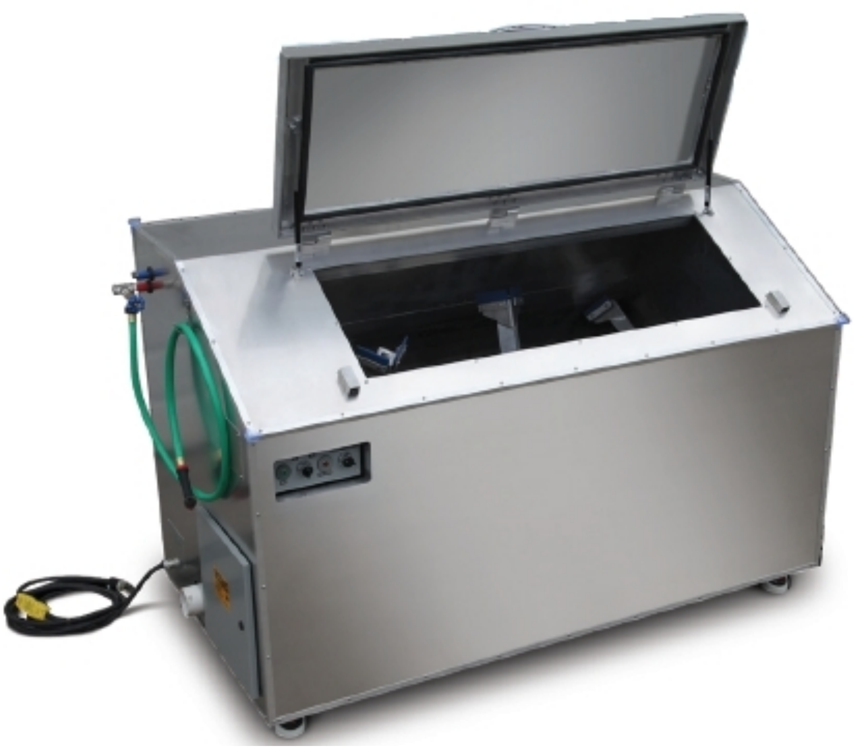
On-Site Systems for Processing Food Waste

A Report to the Massachusetts Department of Environmental Protection



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Executive Summary

In 2014, the Massachusetts Department of Environmental Protection (MassDEP) will introduce a statewide disposal ban on food waste that will impact the approximately 3,000 institutions in the Commonwealth that produce one ton or more of organic waste per week. Some institutions may choose to have their organic waste hauled away and processed off-site, while others are looking at on-site solutions to managing food waste. This report examines three types of technologies – 1) Non-biological systems, 2) In-vessel dry composters, and 3) Biological liquefaction (or wet systems) – to provide affected institutions with information useful in making such choices.

Non-biological systems use mechanical processes and heat to remove water and reduce the weight and volume of food waste. *Pulpers/shredders* grind food waste and remove water content, producing a pulped product with the consistency of coffee grounds. This product can be sent off-site for processing or used as a feedstock for other on-site systems. *Dehydrators* use heat and mechanical processes to break down food waste into a dry, sterile, odorless biomass product with the consistency of sawdust. This product is suitable for use as compost feedstock, and – after testing – in some instances may be used directly as a soil amendment.

In-vessel dry composters are a high-tech form of traditional composting, utilizing carefully controlled mixing, aeration, temperature and moisture to accelerate the natural decomposition process. Some systems require the addition of a patented blend of micro-organisms or nutrients to function. Processing time varies from 14 days at the high end to just 24 hours at the lower end. While manufacturers claim these systems produce soil-ready compost, in some cases the output of these machines has been found to need further treatment before it is soil-ready. Testing is recommended prior to soil application.

Biological liquefaction ("wet") systems grind food waste and mix it with water and patented micro-organism or nutrient mixes. This accelerates the decomposition process, causing most of the food waste to turn into a liquid effluent that is discharged into the municipal wastewater system. While manufacturers claim that this effluent is safe as discharge, some sewer districts are reluctant to allow their use. Independent tests have indicated levels of biochemical oxygen demand that exceed most municipal wastewater standards. Institutions should consult with their local wastewater district before considering use of this type of system.

This report identifies considerations for institutions exploring on-site systems:

- Calculate return on investment based on current waste hauling costs and the electricity, water and sewer use of the particular system.
- Calculate physical space and utility requirements of the system
- Conduct a waste audit to help institutions understand their waste profile and develop systems to ensure that "pure" food waste is available for the on-site system.
- Consider likely points of failure of an on-site system and develop contingency plans.
- Decide how the end product of on-site systems will be managed with an eye to preparing it for beneficial reuse.

MassDEP could also consider the following steps as it assists regulated institutions and advances the state of understanding of these systems:

- Host a vendor fair to allow representatives of affected institutions to meet with vendors for on-site systems, as well as vendors of ancillary products and organic waste haulers.
- Work with local universities to perform analyses of the end products of various on-site systems and foster greater understanding of the applications for these products.
- Partner with local universities to carry out performance testing of on-site systems with regard to waste volume reduction, operating conditions, and electricity and water use.
- Conducting environmental lifecycle analyses of on-site systems with respect to greenhouse gas mitigation.

While our analysis indicates that these systems are often successful ways to manage food waste on-site, we also identify areas of uncertainty, particularly with regard to the end products of some systems. We recommend that institutions considering these systems exercise careful planning and due diligence prior to purchase.

Introduction

According to the Massachusetts Department of Environmental Protection (MasssDEP), 90 percent of the 1.4 million tons of organic waste produced in the state each year is thrown away; it is either incinerated or sent to a landfill.[1] After recycling, this organic waste represents more than 25 percent of the overall waste stream, the largest percentage by volume overall.[2] To address this and other issues related to organic waste, MassDEP drafted a Solid Waste Master Plan that seeks to divert food and other organic materials such as compostable paper from the solid waste stream. One stated objective is to divert at least 350,000 tons, or 35 percent, of food waste by 2020.[3] To achieve this objective, and meet the larger goals of the Master Plan, MassDEP will impose a ban on the disposal of organic waste into landfills, to take effect in 2014 and applying to institutions generating at least one ton of organic waste per week. Affected institutions will include, for example, large-scale restaurants, hotels, hospitals, colleges and universities, elder care centers, supermarkets, correctional facilities, and food manufacturers. There are approximately 3,000 of these qualifying institutions in Massachusetts.[4]

Many institutions have already taken steps to reduce their volume of food waste. Common methods include separating compostables, recycling, and hauling organic waste offsite. However, to meet the requirements of the proposed ban, all affected institutions will need to assess their waste production and content, examine available on-site waste management technologies, ranging from composting to pulping and dehydration, and develop strategies for implementing waste-reduction plans.

While tools, resources, products and technologies to address food waste have been available and in use for some time, MassDEP identified a gap in information on commercially available

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[1] *MassDEP Streamlining Organic Waste Rules to Foster Clean Energy*. MassDEP, 2011. Web. 14 Apr. 2013. <http://www.mass.gov/dep/public/publications/0611andi.htm>.

[2] MassDEP Organics Study and Action Plan May 10, 2012

[3] "Composting & Organics." MassDEP, n.d. Web. 14 Apr. 2013. <http://www.mass.gov/dep/recycle/reduce/composti.htm>.

[4] "MassDEP Organics Subcommittee Meeting Summary." Joe Rasmussen, Ed.D. Loyola Marymount University. 9 Jul. 2012. Web. 14 Apr. 2013. <http://www.mass.gov/dep/public/committee/oscsm79.pdf> PDF.

on-site options. To provide such information, MassDEP commissioned a study by a team of graduate students at School of Public Policy and Urban Affairs at Northeastern University. Their report, *On-Site Systems for Processing Food Waste*, is intended to provide key stakeholders with information needed to make informed, site- and institution-specific decisions on managing food waste as they prepare to comply with the coming disposal ban.

For the purpose of this report, three main types of technologies were studied: 1) Pulpers/Dehydrators; 2) In-Vessel Dry Composters; and 3) Biological Liquefaction/Wet Systems. The analysis is based on a range of methods, including a literature review, vendor interviews, market analysis, data collection on products where available, site visits, and case studies. Each section of the report includes a description of the technology as well as the scientific process and principles. Each will reference the corresponding technologies and systems available on the market today with system-specific information as well as the intended results and benefits. Depending on the institution and system, considerations may include purchase or lease costs, siting, installation, training, maintenance, and needed/intended results.

Waste Management System 1: Non-Biological Volume/Weight Reduction

A non-biological volume/weight reduction approach to managing food waste relies on mechanical processes and heat to reduce the volume of food and other food-service waste (including some non-organics) by removing water, which makes up the bulk of organic waste by volume.

These systems can be broken down into two broad types:

> *Pulpers and Shredders: Waste pulping systems* first reduce the waste to slurry, consisting of mostly water, and then remove the water to create a semi-dry waste pulp of a consistency similar to coarse coffee grounds. *Shredders* grind the waste and then press out the water content, without reducing to slurry. Volume and weight reductions vary but are typically between 80 and 90 percent. In addition to food waste, these

systems can typically accept other organic and inorganic wastes including cardboard, paper, Styrofoam and plastic flatware. However, the inclusion of inorganic waste would render the output of the machine contaminated and unsuitable for composting at most facilities. These types of systems are typically installed in a food processing area or dish room, though some systems allow the water extraction unit to be located remotely. The output of these systems is not stable for long-term storage and must be refrigerated or collected frequently to prevent odors and pests.

Dehydration systems use heat to process organic wastes into a sterile, odorless organic material with the consistency of sawdust. This type of system can be combined with a pulping system to create greater total waste volume reduction and maximize dehydrator capacity. These systems are generally not designed to process inorganic waste. The dehydrated output of these machines is not compost and requires further treatment before it can be used as a fertilizer.

Technical Overview of Somat Systems[5]

The Somat Company, based in Lancaster, Pennsylvania, manufactures an extensive line of food-waste volume reduction systems that are widely used in Massachusetts. This product line includes pulpers, shredders, and dehydrators. This section provides an in-depth look at these systems, followed by an overview of some other systems on the market.

Photo: Somat Company

Somat's pulping systems reduce food waste to slurry of 95 percent water and 5 percent solids. This mixture is fed through a separate unit called a Hydra-Extractor®, where most of the water

[5] Product specifications obtained from Somat company website: http://www.somatcompany.com/products/. Follow-up email exchange with Somat company representative Herman Williams regarding system pricing, capacity and electricity usage.

is spun out and fed back into the pulper for re-use. Semi-dewatered, pulped food waste is discharged from the system, producing a roughly 8-to-1 reduction in volume. In addition to food waste, these systems are capable of processing a variety of compostable and non-compostable materials including plastic flatware, paper and cardboard, Styrofoam, and aluminum foil. Pulped food waste can either be hauled off-site or used as a feedstock for a dehydrator, composter or other on-site system for further weight and volume reductions.

Somat pulping systems come in a variety of sizes and configurations and can fit many different end-user space and capacity requirements (see Appendix A). Close-coupled units combine the pulper and the Hydra-Extractor® into a single unit, saving space, money and electricity. Remote pulping systems provide greater flexibility by allowing the pulping unit and the Hydra-Extractor® to be separated by up to several hundred yards, allowing more than one pulping unit to be connected to a single Hydra-Extractor®, and allowing the units to be located on different floors of a building. Pulping units come in two sizes: one capable of handling 1,000 pounds of waste per hour and a larger unit capable of handling 1,250 pounds of waste per hour. Because of its larger tank volume and cutting mechanism, the larger-sized pulper is often recommended for non-food waste such as plastic or Styrofoam. The company also offers smaller table-mounted pulping units with capacities of roughly 400 pounds per hour. Standalone Hydra-Extractor® units have capacities of 1,600 pounds per hour and 3,000 pounds per hour and can be attached to multiple pulpers. Because of the large number of possible configurations, the company prefers to have its engineers review the layout drawings for a project and recommend the appropriate size of system to the end user.

The Somat ES-1200 waste shredder is similar to a pulping system but does not reduce the waste to slurry. The system is capable of processing a throughput of up to 1,200 pounds of waste, both food waste and other disposables, and is recommended for small- to medium-sized facilities. This waste is shredded and then pressed to remove water, leading to a volume reduction of up to 8-to-1, and discharged into a garbage can. The shredder has the advantage of reduced water and electricity consumption compared to a traditional pulper, but is only available in a single configuration and cannot be decoupled as the pulping systems can.

The Somat DH-100 dehydrator can accept either pulped or un-pulped waste, and uses temperatures of up to 180º F to break it down into a dry, sterile, odorless biomass with the consistency of sawdust. The manufacturer claims that this machine produces a roughly 90 percent reduction in weight and 70 to 90 percent reduction in volume. If coupled with a Somat pulping system, the company claims a total volume and weight reduction of 95 percent is possible. The machine is has a rated capacity of 110 to 220 pounds per cycle, which the company claims can be increased by up to 8 times by running the waste through a pulping system first. Cycle times vary with the composition of the input and are estimated to be between 12 and 18 hours. The output of this system is classified as "sterile biomass" rather than compost. It requires additional time to break down before it can be used as fertilizer. While the company claims the end product is suitable for use as a soil amendment, additional testing should be carried out before soil application.

Factor: Cost of Equipment[6]

Depending on usage scenario and end-user requirements, Somat pulping systems range in price from just over $50,000 to well over $100,000. System prices are listed in Appendix A. Close-coupled systems, which combine the pulping unit and the Hydra-Extractor® into a single machine, have lower costs. Remote systems allow greater flexibility but can cost considerably more when the costs of pulping units and Hydra-Extractor® are combined. Smaller table-mounted grinders (which also need to be paired with a Hydra-Extractor®) cost between $26,100 and $42,000. The ES-1200 shredder is more expensive than a close-coupled pulping system of similar capacity, but uses less water and electricity. The Somat DH-100 dehydrator system is less expensive than a pulping system, but is often used in combination with other systems to maximize its limited capacity. Prices include installation and training.

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[6] Somat company representative Herman Williams. Prices are estimates and include freight and start-up. Actual prices may vary.

Factor: Electricity Usage

Energy use can be a significant ongoing cost in using such systems. Moreover, for institutions looking to bolster their overall sustainability portfolios, greenhouse gas emissions from electricity generation can offset any environmental benefits obtained from food waste diversion. Estimates of weekly electricity use, cost, and carbon emissions due to electricity generation for each Somat machine are provided in Table 1.1, below.

As suggested, the ES-1200 Dry Shredder uses the least electricity overall, followed by the two sizes of close-coupled system. Remote pulping systems, which would typically combine one or more pulping units with a Hydra-Extractor®, use more electricity overall. The dehydrator system is able to recycle most of its heat energy and uses less electricity than other systems, but is often used in combination with a pulping or shredding system so its energy use is additional to that of the other system. It should be noted that the above electricity-use figures are estimates based on a relatively aggressive use case, and should be seen as an upper bound of what these systems are capable of using rather than a prediction of what they will use in a given situation.

Table 1.1: Electricity Requirements

System	Electricity Use at Full Load[7]	Estimated Weekly Operation	Estimated Weekly Electricity Used[8]	Estimated Weekly Cost of Electricity[9]	Estimated Weekly CO_2 Emissions[10]
Somat SPC-60S (close coupled)	10 kw (208v max)	84 hours (7 12-hour days)	840 kwh	$126	655 lbs.
Somat SPC-75S (close-coupled)	11 kw (208v max)	84 hours (7 12-hour days per week)	924 kwh	$139	721 lbs.
Somat Remote Pulper SP-60S	7 kw (208v max)	84 hours (7 12-hour days per week)	588 kwh	$88	459 lbs.
Remote Hydra-Extractor HE-6S-3	5 kw (208v max)	84 hours (7 12-hour days per week)	420 kwh	$63	328 lbs.
Somat Remote Pulper SP-75S	8 kw (208v max)	84 hours (7 12-hour days per week)	672 kwh	$101	524 lbs.
Remote Hydra-Extractor HE-9S	11 kw (208v max)	84 hours (7 12-hour days per week)	924 kwh	$139	721 lbs.
Somat DH-100w Dehydrator	3 kw (208v max)	126 hours (7 18-hour cycles per week)	378 kwh	$57	295 lbs.
Somat ES-1200 Dry Shredder	8 kw (208v max)	84 hours (7 12-hour days per week)	672 kwh	$101	524 lbs.

[7] Source: Somat Company representative Herman Williams. Assumes system is operating at capacity.

[8] This is likely an over-estimate as systems may not run at full load all the time. Actual electricity usage will depend on operating conditions.

[9] Based on Massachusetts February 2013 commercial rate of 15.01 cents per KWh. Energy Information Agency Electric Power Monthly http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

[10] Based on 2011 emissions rate of .78 lbs/kwh (780 lbs/mwh). 2011 ISO New England Electric Generator Air Emissions Report. http://www.iso-ne.com/genrtion_resrcs/reports/emission/2011_emissions_report.pdf

Factor: Water and Drainage

All Somat pulping systems require a fresh water connection, and some require a hot water connection as well. The DH-100 Dehydrator system does not require a water connection, though it does require a floor drain for its condensate. The ES-1200 Shredder system uses water only for its cleanup cycle and actually consumes very little water.

Table 1.2: Water and Drainage Requirements

System	Water and Drainage Requirements
Somat SPC-60S (close coupled)	3 gpm fresh water; 3" floor drain
Somat SPC-75S (close-coupled)	3 gpm fresh water (operational usage: 60-120 gallons per hour); 3" floor drain
Somat Remote Pulper SP-60S	3 gpm fresh water (operational usage: 60-120 gallons per hour), 3" floor drain
Remote Hydra-Extractor HE-6S-3	4 gpm fresh hot water (approx. 160 gallons/cycle)
Somat Remote Pulper SP-75S	6 gpm fresh water, 3" floor drain
Remote Hydra-Extractor HE-9S	6 gpm fresh hot water (approx. 180 gallons/cycle), 6" floor drain
Somat DH-100w Dehydrator	Floor drain for condensate
Somat ES-1200 Dry Shredder	10 gpm fresh water connection required; used only for cleaning cycle

Examples of Other Systems on the Market:

Three examples of competing pulping/dehydration systems are discussed below. This list is intended to be representative of what is available on the market and is not intended to be exhaustive.

GaiaRecycle Modular Systems

GaiaRecycle, the U.S. branch of Korean company Gaia Corporation, markets a range of modular dehydrator systems in the United States. Sales, service and

Photo: GaiaRecycle

engineering support for these systems is provided by Industrial Integration, located in South Carolina with a regional office in New York. Modular systems are available in capacities ranging from 30 kilograms (66 lbs.) to 2000 kilograms (4,400 lbs.) per day, with even larger systems suitable for municipal waste processing facilities also available. These machines employ a patented “double helix” shredder blade to grind food waste as it is dehydrated and sterilized, resulting in up to a 90 percent weight and volume reduction. The end product is a sterile, odorless biomass product that can be used as a compost amendment, though the company recommends testing to determine the most appropriate application. With a rated processing cycle of between 8 and 11 hours, these machines are able to achieve greater throughput by running two full cycles per day. These systems utilize a six-step deodorization process that the company claims largely neutralizes unpleasant odors, and can be fitted with an animal-oil extractor attachment that can capture oil for use in biodiesel production[11].

Pricing on these systems is between $20,000 and $300,000 depending on size (see Appendix A). Power use is between 0.2 and 0.7 kilowatt hours per kilogram of material processed, depending on composition of the input. A 100-kilogram (220-pound) machine running at capacity every day would use between 140 and 490 kilowatt hours ($21-$74 at Massachusetts commercial rates) per week. The company offers pilot programs in which institutions can trial a system in exchange for testing and joint PR, as well as an incentive program in which institutions can have their equipment cost partially subsidized by referring others to the company[12]. Institutions interested in these options should contact Industrial Integration for information on availability.

EcoVim

EcoVim offers a line of dehydrators in capacities ranging from 66 lbs. to 3,300 lbs. per batch. As with other dehydrator systems, these units use a combination of mixing and controlled heat (180 degrees F) to break food waste down into a mulch- or

Photo: Integrated Veterans Services

[11] GaiaRecycle website: http://www.gaiarecycle.com/

[12] Source: email exchange with Jim Gosnell, Application Engineer at Industrial Integration, which provides sales, installation and maintenance of Gaia systems in the U.S.

sawdust-like sterile biomass product. These systems are capable of handling up to 20% paper and uncoated cardboard in addition to food waste. Cycle times range from 6 to 23 hours, depending on the composition of the input and the size of the machine. Like other dehydrators, these systems require only an electrical connection and a floor drain for the condensate byproduct, and do not require additives such as microbes or enzymes. Depending on the nature of the feedstock, weight and volume reductions of 83 to 93 percent are possible.[13]

According to vendor Integrated Veterans Services[14], machines are priced between $18,500 and $132,000 depending on size (not including shipping, installation and training). Shipping is FOB Long Beach, CA, and installation and training cost an additional $750. Integrated Veterans Services can assess the facility and operating procedures and make recommendations on system size accordingly. Electricity use is similar to the Somat dehydrator system described above, with the mid-sized 250-pound machine rated at 3 kilowatts. With a 13- to 16-hour rated run time, this machine could be expected to use between $40 and $50 worth of electricity per week at Massachusetts commercial rates. Integrated Veterans Services also offers financing, 2- to 7-year leasing programs, and rental programs (all service included) for 36 to 60 months. Interested institutions should contact Integrated Veterans Services (see Appendix B) for details.

The Defense Commissary Agency (DeCA) ran a pilot test[15] of two EcoVim 250-pound dehydrators in 29 Palms, California, from August through December, 2012. During this pilot test, 3,100 lbs. of food waste were reduced to 150 lbs. of sterile, dehydrated biomass, generating 310 gallons of condensate. Depending on the composition of the input, weight reductions of 86 to 96 percent (slightly higher than the range suggested by the manufacturer) were reported. Based on this, DeCA estimated that it could go from three dumpsters picked up three times per week to one dumpster picked up every other week at that location. Analysis of the output found it to be acidic (which can be easily mitigated) but high in organic matter and with a good carbon-nitrogen ratio, indicating that it would be a good compost feedstock.

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[13] Integrated Veterans Services website: http://integratedveteranservices.com/green-technology/ecovim/

[14] Information provided by Walter "Butch" Maki, CEO of Integrated Veterans Services

[15] Pilot test report supplied by Integrated Veterans Services CEO Walter "Butch" Maki. Does not appear to be publicly available online.

InSinkErator Waste Xpress[16]

InSinkErator, a division of Emerson Electric Company, markets a close-coupled waste-pulping system similar to those manufactured by Somat. The InSinkErator Waste Xpress WX-300 is designed to be installed under a table and is capable of processing 700 lbs. of liquid and solid waste (100 percent food waste or up to 50 percent disposables) per hour with a volume reduction of up to 85 percent. Waste enters the system through a sink bowl and is first pulped, then pumped into an attached dewatering unit where the liquid content of the waste is squeezed out and discharged into a drain. Pulped, partially dewatered solids are discharged into a 10-gallon waste bucket from a chute in the front of the machine. Electricity use data were not available, but a company representative estimates that the machine would cost on average less than $100 per year to operate. If accurate, this would be significantly less than a comparable Somat machine. The InSinkErator machine requires hot and cold-water connections and a connection to a floor sink or floor drain. It does not recycle water and requires between two and five gallons per minute. In comparison, Somat's SPC-75S close-coupled pulper (which recycles water) is rated at one to two gallons per minute despite having a much larger capacity. The initial price of this machine, $24,000, is lower than Somat's pulping machines, but InSinkErator machines can be found through several online retailers for less than $15,000.[17]


Photo: InSinkErator

[16] InSinkErator website and WX-300 Spec Sheet. http://www.insinkerator.com/en-us/Foodservice-Equipment/Pulper-Systems/Pages/Model-WX-300.aspx. Follow-up email exchange with company representative.

[17] For example, online retailer The WEBstaurant Store listed this machine for $13,169 in April, 2013

INSTITUTIONAL CASE STUDIES

The case studies to follow offer institutionally based insights into the use of respective systems.

Case Study 1: Harvard University's Annenberg Hall[18]

Harvard University employs a number of on-site food waste management systems to reduce the volume of organic waste being shipped off-site for composting. These include Somat remote pulping systems in Dunster Mather, Quincy and Annenberg Halls. The system installed in Annenberg Hall uses the larger size of pulping unit (SP-75S) paired with the larger sized Hydra-Extractor® (HE-9S) to process pre- and post-consumer food waste[19]. Plates that are returned from the dining hall are scraped into a water-filled channel in the dish room, which washes the food waste into the pulping unit. This unit is equipped with a grabber attachment to prevent silverware from entering the system and causing a malfunction. Food waste is pulped into slurry consisting of 95 percent water and 5 percent solids and piped to a Hydra-Extractor® located at the back of the dining hall. Here most of the water content of the slurry is removed and pumped back into the pulping system for reuse. The semi-dewatered food waste pulp is discharged through a chute into a compactor in a screened-off garbage collection area behind the dining hall. The pulped food waste is then used as a feedstock for a BioGreen 360 food waste disposer located in the Harvard Law School's Wasserman Hall, which further reduces weight and volume and creates a sterile, dry, semi-composted material that is hauled off-site and used as a compost amendment at the Brick Ends Farm composting facility.

According to Harvard staff, the Somat pulping system in Annenberg Hall has been very reliable, able to handle the dining hall's needs with very little downtime or maintenance requirements. Because of the installed grabber unit and because the system only handles back-of-house food waste, it is not susceptible to damage or contamination from unacceptable materials entering the system. The system is also much more water efficient than a traditional garbage disposal

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[18] Tour of food waste systems in Wasserman Hall and Annenberg Hall with Waste and Recycling Manager Rob Gogan and Annenberg Hall Manager Mary Lou Kearns, February 22, 2013.

[19] List of Somat installations in Massachusetts. Provided by Somat Company to Massachusetts Department of Environmental Protection.

unit, using only an estimated one gallon per minute compared to 8 gallons per minute for a garbage disposal, saving the university a significant amount of money in water and sewer costs.

The output of the Somat system is not refrigerated and is collected outside, which has led to some issues with odors and with attracting animals. The outdoor collection receptacle is tightly sealed to prevent vermin from entering and to help control odors. According to Annenberg Hall manager Mary Lou Kearns, birds were initially able to get into the receptacle through an opening near the discharge chute. This was addressed by installing a rotating brush-like device to scare the birds away. Odors were not present on visiting the site in February, though they may present more of a problem in warmer months. An ozone-generating machine was recently installed in the enclosure housing the BioGreen 360 in Wasserman Hall to help mitigate odors and fruit flies, with initial results indicating a substantial improvement.

Case Study 2: Framingham State University[20]

As a public institution, Framingham State University is required by executive order to achieve greenhouse gas emissions reductions of 40 percent by 2020 and 80 percent by 2050.[21] While landfill methane emissions are not covered under this executive order, the university is committed to composting and food waste reduction as part of its overall goal of making dining services as energy and food efficient as possible[22]. The university, along with its food service contractor, Sodexo, has a number of source reduction initiatives in place. These include tray-less dining at all dining halls, donation of servable excess food to charity, and the switch to all-compostable plates and flatware at retail locations. The university also sends its pre- and post-consumer food waste to We Care Composting in Marlborough.

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[20] Telephone interview with Ralph Eddy, Dining Services Manager, March 10, 2013 and subsequent email exchange.

[21] Massachusetts Executive Order No. 484, signed April 18, 2007. http://www.mass.gov/governor/legislationeexecorder/executiveorder/executive-order-no-484.html

[22] Framingham State University 2012 Climate Action Plan, pp. 13-15. http://www.framingham.edu/facilities/documents/climate-action-plan-2012.pdf

The university employs both waste pulping and dehydration to reduce the volume of waste being shipped off-site. Organic waste (food waste and other compostables) is first pulped using an InSinkErator Waste Xpress pulping unit. The pulp is collected in 10-gallon Rubbermaid buckets, which are covered and stored under refrigeration for between 12 and 48 hours until they can be added to the university's two Somat DH-100 waste dehydrators. These machines handle all of the university's pre- and post-consumer food-service waste as well as paper and compostable flatware from retail locations, a total of 89 tons annually. The machines are able to handle all types of food waste with the exception of large bones such as those found on a leg of lamb or a porterhouse steak. Each batch consists of two 10-gallon buckets and each cycle takes roughly 19 hours depending on the composition of the input. This is slightly higher than the 12 to 18 hours claimed by the manufacturer. According to Dining Services Director Ralph Eddy, these systems produce a final weight reduction of between 70 and 90 percent and create a stable, odorless product with the consistency of sawdust. The university ships all of this material to off-site composting and does not use any of it on its own grounds.

According to Ralph Eddy, the Somat dehydrator machines cost between $25,000 and $26,000 when they were purchased in 2010 (this model is currently priced at $32,030). Mr. Eddy feels that the machines were the best product available at the time and is very satisfied with their performance. The machines are installed inside in a loading dock area and require only an electrical hookup (AC 200v/220 50-60hz 3-phase according to the manufacturer) and a floor drain for the condensate. They do not require water or sewer hookup, need very little ventilation, and require little staff time to operate. The systems have required very little maintenance to date, with the exception of a switch that needed to be replaced. The university has not had a preventive maintenance service up to now, but plans to use one through ACE Service in Needham (the manufacturer-recommended service company) going forward as bearings require regular lubrication and air filters must be changed regularly.

Considerations and Recommendations

This analysis indicates that non-biological waste reduction technologies are generally successful at generating weight and volume reductions of greater than 80 percent without the use of proprietary micro-organisms or enzymes. However, a number of issues became apparent that should be taken into consideration by institutions looking at these systems:

Storage and disposal of pulped food waste. Unlike the output of other systems, this product is still recognizably food waste. If not stored properly–under refrigeration and in well-sealed containers–it can create odors and attract pests. Pulped food waste is *not* compost and needs to be further processed before it is ready for any sort of beneficial application. Because it has not been broken down biologically, pulped food waste will generate methane emissions if sent to landfill. Institutions interested in using waste pulping should carefully consider their storage and disposal options for pulped food waste. Institutions interested in enhancing their environmental profile should consider using other on-site systems or off-site composting to prepare pulped food waste for beneficial re-use.

Properties of dehydrated food waste. Manufacturers claim that dehydrated food waste can be used as a soil amendment. However, analysis of the rehydrated output of a Somat dehydrator at Loyola Marymount University in 2010[23] suggests that this may not be the case. When rehydrated, the machine's output initially had a low pH and experienced an initial spike in temperature. Of greater concern, the material experienced rapid fungal growth, soon covering the entire sample. These results led the Loyola Marymount team to conclude that the dehydrated product was not suitable for use as a soil amendment without additional processing. While further research into the properties and uses of dehydrated food waste is needed, it is important to restate that this material is not biologically decomposed enough to be considered compost. Institutions considering use of this product as a soil amendment should have their output thoroughly tested to ensure that it is in fact suitable for this application.

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[23] Rasmussen, Joe, Sustainability Manager at Loyola Marymount University. Slideshow presented at Biocycle Conference in Portland Oregon, April 17, 2012. http://www.biocyclewestcoast.com/2012/Presentations/Tuesday/Rasmussen_s.pdf

Waste Management System 2: Composting and In-Vessel Dry Composters

Composting is a biological process using heat and oxygen to break down and transform organic material into a nutrient-rich product. Compost, the end product, is typically used as mulch or conditioner to enrich the soil's overall structure. When properly used and applied, compost helps reduce erosion, improve and stabilize the pH balance of soil, supply beneficial microorganisms and improve overall moisture retention. [24] There are a number of composting practices ranging from low to high technology. Some of the commonly known methods on the low-tech end of the spectrum are: Windrow composting, static piles and separated bins of compost with manual mixing and aeration. [25] For the purpose of this report, this section focuses on in-vessel, dry composting systems and technologies for on-site, commercial use.

For the institutions impacted by DEP's waste ban, onsite processing is a viable cost-effective alternative to current waste management practices including landfill and incineration. In-vessel, dry composters are enclosed containers that range from small bins to tub grinders to large vertical structures. The large in-vessel composters are ideal for high-volume, high-capacity use and require advanced or high technology. Regardless of the individual design, these systems generally employ the same principles and practices. Clean, separated organic waste such as vegetables, egg shells and coffee grounds, is loaded into the vessel. Air is then removed though a ventilation system, which encourages oxygenation of the waste. If the waste is particularly wet, a bulking agent also referred to as 'brown matter', will be needed; common types of brown matter are woodchips, compostable papers and sawdust. These natural, porous materials absorb additional moisture in the vessel and help provide overall structure to the waste during the decomposition phase. [26] For the commercial composters on the market, heat

[24] "Guide to Compost." Composting Council. 19 Mar 2013. http://compostingcouncil.org-pdfupload/pdf/1330/Field_Guide_to_Compost_Use.pdf

[25] "Compost Basics." US Environmental Protection Agency. 2 April 2013. http://www.epa.gov/compost/basic.htm

[26] "Guide to Compost." Composting Council 19 Mar 2013. http://compostingcouncil.org-pdfupload/pdf/1330/Field_Guide_to_Compost_Use.pdf

and microorganisms are typically introduced to kill bacteria and pathogens. This stage is followed by a cooling and curing period. In most commercial composters, automated systems aerate and rotate the waste during the decomposition process.[27]The end product is pasteurized compost or mulch that must be tested and in some cases treated to ensure it is safe for use and application. [28]

Processing waste into usable compost extends has several benefits. On the larger, environmental level, it extends landfill life, minimizes greenhouse gas emissions, conserves natural resources and results in an environmentally beneficial end product.[29] As such, composting is one of the 'full circle' or 'zero waste' waste reduction practices that measurably minimizes environmental impact. More than the environmental benefits, however, processing waste into compost will reduce the overall volume and allow institutions to comply with the waste ban.

Overview of the Commercial Market

In-vessel compost systems are popular in Canada, Europe and Asia; there seems to be a particularly strong presence in the United Kingdom and Scandinavia. [30]

These systems, of various design and size, are gaining in popularity and being used more widely in the United States. [31]There are several types of in-vessel composters available for purchase and lease and this section of the report provides an overview of three of the better known

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[27] "Types of Composting." US Environmental Protection Agency. 2 April 2013. http://www.epa.gov/compost/types.htm#ves

[28] Issue Relating to Organic Waste Disposal. Part 1 – The Science of Organic Waste Disposal. p.3-4. Hot Rot Organic Solutions. Web Report. 2 April. www.hotrotsolutions.com/images/stories/General_docs/part%201%20composting%20context%20report.pdf

[29] 'Fast Sheet. Food Waste Composting.' Massachusetts Department of Environmental Protection. 23 March 2013. http://www.mass.gov/dep/recycle/reduce/organics.pdf

[30] Based on reviews of product information and distribution data from Tidy Planet, Big Hanna, Hot Rot and BioGreen 360 Systems.

[31] "First Rocket Composter in State Unveiled in Chatham.' *Chatham Patch*. Rao, Antonella; Silvus, Laura. Web. 14 April 2013. http://www.natradinghouse.com/imagenes/Chatham%20Unveling%20-%20First%20Rocket%20Composter%20in%20State%20Unveiled%20in%20Chatham%20%20%204-13-11.pdf

commercial systems available and installed nationally: BioGreen 360; Enviropure Dry; and The Rocket. Information is also included on in-vessel system Hot Rot, a system manufactured by New Zealand-based company, Hot Rot Organics.

Model specifications with capacity, end product, additional materials and average electricity usage for each of the systems is included the Appendix.

BioGreen 360

BioGreen 360 is a top loading, continuous feed, dry compost system that accelerates organic waste decomposition with aeration, moisture management and, unique to this system, very high levels of heat exceeding 284 degrees Fahrenheit combined with microorganisms. [32] The major difference with this unit is the reduction in waste volume and the turnaround time to create compost from organic: 'BioGreen 360 will safely reduce organic waste to 10% of its original volume in 24 hours.' [33]

Photo: BioGreen

BioGreen 360 is available in four sizes: the 250, 500, 1000 and 1500 models. [34] While size and processing capacity differ between the three models, each is designed to process food waste biologically and produce compost that is 95 percent mature and stable. [35] The smallest one of the three models, BG250, can process up to 250 pounds of organic waste and produce approximately 25 pounds of stable, dry compost per cycle. The mid-sized model, BG1000, has capacity for up to 1150 pounds of waste. The result, with a similar 5-10 percent residual waste, is about 115 pounds. The BG1500, the largest of the three models manages between 1500-

[32] Biogreen 360. 2 April 2013. http://www.biogreen360.com/how-our-recycling-food-waste-units-work.

[33] MPE Services, Inc. 4 March 2013. http://mpeservicesinc.com/images/Biogreen_Presentation_1-24-12.pdf

[34] BioGreen 360. 4 Marc 2103. http://www.biogreen360.com/commercial-food-waste-recycling-technical-information

[35] BioGreen 360. 4 April 2013. http://www.biogreen360.com/faq

1750 pounds and will produce 175 pounds of compost. [36] In all cases, the final product has an average pH level of 4.13 NOTE making it an ideal soil amendment or compost for plants requiring higher acidity such as roses, fruit trees, tomatoes and potatoes [37]In all cases, the result is a dry soil-like substance that can be stored for several months. [38]

Central to the design of all of the BioGreen 360 models is the high-tech PLC (Programmable Logic Controller) system. The PLC automatically monitors heat and moisture levels as well as the mixing and aeration processes. [39] It also serves to monitor each stage of the operation and is programmed to detect and report any problem with operation. Sensors and display screens will diagnose the problem and indicate a system failure, a stoppage or if general maintenance is needed; this is done with both light and sound. Their custom software is designed to offer remote diagnostics that can send requests for repair and service automatically. [40] Each of the three BioGreen 360 models claims low utility usage. Based on their 'FAQs' webpage, electricity costs are, on average, are $250.00. per month.[41]

While the manufacturer's website lists ample information on the science behind the system available with information on energy and maintenance costs, specific information on purchasing and installation costs are not readily available. One cost that is found on the official website is for the proprietary microorganisms [42]required for all BioGreen 360 models. These microorganisms play a critical role in the BioGreen 360 decomposition process. While costs for the first batch of the proprietary mix are included in the initial purchase price, the listed price for subsequent orders has an average cost of $1200 per year [43] and is typically replenished on an annual basis. [44]

[36] BioGreen 360 'FAQ'
[37] MPE Services, Inc. 4 March 2013. http://mpeservicesinc.com/images/Biogreen_Presentation_1-24-12.pdf
[38] MPE Services, Inc. 4 March 2013. http://mpeservicesinc.com/images/Biogreen_Presentation_1-24-12.pdf
[39] BioGreen 360 'FAQ'.
[40]MPE Services, Inc. 4 March 2013. http://mpeservicesinc.com/images/Biogreen_Presentation_1-24-12.pdf
[41] BioGreen 360 'FAQ'.
[42] BioGreen 360. biogreen360.com/who-needs-our-commercial-food-waste-disposers
[43] BioGreen 360 'FAQ'.
[44] BioGreen 360 'FAQ'.

BioGreen 360's parent company is MPE Services in California. There is a distribution and sales office is in Stratham, New Hampshire. According to MPE, 37 units have been purchased for use and in the northeastern United States.[45] Massachusetts and greater Boston installations include The Fairmont Copley, Harvard University's Law School and The Seaport Hotel. Regional installations can be found in Cleveland, Ohio's Tower City Mall and Goodall Hospital in Sanford, Maine. [46]

Enviropure Dry

The EnviroPure System produces two waste processing products, one 'wet system' and one 'dry system.' [47] The wet system will be discussed in detail in Section 3 of this report. This section is dedicated to the EnviroPure Dry (EPD) System, a self-contained, top loading unit that allows for continuous or 'batch feed' waste processing. [48] Similar to other commercial composters on the market, this system processes large volumes of waste and produces a soil like substance that can be used as compost or a soil amendment. [49]

Photo: MG Rentals, Inc.

Different from other system represented in this report, however, is the need for both natural cedar chips and a special proprietary bacteria mixture. [50] The wood chips serve as a natural bulking agent and will absorb excess moisture. According to the manufacturer's website, these can be purchased and sourced from any supplier. The mixture, trademarked as BioMix ™ and only available through Enviropure Systems, is a formula of 'natural minerals, nutrients and

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[45] "BioGreen 360: Food Waste Becomes an Oxymoron." *The Press Enterprise.* Blog. Posted on 22 February 2013. http://blog.pe.com/environment/2013/02/22/biogreen-360-food-waste-becomes-an-oxymoron/

[46] BioGreen 360. 4 March 2013. http://www.biogreen360.com/who-needs-our-commercial-food-waste-disposers

[47] EnviroPure Systems. 10 April 2013. www.enviropuresystems.com/epd.php

[48] EnviroPure Systems.

[49] EnviroPure Systems - The Technology - EPD Dry System." *EnviroPure Systems - The Technology - EPD Dry System*. 10 April 2013. www.enviropuresystems.com/epd.php

[50] EnviroPure Systems. 3 April 2013. http://www.enviropuresystems.com/biomix.php

organic growth.' [51] It is described as a natural, non-toxic, biodegradable substance stimulates and accelerates the metabolic processes. [52] The general turnaround time for producing mulch from waste with this system is between 24-48 hours. [53]

The EPD's end product, while it is mulch by product, is markedly reduced in volume at the end of the process. Based on manufacture's information, 1000-1500 pounds of food waste will only generate about 1 pound of mulch (Both 1500:1 and 1000:1 ratios were listed on their website).[54] With this amount, end-use as compost or is limited. The EPD system is designed to store mulch in the vessel, though, thus reducing the number of times it needs to be emptied and cleaned. Based on average commercial use for its size, EPD estimates the mulch will need to be removed every 4-6 months, [55] a consideration for institutions that do not have immediate use for compost or mulch onsite.

EPD has six dry system models that range in processing capacity from 220 pounds per day to 2200 pounds per day. The sizes vary; range, the smallest is 7' 2" and the largest is 17'0" in length and heights range from 4' to 8' feet high. [56] Costs for the individual systems are not listed, but every installation is custom designed and fitted. [57] The one cost listed on their website, as with BioGreen 360, is for electricity. Although costs will vary according to individual systems and institutional and use, stated electricity costs are less than $100.00. per month.[58] This company has offices in both the United States and Canada and provides service and maintenance throughout North America. [59]

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[51] EnviroPure Systems.

[52] EnviroPure Systems.

[53] EnviroPure System. 10 April 2013. http://www.enviropuresystems.com/EP%20-%202011%20Product%20Information%20Sheet.pdf

[54] EnviroPure System. 3 April 2013. http://www.enviropuresystems.com/faq.php?pg=6

[55] EnviroPure Systems.

[56] Enviropure Systems. 10 April 2013. *Food Waste Decomposition Systems.* http://www.enviropuresystems.com/EP%20-%202011%20Product%20Information%20Sheet.pdf

[57] Enviropure Systems.

[58] Enviropure Systems. 3 April 2013. http://www.enviropuresystems.com/faq.php?pg=5

[59] Enviropure Systems. 10 April 2013. *Food Waste Decomposition Systems.* http://www.enviropuresystems.com/EP%20-%202011%20Product%20Information%20Sheet.pdf

The Rocket

The Rocket is another self-contained, continuous feed unit. Different from the other models reviewed to date, this system requires 14-days to decompose the waste into mulch. If the end product is needed for agricultural use, it should be left in a covered heap for an additional 2-4 weeks to allow it to mature into safe and useable compost. [60]

Photo: NATH Sustainable Solutions

The Rocket is capable of breaking down a variety of clean organics, but requires a bulking agent. For this system, woodchips, 40mm or smaller, are required and a 1:1 ratio (waste to woodchip) is recommended. [61]Like the other models in this section, The Rocket is a continuous feed model and uses heat to decompose the waste.

The Rocket comes in four different sizes: A500, A700, A900 and A1200. [62] The smallest has capacity for 160 gallons of waste per week and required daily loading. With additions such as the macerator and dewaterer, this model, measuring 8'2" in length and 4'3" in height, can decompose 240 gallons of food waste. [63] The largest model, the A1200, is suitable for high volume on-site disposal applications. It is 23' 7" in length and 6' high. This model can process up to 1850 gallons of waste per week and with the needed accessories, up to 2,775 gallons per week. [64] This particular model weighs over 8,000 pounds, so siting is a key consideration. [65]

All four models are self-contained units, but require 'under cover' storage and a solid base. [66]

[60] Rocket Composter. NATH Sustainable Solutions. 2 Apr. 2013. http://www.natradinghouse.com/faq.php
[61] Rocket Composter. NATH Sustainable Solutions. 2 Apr. 2013. http://www.natradinghouse.com/faq.php
[62] Tidy Planet. 23 March 2013. http://www.tidyplanet.co.uk/food-waste-composters
[63] Tidy Planet.
[64] Tidy Planet.
[65] Tidy Planet.
[66] Rocket Composter. NATH Sustainable Solutions. 2 Apr. 2013. http://www.natradinghouse.com/modela500.php

The Rocket system is distributed in the United States by NATH (North American Trading House) Sustainable Solutions in New York in partnership with United Kingdom-based, Tidy Planet. [67] While relatively new to the United States market, the Rocket is gaining in popularity and use. [68]In 2011, Chatham Township Environmental Commission was awarded a $25,000 from Sustainable New Jersey and Walmart and used the funding to purchase the A500 Rocket composter. The A500 installation was the first for a K-12 school in the States. [69]

Hot Rot

Manufactured in New Zealand, Hot Rot is the last in-vessel model of this section. This system uses the same basic technology of the other systems, but is larger in capacity, size and distribution and use.

Photo: HotRot Organic Solutions

It is a continuous feed, self-contained vessel designed to process waste into compost waste enters the vessel at one end and is then turned, rotated and aerated in the central shaft to ensure the waste product is uniform and moisture and heat are both distributed evenly. This is another high-tech system operated by Programmable Logic Controller (PLC) that manages rotation, heat and aeration of the waste with its U-shaped, horizontal design with central tine-bearing shaft. [70] Different from the other systems in the report, Hot Rot is modular design allowing institutions to purchase one or more models of the same or varying sizes to best meet their waste disposal needs. [71]

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[67] Tidy Planet.

[68] 'First Rocket Composter in State Unveiled in Chatham.' *Chatham Patch*. Rao, Antonella; Silvus, Laura. Web. 14 April 2013. http://www.natradinghouse.com/imagenes/Chatham%20Unveling%20-%20First%20Rocket%20Composter%20in%20State%20Unveiled%20in%20Chatham%20%20%204-13-11.pdf

[69] 'Chatham Township Receives Grant for an A500 Rocket Composter." *PR.com*. 2 April. http://www.pr.com/press-release/261232

[70] Hot Rot Organic Solutions Product Range. 23 Mar 2013. http://www.hotrotsolutions.com/productrange

[71] Hot Rot Organic Solutions. 18 March 2013. http://www.hotrotsolutions.com/images/stories/General_docs/part%202%20hotrot%20system%20summary.pdf

The HotRot is manufactured in four sizes: the two smaller sizes are designed for on-site commercial use, managing 800 pounds to 1.5 tons of waste per day; the medium-sized unit can process up to 2.5 tons daily. The larger unit has capacity for processing 10-12 tons of waste per day and is therefore ideal for municipalities and large-scale composting facilities. [72] The daily amount of waste processed for each vessel will depend upon the content, density and volatility of the waste; for this reason, average throughout time will vary for each institution. [73]

The stated benefits of the HotRot system [74] are summarized as follows:

- End-product consistency requiring little to no storage for maturation
- Odor control
- Leachate-free
- Dust management
- Minimal noise
- Aerosol (such as ammonia) and pathogenic microorganism capture
- Minimized capital and minimal operating costs
- Electronic data tracking for reporting and compliance needs
- Modular, complementary design
- Low environmental impact; beneficial use

While prices are not available on the corporate website, other resources [75] help to provide a baseline for cost consideration. The HotRot 1206 model, with capacity to process 600-800 pounds per day, is listed as $125,000. Little to no information was on related costs.

According to their company website, the HotRot vessel is operating in 10 countries and in 23 sites. [76] Over 260 models have been installed in the Europe, Australia and New Zealand with the United Kingdom having the largest number of installations.

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[72] Hot Rot Organic Solutions Product Range. 23 Mar 2013. http://www.hotrotsolutions.com/productrange/
[73] Hot Rot Organic Solutions.
[74] Hot Rot Organic Solutions.
[75] 'Critical Considerations.' *BioCycle. p. 51.* March 2011. Retrieved. 12 April 2013. http://cwmi.css.cornell.edu/invesselcomposting.pdf
[76] Hot Rot Organic Solutions.

Containerized Composting Units

On the larger end of the in-vessel compost system is the 'containerized' composting unit. These stand-alone containers were first introduced to the market in 1992 as 'mobile, roll off containers.' [77] They have evolved from their original transport-ready design, but the basic design and process are the same. This system uses principles similar to those used in the mid-size composters, but the process is based more on air flow than temperature regulation. Because of their size, these containers can manage massive amounts of waste. They are suitable for some of the largest institutions impacted by the ban, but are best for offsite organic waste processing since size, space and location are important considerations.

Overall Considerations for On-Site In-Vessel Systems

The models presented here use the same basic process of aerobic, biological decomposition of food waste. Some, like BioGreen 360, rely on very high heat and proprietary formulas, while others like the Rocket rely more on longer periods of time to decompose waste. With similarities in the processes come the considerations of cost, capacity, staffing and maintenance, siting and placement, end product use and overall environmental contributions.

> ***Cost.*** Generally, costs were difficult to determine. The upfront capital investment in a comprehensive, onsite in vessel dry compost system is a primary consideration. Related to capital costs are costs associated with multiple system purchases, companion products such as grinders and tubs, ongoing staff training, process management and any proprietary materials needed for a particular system. Most of the systems in this section claim to be low maintenance; the labor that was required was generally limited to preparing the feedstock, filling the vessel, monitoring the PLC and emptying the vessel of the cured mulch or compost.

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[77] Green Mountain Technologies. 4 April 2013. *In-Vessel Systems.* http://compostingtechnology.com/products/compost-systems

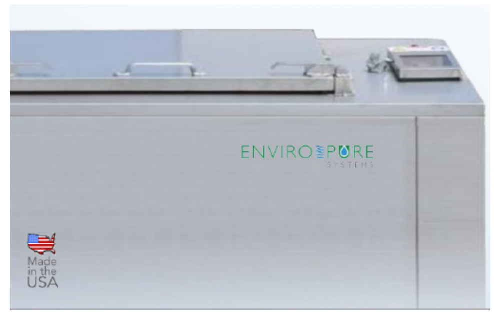
Capacity. Processing capacity is a major consideration for on-site composting. It is important for the individual institution to know the type and amount it produces on a daily, weekly even monthly basis and the corresponding system that will best accommodate the institution's needs. A waste audit is an important first step that will inform the research and decision-making process. For institutions generating 1-ton or more a week there are a number of large scale systems able to manage this volume of waste.

End Use. The end use or disposal of the final product is still a consideration. If the end product is to be used for agricultural or landscaping purposes, it is important to test the material. While most systems claim to have safe pH levels, there is general concern then end product is not fully compostable and ready for immediate use at the end of their system's cycle.

Waste Management System 3: “Wet” Systems

Overview

Photo: EnviroPure



Wet systems all maintain internal temperatures, oxygen levels, and use fresh tap water to optimize the decomposition process.[78] Where the systems may be differentiated is in their proprietary blends of additives, each of which is kept secret and supplied only by the manufacturers. These mixtures are typically characterized as "all-natural, non-toxic, biodegradable" and are designed to accelerate the breakdown of organics solids to the extent that they may be virtually eliminated in a 24-hour period.[79] The result in all cases is an effluent, or liquid waste that is then flushed into the municipal sewer system.[80] All of the manufacturers describe the effluent their machines produce as either benign or even helpful to the environment.[81]

Several companies distribute so-called “wet” systems for the large-scale processing of food waste. Producers serving the North American market include BioHitech America, EnviroPure, Totally Green, and Power Knot; others, such as Advanced Biotechnology and Eco-Wiz, list only customers in Asia. These systems all use essentially the same process, described below.

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[78] "How It Works." *EnviroPure Systems*. N.p., n.d. Web. 24 Mar. 2013. <http://www.enviropuresystems.com/works.php?pg=3>

[79] "Benefits of On-Site Organic Processing." AtSource, n.d. Web. 24 Mar. 2013. <http://www.atsource.ca/organics_benefits.asp>.

[80] "Wet System Organic Processing." AtSource, n.d. Web. 24 Mar. 2013. <http://www.atsource.ca/organics_wet.asp>.

[81] "How The Eco-Safe Digester System Works." *BioHitech America*. N.p., n.d. Web. 24 Mar. 2013. <http://www.biohitech.com/HowItWorks.htm>.

The Process

EnviroPure, which produces the EPW system, lays out its eight-step wet-system process in a promotional PDF entitled "The EnviroPure Solution":[82]

1 Load food into unit
2 Mechanical grinding process occurs
3 Food waste enters processing vessel & is stirred in the vessel
4 Air is introduced into the processing vessel water
5 Bio Mix (micro nutrient) is added
6 Filter clean cycle
7 Fresh water
8 Settle time to allow for solids Breakdown and water treatment

Although each of the systems studied here follows largely the same process, some further explanation of each step is useful for a deeper understanding of both the various systems' commonalities and differences:

Photo: Totally Green

In Step 1, the types of food waste involved are crucial to proper system processing. Importantly, these systems are calibrated to process food waste, not to dispose of inorganic materials such as plastics, metal, paper, or wood. However, these systems vary in what types of food waste can be accommodated. For example, BioHitech America's Eco-Safe Digester is not intended for the disposal of "clam, mussel and oyster shells, corn husks, fats and oils, large bones (t-bone, ham and veal shank bones), pineapple skins and tops."[83] In contrast, both EnviroPure and AtSource systems can process "bones, shells, and pits."[84, 85] Last, while the Eco-Safe Digester is able to handle frozen foods, the company cautions against disposing of too much frozen material at any one time due to the need to maintain high running temperatures.[86]

[82] EnviroPure Systems. THE ENVIROPURE SOLUTION. n.d. Web. 24 Mar. 2013. PDF file.
[83] "Frequently Asked Questions (FAQ)." *BioHitech America*.
[84] "Frequently Asked Questions." EnviroPure Systems
[85] "Wet System Organic Processing." AtSource
[86] BioHitechAmerica. "Presented to: Temple University School of Medicine". n.d. Email. 13 April. 2013. Microsoft Powerpoint file.

Step 2 is the major mechanical part of the process, whereby the food is ground using stainless-steel blades similar to the operation of non-biological food shredders. Totally Green notes that this is similar to the process of turning the waste used in outdoor composting.[87]

Steps 3 and 4 follow the waste being ground into a more homogenized mixture, the beginning of the biological process. Air is pumped into the water and waste, starting decomposition. For the sake of comparison, it is useful to note that in an in-vessel composting unit such as those described in Section 2, food-waste breakdown occurs in this stage, over a period of about 14 days.[88] In a backyard compost pile, such a process takes several months.

Photo: Digestion takes place inside an Orca Green Machine (Credit: Biocycle.net)

Step 5 is the most significant, as it distinguishes wet systems from all others on the market, with the exception of a few "dry" systems such as the EnviroPure EPD "Dry" System, which uses its patented BioMix.[89] In this stage in the wet systems, the additive feeds the bacteria already in the food waste, inducing them to reproduce and accelerating the decomposition process.[90] BioMix and its competitor products are proprietary, so independent information about their precise ingredients is difficult to obtain. This said, BioMix is described by the company as an "all natural non-toxic, biodegradable nutrient mix that is "non-persistent, non-toxic and completely biodegradable".[91] It is said to contain minerals, nutrients, amino acids, and vitamins, but not bacteria, enzymes, toxic chemicals, or masking agents.[92] In contrast, BioHitech America

[87] Totally Green. Untitled presentation. n.d. Email. 13 April. 2013. PDF file.
[88] "Rocket® Composter." *NATH Sustainable Solution*. N.p., n.d. Web. 13 Apr. 2013. <http://www.natradinghouse.com/solutions.php>.
[89] "EnviroPure Systems - The Technology - EPD Dry System." *EnviroPure Systems - The Technology - EPD Dry System*. N.p., n.d. Web. 13 Apr. 2013. <http://www.enviropuresystems.com/epd.php>.
[90] EnviroPure Systems. THE ENVIROPURE SOLUTION.
[91] EnviroPure Systems. THE ENVIROPURE SOLUTION.
[92] EnviroPure Systems. THE ENVIROPURE SOLUTION.

describes its additive as a “blend of micro-organisms and wood chips.”[93] The company goes so far as to list the microorganisms: saccharomyces cerevisiae, lactobacillus paracasei, bacillus subtilis, aspergillus oryzae.[94] These are, respectively: brewer’s yeast; a bacterium used in dairy production; a bacterium found in “water, soil, air, and decomposing plant residue”; and a fungus used to ferment soybeans for the production of miso, soy sauce, and *sake*.[95] [96] [97] [98] Totally Green, like BioHitech America, promotes its additive as “liquid microorganisms and reusable BioChips.”[99]

Steps 6-8 involve filter cleaning, adding additional fresh water, more time for the solids to decompose, and disposal of the effluent into the the sewer drain.

Benefits

The advantages of this system most touted by vendors are environmental, economic, and operational.[100] On the environmental side, two benefits have a positive impact in mitigating greenhouse gases: (1) lower carbon dioxide emissions as less food waste is hauled away by diesel -burning trucks, and (2) far lower emissions of methane as a result rotting food buried in landfills.[101] When food waste decomposes aerobically (i.e., in an environment where oxygen is present), it is considered to be “biogenic,” or a part of the natural cycle in which carbon returns to the ecosystem that originally produced it.[102] Other environmentally positive effects of wet system include expected decreases in the use of plastic garbage bags, the need for chemical

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[93] BioHitechAmerica.
[94] BioHitechAmerica.
[95] "Saccharomyces Cerevisiae." BioWeb, n.d. Web. 13 Apr. 2013. <http://bioweb.uwlax.edu/bio203/s2007/nelson_andr/>.
[96] "What Is Lactobacillus Paracasei?" *LIVESTRONG.COM*. N.p., n.d. Web. 13 Apr. 2013. <http://www.livestrong.com/article/395836-what-is-lactobacillus-paracasei/>.
[97] "Bacillus Subtilis Final Risk Assessment." *EPA*. Environmental Protection Agency, Feb. 1997. Web. 13 Apr. 2013. <http://www.epa.gov/oppt/biotech/pubs/fra/fra009.htm>.
[98] "Aspergillus Oryzae Final Risk Assessment." *EPA*. Environmental Protection Agency, Feb. 1997. Web. 13 Apr. 2013. <http://www.epa.gov/biotech_rule/pubs/fra/fra007.htm>.
[99] *ORCA Green Food Composter*. Totally Green. 29 Mar. 2013. Web. 13 Apr. 2013. <http://www.youtube.com/watch?feature=player_embedded&v=lFz14CddQFY>.
[100] BioHitechAmerica.
[101] EnviroPure Systems. THE ENVIROPURE SOLUTION.
[102] EnviroPure Systems. 2011 Product Information Sheet. Web. 13 April. 2013. PDF file.

rodent- and pest-control measures, and alleviation of odors associated with rotting food.[103] Additional ecological benefits include the diversion of wastewater from landfills to the ecosystem, although there are concerns about this, outlined below.[104]

Real economic benefits depend on whatever alternative disposal system would be used if a wet system were not in place, and are often positioned by vendors in three major areas of savings: hauling, supplies, and labor.[105] Waste generators must pay haulers to remove organics whether they are separated and sent to a composting site or mixed with other trash and delivered to a landfill. Haulers may charge stopping fees, landfills tipping fees, and container/dumpster rental fees as needed. Supplies not necessary with a wet system, such as industrial trash bags, may be less costly, but do add to the bottom line when measured on an annual basis.[106] Labor savings are debatable, but it is possible that reduced hauling and carrying of garbage to dumpsters will require fewer staff hours.

Oft-cited operational advantages include streamlined workflow, the ability to measure environmental performance, and the fact that wet systems may be incorporated into larger sustainability programs.[107]

System Capacity

In terms of food waste capacity/throughput, specific numbers depend primarily on the model, as each manufacturer produces up to nine different versions using the same wet-system technology.[108] That said, there is a range from a low of 17 lbs. per day with the GOMIXER's SG8 model all the way up to EnviroPure's system that claims to be able to dispose of up to 6,000 lbs.

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[103] Totally Green.
[104] "Totally Green." *Totally Green*. N.p., n.d. Web. 13 Apr. 2013. <http://www.totallygreen.com/>.
[105] BioHitechAmerica.
[106] BioHitechAmerica.
[107] BioHitechAmerica.
[108] "Food Waste Decomposition Systems." EnviroPure Systems, 2011. Web. 24 Mar. 2013. <http://www.enviropuresystems.com/EP%20-%202011%20Product%20Information%20Sheet.pdf>.

in 24 hours.[109][110] In a recent interview, an EnviroPure representative asserted that the company's systems are fully customizable, and that it would be theoretically possible to create a system that could digest 14,000 lbs. in 24 hours.[111] See the table in Appendix A for a more comprehensive comparison of the systems studied in this report.

Siting requirements

Another important consideration apart from throughput is the dimensions of a given system. This is particularly true in urban areas and crowded facilities in which space is at a premium. Among the vendors in this report, the smallest system on offer is the Eco-Safe 4 from BioHitech America, which weighs 683 lbs. and measures 43" deep by 36" wide and 48" high.[112] On the other end of the scale, the EPW 2000 has a footprint of 7'10" wide by 7'10" long by 9'7" high.[113]

Utility requirements

In terms of water usage and discharge, rates vary, but about one gallon of fresh water is pumped in for every four lbs. of food added to the system at the low end, with approximately two gallons of effluent discharged.[114] On the higher end of the scale, about one gallon is discharged for every one pound of food waste.[115] Some systems, such as the EnviroPure, operate with cold water only, while others need both cold and hot water input.[116][117] Following the principle of what comes in must go out, the water already present in the food waste itself is added to the pumped-in water. Thus, the effluent from the machines will be the accumulation of both those totals, which may be up to twice as much as enters as running water.

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[109] "Organic Waste Management System." GOMIXER, n.d. Web. 24 Mar. 2013. <http://www.gomixer.com/htm pages/g50.htm>.
[110] "Linda Basinger." Telephone interview. 4 Apr. 2013.
[111] "Linda Basinger."
[112] BioHitechAmerica.
[113] EnviroPure Systems. 2011 Product Information Sheet.
[114] "Frequently Asked Questions (FAQ)." *BioHitech America*. N.p., n.d. Web. 24 Mar. 2013. <http://www.biohitech.com/FAQ.htm>.
[115] "Frequently Asked Questions." EnviroPure Systems, n.d. Web. 24 Mar. 2013. <http://www.enviropuresystems.com/faq.php?pg=5>.
[116] "EPW Systems - Food Waste Elimination System." EnviroPure. N.p., n.d. Email. 14 Apr. 2013. PDF.
[117] BioHitechAmerica.

Electricity use varies across models, and can be as low as 110v, 1-phase, and 15 amps for the smallest ORCA Green™ Machines, models OG600 and OG1200.[118] With other manufacturers, base power requirements are higher, starting at 208v or 220v, 3-phase, and 30 or 40 amps.[119]

Pricing

There is a wide range of prices for wet systems, obviously depending mainly on size and capacity. There are two main ways to pay for systems, either through a complete purchase as a one-time capital expense, or as a monthly rental. Additionally, all of the systems require monthly fees for their proprietary additives (e.g. BioMix) and some include maintenance and service in their contracts. The Eco-Safe Digester 400 costs $23,000, the 800 $36,000, and the 1200 $42,000.[120] The system's vendor, BioHitech America, charges between $2,050 and $2,450 for those models' annual maintenance contracts, which include the microorganism mix, repairs, and cleaning.[121] It is also possible to rent an Eco-Safe Digester monthly with a five-year contract, which automatically includes the maintenance plan.[122] Monthly charges are $625 for the 400 model, $850 for the 800, and $975 for the 1200.[123]

These prices are consistent with those of BioHitech America's competitors. EnviroPure's EPW prices were not publicly available but were quoted by salesperson Linda Basinger as starting at roughly $20,000 for the 240 model and $40,000 for the 2000.[124] EPW rentals and leases are also options.[125] The Orca Green Machine, interestingly, is no longer available for purchase, but only as a rental. Sean Larmond of Totally Green explained that the technology is advancing so rapidly that customers might purchase a model only to have it become quickly obsolete.[126] Therefore,

118 EnviroPure Systems. 2011 Product Information Sheet.
119 EnviroPure Systems. 2011 Product Information Sheet.
120 "Price Sheet." BioHitech America. 28 Mar. 2013. Email. 14 Apr. 2013. PDF.
121 "Price Sheet."
122 "Price Sheet."
123 "Price Sheet."
124 "Linda Basinger."
125 "Linda Basinger."
126 "Sean Larmond." Telephone interview. 3 Apr. 2013.

the Orca Green Machine is only available as a rental that includes the service package and costs between $1,000 and $2,000 a month.[127]

Who Uses Wet Systems?

The sustainable disposal of food waste is a challenge for all levels of society, from the single apartment-dweller to the largest food-processing plant. The wet systems discussed here, however, are generally suitable for larger-scale waste generators, given that the machinery is set up to handle more than 100 lbs. of organics per day, much more than a household produces. Therefore, vendors of wet systems typically market their products to institutional customers such as colleges, country clubs, hospitals, hotels, mall food courts, military bases, prisons, restaurants, stadiums, and supermarkets. Here is a sample list of each vendor's actual clients, showing the geographical and sectoral diversity of wet-system placements:

BioHitech America:[128]

- Broward Convention Center
- Federal Correctional Institution Lewisburg
- Foodbank Southern Wisconsin
- Grand Canyon Lodge

EnviroPure:

- The Hyatt Regency McCormick Place[129]
- The Hyatt Regency Chesapeake Bay Golf Resort, Spa and Marina[130]
- Providence Healthcare[131]
- Scarboro Golf & Country Club[132]
- University of Nevada, Reno[133]

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127 "Sean Larmond."
128 "Customer Contact List." BioHitech America. n.d. Email. 14 Apr. 2013. PDF.
129 "Enviropure System Helps Hyatt Hotel Meet Environmental Targets." EnviroPure. n.d. Email. 14 Apr. 2013. PDF.
130 "Hyatt Regency Chesapeake Bay Resort Employs Revolutionary Food Waste Disposal System." Hyatt Regency Chesapeake Bay Resort. n.d. Email. 14 Apr. 2013. PDF.
131 "Providence Healthcare turns food waste into water." Hospital News. Feb. 2012. Email. 14 Apr. 2013. PDF.
132 "Eliminating Food Waste: Saving Money and the Plante One Food Scrap at a Time." Club Manager Quarterly. 2012. Email. 14 Apr. 2013. PDF.
133 "University's cafe wins award for commitment to environmental sustainability." Nevada Today. 6 Jul. 2012. Email. 14 Apr. 2013. PDF.

Totally Green:[134]

- Dallas Cowboys
- Emory University
- Hard Rock Casino
- Oklahoma State University
- Royal Caribbean International

Case Study 3: Markville Shopping Centre[135]

The experience of Markville Shopping Centre (in Unionville, Ontario, Canada) may be instructive for the malls and other institutions with food courts likely to be affected by Massachusetts upcoming organics waste ban. Markville was, prior to its decision to work with Totally Green, already diverting its food waste from landfill through a program that involved the pickup of 32 bins on site and two weekly pickups by a waste hauler. In October 2012, Markville contracted with Totally Green to install an Orca Model OG2400. The impetus for this change in policy was driven by several factors including:

Photo: Markville, CA

- Contamination of organics by inorganic materials such as plastics resulted in landfill disposal of organics
- Length of time food waste remained on site, which caused odors and attracted fruit flies
- Cost of off-site disposal

According to a promotional white paper prepared by Totally Green, switching to the Orca has resulted in more than $1,000 in monthly savings for Markville. Prior to the change, the shopping mall was paying $3,353 per month for organics waste hauling, a figure that was cut by 33 percent, to $2,235 with the Orca. The latter number consists of $2,100 in service charges

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[134] "Marquee Customers." *Totally Green*. N.p., n.d. Web. 14 Apr. 2013. <http://www.totallygreen.com/orca/marqueecustomers>.

[135] Totally Green. "WHITE PAPER: On-site Organic Waste Processing System Markville Shopping Centre - Analysis of The ORCA System from Totally Green." n.d. Email. 25 Apr. 2013. PDF file.

(microorganism solution and BioChips plus maintenance and repairs) as well as $79 in electrical bills and $59 in water.

On the environmental side, Totally Green claims several benefits:

- Lowering of carbon emissions via elimination of waste hauler truck trips
- Lowering of methane emissions via diversion of food waste (at least the contaminated batches) from landfills
- Gray water recycled back to ecosystem after wastewater treatment
- Cleaner facilities due to odor reduction and less material attractive to pests

Concerns

One of the primary concerns that municipalities have about wet systems is the quality of the wastewater they discharge. Specifically, the authorities responsible for a city or town's sewer system want to prevent wastewater with excessive levels of biochemical oxygen demand (BOD).[136] When BOD is too high, as is the case when pollution is present in a body of water, the microorganisms that decompose the pollution use too much of the oxygen, depriving other aquatic life such as fish and plants of it.[137]

One skeptical voice outside of government is Ian McIlane, in equipment sales for AtSource, a food-waste disposal system vendor in British Columbia. McIlane has researched wet systems with an eye toward selling them to clients. He argues that waste is pushed through the system too quickly, before complete decomposition occurs, and that the Orca Green Machine in particular showed much higher BOD levels than the company claimed.[138] He described wet systems as akin "to what wastewater treatment plants do using microorganisms." Experts he hired found that of the 15 percent solids in the food waste (the other 85 percent being water),

[136] "What Is Biological Oxygen Demand and How Does It Affect Water Quality?" FreeDrinkingWater.com, n.d. Web. 06 Apr. 2013. <http://www.freedrinkingwater.com/water_quality/quality1/1-bod-effects-on-water-quality.htm>.

[137] "What Is Biological Oxygen Demand..." FreeDrinkingWater.com

[138] "Ian McIlane." Telephone interview. 28 Mar. 2013.

most of what was being pushed down the drain and into the sewer system would likely result in BOD levels far exceeding the limits for municipal wastewater.[139]

Echoing McIlane is a study by Rasmussen and colleagues at Loyola Marymount University.[140] Rasmussen, et al, found that, using standard tests for wastewater, the Orca Green Machine's effluent was "more concentrated" than raw sewage in terms of its BOD as well as its oil and grease content.[141] The raw sewage tested at 345 mg/l BOD when it came into the plant and 161 mg/l after treatment while the Orca Green's effluent had a BOD level of 2,121 mg/l, 515 percent higher than the raw sewage.[142] Interestingly, EnviroPure, whose EPW system does not use microorganisms, claims that its effluent contains less than 30 mg/l of BOD as well as fats, oils and greases (FOGs) and total suspended solids (TSS) far below typical municipal limits.[143]

Recommendations

Above all, waste generators considering purchase or rental of a wet system should first ensure its compliance with municipal wastewater pollution limits. This will involve research into both the regulations in a particular municipality as well as an assessment of the BOD, FOG, and TSS levels in the wet system's actual effluent, as opposed to its optimal or advertised levels.

Assuming that those considerations are addressed, the waste generator must also ensure that the electrical, water, and drainage systems are adequate to meet the demands of the wet system.

Last, the question of return on investment for a waste generator is a crucial one. To effectively answer this, financial comparisons of all alternative systems—those covered by this report, and other solutions like organics haulers, anaerobic digesters, and on-site composting—must be

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139 "Ian McIlane."
140 Rasmussen, Joe. "Implementing and Studying an Innovative Food Waste Diversion Program." Loyola Marymount University. 17 Apr. 2012. Email. 14 Apr. 2013. PDF.
141 "Implementing and Studying an Innovative Food Waste Diversion Program."
142 Rasmussen
143 "EPW Systems - Food Waste Elimination System."

made. A comprehensive comparison is possible only when the wet system's capital expenses, maintenance contracts, and patented additive prices are calculated. Lastly, it is worth noting that because the additive is proprietary and kept largely secret, the potential bankruptcy of a wet-system manufacturer presents a significant risk to waste generators, who would be left with machinery that was unusable in such an occurrence.

Overall Considerations for On-Site Systems

Institutions interested in employing on-site food waste processing systems will need to consider a number of factors in making their decision. Many of these factors will be specific to the institution: siting needs will vary, and pricing and system configurations were found to be flexible and in some cases negotiable. While this report provides a snapshot of a number of technologies and systems to manage food waste on-site, it is not exhaustive and does not attempt to make specific recommendations. Rather, it is to highlight a number of key questions and considerations that institutions should take into account when looking at these systems.

1. Return on Investment

On-site food waste management systems represent a significant investment, and each institution must carefully consider the mechanisms by which this investment will be repaid. Factors that should be considered in calculating return on investment include:

- *Capital cost* of the equipment itself. This varies from tens to hundreds of thousands of dollars (see appendix) depending on system type and complexity. Leasing and rental options are also available for certain systems.
- *Installation and staff training costs*. These may be included in the initial purchase price of the system.
- *Electricity, water and sewer costs*. These vary greatly by model and can be a significant ongoing expense for certain systems.

- *Ongoing maintenance costs*. These can be difficult to estimate, as technology is changing rapidly in this field. More mature technologies, such as in-vessel composting and waste pulping, may allow for better estimates of lifetime maintenance costs.
- *Ongoing costs of additives such as microorganisms or enzymes*. These are often patented mixes that are specific to a manufacturer's systems, meaning that owners are locked into buying from the original manufacturer.
- *Staff time*. For many of the systems studied here, staff time for operation was limited to loading/unloading and occasional cleaning. On-site systems may also reduce the number of times per day that employees need to take out trash, enhancing safety and productivity.
- *Avoided costs of dedicated organics waste hauling (see below)*. Under the proposed waste ban, dedicated waste hauling is the primary alternative to on-site management. Some on-site systems may entirely replace dedicated hauling, while others will reduce the volume of waste and/or frequency of pickups.
- *Value of the end product*. The end product may be suitable for use as a mulch, soil amendment, or fertilizer, offsetting purchases of these products for on-site landscaping. For systems that generate soil-ready compost, there may be a market to sell the product as a fertilizer. The physical and chemical properties of the end product will vary depending on input, and testing should be carried out to determine the best use of the product at a specific institution.

2. Cost of Dedicated Hauling and Off-Site Composting

Under the proposed waste ban, hauling and off-site composting will be the primary alternative to on-site food waste processing. The Massachusetts Department of Environmental Protection maintains a list of active commercial and municipal composting sites on its website.[144] Commercial organics hauling rates vary by vendor, location and proximity to recycling facilities. While a detailed analysis of the organic waste hauling market in Massachusetts is beyond the

[144] Available at http://www.mass.gov/dep/recycle/actcomp.pdf

scope of this report, two Massachusetts vendors were contacted to obtain sample rates.[145] Their input is used to discuss potential savings from the use of on-site systems.

Vendor 1 services the Boston metro area and quoted a rate of $116 per ton for food waste collection and processing. An institution using this company and generating three tons of food waste per week would thus pay $348 per week, or $18,096 per year. Achieving a weight reduction of 80 percent using on-site processing (a conservative estimate) would reduce weekly waste-hauling costs to $70 per week ($3,640 per year), leading to an annual savings on waste-hauling costs of $14,456.

Vendor 2 services eastern Massachusetts and typically charges between $6 and $15 per 64-gallon tote, plus a $10 stopping fee. According U.S. EPA conversion rates, a gallon of food waste weighs approximately 7.5 lbs.[146]. An institution generating three tons of food waste per week would produce approximately 13 such totes (~800 gallons) per week. This would cost between $78 and $195 per week (or $4,056 to $10,140 per year) for hauling, plus an estimated $30 per week in stopping fees assuming at least three pickups. An 80 percent volume reduction (a conservative estimate) using on-site processing would reduce this to approximately three totes (160 gallons) per week, costing between $18 and $45 ($936 to $2,340 per year), plus pickup fees. Estimated annual savings on hauling costs from using the on-site system would be between $3,120 and $7,800. If the output of the on-site system is stable for long-term storage, the institution could conceivably accumulate this output for weeks between pickups, significantly reducing the amount paid for stopping fees.

While detailed return on investment calculations will be specific to an institution and technology, these estimated savings based on waste hauling rates do suggest that on-site systems have the potential to be cost-effective alternatives to off-site processing despite their high up-front costs.

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[145] Because hauling rates are sensitive business information, these vendors requested not to be identified by name.
[146] 412 lbs. per 55-gallon drum. *Measuring Recycling: A Guide for State and Local Governments, Appendix B: Standard Volume-to-Weight Conversion Factors.*
[146]Available at: http://www.epa.gov/epawaste/conserve/tools/recmeas/docs/guide_b.pdf

3. Physical Requirements of System

In addition to their physical space requirements, most on-site systems will require an electrical connection (typically 220 volt), access to a floor drain, and an adequately ventilated area. Some also require hot or cold water and sewer connections with a specific flow rate. Systems that can be installed outside will need an adequately sheltered area. Institutions should confirm that they have a space that meets the specific requirements of the system(s) they are considering.

4. Possible Points of Failure

It is important to identify possible points of failure; both in individual pieces of equipment and in an institution's food waste management system as a whole, and develop contingency plans for how to handle anticipated issues. Possible points of failure include the accidental introduction of unsuitable items causing machine downtime, electrical or plumbing failures, odors or vermin related either to the equipment itself or the storage of food waste, and the possibility of the original manufacturer going out of business. The latter may be a concern especially for systems that rely on patented, proprietary mixes of micro-organisms or enzymes, for which there may not be ready substitutes if the manufacturer goes out of business. Institutions should carefully assess their exposure and tolerance to these sorts of risks before committing to a given system.

5. Institutional Waste Profile

It is important to consider how your institution generates food waste in considering the suitability of on-site food waste management options. Most on-site systems (as well as composting facilities) require a "clean" stream of compostable organic waste. The presence of even small amounts of contaminants such as plastic flatware or cups can cause equipment to fail or render a batch contaminated and unsuitable for beneficial use. Controlling the purity of the organic waste stream can be easier for "back-of-house" waste (which requires staff training) than for "front-of-house" waste (which relies on consumers understanding the system and doing the right thing). Maintaining a "clean" stream of organic waste from "front-of-house" settings may require extensive consumer education, signage, and measures such as switching to compostable plates, cups and flatware. Understanding your institution's waste profile by conducting a waste audit (either internally or externally) may be a useful step in considering the feasibility of these systems.

6. Disposition of End Product

A major consideration is what will be done with the end product. If it is to be hauled off-site for processing, arrangements will need to be made for storage and pickup. If pulping/shredding systems are used alone, pickups will need to be frequent and potential issues with odors and vermin will need to be taken into consideration when setting up storage. Systems that create a stable end product may require less frequent pickups, but the end product will need to be stored in a dry location. If the end product is to be used for landscaping or gardening purposes on-site, it is important to conduct testing to determine the most appropriate use of the product and to assess the level of demand for this product on-site. If the product is to be sold or given away as a fertilizer, assessing the market and building relationships with potential buyers or takers will also be important.

For systems that discharge effluent into the wastewater system, it is important to consult with the local wastewater district to ensure that the effluent meets standards for BOD and other pollutants. Some cities, including Boston, are reluctant to allow the discharge of organic effluent into their sewer systems. While manufacturers and vendors typically claim that their products do not pose problems for municipal wastewater systems, our research suggests that in some cases these claims are inaccurate. Institutions considering these systems should seek independent analysis to support claims made by manufacturers and vendors.

Next Steps

This report serves as a starting point in gaining an understanding of the options that are available for on-site food waste processing. This said, there is additional work to be done, and we recommend that MassDEP consider the following steps as it assists regulated institutions and advances the state of understanding of these systems:

Host a vendor fair to allow representatives of impacted institutions and interested members of the general public to compare options for managing food waste. This event would include vendors and manufacturers of on-site food waste systems, as well as producers of ancillary products such as compostable bin liners, and representatives of waste haulers offering organics pickup. Manufacturers and system vendors should be encouraged to set up demo systems. This event would allow potential customers to conveniently compare their options, and would generate interest that could help vendors identify market opportunities.

Facilitate lab testing on system end products. During the course of our research we encountered a number of conflicting claims about the properties of system end products. We were not equipped to test these claims, and there was a lack of publicly available independent research on these questions. We recommend that DEP partner with an environmental science program at a local university to perform testing on samples obtained from institutions that have these systems installed. Specifically, we recommend testing whether or not dehydrated food waste is suitable as a soil amendment, determining whether the output of certain rapid in-vessel composters is fully composted, and testing the levels of biochemical oxygen demand and other pollutants in the liquid effluent of "wet" systems. While results from one system may not be generalizable to all systems of the same type, this independent analysis would provide a valuable starting point to help institutions make sense of the claims that exist.

Conduct performance testing on systems. Similarly, we recommend engaging local universities in testing system cycle times, utility usage, volume and weight reductions, noise, odors and other parameters associated with operation. This would require gaining regular access to locations where these machines are installed. Since many of these systems are installed at universities, it may make sense to pursue partnering with teams in the environmental science or engineering departments at the same university to perform the testing.

Conduct environmental life-cycle analysis. On-site systems are presented as an environmentally friendly option to manage food waste, but this claim is not well supported by independent research. While these systems can significantly reduce the volume of food waste being sent to landfill and in some cases prepare it for beneficial reuse, they often also use significant amounts of electricity and water. A life-cycle comparison of the different types of system with each other and with alternatives like off-site composting would be very useful to institutions with an environmental or sustainability agenda.

Institutions considering these systems face time constraints and a lack of independent testing and analysis to make informed purchasing decisions. Providing an opportunity to compare systems in one place at a vendor fair, as well as sponsoring independent analysis of the outputs, performance, and environmental impacts of these systems would improve the ability of Massachusetts institutions to comply with the coming waste ban and advance the state of understanding about on-site systems generally.

Conclusion

On-site food waste systems are alternatives to landfill disposal and can facilitate compliance with the proposed waste ban. These systems can be used as an alternative or a complement to off-site composting of food waste. While interviews with staff at facilities using these technologies indicate general success at reducing the volume and weight of food waste generated, a number of potential concerns also came to light. Many of these systems are relatively new to the market and have not been thoroughly tested. While our findings suggest that they can be a valuable component of an institutional food waste management program, they also point to the need for careful planning and due diligence prior to purchase.

Appendix A: Overview of Systems Studied [147]

Model	Type	Capacity	Price	Electricity Use[148]	Other Requirements
Somat Company					
SPC-60S (close coupled)	Pulper	1000 lbs./hr	$53,190	10 kw	Fresh water: 3 gpm[149]; 3" floor drain
SPC-75S (close-coupled)	Pulper	1250 lbs./hr	$55,000	11 kw	Fresh water: 3 gpm (operational usage: 60-120 gallons per hour); 3" floor drain
Remote Pulper SP-60S (requires HydraExtractor)	Pulper	1000 lbs./hr	$47,000	7 kw	Fresh Water: 3 gpm (operational usage: 60-120 gallons per hour), 3" floor drain
Remote Pulper SP-75S (requires HydraExtractor)	Pulper	1250 lbs./hr	$46,000	8 kw	Fresh Water: 6 gpm, 3" floor drain
Remote HydraExtractor HE-6S-3	De-waterer	1600 lbs./hr	$30,050	5 kw	4 gpm fresh hot water (approx. 160 gallons/cycle)
Remote HydraExtractor HE-9S	De-waterer	3000 lbs./hr	$63,910	11 kw	6 gpm fresh hot water (approx. 180 gallons/cycle), 6" floor drain
DH-100w Dehydrator	Dehydrator	110-220 lbs. per cycle	$32,030	3 kw	Floor drain for condensate
ES-1200 Dry Shredder	Shredder	1200 lbs./hr	$63,090	8 kw	Floor drain, 10 gpm fresh water (cleaning cycle)

[147] List is not intended to be exhaustive. Models and configurations not listed here may be available.
[148] Actual electricity use for a given machine will vary based on operating conditions.
[149] gpm = gallons per minute

Model	Type	Capacity	Price	Electricity Use[150]	Other Requirements
GaiaRecycle					
G-30H	Dehydrator	66 lbs./day	$20,000-$65,000 for models G-30H through G-300H	6-21 kwh/day[151]	Floor drain for condensate
G-100H	Dehydrator	220 lbs./day		20-70 kwh/day	Floor drain for condensate
G-200H	Dehydrator	440 lbs./day		40-140 kwh/day	Floor drain for condensate
G-300H	Dehydrator	660 lbs./day		60-210 kwh/day	Floor drain for condensate
G-400H	Dehydrator	800 lbs./day	$95,000-$300,000 for models G-400H-G2000H	80-280 kwh/day	Floor drain for condensate
G-600H	Dehydrator	1320 lbs./day		120-420 kwh/day	Floor drain for condensate
G-1200H	Dehydrator	2640 lbs./day		240-840 kwh/day	Floor drain for condensate
G-2000H	Dehydrator	4400 lbs./day		400-1400 kwh/day	Floor drain for condensate
EcoVim					
Eco-66	Dehydrator	65 lbs./cycle	$18,500[152]	1.8 kw	Floor drain for condensate
Eco-250	Dehydrator	250 lbs./cycle	$28,500	3 kw	Floor drain for condensate
Eco-650	Dehydrator	650 lbs./cycle	$75,000	8 kw	Floor drain for condensate
Eco-1100	Dehydrator	1100 lbs./cycle	$132,000	11 kw	Floor drain for condensate
Eco-2200	Dehydrator	2200 lbs./cycle	Needs quote	16-20 kw	Floor drain for condensate
InSinkErator					
WX-300	Pulper	700 lbs./hour	$24,000[153]	Unknown[154]	Hot and cold water supply; floor drain or sink

[150] Actual electricity use for a given machine will vary based on operating conditions.
[151] Power consumption of 0.2-0.7 kwh per kilogram processed, depending on input.
[152] Freight and staff training costs extra
[153] Can be found cheaper through online retailers
[154] Company representative claims average electricity costs are less than $100 per year

Model	Type	Capacity	Price	Electricity Use[155]	Other Requirements
		EnviroPure[156]			
EPW-120	Biological Liquefaction/"Wet" system	120 lbs./day	$17,000 - $45,000[157]	.24 kw	Biomix, 220v, 3 phase, 30 amp, cold water supply, sewer drain
EPW-240	Biological Liquefaction/"Wet" system	240 lbs./day	$17,000 - $45,000	.24 kw	Biomix, 220v, 3 phase, 30 amp, cold water supply, sewer drain
EPW-360	Biological Liquefaction/"Wet" system	360 lbs./day	$17,000 - $45,000	.24 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain
EPW-480	Biological Liquefaction/"Wet" system	480 lbs./day	$17,000 - $45,000	.24 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain
EPW-600	Biological Liquefaction/"Wet" system	600 lbs./day	$17,000 - $45,000	.24 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain
EPW-720	Biological Liquefaction/"Wet" system	720 lbs./day	$17,000 - $45,000	.32 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain
EPW-1000	Biological Liquefaction/"Wet" system	1,000 lbs./day	$17,000 - $45,000	.32 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain
EPW-1500	Biological Liquefaction/"Wet" system	1,500 lbs./day	$17,000 - $45,000	.32 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain
EPW-2000	Biological Liquefaction/"Wet" system	2,000 lbs./day	$17,000 - $45,000	.32 kw	Biomix, 220v, 3 phase, 40 amp, cold water supply, sewer drain

[155] Actual electricity use for a given machine will vary based on operating conditions.
[156] EnviroPure Systems. 2011 Product Information Sheet.
[157] According to an EnviroPure representative, EPW system prices are customized by individual installation; $17,000 to $45,000 is the range.

BioHitech America[158] [159]					
Model	**Type**	**Capacity**	**Price**	**Electricity Use[160]**	**Other Requirements**
Eco-Safe Digester 400	Biological Liquefaction/"Wet" system	400 lbs./day	$23,000	.56 kw	Microorganism formula, 220v, 3 phase, 30 amp, cold & hot water supply, sewer drain
Eco-Safe Digester 800	Biological Liquefaction/"Wet" system	800 lbs./day	$36,000	1.13 kw	Microorganism formula, 220v, 3 phase, 30 amp, cold & hot water supply, sewer drain
Eco-Safe Digester 1200	Biological Liquefaction/"Wet" system	1,200 lbs./day	$42,000	1.50 kw	Microorganism formula, 220v, 3 phase, 30 amp, cold & hot water supply, sewer drain
Totally Green[161] [162] [163] [164]					
ORCA Green™ Machine - Model OG600	Biological Liquefaction/"Wet" system	600 lbs./1-2 days	$1,000-$2,000/ month rental	.37 kw	Micro-Organism Solution & BioChips, 110v, 1 phase, 15 amp, cold & hot water supply, sewer drain
ORCA Green™ Machine - Model OG1200	Biological Liquefaction/"Wet" system	1,200 lbs./1-2 days	$1,000-$2,000/ month rental	.37 kw	Micro-Organism Solution & BioChips, 110v, 1 phase, 15 amp, cold & hot water supply, sewer drain
ORCA Green™ Machine - Model OG2400	Biological Liquefaction/"Wet" system	2,400 lbs./1-2 days	$1,000-$2,000/ month rental	.74 kw	Micro-Organism Solution & BioChips, 110v, 1 phase, 20 amp, cold & hot water supply, sewer drain

[158] "How The Eco-Safe Digester System Works."
[159] "Price Sheet."
[160] Actual electricity use for a given machine will vary based on operating conditions.
[161] Totally Green. "ORCA Green™ Machine - Model OG600." n.d. Email. 15 Apr. 2013. PDF file.
[162] Totally Green. "ORCA Green™ Machine - Model OG1200." n.d. Email. 15 Apr. 2013. PDF file.
[163] Totally Green. "ORCA Green™ Machine - Model OG2400." n.d. Email. 15 Apr. 2013. PDF file.
[164] Totally Green. "ORCA Green - The Smart Solution to Organic Waste." n.d. Email. 15 Apr. 2013

Power Knot[165]					
Model	**Type**	**Capacity**	**Price**	**Electricity Use[166]**	**Other Requirements**
LFC-50	Biological Liquefaction/" Wet" system	110-200 lbs./day	<$16,000	0.5 kw	110V, 1 phase, 10 amp,
LFC-70	Biological Liquefaction/" Wet" system	150-280 lbs./day	<$16,000	0.5 kw	110V, 1 phase, 10 amp,
LFC-100	Biological Liquefaction/" Wet" system	220-400 lbs./day	<$16,000	0.8 kw	110V, 1 phase, 10 amp,
LFC-200	Biological Liquefaction/" Wet" system	440-800 lbs./day	<$16,000	1.6 kw	208V, 3 phase, 10 amp,
LFC-300	Biological Liquefaction/" Wet" system	660-1,200 lbs./day	<$16,000	2.5 kw	208V, 3 phase, 10 amp,
LFC-500	Biological Liquefaction/" Wet" system	1,110-2,000 lbs./day	<$16,000	4.0 kw	208V, 3 phase, 10 amp,
Enviropure Dry Systems [167]					
Model	**Type**	**Capacity**	**Price[168]**	**Electricity Use[169]**	**Other Requirements**
EPD-220	Dry Compost System	220lbs./day	$17,000 - $45,000	N/A	220V, 3Ph, 30A
EPD-440	Dry Compost System	440lbs./day		N/A	220V, 3Ph, 30A
EPD-660	Dry Compost System	660lbs./day		N/A	220V, 3Ph, 30A
EPD-880	Dry Compost System	880lbs./day		N/A	220V, 3Ph, 30A
EPD-1100	Dry Compost System	1100lbs/day		N/A	220V, 3Ph, 30A
EPD-2200	Dry Compost System	2200lbs/day		N/A	220V, 3Ph, 30A

[165] Power Knot. "Data sheet for the Liquid Food Composter." n.d. Web. 25 Apr. 2013. PDF file.
[166] Actual electricity use for a given machine will vary based on operating conditions.
[167] ww.enviropuresystems.com/EP%20-%202011%20Product%20Information%20Sheet.pdf
[168] EPD Systems are customized by individual installation; $17,000 to $45,000 is the range.
[169] Actual electricity use for a given machine will vary based on operating conditions.

Biogreen 360[170]					
Model	**Type**	**Capacity**	**Price[171]**	**Electricity Use[172]**	**Other Requirements**
250	Dry Compost System	250lb./day	N/A	62 kWh per day	208/220V, 3Ph, 30A
500	Dry Compost System	500lb./day	N/A	62 kWh per day	208/220V, 3Ph, 60A
1000	Dry Compost System	1000lb./day	N/A	62 kWh per day	208/220V, 3Ph, 60A
1500	Dry Compost System	1500lb./day	N/A	62 kWh per day	208/220V, 3Ph, 60A

The Rocket[173]					
Model	**Type**	**Capacity**	**Price[174]**	**Electricity Use [175]**	**Other Requirements**
A500	Dry Compost System	80 Gallons food waste/ weekly	N/A	12 Kwh/ weekly	Macerator is recommended for increasing volume to be composted
A700	Dry Compost System	180 Gallons/wk	N/A	26 Kwh/ weekly	Macerator is recommended for increasing volume to be composted
A900	Dry Compost System	460 Gallons/wk	N/A	30 Kwh/ weekly	Macerator is recommended for increasing volume to be composted
A1200	Dry Compost System	925 Gallons/wk	N/A	32 Kwh/ weekly	Macerator is recommended for increasing volume to be composted

[170] http://www.biogreen360.com/commercial-food-waste-recycling-technical-information
[171] Will Depend Upon make, model and Installation
[172] Actual electricity use for a given machine will vary based on operating conditions.
[173] http://www.natradinghouse.com/why_the_rocket.php
[174] Will Depend Upon make, model and Installation

Appendix B: Company Information

Company	Address	Telephone/Website	Notes
Non-Biological Systems			
Industrial Integration (Gaia Recycle)	156B Landmark Drive Taylors, SC 29687	864.612.8710 (Jim Gosnell) http://www.indintegration.com	Provides US sales, service and engineering support for Gaia Recycle. Application Engineer Jim Gosnell was primary contact
InSinkErator (Emerson Electric)		1.800.845.8345 http://www.insinkerator.com	Produces WX-300 pulping system
Integrated Veterans Services (Eco Vim)	P.O. Box 22993 Santa Fe, NM 87502	505-577-2220 http://integratedveteranservices.com/	Provides sales and support for Eco Vim dehydrators. CEO Walter "Butch" Maki was primary contact
Livoli Group	52 Adams Drive Stow MA 01775	978-461-2555 http://www.livoligroup.com/	Local representative for Somat Company
Somat Company	165 Independence Court Lancaster, PA 17601	1-800-237-6628 http://somatcompany.com/home/	Produces a range of pulping, shredding and dehydrating equipment.

Biological Systems			
EnviroPure Systems	2011 West Fulton Street, Chicago, IL 60612	(312) 238-9332 http://www.enviropuresystems.com	info@enviropure systems.com
HotRot Organic Solutions	193a Durham Street, PO Box 4442, Christchurch 8140, New Zealand	+64 3-377-8822 http://www.hotrotsolutions.com	info@hotrotsolut ions.com
MPE Services, Inc.	3030 Armstrongs Dr. Corona, CA 92881	(951) 735-4418 http://mpeservicesinc.com	Manufacturer of BioGreen 360 Product info: sueb@mpeservic esinc.com
BioGreen 360	Portsmouth Avenue, Stratham, NH	(603) 772-6855 http://www.biogreen360.com	Direct sales and/or product info: bhanley@biogree n360.com,bh42us @gmail.com,pag assoc@comcast.n et,luis@lucidity.ie
Tidy Planet		+44 (0) 1625 666798 http://www.tidyplanet.co.uk	UK Parent Company for Rocket Composter Distribution
NATH Sustainable Solutions	21 North Broadway 2nd floor, Tarrytown, New York 10591	(212) 729-0757 (716) 740-0915 http://www.natradinghouse.com/so lutions.php	US-based distributor/ supplier for Rocket Composter; sales@natrading house.com
Susteco AB, Big Hanna Composter	Sockerbruket 25, 414 51 Gothenburg, Sweden	+46) (0) 3169 41 03 http://www.bighanna.com	info@susteco.se