FOOD WASTE MANAGEMENT SCOPING STUDY

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF RESOURCE CONSERVATION AND RECOVERY

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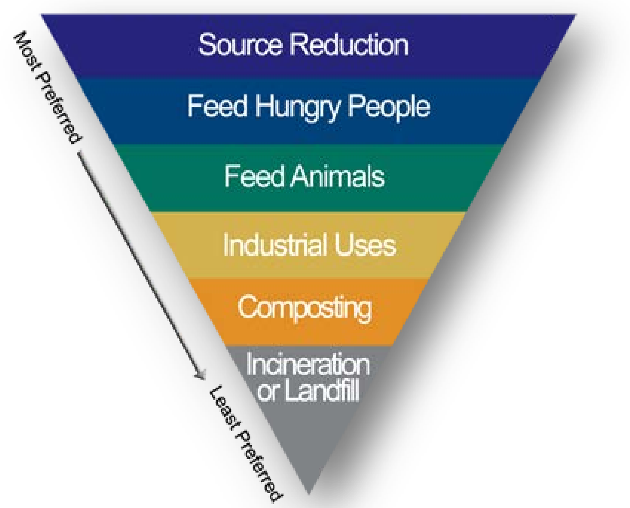
I. INTRODUCTION

To support municipal solid waste (MSW) characterization efforts, EPA conducted a scoping study on food waste and the methods by which they are managed. The end-of-life sustainable food management (SFM) techniques presented in this scoping study include practices currently used as well as emerging technologies. While the research did not result in much quantifiable data, this study provides summaries of the following SFM techniques:

- Food Donation
- Animal feeding
- Rendering
- Composting
- Anaerobic digestion
- Aerobic digestion
- Liquefaction
- Hydrolysis
- Gasification
- Pyrolysis
- Briquetting
- Incineration

The SFM techniques reviewed as part of this scoping study are not intended to be all inclusive. EPA strongly encourages the beneficial use of food waste residuals by all methods as opposed to disposal through incineration or landfilling. The SFM practices are roughly organized in Section II in order of preference according to EPA's hierarchy, as shown in Figure 1. Conversion techniques are presented in Section III. Disposal through incineration is discussed in Section IV.

Figure 1. Food Recovery Hierarchy



Although the intended focus is post-consumer food waste, information was often presented collectively for all sources of food waste. In these cases, we were unable to separate data corresponding to food waste generated at the manufacturing level from data corresponding to food waste generated at the retail or consumer level.

II. SOURCE REDUCTION

EPA's primary preference for food recovery is source reduction. This has the greatest potential for environmental benefit and cost savings.[1] Disposal costs are reduced by decreasing the amount of food entering the solid waste stream. In addition, the resources associated with producing food can be reduced if the amount of food purchased is more closely aligned with food use.[2] Tracking the amount of food waste with an assessment is a useful way to determine how best to reduce food waste at both a consumer and retail level.

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[1] Personal communication with Ashley Zanolli, EPA Region 10

[2] http://www.epa.gov/waste/conserve/foodwaste/fd-reduce.htm

III. Donation and Recovery

Apart from reducing food waste at the source, the most desirable SFM practice is to divert food waste through food donation to people, as animal feed, industrial uses (such as rendering fats into value-added materials), or composting. Organizations such as the Food Waste Reduction Alliance (FWRA), a workgroup with members from the Food Marketing Institute, Grocery Manufacturers Association and the National Restaurant Association, aim to reduce the amount of food waste entering landfills by increasing the quantity of food donated to those in need and by recycling unavoidable food waste. According to a recent study commissioned by FWRA,[3] food waste generated at the manufacturing level, typically comprising unused ingredients, unfinished product, trimmings, peels, or other unavoidable food wastes, is easier to divert from landfills because of economies of scale that allow manufacturers to recover waste at a high rate. However, at the wholesale and retail level, food waste diversion is a bigger challenge because of the logistical issues resulting from the number of locations and diverse product offerings.

Food Donation

Non-perishable or unspoiled perishable foods can be donated to local food banks, soup kitchens, pantries, and shelters. Food banks donors typically include manufacturers, grocery store chains, food service entities, restaurants, wholesalers, and farmers.

Based on extrapolated survey data collected from food manufacturers and grocery retailers/wholesalers, FWRA estimates that in 2011, approximately 335,000 tons (out of 1.9 million tons generated) were donated by the wholesale/retail sector. Liability concerns and transportation limitations are the most commonly noted barriers to food donation. Specifically, transportation costs, lack of refrigerated trucks and drivers, and chain of custody issues in case of recall were noted. Other barriers included insufficient storage and refrigeration at food banks and onsite at grocery stores, regulatory constraints (which impact, for instance, good food past saleable date or food bank acceptance limitations), and misinformation about the Emerson Good Samaritan Act which protects donors from legal liability. However, many of these barriers result from misinformation and misunderstanding and may be overcome.

Among the largest food donation organizations in the nation are Feeding America (FA) and Food Donation Connection (FDC):

- FA comprises over 200 food banks across the U.S. and supplies more than 1.5 million tons of food annually to those in need.[4] However, this includes food generated specifically for donation (i.e. non-waste) as well as food from the manufacturing and agricultural sectors. Among other programs, FA runs a Retail Store Donation (RSD) program, which coordinates the donation of surplus food from over 10,500 grocery stores representing the country's largest firms in the food retail industry. In 2012, around 450,000 tons of food waste were donated through the FA's RSD program.[5]

- FDC consists of around 250 food-service entities and restaurants and coordinates the donation of surplus food from restaurants – food that would otherwise be handled through the solid waste management system. In 2012, 18,000 tons of food waste were donated through FDC programs.[6]

Animal Feed

Depending on the proximity of food waste generators to local farms or zoos, it may be viable to recover discarded food as feed for livestock, poultry, or other animals. Some food scraps, such as coffee or foods with high salt content, can be harmful to animals, and regulations pertaining to the types of food waste

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3 http://www.foodwastealliance.org/wp-content/uploads/2013/06/FWRA_BSR_Tier2_FINAL.pdf
4 http://feedingamerica.org/how-we-fight-hunger/our-food-bank-network/how-our-network-works.aspx
5 Zastrow (Food Marketing Institute) and Hewett (Publix Super Markets, Inc.) 2012. *Major Initiatives Addressing Food Waste.* (November).
6 Personal communication with Jim Larson, a representative from FDC.

that can be used vary from state to state. One small scale example is Rutgers University, which diverts dining hall food scraps to a local farm to feed its cattle and hogs. The farm collects around 1.125 tons of food waste per day and charges half the price of what it would cost to send the waste to a landfill. Another example is Barthold Recycling & Roll-off Services, which collects food from approximately 400 commercial customers – including restaurants, hotels, schools, nursing homes, grocery stores, as well as large food processors – to feed nearly 4,000 pigs and 250 head of cattle at its facility in St. Francis, Minnesota.

Based on the FWRA study noted above, about 116,000 tons of wholesale/retail food waste (or about 6 percent of the total food waste generated from this sector) were diverted as animal feed in 2011. The study did not specify whether the food discards were diverted directly as animal feed or if they were rendered into commercial animal feed (see below for details regarding rendering). Barriers to recycling food waste as animal feed include transportation constraints, liability issues, costs to separate food waste from packaging, and concerns about the safety of food for animal consumption.

Rendering

Food wastes composed of animal by-products, fats, and oils can be rendered into saleable commodities such as high-protein meat, tallow, or grease, which are used in the production of animal feed, soap, paints and varnishes, cosmetics, explosives, toothpaste, pharmaceuticals, leather, textiles, lubricants, biofuels, and other valuable products.[7, 8] Rendering can be accomplished using edible rendering processes or inedible rendering processes. Edible rendering plants are typically operated in conjunction with meat packing plants and produce edible fats and proteins (e.g., lard and edible tallow), while inedible plants produce tallow and grease. Inedible rendering is accomplished using either wet or dry processes. Wet rendering separates fat from raw materials by boiling in water. Dry rendering dehydrates the raw material to release the fat. Only dry rendering is used in the U.S. because wet rendering is more costly and has an adverse affect on the fat quality.[10]

There are approximately 300 rendering facilities in North America.[9] Integrated rendering plants are those that operate in conjunction with animal slaughterhouses or poultry processing plants, while independent rendering plants collect their raw materials from a variety of offsite sources, such as butcher shops, supermarkets, restaurants, farms, poultry processors or slaughterhouses.[10]

In the U.S., the rendering industry produces over 11 million tons of rendered fats and animal-derived proteins annually. About 85 percent of what is produced in rendering plants is used as ingredients for animal feed. Based on data from the National Renderers Association, approximately 950,000 tons of the raw materials are derived from spoiled and outdated meat and seafood products from grocery stores.[11,12] Data pertaining specifically to the quantities derived from manufacturing, retail, and post-consumer food waste were not readily available.

Composting

Composting is an aerobic process that decomposes organic material into a nutrient-rich soil amendment.[13] Types of composting include backyard or on-site composting, vermicomposting, aerated windrow composting, aerated static pile composting, and in-vessel composting. While backyard composting and

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7 California Department of Resources Recycling and Recovery. http://www.calrecycle.ca.gov/Organics/Food/Rendering/
8 National Renderers Association. http://www.nationalrenderers.org/about/process/
9 "An Overview of the Rendering Industry." David L. Meeker and C. R. Hamilton. http://assets.nationalrenderers.org/essential_rendering_overview.pdf
10 http://www.epa.gov/ttn/chief/ap42/ch09/final/c9s05-3.pdf
11 National Renderers Association. "Survey Says: A Snapshot of Rendering" Render Magazine. April 2011. http://nationalrenderers.org/assets/4dcab683dabe9d1c690006ed/techtopicsapr11.pdf.
12 National Renderers Association reports that the quantity of meat products and restaurant grease generated and recovered through rendering has remained fairly constant over the past few years. Tom Cook, President. (Telephone conversation September 26, 2012.)
13 Composting is only an aerobic process if done correctly.

vermicomposting are generally conducted on a small scale, aerated and in-vessel composting are well suited to larger volumes of waste like those managed by local governments, institutional facilities, food processing facilities, or farms. Brief descriptions of these processes are provided below:[14]

- Backyard or onsite composting can be conducted by homeowners or small business on their own property, but this method is intended for yard waste and only small amounts of food scraps.
- Vermicomposting uses bins in which worms break down organic matter into high-value compost called castings. This method is ideal for apartment residents with limited space and is often used for educational purposes.
- Aerated windrow composting is conducted by forming waste into rows of long piles (windrows) and aerating the piles by periodically turning them. This method is suited for large volumes of diverse waste, including food wastes, generated by communities or food processing plants.
- Aerated static pile composting is accomplished by layering loosely piled bulking agents (such as wood chips) in a single large pile to allow air to pass through the pile. These compost piles are suited for homogeneous mixtures of waste from larger generators but does not work well for animal byproducts or grease.
- In-vessel composting uses a drum, silo, concrete-lined trench, or similar structure to contain the waste at a controlled temperature, moisture level, and oxygen level. This method can accept any type of organic waste and requires less space than aerated windrow composting. An agitator is typically used for proper aeration. In some cases, in-vessel composting is integrated with anaerobic digestion.

Readily available data quantifying the amount and type of waste composted in the U.S. is limited. However, of the roughly 3 percent of food waste diverted from the waste stream in the U.S. every year, composting is the most common alternative to landfilling.[15] As of 2010, there were over 3,000 commercial composters in the U.S.[16] Based on the FWRA study noted previously, about 454,500 tons (or 24 percent) of food waste generated from the retail/wholesale sector were diverted by composting. Barriers to composting include lack of on-site storage space, the cost to separate food waste from packaging, and transportation constraints. Odor issues are also often commonly noted as a barrier to composting.[17] On a smaller scale, it is becoming more and more common for households to compost yard waste and food waste and state and local recycling programs have been developed in many areas to educate the general public. It was estimated in 2011 that 900,000 tons of municipal food waste were composted.[18] This estimate includes food waste from residences, commercial establishments, institutional sources (e.g. school cafeterias), and industrial sources (e.g. factory lunchrooms).

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[14] http://www.epa.gov/waste/conserve/composting/types.htm

[15] The Benefits of Anaerobic Digestion of Food Waste At Wastewater Treatment Facilities http://www.epa.gov/region9/organics/ad/Why-Anaerobic-Digestion.pdf

[16] "Stand-Alone Industry Code For Composting." *BioCycle*, December 2010. http://www.biocycle.net/2010/12/22/stand-alone-industry-code-for-composting/

[17] Odor in Commercial Scale Compost: Literature Review and Critical Analysis. Washington State University for Department of Ecology, State of Washington. October 17, 2013. https://fortress.wa.gov/ecy/publications/publications/1307066.pdf

[18] Municipal Solid Waste in The United States 2011 Facts and Figures. United States Environmental Protection Agency. May 2013. http://www.epa.gov/epawaste/nonhaz/municipal/pubs/MSWcharacterization_fnl_060713_2_rpt.pdf

IV. Conversion Techniques

Possible conversion technologies are discussed in this section. A summary of these techniques is presented in Table 1.

Anaerobic Digestion

In anaerobic digestion, bacteria break down organic feedstocks in an oxygen-free environment.[19] Digesters can be used to digest food waste alone, or it can be co-digested with biosolids at wastewater treatment plants and used to supplement manure at farms. While facilities that digest only food waste are not widespread and data about them are limited, co-digestion of food waste with biosolids and manure is becoming more common. Digestate from anaerobic digestion can be land applied as a soil amendment or composted. Digestate is also often landfilled.[20]

Table 1. Conversion Techniques for Food Waste

Technique	Brief Description
Anaerobic digestion	This process uses bacteria to break down organic matter in an oxygen-free environment
Aerobic digestion	Aerobic digestion uses micro-organisms in the presence of oxygen to oxidize and decompose organics
Liquefaction	Liquefaction converts solid food waste into a liquid effluent that may be discharged into the municipal wastewater system
Hydrolysis	This process breaks down organic waste; cellulose in organic matter is converted to glucose, which can be fermented to ethanol
Gasification	Gasification converts organic materials into carbon monoxide, hydrogen, and carbon dioxide by reacting the material at high temperatures (>700 degrees C) with a controlled amount of oxygen and/or steam
Pyrolysis	Pyrolysis is the heating of an organic material in the absence of oxygen, resulting in the decomposition of organic material into gases and charcoal
Briquetting	This process forms processed waste into chunks of renewable fuel which can be fed into boilers and used for industrial cogeneration

Anaerobic digestion is frequently used at wastewater treatment plants to treat biosolids, and more recently, facilities have begun using food waste as a supplement. Co-digestion can be beneficial because existing infrastructure can be used to divert organic materials from the waste stream and can be used to adjust the percent solids for optimal digestion and increase biogas production. Food waste is more digestible than biosolids, and methane production from food waste can be three times greater than that of sewage sludge.[21]

As of 2013, there were about 1,500 anaerobic digesters at U.S. farms and wastewater treatment plants.[22] While the total number of treatment plants that co-digest with food waste is not known, the EPA's AgSTAR database lists over 50 manure digesters that use food waste as a supplemental feedstock.[23] Based on limited quantitative data in the database, we estimate that these systems digest at least 140,000 tons of food waste per year. Note, however, that this value includes industrial food waste (e.g., cheese

[19] http://www.epa.gov/agstar/anaerobic/
[20] Personal communication with Jean Schwab, EPA
[21] Turning Food Waste into Energy at the East Bay Municipal Utility District (EBMUD). United States Environmental Protection Agency. http://www.epa.gov/region9/waste/features/foodtoenergy/ebmud-study.html
[22] Anaerobic Digestion: The last frontier for municipal solid waste. *American Recycler News*. December 2013. http://www.americanrecycler.com/1213/2391anaerobic.shtml
[23] http://www.epa.gov/agstar/projects/index.html

whey). We contacted the American Biogas Society and multiple technology providers to augment this information; however none of the contacts were able to provide more detailed data about the quantity of food waste processed through anaerobic digestion. One vendor noted that approximately 30 percent of their systems process food waste.[24]

While digestion of food waste alone isn't widespread, there are a number of small-scale projects. The city of West Lafayette, Indiana has anaerobic digesters that digest only food waste.[25] They receive 1-2 tons of food waste a day from Purdue University and 3,000 gallons/day of fats, oil, and grease from the surrounding area. As an additional service, they provide nearby residents with bottles to collect their waste grease which is then collected and digested. The digester generates 63,000 kWh/month which is used to provide power for the wastewater treatment plant.

At the University of Wisconsin Oshkosh, a dry fermentation anaerobic digester is used to digest agricultural plant waste, yard waste, and food waste from the University. This digester is the first operational dry digester in the United States and processes 6,000 tons of waste per year.[26] Biogas produced by the facility provides 10 percent of the university's power.

In California, as of August 2013, there were 6 operational and 27 other projects in various stages of planning that would receive food waste, green waste, fats, oils and grease or post or pre-consumer feedstock.[27, 28] As of 2011, the 5 operating anaerobic digestion facilities that diverted organics from the waste stream had 0.14 million tons per year of processing capacity. An additional 11 projects were projected to add 0.4 million tons of capacity.[27]

Notably, California was the site of the first wastewater treatment plant that diverted food waste for energy via anaerobic digestion at the East Bay Municipal Utility District in Oakland. As oil in food waste can clog piping infrastructure, food waste is collected separately and pumped into the co-digester.[29] As of 2010, about 7,000 to 15,000 tons of post-consumer food waste was collected and digested with an increase to 35,000 tons in 2011.[26] The biogas produced in turn powers the treatment plant and excess energy is sold. The digested material is then composted and used as fertilizer. The grit and debris remaining from this operation are recycled or disposed of through landfilling.[30]

Aerobic Digestion

Aerobic digestion uses micro-organisms in the presence of oxygen to oxidize and decompose the organic component of a waste stream. In the processes, bacteria rapidly consume and covert organic matter into CO_2.[31] Aerobic digestion is used to stabilize organic material, reduce its mass and volume, and remove pathogenic organisms. The organic matter remaining is generally landfilled or spread on agricultural land.[32]

Aerobic digestion can be wet or dry. Dry aerobic digesting is the same as composting, which is discussed in Section II. Wet aerobic digestion is an emerging technology which consists of the following steps: pulping, heating, aeration, inoculation with microbes, and separation of solid and liquid fertilizer

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24 Email communication with Carolyn Henry of Quasar Energy Group
25 http://www.epa.gov/greenpower/documents/events/17aug11_henderson.pdf
26 Update on Anaerobic Digester Projects Using Food Wastes in North America. Institute for Local Self-Reliance. October 2010. http://www.ilsr.org/wp-content/uploads/2012/03/atlanta-adreport.pdf
27 California Department of Resources Recycling and Recovery. Composting and Anaerobic Digestion. June 18, 2013 Draft. http://www.calrecycle.ca.gov/actions/Documents/77/20132013/900/Composting%20and%20Anaerobic%20Digestion.pdf
28 California Department of Resources Recycling and Recovery. http://www.calrecycle.ca.gov/organics/Conversion/adprojAug13.pdf
29 Personal communication with Ashley Zanolli, EPA Region 10
30 Turning Food Waste into Energy at the East Bay Municipal Utility District (EBMUD). United States Environmental Protection Agency. http://www.epa.gov/region9/waste/features/foodtoenergy/ebmud-process.html
31 Aerobic Digestion. Steve Last. http://www.anaerobic-digestion.com/html/aerobic_digestion.php
32 Aerobic Digestion. Steve Last. http://www.anaerobic-digestion.com/html/aerobic_digestion.php

products.[33] There is a demonstration scale operating facility in Vancouver, Canada and a plant is under construction in New Jersey to process MSW from New York City.[34]

There were insufficient data available to determine the amount of food waste currently being aerobically digested using wet aerobic digestion.

Liquefaction

Liquefaction is the conversion of solid waste to a liquid. Liquefaction of MSW can be performed by multiple methods, including hydrothermal, enzymatic and biological.

Biological liquefaction systems use mechanical grinders to shred food waste, which is then mixed with water and proprietary additives to aid decomposition[35]. These "wet" systems are often precisely suited for particular types of food waste. This mixture of air, water, microorganisms accelerates the decomposition of the food waste and causes it to turn into a liquid effluent that can be discharged into the municipal wastewater system after about 14 days. These systems have a range of capacities from under 20 lbs/day to 6,000 lbs/day, and as such, the majority of these wet systems area in place at large facilities such as colleges, hospitals, prisons, and hotels. While an estimate of the amount of food waste treated by these types of systems is not available, there is individual information on particular case studies. For example, the University of Nevada, Reno's Down under Cafe has a biological liquefaction system that treats 25 tons of food waste annually[36]. The system completely decomposes food waste from the cafeteria in 48 hours.

Hydrolysis

Hydrolysis is the process in which cellulose in organic matter is converted to simple sugars (such as glucose). These sugars can then be fermented to ethanol. Cellulose can be hydrolyzed by several means, including acids or enzymes.

In acid hydrolysis, a dilute or concentrated acid is used to hydrolyze the cellulose. Typically, crushed biomass is treated in a dilute acid medium at process temperatures near 460 °F. Concentrated sulfuric acid may also be used initially to decrystallize the cellulose before the dilute acid process.

In enzymatic hydrolysis, enzymes derived from common fungi are used. Enzymatic processes are commercially unproven, but once improved it is thought that they will have a significant cost advantage over acid processes.[37]

Although hydrolysis has been well established from a technological perspective for some time, it is expensive and there are difficulties in hydrolyzing food waste materials into fermentable sugars.[38] BlueFire Renewables Inc., a cellulose conversion company, states that their technology can use food waste such as vegetable and fruit waste as process feedstock; however, no operating facilities using these types of MSW food waste could be identified.[39]

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[33] Evaluation of New and Emerging Solid Waste Management Technologies. New York City Economic Development Corporation and the New York City Department of Sanitation. September 16, 2004. http://www.nyc.gov/html/dsny/downloads/pdf/swmp_implement/otherinit/wmtech/phase1.pdf

[34] Products and Processes. Envirco. http://www.envirco.us.com/products.html

[35] On-Site Systems for Processing Food Waste. A Report to the Massachusetts Department of Environmental Protection. April 26, 2013. http://www.mass.gov/eea/agencies/massdep/recycle/reduce/massdep-food-waste-final-report.pdf

[36] Enviro Pure. http://www.enviropuresystems.com/downloads/EnviroPure%20-%20Nevada%20Today%20UNV%20Environmental%20Award.pdf

[37] California Department of Resources Recycling and Recovery. New and Emerging Conversion Technologies Report to the Legislature. June 2007.http://www.calrecycle.ca.gov/Publications/Documents/Organics/44205016.pdf

[38] California Department of Resources Recycling and Recovery. Conversion Technologies Biochemical Conversion Processes. http://www.calrecycle.ca.gov/organics/conversion/Pathways/BioChem.htm

[39] Bluefire Renewables.http://bfreinc.com/our-technology/

Gasification

Gasification is a partial combustion process that uses air or oxygen and high heat (usually greater than 1300°F) to convert feedstock into a synthetic gas (carbon monoxide, hydrogen) or fuel gas (methane and lighter hydrocarbons). Heating can be direct or indirect, depending on the system's configuration. The resulting fuel gases can be cleaned and used in engines or fuel cells, and synthetic gases generated can be used for methanol, ethanol, or other chemical production.

Although gasification technologies have been widely demonstrated and have been applied on a commercial scale, coal has been the predominant feedstock. The commercial application of gasification for waste feedstocks is growing, with plants that gasify poultry processing waste in eastern Washington and Oregon. However, and according to a survey conducted by California's Integrated Waste Management Board[40] there are several planned commercial-scale facilities in the U.S. that intend to use municipal solid waste as a feedstock. Several survey respondents indicated that California permitting requirements would make expanding or developing these types of facilities more difficult.

Pyrolysis

Pyrolysis is the thermal decomposition of a feedstock at temperatures greater than 400°F in the absence of air. Because no oxygen is present, the material does not combust. However, the chemical compounds that make up an organic feedstock (i.e. cellulose, hemicelluloses, and lignin) thermally decompose into combustible gases and charcoal.

Similar to gasification, pyrolysis is technologically mature but does not appear to have widespread application on a commercial scale with MSW. There were six laboratory and pilot scale projects and one commercial scale demonstration project (Emerald Power Corporation in New York) reported to the 2009 survey conducted by California's Integrated Waste Management Board. Several survey respondents indicated that California permitting requirements would be an impediment to expanding or developing these types of facilities.

Briquetting

Briquetting is a process in which ground waste is forced through a heated conical-shaped die. The material forms into a continuously long, three-inch-wide piece of biomass. The log is then broken into chunks of renewable fuel. The chunks are bagged and distributed for use in private wood burners and fireplaces, or broken into hockey puck-sized pieces that can be fed into boilers and used for industrial cogeneration.[41]

V. INCINERATION

Incineration is the controlled combustion of solid waste at extremely high temperatures. Originally, incinerators were designed only to reduce the volume of MSW to be disposed of. Since those days, however, these waste burning facilities have evolved to include energy extraction from the combustion process.[42] There are around 86 facilities in the U.S. that combust MSW with energy recovery. In 2011 about 12 percent of the total MSW generated (17.9 percent of the MSW disposed) was disposed of through combustion with energy recovery of which food waste comprised 21.3 percent. In 2011, 34.91 million tons of MSW food waste was disposed of through landfilling or incineration.[43] Assuming food waste accounted for 21.3 percent of the MSW disposed, about 7.4 million tons of food waste were

[40] California Department of Resources Recycling and Recovery. Conversion Technologies Status Update Survey. April 2009. http://www.calrecycle.ca.gov/Publications/Documents/Organics%5C2009008.pdf
[41] Briquetting of Agricultural Waste for Fuel. S. Eriksson and M. Prior. http://home.fuse.net/engineering/biomass/The%20Briquetting%20of%20Agricultural%20Waste%20for%20Fuel.pdf
[42] Introduction to Municipal Solid Waste Incineration. Maggie Clark. http://www.geo.hunter.cuny.edu/~mclarke/IntroMSWincineration.htm
[43] Municipal Solid Waste in the United States: 2011 Facts and Figures. Tables 3 and 29.

incinerated in 2011.[44] It is also assumed that a small (but not reported) percentage of generated MSW is incinerated without energy recovery.[45]

[44]The MSW feedstock composition combusted by incinerators may differ from the composition shown in Table 3 (reference 43) due to facility requirements. For example, bulky items may be removed from the feedstock prior to combustion therefore altering the percentage that food waste is of the total. In this example, the percentage that food waste represents of the MSW feedstock entering a combustion facility would be higher than 21.3 percent.

[45] Municipal Solid Waste in The United States 2011 Facts and Figures. United States Environmental Protection Agency. May 2013. http://www.epa.gov/epawaste/nonhaz/municipal/pubs/MSWcharacterization_fnl_060713_2_rpt.pdf