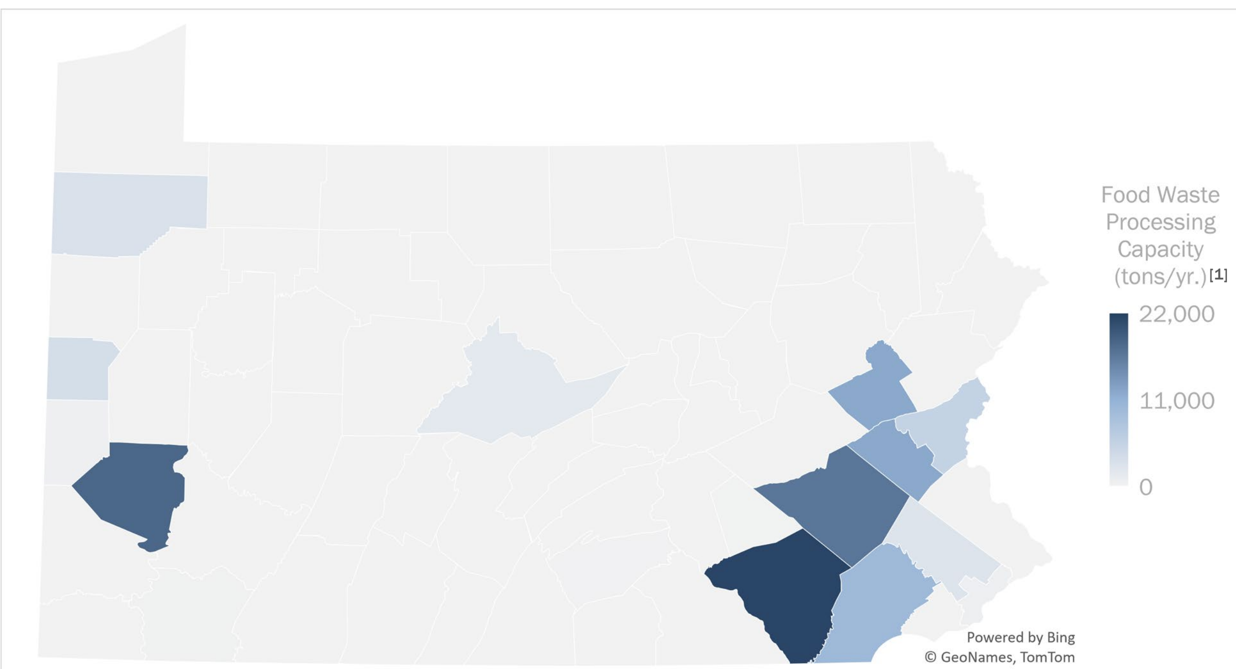


Figure 3-14 Map of Current Food Waste Compost Processing Capacity by County

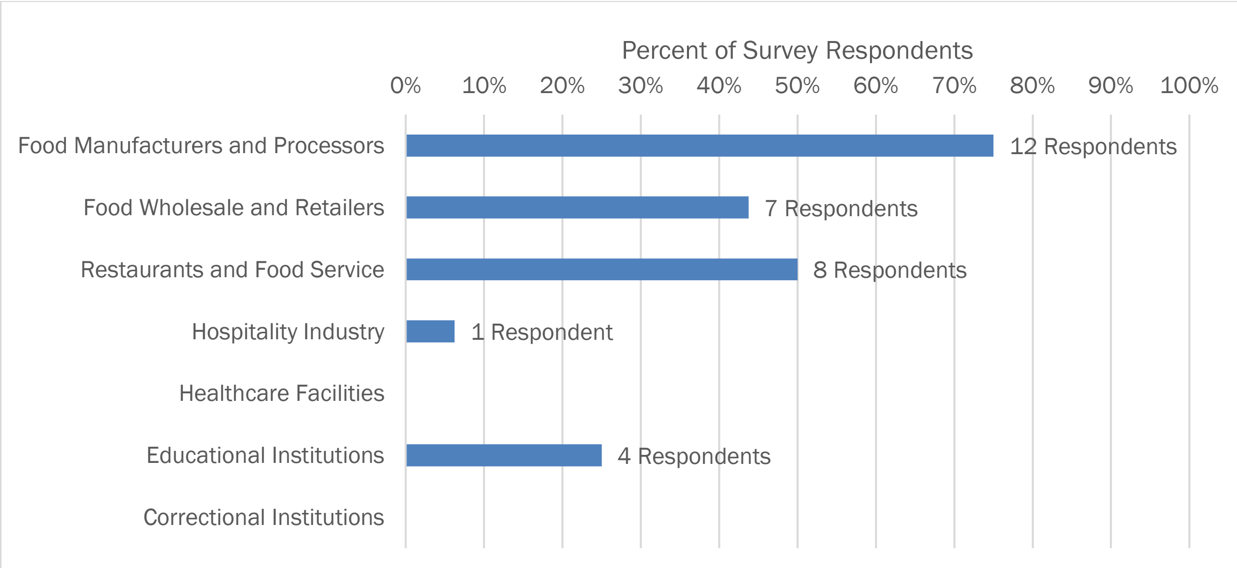


[1] Includes current throughput and additional unused capacity from survey respondents, as well as estimated throughput of nonrespondents.

3.3.2.2 Food Waste Sources

Survey respondents were asked to report the generator sector(s) from which their processed food waste originated. One survey respondent reported that all processed food waste originates from its on-site cafeteria and that no external wastes are accepted. Figure 3-15 shows the percent of respondents (including one facility not accepting external waste) that reported processing food waste from each generator sector.

Figure 3-15 Current Sources of Food Waste for Compost Facilities

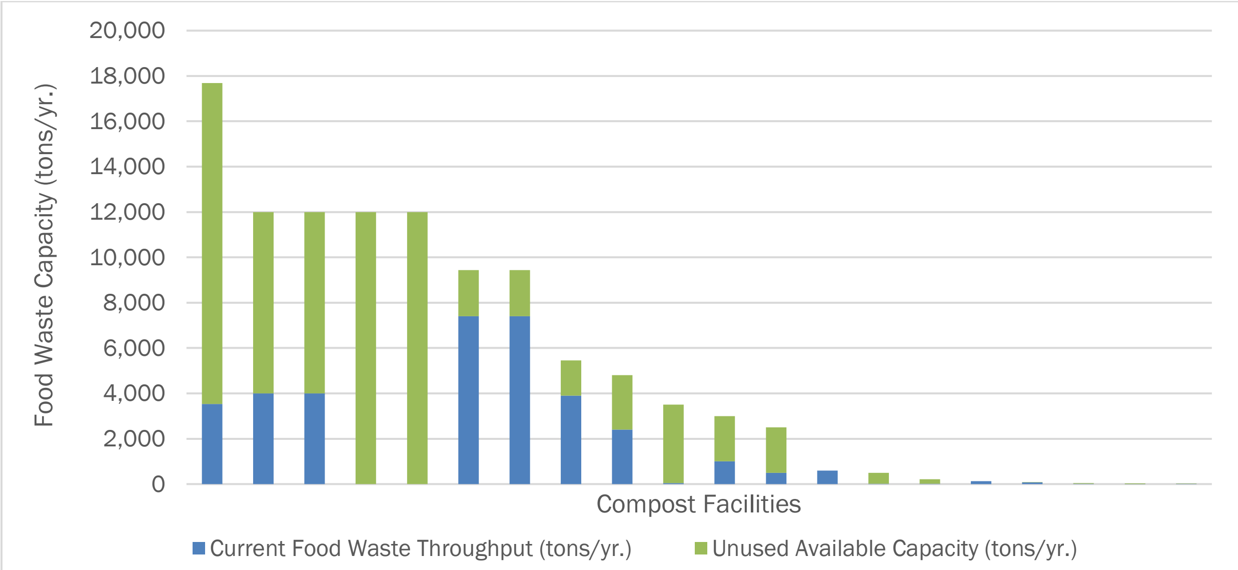


Though food manufacturers and processors are still the most common sources of food waste, a greater diversity of food waste sources are accepted by compost facilities compared to AD facilities. Though contamination is also an issue faced by compost facilities, compost facilities are at less risk of encountering serious facility disruptions due to contaminants which might otherwise damage equipment and upset biological and chemical reactions at an AD facility. Additionally, compost facilities are more capable of processing solid food wastes, thus avoiding the costs and logistics of slurrying food waste.

3.3.2.3 Unused Available Capacity

In addition to current food waste throughputs, survey respondents were asked to approximate the additional quantity of food waste that could be processed using existing infrastructure (or with limited capital improvements) if unlimited feedstock supply was available. This hypothetical scenario also assumes that food waste generators would be willing to pay a reasonable tip fee that justifies the cost of processing, and that facilities were not limited by permit constraints. Figure 3-16 shows the current food waste throughputs and the approximate unused available capacity self-reported by each survey respondent. Survey respondents that do not accept external wastes or that have no interest in increasing the amount of food waste processed are shown as having no unused available capacity.

Figure 3-16 Food Waste Processing Capacity by Compost Survey Respondent



About two-thirds (70,000 tons per year) of total food waste processing capacity via composting is currently unused. The facility that reported the greatest amount of capacity stated that substantially more food waste (even beyond what is shown in the above figure) could be accepted if the feedstock supply existed. For the purposes of this study, the total capacity shown for this facility was limited to five times its current throughput.

Over 70 percent of compost facilities that responded to the survey mentioned experiencing issues in permitting as a barrier to increasing capacity. The "5-acre footprint rule," which limits facilities to using only five acres of land for composting and the storage of finished compost, was frequently mentioned as a limiting factor (detailed further in Section 4.4.8). Additionally, nearly 40 percent of respondents mentioned having issues in procuring consistent food waste supply, some of which specifically suggested that the issue was the result of current economics.

3.3.2.4 Tip Fees

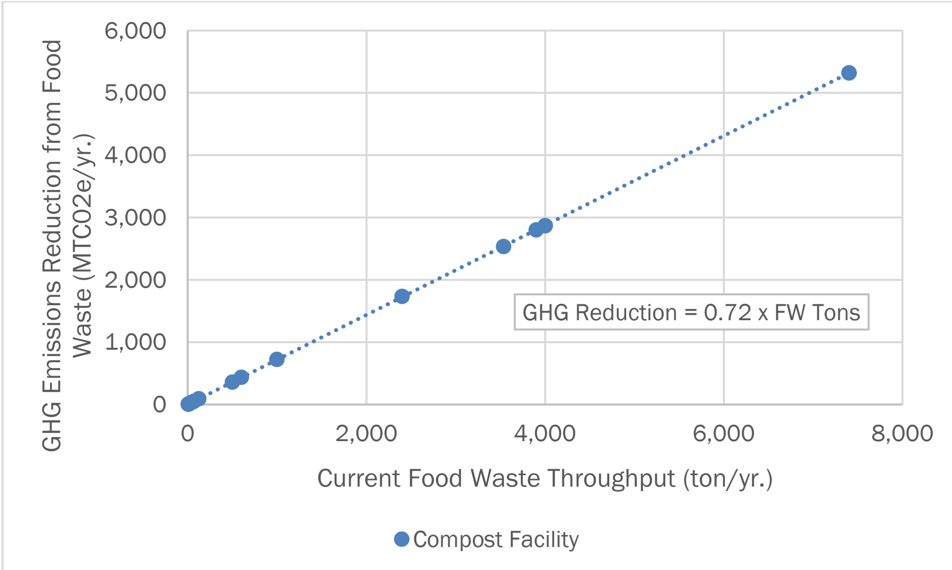
Survey respondents were asked about the tip fees they currently charge to accept food waste. Six survey respondents agreed to disclose their tip fees, however most stated that tip fees were highly variable depending on the type and quality of the food waste. Reported tip fees roughly ranged from about $25 per ton for clean, pre-consumer food waste up to about $60 per ton for heavily contaminated, post-consumer food waste, with the average at about $35 per ton.

3.3.2.5 Food Waste Travel Distance and Emissions

Survey respondents were also asked to approximate the distance that external food waste travels before reaching their facility. On average, survey respondents estimated that food waste travels about 30 miles from its origin to their facility. No facility respondents estimated that food waste travels more than 50 miles.

Figure 3-17 shows the relationship between the amount of food waste processed via composting and the reduction in GHG emissions (with the assumption that the food waste would have been otherwise been landfilled) using WARM.

Figure 3-17 Emissions Reduction per Food Waste Ton Processed at Compost Facilities

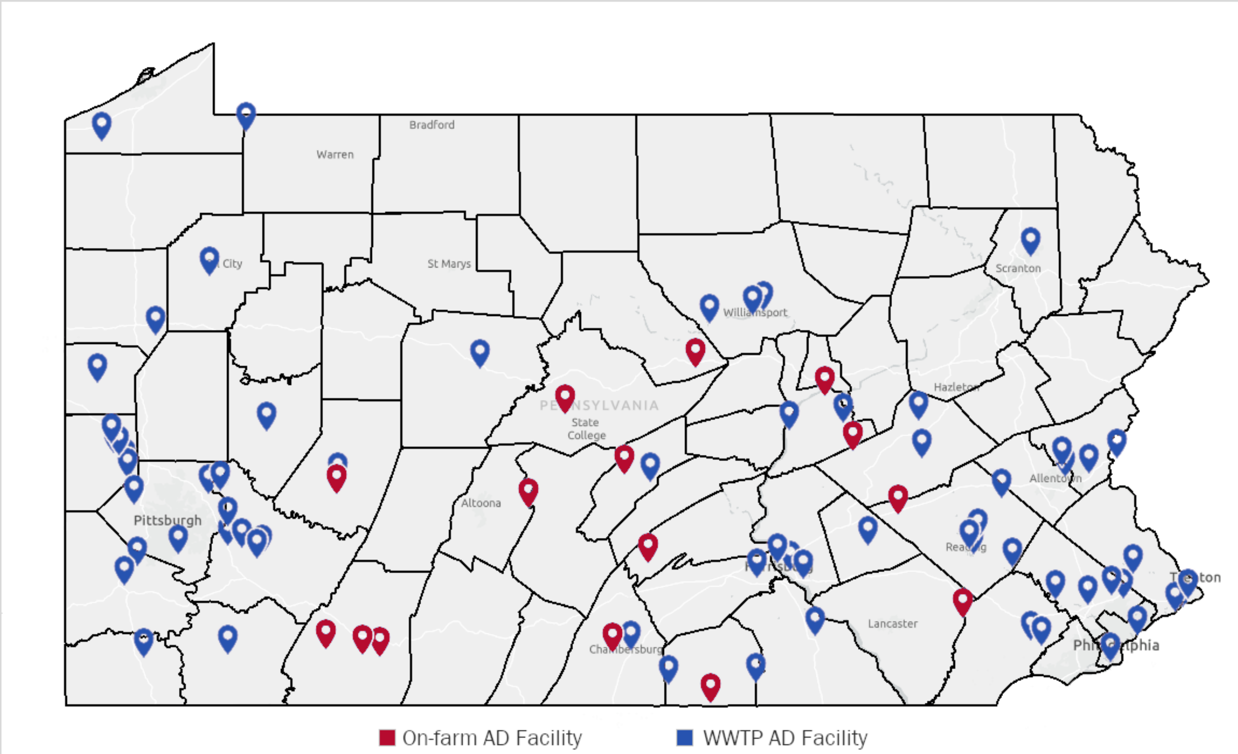


Similar to the results for AD facilities, WARM estimates suggest that the reduction in GHG emissions is almost exclusively a function of the amount of food waste processed. Comparing the trendline of Figure 3-17 to its AD equivalent shows that WARM estimates a slightly greater reduction in GHG emissions for composting compared to anaerobic digestion, assuming equal amounts of food waste were diverted using each method. However, it should again be noted that in practice, the true reduction in GHG emissions will vary based on the composition of the food waste and the design and operating specifications of each facility.

3.3.3 Anaerobic Digesters Not Currently Processing ICI Food Waste

A total of 83 AD facilities not currently processing ICI food waste were identified. Their locations within the Commonwealth are shown in Figure 3-18.

Figure 3-18 Map of AD Facilities Not Currently Processing Food Waste



Twenty-eight AD facilities not currently processing food waste responded to the survey, including 6 on-farm AD facilities and 22 WWTP AD facilities. A comparison of the flow rates of WWTPs that responded to the survey with the flow rates of those that did not respond to the survey showed that the two strata were similarly distributed (i.e., a balanced mix of small, medium, and large WWTP facilities responded).

Of the 28 facilities, 18 were evaluated using Co-EAT and 5 had previously conducted a feasibility study to assess co-digestion. The remaining five facilities (all of which are on-farm AD systems) were previously contacted in separate correspondence and reported that they were either at max capacity or had no interest in accepting food waste. Table 3-7 summarizes this study's findings on the potential for AD facilities not currently processing food waste to begin co-digestion.

Table 3-7 Summary of AD Facilities' Potential to Begin Co-digesting Food Waste

Based on…	Potentially Capable of Co-digestion	Not Likely Capable Due to Physical Capacity	Not Likely Capable Due to Economics	Total
Co-EAT Modeling	4	10	4	**18**
Feasibility Study	3	0	2	**5**
Facility Operator's Assessment	0	5[1]	0	**5**
Total	**7**	**15**	**6**	**28**
Percent	**25%**	**54%**	**21%**	**100%**

[1] Three responses which reported a lack of interest in accepting food waste are grouped here.

One-quarter of AD facilities that responded to the survey may be capable of co-digesting food waste alongside their current feedstock. It should again be mentioned that due to the necessary assumptions inherent to Co-EAT modeling, the results of the Co-EAT modeling should be interpreted as initial assessments of potential and more rigorous analyses must be conducted before co-digestion capabilities can be confirmed.

Table 3-8 shows the estimated food waste throughputs, beneficial impacts, and capital improvement costs if the seven facilities potentially capable of co-digestion were to maximize their projected potential to process food waste.

Table 3-8 Estimated Effects of Beginning Co-digestion at Potentially Capable Facilities

Estimated Parameter	Average per Facility	Combined Total
Food Waste Throughput (tons/yr.)	11,000	77,000
Biogas Generation from Food Waste (million ft^3/yr.)	35	246
GHG Emissions Reduction from Food Waste (MTCO2e)	7,200	51,000
Capital Improvement Costs (million $)	$2.9	$20.1

If all seven facilities processed the maximum amount of food waste that they are projected to be capable of processing, an additional 77,000 tons of food waste would be diverted each year. Additional facilities that did not respond to the survey may be capable of beginning co-digestion, however, no attempts were made to extrapolate these results to nonresponsive facilities. Co-EAT results also suggested that an additional total of 17,000 tons per year of physical capacity to digest food waste was available through four other facilities, however, a net loss in revenue was projected for these facilities resulting in them being determined not likely capable of co-digestion due to economics.

An estimated total of $20.1 million in capital improvements would be required to access the 77,000 tons per year of additional capacity, however, the seven facilities are projected to experience an increase in revenue that would cover the cost of these capital improvements assuming they can be amortized over a 15-year period at a reasonable interest rate. The capital improvements include weigh scales, preprocessing (depackaging) equipment, buffer tanks, and transfer pumps to enable facilities to accept hauled-in, solid food wastes. In practice, some of these capital improvements may be avoided if food waste is instead only accepted in liquid or pre-slurried forms directly from food manufacturers or external preprocessing sites, however, this scenario was not modeled. Additional capital improvements include gas purification systems, CNG fueling stations, and truck upgrades to utilize CNG for facilities where the generation of CNG from biogas was estimated as the most cost-effective use of biogas (described further below).

Facilities can offset the cost of capital improvements through the revenue from tip fees and the value realized from using the generated biogas to generate heat, electricity, or renewable natural gas ("CNG" when compressed). The Co-EAT produces four scenarios (in addition to the baseline) which model the economic effects of different biogas usage methods. The estimated net change in annual revenue from beginning (and maximizing) food waste co-digestion at the four facilities that Co-EAT modeling suggested are both physically and economically capable of co-digestion is shown in Table 3-9. The table also compares the estimated differences in annual revenue for each biogas usage method that Co-EAT models.

Table 3-9 Estimated Change in Annual Revenue from Co-digesting Food Waste

		Estimated Net Change in Annual Revenue from Co-digesting Food Waste[1]			
	Current Biogas Use	Heat-only Scenario	Heat and Power Scenario	Heat and CNG Scenario	CNG-only Scenario
Facility 1	Heat, Flare	$240,000	$180,000	$300,000	$420,000
Facility 2	Heat, Flare	-$10,000	-$50,000	$40,000	$100,000
Facility 3	Heat, Flare	$80,000	$60,000	$60,000	$110,000
Facility 4	Heat, Power	N/A	$210,000	$600,000	$660,000

[1] Assumes potential food waste processing capacity after capital improvements is fully utilized.

With the assumption that adequate demand for CNG exists for each facility, Co-EAT results suggested that converting all biogas to CNG for use as vehicle fuel was the most cost-effective biogas usage method for the four facilities potentially capable of co-digestion. The value of CNG used in Co-EAT is $2.08 per GGE (gasoline gallon equivalent) which it sources from the U.S. Department of Energy's national average.[12] This study has not made any attempt to evaluate the reasonableness of Co-EAT's estimated biogas to CNG conversion rates, or the subsequent value of CNG projected. However, one consideration with CNG is that its value is not realized until it is purchased and used as fuel. For rurally-located AD facilities, the prevalence of CNG-powered vehicles may be small or nonexistent, and therefore, CNG would need to be hauled to an in-demand CNG fueling station or to a gas transmission pipeline. This potential factor is not considered in Co-EAT.

3.3.4 Summary

Table 3-10 summarizes all of the preceding results to show:

- **Current Food Waste Processing**: the amount of food waste currently being processed at AD and compost facilities,
- **Additional Food Waste Processing (Using Existing Capacity):** the additional amount of food waste that could be processed if the available capacity from existing infrastructure were fully utilized, and
- **Additional Food Waste Processing (Capital Investment)**: the additional amount of food waste that could be processed if AD facilities that are not currently processing food waste were upgraded to enable them to do so.

[12] U.S. Department of Energy. (n.d.). *Alternative Fuel Price Report.*

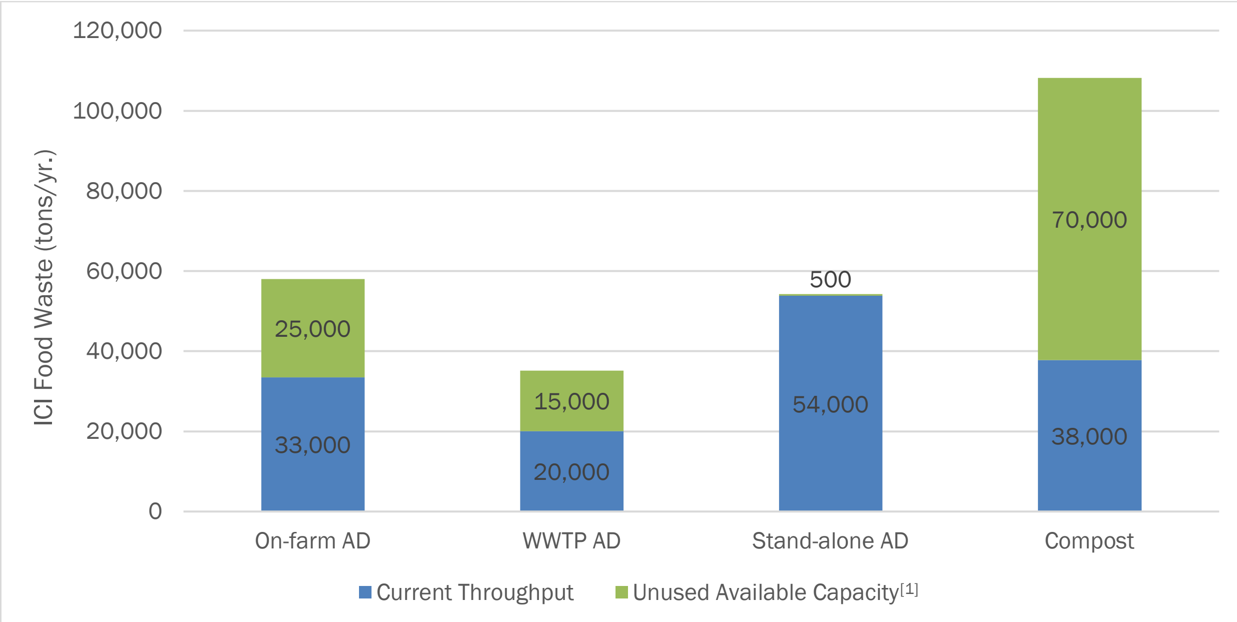
Table 3-10 Results Summary of All Current and Potential Food Waste Processing Capacity

Facility Type	No. of Facilities	Food Waste (tons/yr.)	Biogas Generation from Food Waste (million ft^3/yr.)	GHG Emissions Reduction from Food Waste (MTCO2e/yr.)
Current Food Waste Throughput				
On-farm AD	17	33,000	177	22,000
WWTP AD	3	20,000	82	13,000
Stand-alone AD	6	54,000	104	36,000
Compost	25	38,000	0	27,000
Subtotal	*51*	*145,000*	*363*	*99,000*
Unused Available Capacity (using existing infrastructure)				
On-farm AD	7	25,000	138	16,000
WWTP AD	2	15,000	53	10,000
Stand-alone AD	1	500	6	300
Compost	18	70,000	0	50,000
Subtotal	*28*	*111,000*	*197*	*77,000*
Additional AD Capacity Accessible via Capital Investment				
On-farm AD	1	6,000	37	4,000
WWTP AD	6	71,000	209	46,000
Subtotal	*7*	*77,000*	*246*	*51,000*
Grand Total	**N/A**	**333,000**	**807**	**226,000**

Note: Numbers in this table may not sum to their totals due to rounding.

An estimated total of nearly 145,000 tons of ICI food waste is currently diverted through Pennsylvania AD and compost facilities. Survey respondents collectively reported that an additional 110,000 tons of food waste processing capacity exists using current infrastructure but is currently unused due to factors including a lack of motivated food waste supply and, particularly in the case of compost facilities, permit restrictions. Figure 3-19 shows the breakdown of overall food waste processing capacity using existing infrastructure by facility type.

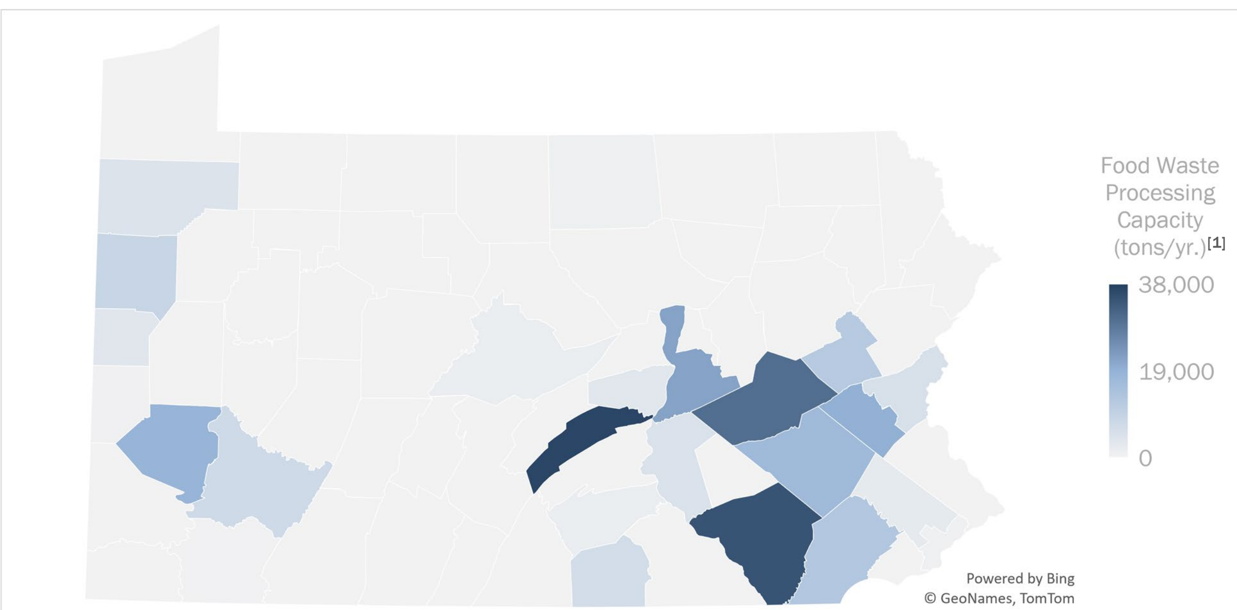
Figure 3-19 Existing Food Waste Processing Capacity by Facility Type



[1] "Unused available capacity" includes capacity that is: 1) immediately available and not in-use due to lack of feedstock, or 2) that is physically available but is currently limited by economics or permits. It does not include capacity that could potentially be created through significant capital improvements, such as installing a new anaerobic digester reactor or enabling co-digestion at an AD facility not currently accepting food waste.

Figure 3-20 shows the total current food waste processing capacity from both AD and compost facilities by county. Note that this figure does not include the potential capacity from AD facilities not currently processing food waste.

Figure 3-20 Map of Current Food Waste Processing Capacity by County



[1] Includes current throughput and unused available capacity from survey respondents processing ICI food waste, as well as estimated throughput of nonrespondents processing ICI food waste.

3.4 OTHER FOOD MANAGEMENT PATHWAYS

While the focus of this study centered on food waste diversion via AD and composting, additional management pathways exist to recover food, including the more preferrable options of donating food to people in need and repurposing food as animal feed. A significant portion of Pennsylvania food is likely recovered to these programs, and some amount of food waste is also likely diverted to industrial reuse and direct land application. Because these management pathways are arranged privately and fall outside the permitted solid waste facility infrastructure, little data exists to quantify them.

The U.S. EPA and ReFED have conducted desktop analyses that attempt to estimate the proportion of ICI food waste for each management pathway (though the U.S. EPA did so only at the national level). Table 3-11 summarizes the results of these studies and compares their estimates for food waste managed via AD and composting to this study's estimates. This information provides some perspective on the order of magnitude of ICI food wastes needing management within Pennsylvania's solid waste management facility infrastructure, but are not verified (or verifiable) estimates.

Table 3-11 Comparison of Total ICI Food Waste Management Estimates

	U.S. EPA's Study		ReFED's Insights Engine[1]		
Management Pathway	National Percentage of Food Waste	National Percentage Applied to This Study's Food Estimate (tons)	PA Percentage of Food Waste	PA Food Waste Estimate (tons)	This Study's Food Waste Estimate (tons)
Food Donation	12%	199,000	7%	91,000	N/A
Animal Feed	27%	558,000	18%	218,000	N/A
Anerobic Digestion	**14%**	**270,000**	**3%**	**42,000**	**107,000**
Industrial Reuse	3%	56,000	5%	63,000	N/A
Composting	**3%**	**66,000**	**9%**	**109,000**	**38,000**
Land Application	11%	232,000	8%	105,000	N/A
Disposal	30%	600,000	50%	616,000	N/A
Total	**100%**	**1,982,000**	**100%**	**1,244,000**	**145,000**

Note: Numbers in this table may not sum to their totals due to rounding.

[1] The ReFED Insights Engine provides state-level food waste estimates for the manufacturing, foodservice, and retails sectors, as well as for residential and agricultural generation. Numbers in this table reflect the tool's 2019 estimates for the Pennsylvania manufacturing, foodservice, and retail sectors.

As a final note on the potential scale of current food donation, the Pennsylvania Department of Human Services publishes a list of known food banks on its website.[13] The list includes 74 food bank locations which are operated by 23 unique organizations. The annual reports published by the four largest of these organizations (which collectively operate 49 of the food bank locations) report that the four organizations collectively recover about 25,200 tons of food annually (from all sources).[14,15,16,17]

13 Pennsylvania Department of Humans Services. (n.d.). *Food Banks by County.*

14 Central Pennsylvania Food Bank. (January 2020). *2020 Report to the Community.*

15 Philabundance. (2020). *Annual Report 2019.*

16 Second Harvest Food Bank of Northwest Pennsylvania. (2017). *2015-2016 Impact Report.*

17 Second Harvest Food Bank of the Lehigh Valley and Northeast Pennsylvania. (Spring 2021). *Spring Newsletter 2021.*

4. STRATEGIES TO INCREASE FOOD WASTE DIVERSION

4.1 OVERVIEW

In addition to surveying organics processors, this study reached out to other stakeholders involved in the diversion of food waste including the Pennsylvania Recycling Markets Center, as well as several AD developers, food waste haulers, food rescue and donation organizations, and food waste generators applying diversion practices. The overarching question of "What should be done to increase food waste diversion in Pennsylvania?" guided most of these discussions.

Additionally, this study included a brief review of food waste diversion initiatives in other states to identify policies that may be replicated in Pennsylvania.

This chapter summarizes the findings from the stakeholder outreach and review of state initiatives, then combines those insights with the findings from previous sections to offer potential strategies to increase food waste diversion.

4.2 FOOD WASTE DIVERSION SUCCESS STORIES

This study compiled six case studies from Pennsylvania stakeholders successful in diverting food waste. The subjects of these case studies were intentionally varied to highlight some of the different aspects of food waste diversion, and included:

1. **Reinford Farms**, an on-farm AD facility,
2. **Milton Regional Sewer Authority**, a WWTP AD facility,
3. **Derry Township Municipal Authority**, a WWTP AD facility,
4. **Two Particular Acres** and **American Biosoils & Compost**, which collectively represent six compost facilities,
5. **Square Café** and **Zero Waste Wrangler**, a Pittsburgh restaurant and its contracted hauler, and
6. **Weis Markets, Inc.**, a Pennsylvania-based food retail chain.

A summary of each case study is given on the following pages. More detailed versions of the case studies are provided in Appendix C.

4.2.1 Reinford Farms

Photo courtesy of Reinford Farms.

Reinford Farms is located in Mifflintown in Juniata County. In 2008, the farm installed a 526,000-gallon anaerobic digester sized to treat manure from 800 dairy cows. Almost immediately, Reinford Farms was contacted by food waste haulers about receiving loads of food waste to co-digest with the dairy manure. The Reinfords recognized the benefits of accepting food waste and within a year, the digester was close to its capacity. In 2019, a second digester, nearly three times the size of the first digester, was added.

HIGHLIGHTS:

- Currently processes 10,000 to 12,000 tons of food waste per year but has capacity to process up to 25,000 tons annually.
- Generates about 42 million cubic feet of biogas per year from food waste.
- Uses biogas in CHP system. Heat is used to dry harvested corn for feed, saving about $3,000 to $5,000 in utility costs per year. All electricity is sold to PPL Utilities for $0.06 per kWh as part of a net metering agreement.
- Digested and separated solids are used as bedding for the cows, saving about $50,000 to $60,000 per year versus purchasing bedding.

SUCCESS FACTORS:

- Net-positive cash flow from receipt and processing of food waste, use of digested solids as bedding for dairy cows, and use of heat from combined heat and power system.
- Land application of liquid digestate reduces the quantity of conventional fertilizers required for crop production.

CHALLENGES:

- After installing depackaging equipment, DEP staff noticed some plastic contamination remaining in the depackaged food waste was carried through the digestion process and ultimately land applied. DEP conveyed to the farm that the depackaging activities would require authorization through a permit aimed to control and eliminate plastic before land application. At the time, contamination limits were not specified in the farm's WMGM042 General Permit. An amendment to the permit has since been issued to the farm, making it the first entity that has obtained authorization to operate a food waste depackaging unit.
- As of Spring 2021, the U.S. EPA has not activated the e-RIN (Electric Renewable Identification Number) pathway, which would allow AD facilities to participate in the Renewable Fuel Standard program. Once activated, Reinford Farms plans to explore selling e-RINs, which would have significantly more value than the farm's current $0.06 per kWh received from electric utilities.

4.2.2 MILTON REGIONAL SEWER AUTHORITY

Photo courtesy of Milton Regional Sewar Authority.

The Milton Regional Sewer Authority (MRSA) operates a WWTP serving six municipalities in Northumberland County. In 2016, installation of the MRSA's new wastewater-to-energy facility was completed which included two anaerobic digesters with a combined total of 2.4 million gallons.

The largest industrial user of the WWTP is a food manufacturer, Conagra Brands, which has a plant less than a quarter mile away. Prior to installing the anaerobic digesters, Conagra was discharging wastewater into the dedicated primary clarifier upstream of the aerobic biological wastewater treatment process – consuming a large amount of electricity for aeration and generating a large amount of sludge. After a successful pilot test, the MRSA installed the AD system and receives Conagra's wastewater via a direct pipeline.

HIGHLIGHTS:

- Currently processes about 10 dry tons of food waste per day (~11,000 wet tons per year) from Conagra. Also accepts a few thousand gallons per month of restaurant grease from haulers.
- Has capacity to comfortably process at least 20 dry tons per day (~22,000 wet tons per year) of food waste in a liquid or slurry form.
- Generates about 39 million cubic feet of biogas per year from food waste.
- Biogas is used to generate heat and power using two 1,000 kW generators. Power goes directly to PPL via net-metering agreement.
- Capital costs for the wastewater-to-energy facility were around $55 million, funded primarily through U.S. Department of Agriculture Rural Development loans.

SUCCESS FACTORS:

- Conagra's large volume of organic waste and close proximity to the WWTP made it an ideal partner for securing reliable feedstock.
- Receives about $200,000 per month in revenue from tip fees billed to Conagra and $8,000 per month from hauled-in waste.
- The AD system decreased the WWTP's sludge generation from about 2,000 dry tons per year to 620 dry tons per year – saving MRSA about $48,000 per year in landfill costs.

CHALLENGES:

- In the past, MRSA received $0.07-$0.08 per kWh in a net metering agreement with PPL. The price offered by PPL has since dropped to $0.03 per kWh or less. MRSA is evaluating alternative biogas uses, including conversion to renewable natural gas.

4.2.3 DERRY TOWNSHIP MUNICIPAL AUTHORITY FARMS

Photo courtesy of Derry Township Municipal Authority.

The Derry Township Municipal Authority (DTMA), located in Hershey, Dauphin County, operates two WWTPs. Its Clearwater Road facility has a 1.2-million-gallon primary anaerobic digester, as well as a secondary digester to provide additional volatile solids reduction.

The Clearwater Road plant is located directly across from the Hershey Co. chocolate factory and began co-digestion in by processing the company's food processing sludge (though Hershey Co. now digests the sludge themselves). The plant currently accepts food waste from a brewery and a pet food manufacturer, as well as pre-processed grocery store food waste from organics haulers. DTMA is currently expanding the plant's capacity to process food waste by installing a new biogas utilization and handling system that includes: two 1,000 kW CHP engines, dual membrane cover for gas storage in the secondary digester, and improved biogas conveyance with potential to achieve on-site energy neutrality.

HIGHLIGHTS:

- Processes nearly 1,400 dry tons (~4,900 wet tons) of hauled-in food waste per year.
- The biogas from food waste during the 2020 operating year yielded 1,353,527 kWh of energy resulting in $100,000 in electricity cost savings and savings of 20,000 gallons in fuel oil purchases worth $31,500.
- Electricity is currently used entirely on-site; however, DTMA is intending to connect with PPL after improvements are completed.

SUCCESS FACTORS:

- Excess digester capacity in for co-digestion.
- Location along major transportation route provides convenient option for receipt of hauled-in wastes.
- Minimal upfront capital costs to accept pre-processed food waste slurry from haulers.

CHALLENGES:

- Although the digester has additional capacity, supporting infrastructure (generators, gas management system, dewatering equipment, etc.) has prevented DTMA from benefiting from accepting additional food waste. This limitation is expected to be resolved when plant improvements are completed.
- As a public authority, DTMA approaches capital investments such as co-digestion infrastructure cautiously. The risk is mitigated by the potential to generate revenues which subsidizes ongoing costs.
- Potential for contamination in food waste.

4.2.4 Two Particular Acres and American Biosoils & Compost

Photos courtesy of Ned Foley.

Two Particular Acres (TPA) is a farm and composting operation in Royersford, Montgomery County that was founded in the early 2000s by Ned Foley. TPA has been processing food waste since 2003.

In 2011, Foley formed a joint venture with the H&K Group to create American Biosoils & Compost (AB&C), a full-service composting and organics recycling company that collects and processes source-separated food waste on land at three H&K quarries in east/central Pennsylvania and is permitted to compost food waste at two additional H&K quarries, though is not currently doing so.

HIGHLIGHTS:

- TPA processes up to 500 tons per year (its permitted maximum) of food waste in the form of coffee grounds from roasters and cafés and spent grain from microbreweries.
- The three AB&C sites accepting food waste compost about 12,000 tons per year (combined) from grocery stores, convenience stores, microbreweries, and cafés.
- AB&C operates its own truck fleet to collect food waste from generators and haul it to its quarry sites for composting.
- TPA's compost is utilized on Foley's farm where he has been growing barley that is used for malt by microbrewers. AB&C's finished compost is used primarily in engineered soils sold by H&K for storm water management.

SUCCESS FACTORS:

- Utilization of H&K quarries for AB&C food waste composting operations has mitigated challenges related to composting facility siting.
- Strong markets for compost and soil blends using compost, such as engineered soils used in bioretention ponds and green roofs.

CHALLENGES:

- A limiting factor to AB&C growth is finding truck drivers for its food waste collection routes. The company taps the same labor pool as Amazon, Walmart, and similar large entities.
- Permit restrictions on the quantity of food waste allowed limits growth. For example, TPA is limited to 500 tons of food waste annually, but the site could accept up to 2,500 tons per year if the permit allowed. Similarly, AB&C sites could at least triple the current amount of food waste received if the sites were not limited to the 5-acre footprint rule in the permits and it could access adequate volumes of carbon feedstocks to blend with the food waste streams.

4.2.5 SQUARE CAFÉ AND ZERO WASTE WRANGLER CASE STUDY

Photo courtesy of Zero Waste Wrangler.

Square Café is a Pittsburgh restaurant owned and operated by Sherree Goldstein since it opened in 2003. The restaurant's food waste, soiled napkins and paper, soiled cardboard, and over 100 lbs per week of coffee grounds are collected in both the dining areas and the. Diners' plates are scraped by employees, which minimizes front-of-house contamination. Square Café uses small 5- and 23-gallon containers lined with compostable bags for interior use which are then aggregated to 64-gallon carts outside.

Square Café's food waste is collected by Zero Waste Wrangler (ZWW), an organics collection company started by Kyle Winkler in 2018. ZWW supplies its customers with 35-gallon, or 64-gallon carts lined with compostable bags. ZWW collects the organics using a box truck and aggregates the organic waste to a 3-cubic yard dumpster which is then serviced by the nearby compost facility, AgRecycle.

HIGHLIGHTS:

- Seven 64-gallon carts of organics, roughly equivalent to 1,400-1,750 lbs in total, are collected from Square Café each week.
- Square Café has been recognized as a Platinum Level restaurant by Sustainable Pittsburgh.
- About half of ZWW's clients utilize one 35-gallon cart that is serviced once a week because they generate smaller amounts of dense material and/or do not have much post-consumer organics that could be collected.

SUCCESS FACTORS:

- For Square Café, being able to reduce carbon emissions is the biggest benefit of its food waste recycling program and is part of the restaurant's sustainability mission.
- Square Café's employee engagement and training, often done multiple times, are critical to proper source separation.
- "Anchor" customers, such as Square Café, along with adequate collection route density are important to ZWW's success.

CHALLENGES:

- Composting is more expensive than disposal for Square Café, especially in terms of employee labor costs to source separate.
- Square Café's biggest challenge is educating staff about proper separation and overall participation in the steps needed to divert food waste.
- ZWW estimates it needs about 12-16 customers per day (5 days per week) within 25-30 miles to make the economics work. This has been particularly challenging due to COVID-19.

4.2.6 WEIS MARKETS, INC.

Photos courtesy of Weis Markets, Inc.

Weis Markets, Inc., is a food retailer based in Sunbury, Northumberland County. Weis Markets operates nearly 200 stores in the Mid-Atlantic region, 117 of them located in Pennsylvania.

All of Weis Market's Pennsylvania stores recycle their organic waste, as do its distribution center and meat-processing plant. As one of the U.S. EPA's Food Loss and Waste 2030 champions, Weis follows the EPA's food recovery hierarchy and is committed to reducing its food waste by 50 percent by 2030.

HIGHLIGHTS:

- In 2019, donated 860 tons of food to regional food banks and diverted 1,360 tons to animal feed and 2,100 tons to composting.
- All in-store meat departments utilize meat rendering programs to recycle or compost meat trimmings, fat, and bones.

SUCCESS FACTORS:

- Ensuring that food waste diversion is equally as straightforward as solid waste disposal from the perspective of store employees.
- Committing to sustainable food waste management practices in both its mission statement and through the aforementioned U.S. EPA program continuously pushes Weis Markets to take action in diverting food waste.
- Auditing and characterizing waste streams to identify source reduction opportunities and to determine which waste diversion practice best fit the waste streams is invaluable.

CHALLENGES:

- Lack availability of a one size fits all program; no compost facilities are large enough to service all Weis Markets locations. Utilizing multiple processing facilities is difficult to manage from both an operational and data-tracking perspective due to their differing processes and accepted materials lists.
- Few processing facilities are able to accept packaged foods. Whereas Weis Markets diverts food as a trash reduction strategy, its processing facilities view the materials as inputs to their production processes and view compostable, non-food items like packaging and paper products as contaminants to their production processes as they take longer to degrade than food waste. This difference impedes Weis Markets' ability to divert packaged foods that could otherwise be beneficially repurposed from landfill.

4.3 FOOD WASTE DIVERSION INITIATIVES IN OTHER STATES

As of 2020, the eight states of CA, CT, MA, NJ, NY, RI, VT, and WA have initiated legislative initiatives to reduce food waste disposal. Seven of the states (excl. WA) have mandated that food waste from ICI establishments meeting certain criteria be banned from landfill disposal. Supporting criteria for food waste landfill bans customarily include:

1. **ICI establishments must exceed a specified threshold of food waste generation**. For example, Massachusetts bans landfill disposal of food waste from ICI establishments that generate more than one ton per week. Some states have structured their laws to start at a higher generation threshold which is then lowered over the course of several years to target increasingly smaller food waste generators. Common thresholds chosen are either one ton per week or two tons per week.
2. **ICI establishments must have reasonable access to a food waste recycling facility**. Many states only mandate ICI establishments that are within a specified distance (usually 15-25 miles) from a permitted food waste recycling facility that is able to accept the establishments' food waste. In the state of New Jersey, ICI establishments are also given the option to request an exemption to the diversion mandate if the transportation and processing costs to a recycling facility exceed the transportation and disposal costs to a disposal facility by more than 10 percent.[1]

Other ways in which these states have supported food waste diversion include:

- **Offering technical assistance** to food waste generators. For example, Massachusetts' RecyclingWorks[2] offers one-on-one technical assistance to food waste generators to help them:
  - Evaluate the composition of their waste streams,
  - Identify diversion opportunities,
  - Educate and train employees on diversion best practices,
  - Create customized waste bin signage,
  - Conduct a cost analysis of potential diversion programs, and
  - Connect with haulers and recyclables processors.
- **Providing online resources** that offer guidance to food waste generators and show the locations of permitted food waste recycling facilities.
- **Offering financial support** for AD facilities in the form of grants and loans to offset capital costs of equipment. For example, in 2018, the New York State Energy and Research Development Authority made $16 million in grants available for the construction of new and improvement of existing AD facilities.[3]
- **Improving the economics of GHG emissions reductions**. For example, California's Low Carbon Fuel Standard allows anaerobic digestion facilities (including those outside of California) that are converting their biogas to RNG to participate in the California market.[4]

Exhibit 4-1 provides an overview of the food waste diversion policies enacted by the states of CT, MA, NY, RI, and VT.

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[1] Assembly Telecommunications and Utilities Committee, (February 2020). *Assembly, No. 2371.*

[2] RecyclingWorks in Massachusetts. (n.d.). *RecyclingWorks Technical Assistance.*

[3] New York State Energy and Research Development Authority. (December 2018). *NYSERDA Announces $19 Million Available to Accelerate the Use of Clean Energy Technologies on Farms.*

[4] California Air Resources Board. (n.d.). *Low Carbon Fuel Standard.*

4.4 STRATEGIES TO INCREASE FOOD WASTE DIVERSION

Based on the survey responses, interviews with stakeholders, and the preceding analysis, this study offers the following potential strategies to be considered for increasing food waste diversion, organized by general subject matter. Individual strategies are categorized as either near-term (0-2 years), mid-term (2-5 years), long-term (5+ years), or ongoing (not time specific) and are labeled with a number for ease of reference. **Note that the number does not indicate the priority of the strategy; no attempt was made to prioritize or otherwise estimate the degree of impact of these strategies.**

4.4.1 Overall Economics of Food Waste Diversion

The single most important factor to the success of organics recycling programs is that they are cost effective. This study discovered that permitted capacity at organics processing sites is available but unused, which suggests that the current economics of food waste diversion in Pennsylvania could be improved. This conclusion is corroborated by testimonials from some of the AD and compost facilities currently processing food waste that have reported difficulty in finding large "anchor" customers that are willing to pay sufficient processing facility tip fees.

1. **Long-term Strategy:** *Mandate that food waste from generators meeting certain criteria is banned from disposal.*

Other states, such as CA, CT, MA, and VT, have seen success in their organics recycling programs due to either: 1) a ban on the disposal of food waste for generators beyond a specified threshold, and/or 2) limited regional disposal capacity resulting in high disposal tip fees. Both situations allow organics processing facilities to charge more in tip fees without losing customers to landfill or waste-to-energy disposal. Particularly in western PA, competition with low-cost disposal options makes cost-effective organics recycling difficult.

All states that have implemented such a mandate have (at least initially) conditioned that it only applies to ICI establishments exceeding a specified amount of food waste generation – commonly either one ton per week or two tons per week. As a preliminary estimate of the effects of such a mandate in Pennsylvania, Table 4-1 shows the percent of ICI establishments estimated to exceed these common thresholds, as well as the estimated amount food waste generation from establishments exceeding the thresholds.

Table 4-1 Comparison of Food Waste Generation Thresholds

	Food Waste Generation Threshold	
	One Ton/Week Threshold (52 tons/yr.)	Two Tons/Week Threshold (104 tons/yr.)
Percent of Establishments Exceeding Threshold		
Food Manufacturers and Processors	31%	24%
Food Wholesale and Retailers	17%	10%
Restaurants and Food Service	11%	3%
Hospitality Industry	12%	6%
Healthcare Facilities	59%	37%
Educational Institutions	2%	1%
Correctional Institutions	40%	33%
Percent of All Establishments Exceeding Threshold	**14%**	**7%**
Total No. of Establishments Exceeding Threshold	**7,420**	**3,925**
Total Tons of Food Waste Generation Captured	**2.0 million**	**1.7 million**
Percent of All ICI Food Waste Generation Captured	**73%**	**64%**

A two-ton-per-week food waste generation threshold is estimated to affect about 3,900 ICI establishments, which are collectively estimated to generate over 1.7 million tons of food waste per year, or about 64 percent of all ICI food waste generation. A lower, one-ton-per-week food waste generation threshold is estimated to affect about 7,400 ICI establishments and would capture an additional 0.3 million tons of food waste compared to the two-ton threshold.

Such a mandate would have substantial implications for food waste generators, haulers, and processing facilities. When considering the implementation of such a mandate for its own state, the New York State Energy Research and Development Authority conducted a cost-benefit analysis of the proposed legislation.[5] Similar research would be necessary if Pennsylvania is interested in further considering this potential strategy.

2. **Long-term Strategy:** *Identify strategies for organics processing facilities to monetize renewable natural gas generation, greenhouse gas reductions, and electricity production through participation in transportation fuel, carbon offset, and renewable electricity markets and programs.*

Beyond the commodity value of the biogas and soil amendments produced through the processing of food waste, there are pathways for organics processors to generate additional revenue by participating in renewable transportation fuel, carbon offset, and renewable electricity markets based on operations and products generated during the food waste diversion process. Although some AD facilities in Pennsylvania are already taking advantage of these existing markets, particularly through Alternative Energy Portfolio Standard (AEPS) program for renewable energy generation, assistance and resources designed to help operators overcome administrative and technical barriers to entry may increase participation in both compliance and voluntary markets, and improve the overall economics of food waste diversion.

- *Renewable Transportation Fuel.* Beyond using biogas for on-site combined heat and power generation, biogas generated through AD has the potential to be processed into pipeline-quality renewable natural gas (RNG) for use as a transportation fuel. When injected into the natural gas transmission pipeline or used for fueling vehicles on-site, this RNG may be eligible for participation in the California Low Carbon Fuel Standard program or the U.S. EPA Renewable Fuel Standard Program through the generation and sale of credits with a Renewable Identification Number. Landfills in Pennsylvania currently participate in each of these programs by converting landfill natural gas into RNG, and opportunities may exist for AD facilities if challenges to pipeline access can be overcome.
- *Carbon Offset Markets.* Compliance and voluntary carbon offset markets provide opportunities for organics processing facilities to generate additional revenue through the sale of verified carbon offsets. Carbon offset markets are typically managed by non-profit organizations who define the methodologies for setting up projects and quantifying emissions reductions, verify and certify and projects achieve emissions reductions, and offer a system to track the issuance, sale, and retirement of credits. Some of these organizations, such as the Climate Action Reserve, have protocols in place for organic waste composting and digestion. Credits may be used to satisfy compliance markets where organizations are required to hold carbon offset credits, or voluntary markets where organizations are looking to demonstrate progress to sustainability goals. In order to be eligible to generate credits, organic processing facilities must work with the verifying agency to ensure projects lead to the permanent removal of greenhouse gases from the atmosphere, are in excess of a "business-as-usual" case, can be independently verified by a third party, are not being double counted to satisfy other requirements, and demonstrate measurable reductions from a baseline scenario.

[5] New York State Energy Research and Development Authority. (March 2017). *Benefit-Cost Analysis of Potential Food Waste Diversion Legislation.*

- *Renewable Energy Credits.* Some AD facilities in the Commonwealth are already participating in the Alternative Energy Portfolio Standard (AEPS) program through the sale of excess electricity from on-site generators. This type of electricity is considered a Tier I resource and is categorized as Biologically Derived Methane Gas by the AEPS program. Future modifications to the AEPS program that prioritize the use of biologically derived methane gases, particularly from food waste, could improve the economics of using AD as a food waste management pathway and result in greater opportunities for food waste diversion and renewable energy generation.

4.4.2 General Administration

3. **Near-term Strategy:** *Create a state organics recycling coordinator position or task force.*

Organics recycling in the Commonwealth is currently managed independently by the facility managers of each DEP regional office. The permitting and enforcement of organics recycling facilities is only one set of the many responsibilities under the purview of facility managers. Some stakeholders commented as feeling that there is no "champion" for organics recycling in DEP that is attuned to the unique needs of AD and composting facilities. Additionally, because organics recycling management is done at the regional level rather than the Commonwealth level, some stakeholders have described disconnects between the management of each regional office.

Some states, such as Washington and North Carolina, have established a dedicated, state-level position (or division) within their pollution prevention and recycling groups to promote organics recycling. Functions of an organics recycling coordinator may include permitting organics processing facilities, providing technical assistance to public and private entities, administering small grant programs for equipment purchases, and offering education and outreach to recyclers, solid waste professionals, local officials, and the general public. Additionally, this position could be designated as the singular point of contact for organics recycling facilities which would allow the Commonwealth to stay up-to-date on organics recycling activities and would ensure the recycling facilities are receiving consistent and timely instructions from DEP. Although a position with similar responsibilities to those listed above once existed, the role has since been reclassified, and a new position with a primary focus on organics recycling would need to be created to address tasks identified in this recommendation.

One stakeholder opined that a regulatory task force made up of representatives from DEP's air, water, energy, and waste bureaus/offices would be monumental in driving development of new organics processing capacity, as it would allow facilities and developers to receive feedback from a unified source rather than engaging with four separate entities.

4. **Mid-term Strategy:** *Set a food waste diversion goal and establish methodology to benchmark progress.*

Establishing diversion goals signifies governments' commitment to recycling, and the benchmarking methodologies typically developed alongside the goals allow the enacting bodies to measure their progress and make educated policy decisions in response to it.

4.4.3 Permitting Process and Regulations

5. **Near-term Strategy:** *Establish clear, consistent, and comprehensive processes for permitting organics processing facilities.*

One stakeholder commented that confirming site permitting is the biggest hurdle for securing financing for new organics processing facilities, and therefore, transparency and clarity on the permitting process is strongly advantageous to the development of new infrastructure. Numerous organics processors who responded to the survey mentioned obstacles associated with the permitting process, with some remarking that permits took more than 12 months, even upwards of three years, to be issued. Although the timeframe to issue a permit can often depend on the quality of the application, there may be opportunities to streamline or clarify the permitting process to applicants in order to reduce the potential for delays.

As described in the previous section, having an organics recycling coordinator or task force to offer technical assistance during the permitting process would likely alleviate some of the issues encountered during the permitting process. Additional improvements to the permitting process could include:

- Reviewing the various General Permits for composting facilities (WMGM017, WMGM045, etc.) which were developed in early the 2000s and updating them to reflect the current state-of-knowledge in the composting,
- Developing clear regulations (and/or a new General Permit) concerning anaerobic digestion systems processing regulated solid wastes – drawing from the regulatory programs developed in New York, Maryland, and California,
- Publishing updated permits and regulations on the DEP website and clearly explaining the steps processors will need to follow to receive a permit, and
- Ensuring all regional offices are trained to interpret the permits and regulations in a consistent manner.

6. **Near-term Strategy:** *Develop permit tools for small-scale and developing facilities.*

Seven of the compost facilities that responded to the survey reported processing less than 100 tons of food waste per year. Small-scale facilities such as these may take the form of an institution (such as a university) or business composting its own food waste, a farm accepting small amounts of food waste from local businesses, or as part of a municipality's solid waste program. Though small-scale facilities are not the main drivers of food waste diversion, they are likely to offer the greatest per-unit rate of GHG emissions reduction because they are typically located in close proximity to the source of generation. However, multiple stakeholders described having to wait several years to receive a permit to ultimately compost small amounts of food waste. One stakeholder described this wait as "crippling" to a new facility. New permit tools may take the form of simplified general permits that can be quickly dispatched to facilities with the understanding that they will not accept beyond a specified amount of waste.

4.4.4 FOOD WASTE GENERATORS

7. **Ongoing Strategy:** *Offer food waste generators technical assistance.*

Food waste diversion ultimately depends on food waste generators having access to cost-effective and convenient diversion opportunities. Some states, such as Massachusetts and Rhode Island, offer no-cost technical assistance to help ICI establishments identify diversion opportunities that work with their operation. As demonstrated by the Massachusetts RecyclingWorks program, technical assistance can take the form of evaluating the establishment's waste stream and suggesting practical methods to source-separate food, offering employee training on diversion practices, or helping establishments identify cost-effective haulers and processors to service their material.

Based the generation analysis in Chapter 2, food manufacturers and processors are the estimated to generate the largest amount of food waste per establishment on average, followed by food wholesalers and retailers. While it is likely that the largest of establishments have already optimized their waste stream to identify the most cost-effective use of their material, mid-size food manufacturers and multi-site wholesalers/retailers may be good candidates to receive technical assistance.

8. **Near-/Mid-term Strategy:** *Establish or join a coalition of organizations successful in food waste diversion.*

Offering technical assistance to industrial-type establishments may require a type of expertise not possessed by individuals external to the manufacturing industry. It can be mutually beneficial for private organizations to assist DEP in providing technical assistance to food waste generators in exchange for recognition of their efforts. This coalition could in some ways also mirror the U.S. EPA's and USDA's United States Food Loss and Waste 2030 Champions program, that recognizes businesses committed to diversion. Pennsylvania-based retailers Giant Eagle Inc. and Weis Markets Inc. have been recognized by this program.

9. **Near-term Strategy:** *Provide online resources to suggest best practices and help food waste generators connect with haulers and processors.*

As evidenced by the methodology required in this study to identify food processors accepting food waste, there is currently no convenient and comprehensive source for food waste generators in Pennsylvania to identify processors near them. Access to maps/lists of haulers and processors operating in their area and accepting their type of material would reduce the initial burden for food waste generators to seek out diversion options. The data collected for this assessment can serve as a foundation for this resource.

4.4.5 FOOD DONATION

10. **Long-term Strategy:** *Standardize date labels to clearly distinguish between food safety and food quality.*

A report prepared by the Harvard Law School Food Law and Policy Clinic for Philabundance, the Philadelphia region's largest hunger relief organization, listed standardizing date labels as one of the two most important regulatory opportunities to reduce food loss.[6] Currently, date labels on food packaging are typically at the discretion of the manufacturer and can vary in language such as "Best if used by," "Use before," or "Sell by." These labels are typically indicative of the date to which the food is expected to retain its desired flavor; however, they can be misinterpreted by consumers as the date to which the food is safe to eat. Standardizing date labels to clarify this misconception can help reduce the amount of edible food that is disposed, as well as reduce the stigma surrounding food donation. According to the report, addressing this issue would require coordination between the Pennsylvania Departments of Agriculture, Health, and Environmental Protection.

The Philabundance report also recommends that regulatory agencies:

- "Broaden and expand public education regarding food waste and food recovery," and
- "Encourage food waste reduction through a food waste reduction challenge or certification program."

Both of which could be accomplished, in part, through implementing the potential strategies described in the previous section for food generators.

4.4.6 CONTAMINATION AND DEPACKAGING

11. **Mid-term Strategy:** *Develop permits and regulations for depackaging.*

Issues with contamination were noted by both AD and compost facilities as reasons that some facilities were not accepting up to their maximum physical or permitted amounts of food waste. Contamination is particularly detrimental to AD facilities as it can damage equipment or upset the chemical balance of the reactor. Like traditional recycling, dealing with contamination in organics recycling is likely an issue that needs to be addressed on both the generator and processor sides of the process. Depackaging equipment (which separates food waste from packaging and other contaminants) is a relatively new technology that is becoming increasingly popular as a solution to transforming post-consumer and expired food wastes into useable feedstock for anaerobic digestion and composting.

As described in first case study, an issue was encountered in which DEP conveyed to Reinford Farms that authorization to depackage food waste through a permit was required. At the time, there was no specific

[6] Philabundance. (September 2017). *Moving Food Waste Forward: Policy Recommendations for Next Steps in Pennsylvania.*

permit that authorized the processing of food waste through depackaging and Reinford Farms was the only known on-farm AD operation that was also operating a depackaging unit. After two years, subsequent to an application submitted by Reinford Farms to modify WMGM042, amendments were issued to the WMGM042 permit that authorized Reinford Farms to operate the depackaging equipment.

12. **Mid-term Strategy:** *Monitor and offer assistance in the development of organic transfer stations.*

Several stakeholders interviewed in this study have forecasted that establishing stand-alone depackaging facilities to serve as consolidation points before transportation to regional compost and anaerobic digestion facilities may be the future of organics recycling. This strategy also allows organics processors to potentially develop stand-alone depackaging sites into full-scale AD facilities once adequate amounts of feedstock supply are demonstrated. Permits for new facility types such as this are typically developed on an as-needed basis and are site-specific, thus there is currently no general permit for this concept of an "organics transfer station," and it is uncertain what regulations will be applied to them in the future – making it risky to invest in the technology in Pennsylvania. Therefore, clarifying the Commonwealth's stance on depackaging and proactively creating permits for its use would likely bolster their development, and consequently, food waste diversion.

4.4.7 Anaerobic Digestion Facilities

13. **Ongoing Strategy:** *Offer technical assistance for anaerobic digestion.*

Anaerobic digestion is a complex and constantly-evolving technology that requires knowledge of many different subjects for its successful implementation. There is currently no Pennsylvania-specific public resource to engage and assist organizations in evaluating potential opportunities for the anaerobic digestion of their food waste.

Technical assistance could include developing high-level feasibility analyses, offering guidance though the permitting process, and identifying funding sources, such as the Waste-to-Energy Technical Assistance for Local Governments administered through NREL.[7] Additionally, DEP's Local Climate Assistance Program (LCAP), which pairs municipalities with college students for assistance in developing GHG inventories and climate action plans,[8] could be expanded to help municipalities identify potential AD opportunities. Immediate candidates that may benefit from technical assistance include the four AD facilities identified in this study through Co-EAT modeling as being potentially capable of co-digesting food waste. If more in-depth feasibility studies can be conducted and their results align with those of the Co-EAT, upwards of 40,000 tons of AD capacity may become available for processing food waste.

14. **Mid-term Strategy:** *Make capital improvement grants available for existing anaerobic digestion facilities.*

During surveying (Chapter 3), AD facilities currently processing ICI food waste were asked what capital improvements, if any, would be necessary to continue increasing their food waste processing capacity beyond the physical capacity of the current infrastructure. Table 4-2 shows the number of times each equipment type was mentioned by survey respondents as necessary upgrades to increase food waste processing capacity. Additionally, the table shows approximate capital costs for each equipment type based on an assumed sizing specification.

[7] National Renewable Energy Laboratory. (n.d.). *Waste-to-Energy Technical Assistance for Local Governments.*

[8] Pennsylvania Department of Environmental Protection. (n.d.). *Local Climate Action Program.*

Table 4-2 Estimated Capital Costs of Select Anaerobic Digestion Equipment

Equipment Type	Mentions by Facilities[1]	Capital Cost Estimate[2]	Sizing Assumption
Additional Digester Reactor	7	$350k	500k gallons
Larger Capacity Generator	5	$300k-$500k	500 kW
Effluent Storage Tank	3	$8k	20k gallons
Dewatering Equipment	2	$400k	N/A
Depackaging Equipment	1	$400k-$600k	N/A
Buffer Tank	1	$40k	100k gallons

[1] Based on survey responses from 12 facilities that were already processing food waste from external generator sources. Survey respondents could name multiple equipment types.
[2] Source: Coker Composting and Consulting estimates.

Providing grants to help subsidize these and other capital improvements may help increase food waste processing capacity for less than the cost of constructing new facilities.

15. **Long-term Strategy:** *Develop a food-waste-to-renewable-energy siting database.*

For organics processing companies interested in developing stand-alone AD facilities to accept external food waste, a facility site needs to be identified that possesses several key attributes:

- Properly zoned land,
- Existing buildings,
- Sewer access to discharge pretreated effluent,
- Reasonable proximity to food waste supply, and
- Access to a natural gas transmission pipeline if biogas will be used for renewable natural gas generation.

An additional consideration to facility siting is the local interest in AD development. Stakeholders commented that, in their experience, some communities are more welcoming to AD development than are others. One stakeholder suggested that it would be very beneficial for states to publicize which of its communities are interested in economic development via an AD facility and to maintain a database of potential sites identified by these communities.

Additionally, publishing the data compiled in this study, such as locations of food waste generators and processing facilities, would likely reduce the level of effort needed for market analysis when considering the development of a new processing facility.

4.4.8 COMPOST FACILITIES

16. **Near-term Strategy:** *Revisit composting permit limits.*

Many of the compost facilities that responded to the survey commented that, though physical capacity to process additional food waste is available, their throughputs are limited due to restrictions imposed in their General Permits, as is demonstrated in the fourth case study (TPA and AB&C).

4. STRATEGIES TO INCREASE FOOD WASTE DIVERSION

The "5-acre footprint rule" was frequently mentioned as a limiting factor. Facilities with the WMGM017 General Permit (on-farm composters) are limited to a 5-acre permit area,[9] cannot exceed 500 tons or 1,000 cubic yards per year of source separated food scraps, and cannot exceed 3,000 cubic yards per acre of total materials at any one time. Facilities with the WMGR025 General Permit are limited to a 15-acre permit area; however, if the permit area is greater than 5-acres or if the total on-site volume exceeds 6,000 cubic yards per acre, the permittee is subject to bonding to ensure proper closure upon cessation of operation. Compost sampling and analysis are also required at frequencies based on production. Stakeholders reported that the bonding and sampling requirements create a disincentive to operate larger facilities that provide greater capacity to manage food waste, given the current economics of food waste diversion. These requirements were established to mitigate clean-up costs if sites were ever abandoned. Compost facilities interested in expanding their operations beyond the initial 5-acre permit areas would be considered for a modification to their existing general permits on a case-by-case basis.

Stakeholders recommended that the current 5-acre rule for composting operations apply only to land used for the active composting process (the first stage of composting) and initial curing. Excluding land used for final curing, amendment storage, and finished compost storage would allow greater materials management flexibility given the compost product's stability.

17. **Ongoing Strategy:** *Facilitate public-private partnerships for composting food waste.*

Some surveyed compost facilities also reported difficulty in gathering the necessary amount of carbon-rich material (i.e., "brown waste"), such as yard waste, to mix with the nitrogen-rich food waste they accept. Stakeholders attributed this difficulty to the competition with municipal compost facilities for yard waste. However, municipal compost facilities are able to receive financial support from DEP that enable them to charge substantially less in tip fees and for finished compost than privately-owned compost facilities.

Stakeholders suggested that public-private partnerships (i.e., private companies managing municipal yard trimmings operations) may be a mutually beneficial solution. This would allow private composting companies access to brown waste and would reduce the administrative, labor, and technical burdens on municipalities.

18. **Near-term Strategy:** *Develop and maintain compost equipment list.*

Stakeholders also opined that many municipal compost facilities are oversized for the amount of yard waste they process, and as a result, expensive processing equipment is substantially underutilized. One stakeholder proposed that maintaining a list of the composting equipment owned by each municipality could enable municipalities to share equipment, thus conserving DEP grant funds.

19. **Ongoing Strategy:** *Encourage the use of finished compost in public capital projects where possible.*

Another way in which the economics of food waste composting can be improved is to increase the demand for finished compost. As an example, one method to accomplish this would be to model the 2020 New Jersey bill which (among other things) mandated that the state's departments and agencies use "compost, mulch, or other soil amendments produced from municipal solid waste, food waste, sludge, yard waste, clean wood waste, or other similar materials" wherever "technically feasible, environmentally sound, and competitively priced."[10]

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[9] The permit includes waste material storage areas, the composting and curing areas, and the finished compost storage area (other than areas storing bagged product for retail sale).

[10] Assembly Telecommunications and Utilities Committee, (February 2020). *Assembly, No. 2371.*

CHAPTER 4 EXHIBITS

Exhibit 4-1 Overview of Food Waste Diversion Policies in CT, MA, NY, RI, and VT

	Connecticut	Massachusetts	New York	Rhode Island	Vermont
Title	Commercial Organics Recycling Law	Commercial Food Material Disposal Ban	Food Donation and Food Scraps Recycling Law	Rhode Island Organic Waste Recycling Law	Universal Recycling Law
Year Implemented	2014	2014	2020	2016	2014 (Commercial) 2020 (All users)
Policy / Law	General Statutes of Connecticut Sec. 22a-226e. Recycling of source-separated organic materials	Code of Massachusetts Regulations 310 CMR 19.000	Consolidated Laws of New York Article 27: Title 22: Food Donation and Food Scraps Recycling	Rhode Island General Laws Title 23 Chapter 23-18.9 Section 23-18.9-17 - Food waste ban.	Universal Recycling Law (Act 148)
Enacting Agency	CT DEEP	MassDEP	NYSDEC	RIRRC	VT DEC
Assistance Program		RecyclingWorks in MA (funded by DEP)	Pollution Prevention Institute (funded by DEC)	Rhode Island Food Policy Council	
Amount of Food Waste Threshold	2 tons/week (2014) 1 ton/week (2020)	1 ton/week	2 tons/week	2 tons/week (2016) 1 ton/week (2018)	2 tons/week (2014) 1 ton/week (2015) ½ ton/week (2016) ⅓ ton/week (2017) All food waste (2020)
Distance from Facility Threshold	20 miles	No restriction	25 miles	15 miles	20 miles (2014) No restriction (2020)
Resources[1]	Map & list of food waste generators	Food waste estimation guide Food waste best management practices Technical assistance to food generators Map & list of food waste generators Map & list of sites accepting diverted food	Resources and funding opportunities for businesses Map & list of sites accepting diverted food Food waste estimation guide Benefit-cost analysis of potential food waste diversion legislation	Technical assistance to food generators including: ◆ waste stream analysis, ◆ review of physical constraints, ◆ development of procedures for food waste separation, ◆ cost analysis, and ◆ help identify haulers.	Guidance for businesses & institutions Guidance for haulers & facilities Guidance for municipalities Residential composting & other organics resources
Financial Support for Digesters	energizeCT	MA Department of Energy Resources	NYSERDA		

[1] Not a complete list.

5. CONCLUSIONS

5.1 CURRENT AND POTENTIAL BENEFICIAL IMPACTS

Reducing the amount of disposed food waste has many social and environmental benefits. Food insecure people can be fed, jobs at food banks and organic processing facilities can be created, and landfill space can be preserved. When diverted to anaerobic digestion, it can heat buildings, create electricity, and produce renewable natural gas. When diverted to composting, it can produce a nutrient-rich soil amendment that reduces the need for chemical fertilizers, promotes higher crop yield, and enhances water retention. Management pathway alternatives to disposal will, in almost all cases, result in a reduction in GHG emissions.

This study quantified the beneficial impacts of AD and composting in terms of 1) tons diverted, 2) GHG emissions reduced, and 3) biogas generated. Table 5-1 summarizes the beneficial impacts of current diversion efforts and projects the increase in these impacts if diversion were to increase further through the utilization of unused available capacity. Additionally, the final scenario presented in Table 5-1 presents the impacts if diversion via AD and composting was yet further increased to account for 35 percent of total ICI food waste generation from establishments exceeding 52 tons per year. This percentage was chosen to emulate the food waste diversion goal of Massachusetts, which in 2014 implemented a disposal ban on food waste from establishments exceeding one ton per week in generation. (It should be noted that Massachusetts also counts food donation and animal feed towards this goal. The prevalence of food donation and animal feed in Pennsylvania is currently unknown and is not considered in the table below.)

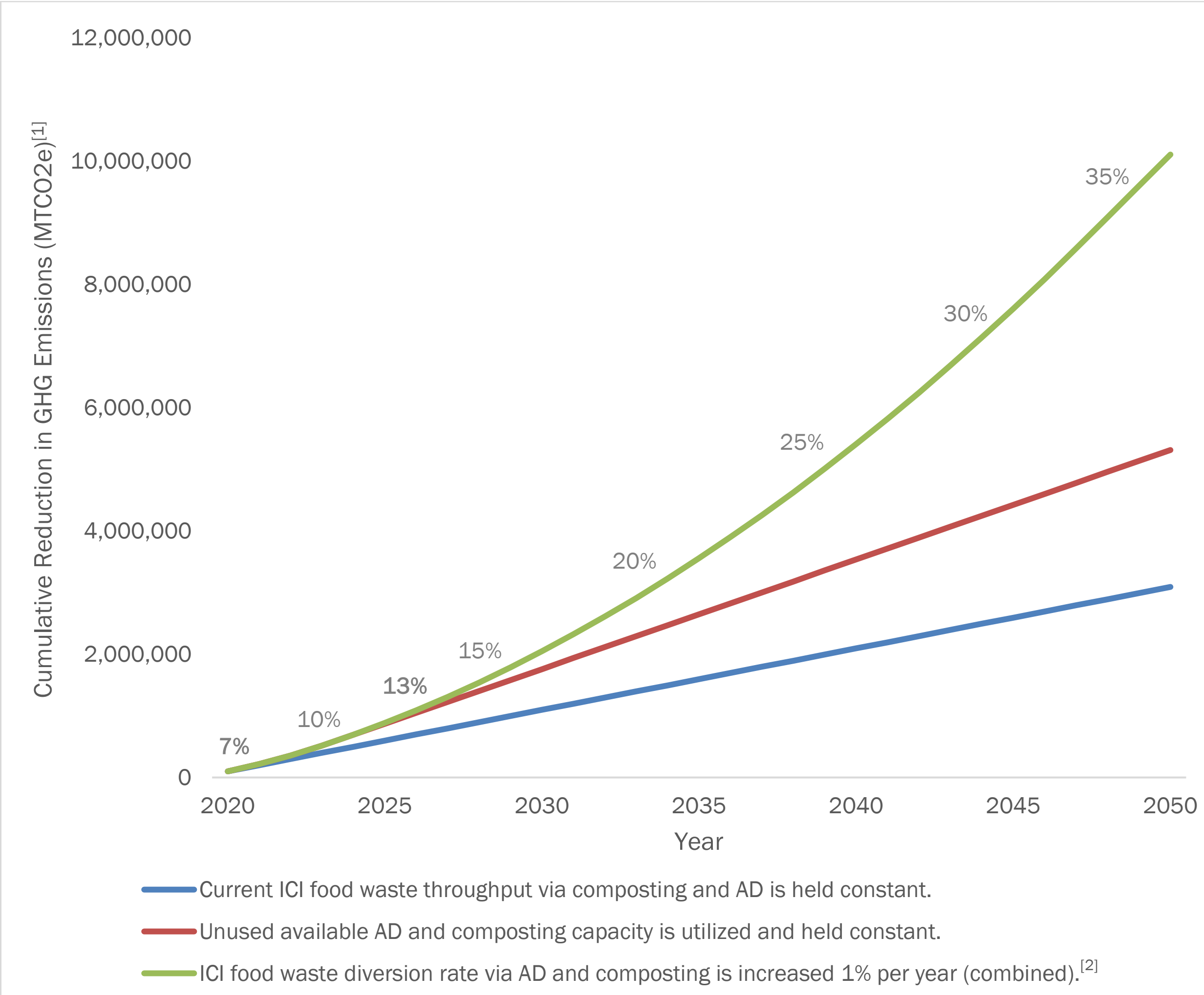
Table 5-1 ICI Food Waste Diversion Summary and Scenarios

	Scenarios		
Parameter	Current Diversion via AD and Composting	Potential Diversion Using All Unused Available Capacity	Potential Diversion at 35% Diversion Rate via AD and Composting[1]
ICI Food Waste Tons Diverted[2]	145,000	255,000	731,000
ICI Food Waste Diversion Rate[2][3]	7%	13%	35%
GHG Emissions Reduction (MTCO2e/yr.)[2][4]	99,000	176,000	508,000
Biogas Generation (million ft^3/yr.)	363	561	1,605

[1] Under this scenario, processing capacity at AD and compost facilities would be increased until sufficient capacity exists to achieve a diversion rate of 35% for ICI food waste. The current ratio of AD capacity to composting capacity (roughly 1.2:1) would be maintained, resulting in an additional 361,000 tons of food waste diverted through AD and 300,000 tons diverted through composting.
[2] Does not account for food waste diverted from disposal via direct land application, animal feed, or food donation.
[3] The total estimated amount of food waste generation from ICI establishments exceeding 52 tons per year in generation (2 million tons) is used as the denominator for calculating the diversion rate.
[4] Assumes diverted food waste would have been disposed of via landfill.

The three scenarios presented in Table 5-1 are further examined in the context of their cumulative reduction in GHG emissions in Figure 5-1. For the third scenario, in which the food waste diversion rate via AD and composting is projected as increasing to 35 percent, the diversion rate is increased one percent each year, beginning at the current rate of 7 percent in 2020 and reaching 35 percent in 2048 after which it is held constant. The figure shows these estimates through 2050 to correspond with the Commonwealth's goal to reduce GHG emissions by 80 percent by 2050 (relative to 2005 emission levels).[1]

Figure 5-1 Comparison of Cumulative GHG Emissions Reduction by Diversion Scenario



[1] Assumes diverted food waste would have been disposed of via landfill.
[2] The total estimated amount of food waste generation from ICI establishments exceeding 52 tons per year in generation (2 million tons) is used as the denominator for calculating the percentage.

If the current AD and composting throughputs were to remain unchanged through to 2050, nearly 3.1 million MTCO2e emissions would be eliminated compared to a scenario in which that food waste is landfilled. Utilizing the currently unused, but available capacity that exists at AD and compost facilities would result in a cumulative reduction of over million 5.3 MTCO2e by 2050 – equivalent to removing emissions from the energy usage of over 21,000 homes each year for the entire 30-year period.[2]

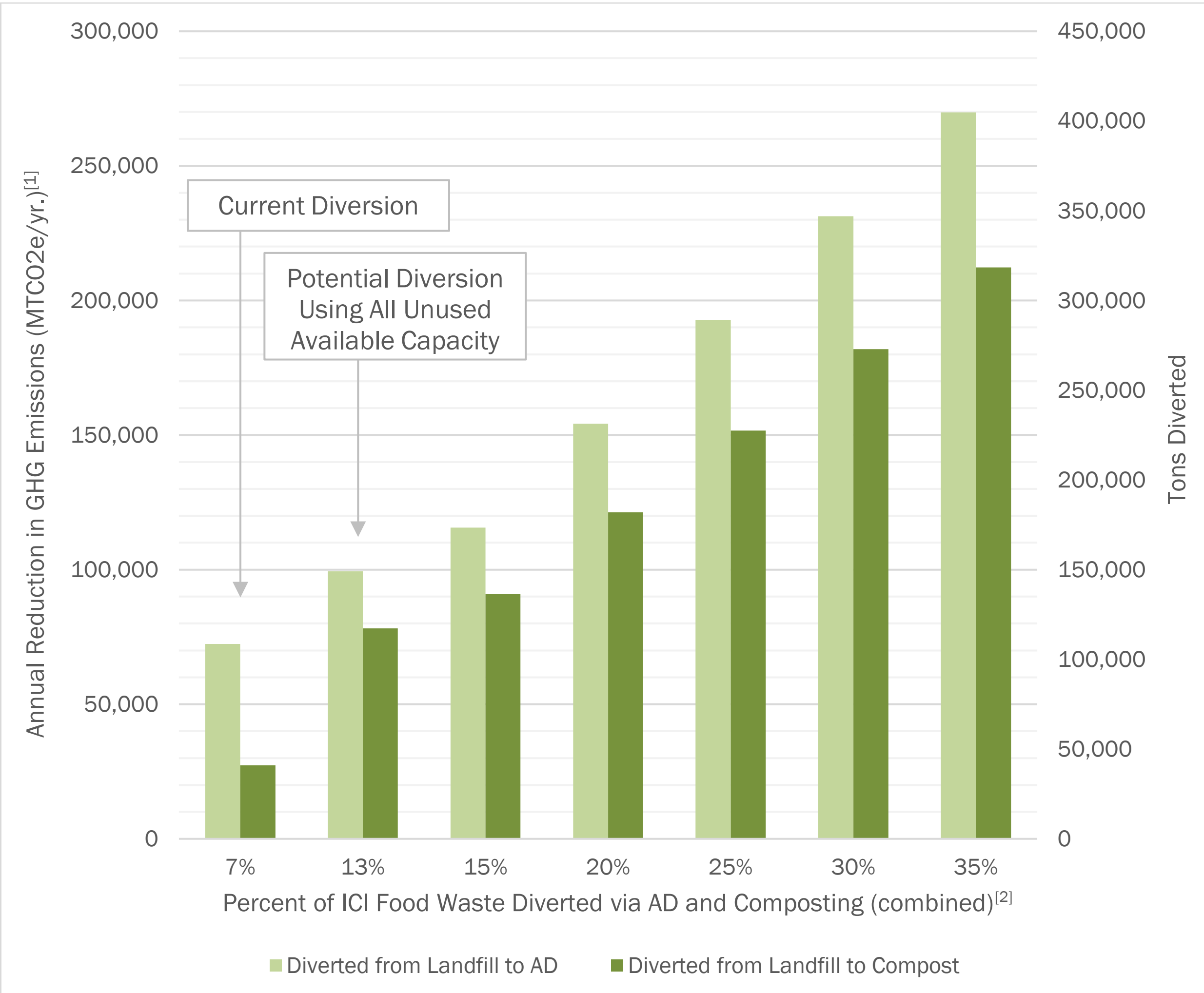
[1] Pennsylvania Exec. Order No. 2019-1 (January 2019). *Commonwealth Leadership in Addressing Climate Change and Promoting Energy Conservation and Sustainable Governance*

[2] U.S. Environmental Protection Agency. (March 2021). *Greenhouse Gas Equivalencies Calculator.*

Alternatively, the hypothetical scenario in which 35 percent of food waste from ICI establishments exceeding 52 tons per year was eventually diverted to AD and composting is projected to result in a nearly 10.8 million reduction in MTCO2e compared to landfilling – equivalent to removing emissions from the energy usage of over 43,000 homes each year for the entire 30-year period.

Figure 5-2 breaks down the third scenario into the annual GHG emissions reduction from AD and from composting.

Figure 5-2 Annual GHG Emissions Reduction by Diversion Method



[1] Assumes diverted food waste would have been disposed of via landfill.
[2] The total estimated amount of food waste generation from ICI establishments exceeding 52 tons per year in generation (2 million tons) is used as the denominator for calculating the percentage.

5.2 CONCLUSIONS

The following salient conclusions can be drawn from this study:

- Food waste generation is heavily skewed towards the largest of ICI establishments, many of which are food manufacturers and processors, and to a lesser extent, food wholesalers and retailers.

- Allegheny County and the region between (and including) Philadelphia and Harrisburg generate the most food waste.
- Food waste processed at AD facilities is currently comprised largely of material directly from food manufacturers and processors that is delivered in a liquid or slurried form, though depackaging equipment may enable more AD facilities to process other kinds of food waste. Compost facilities offer greater flexibility in the varieties of food waste they can accept.
- Most AD facilities currently processing food waste utilize biogas for the combined generation of heat and power. No AD facilities that responded to the survey are currently converting biogas to renewable natural gas, however some are exploring the possibility of doing so.
- There is existing processing capacity at AD and compost facilities that is currently underutilized due to a lack of motivated food waste supply given current economics.
- Many compost facilities have additional capacity to process food waste using existing infrastructure, however, are prohibited from doing so due to permit restrictions.
- Preliminary analyses suggest there is some potential to enable co-digestion of food waste at AD facilities not currently doing so. More in-depth feasibility studies are necessary to confirm this potential.

Based on the above conclusions and with further input from stakeholders, this study ultimately identified 19 potential strategies that should be considered for increasing food waste diversion. These potential strategies are repeated in Figure 5-3 and are assigned an approximate timespan in which they could be implemented. Note that the ordering of the potential strategies does not in any way indicate the priority or otherwise estimate the potential impact of a strategy.

Figure 5-3 Timeline of Potential Strategies to Increase Food Waste Diversion

Potential Strategies	Near-term (0-2 yrs.)	Mid-term (2-5 yrs.)	Long-term (5+ yrs.)
Overall Economics of Food Waste Diversion			
1. Mandate that food waste from generators meeting certain criteria is banned from disposal.			
2. Monetize GHG emissions reductions.			
General Administration			
3. Create a state organics recycling coordinator position or task force.			
4. Set a diversion goal and establish methodology to benchmark progress.			
Permitting Process and Regulations			
5. Establish clear, consistent, and comprehensive processes for permitting organics processing facilities.			
6. Develop permit tools for small-scale and developing facilities.			
Food Waste Generators			
7. Offer food waste generators technical assistance.			
8. Establish or join a coalition of organizations successful in food waste diversion.			

Potential Strategies	Near-term (0-2 yrs.)	Mid-term (2-5 yrs.)	Long-term (5+ yrs.)
9. Provide online resources to suggest best practices and help food waste generators connect with haulers and processors.			
Food Donation			
10. Standardize date labels to clearly distinguish between food safety and food quality.			
Contamination and Depackaging			
11. Develop permits and regulations for depackaging.			
12. Monitor and offer assistance in the development of organic transfer stations.			
Anaerobic Digestion Facilities			
13. Offer technical assistance for anaerobic digestion.			
14. Make capital improvement grants available for existing anaerobic digestion facilities.			
15. Develop a food waste-to-renewable-energy siting database.			
Compost Facilities			
16. Revisit composting permit limits.			
17. Facilitate public-private partnerships for composting food waste.			
18. Centrally manage and publicize grant-funded equipment.			
19. Encourage the use of finished compost in public capital projects where possible.			

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APPENDIX A

Food Waste Generation by NACIS Code

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APPENDIX A FOOD WASTE GENERATION BY NAICS CODE

The North American Industry Classification System (NAICS) is a code-based system for classifying ICI establishments by industry-type. Establishments self-assign their NAICS code – choosing one NAICS code as their primary code, and optionally, additional NAICS codes as secondary codes.

This appendix breaks down the number of establishments identified and the estimated food waste (FW) generation for establishments in each NAICS code (based on primary code). Table A-1 shows this information for all establishments, including those estimated to generate less than 52 tons per year of food waste. Table A-2 shows this information only for establishments estimated to generate at least 52 ton per year.

APPENDIX A FOOD WASTE GENERATION BY NAICS CODE

Table A-1 Estimated Food Generation by NAICS Code (all establishments, any size)

NAICS Code	NAICS Description	No. of Establi-shments	% of Total Establi-shments	Avg. FW per Establi-shment (tons)	Total FW Generation (tons)	% of Total FW Gen.	% Estimated ≥52 Tons/Yr. of FW Gen.
Food Manufacturers and Processors							
112930	Fur-Bearing Animal and Rabbit Production	28	0.1%	8	210	0.0%	3.6%
311111	Dog and Cat Food Manufacturing	19	0.0%	543	10,310	0.4%	36.8%
311119	Other Animal Food Manufacturing	71	0.1%	449	31,882	1.2%	84.5%
311211	Flour Milling	35	0.1%	1,459	48,146	1.8%	80.0%
311213	Malt Manufacturing	6	0.0%	331	1,653	0.1%	50.0%
311221	Wet Corn Milling	3	0.0%	1,127	3,380	0.1%	66.7%
311224	Soybean and Other Oilseed Processing	1	0.0%	N/A	0	0.0%	0.0%
311225	Fats and Oils Refining and Blending	25	0.0%	362	9,042	0.3%	68.0%
311230	Breakfast Cereal Manufacturing	12	0.0%	2,533	22,796	0.8%	75.0%
311314	Cane Sugar Manufacturing	16	0.0%	87	1,390	0.1%	87.5%
311340	Nonchocolate Confectionery Manufacturing	43	0.1%	80	3,187	0.1%	30.2%
311351	Chocolate and Confectionery Manufacturing from Cacao Beans	150	0.3%	208	29,910	1.1%	54.7%
311352	Confectionery Manufacturing from Purchased Chocolate	105	0.2%	150	15,463	0.6%	38.1%
311411	Frozen Fruit, Juice, and Vegetable Manufacturing	17	0.0%	397	6,352	0.2%	52.9%
311412	Frozen Specialty Food Manufacturing	41	0.1%	521	19,803	0.7%	56.1%
311421	Fruit and Vegetable Canning	74	0.1%	470	31,466	1.2%	43.2%
311422	Specialty Canning	19	0.0%	777	13,990	0.5%	47.4%
311423	Dried and Dehydrated Food Manufacturing	7	0.0%	194	1,355	0.0%	42.9%
311511	Fluid Milk Manufacturing	39	0.1%	1,959	60,729	2.2%	48.7%
311512	Creamery Butter Manufacturing	23	0.0%	215	4,951	0.2%	56.5%
311513	Cheese Manufacturing	35	0.1%	725	23,920	0.9%	48.6%
311514	Dry, Condensed, and Evaporated Dairy Product Manufacturing	17	0.0%	193	2,897	0.1%	29.4%
311520	Ice Cream and Frozen Dessert Manufacturing	101	0.2%	115	11,400	0.4%	43.6%
311611	Animal (except Poultry) Slaughtering	187	0.4%	313	57,045	2.1%	58.8%
311612	Meat Processed from Carcasses	130	0.2%	182	23,279	0.9%	65.4%
311613	Rendering and Meat Byproduct Processing	33	0.1%	237	7,814	0.3%	63.6%
311615	Poultry Processing	38	0.1%	528	19,523	0.7%	65.8%
311710	Seafood Product Preparation and Packaging	20	0.0%	112	2,246	0.1%	25.0%
311811	Retail Bakeries	2,958	5.6%	13	37,475	1.4%	1.5%
311812	Commercial Bakeries	187	0.4%	280	47,923	1.8%	29.9%
311813	Frozen Cakes, Pies, and Other Pastries Manufacturing	7	0.0%	132	921	0.0%	28.6%

NAICS Code	NAICS Description	No. of Establi-shments	% of Total Establi-shments	Avg. FW per Establi-shment (tons)	Total FW Generation (tons)	% of Total FW Gen.	% Estimated ≥52 Tons/Yr. of FW Gen.
311821	Cookie and Cracker Manufacturing	26	0.0%	272	6,263	0.2%	42.3%
311824	Dry Pasta, Dough, and Flour Mixes Manufacturing from Purchased Flour	26	0.0%	111	2,662	0.1%	23.1%
311830	Tortilla Manufacturing	3	0.0%	2	7	0.0%	0.0%
311911	Roasted Nuts and Peanut Butter Manufacturing	4	0.0%	133	534	0.0%	50.0%
311919	Other Snack Food Manufacturing	204	0.4%	395	77,511	2.9%	81.9%
311920	Coffee and Tea Manufacturing	37	0.1%	84	3,106	0.1%	37.8%
311930	Flavoring Syrup and Concentrate Manufacturing	3	0.0%	422	844	0.0%	33.3%
311941	Mayonnaise, Dressing, and Other Prepared Sauce Manufacturing	34	0.1%	192	6,522	0.2%	70.6%
311942	Spice and Extract Manufacturing	36	0.1%	244	7,560	0.3%	38.9%
311991	Perishable Prepared Food Manufacturing	21	0.0%	276	5,795	0.2%	38.1%
311999	All Other Miscellaneous Food Manufacturing	573	1.1%	355	202,791	7.5%	65.3%
312111	Soft Drink Manufacturing	157	0.3%	550	83,103	3.1%	67.5%
312120	Breweries	575	1.1%	416	239,338	8.8%	83.3%
312130	Wineries	459	0.9%	32	14,400	0.5%	8.1%
312140	Distilleries	78	0.1%	113	8,850	0.3%	79.5%
	Unknown NAICS	67	0.1%	1,967	55,087	2.0%	16.4%
	Subtotal	*6,750*	*12.9%*	*192*	*1,264,833*	*46.6%*	*31.3%*
Food Wholesale and Retailers							
424410	General Line Grocery Merchant Wholesalers	360	0.7%	59	21,224	0.8%	10.3%
424420	Packaged Frozen Food Merchant Wholesalers	526	1.0%	148	77,597	2.9%	45.4%
424430	Dairy Product (except Dried or Canned) Merchant Wholesalers	165	0.3%	75	12,438	0.5%	29.1%
424440	Poultry and Poultry Product Merchant Wholesalers	82	0.2%	95	7,830	0.3%	41.5%
424450	Confectionery Merchant Wholesalers	347	0.7%	64	22,301	0.8%	28.5%
424460	Fish and Seafood Merchant Wholesalers	106	0.2%	27	2,834	0.1%	10.4%
424470	Meat and Meat Product Merchant Wholesalers	206	0.4%	99	20,361	0.8%	23.8%
424480	Fresh Fruit and Vegetable Merchant Wholesalers	348	0.7%	49	17,104	0.6%	25.3%
424490	Other Grocery and Related Products Merchant Wholesalers	1,902	3.6%	39	74,038	2.7%	10.5%
445110	Supermarkets and Other Grocery (except Convenience) Stores	4,108	7.8%	74	302,898	11.2%	25.0%
445210	Meat Markets	345	0.7%	49	16,780	0.6%	7.2%
445220	Fish and Seafood Markets	87	0.2%	46	3,979	0.1%	5.7%

APPENDIX A FOOD WASTE GENERATION BY NAICS CODE

NAICS Code	NAICS Description	No. of Establi-shments	% of Total Establi-shments	Avg. FW per Establi-shment (tons)	Total FW Generation (tons)	% of Total FW Gen.	% Estimated ≥52 Tons/Yr. of FW Gen.
445230	Fruit and Vegetable Markets	322	0.6%	51	16,330	0.6%	6.8%
445291	Baked Goods Stores	1,223	2.3%	41	50,266	1.9%	0.4%
445292	Confectionery and Nut Stores	354	0.7%	44	15,410	0.6%	1.4%
445299	All Other Specialty Food Stores	724	1.4%	45	32,829	1.2%	4.7%
452311	Warehouse Clubs and Supercenters	107	0.2%	115	11,803	0.4%	49.5%
	Subtotal	*11,312*	*21.6%*	*62*	*706,022*	*26.0%*	*17.5%*
Restaurants and Food Service							
722320	Caterers	1,415	2.7%	18	24,766	0.9%	6.8%
722330	Mobile Food Services	267	0.5%	6	1,596	0.1%	0.7%
722511	Full-Service Restaurants	13,163	25.1%	28	365,131	13.5%	15.9%
722513	Limited-Service Restaurants	10,193	19.5%	17	170,790	6.3%	5.0%
722514	Cafeterias, Grill Buffets, and Buffets	56	0.1%	14	760	0.0%	3.6%
722515	Snack and Nonalcoholic Beverage Bars	370	0.7%	28	10,510	0.4%	5.9%
	Subtotal	*25,464*	*48.6%*	*23*	*573,553*	*21.1%*	*10.7%*
Hospitality Industry							
713210	Casinos (except Casino Hotels)	47	0.1%	127	5,962	0.2%	59.6%
721110	Hotels (except Casino Hotels) and Motels	2,238	4.3%	24	54,802	2.0%	11.4%
721120	Casino Hotels	7	0.0%	4	30	0.0%	0.0%
	Subtotal	*2,292*	*4.4%*	*27*	*60,795*	*2.2%*	*12.4%*
Healthcare Facilities							
622110	General Medical and Surgical Hospitals	154	0.3%	139	21,481	0.8%	70.8%
622210	Psychiatric and Substance Abuse Hospitals	33	0.1%	81	2,663	0.1%	63.6%
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals	52	0.1%	49	2,554	0.1%	21.2%
	Subtotal	*239*	*0.5%*	*112*	*26,698*	*1.0%*	*59.0%*
Educational Institutions							
611110	Elementary and Secondary Schools	5,842	11.1%	7	39,082	1.4%	0.2%
611310	Colleges, Universities, and Professional Schools	345	0.7%	68	23,358	0.9%	31.0%
	Subtotal	*6,187*	*11.8%*	*10*	*62,441*	*2.3%*	*1.9%*
Correctional Institutions							
922140	Correctional Institutions	159	0.3%	118	18,569	0.7%	40.3%
	Subtotal	*159*	*0.3%*	*118*	*18,569*	*0.7%*	*40.3%*
	Grand Total	**52,403**	**100%**	**52**	**2,712,911**	**100%**	**14.2%**

Note: Numbers in this table may not sum to their totals due to rounding.

Table A-2 Estimated Food Generation by NAICS Code (≥52 Tons/Yr.)

NAICS Code	NAICS Description	No. of Establi-shments	% of Total Establi-shments	Avg. FW per Establi-shment (tons)	Total FW Generation (tons)	% of Total FW Gen.
Food Manufacturers and Processors						
112930	Fur-Bearing Animal and Rabbit Production	1	0.0%	55	55	0.0%
311111	Dog and Cat Food Manufacturing	7	0.1%	1,395	9,763	0.5%
311119	Other Animal Food Manufacturing	60	0.8%	525	31,512	1.6%
311211	Flour Milling	28	0.4%	1,717	48,083	2.4%
311213	Malt Manufacturing	3	0.0%	546	1,637	0.1%
311221	Wet Corn Milling	2	0.0%	1,689	3,378	0.2%
311224	Soybean and Other Oilseed Processing	0	0.0%	N/A	0	0.0%
311225	Fats and Oils Refining and Blending	17	0.2%	526	8,941	0.5%
311230	Breakfast Cereal Manufacturing	9	0.1%	2,533	22,796	1.2%
311314	Cane Sugar Manufacturing	14	0.2%	96	1,346	0.1%
311340	Nonchocolate Confectionery Manufacturing	13	0.2%	216	2,813	0.1%
311351	Chocolate and Confectionery Manufacturing from Cacao Beans	82	1.1%	355	29,120	1.5%
311352	Confectionery Manufacturing from Purchased Chocolate	40	0.5%	353	14,112	0.7%
311411	Frozen Fruit, Juice, and Vegetable Manufacturing	9	0.1%	694	6,249	0.3%
311412	Frozen Specialty Food Manufacturing	23	0.3%	848	19,502	1.0%
311421	Fruit and Vegetable Canning	32	0.4%	970	31,049	1.6%
311422	Specialty Canning	9	0.1%	1,541	13,872	0.7%
311423	Dried and Dehydrated Food Manufacturing	3	0.0%	431	1,293	0.1%
311511	Fluid Milk Manufacturing	19	0.3%	3,187	60,545	3.1%
311512	Creamery Butter Manufacturing	13	0.2%	375	4,869	0.2%
311513	Cheese Manufacturing	17	0.2%	1,396	23,740	1.2%
311514	Dry, Condensed, and Evaporated Dairy Product Manufacturing	5	0.1%	549	2,747	0.1%
311520	Ice Cream and Frozen Dessert Manufacturing	44	0.6%	241	10,595	0.5%
311611	Animal (except Poultry) Slaughtering	110	1.5%	506	55,665	2.8%
311612	Meat Processed from Carcasses	85	1.1%	260	22,080	1.1%
311613	Rendering and Meat Byproduct Processing	21	0.3%	355	7,455	0.4%
311615	Poultry Processing	25	0.3%	775	19,365	1.0%
311710	Seafood Product Preparation and Packaging	5	0.1%	397	1,984	0.1%
311811	Retail Bakeries	45	0.6%	370	16,657	0.8%
311812	Commercial Bakeries	56	0.8%	823	46,106	2.3%
311813	Frozen Cakes, Pies, and Other Pastries Manufacturing	2	0.0%	450	899	0.0%

NAICS Code	NAICS Description	No. of Establi-shments	% of Total Establi-shments	Avg. FW per Establi-shment (tons)	Total FW Generation (tons)	% of Total FW Gen.
311821	Cookie and Cracker Manufacturing	11	0.1%	553	6,088	0.3%
311824	Dry Pasta, Dough, and Flour Mixes Manufacturing from Purchased Flour	6	0.1%	371	2,224	0.1%
311830	Tortilla Manufacturing	0	0.0%	N/A	0	0.0%
311911	Roasted Nuts and Peanut Butter Manufacturing	2	0.0%	264	528	0.0%
311919	Other Snack Food Manufacturing	167	2.3%	460	76,887	3.9%
311920	Coffee and Tea Manufacturing	14	0.2%	193	2,704	0.1%
311930	Flavoring Syrup and Concentrate Manufacturing	1	0.0%	838	838	0.0%
311941	Mayonnaise, Dressing, and Other Prepared Sauce Manufacturing	24	0.3%	268	6,430	0.3%
311942	Spice and Extract Manufacturing	14	0.2%	517	7,232	0.4%
311991	Perishable Prepared Food Manufacturing	8	0.1%	703	5,621	0.3%
311999	All Other Miscellaneous Food Manufacturing	374	5.0%	530	198,063	10.0%
312111	Soft Drink Manufacturing	106	1.4%	777	82,343	4.2%
312120	Breweries	479	6.5%	497	238,026	12.0%
312130	Wineries	37	0.5%	141	5,221	0.3%
312140	Distilleries	62	0.8%	137	8,519	0.4%
	Unknown NAICS	11	0.1%	4,991	54,903	2.8%
	Subtotal	*2,115*	*28.5%*	*574*	*1,213,853*	*61.2%*
Food Wholesale and Retailers						
424410	General Line Grocery Merchant Wholesalers	37	0.5%	503	18,595	0.9%
424420	Packaged Frozen Food Merchant Wholesalers	239	3.2%	291	69,593	3.5%
424430	Dairy Product (except Dried or Canned) Merchant Wholesalers	48	0.6%	230	11,055	0.6%
424440	Poultry and Poultry Product Merchant Wholesalers	34	0.5%	212	7,224	0.4%
424450	Confectionery Merchant Wholesalers	99	1.3%	190	18,816	0.9%
424460	Fish and Seafood Merchant Wholesalers	11	0.1%	166	1,825	0.1%
424470	Meat and Meat Product Merchant Wholesalers	49	0.7%	362	17,723	0.9%
424480	Fresh Fruit and Vegetable Merchant Wholesalers	88	1.2%	157	13,827	0.7%
424490	Other Grocery and Related Products Merchant Wholesalers	199	2.7%	243	48,271	2.4%
445110	Supermarkets and Other Grocery (except Convenience) Stores	1,026	13.8%	173	177,150	8.9%
445210	Meat Markets	25	0.3%	149	3,720	0.2%
445220	Fish and Seafood Markets	5	0.1%	128	642	0.0%

APPENDIX A FOOD WASTE GENERATION BY NAICS CODE

NAICS Code	NAICS Description	No. of Establi-shments	% of Total Establi-shments	Avg. FW per Establi-shment (tons)	Total FW Generation (tons)	% of Total FW Gen.
445230	Fruit and Vegetable Markets	22	0.3%	194	4,266	0.2%
445291	Baked Goods Stores	5	0.1%	87	433	0.0%
445292	Confectionery and Nut Stores	5	0.1%	242	1,209	0.1%
445299	All Other Specialty Food Stores	34	0.5%	146	4,957	0.3%
452311	Warehouse Clubs and Supercenters	53	0.7%	217	11,512	0.6%
	Subtotal	*1,979*	*26.7%*	*208*	*410,816*	*20.7%*
Restaurants and Food Service						
722320	Caterers	96	1.3%	88	8,487	0.4%
722330	Mobile Food Services	2	0.0%	89	178	0.0%
722511	Full-Service Restaurants	2,093	28.2%	100	208,888	10.5%
722513	Limited-Service Restaurants	505	6.8%	67	33,992	1.7%
722514	Cafeterias, Grill Buffets, and Buffets	2	0.0%	72	144	0.0%
722515	Snack and Nonalcoholic Beverage Bars	22	0.3%	88	1,946	0.1%
	Subtotal	*2,720*	*36.7%*	*93*	*253,635*	*12.8%*
Hospitality Industry						
713210	Casinos (except Casino Hotels)	28	0.4%	208	5,829	0.3%
721110	Hotels (except Casino Hotels) and Motels	256	3.5%	131	33,568	1.7%
721120	Casino Hotels	0	0.0%	N/A	0	0.0%
	Subtotal	*284*	*3.8%*	*139*	*39,397*	*2.0%*
Healthcare Facilities						
622110	General Medical and Surgical Hospitals	109	1.5%	187	20,332	1.0%
622210	Psychiatric and Substance Abuse Hospitals	21	0.3%	108	2,278	0.1%
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals	11	0.1%	127	1,394	0.1%
	Subtotal	*141*	*1.9%*	*170*	*24,003*	*1.2%*
Educational Institutions						
611110	Elementary and Secondary Schools	10	0.1%	147	1,472	0.1%
611310	Colleges, Universities, and Professional Schools	107	1.4%	203	21,682	1.1%
	Subtotal	*117*	*1.6%*	*198*	*23,154*	*1.2%*
Correctional Institutions						
922140	Correctional Institutions	64	0.9%	268	17,148	0.9%
	Subtotal	*64*	*0.9%*	*268*	*17,148*	*0.9%*
	Grand Total	**7,420**	**100%**	**267**	**1,982,005**	**100%**

Note: Numbers in this table may not sum to their totals due to rounding.

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APPENDIX B

Survey Questionnaires

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APPENDIX B SURVEY QUESTIONNAIRES

This appendix provides the three survey questionnaires distributed to:

1. AD facilities currently processing ICI food waste,
2. Compost facilities currently processing ICI food waste, and
3. AD facilities not currently processing ICI food waste.

Note that the surveying of the first two groups was primarily conducted via telephone interview. Survey questionnaires were only mailed to the third group by default.

APPENDIX B SURVEY QUESTIONNAIRES

B.1. AD FACILITIES CURRENTLY PROCESSING ICI FOOD WASTE

For the purposes of this survey, food waste includes organic waste streams from these sectors: commercial and institutional (e.g., grocery stores, universities, cafeterias) and food and beverage manufacturing.

1. In gallons or tons, about how much food waste do you process annually?
2. Please describe the food waste (i.e., "wastewater from food processing" or "expired food").
3. Where does the food waste originate from?
4. Do you have an estimate of how far the food waste is transported before arriving at your facility?
5. Do you charge any fee to accept the food waste? If so, how much do you charge?
6. Do you have any additional capacity for food waste? If so, could you estimate about how many additional gallons or tons you could accept?
7. Are there any capital improvements that could be made to accept more food waste?
8. Are there any operational issues you can foresee with increasing capacity?
9. Do you use wet or dry digestion?
10. Do you process digestate before land application? If so, how?
11. How much biogas does your digester produce annually (in cubic feet/year)? Would you be able to estimate how much that biogas is the result of digesting food waste?
12. How is the biogas generated by your digester used?
13. [If used for heat/power] What size generator do you have in kW?
14. [If connected to electrical grid] Which electric company or utilities provider is your generator connected to?
15. Is there any additional information that might benefit our study for PA DEP.

B.2. COMPOST FACILITIES CURRENTLY PROCESSING ICI FOOD WASTE

For the purposes of this survey, food waste includes organic waste streams from these sectors: commercial and institutional (e.g., grocery stores, universities, cafeterias) and food and beverage manufacturing.

1. In tons, about how much food waste do you process annually?
2. What percent of this food waste is from industrial, commercial, and institutional sources?
3. Where does this commercial food waste originate from (grocery stores, food manufacturers, etc.)?
4. Do you have an estimate of how far the food waste is transported before arriving at your facility?
5. Do you charge any fee to accept the food waste? If so, how much do you charge?
6. Do you have any additional capacity for food waste? If so, could you estimate about how many additional tons you could accept?
7. Are there any capital improvements that could be made to accept more food waste?
8. Are there any operational issues you can foresee with increasing capacity?
9. Is there any additional information that might benefit our study for PA DEP?

B.3. AD FACILITIES NOT CURRENTLY PROCESSING ICI FOOD WASTE

[Page 1]

Please fill-in the below information. Note: results of this analysis will be sent to the email provided.

Organization Name ______________________________

Respondent Name ______________________________

Email ______________________________

Phone ______________________________

1. Does your facility currently accept food waste for anaerobic digestion?
   - ☐ Yes – **please disregard this survey.** However, we would appreciate you contacting Greg Lenaz at MSW Consultants to relay this information and answer a short series of follow-up questions. Greg can be reached at (407) 745-0288 or by email at glenaz@mswconsultants.com. Thank you.
   - ☐ No – **please continue to the questions below.**

2. What type of digester do you use?
   - ☐ Combined stirred tank reactor – cylindrical reactors
   - ☐ Combined stirred tank reactor – egg-shaped reactors
   - ☐ Horizontal plug flow
   - ☐ Dry fermentation
   - ☐ Multiple stage
     ↳ Number of stages ________

3. How much biogas does your digester produce annually (in cubic feet per year)?

4. How is the biogas generated by your digester used (heat, power, CHP, transportation fuel, flared, etc.)?

5. If applicable, what size generator is connected to the digester (in kW)

6. If applicable, which electric distribution company is your generator connected to?

7. Have you (or your organization) ever evaluated the feasibility of co-digesting food wastes with manures (for farms) or with sewage sludge (for WWTPs)?
   - ☐ Yes – **please complete Page 2. You do not need to complete Pages 3 or 4.**
   - ☐ No – **please skip to Page 3. You do not need to complete Page 2.**

[Page 2]

8. What type of food wastes were evaluated for co-digestion (post-consumer food scraps, dairy byproducts, food processing residuals, fats/oils/greases, etc.)?

9. For the food wastes specified in the previous questions, what was the estimated amount of food wastes that could have been co-digested annually? Please specify the unit (tons, gallons, cubic yards).

10. What was the estimated increase in biogas production (in cubic feet per year)?

11. What was the estimated capital cost for adding co-digestion?

12. What was the projected change in net revenue from adding co-digestion?

13. Were there any regulatory or operational issues associated with co-digesting food wastes that were identified?

14. Are you planning to move forward with implementing co-digestion? If not, why? (check all that apply)
    - ☐ We are planning to move forward

    OR

    - ☐ Capital costs were too expensive
    - ☐ Projected net revenue was too low
    - ☐ Not enough digester capacity
    - ☐ No use for extra biogas
    - ☐ No contracted source for food scraps
    - ☐ Regulatory impediments
    - ☐ Lack of institutional support
    - ☐ Other____

15. Is there any additional information that might benefit our study for PA DEP?

Thank you for your participation. Please place Pages 1 and 2 in the prepaid envelope and return them via USPS. You do not need to complete Pages 3 or 4.

[Page 3]

Please complete the below questions only if you answered "No" to Question 7.

16. Is there any particular reason why co-digestion has not been evaluated? (select all that apply)
    a. No interest
    b. Not enough digester capacity
    c. Not enough food scraps nearby
    d. Other____

17. What feedstocks are currently processed in your digester (municipal wastewater, primary sludge, waste activated sludge, water, etc.)? For each feedstock, please specify the average amount per day processed (and specify the units). If known, please also provide the average percent solids and VS/TS ratio for each feedstock.

18. Do you have any of the following equipment (check all that apply)?
    - ☐ Weigh scale
    - ☐ Depackager
    - ☐ Transfer Pumps
    - ☐ Slurry Storage Tank
    - ☐ None of the above

19. Are you aware of any significant food waste generators (such as food manufacturers) near your facility?

20. Are there any regulatory or operational issues that you foresee associated with co-digesting food wastes?

21. The EPA's Co-EAT model requires a number of technical specifications in order to accurately model your facility's digester. **Please provide as much information as you can for the table on Page 4.**

22. Is there any additional information that might benefit our study for PA DEP?

Thank you for your participation. Please place Pages 1, 3, and 4 in the prepaid envelope and return them via USPS. You do not need to complete Page 2.

[Page 4]

	Parameter	Value	Unit
Digester	Total Digester Volume		gal
	Digester Liquid Level		ft
	Digester diameter		ft
	Number of digesters		#
	Effective operating capacity		%
	Percent of total volume for buffer capacity		%
	Annual operational and maintenance costs		$/yr
	Volatile solids reduction percentage		%
	Hydraulic retention time		days
Feedstock	Percent solids of homogenized feedstock sent to the digester		%
Biosolids	Percent solids of biosolids		%
	Biosolids processing cost per ton		$/ton
	Biosolids transportation cost per ton		$/ton
	Biosolids disposal cost per ton (i.e., tipping fee)		$/ton
	Annual amount of biosolids disposed (no revenue)		ton/yr
	Revenue from biosolids per ton		$/ton
	Annual amount of biosolids sold		ton/yr

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APPENDIX C

Food Waste Diversion Success Stories

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APPENDIX C FOOD WASTE DIVERSION SUCCESS STORIES

CASE STUDY 1. REINFORD FARMS

Highlights

- Equipped with two digesters with total capacity in excess of two million gallons, as well as two combined-heat-and-power (CHP) generators: one 499-kW and one 140-kW.
- Currently accepts about 10,000 to 12,000 tons per year of food waste but has capacity to accept and co-digest up to 25,000 tons per year of food waste, in addition to manure from 800 cows.
- Food waste is sourced from a variety of generators, including food manufacturers, cold storage warehouses, and brokers managing the waste streams of national companies. Reinford Farms manages its own fleet of trucks to collect about 70 percent of the food waste it processes.
- About 105 million cubic feet per year of biogas is produced in total (including from manure). Roughly 40 percent of total biogas, or about 42 million cubic feet per year, is produced from food waste. Biogas is used in CHP generators to produce heat and electricity.
- Renewable electricity generated from CHP generators is sold to PPL Utilities for $0.06 per kWh as part of a net metering agreement.
- Uses heat recovered from CHP generators to dry harvested corn for feed, saving about $3,000 to $5,000 each year.
- Digested and separated solids are used as bedding for the cows, saving the farm about $50,000 to $60,000 per year versus purchasing bedding.

Facility Overview

Reinford Farms is located in Mifflintown in Juniata County. Steve and Gina Reinford purchased the farm in 1991, starting out with 57 dairy cows and 144 acres. In 2008, the farm installed a 526,000-gallon, complete-mix anaerobic digester sized to treat manure from 800 dairy cows. There were about 400 cows at the time. Capital costs for the digester and related equipment were about $1.1 million with federal and state grants and/or tax credits covering about half of the cost.

Almost immediately, Reinford Farms was contacted by food waste haulers about receiving loads of food waste to co-digest with the dairy manure. The Reinfords agreed and within a year, the digester was close to its capacity. In 2019, a 1.5 million-gallon, second digester was added, increasing the farm's total digester capacity to over 2 million gallons. Reinford Farms now has 800 dairy cows and accepts about 10,000 to 12,000 tons per year of food waste. The farm has capacity to accept and co-digest 25,000 tons per year of food waste, though is not currently doing so due to a combination of factors including reduced ICI food waste supply due to COVID-19, delays in utilizing depackaging equipment (detailed below), and competition for food waste supply.

Funds for the second digester's construction included a federal tax credit, a $400,000 grant from the U.S. Department of Agriculture's Natural Resources Conservation Service, and a grant from the Commonwealth of Pennsylvania for about 30 percent of total project costs. The two digesters are adjacent to each other. In addition to its original 140-kW generator, Reinford Farms acquired a new 499-kW CHP generator when the second digester was added. Also installed was a 50,000-gallon food waste storage tank.

In 2017, Reinford Farms installed a Scott Equipment Turbo Separator to remove contamination from incoming food waste streams and to depackage food waste arriving in its original packaging. Food waste is slurried as it is separated from its packaging and goes into the food waste storage tank. Both the manure influent tank and the food waste tank are equipped with piston pumps that feed both streams into the digesters. Top-mounted mixers (on the covers of the digesters) agitate and combine the food waste and manure. Digested solids are separated by Doda presses.

Food Waste Source / Biodigester Feedstock

When Reinford Farms first began co-digesting food waste in its digester, it was primarily servicing supermarkets; however, the supermarkets later began redirecting their food waste to animal feed. Today, food waste is sourced from a variety of generators, including food manufacturers, cold storage warehouses, and waste brokers that manage organics recycling for national companies. Reinford Farms collects about 70 percent of the food waste it processes. In some cases – primarily with packaged foods that are no longer edible – it provides a trailer at the generator's facility and will haul it to the farm when filled.

Biogas End Use

The two digesters produce about 105 million cubic feet per year of biogas (42 million cubic feet from food waste alone) which is fed to the two CHP generators. Power is sold to PPL Utilities for $0.06 per kW, which is about half of what the utility used to pay Reinford Farms. The farm also receives a small amount of revenue generated from sale of its Renewable Energy Certificates to its dairy co-op.

The farm uses heat recovered from its CHP generators to dry harvested corn for feed, saving about $3,000 to $5,000 per year in avoided propane costs. The heat also is used in the milking barn to provide hot water for cleaning, which reduces fuel oil purchases by about $1,500 per month.

The Reinfords are exploring the opportunity for producing renewable natural gas (RNG), but the closest natural gas pipeline, where it could inject the RNG, is 15 miles from the farm. One possibility is to use the RNG as fuel for its fleet of trucks (though this would require that the trucks be converted to compressed natural gas engines). Another possibility is to supply compressed natural gas to a nearby chicken processing facility.

Digestate

Digested and separated solids are used as bedding for the cows, saving the farm about $50,000 to $60,000 per year versus purchasing bedding. The liquids are land applied on 1,400 acres that the Reinfords own or rent. While it has adequate acreage at the moment to comply with its nutrient management plan, the farm foresees a time when it will have to explore nutrient recovery options in order to continue complying. Several nutrient recovery technologies are being evaluated.

Success Factors

- Receipt and processing of food waste streams for co-digestion with dairy manure is a beneficial business practice for Reinford Farms, leading the farm to expand its food waste recycling capacity with installation of a second digester.
- Beneficial economics for Reinford Farms are also realized in the use of digested solids as bedding for dairy cows, and use of heat from CHP generators for hot water and drying corn for feed.
- Liquid digestate reduces quantity of conventional fertilizers required for crop production.

Challenges

- After installing depackaging equipment, DEP staff noticed some plastic contamination remaining in the depackaged food waste was carried through the digestion process and ultimately land applied. DEP conveyed to the farm that the depackaging activities would require authorization through a permit aimed to control and eliminate plastic before land application. At the time, contamination limits were not specified in the farm's WMGM042 General Permit. An amendment to the permit has since been issued to the farm, making it the first entity that has obtained authorization to operate a food waste depackaging unit.
- The U.S. EPA formally established a renewable electricity pathway under its Renewable Fuel Standard (RFS) program in 2014. This expanded the RFS to include "non-liquid" renewable fuels. This pathway, or "electric RFS," allows biogas-based electricity to be considered a cellulosic biofuel when used to power electric vehicles. Under this pathway, farms would sell e-RINs, which represent corresponding amounts of electricity produced with biogas and consumed on the same electric grid. Similar to RNG RINs, the e-RINs would be purchased by obligated parties in the transportation fuel sector – petroleum refiners and importers of refined fuel into the U.S. As of Spring 2021, the U.S. EPA has not activated the e-RIN pathway. Once activated, Reinford Farms plans to explore selling e-RINs, which would have significantly more value than the farm's current $0.06 per kWh received from electric utilities, and also plans to explore installing solar panels on the barn's roof.

CASE STUDY 2. MILTON REGIONAL SEWER AUTHORITY

Highlights

- Equipped with a 2.4-million-gallon anaerobic digestion system and two 1,000-kW CHP generators.
- Currently processes about 10 dry tons of food waste per day (roughly equivalent to 11,000 wet tons of food waste per year), though has capacity to comfortably process at least 20 dry tons per day (22,000 wet tons per year) and is permitted to accept up to 25 dry tons per day.
- All food waste is currently sourced from its "anchor" feedstock provider, Conagra Brands, which makes its Chef Boyardee and Healthy Choice lines at its Milton, Pennsylvania plant. A small amount of grease trap waste from restaurants is also processed.
- About 44 million cubic feet per year of biogas is produced in total. Roughly 90 percent of total biogas, or about 39 million cubic feet per year, is produced from food waste.
- Previously received $0.07-$0.08 per kWh in a net metering agreement with PPL Electric Utilities, however, currently receives $0.03 per kWh or less.
- Collects roughly $2.4 million in tip fees from accepting food waste and an additional $100,000 in tip fees from accepting FOG.

Facility Overview

The Milton Regional Sewer Authority (MRSA) wastewater treatment plant (WWTP), which serves six municipalities in Northumberland County, has the capacity to treat 4.25 million gallons of wastewater per day.

In order to better manage the food-manufacturing wastewater it was receiving, MRSA initiated a host of facility upgrades in 2012 as part of a "wastewater-to-energy" project which came fully online in mid-2016. These upgrades included the installation of a two-tank, 2.4-million-gallon anaerobic treatment system that, according to its developer, has a lower volumetric loading rate and longer hydraulic retention time than other anaerobic digestion technologies, resulting in greater biomass inventory. Food waste and FOG coming into the facility is directed to the line that feeds the two reactors. Prior to installation of the anaerobic system, the permitted BOD loading was about 12.5 tons per day. That increased to almost 25 tons per day after the upgrade. Capital costs for the wastewater-to-energy project were around $55 million, funded primarily through the U.S. Department of Agriculture's Rural Development loans for wastewater.

Food Waste Source / Biodigester Feedstock

The largest industrial user of the WWTP is Conagra Brands, which makes its Chef Boyardee and Healthy Choices lines, among others, at its plant in Milton. At first, Conagra was discharging its process wastewater into the dedicated primary clarifier upstream of the aerobic biological wastewater treatment process. The process wastewater includes spaghetti sauces, meatballs, and noodles, with larger chunks screened out prior to discharge into the WWTP. The treated Conagra wastewater was combined with separately treated wastewater and put into aeration tanks. This process consumed a lot of electricity for aeration and generated a large volume of sludge due to the organics in the Conagra stream. To reduce sludge volume and electricity usage, a pilot test was conducted with the food-laden wastewater in an anaerobic reactor. The pilot yielded positive results, leading to the installation of the 2.4-million-gallon anaerobic digestion system.

Conagra food-processing wastewater, which contains about 10 tons of food waste per day in dry weight, is now routed directly to the anaerobic digester. When standardized to the average moisture content of traditional food waste (72.2 percent[1]), the food-processing wastewater is equivalent to nearly 10,800 wet tons of food waste per year. MRSA bills Conagra as a regular industrial wastewater customer, charging them a variable tip fee (based on organic content, BOD, and COD) roughly averaging to $0.015 per gallon which totals to about $200,000 per month (or $2.4 million per year). From an economic development perspective, MRSA took the initiative to upgrade the plant to ensure capacity would be available to service Conagra if it wanted to expand, as well as service similar industrial users.

MSRA supplements the feedstock from Conagra with fats, oils and grease (FOG) from restaurants (fed into the same line as the Conagra wastewater). The plant has capacity to treat slurried food waste from organic waste haulers, but the only external waste accepted at this time is FOG. The tipping fee for hauled-in FOG averages about $0.10 per gallon and yields about $100,000 per year in revenue.

Biogas End Use

The anaerobic reactors generate more than 39 million cubic feet per year of biogas from food waste which is then fed to its two 1,000-kW CHP generators. Biogas conditioning includes removal of hydrogen sulfide in two tanks with an iron sponge type media, followed by siloxane removal in two tanks with activated carbon media. All of MRSA's generated power – about 300,000 kW per month – is sent to the grid via a net metering arrangement with PPL.

Success Factors

- The most significant success factor related to its anaerobic reactor system is the decrease in the amount of sludge generated – from about 2,000 dry tons per year prior to anaerobic treatment to 624 dry tons per year in 2019. MRSA landfills its biosolids at a cost of $35 per ton so this reduction has yielded significant savings.
- A related success factor is much improved odor control, with Conagra wastewater going directly into the enclosed tanks versus the open-air primary clarifier, which generated unpleasant odors, especially during the summer months.
- Generation of biogas for use as renewable energy is also a plus. MRSA is evaluating energy markets that yield a higher revenue stream, including renewable natural gas. Multiple options are being explored.
- Having Conagra as an "anchor" feedstock provider has allowed MRSA to invest in high-capacity AD system with reduced risk.

Challenges

- In the past, MRSA received $0.07-$0.08 per kilowatt hour (kWh) in a net metering agreement with PPL Electric Utilities. The price per kWh offered by PPL has dropped significantly (to $0.03 per kWh or less). MRSA is evaluating the impact of this on digester economics.

[1] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model.*

CASE STUDY 3. DERRY TOWNSHIP MUNICIPAL AUTHORITY

Highlights

- Current equipment includes a 1.2-million-gallon anaerobic digester, 280-kW CHP generator, septage and FOG offloading station, FOG pretreatment tank, and a gas conditioning system.
- Is in the process of expanding its capacity to process food waste by installing a new biogas utilization and handling system that includes: two 1,000-kW CHP generators, dual membrane cover for gas storage in the secondary digester, and improved biogas conveyance with potential to achieve on-site energy neutrality.
- Food waste acceptance includes grocery store food waste slurry, pet food manufacturing waste, and brewery yeast waste. Also accepts FOG collected from restaurants by haulers.
- Currently processes nearly 1,400 dry tons of food waste per year (roughly equivalent to 4,900 wet tons per year). Would not currently benefit from accepting additional food waste, though is looking to do so after plant improvements are completed.
- Generates 8,000 to 12,000 cubic feet of biogas per hour in total (including from non-food-waste feedstocks). Approximately 29 million cubic feet per year are generated from food waste.
- The biogas from food waste during the 2020 operating year yielded 1,353,527 kWh of energy resulting in $100,000 in electricity cost savings and savings of 20,000 gallons in fuel oil purchases worth $31,500. All generated electricity is currently used on-site – covering about 25 percent of the plant's electricity demands.
- In 2020, collected approximately $180,000 in tip fees from accepting food waste and an additional $500,000 in tip fees from accepting FOG.

Facility Overview

The Derry Township Municipal Authority (DTMA), located in Hershey, Dauphin County, operates two WWTPs.

The Clearwater Road (Clearwater) plant, which has the capacity to process 5.02 million gallons per day of wastewater, has an established co-digestion program for acceptance and processing of food waste and FOG. Infrastructure includes a 1.2-million-gallon primary, mesophilic, egg-shaped digester providing 55 percent solids reduction and yielding Class B biosolids; and a secondary digester to provide additional volatile solids reduction. The food waste and FOG is received at a designated offloading station (referred to as the blend tank), mixed with the municipal sludges (from the biological wastewater process), and fed directly to the digester. However, food waste acceptance has been limited by the Clearwater WWTP's current biogas handling system, including its 280-kW CHP generator, which has limited the beneficial use generating additional biogas. A $12 million improvement project is underway to resolve this limitation.

Food Waste Source / Biodigester Feedstock

The Clearwater WWTP is located along Hershey Park Drive and directly across from the Hershey Co. chocolate factory. Since inception of the treatment plant in the 1970s, Hershey Co.'s pretreatment waste sludge has been accepted and mixed with the municipal sludges (primary and waste activated sludge). Once the digester was installed in 2001, the Hershey sludge (in combination with the municipal sludges) was fed directly to the digester, which was essentially the beginning of "co-digestion" for DTMA. In 2020, Hershey Co. upgraded their own pretreatment facility to digest the food processing sludge before it is discharged to the Clearwater plant, thus, the sludge received by DTMA is already at a minimal volatile solids content and is now more akin to municipal sludges than traditional food waste.

Between October 2020 and March 2021, the Clearwater plant received nearly 1.3 million gallons of trucked-in food wastes. Extrapolated to a 12-month timespan, annual food waste volumes are estimated to include:

- 1.5 million gallons (970 dry tons) of preprocessed grocery-store waste from Divert, Inc.,
- 1.0 million gallons (367 dry tons) of brewery waste, and
- 50 thousand gallons (35 dry tons) of pet food waste.

When standardized to the average moisture content of traditional food waste (72.2 percent[2]), the cumulative dry food waste weights are roughly equivalent to 4,900 wet tons of food waste per year.

Septage haulers continue to be DTMA's largest customer base. However, the small percentage of food waste and FOG (10-12 percent of total digester feed volume) provides sufficient feedstock for co-digestion and generation of renewable energy for on-site beneficial use given the current infrastructure.

The Clearwater WWTP is accessible to major transportation systems, which facilitates delivery of food waste and FOG from various waste generators and haulers in the region. In 2017, DTMA began receiving food waste from local grocery stores that is preprocessed by Divert, Inc. into a slurry at an off-site location and delivered to the Clearwater plant via a tanker truck. The food waste slurry is offloaded into the blend tank. Minimal infrastructure changes were needed to accept the slurry.

DTMA and Divert mutually agreed to a current tipping fee for food waste slurry of $29.75 per 1,000 gallons, compared to a tip fee of $115.05 per 1,000 gallons of FOG and $39.40 per 1,000 gallons of septage (DTMA's current rate schedule).[3] Surcharges are added for comingled wastes in order to encourage haulers to separate wastes (for example, FOG should be in a separate truck from septage). In addition, DTMA's billing is based on the actual volume capacity of the hauling trucks to encourage full truckloads.

In 2020, the Clearwater WTTP collected $1.5 million in tip fees from FOG, septage, municipal sludge, and food waste. FOG wastes represented 13 percent of accepted volume and 33 percent of tip fee revenues (about $500,000). Other food wastes represented 16 percent of accepted volume and 12 percent of tip fee revenues (about $180,000).[3]

Biogas End Use

DTMA's existing 280-kW CHP generator was originally designed based on the amount of excess biogas (4,000 to 6,000 cubic feet per hour) produced at the plant from the digestion of municipal sludges alone. As a result of the co-digestion program, the current biogas production (8,000 to 12,000 cubic feet per hour depending on variance of hauled-in food waste and FOG) exceeds the current capacity of the CHP generator, resulting in excess biogas being flared. DTMA has procured two new 1,000 kW CHP generators through the Pennsylvania COSTARS Cooperative Purchasing Program. These generators will be installed as part of an energy enhancement project (expected to be completed

[2] U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (November 2020). *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model.*

[3] The Water Research Foundation. (January 2021). *Food Waste Co-Digestion at Derry Township Municipal Authority (PA).*

in early 2022) which includes construction of a new building to house the generators, installation of a dual membrane gas storage cover on the secondary digester, and upgrades to the existing gas conveyance and biogas conditioning system (to remove moisture, siloxane and hydrogen sulfide). With completion of this project, DTMA will have improved process and operational flexibility at the plant, enhancing its ability to accept additional food waste and approach energy neutrality into the future.

A 2019 Water Research Foundation case study on food waste co-digestion at DTMA was updated in 2021 by the Environmental Law Institute. It reports that:

- The additional biogas from food waste and FOG feedstocks during the 2020 operating year yielded 1,353,527 kWh of energy resulting in $100,000 in electricity cost savings and savings of 20,000 gallons in fuel oil purchases worth $31,500 (2020 pricing).
- Between 2014-2018, on average, 21 percent of DTMA's energy usage was offset using the renewable power generated at the plant. In 2020, renewable power provided 25 percent of the Clearwater plant's energy needs.

Success Factors

- Ample excess capacity in digester to utilize for co-digestion.
- No retrofits or minimal upfront capital costs necessary to accept Divert food waste slurry or other food waste.
- Location near Hershey chocolate plant, Hershey Park amusement park, local restaurants, and many other Hershey-related destinations yields ample supply of local sources of food waste and FOG. Additionally, plant location along major transportation route provides convenient option for receipt of trucked-in wastes.
- Tipping fee revenues and energy savings reduce financial risk of capital investments required to scale up co-digestion.

Challenges

- While the digester has capacity to receive additional food waste, supporting infrastructure – insufficient biogas handling system and CHP generator, inadequate dewatering capacity, and lack of thermal dryer – have stymied DTMA's ability to receive greater amounts of food waste.
- The DTMA works within the confines of a public utility with a public budget thus approaches capital investments such as co-digestion infrastructure cautiously.
- Potential for contamination in food waste feedstocks.

CASE STUDY 4. TWO PARTICULAR ACRES AND AMERICAN BIOSOILS & COMPOST

Highlights

- Two Particular Acres is a farm that accepts and composts up to its permitted maximum of 500 tons of food waste per year.
- American Biosoils & Compost currently composts a combined 12,000 tons per year across three quarry sites and is permitted to compost at two additional quarries.
- Food waste generators serviced include WaWa, Wegmans, Weis Markets, and other retail establishments, along with many coffee shops and breweries.
- American Biosoils & Compost has its own food waste collection fleet.
- Two Particular Acres' finished compost is utilized on the farm for growing barley that is used for malt by microbrewers. American Biosoils & Compost's finished compost is used primarily in engineered soils sold for stormwater management.

Facility Overview: Two Particular Acres

Two Particular Acres (TPA) is a farm and composting operation in Royersford, Montgomery County, that was founded in the early 2000s by Ned Foley. TPA started by composting horse manure, and then gradually started to accept yard trimmings from local municipalities. It began composting food waste in 2003 under an on-farm composting General Permit (WMGMO17) that Foley helped develop which allows farms with a minimum of 5 acres to take in a maximum 500 tons per year of food waste feedstocks.

Originally, TPA utilized windrows to compost, but switched to aerated static piles in 2006 to manage more materials on the same footprint and to better control odors. In 2010, TPA worked with Weis Markets to collect and compost its food waste from four stores.

Facility Overview: American Biosoils & Compost Quarry Sites

Gearing up for the possibility of taking on the entire Weis Markets chain, Foley created FCS Partners and in 2011 joined forces with the H&K Group, an aggregate producer operating in Pennsylvania and New Jersey, to form American Biosoils & Compost (AB&C). With more than 40 operating quarries, a fleet of more than 700 trucks and other necessary equipment, and real estate, that partnership meant instant infrastructure and the regional capacity to handle incoming organic feedstocks.

AB&C is permitted to operate food waste composting at five of H&K quarries, but to date is operating at only three of the quarry sites. Combined, the three quarry sites compost about 12,000 tons per year of food waste from grocery stores, convenience stores, microbreweries and coffee shops. Under PA DEP's WMGMO45 General Permit, each site is limited to five acres and can process up to 6,000 cubic yards per acre at any one time. The facilities all use aerated static piles. AB&C's service area collectively encompasses Philadelphia and areas west up to Harrisburg (including north and south of Harrisburg).

Food Waste Sources

In the past two years, food waste composted at TPA has consisted primarily of coffee grounds from roasters and coffee shops and spent grains from microbrewers. These generators are located within about 35 miles from the farm in Royersford. TPA receives coffee grounds from chains such as WaWa and La Columbe.

AB&C services grocery stores, such as Wegmans and Weis Markets. It also collects from convenience stores, including coffee grounds and food waste from WaWa.

Compost Markets

Compost made at TPA's facility is utilized for its farming operation. One crop grown using compost is barley, which is malted and sold to craft brewers. Compost from AB&C's facilities is marketed internally to H&K for use in engineered soils for stormwater management bioretention ponds and green roofs.

Success Factors

- Utilization of H&K quarries for AB&C's food waste composting operations has mitigated challenges related to composting facility siting.
- Strong markets for engineered soil blends that include compost for applications such as bioretention ponds and green roofs.

Challenges

- A limiting factor to AB&C's growth is finding truck drivers for its food waste collection routes. The company taps the same labor pool as Amazon, Walmart, and similar large entities which have significant distribution operations in the region.
- Permit restrictions on the quantity of food waste allowed limits growth. For example, TPA is limited to 500 tons of food waste annually, but the site could accept up to 2,500 tons per year if the permit allowed. Similarly, AB&C sites could at least triple the current amount of food waste received if the sites were not limited to the 5-acre footprint rule in the permits and it could access adequate volumes of carbon feedstocks to blend with the food waste streams.

CASE STUDY 5. SQUARE CAFÉ AND ZERO WASTE WRANGLER

Highlights

- Square Café diverts post-consumer plate scrapings as well as pre-consumer, back-of-house food waste.
- Seven 64-gallon carts of food waste from Square Café are collected weekly by Zero Waste Wrangler, a Pittsburgh-based organics collection company. This is equivalent to roughly 1,400 lbs to 1,750 lbs of food waste per week.
- Collected food waste taken to Pittsburgh-located AgRecycle for composting.
- Square Café has been recognized as a Platinum Level restaurant by Sustainable Pittsburgh.

Food Waste Generator: Square Café

Square Café, owned and operated by Sherree Goldstein, opened in May 2003. In 2020, it relocated to a different Pittsburgh neighborhood, quadrupling its restaurant space from 2,000 to 8,000 square feet. The restaurant sources much of the food it serves locally. Square Café initiated recycling when it opened and added food waste recycling in 2015 when Goldstein signed up for commercial organics collection. The primary motivation for taking this step was to stop contributing to the negative carbon impacts on the planet when food waste is landfilled and emits methane. The restaurant uses Zero Waste Wrangler to collect its organics. Square Café has seen a 75 percent reduction in its trash, attributed to recycling conventional recyclables, edible foods donation, and diversion to composting. For its efforts, Square Café has been recognized as a Platinum Level restaurant by non-profit organization, Sustainable Pittsburgh.

Food Waste Hauler: Zero Waste Wrangler

Kyle Winkler started Zero Waste Wrangler (ZWW) in late 2018. He acquired a small organics collection service that was using a pick-up truck and 18-gallon totes that had to be hand-lifted into the truck bed. Winkler quickly upgraded to 35-gallon wheeled carts and a 16-foot box truck with a hydraulic lift to accommodate the weight of the carts. The original company had been taking collected food waste to a farm about an hour outside of Pittsburgh for composting. Winkler was getting requests from customers to include post-consumer compostable foodservice products in their carts, which the farm composter would not accept. He decided to start bringing collected organics to AgRecycle, beginning in March 2020.

To limit the number of trips to the composting site, ZWW utilizes a 3-cubic-yard dumpster near its organics collection route, which is then serviced by AgRecycle. About half of ZWW's clients utilize one 35-gallon cart that is serviced once a week because they generate smaller amounts of dense material and/or do not have much post-consumer organics that could be collected. Winkler notes he needs over 60 customers on ZWW's 25-30 mile route (spread over the course of 5 days per week or an average of 12-16 stops per day), to make the economics work. The actual number is fluid, depending on customer type, e.g., smaller volume coffee shop vs. larger volume full-service restaurant.

Food Waste Processor: AgRecycle

AgRecycle, founded in 1991, is an organics collection and composting company based in Pittsburgh, which has been receiving food scraps collected by ZWW. Its composting facility in Washington County operates under a PA DEP General Permit 25, which allows the site to accept pre- and post-consumer food waste, as well as soiled paper and certified compostable packaging. Ground yard trimmings, leaves and chipped wood are mixed with the food waste and put into windrows. AgRecycle has built strong markets – including landscape, residential, nursery and green infrastructure applications – for its compost and soil blends. The COVID-19 pandemic curtailed collection of commercial organics in 2020. AgRecycle collects source separated organics from PNC Park, the Pittsburgh Convention Center, corporate campuses, local universities, restaurants and numerous other food waste generators.

Food Waste Separation and Collection

Square Café has utilized BPI- (Biodegradable Products Institute) certified compostable foodservice ware for many years, which allows it to include it in the organics stream diverted to AgRecycle. Food waste, soiled napkins and paper, soiled cardboard, and over 100 lbs per week of coffee grounds are collected in the dining areas using 23-gallon containers and in the kitchen using 5-gallon buckets. All containers are lined with compostable bags. These are emptied into 64-gallon wheeled carts (located outside). ZWW supplies the restaurant with the 64-gallon carts and this accommodates bulk egg trays and other larger packaging that was limiting the capacity of the 35-gallon carts that were formerly used. Diners' plates are scraped by Square Café employees, which minimizes front-of-house contamination in the organics stream. ZWW notifies Square Café (via photos) when contamination is identified. The photos are posted in the restaurant as a reminder to employees to keep contamination causing items out of the carts. Goldstein notes that employee engagement and training, often done multiple times, are critical to proper source separation and ensuring that only food waste and other accepted materials (soiled paper, cardboard, etc.) are captured for composting.

Source separation of back- and front-of-house (i.e., pre- and post-consumer) food waste is more expensive for Square Café than throwing it away, primarily due to the labor costs related to training, retraining, and the time required to source separate. Square Café has committed to operating sustainably and incurs the expense to achieve that goal. While Goldstein hopes customers appreciate the effort (and contribute to why they patronize the Café), the primary benefit is "for the planet."

Success Factors

- For Square Café, being able to reduce carbon emissions is the biggest benefit of its food waste recycling program. In addition, organics diversion is part of the restaurant's sustainability mission.
- Finding "anchor" customers, such as Square Café, along with adequate collection route density are important to ZWW's success.

Challenges

- Composting is more expensive than disposal for Square Café, especially in terms of employee labor costs due to source separation.
- Biggest challenge is educating staff about proper separation and overall participation in the steps needed to divert food waste.
- Square Café has "barely scratched the surface" of educating its customer base about all of its sustainability practices, which would contribute to building "brand" loyalty.
- ZWW estimates it needs about 12-16 customers per day (5 days per week) within 25-30 miles to make the economics work. This has been particularly challenging due to COVID-19.

CASE STUDY 6. WEIS MARKETS, INC.

Highlights

- Weis Markets is a U.S. EPA Food Loss and Waste 2030 Champion that applies the principles of the EPA's Food Recovery Hierarchy to prioritize the diversion of food waste. This includes reducing excess waste through:
  - Better inventory management practice,
  - Donating edible excess food waste to hungry people,
  - Diverting applicable food waste to be used as animal feed,
  - Providing decontaminated food waste for use in energy production, and
  - Composting remaining food waste before sending the rest for landfilling.
- In 2019, diverted nearly 3,500 tons of food waste to animal feed and composting programs, and recovered another 800 tons for food donation.
- The company considers "ease-of-use" as the biggest component of food waste recycling program success and "cost-effectiveness compared to disposal costs" as the second main factor.

Overview

Weis Markets, Inc. (Weis), based in Sunbury, Northumberland County, was founded in 1912. Today, the company operates 117 stores in Pennsylvania and 79 stores in the surrounding Mid-Atlantic region – employing more than 23,000 associates in its stores, distribution center, corporate office, and manufacturing facilities.

The majority of Weis's stores (187 out of 196), its distribution center, and its meat-processing plant recycle their generated food waste, resulting in the diversion of nearly 3,500 tons of food waste to animal feed and composting programs in 2019, and an additional 800 tons recovered to food donation programs.

Weis is a U.S. EPA Food Loss and Waste 2030 Champion and applies the principles of the U.S. EPA's Food Recovery Hierarchy to prioritize the diversion of food waste. A 2019 waste audit at one store found packaged or unpackaged food waste was 32.5 percent of the store's total waste generation, down significantly from a 2012 audit that found 50 to 70 percent food waste in one store's waste stream.

Source Reduction

Weis utilizes technology to optimize store-level inventory control, a first step in reducing food waste. Additionally, Weis audits and characterizes its waste streams to identify the commonly wasted constituents to identify source reduction opportunities.

Feeding Hungry People

The company continues to increase its involvement with Feeding America, a nationwide food bank network with affiliates in its market area. This donation program now includes additional store departments. The amount of donated food has increased from just over 100 tons in 2016 to over 800 tons in 2018, 2019 and 2020.

Feeding Animals

Weis rolled out its animal feed program in the second half of 2019 and is now in place at 161 stores and its distribution center. In 2019, the food waste-to-animal feed programs resulted in the diversion of 1,360 tons. The animal feed stream is "vegetarian" – no meats or seafood – and includes produce, bakery, dairy (eggs, yogurt, cheese, etc.), and some deli items. Weis uses 3-cubic-yard bins located behind its stores for food waste going to animal feed.

Recycling food waste to animal feed has a slightly lower collection fee than the cost to divert to composting, but, notes Weis, "considering that the compost programs have a broader accepted materials list and thus can take more material, it's essentially a wash."

Anaerobic Digestion

Weis does not utilize anaerobic digestion for management of its food waste on an ongoing basis. (On one occasion, it utilized a farm digester to dispose of recalled dairy products.) However, it does use anaerobic digestion for the recycling of some of its grease trap waste.

Composting

In 2019 (while animal feed programs were still being implemented), 2,100 tons of food waste were diverted to composting. Today, 26 Pennsylvania stores not enrolled in animal feed continue to utilize composting. Source-separated food waste (and other organics such as paper packaging) for composting are collected in 96-gallon wheeled carts that are stored in a refrigerated room prior to being taken outside for collection. Some soiled cardboard is disposed, though most cardboard and waxed cardboard are recycled. The organics are brought to American Biosoils & Compost (AB&C) sites where they are processed. Finished compost from AB&C was also used in the construction of a Weis store in Bedminster Township, Pennsylvania.

Success Factors

- Ensuring that food waste diversion is equally as straightforward as solid waste disposal from the perspective of employees.
- Committing to sustainable food waste management practices in both its mission statement and through the aforementioned U.S. EPA program continuously pushes Weis Markets to take action in diverting food waste.
- Auditing and characterizing its waste streams to identify source reduction opportunities and to determine which waste diversion practice best fits the waste stream are invaluable.

Challenges

- Lack availability of a one size fits all program; no organics processors are large enough to service all Weis locations. Utilizing multiple processors is difficult to manage from both an operational and data-tracking perspective due to their differing processes and accepted materials lists.
- Few organics processors are able to accept packaged foods. Whereas Weis diverts food as a trash reduction strategy, its organics processors view the materials as inputs to their production processes and view compostable non-food items, like packaging and paper products, as contaminants to their production processes as they take longer to degrade than food waste. This difference impedes Weis' ability to divert packaged foods that could otherwise be beneficially repurposed from landfill.

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