# Food Waste to Energy: Community Responses and the Potential for Anaerobic Digestion in Madison


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## Abstract

Over-consumption coupled with limited landfill capacity necessitates consideration of alternative waste management strategies, such as anaerobic digestion of organic waste. We investigate the potential of anaerobic digestion in Madison considering the economic, environmental, and social dimensions, as well as the community's responses to organics recycling efforts. Because the success of a household collection program hinges on community participation, our research centers on participant perceptions of the city's Organics Collection Pilot Program. Our research suggests that participants have an overwhelmingly positive opinion of the program with minor suggestions for improvement. Based on these responses, we develop a set of recommendations to address problems as the program expands. These recommendations prioritize improving education and maximizing convenience for participants, while bearing in mind the normative nature of recycling behavior. The results of this study indicate that, with a few minor improvements to the household organics collection program, anaerobic digestion is a promising waste management strategy for Madison.

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## Introduction

*The Waste Problem*

Excessive waste production is a global problem that is exacerbated by growing populations and increasing rates of consumption. In 2012, the average American produced 4.38 pounds of waste per day, approximately one fifth of which was food waste (US EPA 2014, 1). In the United States, 34 million tons of food waste is sent to landfills annually, making it the single largest component of waste disposed in landfills (Franchetti 2013, 42). Identifying alternative ways to dispose of this organic waste will help take pressure off of landfills that are reaching capacity.

When organic waste decomposes in landfills, methane produced through decomposition is released into the atmosphere. All active landfills in the United States are required to have gas collection systems in place, however the EPA estimates that 25 percent of methane produced in landfills inadvertently escapes. In 2002, this leakage represented 3 percent of total greenhouse gas emissions in the United States (DiStefano and Belenky 2009, 1097). Because methane is a highly potent greenhouse gas, this has significant implications for climate change.

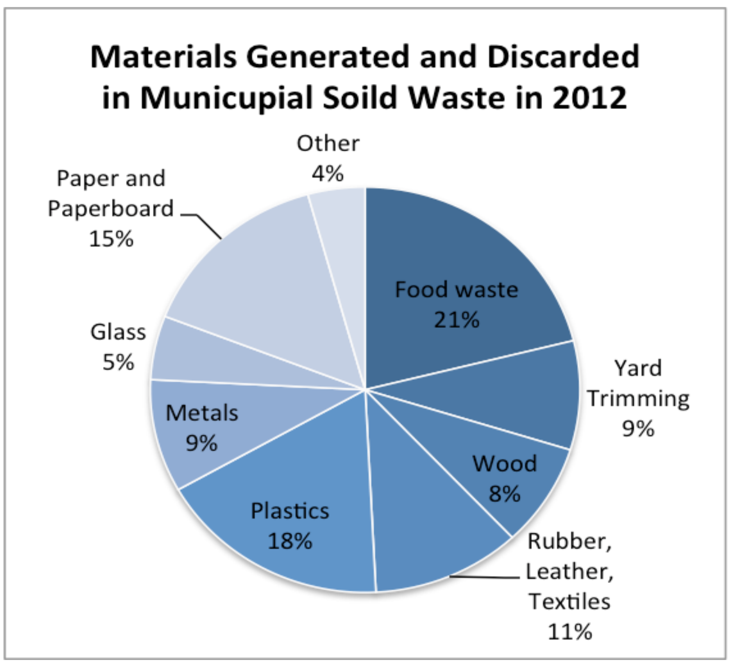


***Figure 1*** *Municipal Solid Waste in the United States (Source: EPA Municipal Solid Waste Generation, Recycling and Disposal in the United States: Tables and Figure for 2012, 2014)*

However, there is reason to be optimistic about the United States' waste problem because municipal solid waste recovery rates have been increasing in recent years. In the 1980s, only 10 percent of municipal solid waste was recovered through recycling. This percentage rose to over 34 percent by 2012 (US EPA 2014, 2). Most of these observed reductions are attributable to increased recycling rather than composting, and thus most organic waste is still not recovered. With the emergence of new technologies in food waste recycling, there is potential to significantly reduce the amount of waste directed to landfills.

We intend to address the potential of one solution to the waste problem, anaerobic digestion of organic materials, within the context of Madison, Wisconsin. Because Madison's organics collection program is primarily focused on household collection, the community's response to organics recycling will be instrumental in determining the program's success. Using experiences of participants in the city's organics recycling pilot program, we will investigate the following question: How do community responses to the Organics Collection Pilot Program shape the potential for anaerobic digestion in Madison?

*Anaerobic Digestion as a Solution*

Anaerobic digestion (AD) represents one solution to the waste problem. It is a biological process in which organic material is broken down by microorganisms in the absence of oxygen inside of a biodigester (Figure 2). In addition to its value as a landfill diversion option, AD may also ameliorate greenhouse gas emissions. Because anaerobic digesters are generally sealed facilities, AD does not have the same issues of methane leakage that are associated with landfills. Finally, AD is a promising form of renewable energy as we move away from our dependence on fossil fuels.

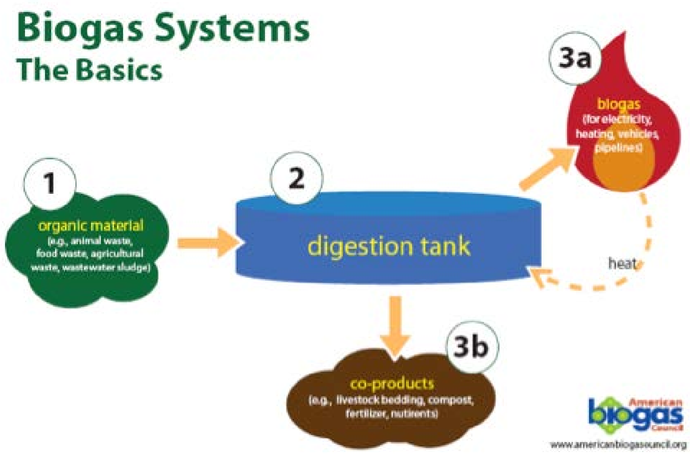


***Figure 2*** *The Anaerobic Digestion System (Source: American Biogas Council)*

The AD process consists of hydrolysis, acidogenesis, and finally methanogenesis. Hydrolysis breaks the organic matter (lipids, carbohydrates, and proteins) into smaller molecular materials and soluble organic substrates. In acidogenesis, these substances are degraded into compounds and elements such as volatile fatty acids, and finally into acetate, $H_2$, and $CO_2$ that are used for methanogenesis (i.e. the production of methane) (Zhang et al 2014, 384). The primary outputs are biogas, predominantly consisting of methane and carbon dioxide, and a nutrient-rich solid mass. This biogas can be used as an energy source either by generating heat and electricity in a process called combined heat and power (CHP), or it can be further processed into compressed natural gas (CNG), which can be used to fuel vehicles. The remaining solid mass also has productive applications as a compost additive and fertilizer (Brian Langolf, Interview, 10/13/14).

Different technologies are designed to handle specific feedstocks. There are many types of potential input streams, including food waste, agricultural waste, manure, and yard waste. There are two types of AD systems, wet and dry. Wet digestion is primarily used for manure and waste water treatment. This technology can only process materials with high liquid content (materials with 8-12 percent solids) and is constantly mixed. Dry digestion functions for substrates with at least 25 percent solid content, making it more suitable for food waste. Because of this characteristic, dry AD is an appropriate technology to treat the organic portion of municipal solid waste (Whitney Beadle, Interview, 10/17/14). According to Zhang et al (2014), food waste is appropriate for anaerobic digestion due to the high moisture content of the solids (70-80%), its nutrient and trace element content, and that the organic matter in food waste is suitable for anaerobic microbial growth (384).

### *Role of Anaerobic Digestion in Global Energy Production*

Anaerobic digestion provides an opportunity to create useful products from materials that otherwise would be sent to the landfill, and is a promising source of renewable energy as we attempt to decrease our dependence on fossil fuels. The biogas captured through fermentation can be used to generate electricity and produce heat, or can be further processed to form compressed natural gas (CNG), which can be used as fuel for vehicles. This energy can help replace non-renewable, environmentally hazardous fossil fuels. If widely adopted, this has the potential to contribute significantly to global energy production.

In Europe, anaerobic digestion of municipal solid waste on an industrial scale has been developing since the 1980s. Today there are over 120 facilities in operation. This has largely been motivated by high energy costs and policies that restrict the disposal of organic waste to landfills (Levis et al 2010, 1486). In 1999, the European Union created the EU Landfill Directive which established a requirement that by 2016, the percentage of organic waste sent to landfills throughout the EU must be reduced to 65 percent of that observed in 1995 (Levis et al 2010, 1487). These types of incentives strongly promote the adoption of strategies like anaerobic digestion and are slowly being adopted in other countries.

## Site Setting

Our research analyzes the implementation of an anaerobic biodigester facility in the city of Madison, Wisconsin. Madison is located in Dane County, the south central region of the state, and is home to approximately 233,000 people. Madison is an environmentally progressive city and is presently recognized as a leader in recycling and composting because of its success in diverting 66 percent of its waste stream from landfills (Organic Waste Systems 2012, 1). However, population growth has increased the city's waste production, placing pressures on the current waste management system. Currently, the landfill is close to reaching its capacity. To address this problem, the Dane County Board approved a $20 million expansion of Dane County Landfill in early 2014. This expansion will add 24 acres of landfill space to the existing 169 acres, which is projected to extend the life of the landfill by 30 years (County Executive of Dane County 2014).

*Organics Collection Program*

AD is one way that the city is trying to relieve some of the pressure on the landfill while simultaneously producing renewable energy. In June of 2011, The Organics Collection Program began to collect organic material from volunteer households in two areas of the city to be sent to an anaerobic digester. The first neighborhood is on the far-east side of Madison near Atwood, and the other is on the far west side of town near Hawks Landing. Cumulatively, 497 people volunteered to be part of the program (Figure 3). Additionally, organic waste is collected from five commercial

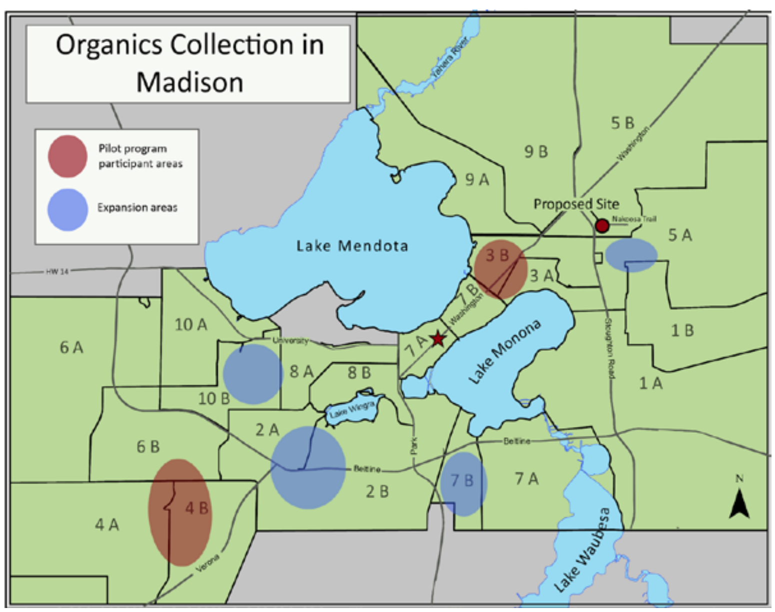


*Figure 3 Current location and planned expansion of Madison's program (Source: Shannon Plunkett)*

participants: American Family Insurance, Concourse Hotel, Madison Children's Museum, Ian's Pizza, and Fair Oaks Diner. All participants are provided with household bins, outdoor pick-up bins, as well as biodegradable bags. If households or businesses run out of bags, more are available upon request.

The food waste is collected every other week and transported to the biodigester in Oshkosh, Wisconsin. This is the first dry industrial size anaerobic biodigester in the Americas (Brian Langolf, Interview, 10/13/14). The facility converts food and yard waste as well as animal bedding into heat and electricity. These outputs supply 8-10 percent of the University of Wisconsin-Oshkosh's electricity needs (Brian Langolf, Interview, 10/13/14). A nutrient-rich solid is also produced through digestion and is used as topsoil and sold to local farmers.

Madison's pilot program contributes about 10 percent of the total waste that is processed in the Oshkosh's biodigester (Brian Langolf, Interview, 10/13/14). Unfortunately, the waste collected from Madison households has high levels of contamination from missorted items such as plastics, glass and metal. This contamination led to the proposed cancellation of the program at the end of September 2014. Faced with this potential cancellation, the Madison City Council voted to purchase a trammel filter, which acts as a screen to separate plastic, metal, and glass from the organic materials before the waste is transported to the UW-Oshkosh biodigester facility. This filter not only permits the program to continue but also allows the pilot program to expand its success to 1,600 households, 22 new restaurants, Meriter and UW hospitals and the Hy-Vee grocery store. This expansion will be called CORE, Community Organics Recycling Effort. (George Dreckman, Interview, 10/3/14).

*Potential for an Anaerobic Digester in Madison*

*Figure 4* Proposed Site for Madison's biodigester (Source: Shannon Plunkett)

Using the pilot program as proof of concept, the Madison Waste Management division can analyze the costs and benefits of creating a permanent organic waste collection program and build a biodigester specifically for Madison. Due to the expansion, the city has begun searching for appropriate sites to install the digester, as well as looking into appropriate technologies. Currently, the most promising location for the biodigester is a vacant lot on Nakoosa Trail on the east side of town (Figure 4). One major advantage of this site is its proximity to the new City Fleet Services facility, which could benefit from the biodigester's outputs, such as CNG.

When considering a site for a biodigester facility, it is important to evaluate the proximity of neighborhoods and other areas with significant levels of human traffic to avoid potentially negative impacts that the facility could bear on the surrounding community. Through our site observations, we found there is a medium-sized neighborhood located only one tenth of a mile east of the proposed site as well as a homeless shelter and transitional housing less than one tenth of a mile to the west.

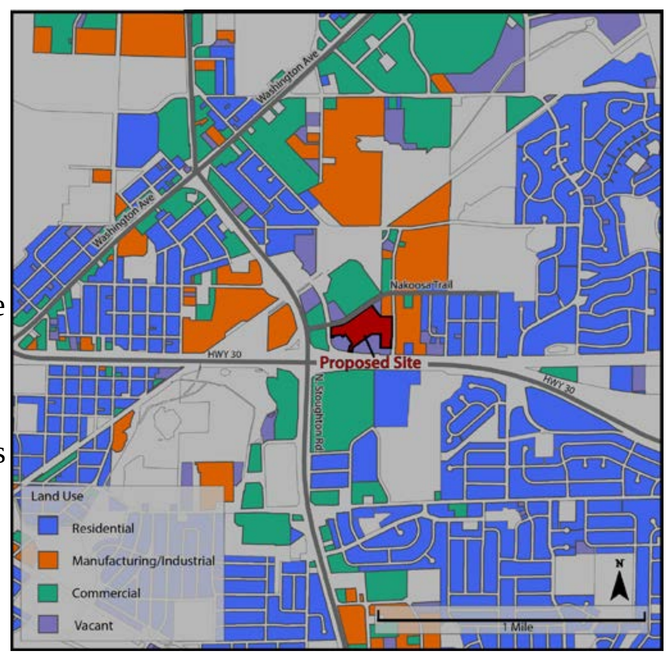


*Figure 5* Current land use surrounding proposed site (Source: Barrett Clausen and Shannon Plunkett)

To ensure that this facility benefits the community as a whole, the surrounding land use activities and any local negative impacts, real or perceived, must be considered (Figure 5). Potential concerns include odor, which could affect intrinsic value of the area and lower housing costs, increased traffic due to the inflow of garbage trucks, and noise pollution of the facility machinery, trucks in operation and collection processes. Because of these potential impacts, residents may fear that living near a biodigester will negatively affect their quality of life. This contributes to the attitude of NIMBYism (Not-In-My-Back-Yard-ism), or the opposition to developments like industrial facilities near residents. Social class and race privilege some groups' ability to protest the installation of these sites in their communities, leaving marginalized communities disproportionately impacted. It is important to resist the tendency to locate undesirable developments near marginalized communities when selecting a site for Madison's anaerobic digester.

*Current Digesters in Dane County*

Although dry anaerobic digestion is a new technology for Dane County, other AD facilities currently serve as precedents for this proposed biodigester. Presently, the county is home to two manure digester that collect cow manure from farms surrounding each facility. By processing manure, these facilities minimize methane emissions and water pollution in the area. Agricultural manure runoff is a significant pollutant in Dane County lakes. Phosphorus is a major component of this runoff and can lead to excessive algae and aquatic plant growth, which negatively impacts the aquatic ecosystem and restricts recreational use of the lakes. Currently, phosphorus runoff peaks in the winter due to the lack of available storage for excess manure in the winter months. This lack of infrastructure has led farmers to spread their extra manure on their fields or neighboring fields during these months. The manure then melts with the snow and runs off into the lakes, polluting these bodies of water. The magnitude of this contamination problem led Dane County to favor the establishment of anaerobic digesters. With AD, groups of farmers combine their manure to be sent to a single digester, which allows them to share the costs of ownership. Co-ownership makes participation in an environmentally responsible solution for manure management affordable, as well as provides the community with green energy. Despite the technical differences, dry anaerobic digestion of Madison's organic waste would address a different environmental issue, thereby furthering the benefits of AD that the county already experiences.

## Literature Review

### *Summary*

A number of economic, environmental, and social factors cumulatively determine the feasibility of organics recycling programs that use anaerobic digestion to treat waste. Each of these dimensions are closely related to the others and together they determine the success of anaerobic digestion programs. In terms of the economic potential of AD, the cost and profits of the system greatly influence its adoption. In terms of the ecological impact, we examine the climatic benefits of AD in its ability to mitigate greenhouse gas emissions. Socially, we explore the links that environmental values, education, convenience, and social norms have with recycling behavior, and their role in shaping the success of AD.

### *Economic Implications of Anaerobic Digestion*

Project economics are a major factor in determining anaerobic digestion implementation (Levis et al 2010, 1486). These economic considerations encompass both the costs involved in the process and the potential value of the outputs. AD facilities are costly to construct and operate, and this is a major barrier to implementation. Furthermore, the economics of AD are highly influenced by the types of technology used and their efficiency.

A number of studies compare the project economics of anaerobic digestion technology with other waste management practices. AD is commonly contrasted with landfilling because most organic municipal solid waste in the United States is currently sent to landfills (Levis et al, 2010; DiStefano et al, 2009). Since the economic implications of anaerobic digestion are a major factor in the technology's adoption, it is important that AD represents a cheaper option than landfill disposal over time. Local landfill tipping fees (the cost per ton to dispose of waste in a landfill,) play a large role in determining whether or not AD is economically viable (Levis et al 2010, 1491). Tipping fees are usually determined from a largely economic lens, but many indirect costs for landfills are neglected in these landfill cost-benefit analyses such as quality of life implications for neighboring residents as well as harmful environmental implications.

There are also differences in the project economics between wet and dry anaerobic digestion. These are largely a result of the differences in technology and their efficiency. Dry fermentation is considered to be more economically viable than wet digestion (Brown 2012, 277). One advantage of dry fermentation is that it can co-digest multiple waste streams at a faster rate than wet digestion systems (Appels 2011, 4296; Brown 2012, 277). This difference in efficiency between the two systems is pertinent because co-digestion increases the initial production of biogas, which improves the overall efficiency of the process. Due to this increase, co-digestion is considered superior to single substrate digestion (Brown 2012, 277). The efficiency of co-digestion itself is determined by the ratio of different waste types that are simultaneously processed. One study that evaluates the efficiency of co-digestion ratios of two waste types (food and yard wastes) concludes that digestion of yard waste alone is less productive in terms of methane production than co-digestion with food waste (Brown 2012, 280).

Dry AD is also more economically viable compared to wet AD because the process itself requires lower energy inputs. Wet digestion is more energy intensive because the waste requires constant mixing to prevent stratification of fats and fibers. (Appels 2011, 4296; Brown 2012, 275). Studies also suggest that mixing may be negatively correlated with biogas production (Lindmark et al 2014). In a study by Lindmark et al (2014), different mixing intensities of source-sorted organic fraction of municipal solid wastes are shown to influence the amount of biogas produced (2014). Specifically, lower mixing intensities are shown to produce more biogas (Lindmark 2014). The results of this study prove to be useful when evaluating energy efficiency as well as the economics of these systems. Lower mixing can lead to monetary savings due to the decrease in energy required as well as increased monetary value with the gain in biogas production.

Whether waste is pretreated prior to digestion also influences the economic outcomes of AD as it can lead to increases in methane production (Zhang et al 2014; Izumi et al 2010, 604). Pretreatment is when waste streams are altered prior to fermentation. This can be seen in the reduction of particle size using a household disposer or using a bead mill (BM) at a waste facility to grind the materials. The rationale behind reducing the particle size is that the surface area increases when particles are made smaller, making more food available to the bacteria for digestion. This in turn increases anaerobic biodegradability and leads to higher methane production (Izumi et al 2010, 604). According to one study, using BM pretreatment to reduce the particle size by 0.17mm can lead to a 28 percent increase in methane production (Izumi et al 2010, 604). It also appears that there is a threshold in size reduction and once that threshold is crossed it no longer leads to higher methane production. Excessive size reduction of the particles can cause organic overloading to happen as well as an accumulation of volatile fatty acids (VFA), which leads to the lower yield of methane production. High VFA concentrations can be an inhibiting factor in the digestion process. This study shows the importance of finding the optimal size reduction of food waste particles contributes to the economic viability of this technology in terms of the increased methane production.

Another factor that predisposes AD to high VFAs and other nutrient imbalances is the content of the substrate itself. According to Zhang et al, methane production inhibition is due to an imbalances in nutrient and ammonium content that occurs in AD of food waste when not combined with other organic substrates (2014, 389). Co-digestion of food-waste with other biomass wastes is a promising solution to counteract these imbalances found in exclusive food waste digestion and therefore also favors higher methane yields (Zhang et al 2014, 389).

An additional consideration is that the outputs of an anaerobic digester, digestate and biogas, are profitable when sold as compost and can be used as an energy source. One study evaluating the potential for nation-wide adoption of AD in the United States, concluded that the adoption would produce 5.9 billion cubic meters of methane annually. This equates to approximately $1.5 billion per year in electricity produced (DiStefano et al 2009, 1103). Globally, if all food waste were processed in an anaerobic digestion facility, the net methane output could account for almost 5 percent of the global electricity needs (Curry and Pillay 2011, 221).

Some studies suggest that national-level environmental policies that address greenhouse gas emissions and promote renewable energy sources could be applied to anaerobic digestion facilities. The capital costs involved in AD are high, so adequate policy and incentives are needed to promote AD over landfilling. For example, creating carbon emission taxes on landfills would improve the economics of the transition, by making landfill tipping fees more expensive (DiStefano et al, 2009, 1104). Additionally, carbon credits are an option due to AD's potential to reduce GHG emissions (DiStefano et al., 2009; Levis et al., 2010). DiStefano et al. calculate that a carbon credit of $30-$60 per ton of $CO_2$, emissions offset would make AD competitive with landfilling waste in the US (2009, 1104). However, the potential for application of carbon credits varies by region, especially depending on local landfill characteristics (Levis et al 2010, 1491).

*Environmental Implications of Anaerobic Digestion*

Anaerobic digestion has a number of potential environmental benefits, most notably the reduction of greenhouse gas emissions through diverting waste from landfills. While some studies argue that the process must be researched more extensively before it is possible to determine which waste management option is most environmentally beneficial (Morris et al 2013), AD is widely considered to be more sustainable than landfilling (Levis et al 2010; DiStefano et al 2009; Franchetti 2013).

A lifecycle analysis is useful for considering the environmental impact of AD in terms of both energy use and emissions. Transporting waste and digeste to and from the digestion facility, as well the construction and operation of the facility are potential sources of emissions and energy inputs associated with AD. Due to the emissions related with transport of waste to and from the facility, the proximity of AD facilities to population centers is important for decreasing emissions (DiStefano et al 2009, 1100).

Despite the potential environmental impacts of AD, it is commonly cited as a highly sustainable option (Sanscartier et al 2011; Levis et al 2010; Franchetti 2013; DiStefano et al 2009). One study utilized a life-cycle approach to evaluate the potential effects of AD and found that, compared with landfilling waste, AD in the United States has the potential to save 324,000 terajoules of energy and between 146 and 153 million tons of $CO_2$ emissions annually (Distefano et al 2009, 1102). With these reductions, DiStefano et al. projects that adopting AD would provide a 41% reduction of net energy as compared to landfilling over 50 years (2009,1103).

A 2011 study conducted by Levis and Barlaz compared emissions and energy implications of various food waste management practices. The management practices outlined in this study include several composting alternatives such as windrows, aerated static piles (ASP), gore cover system, in-vessel systems, and anaerobic digestion (AD), as well as four landfill options like landfills without gas collection (LWOC), landfills where gas in collected but the gas is flared (LWOER), a landfill with energy recovery from collected gas (LWER), and lastly, a bioreactor landfill (LFB). Each of these food waste management strategies of food were analyzed through a life-cycle assessment that compared the global warming potential (GWP), sulfur dioxide, nitrous oxide and total net energy use (TEU) to other management options in order to determine which strategy is most environmentally responsible.

In terms of food waste management, anaerobic digestion was considered the most environmentally responsible practice of all other options based on GWP, sulfur dioxide, nitrous oxide, and TEU. Although AD is the most environmentally friendly alternative for food wastes, it is also one of the most expensive management strategies. In order to be competitive with landfilling and composting, the authors of this study believe that AD must be more cost effective. The authors also propose that when looking at environmental and economic tradeoffs, a hybrid landfill-AD option could prove to be more environmental than traditional landfills as well as more economical than AD on its own (Levis and Barlaz 2012).

In another life-cycle analysis (LCA) Patterson, T., Sandra Esteves, Richard Dinsdale, and Alan Guwy (2011) compared the environmental impacts of waste transportation, facility construction, and operation, with the generation of biogas and its utilization as combined heat and power (CHP) or adding it to the gas grid as transportation fuel or domestic heat (Patterson et al 2011, 7314). While this study concludes that the CHP scenarios with 80% heat utilization are the best option in terms of least environmental impact, other options are also valuable because sometimes the best option is not compatible with the infrastructure already in place. According to this study, if 80% heat utilization is not possible, the second best option would be the production of fuel (Patterson et al 2011, 7322). This study fits into the larger debate as to the most appropriate end use of the methane produced via AD.

## *Social Norms and Behaviors*

Understanding communities' recycling behaviors and responses to collection programs are fundamental in creating a successful AD program. An investigation of previous research suggest that institutional, infrastructural, psychological, and sociological dimensions all influence recycling behavior, but that the psychological perception of convenience and the sociological consciousness of others' recycling behavior are most significant in terms of predicting recycling behavior (Timlett and Williams 2008).

### *Institutional Context*

Institutional context has a significant role in determining environmental attitudes and food waste recycling practices of participants. One study compared residents from two municipalities with differing food waste management practices to determine how attitudes towards food scrap recycling varied between residents. One municipality encouraged source-separation of food waste while the other directed its waste to a landfill. The results of the study reveal that resident perspectives and opinions on what they considered to be “the right thing to do” (Refsgaard and Magnussen 2009) were strongly influenced by the waste management practices of their municipality. Residents of the food scrap recycling municipality reported favorable views towards source-separating as well as organics waste recycling. While the other group of participants expressed distaste for the task of source-separation and were generally pleased to be spared the hassle (Refsgaard et al 2009).

Because the two populations were considered to be very similar in many respects, Refsgaard et al suggest that the divergence might be attributed to the various waste management methods used in each municipality. Local governments’ emphasis or de-emphasis on food waste recycling suggests the city’s perceived importance on the matter. This implicit message is communicated to residents, and evidently, reflected in their own individual views. This study illustrates the power of governing institutions to influence a community’s response to food scrap recycling. In making organics recycling a priority, local governments may help to motivate a positive public response in implementing a new waste management practice.

Given the importance of household participation in determining the results of organics waste collection, policies intended to promote AD must be designed with the protagonists of curbside collection, the households themselves, in mind. Curbside organic waste collection cannot be successful if the public does not participate, or does not participate appropriately (i.e. includes non-digestible materials in food bins such as plastic, glass, and metal). Although existing studies display some diversity in their conclusions on what determinants are most tightly linked to recycling behavior, our research has revealed two recurring factors that appear to drive recycling behavior.  These underlying determinants include the perception of convenience and comfortable within a program, and crucially, consciousness of social norms that value recycling behavior. (Metcalfe et al 2013; O'Connell 2011; Barr et al 2001; Bernstad et al 2013; Refsgaard et al 2009; Bernstad 2014) These results caution us against depending on advocacy campaigns that focus on increasing awareness as the key to behavior change, and instead emphasize the role effective policy can have in communicating the simplicity and socially valued nature of recycling.

*Physical Factor: The Food Bin*

Other logistical factors that influence recycling behavior include the physical constituents needed in curbside food waste collection. Some of these physical factors are the amount of space a home has to store food bins as well as the aesthetic and functional properties of the food bins themselves. Analyzing a swedish case study found that among questionnaire respondents that reported not to source-separate their food waste, 71 percent attributed their non-participation primarily to a lack of kitchen space (Bernstad et al 2013, 99). This finding raises the question of whether a source-separated organics collection program is feasible in neighborhoods with relatively small homes and whether the spatial qualities of the bin limit the potential success to solely wealthy areas with sufficient kitchen space.

Additional physical components of food bins that prove to be influential in determining organics recycling participation include the aesthetic and functional qualities of the bins. In contrast to the above mentioned case, a study determined that concerns about odor and the general "ickiness" of the food bin as the primary deterrents to participation (Metcalfe et al 2013, 147). Consequently, causing for participants not to get involved in a food waste collection trials. According to these authors, the bin itself may be the most decisive factor in determining recycling participation. Therefore, it is critical to carefully design this fundamental component of recycling infrastructure. The authors conclude that the problem recycling programs face is not that of "changing hearts and minds but (rather) to put a system in place whereby the… bin does not disrupt households." (151)

One way collection programs were seen to lessen the disruption food waste recycling had on households was seen by allowing participants to store their waste in their pre-existing disposal infrastructure, such as yard bins. Although this solution appears to address the spatial limitations of small homes as well as problems associated with poor food bin designs, research shows that these programs tend to be unsuccessful because they require a major change in disposal behavior. Due to this change many of the participants were seen actively involved in the program for only a short period of time or not participating at all because they developed the social perception that the yard bin's purpose was solely for yard waste (Sherman 2005, 30-33; Yepsen 2013, 24). These studies prove that changing social perceptions of food waste collection can be problematic due to our pre-existing waste disposal infrastructure.

*Household Convenience and Normative Qualities*

Although the physical properties of the food bin are influential in determining recycling behavior, the impact of the food bin goes beyond its physical capacities. Metcalfe et al (2013) argue that food bins are not merely neutral containers that allow already-eager recyclers to divert their food waste.  Rather, that they possess significant symbolic qualities that, combined with the material properties, result in the agency to "call householders to undertake particular waste practices" (137). When this symbolism positively connotes concepts such as cultural cleanliness, order, and responsibility, the presence of the food bin prompts even reluctant recyclers to reflect on their waste disposal behaviors and acknowledge what they consider to be "the right thing to do”. However, symbolic association may also jeopardize participation if the food bin connotes dirt, garbage, and filth in a space associated with cleanliness such as one’s kitchen. Still, Metcalfe et al conclude that in general, “food bins appear to have encouraged recycling, even by those more reticent” (2013, 152) by “[inviting] rather than just [enabling] action” (143).

Cumulatively, these findings suggest that successful food scrap recycling policies must first invest in developing adequate infrastructure that minimizes unattractive physical qualities of the food caddies. Once the material characteristics of the food caddy are comfortable enough to permit use, understanding how to strengthen the beneficial symbolic association of the bin with responsible citizenship may be sufficient to increase participation.

One of the most influential symbolic links that is seen to promote recycling behavior is that of the food bin to an “external other judging [one’s] inaction” (Metcalfe et al, 143). Although one study (Taylor and Todd 1997) concluded that “...respondents [react] negatively toward pressure from others to compost” (620), the majority have found a positive relationship between social norms and recycling behavior (Metcalfe et al 2013; O’Connell 2011; Barr et al 2001; Bernstad et al 2013; Refsgaard et al 2009; Bernstad 2014). Taylor and Todd’s study is from the 1990s and it is possible that the discrepancy in conclusions is attributable to evolving attitudes towards disposing of organic waste over time.

The importance of social variables on influencing individual recycling behavior is widely documented. According to Barr et al (2001), “recycling behavior is defined by relatively few factors and is fundamentally normative; awareness and acceptance of others’ behavior are crucial to motivating action” (2044). Put simply, “people are more likely to recycle when they observe others in their vicinity recycling… [as] the self-image of being a norm-compliant person represents the major driving force behind households’ recycling efforts” (O’Connell 2011,110).

While an abundance of literature points to the dominantly sociological nature of recycling behavior, social norms are not the only relevant factors in determining recycling participation. According to Barr et al (2001), although recycling behavior is primarily normative, it is enhanced by perceptions of convenience and the knowledge of available recycling services (2044). This study found that understanding how the program works as well as how one's individual effort can have a worthwhile effect may also be beneficial to recycling behavior. Still, their investigation concludes that the link between awareness and action is weaker than normative and convenience determinants as "it cannot be assumed that making individuals aware of the waste problem and informing them of their nearest recycling site will result in the desired behavior" (2027). This finding is significant for advocacy campaigns that function on the assumption that increased awareness and pro-environmentalist values will translate into improved participation. However as many studies have illustrated, "it would seem that recycling is not a value-based behavior.  In other words, people agree in general with the concept of recycling, but it is more normative and logistical barriers that prevent them from taking part" (Barr et al, 2001, 2042). The importance of convenience in determining participation is echoed by Metcalfe et al (2013, 151) in stating that "even those with pro-environmental attitudes may be put off if using the bin proves too troublesome a task."  It would seem then, that "persuading people of the value of recycling is not an issue. Rather, persuading and showing them that it is simple and convenient… seems to be far more crucial" (Barr et al 2001, 2042).

We also researched how food waste recycling programs encourage people to participate in them.  For many people, source separating food scraps from the rest of garbage is a new practice and thus requires people to make new habits. We researched the efficacy of a variety of recycling intervention approaches on improving the overall rate of household recycling as well as the quality of the recycled material (i.e. the presence of missorted materials). These interventions include providing households with equipment to simplify the food sorting process, literature dispersal, door-stepping, incentives, and personalized feedback.

One study evaluates the relative roles of knowledge and convenience in determining recycling behavior (Bernstad 2014) by comparing the success of two intervention campaigns. The first distributed written information to households while the other installed proper food sorting equipment in each household. Results from the study show that the equipment-supplying campaign corresponded to a drastic increase in the amount of food sorted by households while there were no statistically significant increases in the literature-based study. According to the author, these results suggest that increasing people's attention may be more impactful on behavior than improving their knowledge (Bernstad 2014, 1321) and furthermore, that making the process convenient is a critical determinant for participation.

A second study compared the relative impacts of door-stepping campaign, an incentives based campaign, and a personalized feedback campaign on increasing recycling participation and decreasing contaminants (missorted materials in recycling). The door-stepping campaign consisted of a single intensive interaction with residents in which residents received oral, one-on-one information as well as supplementary written information. The incentives program was based on a "traffic light" rating system that scored the content of the recycling bins on four different occasions as either green, amber, or red, and offered a voucher reward for those who secured two green ratings. Finally, the feedback system delivered personalized cards that detailed what households could do to improve the quality of their recycling on four different occasions. All of the techniques measured the number of new recycling bins and boxes requested by households, the volume of recycled material, the range of recycled products, and the presence of contaminants in the recycling (Bernstad et al 2013).

Based on these qualifications, the incentives-based and feedback programs proved to be the most effective at improving recycling quality as both interventions halved the presence of contaminants found in household recycling. None of the programs significantly increased recycling participation, but the authors suggest that this may be a result of the already-high recycling rates in the area.

*Role of Incentives in Food Recycling*

The success of the feedback and incentives programs in terms of inspiring the desired behavior change in recycling households, illustrates that the most effective recycling interventions seem to occur via approaches that focus on regular, personalized communication with households rather than via a single, more intensive interaction like in door-stepping. Additionally, the success of the feedback intervention suggests that the majority of people who miss-sort their recycling do so simply because they are unaware of how to recycle correctly. Although the incentives program offered a reward for correct recycling, only 13 percent of participants said that this reward was a key motivator for behavior change (Bernstad et al 2013). Instead, most participants stated that the desire to "get it right" was more influential in realizing this change. Because the households' scores were posted publicly on the recycling bins, it could be that the desire to improve one's personal score may be more attributable to the normative nature of recycling than to the incentive itself.

Other campaigns such as Pay-As-You-Throw (PAYT) and Less-Than-Weekly (LTW) programs focus on governmental incentives to increase participation in organics collection services. PAYT offers flexible disposal fees that depend on the amount of trash that is discarded, thereby incentivizing the diversion of recyclable materials. LTW program is a communication campaign that helps remind people to compost organic waste instead of throwing their waste in a landfill, which allows individuals to save money that they would have spent on disposal costs (Yespen 2013,27; O'Connell 2011,107). Both incentive programs present financial incentives to encourage individuals to decrease the waste that goes to landfills and in doing so, promotes more environmentally responsible waste management tactics.

*Conclusion*

Together, these economic, environmental, and social dimensions of organics recycling and anaerobic digestion heavily influence the feasibility of AD as an alternative waste management strategy. Under different circumstances, certain dimensions play a greater role in determining the potential for AD adoption. In Madison, the pilot collection program primarily focuses on household-level participation and must consider the role of these individual perceptions in determining the outcomes of organics recycling. Therefore, the social dimensions of organics recycling is a major factor in determining the potential for AD in Madison.

**Methods**

To address our research question, we used a combination of qualitative and quantitative data to give us a well-rounded understanding of the potential for anaerobic digestion of food waste in Madison, as well as the community's perception of the program. Our qualitative data sources include original photographs, interviews and site visits. We also distributed a survey that yielded both qualitative and quantitative results. Through these qualitative and quantitative sources, we will evaluate the potential for anaerobic digestion in Madison and gauge the public's perception of the program. Ultimately, we hope to use these results to inform recommendations for effective policy and outreach techniques as the program expands.

*Interview Methods*

To further our understanding of Madison's Organic Collection Pilot Program and the future plans for anaerobic digestion, we interviewed a variety of the program's key actors. Because this program is relatively young, this was essential to our research because the interviewees were able to provide us with information that was not accessible through other existing sources. This is a main strength of interviewing as a research method (Dunn 102). We conducted semi-structured interviews, meaning that we prepared an interview schedule ahead of time, but that the interview session was flexible to changes in topic (Dunn 110). This structure allowed us to address specific gaps in our knowledge, while also letting the interviewees guide the session.

Our first interview was with George Dreckman, the head coordinator of Madison's organic recycling effort and the Recycling Coordinator for the City of Madison (Appendix p. 51). This interview was essential to further our knowledge of the program's logistics. In conjunction with a site visit to the University of Wisconsin-Oshkosh biodigester facility to conduct field observations, we interviewed Brian Langolf, the Plant Manager of the UW-Oshkosh biodigester (Appendix p. 53). Finally, to better understand the application of AD technologies, we interviewed Whitney Beadle, the Marketing and Communications Specialist at BioFerm Energy Systems (Appendix p. 55). BioFerm Energy Systems is a Madison-based company and a leader in the field of anaerobic digestion technologies. BioFerm constructed the Oshkosh biodigester where food waste from Madison is currently transported for processing.

In addition to these interviews with key actors in the program, we conducted interviews with the owners or managers of three businesses that participate in the Organics Collection Pilot Program. We interviewed Adam Nagy, the General Manager of Ian's Pizza (Appendix p. 57), Kris Austin, the owner of Fair Oaks Diner (Appendix p. 61), and Julie King and Brenda Baker of the Madison Children's Museum (Appendix p. 59). We used the results of these interviews to understand participants' perspectives on the program and how businesses can incorporate organics recycling into their business model.

*Survey Methods*

We partnered with George Dreckmann to develop and distribute a survey to the 497 participants in the Organics Collection Pilot Program using Qualtrics, an online survey platform. We designed our survey to address key concepts and questions related to our research question so that each question served to address our research (McGuirk and O'Neil 193). The survey consisted of nine questions, seven multiple-choice and two open-ended questions as well as included four categories: questions based on respondent's attributes, behaviors, attitudes, and beliefs (McGuirk and O'Neil 194).

We analyzed the results of the seven multiple-choice questions using descriptive statistics. One of the seven multiple-choice questions required further statistical analysis. To analyze the open-ended question results, we classified the responses into commonly-cited concepts. Using this information, we quantified the frequency of each response and represented the results visually using word-clouds (Figure 10, 11, Appendix p. 50).

## Results

*Survey Results*

To understand the Madison communities' responses to the program, we conducted an email survey of the households that are currently participating in the Organic Waste Pilot Program. Of the 497 participants surveyed, 207 participants responded. The survey consisted of various types of questions, which necessitate different levels of analysis. We use both descriptive and inferential statistical analyses as well as qualitative analyses of the open-ended questions for our research process.

We wanted to identify how long respondents have been participating in the program because respondents with more experience participating may have a better understanding of the program. Therefore, offering more informed recommendations to improve the program. Of the 207 respondents, 70 percent joined the program in 2011, 23 percent joined in 2012 and seven percent joined in 2013. No respondents were recorded to have joined in 2014.

To identify the respondent's reasons for participating, we included an open-ended question asking them to identify their motives for joining the program (Figure 10, Appendix p. 50). Some of the commonly cited reasons for participation include: (1) the convenience of having the city compost organics instead of managing an individual compost, (2) an efficient way to dispose of pet waste and diapers, and (3) fulfilling an environmental or moral obligation. Below are a few direct quotes from survey responses:

> "I love the idea of minimizing waste. This gave me the option to compost a bunch of stuff that wasn't compatible with home compost"

> "I'm a gardener and do composting on my own at my home- so the main reason I wanted to do the program was so I could have a place to put my dog waste"

> "It was the right thing to do. This city, this state, this country, the world needs to be moving towards a more sustainable future... this program is a start to that"

Next, we asked the participants' to rate their experience in the program from very poor to very good. These ratings provide insight on the overall reception of the pilot program. Of the 207 respondents, nearly all respondents rated their experience as being favorable and none of the respondents rated their experience as poor or very poor (Figure 6, Appendix p. 44). Additionally, we asked participants to rate the convenience of separating organic waste from other waste. Of the 207 respondents, 75 percent rated separating organics as convenient, 17 percent as somewhat convenient, five percent as average, three percent as moderately convenient, and none of the respondents rated separation of organics as inconvenient (Figure 7, Appendix p. 45). Overall, our data suggests generally convenient experiences and positive impressions of the program among respondents.

Through our survey we also wanted to understand how problematic certain complications associated with organics separation have been thus far. Based on our research, we identified six potential problems: issues with pick-up, uncertainty about sorting materials, issues with bugs, bags, space in the container, and odor. Our original question asked: "Have you experienced any of these potential inconveniences associated with organic waste separation? (Mark all that apply)". Respondents then ranked each category on a scale of 1 to 5, with 1 being "Inconvenient" and 5 being "Convenient". Of the 143 respondents that were asked the original question, seven commented that the scale was inappropriate for the question being asked. Due to this confusion with version one, we rephrased the question for the remaining respondents to be: "Based on your experience with organics separation, how problematic are the following (1 being Not Problematic and 5 being Very Problematic)?"

We analyzed the responses of both versions of the question separately and found the results of both versions to be very similar. This leads us to believe that the majority of respondents interpreted the scales of both questions in a similar way, and that the potentially problematic wording of the first question did not noticeably alter their responses. Therefore, we feel comfortable combining the two different datasets together as the respondents answered the question based on a numerical scale (understanding 1 as being low and 5 as being high) rather than the provided scale rating convenience. With these two sets of responses combined, the median rating for each potential problem was less than 2. This implies that none of these categories have been overly problematic. However, respondents rated bags, bugs, and odor as the greatest complications (Figure 13).

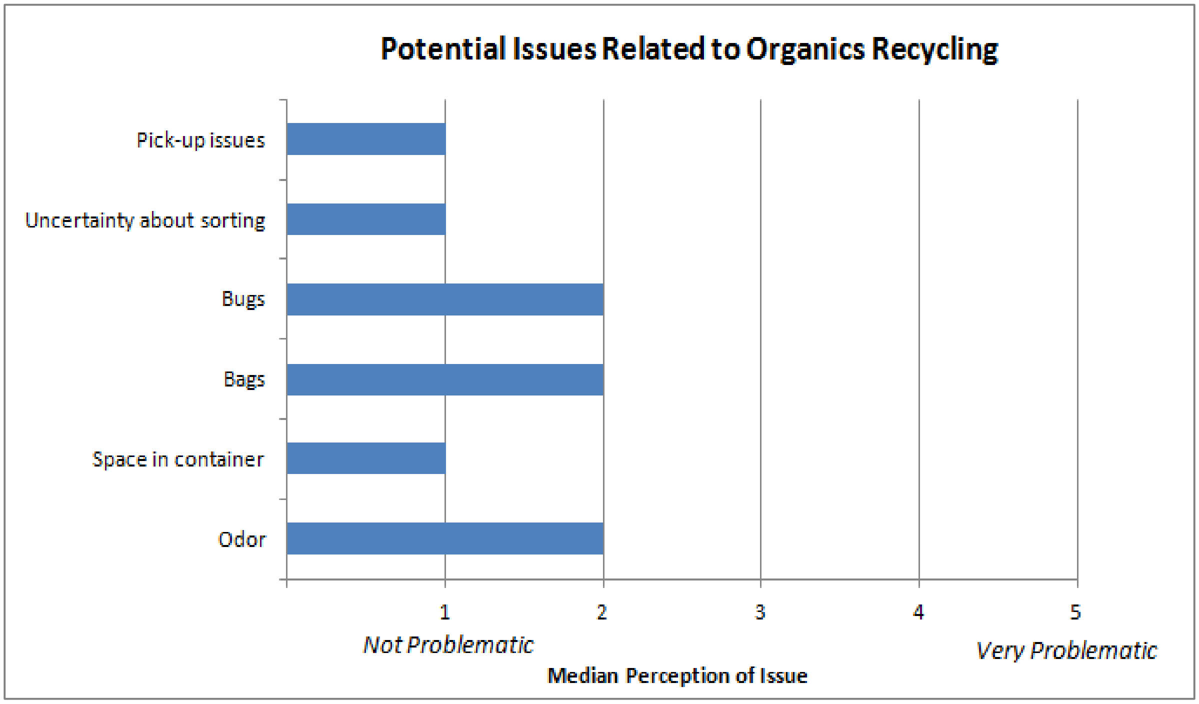


***Figure 13*** *Graph of median responses to survey question 5*

On the adequacy of resources and information distributed to each household, of 207 respondents, 93 percent of the participants felt that they received sufficient information whereas three percent, approximately thirteen respondents, said that they did not. Most of the participants received information about the program through email, snail mail, and the program website (Figure 8 Appendix p. 48). The most widely cited issue is problems with bags and this surfaces many times throughout the survey. The main concerns are that respondents wanted more bags (eight responses), that they need guidance on where to buy the bags (two responses) and that they want sturdier bags (two responses). Five respondents wanted more information on what to compost. Specific concerns are that the organic materials accepted by the program change frequently (such as pet waste, feminine hygiene products and diapers) and that participants do not feel informed about changes, and whether certain food containers should be recycled or composted. To clear up this confusion, surveyed participants expressed that more focus should be on email and program website updates rather than snail mail (Figure 9, Appendix p. 49). The containers that the pilot program provides for each household was another concern. One respondent wanted more household containers and another wanted household containers of a higher quality. Household responses to the size of the containers varied due to differing amounts of waste produced.

Lastly, we asked all respondents how they felt that the program could be improved (Figure 11, Appendix p. 50). Their suggestions include accepting a broader range of materials in pick-up (specifically pet waste and diapers), greater expansion of the program throughout the city, and changes to the program's logistics (in terms of pick-up schedules, and the provided bags and containers). Respondents' answers reflecting these suggestions include:

> "I'd really like to be able to compost diapers and pet waste again… My house could be an almost zero waste household if those were allowed."

> "I work in an elementary school and see incredible waste of compostable materials on a daily basis. I would love to see schools included in the program -- it would be such a valuable learning experience for children, as well as saving a lot of waste from going to the landfill."

> "It's been a real pain trying to get more of the biodegradable bags. The city never really had a plan for distributing those, and I've had to call, write and stop by city offices to pick them up. I've been told that the city recently switched to allowing regular plastic bags; that they have some sort of device to pull those out. But that goes against the whole ethos of composting, and I'm sure I'm not the only participant who really balks at the idea of using plastic grocery bags to put my compost in. I'd suggest the city contract with the manufacturer of these biodegradable bags to sell boxes of them at Madison grocery stores. I would gladly pay money for these bags."

*Results of Interviews with Business Participants*

To get the perspective of businesses involved in the pilot program, we interviewed managers or owners of three participating businesses: the Madison Children's Museum, Fair Oaks Diner and Ian's Pizza on Francis Street. We chose these businesses based on the amount of waste that they contribute to the program, which is greater than the other businesses involved. Owners or managers from each interviewed business sought out the Organics Collection Pilot Program as an alternative to landfilling their waste. Concern for the businesses' environmental responsibility was the dominant motive for this proactivity, although once part of the program, financial factors further incentivized continued participation for two of the businesses.

Environmental responsibility is a fundamental component of the business plan for Ian's Pizza, the Madison Children's Museum, and Fair Oaks Diner. For Ian's Pizza, collaborating with the Organics Collection Program fit into the restaurant's "Triple Bottom Line" business model of profit, people, and planet that emphasizes, among other things, becoming a more environmentally sustainable business. To achieve this, the business invests in compostable pizza boxes, plates, napkins, and silverware to contribute to the organics collection program in addition to back-of house food scraps. The Madison Children's Museum echoes this environmental consciousness in stating that "composting is a big part of our mission" (King and Baker, Interview, 11/18/2014). Although the museum's restaurant is not currently composting due lack of communication, the Organics Collection Program does collect the waste from the rooftop garden. Finally, Kris Austin (Interview, 11/21/14) from Fair Oaks Diner reflected on the moral obligation she feels to run an environmentally responsible business by stating that the program "[saves] our conscience."

While environmental motives may have been most persuasive in catalyzing these businesses into collaboration, for Ian's Pizza and the Madison Children's Museum, this participation also has significant financial advantages. Due to the high quantities of waste these businesses produce, both must contract private waste disposal companies to dispose of trash. Fees for this service depend on the quantity of material that is collected. Because the Organics Collection Program is provided at no cost to participants, diverting organic waste to the Organics Collection bins can result in noticeable savings. According to general manager Adam Nagy at Ian's Pizza, participating in the Organics Collection Program reduced waste disposal fees by about fifty percent in winter months (Interview, 11/18/2014). Similarly, Julie King (Interview, 11/18/2014) at the Madison Children's Museum stated that "we are absolutely saving money and this program should be used by other companies."

Each of the interviewees consider the Organics Collection Program to be a relatively simple and convenient addition to their waste management strategies. At Fair Oaks Diner, owner Kris Austin (Interview, 11/21/2014) reflected that the inconveniences associated with organics recycling are certainly "not worse than any other garbage," and make trash disposal more manageable in terms of controlling odor and keeping receptacles clean. Adam Nagy at Ian's Pizza commented that participation requires "minimal effort" as the "city does most of the work." At the Madison Children's Museum, the Organics Collection Program simplified the task of composting high quantities of garden waste. One commonly cited logistical complication is with the compostable bags used to line trash cans. Some business owners hoped for larger bag sizes to fit large bins while others criticized the increased expense and lower durability of these bags as compared to standard plastic bags. Finally, in the summer months the bags may begin to break down in the bins, leading to leakage and issues with odor.

All of the interviewed businesses commented that employee education helps to create a successful transition to organics recycling. According to General Manager Adam Nagy (Interview, 11/18/2014) at Ian's Pizza, "it all comes down to the education of the staff." Ian's Pizza encourages employee compliance by integrating recycling organics into everyday waste disposal procedures, displaying informational posters that illustrate the proper disposal for each restaurant material, as well as consciously placing trash and organics waste baskets in locations that favor organics recycling. Kris Austin at Fair Oaks Diner comments that after training her employees, securing compliance with organics recycling is not an issue. Brenda Baker and Julie King from the Madison Children's Museum similarly emphasize the importance of education in securing participation. As a teaching institution, one of the museum's educational objectives is to "teach all visitors: children, parents, and adults about the composting," (Interview, 11/18/2014). Specifically, they highlight the importance of introducing organics recycling to children to help shape lifelong habits.

Despite the interviewees' enthusiasm for organics recycling and recognition of the importance of education in securing participation, both understand that within the institution more could be done to educate their own employees. Notably, while garden waste recycling is very successful, this success has not extended to Roman Candle, the restaurant located within the museum. King (Interview, 11/18/2014) reflects on insufficient communication with new staff, volunteers, and the employees at Roman Candle about organics recycling, and suggests that the museum "could do a better job placing the (organics collection) program in the staff manual."

Overall, each of the businesses interviewed expressed positive impressions of the program and an interest in continuing to participate. Common suggestions given echoed those received from household participants: improved communication between the program and participants, changes to program logistics such as the frequency of pick up and the characteristics of the bins, and increased education to improve program outcomes. Naturally, the nature of the suggestions was slightly different for businesses than for households, reflecting a greater volume of waste produced.

**Discussion**

Overall trends observed in both our survey and interview results convey that current participants have had overwhelmingly positive experiences with the program. The importance of environmental responsibility is the dominant motive for participation among both household and business participants, followed by factors of convenience for households and financial motives for businesses. In the aforementioned groups, environmental, financial, and convenience-based motives translated into active participation.

The dominance of environmental values in motivating participation in the pilot program contradicts much of the existing literature about the connection between values and action with regards to recycling (Barr et al 2010; Refsgaard et al 2009). This discrepancy could be attributable to the fact that AD is not established in Madison, meaning that there is not significant social pressure to participate. Additionally, because participants are volunteers, it is more likely that environmental values play a significant role in motivating participation than for the general populace.

Despite the overwhelmingly positive responses to the program, both the business and household participants voiced the need for some improvements to increase program success. Some suggestions for improvement include strengthening the program logistics by providing more information about what items can be disposed of in the composting container, as well as providing a wider selection of higher quality bins and bags. Respondents consistently advocated for the expansion of the program as well as the construction of Madison's own biodigester which would allow for the disposal of currently banned items like pet waste and diapers.

All three of the businesses we interviewed and the 207 surveyed participants joined the program voluntarily. Although this is representative of the current program participants, it is not a representative sample of the broader Madison community's perceptions about the organic collection program. Being volunteers, they are more likely to have a positive outlook on the program's benefits. This optimism may minimize the respondents' expression of the various potential problems associated with composting that they may have experienced. Therefore, when expanding the program to include non-volunteers, the issues expressed by these current participants may be amplified. Additionally, many of the volunteer households we surveyed and two of the interviewed businesses mentioned having previous experience with composting. Because of their previous knowledge and experience with composting, current volunteer participants needed less guidance and resources than would inexperienced participants. Upon integrating more participants without prior experience, the program will need to provide additional resources and improve communication between the program and participants.

Despite these potential drawbacks of our sample population, we also see this bias as being a potential strength. Any issue with the program identified by a population that is largely predisposed to support the program is likely to be amplified among the general population. Using this information, we can make recommendations that anticipate and address problems likely to surface as part of the city-wide expansion.

*Recommendations to Expand the Program City-wide:*

Based on our research, we conclude that a dry anaerobic biodigester is the most appropriate technology for Madison's organics collection program. Some advantages to this technology include the ability to co-digest Madison's varied waste streams that include biosolids such as food scraps, yard waste, paper products, diapers and pet waste. This method is less energy intensive than other biodigester technologies. An additional advantage of dry anaerobic digestion is that the biogas and the solid digestate have economic value as an energy source and a compost additive, respectively (See *Economic Implications of Anaerobic Digestion*).

In regards to selecting a digester site setting for Madison, we recognize the potential benefits of locating the digester on Nakoosa Trail (See *Site Setting*). This location is favorable as it not only could supply electricity and heat for surrounding buildings but most notably, could also convert the captured methane into compressed natural gas (CNG) for the city vehicle fleet located nearby. We agree with Whitney Beadle from BioFerm's suggestion that in terms of the most appropriate end product for Madison's biogas, "CNG makes the most sense at this point," (Interview, 10/17/2014) given the favorable federal subsidies for biofuels and the relatively reliable energy sell-back rates for CNG. Upon converting the city vehicles to process CNG, Madison's fleet would be able to run on energy generated from waste. This would save the city money in fuel costs and decrease Madison's dependence on fossil fuel.

While the proximity of the Nakoosa Trail site to the proposed City Fleet location makes the site an attractive option, the proposed site is less than half a mile from residential and commercial zones. Given the location's proximity to homes and businesses, it is important to consider the potential inconveniences associated with AD such as increased traffic, odor, and noise. While we don't foresee these issues impacting the nearby areas, we stress the importance of thoroughly considering all potential quality-of-life implications for these residents when selecting a site.

The social dimension of the Organics Collection Program is a critical component as the success of the program hinges on the active participation of the Madison community. Two aspects that must be improved are education for, and communication with participants in order to simplify their cooperation. The results from household and business participants indicate that the program needs to expand its educational services, specifically workshops and trainings for all participants. These services would provide a background in organics separation for participants without prior experience. During our interview, the Rooftop Garden Manager and Director of Exhibits from the Children's Museum expressed interest in holding educational workshops in the future, which presents the program with an opportunity for collaborative outreach with local businesses (Appendix p. 59). These trainings should prioritize educating participants about organics separation (i.e. items that can and cannot be included) in order to minimize household contamination. Contamination is a major issue in the pilot program and almost led to its cancellation.

Increasing education presents a platform from which the program can express the benefits of organics recycling in Madison, such as figures on the quantity of waste diverted from the landfill. Presenting the raw numbers in an approachable way could potentially increase participation by boosting excitement for the program. While knowledge of general environmental benefits alone may not motivate participation in recycling programs, information on the tangible benefits of participation in a program is an effective motivator (Barr et al. 2001, 2028).

In addition to instructing participants how to compost and giving more information about the benefits of their participation, these educational workshops should also focus on how to mitigate complications associated with organics separation. For example, in an interview, the program coordinator suggested freezing organic waste to minimize odors, especially in summer months (Appendix p. 51). This is beneficial information for participants and we suggest emphasizing tips of this nature, as it may make organics recycling more convenient for participants. By communicating the simplicity of participation, these workshops can disassemble the ideas that organics recycling is inconvenient.

Perceived inconvenience is a major barrier to participation in organics recycling (See *Social Norms and Behaviors*). Results from our surveys and interviews indicate that currently used countertop household bins as well as liner bags are problematic. With regards to the bins, respondents expressed dissatisfaction with offered container sizes, their unattractive appearance, and odor. Similarly, common criticisms about bags include inappropriate sizes, poor quality, and limited availability. In order to make participation more comfortable, we recommend providing more sizes of bins and bags to meet individual household needs, as well as various design options for bins. This could include multiple color options, bins made from a variety of materials (e.g. stainless steel), as well as a design that does not require liner bags (e.g. a bin without holes on the sides). Providing these options could make participation more agreeable by allowing participants to tailor equipment to their individual preferences and needs.

Additionally, we believe that a greater focus on education will aid in minimizing household contamination. This contamination is a major issue in the pilot program and almost led to its cancellation. Increasing education presents a platform from which the program can express the benefits of organics recycling in Madison, such as figures on the quantity of waste diverted from the landfill. Presenting the raw numbers in an approachable way could potentially increase participation by boosting excitement for the program. While knowledge of general environmental benefits alone may not motivate participation in recycling programs, information on the tangible benefits of participation in a program is an effective motivator (Barr et al. 2001, 2028).

Communication is another area which needs further development in order to facilitate a successful city-wide program. We recommend a more centralized stream of communication between program developers and participating households and businesses. Based on the results of our survey, respondents prefer communication via email so snail mail should not be used as primary means of communication (Figure 9, Appendix p. 49). Communication can also be facilitated through a regularly-updated website that maintains a current list of compostable items and information about the city's pick-up schedule. This comprehensive list could help diminish confusion. It could be modeled after Madison's "Recyclopedia", which details the items that can be recycled through the city's conventional recycling program.

Lastly, we support current efforts towards creating a visual logo or brand for the program. At this point, the coordinator is in the process of developing the program's identity through a more approachable name, CORE (Community Organics Recycling Effort) as well as branding the program with a logo. These efforts function to make the program more visible. An additional strategy would be to produce graphics that would help promote the program.


***Figure 12*** *Example of graphic for household bins*

Developing a graphic can serve different purposes at the business and household level. For businesses, designing window decals and table toppers reveal the business's participation in CORE which helps familiarize the public with the program, as well as contribute to CORE's popularity by communicating that the program is socially valued. Because the willingness to recycle is fundamentally norm-based, awareness of others' support of organics recycling is decisive in motivating participation.  Additionally, these displays will allow businesses to advertise their sustainability initiatives. Given Madison's relatively environmentally conscientious population, the ability to associate one's business with environmental responsibility may serve to attract more clients. At the household level, we believe it is useful to provide an infographic describing how to properly separate organic waste. This graphic is an example of a resource that the city could easily provide directly the countertop containers (Figure 12). This would serve to reduce confusion over what can be composted, ideally resulting in decreased contamination.

**Future Research**

Due to limited funds and time constraints, there are many dimensions of AD and organics recycling that remain to be explored in the future. To better understand the larger community's impressions of organics recycling, it is important to interview households and businesses involved in the expansion. This would provide the individual perspectives that are less familiar with the program and perhaps have less experience with organics separation, thereby addressing the bias in our current results.

Because high levels of contamination in the pilot program, the city needs to explore different way to better communicate the mechanics proper organic sorting. Randomly sampling the contents of household bins could help to identify common contaminants in order to illustrate what remains unclear to participants in regards to separating organic waste. This would dictate what needs to be highlighted in educational materials and ideally ameliorate issues with contaminants.

Since AD is not widely used in the United States to treat municipal solid waste, there are few precedents in the United States on which Madison's program can be modeled. However, AD is widely used in Europe for municipal solid waste and European cities' experiences offer valuable insights into how to implement a program. Acknowledging the differences in the economic and political climates, it is important to study how these European cities have used economic incentives, such as increasing tipping fees, to implement a program on a larger scale. Increased tipping fees increase the cost of municipal waste disposal, making organics recycling more competitive. While the conditions in Madison are very different from the European context, information on how successful city-wide organics collection programs have been implemented will be useful as Madison looks to expand.

Before the city finalizes a site for Madison's own biodigester, it is important to research the surrounding community in order to understand how they may be impacted. Based on our interviews with George Dreckmann and Brian Langolf, it is unlikely that the facility will negatively impact its surroundings (Appendix, p. 51, 53). However due to the potential for unforeseen complications, further research into the facility's impacts on its surroundings, such as pollution and increased traffic, is necessary. If such issues are likely, it is critical to ensure that no population disproportionately experiences these inconveniences, meaning that the installation site may need to be further removed from areas of high human traffic.

**Conclusion**

Our research suggests that there is great potential for anaerobic digestion and citywide organics collection in Madison. Anaerobic digestion is a valuable waste management strategy because it presents the opportunity to convert waste into a productive resource while taking pressure off landfills and mitigating greenhouse gas emissions. Because Madison’s collection program is primarily household based, community responses shape the potential of the program. Based on pilot participants’ feedback, convenience factors and education must be improved. Additionally, continued efforts to brand the program may facilitate awareness and acceptance of the program, subsequently leading to wider participation. Ultimately, the city needs to design the program around the people that produce the waste by incorporating their needs and interests into the program logistics.

**Appendix**:



## A. Tables and Figures

**A.1** Graphics from Survey

**A.2.1** Survey Question 3

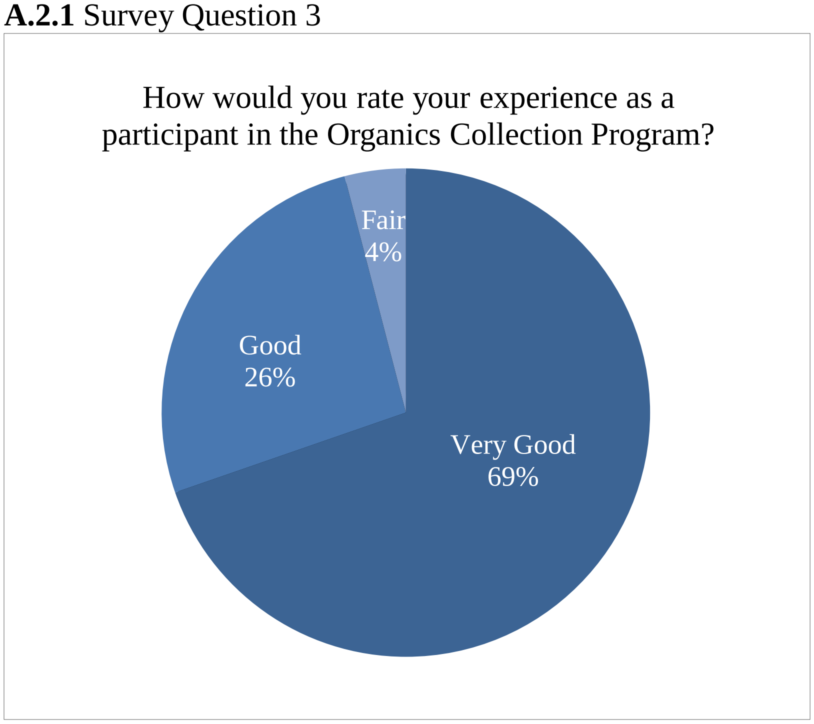


**Figure 6.** Respondents' answers to survey question 3, with a sample size of 201 (n=201). Zero percent of respondents answered "Very Poor" and "Poor".

| Rating | Percent of Respondents |
|---|---|
| Very Poor | 0% |
| Poor | 0% |
| Fair | 4% |
| Good | 26% |
| Very Good | 69% |

**Table 1.** Responses to survey question 3, with a sample size of 201 (n=201).

**A.2.2** Survey Question 4

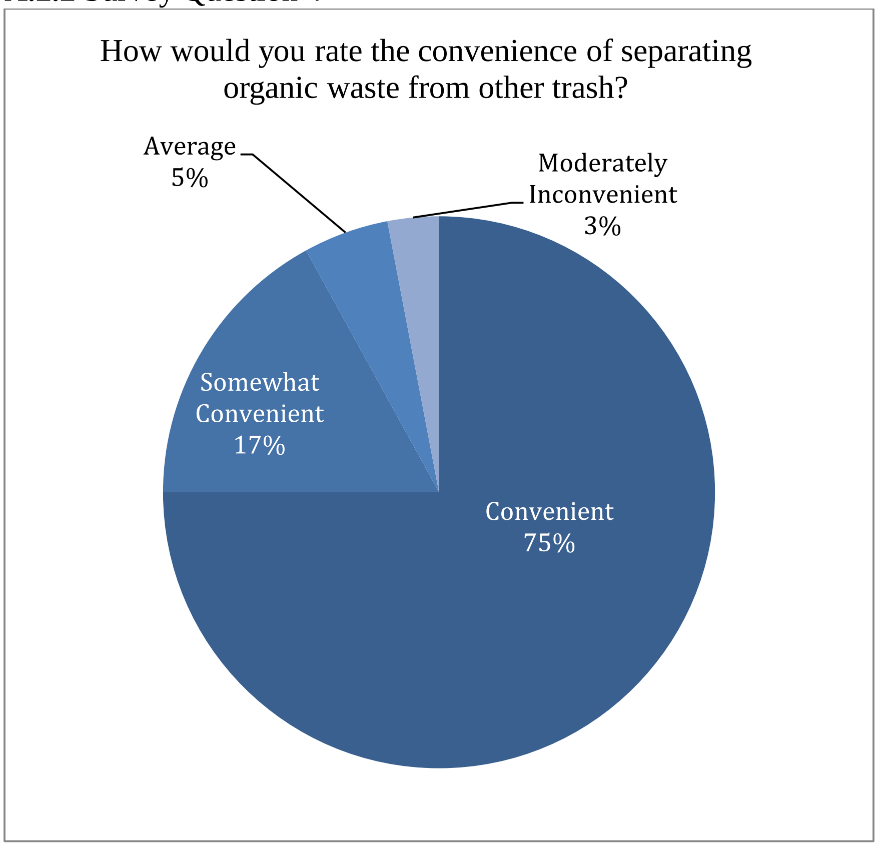


**Figure 7.** Respondents' answers to survey question 4, with a sample size of 207 (n=207). Zero percent of respondents answered "Inconvenient".

| **Rating** | **Percent of Respondents** |
|---|---|
| Inconvenient | 0% |
| Moderately Inconvenient | 3% |
| Average | 5% |
| Somewhat Convenient | 17% |
| Convenient | 75% |

**Table 2**. Responses to survey question 4, with a sample size of 207 (n=207).

**A.2.3** Survey Question 5

| **Q5-1 Odor** | **Data** | **1** | **2** | **3** | **4** | **5** | **Totals** |
|---|---|---|---|---|---|---|---|
| Version 1 (original wording) | Number | 43 | 25 | 46 | 13 | 11 | 138 |
| | **%** | **31%** | **18%** | **33%** | **10%** | **8%** | |
| Version 2 (revised wording) | Number | 26 | 11 | 14 | 7 | 1 | 59 |
| | **%** | **44%** | **19%** | **24%** | **11%** | **2%** | |
| | **Total** | | | | | | |
| **Q5-2 Space in container** | | | | | | | |
| Version 1 | Number | 76 | 19 | 24 | 8 | 9 | 136 |
| | **%** | **56%** | **14%** | **18%** | **6%** | **6%** | |
| Version 2 | Number | 29 | 11 | 10 | 3 | 0 | 53 |
| | **%** | **55%** | **20%** | **19%** | **6%** | **0%** | |
| **Q5-3 Bags** | | | | | | | |
| Version 1 | Number | 43 | 29 | 23 | 21 | 20 | 136 |
| | **%** | **33%** | **21%** | **17%** | **15%** | **14%** | |
| Version 2 | Number | 22 | 7 | 10 | 8 | 4 | 51 |
| | **%** | **43%** | **14%** | **20%** | **16%** | **7%** | |
| **Q5-4 Bugs/Vermin** | | | | | | | |
| Version 1 | Number | 49 | 20 | 35 | 23 | 15 | 142 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **%** | **36%** | **14%** | **24%** | **16%** | **10%** | |
| Version 2 | Number | 26 | 13 | 7 | 9 | 2 | 57 |
| | **%** | **45%** | **23%** | **12%** | **16%** | **4%** | |
| **Q5-5 Uncertainty of Sorting** | | | | | | | |
| Version 1 | Number | 75 | 29 | 19 | 9 | 4 | 136 |
| | **%** | **56%** | **21%** | **13%** | **6%** | **2%** | |
| Version 2 | Number | 39 | 12 | 4 | 4 | 0 | 59 |
| | **%** | **66%** | **20%** | **7%** | **7%** | **0%** | |
| **Q5-6 Pick-up issues** | | | | | | | |
| Version 1 | Number | 104 | 10 | 10 | 0 | 6 | 130 |
| | **%** | **81%** | **7%** | **7%** | **0%** | **5%** | |
| Version 2 | Number | 51 | 5 | 3 | 0 | 0 | 59 |
| | **%** | **86%** | **8%** | **6%** | **0%** | **0%** | |

**Table 3**. Responses to survey question 5, Version 1 ("Have you experienced any of these potential inconveniences associated with organic waste separation? (Mark all that apply)") and revised Version 2 ("Based on your experience with organics separation, how problematic are the following (1 being Not Problematic and 5 being Very Problematic)?"

| **Question 5: Aggregate totals** | NOT PROBLEMATIC | | | | PROBLEMATIC | |
|---|---|---|---|---|---|---|
| **Ranking** | **1** | **2** | **3** | **4** | **5** | **TOTAL** |
| **Q5-1 Odor** | 69 | 36 | 60 | 20 | 12 | 197 |
| **Q5-2 Space in container** | 105 | 30 | 34 | 11 | 9 | 189 |
| **Q5-3 Bags** | 65 | 36 | 33 | 29 | 24 | 187 |
| **Q5-4 Bugs/Vermin** | 75 | 33 | 42 | 32 | 17 | 199 |
| **Q5-5 Uncertainty of Sorting** | 114 | 41 | 23 | 13 | 4 | 195 |
| **Q5-6 Pick-up issues** | 155 | 15 | 13 | 0 | 6 | 189 |

**Table 4.** Aggregate totals of Version 1 and Version 2 of survey question 5.

**A.2.4** Survey Question 7

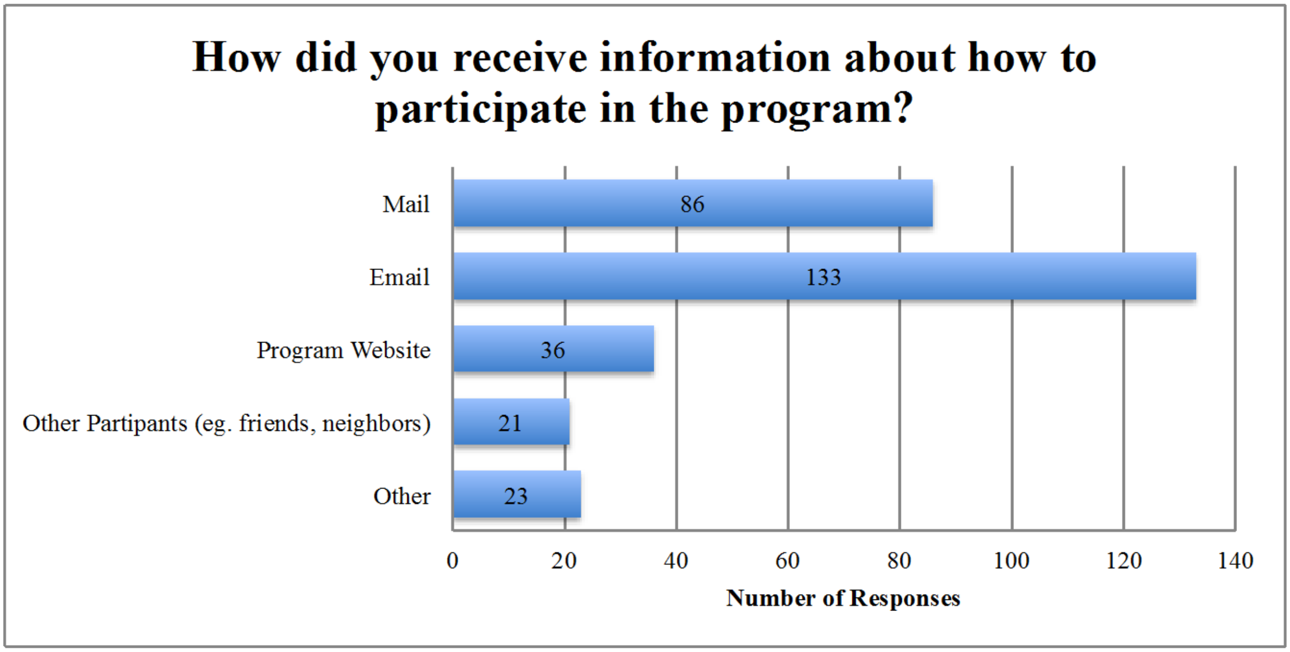


**Figure 8**. Respondents' answers to survey question 7, "How did you receive information about how to participate in the program? (Check all that apply)" with a sample size of 200 (n=200).

| **Information Medium** | **Number of Responses** |
|---|---|
| Mail | 86 |
| Email | 133 |
| Program Website | 36 |
| Other Participants (eg. friends, neighbors) | 21 |
| Other | 23 |

**Table 5.** Respondents' answers to survey question 7, "How did you receive information about how to participate in the program? (Check all that apply), with a sample size of 200 (n=200).

**A.2.5** Survey Question 8

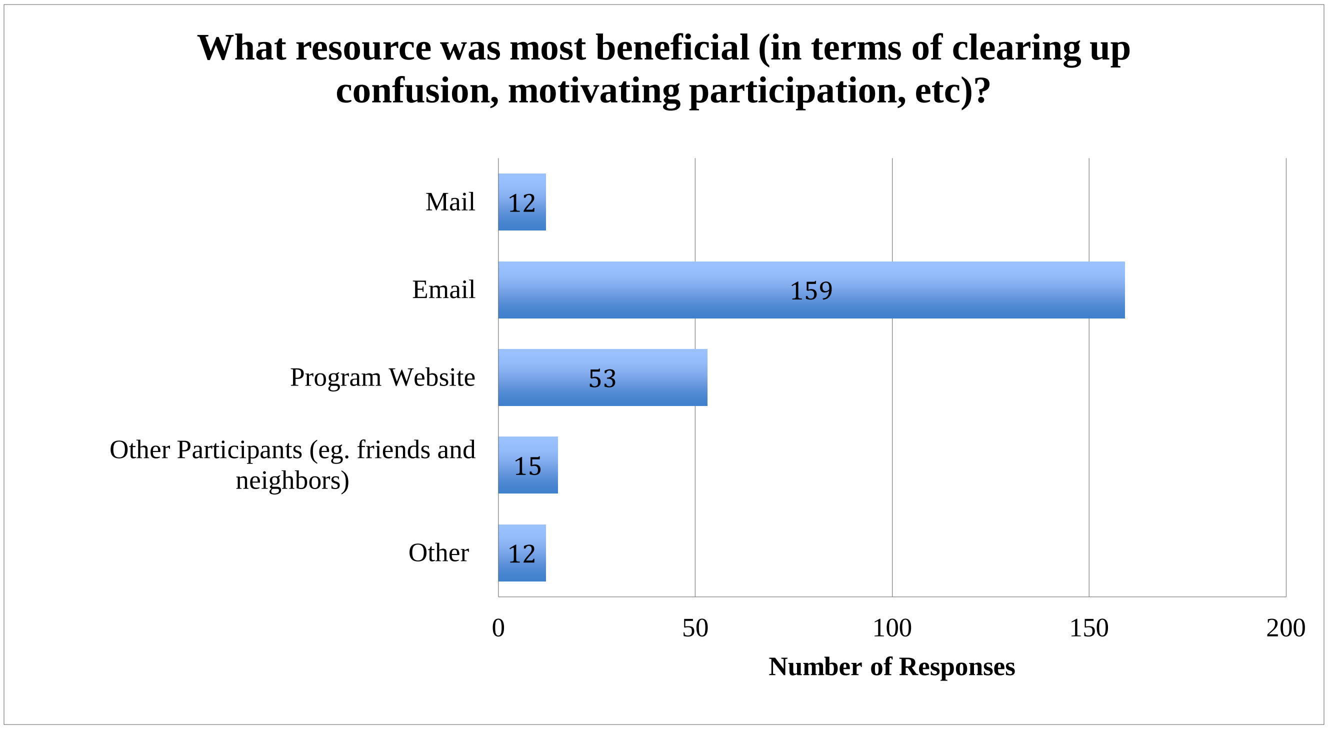


**Figure 9**. Respondents' answers to survey question 8, with a sample size of 200 (n=200).

| **Information Medium** | **Number of Responses** |
|---|---|
| Mail | 12 |
| Email | 159 |
| Program Website | 53 |
| Other Participants (eg. friends, neighbors) | 15 |
| Other | 12 |

**Table 6**. Respondents' answers to survey question 8, with a sample size of 200 (n=200).

**A.2.5** Survey Word Clouds (Question 2 and 9)


**Figure 10**. Word cloud of responses to survey question 2, “Why did you choose to participate in the Organics Collection Pilot Program?”

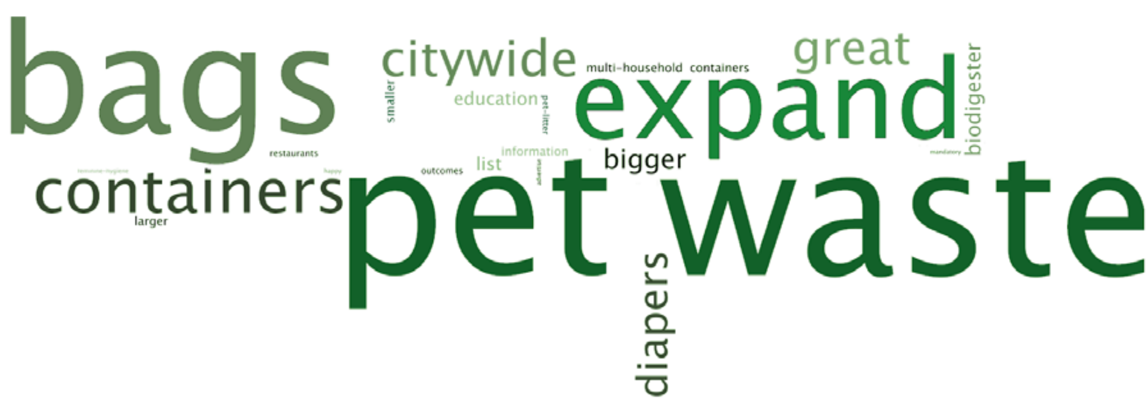


**Figure 11**: Word cloud of responses to survey question 9, “How do you think the Organics Waste Collection Program could be improved?”

**B. Survey questions:**

1. When did you begin to participate in the Organics Collection Pilot Program?
    a. 2011 b) 2012 c) 2013 d) 2014

2. Why did you choose to participate in the Organics Collection Pilot Program?
3. How would you rate your ***experience*** as a participant in the Organics Collection Program?

| Poor | Below Average | Average | Good | Very Good |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

4. How would you rate the ***convenience*** of separating organic waste from other trash?

| Inconvenient | Moderately convenient | Average | Somewhat convenient | Convenient |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

5. Based on your experience, how ***problematic*** are the following (1 being not problematic and 5 being very problematic)
    a. Odor
    b. Space in the container
    c. Issue with bags
    d. Bugs/vermin
    e. Uncertainty of what to sort
    f. Issues with pick-up
    g. Other:____________
1. Do you feel like you were given sufficient resources or materials?
    a. Yes
    b. No
    c. *If answer No:*
        i. What resources or information would be most useful? ________________
2. How did you receive information about how to participate in the program (check all that apply)?
    a. Mail
    b. Email
    c. Program website
    d. Other participants (e.g. friends or neighbors)
    e. Other:_____________
3. What resource was the most beneficial (in terms of clearing up confusion, motivating participation, etc.)?
    a. Mail
    b. Email
    c. Program website
    d. Other participants (e.g. friends or neighbors)
    e. Other:_____________
4. How do you think the Organic Waste Collection Program could be improved?

## C. Interview notes

A. Notes from interview with George Dreckmann, Coordinator of City of Madison Recycling, October 3rd, 2014

1. How does the Organic Collection program work? What is your role in the program?
    a. Collection: Fully automated collection system, weekly every Tuesday (Monday Holiday) to make a single-track route made in one day

    i. 35 gallon black cart – household collection
    ii. More people on East Side
    iii. Now continuing to collect but not transporting to Oshkosh
  b. Transportation: Transfer station where they separate and place in wood shredder
    i. Filter/trammel screen is used to process the food and take out the plastics by removes anything over an inch in size
    ii. Semi-trucks to Oshkosh are only filled to 20 tons capacity (Expansion available)
  c. Treatment: Process in Oshkosh and supply electricity for UW-Oshkosh

2. Is there a model that this program is being based off of, like a similar sized city?
   a. Portland and San Francisco- collection standpoint
      i. Already have the third bin- collection infrastructure, High Cost
   b. Toronto example of a good city digester Evolving more into cities
3. What neighborhoods are involved now? What neighborhoods will be involved with the expansion?
   a. Expansion in next spring due to fall pick-up and winter clean as well as shortage in staff
4. How were neighborhoods chosen?
   a. Expanding to many different neighborhoods. (Monday and Wednesday eastside and Thursday Friday west)
   b. More people than they can handle on East but can recruit about 100 more on Westside
   c. Business- expanded to Hy-Vee, Mertier hospital, and UW hospital, 1,600 household, 22 new restaurants (working on adding State Street)
5. Why was a dry fermentation biodigestor chosen as opposed to the other options? Why aren't we looking into co-digestion (adding food scraps and manure)?
   a. Oakland - WET
      i. Has the capacity to have to bring scraps to digester
   b. Madison wastewater plant-WET
      i. Still on the table to collaboration
      ii. Collection program is at 30percent solid content and the digester only can handle 6percent soiled content. NEED a lot of water. Strict regulations due to Human waste
      iii. Dry- Plastic can decompose, Easier to expand the site, digests more solid content, more expensive?
6. Has it been hard to get people to participate in the program? How are you encouraging people to get involved?
   a. Direct communication- snail mail, Email and surveys, more people want to participate- very popular, a lot of interest
   b. People involved in program are very enthusiastic and going above 15,000lbs trash expected but now transporting 20,000lbs
7. What are the benefits of the program so far?
   a. A lot of interest- above and beyond expected
8. What are the challenges that you have encountered in the program so far?
   a. Money: Surveys, "Staff of none", Collection process cost increase to set up a new system- expensive transition from throwing things away

b. Infrastructure: Low disposable cost, third bins is going to be an issue
c. Individual issues: Odor, summer month increase smell and insects- many stopped in the summer and continued in colder months, space for third bid.**Need to make tips- freezing organics to reduce smell

9. Could you give us more information about the proposed site for the digester in Madison? Are there people that live on the/ near the site? What kind of impact could the digester have on the community?
    a. Proposed site: Far eastside by Walmart, Mayor hasn't approved yet, ideal spot because it by a city garage and is passed by the eastside garbage trucks
    b. Consume 30,000 to 50,000 tons of trash
    c. Need staff and more wear and tear with the higher about of trash
    d. Best used of biogas will be Compressed natural gas (CNG) for cars
        i. CHG- most environmental friendly option
        ii. Electricity not as beneficial but use to self-sustaining the unit and city of garage
        iii. Capture waste heat to heat and cool the plant
        iv. Double efficiency - 90percent
    e. Impact: Small amount of sound, smell, and/or light pollution, traffic etc. Quick opening and closing doors with reverse door handling system draws outside in as they open to prevent odor from leaving
        i. Air goes through filter to remove odor- EXPENSIVE
        ii. Operating 7pm to 5am
10. What is the ideal outcome for the program?
    a. Diverting 30,000lbs from landfills
    b. Decreases emission and leachate problem
    c. Taking food waste to create a product used to grow food through returning organic material to the soil
        i. Issues- Where the soil amendment goes? Where will the fertilizer go?

B. <u>Notes from interview with Brian Langolf, Director of Biogas System at UW- Oshkosh Digester, 10/13/2014</u>

1. Can you walk us through the steps of exactly how the Oshkosh digester works?
    a. Pretreatment: mix contains straw, bedding, and food waste and this is mixed together on the bay floor (50percent straw and bedding, 50percent food waste – (this is an approximation)
    b. Collection processes and sorting of organics: Throughout the week trucks bring in waste 150 tons per week, 40-60 tons of food waste per week
    c. Treatment:150 tons loaded into digesting chamber, spray nozzles soak the solids continuously (every 20-30 minutes), 400 tons in the bay, run on a 28 day cycle to allow for fermentation processes, use of digestate to put on the new waste to prepare it for the chamber, batch fed digester not continuous, bedding and straw are used to add structure, but do not lead to higher yields
    a. Processing: operation runs on mesophilic conditions-30-40 degrees C and the benefits of this was the increased flexibility to temp change, rising biogas is channeled through pipes into a biogas bag that serves as place for the gasses to be

mixed to create a homogenous sample (6 sources of biogas- 4 chambers, waste water treatment plant and the percolator),from dry anaerobic digestion the quality of biogas is at 55-60& methane and the percolator is 60-70percent methane and the sewage plant 62-65percent, percolator is essentially a wet digester- 120 gallon tank and the exact number fluctuates depending of substrate, but what is in there is recycled to be used again-no fresh water being added, the percolate helps kickoff fermentation processes as well as buffer acidity, percolate =2-3percent solids and the solids are a mixture of organic and inorganic materials that are passed through a roto cutter (large industrial garbage disposal), the water is drained from the bay and chambers and channeled into the percolate holding tank for re-use

   b. Energy use: 50 percent methane is minimum to use the biogas in the engine, the gas is chilled prior to being channeled to the engine in order to remove moisture, CHP is 98percent efficiency due to excess heat not being utilized, around 300 kilowatt hours per year is produced from the plant and that can produce electricity for around 200-220 American households, 8-10percent of the Universities electricity comes from the digester
   c. By Product: digestate is composted for 60-80 days and then used for organic topsoil (not truly organic) à Zilgis does the composting of digestate
   d. Dry vs wet digester: dry does not need as much processing and so there are lower production costs, first industrial scale dry digester in USA, nutrients to not need to be added in a dry digester
   e. Biofilter : 50 ft. by 15 ft. container with volcanic rock and bacteria that removes odor and is long living and new levels can be added if odor increases, facility is negatively pressurized to keep the smell contained
2. What were the initial intentions for the digester?
   a. Energy production, educational purposes and to increase Oshkosh's sustainability
3. How significant has the impact been on diverting waste to landfills in Oshkosh?
   a. In terms of landfill capacity and reduction of GHG emissions from decomposition in the landfill, they process around 10,000 tons of organic waste annually and this is waste that is being diverted from the landfill which reduces methane and gas emissions.
4. Apart from the university and the pilot program in Madison, where is the waste coming from?
   a. Wal-Mart, UW-Oshkosh, Madison, two farm inputs
5. How has the community responded to the program?
   a. Very positive- not much resistance,
6. What are the challenges of the digester?
   a. Challenges: being the first of its kind (odor control, heat), contamination of waste streams especially coming from Madison ( Madison brings 20 tons of waste per week, which is only 10percent of their capacity), issues with education the importance, 10 year payback, they are paid a peak rate for their energy which was around 0.08 cents per kilowatt hour, After supplying heating needs to the plant, the excess heat is not being used productively, but is released to the atmosphere—this is a spot for much improvement, goal is to get more value for the end products digestate or electricity or heat etc., there is no perfect system/type of

digester so you must look at the feedstocks available to decide which technology to use.

C. Notes from interview with Whitney Beadle from BioFerm, October 17th, 2014

1. How certain is it that there will be an anaerobic digester built in Madison?
    a. The city is set on it, but exactly when is still to be determined. There are no contracts in place at this point, but aiming for 2016-2017. Pilot was considered to be successful, although there were issues with contamination (bags, diapers, etc.). Was deemed a problem for the UW-Oshkosh's compost contractor who was not equipped to separate contamination. Normally with dry AD, this is part of project planning. In other words, the contamination, although not desired, is not a problem for BIOFerm system to function properly. Contamination, however, is more problematic for other types of technologies.

2. Does BioFerm have an established contract with Madison for the construction of the anaerobic digester?
    a. No. There are no established contracts and no bidding process done yet
    b. Since BIOFerm is located here in Madison to offer a high level of support and our process is precisely designed to manage SSO material, we hope that will be considered in the selection.

3. What do you see to be the future of anaerobic digestion as a means of producing energy and as waste management solution?
    a. "AD has real place because we are living in a nation that struggles with waste management issues. We have so much food waste going to landfills—it is the number one contributor. So, if we can divert that and make energy instead…" Landfills and waste haulers are "green-washing" their organic collection as an environmental solution. In reality, varying amounts of gas are actually recovered; much fugitive methane gas is released to the atmosphere. Nutrients will never be recovered to build soil.
    b. The infrastructure needs to be established.
    c. "A benefit of AD as a means of energy production is that you can also make CNG, which is a unique thing for renewable energy, for switching over vehicles to that fuels sources, so that we are less dependent on foreign oil…"

4. What are the design parameters for Madison's anaerobic digester? Why were these specific parameters deemed ideal for Madison? (E.g. temperature conditions, batch versus continuous fed, dry versus wet etc.)?
    a. It is probably going to be a dry digester due to the nature if the material sampled to date. Dry total solids (TS) of around 30% observed in the pilot program. Dry digesters operate from 25% TS and up. Wet digestion would require dilution and much more pre-processing.
    b. Dry AD has low energy consumption in the process, no internal moving parts, therefore lower maintenance. BIOFerm's latest systems allow for combined wet/ dry hybrid technology. Dry AD uses a front-end loader to put material in the fermenter; this is standard equipment at every waste facility.
    c. Dry AD is in batch operations, this is very biologically resilient. Large continuous systems come to a complete stop if there are any maintenance or biological/ mechanical

disruptions. This is one of the main reasons why many cities have opted for BIOFerm technology.

d. Batch method is better for tracking material throughout entire process from receiving to final curing.

e. Although it is possible to operate a BIOFerm system at higher temperatures, mesophilic temperature operation (around 38C) is more suitable for northern climates and batch operations. There are nearly four times as many species of organisms thriving in mesophilic temperature range than the thermophiles range (50-55C).

5. We are interested in comparing the proposed anaerobic digester in Madison with the anaerobic digester in Oshkosh. What differences need to be considered in designing Madison's digester? For example:

a. Several factors. BD1 (in Oshkosh). 8,000 T/year. About as low as a dry can handle. Madison hopes to do 30,000 T/year and expand to 50,000 T/year. BIOFerm has reference facilities in Great Britain and Europe at this scale and greater. The system is expandable and the City would consider that difference of scale in the design considerations.

b. Madison is doing household collection, along with commercial. When collecting from households, there tend to be more contaminants that will hopefully diminish over time. Education must continue to be a strong part of the program. These contaminants are not problematic for the digester, but create an additional operation step in the post-digestion process. Post digestion screening is typical for SSO.

6. Based on your perception on the situation in Madison, what are the most appropriate end products of anaerobic digestion? (E.g. electricity, compressed natural gas, heating etc.)

a. "Compressed natural gas (CNG) make the most sense at this point"

b. WI doesn't have the most favorable energy sell-back rate, which is a huge challenge for technologies such as AD, but also wind and solar. It is discouraging for renewable energy companies.

c. "Rates are not very favorable right now for selling-back. However, for CNG the sell-back rates stay pretty constant and very favorable"

d. Potential for use in municipal fleets for CNG vehicles, because they travel short distances, no issue of "Is there going to be a fueling-station nearby?"

7. What do you see as being the most appropriate use for, or disposal of biosolids once the digestion process is complete? (Fertilizer? Compost?)

a. "Biosolids" is an industry term specifically for municipal wastewater sludge. Please be careful not to use that to describe solid digestate from this process.

b. Initially were looking into the feasibility of composting, but that is still to be determined. Nutrient recovery for fertilizer additives is a great first step and composting/ screening the rest of the material is the best option for keeping the material out of the landfill.

8. What kind of policy could promote anaerobic digestion in Wisconsin? (e.g. buy back rates)

a. "Yes, absolutely. Buy back rates for utilities." Utilities in Madison just approved a rate change that will be harmful to AD. It would increases the base payment and dis-incentivizes conservation and renewable energy.

b. "We don't need a ton of subsidies, but just need a even playing field"

c. Non-renewable fuels are not covering all of the costs of production, externalities such as resource depletion (extreme water usage/ sand-mining for natural gas/ cooling water

for nuclear reactors), natural habitat destruction (contaminated drinking water with methane from fracking, open-pit coal and frack sand mining), greenhouse gas release (severe climate change, species elimination), security (military escort of foreign oil tankers/ nuclear waste security) and public health costs (particulate matter, asthma, mercury poisoning) are all passed along to the public. A revenue-neutral carbon "tax" or fee would change the game for all renewable energy.
d. Fossil fuel industry receive a tax benefit when a resource is depleted, in other words, the asset (coal, natural gas or oil reserve) is 'depreciated'. Tax code should be changed to where extractors must pay when a resource is forever taken from the land; policy toward renewables and a circular economy will reverse very quickly.
e. CNG fueling stations are popping up in WI. Having this infrastructure is helpful in facilitating widespread adoption. Some at Kwik Trip stations

9. What is the expected payback time for the cost of constructing the biodigester?
    a. Will be determined once a more final proposal is established as it varies by company, etc.
    b. What are the specific estimates for methane yields, heat production, emissions, costs, and capacity etc. for an anaerobic digester for Madison?
        d. She is unsure but believes she can find some ballpark estimates.

10. What site has been selected for the location of the anaerobic digester and what potential impacts to foresee for those that live nearby?
    a. The site the suggested last year is adjacent to the city fleet services. Near Nakoosa Trail on the East side
    b. Drawbacks for community: odor and vehicle traffic
        i. Cites Oshkosh: doesn't smell outside; it is located very close to business, schools and retirement homes; proper systems are in place to minimize odors.
        ii. Having a dry, enclosed AD system, with air quality management mitigates odor.

11. How would you address these concerns?
    a. Haven't developed a plan for this yet but may look into public forums where people can come and ask questions.
    b. Option doing tours of BD1 with members of the community that are concerned
    c. Option of distributing literature

12. Any drawbacks of dry fermentation AD vs. wet?
    a. Not that she can think of. In this case, it makes overall sense.

## III. Business interview questions:

A. <u>Notes: Interview with Adam from Ian's Pizza on Francis, November 18th, 2014</u>

1. When did you begin to participate in the Organics Collection Pilot Program?
    a. About a year and a half ago. They were allowed in the pilot even though they are not in the pilot area. Before participating in the pilot, they composted through FH King's bike composting program in the summer and also contracted a private composting company.
2. Why did you choose to participate in the Organics Collection Pilot Program?
    a. "We sought out all of that on our own… We were the ones initiating all of that." One of Ian's core values is giving back to the community. A large part of this is

environmental. Some examples of this are that they use simple cardboard instead of corrugated pizza boxes and they offer compostable silverware. “We have a triple bottom line: profit, people (i.e. employees) and planet”. In the last three years they have really focused on becoming a more environmentally sustainable business.

3. Can you describe your *experience* as a participant in the Organics Collection Program?
    a. In response to question about communication, said that hasn’t gotten too much but that “it (presumably their participation) was going fine.” (I don’t know if that really works here but I just put it down because I have it.)
4. Based on your experience, have you experience potential inconvenience? (Odor, Space in the container, Issue with bags, Bugs/vermin, Uncertainty of what to sort, Issues with pick-up)
    a. One issue is space in the container. They have 5 bins, but if they fill up, they have to throw the excess in the dumpster. They produce a lot of compostable materials; everything in the “back of the house” is compostable and could be composting much more.
    b. In terms of odor, it is a bit of a problem, especially in the summer. The main issue here is that the bags start to break down even before they are collected, so leakage and odor occurs. “Pretty odiferous”
    c. No real issue with flies/bugs because they leave the bins outside.
    d. Bags have been an issue. The bags are “really expensive” and “not very durable”. Received donated bags for the first year, had to get own after. They have adopted a new method to reduce number of bags needed: use non-compostable bags behind the counter and just dump the content of those bags into compostable bags before disposal. George did not recommend any specific source to get good, cheap bags but Adam didn’t consider this to be a problem.
        i. For a while when they didn’t have the bags, they stopped collecting. The program contacted them saying that they noticed they hadn’t been doing it--shows that the program is following up
    e. Pick up: sometimes they don’t come? for example this week they didn’t come. Also when the bins are sitting out front for long people will treat them as trash bins and throw inappropriate materials in the bins.
    f. Uncertainty: Has had some uncertainty about whether some little things could be included such as tape. For most other issues, “it just comes down to education of the staff.”
5. How have you received information about the program?
    a. At beginning, got quite a bit of information from the program, since then, not so much info from the program. If he has a question, he uses the internet to look it up.
    b. “There hasn’t been that much communication but it’s working fine. Most of the information I need I could just look up online.”
    c. Doesn’t really need or want more information
6. How have you integrated the program into your everyday business practices?
    a. Yes. It comes down to education of the staff. They have also just incorporated it into procedure (For example, only have compostable bins in the front and normal waste bins in the back of the kitchen. Makes employees make conscious effort to

dispose of something in the normal trash. They also have almost entirely compostable materials in the front so there is less risk of contamination in compost bins.)

   b. It is not challenging to get employees to do it, although they have struggled somewhat in getting employees with different cultural backgrounds on the recycling train. “Honestly the biggest issue has been with Spanish speaking cooks where they come from cultures where everything goes in the trash, but they are getting it slowly which is exciting.” Adam would sometimes just stand next to employees that were not composting to point out exactly what needs to be disposed of where.

7. Have you done anything to promote this program as far as advertising for your customers?
   a. Would be interested in having some way to advertise participation to customers.
   b. Not so much to attract customers, but so that customers know that something like that is happening. That it is a possibility.
   c. Would be interested in a decal or something for the window
   d. “I think it would be good to put something up in the window just to get people to know that it’s an option.”
8. Do you dispose your trash through the City of Madison or through a private waste company?
   a. It is lowering cost of disposal in terms of reducing their coverage (the amount of extra waste beyond capacity of dumpster. Charged for this)
9. How do you think the Organic Waste Collection Program could be improved?
   a. They could actually compost more than current capacity in the program
   b. They would like to be able to compost in the front of the house too (i.e. customer’s waste). “That would be awesome. Still, he recognizes that strict composting regulations “won’t be followed at bar time”.
   c. Previous composting company had a filter, so it could accept the whole bag and there wasn’t as much concern about contamination. Something like this would be really helpful and would reduce upfront cost for businesses to participate in programs like this.
   d. If it could be a citywide program that collected waste multiple times a week that would also be helpful.

B. Notes: Interview with Julie King and Brenda Baker from Madison’s Children's Museum November 18th, 2014

1. When did you begin to participate in the Organics Collection Pilot Program?
   a. Museum started the pilot program in 2011
   b. Brenda- “We approached George to get involved… We were the first business to get involved”
2. Why did you choose to participate in the Organics Collection Pilot Program?
   a. Julie- “We believe that composting is a big part of our mission”
   b. B- “ We are a teaching institution and want to get students involved in a cradle to grave methods”

    c. Both- “ The museum’s education component aims teach all visitors children, parents, adults about the composting”

3. Can you describe your ***experience*** as a participant in the Organics Collection Program?
    a. Julie- “ Absolutely positive”
4. Based on your experience, have you experience potential inconvenience?
    a. (Odor, Space in the container, Issue with bags, Bugs/vermin, Uncertainty of what to sort, Issues with pick-up)
    b. Brenda- “ There is a communication factor when dealing with new staff, volunteers, Roman Candle (different waste streams)”
    c. Julie- “ If we won’t part of the program all that waste would be in the landfill” (10 bins full)
        i. Mostly garden waste---- little food scrap and even smaller amount of waste from Roman Candle
5. How have you received information about the program?
    a. Direct communication with George
6. How have you integrated the program into your everyday business practices?
    a. Has it been challenging to motivate employee to participate?
        i. Brenda- “ We could do a better job placing program in staff manual”
        ii. Julie- “ Increase signs and bins”
        iii. “ All participants are excited”
7. Have you done anything to promote this program as far as advertising for your customers?
    a. Do you see this program as something that customers would be interested in?
        i. Very excited about CORE- want to spread the word
        ii. Brenda- “ certifications are very important for businesses”
    b. If a window decal or other form of advertisement were provided through the program, would you be interested in using this for your business?
8. Do you dispose your trash through the City of Madison or through a private waste company?
    a. Does this program lower your disposal fee?
        i. Throw waste through private companies
        ii. “We are absolutely saving money and this program should be used by other companies”
9. How do you think the Organic Waste Collection Program could be improved?
    a. Create wastebaskets for public places that can be used at events- also having large compostable bags that can fit in a large bin
    b. “We suggest the program to host classes and workshops for new participates to get people excited and fully informed in the program”
        i. Brenda- “ It will be harder for people not environmental conscience so we need to have education”
    c. “Giving people different household bins options, maybe having a attractive stainless steel bin for an extra free”
        i. Providing options!
    d. “ Bigger Bins for business”
    e. Brenda- “ Expand program to schools”

C. <u>Notes: Interview with Kris from Fair Oaks, November 21st, 2014</u>

1. When did you begin to participate in the Organics Collection Pilot Program?
    a. 2011- very involved and knowledgeable about the program
2. Why did you choose to participate in the Organics Collection Pilot Program?
    a. My husband works for the streets divisions department and compost at home
3. Can you describe your ***experience*** as a participant in the Organics Collection Program?
    a. "Worked very well"
    b. "Train everyone and it becomes just habit"
        i. Full system- separate bins in kitchen and bins for consumers
4. Based on your experience, have you experience potential inconvenience?
    a. Lack of big bags
    b. "Not worse than any other garbage"
5. How have you integrated the program into your everyday business practices?
    a. Has it been challenging to motivate employee to participate?
        i. "Train everyone and it becomes just habit"
        ii. " Its habitat- train new people but not a big deal"
6. Have you done anything to promote this program as far as advertising for your customers?
    a. Do you see this program as something that customers would be interested in?
        i. " Yes, I do tell people we are in this composting program"
    b. If a window decal or other form of advertisement were provided through the program, would you be interested in using this for your business?
        i. "Yes, it might help to increase consumers"
        ii. " If we we can do it here, it would be easy to do it at home"
7. Do you dispose your trash through the City of Madison or through a private waste company?
    a. " Don't use a dumpster but its a change in conscience"
    b. " Worst having to have one big dumpster"
8. How do you think the Organic Waste Collection Program could be improved?
    a. "Provide more big bags for business"
    b. " Should offer all types of bags"/ " it takes us too much room to have many bins"
    c. Expand- " I'm ready to do it at home"

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