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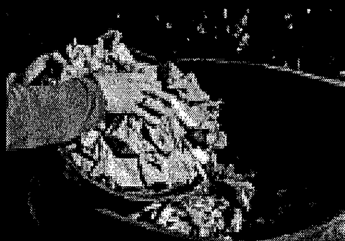

State of Organics Recovery

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INTRODUCTION

Organics are the largest portion of the waste stream by weight. Food and yard waste together comprise slightly less than thirty percent of all municipal solid waste sent to disposal. When other organics such as paper and wood waste are added in, the organics share of disposal rises to almost half. Most programs that separately collect organics define them as food scraps, yard waste and food-soiled paper. Some also include diapers and pet waste. As a result, when state or local governments are trying to boost their recycling rates, these materials must be considered. Food waste in particular, with its low recovery rate of only 5%,[1] is increasingly viewed as a target for achieving higher recycling goals.

These different components of the organic waste stream may share the distinction of being "organic, " but they also have distinct differences. Food waste is heavy and wet compared to yard waste which is bulky but drier. Yard waste varies between grass clippings, leaves and branches, with grass usually being wetter than leaves or branches. The non-recyclable paper fraction is likely to be drier than yard or yard waste. Wood waste poses significant processing problems. These differences have to be taken into account when planning for organics recovery. These non-MSW materials are successfully managed in many organics management facilities. However, their particular characteristics must also be taken into account when determining the technology being used to manage organics.

This white paper examines the prospects for increased recovery of the organics fraction of the waste stream. It looks at the components and amount of organic wastes, the existing recovery infrastrutture, both in terms of operating facilities and the legislative and regulatory framework governing those programs, the technologies used to recover organics and what is necessary to increase organics recovery.

DEFINING "ORGANICS"

"Organics" can be defined narrowly or broadly. Defined narrowly as food and yard wastes they make up less than thirty percent of generated municipal solid waste. If defined broadly to include wood waste such as pallets and paper and paperboard products, then organics are nearly three-fifths of the materials generated, or about half of what is discarded in the waste stream.

While these materials are theoretically suitable for composting or anaerobic digestion, their practical suitability for those systems will vary based on factors such as where they are generated, their appropriateness for a particular technology and their cleanliness. In addition, printed and packaging paper are already extensively recycled. This leaves non-recyclable paper products such as towels, tissues, plates and cups available for organics recovery programs along with wood products, such as pallets and crates. Other materials, such as wood from construction and demolition projects, agricultural and land-clearing wastes, manures and biosolids can also be considered part of the organics waste stream. However, they are not managed as part of the municipal solid waste stream.

> **"Collection and composting of yard waste is commonplace throughout the United States. The U.S. Environmental Protection Agency (EPA) estimates the current recovery rate to be 60 percent, or 20 million tons."**

Therefore, this paper will focus on those organics that are found in everyday garbage and more likely to be available to local programs. Yard waste, food waste, and non-recyclable but compostable wood and paper products are in this larger universe of "organics."

While the focus of this paper is organics as a whole, food waste will receive the most emphasis. This is for several reasons. First, collection and composting of yard waste is commonplace throughout the United States. The U.S. Environmental Protection Agency (EPA) estimates the current recovery rate to be 60 percent, or 20 million tons. In addition, grasscycling and back yard compost piles have kept significant amounts of yard waste out of the waste stream.[2] Second, food waste is slightly more than twenty percent of what goes into municipal solid waste landfills, more than any other material. Finally, food waste has also been the focus of considerable legislative and press interest in the last few years due to the large amounts that we generate and the small amount we recover. Recently, EPA and the U.S. Department of Agriculture announced their support of a 50 percent food waste reduction goal for 2030.[3] As a result, the addition of food discards to existing yard waste programs has major implications for collection, processing and recovery of these materials.

HOW MUCH ORGANICS DO WE GENERATE AND THROW AWAY?

Since EPA began estimating the size of the waste stream, "containers and packaging" has been the most prominent category. Other categories include "durable good" and "non-durable goods" along with "other wastes" with its separate subcategories of "food scraps," "yard trimmings" and "miscellaneous inorganics." Organics are not a separate category in the EPA database. Instead, food and yard waste along with other organic materials are simply parts of other categories. What follows is a look at the components of organics wastes – both in terms of how much is generated, how much is sent to disposal, what products or materials are in the various components and where they are generated.

GENERATION

Food and yard wastes are 28.1 percent, or 71.26 million tons of the municipal solid waste generated in this country. Wood packaging is another 9.4 million tons (3.7 percent) and the non-recyclable portion of paper products (e.g., tissue paper and towels, paper plates and cups and other non-packaging paper that is found in a wide variety of products such as games, novelties and cards) is 8.8 million tons (3.5 percent). This is 89.46 million tons or slightly more than one-third of the waste stream. If all paper and paperboard products are included in the organic universe, the total amount generated rises to 149.16 million tons or 58.7 percent of all municipal solid waste. An interesting sign of changes in the waste stream is that food and yard waste are now a larger fraction than paper products because of the decline in printed paper.

DISPOSAL

When planning an organics recovery facility, what we discard after existing management practices is a more important number than what is generated. If the 48.8 million tons of food and yard wastes we discard (29.2 percent of total discards), are added to the 8.8 million tons of non-recyclable paper products such as tissue papers and towels and paper plates and cups (5.3 percent of total discards), and the 6.94 million tons of wood packaging (5.64 percent of total discards), then 64.54 million tons, or 38.7 percent –

the largest portion of the waste stream - is organic. An additional 20.2 million tons of packaging and printed paper are currently disposed of but could be recovered by composting or anaerobic digestion. Add in those products and organics are half of the existing disposal stream.

Yet these national numbers have little relevance to local waste streams. EPA can reasonably estimate the size of the national municipal solid waste stream, as it has done for more than 40 years. In particular, EPA can estimate the amount of manufactured products, such as newspapers and corrugated boxes and wood packaging using production data reported to the Department of Commerce. Food and yard waste generation and disposal, however, are much harder to assess. EPA's waste characterization data for food waste, for instance, relies on sampling studies in different parts of the country and demographic data such as population trends, along with grocery store and restaurant sales and other factors for food waste. Generation of yard trimmings is also based on sampling studies. As a result, those numbers are softer than the production data.

Even state data can vary due to differences in how they define and account for different elements of their waste stream. Table 1 shows variance among ten states. Local data is likely to vary even more.

Area	Year	Food Waste	Compostable Paper	Yard Trimmings	Targeted Organics
Maine	2011	27.9%	7.9%	1.2%	37.0%
Vermont	2013	16.7%	6.2%	3.2%	26.1%
Massachusetts	2011	15.5%	7.0%	Not reported	NA
Connecticut	2010	13.7%	9.8%	10.7%	34.2%
Washington	2009	22.7%	5.0%	8.7%	36.4%
Wisconsin	2009	17.5%	7.2%	6.9%	31.6%
Oregon	2009	28.9%	3.8%	5.8%	38.5%
Delaware	2006	11.8%	6.9%	14.2%*	32.9%
Georgia	2005	13.4%	10.7%**	2.1%	26.2%
Pennsylvania	2003	12.2%	10.1%**	7.6%	29.9%
Average***		18.0%	6.7%	5.8%	32.5%
				Range	**26.2-38.5%**

**Includes brush.*

*** The reported number of "non-recyclable" paper, which may include non-compostable materials.*

****Average values are determined by category, consequently, the average % targeted organics does not equal the sum of the averages from each category*

Table 1: Organics Composition of Disposed Residential Waste from State Studies, Source: Ecomaine Organics Recycling Feasibility Study

Well-designed recovery facilities need accurate estimates of the current and projected amount of raw materials available locally, not national estimates. Accordingly, companies interested in collecting and processing organics should not rely on national or even state generation averages. Instead they should use data based on local waste sorts and characterization studies along with estimates of quantities and composition available from individual local generators including restaurants, grocery stores, etc.

Equally important to estimates of the size of available organic waste is the composition of that waste.

Yard Waste

EPA defines "yard trimmings" to include grass, leaves, and tree and brush trimmings from residential, institutional and commercial sources. The agency estimates that the average composition by weight is about 50 percent grass, 25 percent brush and 25 percent leaves. EPA also notes that those estimates will vary widely throughout the country depending on climate. Arizona, for instance, can be expected to generate less yard waste than Florida. Accurate data for local yard waste generation will include both the average composition along with data on seasonal variations in that composition.

According to EPA's most recent data, 34.2 million tons of yard trimmings were generated in 2013. Due to the widespread number of yard waste collection and composting facilities, less than half, or 13.6 million tons are landfilled. The success of grass-cycling programs in which mulching lawnmowers are used to leave grass clippings on the lawn and of back-yard compost piles for grass and leaves has reduced the amount of yard waste available for centralized composting or disposal.

Food Waste

Food waste is one of the larger contributors to disposal facilities. However, estimates of the amount we generate and dispose of vary widely, with most focusing on disposal. EPA estimates we dispose of 35.22 million tons food waste each year, or 95 percent of what we generate. Other numbers are considerably higher. The US Department of Agriculture estimates that 67 million tons of food goes uneaten. The Food and Agriculture Organization of the United Nations said that 103 million tons of food goes to waste in the United States. These estimates differ so much because food waste is not defined or measured in the same way by the three organizations.

Quantity

A recent study examined these estimates and concluded that 52.44 million tons of food goes to disposal in the United States in a year.[4] That study, "A Roadmap to Reduce U.S. Food Waste by 20%," was produced by ReFED, which calls itself a "collaboration of more than 30 business, nonprofit, foundation and government leaders committed to reducing food waste in the United States." Because of the thoroughness of the ReFED effort, this paper will use that and other data from the ReFED study to estimate the amount of available food waste, unless otherwise indicated.

Generators

Yard waste is primarily generated at homes. Food waste, however, is generated in a wide variety of locations. According to ReFED, the 52 million tons of food waste are generated almost equally by the residential and commercial sectors. Residences generate 26.56 million tons. Most of the other half is generated by restaurants (11.44 million tons) and supermarkets, grocery stores and distribution centers (7.97 million tons). Other generators include institutions such as universities, hospitals, etc. (4.9 million tons), industrial/manufacturing (1.07 million tons) and government – including prisons and the military – (0.489 million tons) (See Figure 1).

Each type of generator poses unique collection and education challenges in order to guarantee the collection of a feedstock that will meet the needs of a processor/end market. Commercially-generated food waste should pose fewer collection challenges due to the smaller number of businesses as compared to households and the larger amount of material produced by individual businesses. Nonetheless, both commercial and residential programs face severe challenges in educating (and re-educating) residents and staff on what to put in the food waste container. A clean food waste stream is essential to program success. Contaminants such as utensils, plates, containers and other non-food items have plagued composting facilities.

Beyond MSW-generated food waste, ReFED estimates that 95 percent of the 21 million tons of food waste generated by food manufacturing and processing companies is currently diverted from disposal. Most of that goes to animal feed or other products.

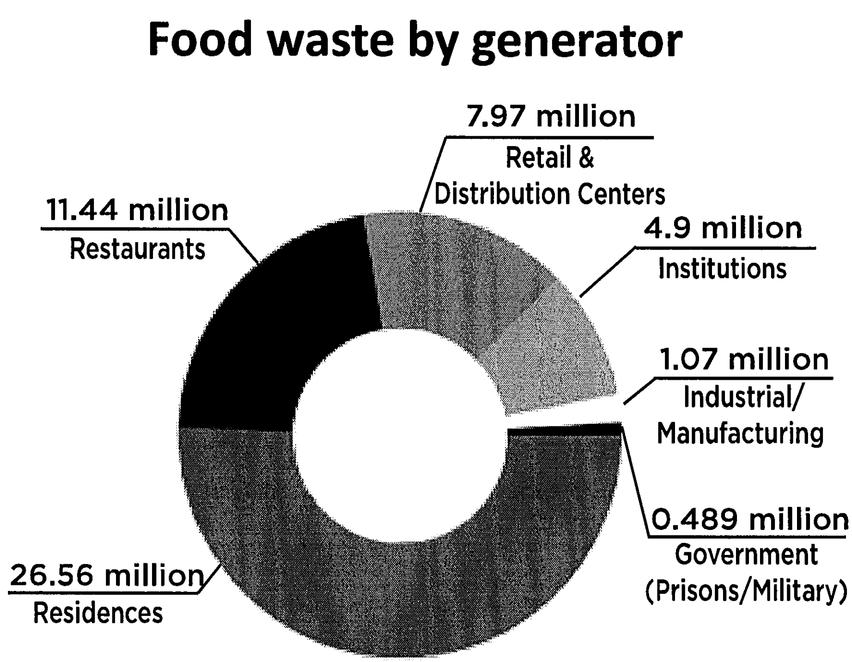

Figure 1 Source: ReFED

Composition

Food waste itself is composed of a wide variety of foods. ReFED divided food waste into five basic categories: fruits and vegetables, milk and dairy, grain products, meat, and seafood. Fruits and vegetables are by far the largest category, comprising 41 percent of food waste. In addition, milk and dairy comprise 26 percent, grain products 19 percent, meat 12 percent and seafood only 2 percent (see Figure 2).

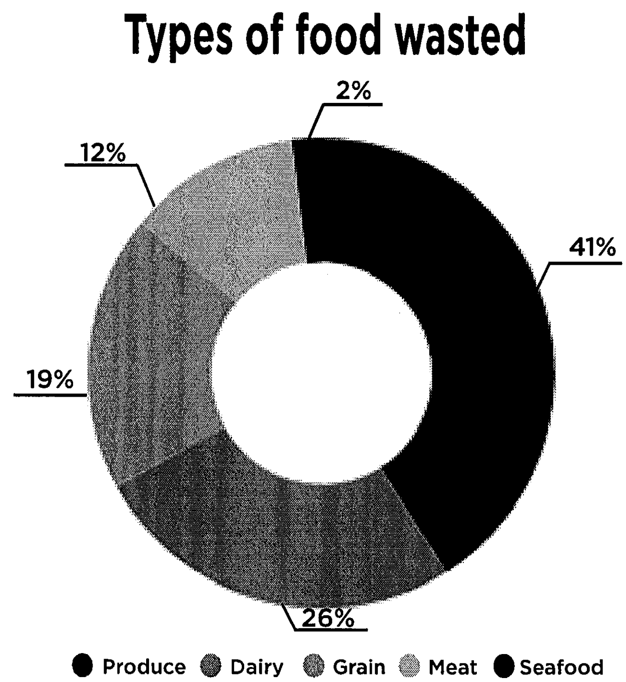

Figure 2 Source: ReFED

Almost 80 percent of this food waste comes from perishable foods that spoil easily. The non-perishable or less-perishable foods include pastas, canned goods, and highly-processed shelf stable products that do not spoil as easily. Obviously, perishable foods should be collected and processed before they begin rotting.

ReFED points out that retailers and consumers generate different percentages of those categories of food waste, with, for instance consumers generating a higher percentage of meat products than retail, but lower percentages of dairy and grain products (see Table 2).

Percentage of food waste by category

	Fruits & Vegetables	Milk & Dairy	Grain Products	Meat	Seafood
Retail	40.4	28.9	22.4	7.1	1.2
Consumer	43.4	22.9	16.0	15. 7	2.1

Table 2: ReFED Technical Appendix

FUTURE TRENDS IN GENERATION

Projecting the amount and type of food waste in the future from these different generators poses several problems. EPA's historical MSW data shows food waste increasing at a faster rate than population growth. However, that increase has progressively lessened over the last two decades. ReFED notes that the "biggest bang for the buck" in regard to food waste is preventing or reducing food waste before it needs to be managed. Prevention techniques include standardized "use by" dates on food products so that consumers don't throw away edible food; better consumer education on smart food shopping and storage; improved packaging to reduce food waste and to prevent food spoilage, etc.

Reduction techniques all center on improving our ability to get edible food to the hungry and to send food that is not edible for human cosumption to animals. Both strategies prevent food from needing to be managed as waste. EPA's "Food: Too Good to Waste Implementation Guide and Toolkit"[5] provides a good introduction into food waste reduction techniques. If the efforts teach Americans how to generate less food waste are successful, the amount of organics available for recovery will decrease, just as grasscycling and backyard composting decreased the amount of yard waste available for disposal. While this is a societal good, it could play havoc on facilities that overestimated the potential stream of available input.

"ReFED estimates that by 2020, 2.6 million tons of food waste can be eliminated annually through waste prevention programs and 1.1 million tons can be recovered through food donation and other programs."

In addition, other factors will lower the amount of organic material, food waste in particular, available for particular recovery options or for disposal. The ReFED report estimates that municipal water resource recovery facilities (also known as waste water treatment plants) with on-site anaerobic digestion facilities could divert an additional 1.6 million tons of food waste by 2026. In this situation, food is diverted from disposal either by truck collection from individul generators or by the use of in-sink food grinders (also known as "garbage disposal units") that are connected to the local sewer system. Milwaukee, Wisconsin, for instance has successfully operated such a facility for decades.

Commercial generators have other on-site options such as collection and delivery to facilities that will create an animal feed product or installing larger on-site grinders that create a slurry that is collected and delivered to an anaerobic digestion facility. Haulers have the opportunity to deliver the slurry produced by in-facility food waste grinders to these municipal facilities. As a result, predicting the amount of available food waste in the future will require estimating the impact of these kinds of on-site management techniques.

The tonnages estimated for waste prevention and recovery are harder to predict because they are so reliant on consumer behavior change. Nonetheless, these techniques can have an impact. Efforts to improve consumer understanding of "use by" and sell by dates on food packaging could reduce the amount of food waste by 8 percent. Similarly, better educating consumers on avoiding food waste along with smaller single serve food packaging and other reduction actions will clearly reduce the amount of food going to disposal. Successful expansion of food donation and other recovery options will also reduce the amount of food waste available for recycling. ReFED estimates that by 2020, 2.6 million tons of food waste can be eliminated annually through waste prevention programs and 1.1 million tons can be recovered through food donation and other programs. This leaves 6.7 million tons that will need to be managed by recovery through composting, anaerobic digestion or waste-water treatment facilities in order to meet ReFED's goal of a 20 percent reduction in food waste going to disposal.

Little data exists on actual results from these waste reduction efforts. Researchers in the United Kingdom claim that a program called "Love Food, Hate Waste" which focused on educating the public on how to create use less waste lead to 15 percent less being generated. Whether such a program would have similar success in this country is unknown. However, research on the impact of "aggressive" food waste prevention, reduction and recovery policies showed a clear reduction in landfill gas volume and landfill gas produced per ton of placed waste.[6]

As a result, companies interested in collecting or processing food wastes must exercise caution with regard to the amount of available raw material. But don't forget, even if we are successful in achieving the 20 percent reduction goal, a considerable amount of food waste and other organics will be going into disposal facilities many of which collect the methane gas produced by the decomposition of organics and turn that gas into an energy source.

ORGANICS LAW AND REGULATIONS

Yard waste

Twenty-four states ban or limit the disposal of yard waste.[7] Almost all of these laws were enacted in the 1990's during the wave of recycling-related legislation. The bans vary widely on what yard waste materials are banned from disposal. Most cover leaves, grass and brush, but some exclude brush. Most of the bans apply to landfills, while some also apply to waste-to-energy facilities. Five of those states do not apply the ban to disposal of yard waste in landfills with landfill gas recovery systems.[8]

State regulation of yard waste compost facilities is common regardless of whether or not a disposal ban exists in that state. Because these facilities do not manage putrescible or hazardous materials, these regulations are far less onerous and restrictive than those found for other waste management facilities.[9]

Food waste

Food waste recovery is subject to more recent legislation. In 2011, the state of Connecticut banned commercially-generated food from disposal.[10] The state of Vermont then enacted its "Universal Recycling" law.[11] The Green Mountain state law bans all food waste from disposal. Since then Rhode Island[12] passed similar legislation. In addition, Massachusetts[13] has adopted a regulatory system with the same purpose. California[14] enacted legislation in 2014 that requires recycling of organic waste that is generated by businesses and multi-family housing with five or more unites. That state defines organic waste as "food waste, green waste, landscape and pruning waste, non-hazardous wood waste and food-soiled paper mixed in with food waste. Because of the time lag in the legislation between enactment of the law and implementation of its provisions, the impact of these laws is still uncertain. Nonetheless, it is clear that they have increased interest in the use of on-site and off-site food waste management options.[15]

While the five states have not adopted identical provisions, they are similar in approach. Most apply to commercially generated, not residentially-generated, food waste. Most first require diversion from large generators of food waste and then scale down to smaller and smaller generators. The Vermont law, for instance, requires that generators of more than 104 tons per year, or 2 tons per week, begin diverting their food waste on July 1, 2014. For the following three years, the requirement ratchets down to 52 tons per year (July 1, 2015), 26 tons per year (July 1, 2016) and 18 tons per year in July, 2017. Finally, in July 2020, all food scraps, including those from households, must be diverted from disposal, with no exemption for distance.

These five states also generally require that a non-disposal option be available. In Vermont, for instance, the law only applies if a "certified" facility is within 20 miles of the generator. In Rhode Island, the diverted food waste must go to a composting or anaerobic digestion facility if one is within 15 miles of the generator. The generator can petition for an exemption if the recovery facility charges a higher tipping fee than that charged by the Rhode Island Resource Recovery Authority's landfill tipping fee for non-contract commercial waste. California's[14] law requires recycling but does not specifically ban disposal of organic waste.

Without composting or anaerobic digestion facilities to turn food waste into a product, laws and regulations to ensure that food waste be diverted from disposal have limited value. Because food waste is putrescible it can attract vectors such as flies and rats. Food waste management facilities also produce water and other emissions. As a result, they are subject to a variety of regulations. The U.S. Composting Council has created a model legislative template.[16] A number of states have vigorous regulatory regimes.[17] The state of Maryland, for instance, does not require food waste diversion. Nonetheless, in response to local governments with food waste recovery programs and businesses seeking certainty in operating requirments, the state recently promulgated requirements for food waste composting facilities.[18] These new regulations create three "tiers" of facilities with differing requirements depending on the nature of materials being handled and the size and throughput of each facility. The U.S. Composting Council has created a web listing of all state regulatory, permitting and legislative requirements with links to relevant state web sites.[19]

CURRENT ORGANICS MANAGEMENT TECHNIQUES: TECHNOLOGY DESCRIPTION AND ASSESSMENT

The two primary methods for managing source separated food waste are composting and anaerobic digestion. Composting can be further differentiated by windrow or aerated piles. Anaerobic digestion can be differentiated by wet or dry. Both methods can be utilized by themselves or with other feedstocks. These other feedstocks are most often yard waste but can also include biosolids and agricultural wastes. Other food waste management technologies exist but are not commonly found in commercial scale operation. These could include liquefaction, gasification or briquetting among others. Both composting and anaerobic digestion can be done viably at very small scales.

Composting

Composting is a process that aerobically (with oxygen) decomposes organic material. Aerobic decomposition is a faster process than anaerobic decomposition. In nature, biodegradation occurs primarily by aerobic microorganisms. Ideally, the complete aerobic decomposition of organic materials results in carbon dioxide (CO_2), water (H_2O) and the composted material which can be used as a soil amendment. Depending on the size and type of composting employed, composting can take anywhere from two weeks to several months for the active composting. The final product may require additional curing for another 30 days.

Composting can be as simple as backyard composting or as complex as in-vessel composting. The methods employed generally try to optimize the feedstock material for carbon to nitrogen ratio, particle size, porosity in order to achieve the best results. Most commercial applications utilize windrows or aerated piles.

Windrow composting places the organic materials, usually yard waste, into long piles. The windrows are turned occasionally to ensure that the oxygen can get into the pile to maintain an aerobic state. This method is suited for large volumes of organics, including yard waste, food waste, and agricultural waste. The opeator needs to ensure that the pile is composed of the appropriate mix of carbon and nitrogen rich materials and monitor the moisture and temperature. Windrows that are not turned frequently can expect odor problems.

Aerated piles composting use static piles that can be actively or passively aerated. These piles can be indoors or outdoors and they can be covered or uncovered. Because the compost is not turned until it is ready for curing, the labor and equipment can be less time-consuming. However, like the windrow copostting, the operators need to monitor moisture and temperature, in particular because the aeration can dry the material out quickly. Capital costs for aerated piles will be a little higher than for windrow composting.

Anaerobic digestion

Although nature primarily uses aerobic decomposition, anaerobic decomposition occurs naturally in areas with low-oxygen, such as wetlands. Anaerobic digestion is a process that anaerobically (without oxygen) decomposes organic material. Anaerobic digestion is used at wastewater treatment plants and is the primary decomposition process occurring in landfills. Increasingly, livestock farms are using anaerobic digestion to mitigate environmental impacts from manure lagoons.

The anaerobic digestion process has four phases: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Anaerobic microorganisms degrade the organic matter in the absence of oxygen and ultimate products are carbon dioxide and methane (CH4). Lignin, found in woody biomass, degrades very slowly under anaerobic conditions.

1. Hydrolysis - Large organic polymers such as protein macromolecules, fats and carbohydrates such as cellulose and starch are broken down into amino acids, fatty acids, and simple sugars

2. Acidogenesis - These products are fermented to form volatile fatty acids, such as lactic, butyric, propionic and valeric acids. Ammonia, carbon dioxide and hydrogen sulfide are also formed during this stage.

3. Acetogenesis – Acetogens (bacteria that produce acetic acids) consume these fermented acids to form acetic acid, carbon dioxide and hydrogen.

4. Methanogenesis – Methanogens (bacteria that produce methane) consume products from the previous stages to produce methane. The methane is generally recovered for use as a fuel source.

5. Digestate – Materials that remain undigested along with dead microorganisms.

This material can be land applied as a soil amendment, composted or landfilled. The most common anaerobic digestion technologies are as follows:

- One-stage continuous systems
  - o Low solids or “wet”
  - o High solids or “dry”
- Two-stage continuous systems
  - o Dry-wet
  - o Wet-wet
- Batch systems
  - o One stage
  - o Two stage

Single stage digesters are simple to design, build and operate and generally less expensive. The load rate is limited because methanogens operate best at a pH near neutral. Acid production from earlier phases would lower the pH which could inhibit the methanogens slowing the anaerobic digestion process. The two stage digesters separate the acid-producing phase from the methanogenesis allowing higher load rates. However, the two stage systems require additional reactors and handling systems. Temperature is also a key operand. The selected operating range, mesophilic or thermophilic, will be suitable for different species of microorganisms.

Another major design consideration is the solids concentration. High solids systems are known as dry systems where low solids systems are known as wet systems. Feedstock with less than 15% solids are considered wet. Dry systems usually operate between 15 and 20% solids or greater. Food waste contains 25 – 50% solids. The transport of wet feedstock can be conducted using pumps and piping whereas dry feedstock will use conveyors and loaders.

An advantage of wet systems is that the feedstock can easily be mixed and homogenized. Wet systems can take a wider array of organics. The organics collection program in Toronto, Canada, includes items such as diapers and cat litter that cannot be processed in dry systems. Wet systems are also more expensive. In addition, since MSW organics tends to have toxic or other inhibitory compounds more frequently, this can become a disadvantage as well.

Last, anaerobic digestion can be configured as either a continuous system or as a batch system. A batch system is placed into the reactor vessels as a batch and once digested, removed and replaced with a new batch. Continuous systems allow materials to be continuously loaded at a controlled rate. Batch systems can be set up in parallel so that multiple batches can be scheduled resulting in an apparent continuous system.

LANDFILL GAS RECOVERY

In addition to the organics recovery activities described above, disposal of organics at landfills or waste-to-energy facilities does not mean the ability to beneficially use those materials has come to an end. Currently 648 landfill gas recovery projects are in operation at 600 active or closed landfills in the United States. Because organic waste decomposes in landfills, creating methane gas, these landfills have installed systems to capture that gas and turn it into an energy project. These existing projects currently reduce the energy used by 4.1 million homes. The U.S. EPA's Landfill Methane Outreach Program estimates that 400 additional landfills could cost-effectively turn methane into energy.[20]

INFASTRUCTURE

Collection

Residential collection

Yard waste collection is widespread throughout the United States. These programs may collect yard waste seasonally or year round. Collected yard waste is usually mulched or composted.

Food waste collection is far less commonplace. Developing the infrastructure to manage food waste organics can be a challenge. Food and other organics can be added to existing yard waste collection. This will be difficult in areas without year round yard waste collection. As with other recyclables, multi-family housing also poses a problem for food waste recovery.

According to BioCycle National Surveys, six municipal waste composting projects were operateing in

1995. By 2005, the number had barely budged. At the same time, the number of private facilities grew from eighteen to about 50 in 2005. Since 2005, curb side collection of food waste has started to increase. The number of households with source separated organic food waste collection grew almost fivefold through 2014, from just over half a million households to 2.74 million households. Leading the way was California with almost half the total, followed by Washington and Oregon with another 30%.

> "Since 2005, curbside collection of food waste has started to increase. The number of households with source separated organic food waste collection grew almost fivefold through 2014, from just over half a million households to 2.74 million households."

Commercial collection

For some companies, managing organic wastes is simply part of doing business. Yard waste management companies generally manage yard waste without issue. Similarly, manufacturers that produce food wastes can effectively manage their waste streams to avoid disposal. As noted above, ReFED estimates that food processing facilities now send 95% of their food waste to recovery operations that convert it into animal feed or other products. Food waste can also be managed at on-site digestion or composting facilities.

These food processing plants have an advantage compared to the retail and restaurant industry. The contents of their food waste are easily predictable. Grocery stores and restaurants and other "consumer-facing" businesses have a much greater challenge in managing their food waste. The type of food waste they generate will vary widely and they are not as likely to generate as much material as a food processing facility. As a result, these businesses are focusing on reducing the quantity of food waste generated and increasing donations of edible food to food banks. They will also look for composting and anaerobic digestion options to divert food waste from the landfill. If processing capacity exists, the business will work with haulers to ensure collection appropriate to their business needs. This may include more frequent collection or refrigerating the food waste until the waste is picked up to avoid odors and attracting vectors.

Processing capacity

As discussed in the technology chapter, the two most common ways of managing organics are through composting or by anaerobic digestion. While other technologies are being pursued, those endeavors have not yet resulted in commercial scale facilities.

Composting

Yard waste composting took off in the 1990's with the advent of disposal bans and the rise of curbside collection of those materials. As a result, most of the earlier composting facilities primarily managed yard waste. That is no longer the case today. A recent study revealed 3,494 composting facilities operating in the United States in 2013.[21] Yard waste was 56.7 percent of the feedstock for these facilities, followed by food waste (12.2 percent) and wood waste (10.1 percent). Non-MSW provided 18.4 percent of feedstock, consisting of wastewater treatment facility biosolids, manures, agricultural residues, and organic industrial streams such as pulp/paper waste. An earlier survey[22] also noted the existence of on-site composting at 337 institutions, agricultural composting at 400 facilities and biosolids at 238 facilities.

Both studies reported similar ammounts of composting. The more recent study estimated 21 million tons of organics were composted in 2013. Most of the composting facilities are small, processing less than 5,000 tons per year. The average tons per facility was 6,098 per year.[23] This represents a five percent increase from the earlier study. Clearly, as the interest in organics spreads, we will see larger, regional facilities designed to handle a wider variety of materials.

Anaerobic digestion

Anaerobic digestion can be standalone facilities designed to manage organics diverted from the landfill, or co-digestion facilities that include co-digestion with agricultural waste or with biosolids. According to a recent report, 154 anaerobic digestion facilities were operating in 2013. Of those, only 25 are standalone facilities. Another 75 are co-digestion with agricultural waste facilities and the remaining 54 are co-digestion with biosolids facilities.[24]

As of 2013, standalone facilities account for managing 52% of the diverted organics for a total about 412,000 tons. By 2017, the standalone capacity is estimated to increase to about 2.4 million tons. Clearly the existing infrastructure is too small to manage this country's organics waste stream. The state of California, which has an aggressive organics recovery goal, estimates it needs 245 new composting or anaerobic digestion facilities to meet those goals.

INCENTIVES AND BARRIERS TO INCREASING ORGANICS RECOVERY

Costs

Nothing is free, at least not when it comes to waste and recycling services. Managing organics is no different. Unfortunately little operating cost data is publicly available. Nonetheless, it is known that the cost of collecting and composting yard and food waste is low comparing to the more capital-intensive cost of anaerobic digestion.

Collection

Source separated organics, especially food waste, are far more challenging to collect than "traditional" recyclables such as paper, cans and bottles. Food waste has a moisture content of 35-40 percent[25] whereas traditional recyclables are low in moisture content. This high moisture content creates collection problems both in terms of getting the food waste into and in managing it in the collection truck. Carts full of food waste can be heavy (370 pounds per cart, according to one recent pilot project).[26] The moisture content requires trucks that can manage leaks and handle frozen water in the winter. Commercial collectors may ultimately use smaller carts for individual generators such as restaurants or larger detachable containers that can be dumped into a truck or switched out full for empty replacement containers.

Operating costs for residential organics collection are difficult to obtain. In part this is due to the limited number and relative newness of these programs. In addition, if food waste is commingled with existing yard waste collection, the incremental costs might be low unless they lead to the need for additional trucks on the route. Food waste collection has led some west coast communities to switch to every other week collection of garbage, with subsequent savings in waste management costs. Due to odor concerns, it is advisable to maintain weekly organics collection.

A study of existing organics curbside collection programs throughout the United States found collection of between 25 – 30 pounds per week per household. Food waste comprised 7 – 9 pounds per week, or a little less than a third of the total. The average collection cost was $5.40 per month per household for residential organics collection. The report noted that organics collection was a third of the total cost of trash collection in those communities.[27]

In 2012, SAIC[28] analyzed hypothetical residential organics collection for three municipalities in Georgia. Two of the municipalities planned to collect organics separately from yard waste at the curb. The third municipality proposed drop-off locations. The report identifies the cost of collection, including personnel, equipment, O&M, fuel costs and processing and anticipates savings from disposal but neglects any potential revenue from the sale of final product. The final costs for collecting and managing source separated organics ranged from $482/ton for the drop-off program to $2,103/ton for the more expensive curbside program. The collection costs represented the bulk of the costs.

The City of Cambridge's Phase 1 Report[29] on curbside collection from residents includes a high estimate from a hauler for year-round citywide food collection from households that already receive trash service from the haulers. The estimate included hauling to a facility further away due to its ability to tolerate higher levels of contamination. The estimate came out to $935,502 for about 8 tons per day. Assuming collection is 6 days per week, the cost per ton is $374.

Seattle, Washington, provides another indicator of the extra cost of managing food and yard waste. That city is one of the pioneers of "pay-as-you-throw" systems in which households are charged garbage fees based on the amount of waste placed on the curbside for disposal. In those programs, higher fees are charged to larger garbage carts and recycling is "free". The idea is to use this economic incentive to increase recycling. Yet the city charges a separate fee for the container used in its mandatory food and yard waste collection program. The fee ranges from $5.45 per month for a 13-gallon "mini" can to $10.50 for a 96-gallon cart.[30]

Operating costs for commercial collection were not obtained for this study.

Processing

Estimating processing costs is challenging due to a lack of published materials. Ontario's Waste Diversion Organization performed a study[31] of three different facility options in 2001. They estimated that the average annual gross processing costs including capital costs would be somewhere between $60CAD and $90 CAD per metric ton. In one study,[32] the authors reviewed costs and revenues for building and operating these facilities in Canada and Spain. The net cost per ton ranged from $130-$185/ton in Canada to a range of $226-$531/ton in Spain.

As can be seen, estimates vary. To aid in estimating these costs, SCS Engineers prepared a "pro forma model" for the costs of building an aerobic digestion facility.[33] For a small, 5,000 ton per year facility, SCS estimated costs of $2.5 million dollars in capital costs along with annual operating costs of 3% of capital costs. See Tables 3 and 4 for the estimated costs and the assumptions behind those costs.

Item	Cost ($)
Digester Components (Leachate collection slab, gas collection bag, heating elements, gas piping, etc.)	1,000,000
Building Superstructure	575,000
Engine Generator Set	200,000
Improved Base for Foundation	200,000
Mixing Platform	100,000
Biofilters	100,000
Food Storage Pad	50,000
Electrical Interconnection	75,000
Design, Permitting Support and Fees	50,000
Contingency	100,000
Total	**2,450,000**

Table 3: Conceptual Aerobic Digestion facility costs estimate (5,000 TPY Capacity)

Variable	Value	Comments
Base Year	2014	Costs estimates were made in current 2014 dollars and escalated based on the inflation factor identified below.
Inflation Rate- Annual Escalation (for Energy, Labor, and Waste Collection)	2%	Based on recent Federal Reserve Board guidance
Organic Waste Received (Tons Per Year)	5,000	Based on model developed by ZWS
Annual Operating Costs ($)	3% of Capital	Estimated from information provided from AD developers
Annual Capital Repair and Replacement	1% of Initial Capital	Estimated from information provided from AD developers
Financing Cost	Interest Rate: 3.35% Term (Years): 20	Agency borrowing costs
Tipping Fees	$35.00 per ton	Assumed
Energy Sales Prices	$0.1044 per kilowatt hour	Assumed retail purchase price
Sale of Digestate	$0.00 per ton	Wholesome compost rates

Table 4: General assumptions for Pro Forma Model

The pro forma model estimated needed tipping fees of $35 per ton. The SCS model predicted a dramatic decline in estimated tipping fees with higher tonnage and an even more dramatic decline if electricity were produced by the AD facility (see Table 5).

Scenario	Tonnage	Electricity Production	Required Tipping Fee Range
1	5,000	None	$45.92-$53.16
2	5,000	203 Kwh/ton @ $0.1044 used onsite	$8.76-$31.97
3	10,000	None	$40.73-$48.33
4	10,000	203 Kwh/ton @ $0.1044 used onsite	$3.57-$27.34

Table 5: Aerobic Digestion Model Results

Data from the Monterey Regional Waste Management District, which operates a 65 ton per day "dry" anaerobic digester shows a further breakdown in tipping fees for yard and food waste (see Table 6).[34]

2015 SmartFerm Actual Operational Performance

Item	Monthly Tons	Annual Tons	Tip Fee	Monthly Cost	Annual Cost
Green Waste	141	1,693	$29.50	$4,162	$49,444
Food Waste	335	4,020	$44.00	$14,740	$176,880
TOTAL Annual Operating Cost		**5,713**		**$18,902**	**$226,824**
District annual operating cost per ton					**$40**
Electricity Production				**$Monthly**	**$Annually**
Electricity Sales				$4,392	$52,698
Electricity Revenue per ton					$9.22

Average tons per digester:	65.2
Average food waste tons received per day:	13
Average weekly operator labor hours:	46
Average kWh Production/Hour	64.3
Average methane % (Ch4)	55.8%

Digestate Data Moisture Content -- 64%, Organic Material Content -- 83%
N=1.2, P=.21, K=.31
No Pathogens, No Trace Metal
Capital Cost, including design, engineering, constructions and commissioning: $2.9 million

Table 6: Monterey Regional Waste Management District tipping fee breakdown

The revenue side of the equation is equally challenging. A compost facility's final product is a relatively low value,[35] as is the digestate from anaerobic digestion. In addition, the energy produced by those facilities has to compete with other energy sources. Current energy prices create an additional obstacle. As a result, tipping fees are usually charged by both kinds of facilities as an additional revenue source. The Monterrey Waste Management District, for instance, charges a green waste tip fee of $23.50 per ton and a food waste tip fee of $38.00 per ton. A tipping fee should be equal or lower than available disposal tipping fees.

INCENTIVES

Market development is a key challenge for organics products. To help, the federal government and some states offer incentives for the use of recovered organics. These include procurement requirements such as those designed by the US EPA for compost and fertilizers made from recovered organics materials as well as landscaping or facilities maintenance services that include the supply or use of compost or fertilizers.[36] Many states have similar requirements giving procurement preference for these products. Thirteen states strengthen those requirements by mandating the use of Certified Compost with the Seal of Testing Assurance created by the U.S. Composting Council to improve compost quality and marketability.[37]

Incentives for the use of energy produced at anaerobic digestion facilities are also available from a variety of sources. Renewable Portfolios Standards require utilities to sell a specified percentage or amount of renewable electricity. Twenty-nine states and Washington, D.C., have adopted a Renewable Portfolio Standard, many of which include the use of biofuels generated by anaerobic digestion facilities.[38] Other incentives such as production or investment tax credits, potential funding from EPA's Global Methane Initiative, DOE's Qualified Energy Conservation bonds and the USDA's Advanced Biofuel Payment Program are available to anaerobic digestion projects. In addition, many states have grant or incentive programs such as CalRecycle's grant program and Connecticut's Green Bank. The American Biogas Council has 25 state profiles on its web site that includes links to funding opportunities within those states.

OTHER BARRIERS

Organics, especially food waste, can be messy. Unlike the dry elements of the waste stream such as newspapers, bottles and cans, organics are usually wet and have a highly heterogeneous mixture of different kinds of materials with varying levels of suitability for composting or anaerobic digestion. In addition, because of their very nature, organics, especially food waste left untended, will start to rot, or decompose, on its own. This process produces a smell that can be nauseating and that attracts rats and other vectors. As a result, food waste must be managed quickly to avoid premature decomposition. One of the most common concerns raised about residential food waste programs is the "yuck" factor caused by the potential for food to rot before it is collected. A pilot food waste collection project in Alexandria, Virginia, noted that traditional recyclables are products designed to look appealing and to produce positive mental images with consumers. In contrast, food waste is not visually appealing and has a negative connotation because it smells.[39] Potential odor problems must be minimized when collecting or processing food waste. More than one promising facility has failed or been forced to add additional odor control technologies when it antagonized neighbors through uncontrolled odors.

Contamination of the organics stream with plastic, glass, or other non-organics, is also a severe challenge for most facilities. Successful recycling including organics recovery, requires behavior change.

What was once put in a garbage can is now placed in a recycling or organics bin. While recycling programs have made strides in changing behavior, even the best programs are struggling with ensuring that people only put recyclables in those bins. Changing behavior to ensure that people will not only use organics bins but will use those correctly is even harder than that required for recycling.

In many cases, food waste will be collected in homes that use small plastic bags placed inside of plastic bins underneath the kitchen sink. These bags can be collected at the same time and mixed with yard waste. In this case, the processing facility must have debagging equipment to remove the plastic bags. Some of those bags are compostable. The city of Seattle recently passed an ordinance requiring that produce bags be compostable to enhance their processing the city food waste collection program.

Employee turnover at businesses such as restaurants and groceries also poses a constant training effort for commercial programs. The closure of the Wilmington, Delaware, food waste composting facility was caused in part by the failure of generators to keep non-organics out of the food waste sent to the facility.

Siting new organics facilities is also challenging. In spite of the need for composting and anaerobic digestion facilities, the usual Not In My Back Yard reaction inevitably kicks in during the siting process. More than one proposed facility did not get built due to local opposition.

Whether food waste will be managed through composting or anaerobic digestion or other processes, the food waste must be collected. Then it must be processed at facilities permitted to handle those materials. Regardless of who set the goal, all the goals for organics recovery – including the EPA/USDA goal of 50% food waste reduction by 2030 – require a massive new infrastructure and considerable effort on educating consumers on how to avoid creating organics waste, food waste in particular, and then how to best manage it.

CONCLUSION

Increased emphasis on managing organics from other municipal solid wastes is inevitable as states continue to look for ways to increase diversion of materials from disposal. Organics clearly offer the most promise and the biggest challenges to increase diversion. Most likely new organics management laws will be enacted in states with high recycling rates. However, organics recovery faces more daunting challenges than those faced by materials recycling when it took off in the late 80's. Organics recovery can achieve the same success as materials recycling only if they are based on solid forecasts of available materials, thorough and ongoing training and retraining of generators, collection crews and facility staff and dedication to controlling odors and any other operational problems at recovery facilities.

FOR FURTHER INFORMATION

American Biogas Council https://www.americanbiogascouncil.org/

Biocycle Magazine https://www.biocycle.net/

Composting News: http://www.compostingnews.com

Environmental Research and Education Foundation: https://erefdn.org/

- Anaerobic Digestion of Municipal Solid Waste, 2016
- Municipal Solid Waste Management in the U.S. 2010 & 2013, Environmental Research and Education Foundation, 2016

Food Waste Reduction Alliance: http://www.foodwastealliance.org/

ReFED: A Roadmap to Reduce U.S. Food Waste by 20%, March 2016 https://www.refed.com U.S. Composting Council http://composting
council.org/

USEPA: https://www3.epa.gov

- Advancing Sustainable Materials Management: Facts and Figures 2013, U.S. Environmental Protection Agency (USEPA), EPA530-R-15-002, June 2015
- Best Management Practices in Food Scraps Programs, USEPA Region 5, 2011
- Food: Too Good to Waste Implementation Guide and Toolkit EPA530-F-16-014-A, February 2016
- National Source Reduction Characterization Report for Municipal Solid Waste in the United States, USEPA, EPA530-R-99-034, November 1999

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1. Advancing Sustainable Materials Management: Facts and Figures 2013, U.S. Environmental Protection Agency (USEPA), EPA530-R-15-002, June 2015 (unless otherwise noted, organics generation, recovery and disposal data are derived from this USEPA report).

2. National Source Reduction Characterization Report for Municipal Solid Waste in the United States, USEPA, EPA530-R-99-034, November 1999

3. See http://www.usda.gov/oce/foodwaste/

4. A Roadmap to Reduce U.S. Food Waste by 20%, ReFED

5. https://www.epa.gov/sustainable-management-food/food-too-good-waste-implementation-guide-and-toolkit. Also see https://www.epa.gov/sites/production/files/2016-10/documents/final_intro_and_new_tool_kit_keeping_food_out_of_landfills.pdf for a webinar and slides with specific information on edible food donation tax deductions.

6. "Trends in Beneficial Use of Landfill Gas & Potential Impacts of Organics Diversion", Environmental Research & Education Foundation, 2016

7. These states are Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, South Dakota, Vermont, West Virginia, and Wisconsin.

8. Those states are Arkansas, Florida, Georgia, Iowa and North Carolina.

9. The U.S. Composting Council maintains a complete list of state regulations at http://compostingcouncil.org/state-compost-regula tions-map

10. http://www.ct.gov/deep/cwp/view.asp?a=2718&q=552676&deepNav_GID=1645

11. http://dec.vermont.gov/sites/dec/files/wmp/SolidWaste/Documents/Universal-Recycling/UR_SummarySheet_CURRENT.pdf

12. http://www.rilin.state.ri.us/pressrelease/_layouts/RIL.PressRelease.ListStructure/Forms/DisplayForm.aspx?List 8baae31-3c10-431c-8dcd-9dbbe21ce3e9&ID=10038

13. http://www.mass.gov/eea/agencies/massdep/recycle/reduce/food-waste-ban.html

14. http://www.calrecycle.ca.gov/recycle/commercial/organics/

15. The EPA webinar cited in footnote 5 also has an analysis of these food waste laws at https://www.epa.gov/sites/production/files/2016-10/documents/final_intro_and_new_tool_kit_keeping_food_out_of_landfills.pdf

16. http://compostingcouncil.org/wp/wp-content/plugins/wp-pdfupload/pdf/14798/US-Composting-Council-Model-Compost-Rule-Tem plate-v1.pdf

17. See for instance, California, Maryland, Minnesota, Ohio, Oregon, Washington and Wisconsin.

18. http://mde.maryland.gov/programs/Land/RecyclingandOperationsprogram/SpecialProjects/Pages/Programs/LandPrograms/Recycling/specialprojects/composting.aspx

19. http://compostingcouncil.org/state-compost-regulations-map/

20. For more information about landfill gas recovery see https://www3.epa.gov/lmop/basic-info/index.html.

21. "Municipal Solid Waste Management in the U.S. 2010 & 2013", Environmental Research and Education Foundation, 2016 ("EREF")

22. "The State of Composting in the U.S." Institute for Local Self-Reliance, 2014, "(ILSR")

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23. "Municipal Solid Waste Management in the U.S. 2010 & 2013", Environmental Research and Education Foundation, 2016 ("EREF")

24. Anaerobic Digestion of Municipal Solid Waste, Environmental Research and Education Foundation, 2016

25. "Testing a New Service: Curbside Food Waste Collection", presentation to Washington Metro Council of Governments Recycling Task Force, September 22, 2016, Michael Clem, Resource Recovery Division, City of Alexandria, Virginia

26. "Testing a New Service: Curbside Food Waste Collection", presentation to Washington Metro Council of Governments Recycling Task Force, September 22, 2016, Michael Clem, Resource Recovery Division, City of Alexandria, Virginia

27. Best Management Practices in Food Scraps Programs, Econservation Institute for U.S. EPA Region 5, 201420

28. Residential Source Separated Organics Collection Tool Kit, June 2012

29. Curbside Organics Collection from Residents, Phase 1 Report, City of Cambridge Department of Public Works, Winter 2012.

30. Seattle Public Utilities, "Rates Food and Yard Waste Cart" http://www.seattle.gov/UTIL/MyServices/FoodYard/HouseResidents/Rates/index.htm accessed June 27 2016.

31. WDO Study: Implications of Different Waste Feed Streams (Source-Separated Organics and Mixed Waste) on Collection Options and Anaerobic Digestion Processing Facility Design, Equipment and Costs, December 2001.

32. Arsova, Ljupka. "Anaerobic Digestion of Food Waste: Current Status, Problems and an Alternative product,May 2010, http://www.seas.columbia.edu/earth/wtert/sofos/arsova_thesis.pdf

33. "Anaerobic Digestion – What Are the Economics?" Rogoff and Clark, Waste Advantage Magazine, July 2014 https://wasteadvantagemag.com/anaerobic-digestion-economics/

34. "Operational Overview of MRWMD SmartFerm "Dry" Anaerobic Digester", Jeff Lilienthal, August, 2016

35. For a price sheet on compost products see "Composting News" at http://www.compostingnews.com/

36. See https://www.regulations.gov/document?D=EPA-HQ-RCRA-2003-0006-0005 and https://www.epa.gov/smm/comprehensive-procurement-guidelines-landscaping-products

37. Those states are Arkansas, California, Colorado, Florida, Iowa, Minnesota, New York, North Carolina, Oregon, South Carolina, Texas, Washington and Wisconsin.

38. See http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx for a list of state renewable portfolio standards and goals.

39. "Testing a New Service: Curbside Food Waste Collection", presentation to Washington Metro Council of Governments Recycling Task Force, September 22, 2016, Michael Clem, Resource Recovery Division, City of Alexandria, Virginia