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Food Waste to Energy

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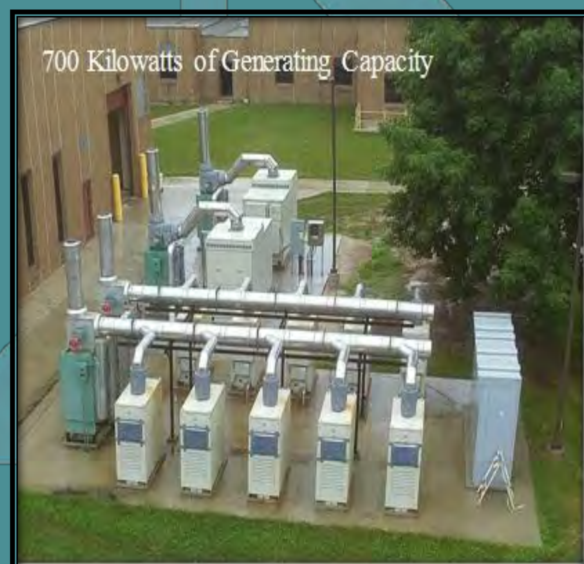
Food Waste to Energy: How Six Water Resource Recovery Facilities are Boosting Biogas Production and the Bottom Line



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September 2014

Food Waste to Energy: How Six Water Resource Recovery Facilities are Boosting Biogas Production and the Bottom Line

Region 9 San Francisco, CA and

National Risk Management Research Lab
Office of Research and Development
Cincinnati, OH

EPA/600/R-14/240
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Foreword

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This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by US EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

Cynthia Sonich-Mullin, Director
National Risk Management Research Laboratory

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Abstract

Water Resource Recovery Facilities (WRRFs) with anaerobic digestion have been harnessing biogas for heat and power since at least the 1920's. A few are approaching "energy neutrality" and some are becoming "energy positive" through a combination of energy efficiency measures and the addition of outside organic wastes. Enhancing biogas production by adding fats, oil and grease (FOG) to digesters has become a familiar practice. Less widespread is the addition of other types of food waste, ranging from municipally collected food scraps to the byproducts of food processing facilities and agricultural production. Co-digesting with food waste, however, is becoming more common. As energy prices rise and as tighter regulations increase the cost of compliance, WRRFs across the country are tapping excess capacity while tempering rates. This report presents the co-digestion practices, performance, and the experiences of six such WRRFs. The report describes the types of food waste co-digested and the strategies—specifically, the tools, timing, and partnerships—employed to manage the material. Additionally, the report describes how the facilities manage wastewater solids, providing information about power production, biosolids use, and program costs.

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Acknowledgements and Notice

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This report has been peer reviewed by the U.S. Environmental Protection Agency Office of Research and Development and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation by EPA for use.

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List of Abbreviations, Acronyms, and Initialisms

AD	Anaerobic digester
ADC	Alternative daily cover
ADM	Anaerobically digested materials
ADWF	Average dry weather flow
ARRA	American Reinvestment and Recovery Act
BOD	Biochemical oxygen demand
GGE	Gallons of gasoline equivalent
CARB	California Air Resources Board
CEC	California Energy Commission
CHP	Combined heat and power
CHPCE	CHP Clean Energy
CMSA	Central Marin Sanitation Agency
CNG	Compressed Natural Gas
CPI	Consumer price index
CPUC	California Public Utilities Commission
CWSRF	Clean Water State Revolving Fund
EA	Enforcement Agency Notification
EBMUD	East Bay Municipal Utility District
EPA	Environmental Protection Agency
F2E	Food to energy
FIT	Feed-in Tariff
FOG	Fats, oil, and grease
GGE	Gallons of gasoline equivalent
HCTP	The Hill Canyon Wastewater Treatment Plant
ICE	Internal combustion engine
kW, kWh/MGD	Kilowatts, Kilowatt hours per million gallons a day
LCFS	Low carbon fuel standard
MSS	Marin Sanitation Service
MG	Million gallons
MGD	Million gallons per day
MSW	Municipal Solid Waste
MW, MWh	Megawatts, Megawatt hour
NPDES	National Pollution Discharge Elimination System
O&M	Operations and maintenance
PG&E	Pacific Gas and Electric
PPA	Power purchase agreement
RFS	Renewable Fuel Standard
RAM	Renewable Auction Mechanism
RIN	Renewable Identification Number
RVO	Renewable Volume Obligations
SGIP	Self generation incentive program
SRF	State Revolving Fund
SWRCB	State Water Resources Control Board
WDR	Waste Discharge Requirement
WERF	Water Environmental Research Foundation
WRRF	Water Resource Recovery Facility (a.k.a WWTFs)
WWTF	Wastewater Treatment Facilities

1 Introduction

To protect human health and the environment, communities must have adequate infrastructure to handle waste, critically the waste we throw away (solid waste) and the waste we flush down toilets (wastewater). Modern solid waste and wastewater management approaches have remedied many of the historically associated aesthetic, ecological, and public health problems; but they have engendered systems that contribute to current crises, notably climate change. By diverting energy-rich food waste from landfills to existing anaerobic digesters at Water Resource Recovery Facilities (WRRFs), co-digestion can help communities manage waste more sustainably, generate renewable energy, and continue to provide essential services at affordable rates. To help communities evaluate solid waste and wastewater management options, this report presents the co-digestion practices and performance of six WRRFs, providing information about the food waste material, including receipt, storage and processing; biogas and biosolids production and use; and program costs.

1.1 Managing Waste More Sustainably

Landfills are the third largest anthropogenic source of methane (CH4) emissions in the United States, accounting for 18.1% of total emissions in 2012 (U.S. EPA 2014b). While emitted in smaller quantities than carbon dioxide (CO_2), CH4 currently contributes to more than one-third of today's anthropogenic warming because its global warming potential is 25 times greater than CO2 (Global Methane Initiative 2014).

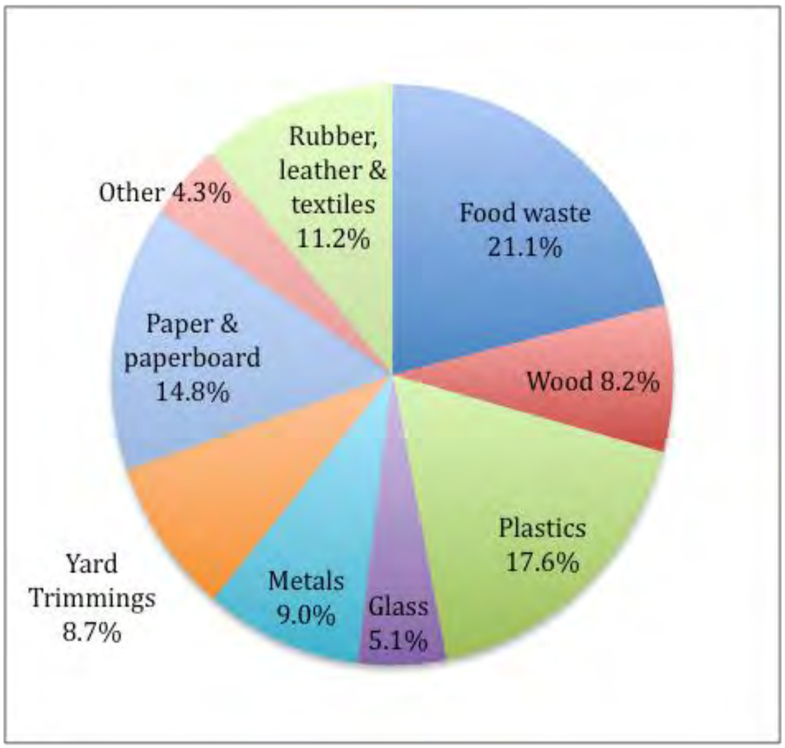


Figure 1: Total MSW waste by percentage after recycling and composting (U.S. EPA 2014a)

According to the U.S. Environmental Protection Agency (EPA), food waste represents 14.5% of the municipal solid waste (MSW) stream, and most of what's generated is wasted. Of the more 251 million tons of MSW Americans generated in 2012, food waste comprised 36.43 million tons, only 1.74 million tons (4.8%) of which was recovered (U.S. EPA 2014a). Of the 163 million tons of discarded MSW, food waste comprised 34.69 million tons, or 21% of total MSW discards (Figure 1). By diverting food waste from landfills and into existing WRRF digesters, communities can reduce greenhouse gas emissions and protect water quality.

Co-digestion at WRRFs can reduce the carbon footprint of waste management by diverting food waste from landfills, where methane may be generated and released into the atmosphere; by capturing and combusting CH4[1]; by minimizing MSW hauling distances, reducing truck traffic and associated air

[1] Of the 2,400 or so currently operating or recently closed MSW landfills in the United States, only 636 have methane utilization projects (U.S. EPA 2014c). Furthermore, landfill methane capture efficiency varies considerably—from as low as 35% to as high as 90% (Spokas et al 2006), resulting in significant fugitive emissions. In comparison, WRRFs harness methane much more efficiently, typically capturing and combusting 99% of the biogas produced in their anaerobic digesters (WERF 2012a).

emissions (DiStefano and Belenkey 2009); and by sequestering carbon into soil structure through the land application of biosolids (Brown and Leonard 2004). In an evaluation of food waste disposal options, the Water Environmental Research Foundation (WERF) identified co-digesting hauled-in food waste at WRRFs as the only carbon negative, i.e. greenhouse gas reducing, waste management strategy (Figure 2) (WERF 2012a).

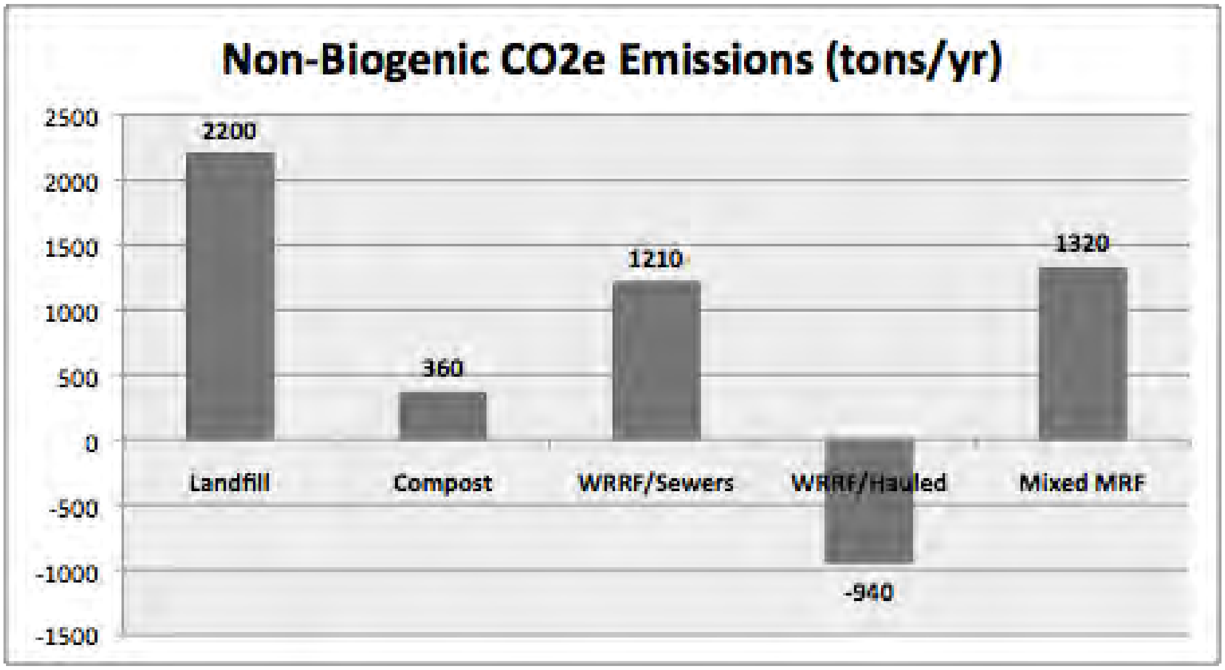


Figure 2: **Comparing the carbon footprint of several food waste disposal options: landfilling, composting, delivering food waste to WRRFs via sewers, hauling food waste to WRRFs via trucks, and separating food waste at a mixed materials recovery facility (MRF) (WERF 2012a)**

Diverting food waste from landfills can also protect water quality. When waste decomposes in landfills, it creates leachate, a liquid composed primarily of dissolved organic matter, inorganic ions such as ammonia, phosphate, and sulfate, and heavy metals (Christensen et al. 2001). Diverting food waste from landfills reduces the volume of organic matter, correspondingly reducing not only the amount of leachate but also the concentration of dissolved organic matter in the leachate. Leachate leaks from landfills without adequate liners, percolating into soils and groundwater, potentially increasing biological oxygen demand and nutrient loads in adjacent water bodies (Camargo and Alonso 2006, Diaz 2001, Kronvang et al. 2005). By diverting food waste, landfills are less likely to contribute eutrophic and hypoxic events and hence can help protect water quality.

1.2 Generating Renewable Energy

Delivering water and wastewater services is an energy-intensive effort, as the water is treated, pumped, and consumed, and then the resulting wastewater is pumped to and treated at WRRFs. WRRFs in the United States use approximately 30.2 billion kWh per year, or about 0.8% of national electricity use (Electric Power Research Institute 2013). Water and wastewater utilities are typically the largest energy consumers in municipalities, often accounting for 30-40% of total energy consumed by municipal governments (U.S. EPA 2012). For WRRFs, energy bills can be ~30% of total operation and maintenance (O&M) costs (Carns 2005), usually representing a facility's second or third biggest expense.

While WRRFs consume a lot of energy, they also have the potential to harness energy. Municipal wastewater contains five to ten times as much chemical and thermal energy as is currently required to treat it (WERF 2011). WRRFs with anaerobic digesters can utilize existing infrastructure to become net producers of energy (Frijns et al. 2013).When microorganisms break down organic materials in the absence of oxygen, they produce biogas as a byproduct. Biogas, composed primarily of CH4 (60 to 70%) and CO2, can be used as a fuel source, much like natural gas. Fueling engines with biogas generates electricity and heat, providing many benefits to WRRFs, such as producing power at a cost below retail rates, displacing purchased fuels for thermal needs, and enhancing power reliability for the plant. “Sewage gas” has been powering some WRRFs since at least the 1920s (Figure 3).


March, 1922 67

Gas from Sewage Waste Runs City Power Plant

How the sewage disposal plant at Birmingham, England, supplies its own power is described in the illustration. Gas from the sewage drives an engine of 20 brake horsepower, which operates a centrifugal sludge pump

SEWAGE that costs large cities tremendous sums each year can be turned into a source of power equivalent to thousands of tons of coal! The waste now dumped into rivers or shipped to sea may be used to run factories or to light buildings!

That conversion of sewage into power is possible has been proved conclusively by the city of Birmingham, England. There a suction gas engine of 20 brake horsepower has been successfully driven by the gases given off by sewage sludge.

On the basis of the Birmingham experiments, an American city that must now pay for the disposal of 400,000 tons of sewage sludge a year might produce 320,000,000 cubic feet of gas suitable for heat and power, or, in terms of energy, 16,000,000 horsepower hours at 20 cubic feet per brake horsepower.

The apparatus for producing gas from sewage consists of two sludge digestion tanks in which the sewage is allowed to ferment. The gases given off are composed of from 25 to 75 per cent of methane, or marsh gas.

A gas engine of the usual type will run on sewage gas without adjustment of the valves. Sewage gas has a higher calorific value than some illuminating gas, averaging about 650 thermal units to the cubic foot, as against 550.

The Birmingham engine runs about six hours a day and is used to operate a centrifugal sludge pump that moves the wet sludge from the gas-generating tank to the drying grounds. In this process a small proportion of the waste material produces enough power to run the pumps of the sewage disposal plant. If all the material were used, there would probably be enough gas available to light the city.

Figure 3: **Description of biogas to energy project in Birmingham, England (Popular Science Monthly 1922)**

According to a 2013 study, 1,238 American WRRFs process wastewater solids with anaerobic digesters; 85% (1,054) beneficially use the biogas, and 22% (270 facilities) generate electricity (Qi, Beecher and Finn 2013). While Combined Heat and Power (CHP) systems help facilities save money on displaced energy needs, they also require substantial investments, both immediately (i.e. purchasing equipment) and over the long-term (i.e. operation and maintenance costs). Even with energy savings, installing or expanding a CHP system may not appear to be a financially viable option, particularly for smaller WRRFs.

1.3 Ensuring Affordable Rates

WRRFs interested in CHP systems but deterred by lengthy payback periods have several options. They could apply for a grant. They could raise rates. They could increase energy efficiency and boost biogas production. These strategies are increasingly common and increasingly necessary. To address population change, climate change impacts, increased energy costs, deteriorating infrastructure, and stricter water quality regulations, WRRFs must invest in repairs and upgrades.

Many cities spend more money than they take in on providing sewer services. Between 1991 and 2005, local governments, on average, generated only 88% of the funds expended (U.S. Conference of Mayors 2007). Nationally, the wastewater "funding gap" amounts to billions of dollars. Over the next 20 years, the country nationally faces a shortage of $298.1 billion for wastewater and stormwater needs (U.S. EPA 2008). Historically, the federal government provided about 70% of the funds needed to build and upgrade treatment plants (U.S. EPA 2000). Today, about 25% of the public funding for water infrastructure projects is provided by the federal government (Musick 2010).

Since the dissolution of the construction grants program, the federal government's largest contribution to America's wastewater infrastructure has been through the EPA's Clean Water State Revolving Fund (CWSRF). Over the last two and half decades, the CWSRF provided over $100 billion in low-interest loans. But the country's projected wastewater infrastructure costs over the next 20 years are nearly three times greater than what EPA has funded over the past 25. With less public funding available and increased costs expected, creative financing is essential.

For many WRRFs, boosting biogas production by co-digesting with food waste may help bridge funding gaps. For facilities that do not produce sufficient biogas to economically justify CHP, co-digestion can improve project economics and, in many cases, be the tipping point for investing in CHP (WERF 2012b). For facilities already invested in CHP, co-digestion can facilitate goals for energy independence. Minimizing and, for an increasing number of WRRFs, eliminating energy costs conserves capital needed for repairs and upgrades. Furthermore, FOG and food waste tipping fees can generate revenue. By saving money on energy and earning money through tipping fees, many WRRFs can secure funding for capital improvements that would otherwise be obtained by raising rates.

1.4 Celebrating Success: Six examples of WRRF co-digestion projects

An estimated 216 WRRFs located in the U.S. haul in food waste (primarily FOG) for co-digestion with sewage sludge. This accounts for approximately 17% of WRRFs that process sewage sludge using anaerobic digestion (Qi, Beecher, and Finn 2013). This report presents the experiences of six WRRFs that are co-digesting with food waste to boost biogas production. These facilities were selected because they were willing to share their stories. Based on published articles, webinars, and conference presentations, numerous WRRFs were identified as potential candidates. Candidate plants were contacted and asked to participate. Six responded. Those who responded were given a list of questions (Appendix A), the answers of which provided a basic understanding of the operation and management of the plant. After the plant operators compiled the requested data, interviews were conducted over the phone. While a limited sample, they nonetheless reflect the diversity of their sector, varying in capacity and employing management strategies suited to their unique infrastructural, geographic and economic circumstances. The following plants were interviewed (also see Table 1, Figure 4):

The Central Marin Sanitation Agency (CMSA) is located in San Rafael, California. CMSA is a regional wastewater agency serving about 120,000 customers. Up to six billion gallons of wastewater per year are treated and released. The CMSA treats an average dry weather flow (ADWF) of seven million gallons per day (MGD) with the capacity to treat 125 MGD. The WRRF has two anaerobic digesters, with a combined capacity of approximately two million gallons (MG). The facility started their co-digestion program in 2013 with FOG and began receiving food waste in late January 2014. Before co-digestion, CMSA produced enough biogas to provide approximately eight hours of power. With co-digestion, they are hoping to meet all the plant's power needs with the biogas produced on site.

The East Bay Municipal Utility District (EBMUD) serves approximately 650,000 people in an 88-square-mile area along the east shore of the San Francisco Bay, treating wastewater from Alameda, Albany, Berkeley, El Cerrito, Emeryville, Kensington, Oakland, Piedmont, and a part of Richmond. The facility treats an ADWF of 60 MGD with the capacity to treat 168 MGD. It has 11 anaerobic digesters with the combined capacity of approximately 22 MG. EBMUD began co-digesting in 2002 and, in 2012, EBMUD became the first wastewater treatment plant in North America to produce more renewable energy onsite than is needed to run the facility.

The Hill Canyon Wastewater Treatment Plant (HCTP) provides wastewater treatment for 90% of the 128,000 residents of Thousand Oaks in California. HCTP currently treats an ADWF of 9.5 MGD and has the capacity to treat 14 MGD. The digester design capacity is 2.8 million gallons. Biogas produced from digested solids and food waste fuels a 295 kW and a 630 kW engine. Hill Canyon will soon become energy positive.

The Sheboygan Regional Wastewater Treatment Facility in Wisconsin, serves the city of Sheboygan, Sheboygan Falls, Village of Kohler, the Town of Lima, the Town of Sheboygan, and the Town of Wilson. The WRRF treats an average dry weather flow of 18.4 MGD and has the capacity to treat 56.8 MGD. The WRRF has three anaerobic digesters with a capacity of 4.8 MG. The resulting biogas fuels ten 30kW and two 200 kW microturbines, producing 2,300 megawatt hours of electricity annually. This is used to meet 90% of the facility's annual electrical needs and 85% of its annual heating requirements.

The West Lafayette Wastewater Treatment Utility in Indiana serves West Lafayette's 29,000 residents and Purdue University. The plant treats an ADWF of 7.8 MGD, and has the capacity to treat 10.5 MGD. West Lafayette has two anaerobic digesters with a combined capacity of 1.0 MG. On average, the facility meets 20% of its power needs using the biogas generated on-site.

The Janesville Wastewater Treatment Facility in Wisconsin serves approximately 62,000 people. The facility's ADWF is 12.5 MGD with a capacity of 17.75 MGD. The anaerobic digester capacity is 2.5 MG. In 2013, the facility co-digested approximately 300,000 gallons of food waste. 90% of Janesville's biogas is used to generate electricity that is sold to the grid, enabling the facility to meet 27% of its electricity needs and 65% of its digester heating needs. The remaining biogas (10%) is used to produce clean natural gas for use in facility vehicles.

Table 1: Basic facility descriptions

Facility Name	Location	Treatment Plant Flow ADWF (MGD)	Treatment Plant Flow Capacity (MGD)	Anaerobic Digester Capacity (MGD)
CMSA	San Rafael, CA	7.0	125.0	2.0
EBMUD	Oakland, CA	60.0	168.0	22
Hill Canyon	Thousand Oaks, CA	9	14	2.8
Sheboygan	Sheboygan, WI	18.4	56.8	4.8
West Lafayette	West Lafayette, IN	7.8	10.5	1.0
Janesville	Janesville, WI	12.5	25	2.5

Figure 4: **Wastewater treatment facility photos**

Photo provided courtesy of CMSA

Photo provided courtesy of EBMUD

Photo provided courtesy of Hill Canyon

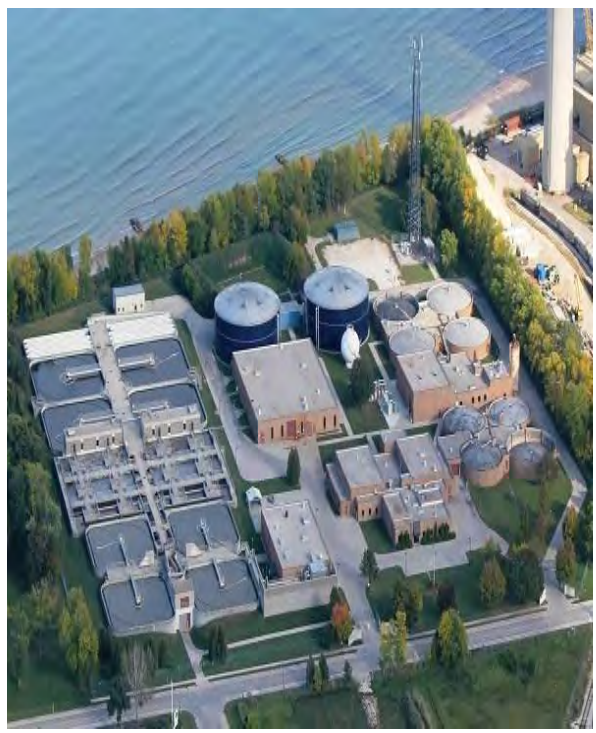


Photo provided courtesy of Sheboygan

Photo provided courtesy of West Lafayette

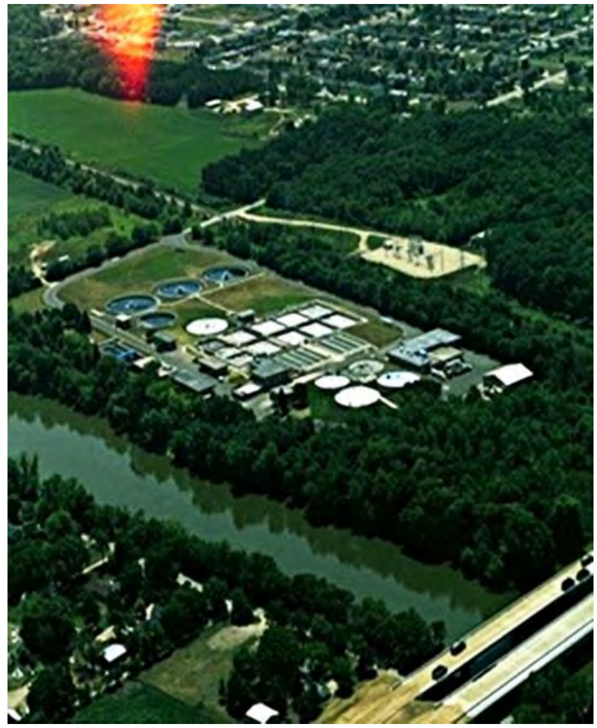


Photo provided courtesy of Janesville

2 What is co-digested?

Increasingly, water resource recovery facilities (WRRFs) with excess digester capacity are co-digesting a variety of organic waste materials, especially energy-rich carbohydrate, protein, and lipid wastes.

- Lipid wastes include fats, oils, and greases (collectively referred to as FOG).
- Simple carbohydrate wastes include bakery waste, brewery waste, and sugar-based solutions such as those from confectionaries and soda pop producers; more complex carbohydrate wastes include fruits and vegetables as well as mixed organics—including the organic fraction of municipal solid waste stream.
- Protein wastes include meat, poultry, and dairy waste products such as cheese whey.
- Other waste organic feedstocks include glycerin from biodiesel fuel production.

In 2002, EBMUD partnered with San Francisco and its waste hauler, Recology, to co-digest post-consumer food waste. Recology collects an average of 600 tons of source-separated organic material each day, 20-40 tons of which has been preprocessed and delivered to EBMUD.

In 2014, CMSA partnered with the Marin Sanitation Service (MSS) to launch the Central Marin Food-to-Energy Program. MSS collects post-consumer food waste from 41 commercial customers (including restaurants and supermarkets), preprocesses the waste and then delivers it to CSMA.

Both Recology and MSS work closely with local governments to attain aggressive zero waste goals: San Francisco aims to reach zero waste by 2020; Marin County by 2025.

Because food waste comprises such a large percentage of the MSW stream, both communities have heavily invested in residential and commercial organic collection programs (San Francisco Department of the Environment 2014, Zero Waste Marin 2014).

For more information, WERF (2014) provides an extensive literature review summarizing the performance of these various materials.

The interviewed facilities co-digested with various types of carbohydrate, protein, and lipid wastes. The wastes were selected for a number of different reasons, including proximity, availability, dependability, associated tipping fees, and biogas yield. Some food waste materials (e.g. sugary wastes) appear to produce biogas with a relatively low percentage of methane while other food waste materials (e.g. glycerin) produce biogas with a relatively high percentage of methane. Some food waste materials came from relatively far sources. For example, EBMUD receives chicken blood from as far away as California's Central Valley. Others only accepted food waste from nearby sources. West Lafayette, for example, receives cafeteria waste from Purdue University, which is located across the street from the facility.

Some facilities accept a variety of wastes. The Hill Canyon operator explained that, as food waste sources can be intermittent and inconsistent, co-digestion has required some experimentation. Other facilities co-digest with one material. Janesville, for example, only co-digests with chocolate waste. In the past, Janesville accepted soft drink and whey wastes, but stopped because the soft drink waste was often contaminated with plastics, and the whey waste too high in chlorides, which can be corrosive. Other facilities—notably EBMUD and CMSA— have forged partnerships with municipal waste haulers, helping nearby communities to reach waste diversion goals.

Almost all of the interviewed WRRFs co-digest with FOG. Most of the facilities obtain FOG from local restaurants, groceries, and bakeries. West Lafayette also receives FOG directly from residents. Table 2 summarizes what food waste materials the facilities co-digest.

CMSA	EBMUD	Hill Canyon	Sheboygan	West Lafayette	Janesville
FOG Post-consumer commercial	FOG Winery waste Industrial liquids and solids Animal processing & rendering Post-consumer commercial Post-consumer residential (pilot)	FOG Industrial, including from fruit juice, frappe, beer, and cheese producers. Restaurant Biodiesel waste, e.g. glycerin	FOG Industrial including: dairy, soda processing, and off-spec beverage Ethanol production waste: including thin stillage and corn syrup	FOG Purdue cafeteria food scraps Agricultural waste from Purdue's Ag. Research program Spoiled produce donations	Chocolate waste

Table 2 Types of co-digested food waste

3 How much is co-digested, and when? How is it delivered?

The six interviewed facilities accept varying amounts of food waste throughout the year. For West Lafayette, its deliveries are seasonal. The WRRF receives an annual average of 370 gallons of food from Purdue University's cafeteria, but that material is only delivered while school is in session. Janesville accepts 350,000 gallons of waste per year (i.e. 958 GPD), but greater volumes of chocolate waste are delivered during holidays (Christmas, Valentine's Day, etc.). CMSA started co-digesting in February 2014, and the facility is currently receiving about 10,000 gallons of FOG per day and four tons (i.e. 1,100 gallons) of food waste per day. As more commercial customers (an anticipated 200) participate in MSS's organics collection program, CMSA may receive as much as 20 tons per day.

EBMUD accepts food waste seven days a week, 365 days a year. EBMUD has daily received 20-40 tons of post-consumer food waste from San Francisco's waste hauler, Recology. Each day, EBMUD additionally receives 100 truckloads containing liquid- and solid wastes from 20-30 industrial food processors. While EBMUD would not disclose the exact volume of co-digested food waste, the interviewed representative did acknowledge that the facility brings in a volume of food waste equal to less than 1% of their average flow (i.e. 0.6 MGD). Because so much waste arrives from so many different sources, EBMUD carefully monitors deliveries.

EBMUD permits haulers to deliver food waste, and is permitted to accept it. To receive, process and co-digest solid and liquid food waste in California, a WRRF may hold two permits from two state agencies: A National Pollution Discharge Elimination System (NPDES) permit from the State Water Resources Control Board (SWRCB), and a solid waste permit from the California Department of Resources and Recycling (CalRecycle).

CalRecycle has issued EBMUD and CMSA "Enforcement Agency Notifications" (EAs), the least burdensome of the permitting tiers (CalRecycle 2014). EBMUD's EA classifies their receipt of solid food waste as a "biosolids composting" activity and limits their intake to 250 tons per day (CalRecycle 2009); CMSA's EA classifies their receipt of solid food waste as "solid waste disposal" activity and limits their intake to 15 tons per day (County of Marin Environmental Health Services 2012).

Both CMSA and EBMUD NPDES permits additionally address the management of "food processing waste" (SWRCB 2012) and "food industry waste" (SWRCB 2010), respectively. The NPDES permits do not limit the volume of food waste the facilities can receive.

The EBMUD Materials Management program facilitates the addition of outside liquid and solids wastes, providing customer service to the waste generators and haulers, and ensuring that the added material is safe (EBMUD 2012a). In order to deliver outside waste, the waste must be permitted. In addition to a permit, EBMUD also requires the customer be insured, that appropriate analytical data and "material safety data sheets" be provided, and that a "material acceptance agreement" is signed. Once the waste material is reviewed and approved, deliveries to EBMUD occur as they do at the other interviewed facilities. Haulers approach the facility and are recognized either by a guard at a guard station or through a mechanized identification system. The haulers enter the facility and deliver the waste to the designated area. Table 3 shows the volumes of waste accepted throughout the year and summarizes how the facilities manage deliveries.

Table 3 Food waste (FW): Volume and delivery process

	CMSA		EBMUD		Hill Canyon		Sheboygan		West Lafayette		Janesville
Waste Type	FOG	FW	FOG	FW	FOG	FW	FOG	FW	FOG	FW	FW
Average Quantity Processed (GPD)	10,000	1,100	<600,000*	<600,000*	>25,000	>25,000	500	60,000	142	1	857
Delivery	Monitored entrance to receiving facility Hauler must fill out form and show permit		Monitored entrance Hauler must show ID badge, permit, and tanker decal number		Monitored discharge Random sampling to ensure safety of co-digested material		Permitted haulers enter a monitored entrance when open After hours, permitted haulers enter the facility via Radio Frequency Identification (RFID)		Monitored and limited delivery		Monitored delivery and discharge

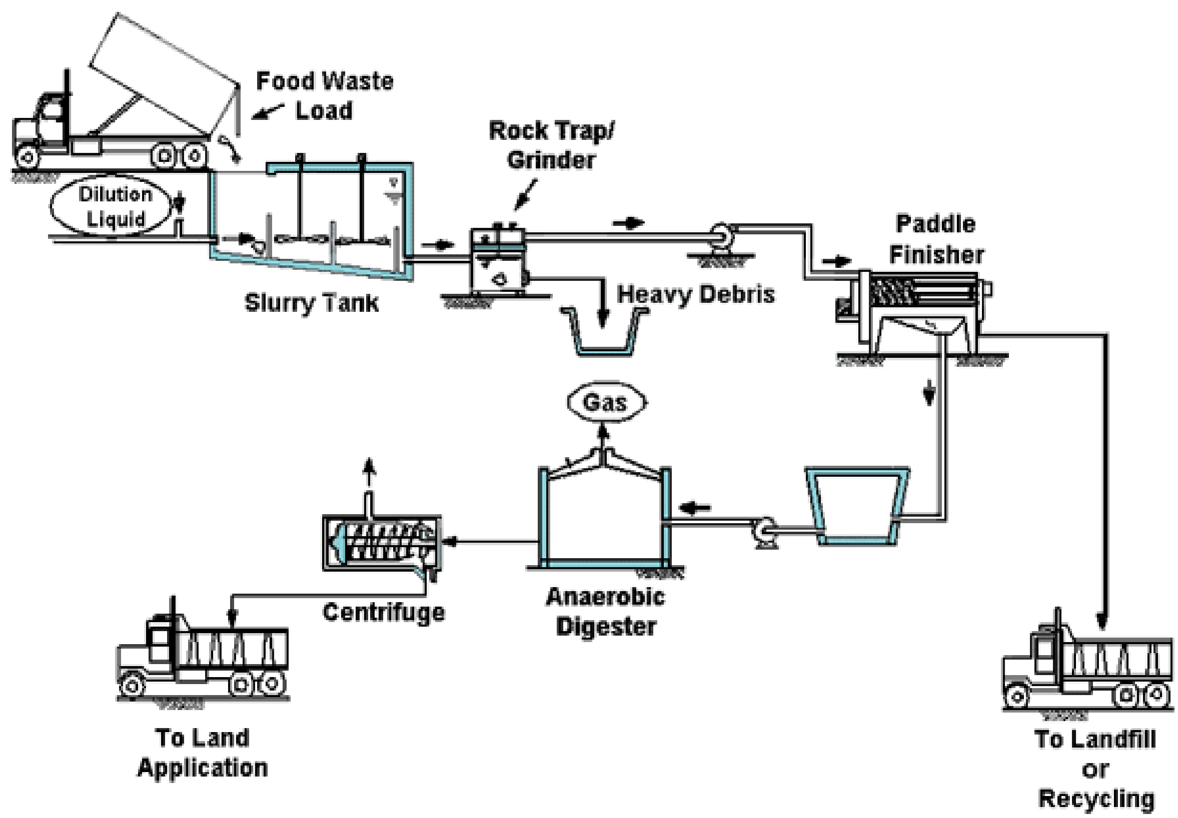
*exact sums not provided

4 How much is stored? What processing is required?

Generally, the interviewed facilities add FOG and food waste into the digesters as soon as possible. Janesville, for example, pumps half of their weekly load (i.e. ~3,000 gallons of chocolate waste) into the digesters the day they receive it, and the rest the next day. Janesville does this because their holding tanks do not mix the waste. As the material will settle over time, Janesville must feed the chocolate into the digesters before it becomes too difficult to pump. Most of the interviewed facilities, however, possess the capacity to store waste over longer periods, if needed. Table 4 summarizes the food waste storage capacity of each facility

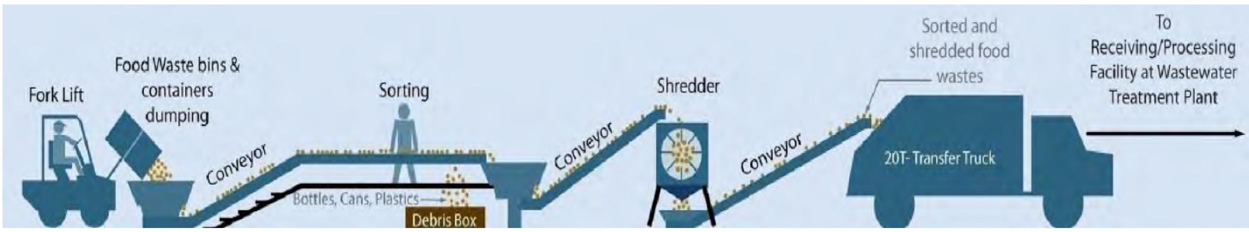
While FOG does not require much processing, other types of food waste do. As with wastewater entering the headworks, the facilities remove large pieces of debris with bar screens. Food waste is then chopped and ground before entering the digesters. Some facilities (e.g. Thousand Oaks) chop and grind food waste on-site. EBMUD and CMSA chop and grind food waste that has also been chopped and ground elsewhere. After receiving preprocessed source-separated commercial food waste, EBMUD further processes the material, using a rock trap/grinder to remove larger debris and then a paddle finisher to remove grit and fibrous material (Figure 5).

Figure 5: **EBMUD process schematic**



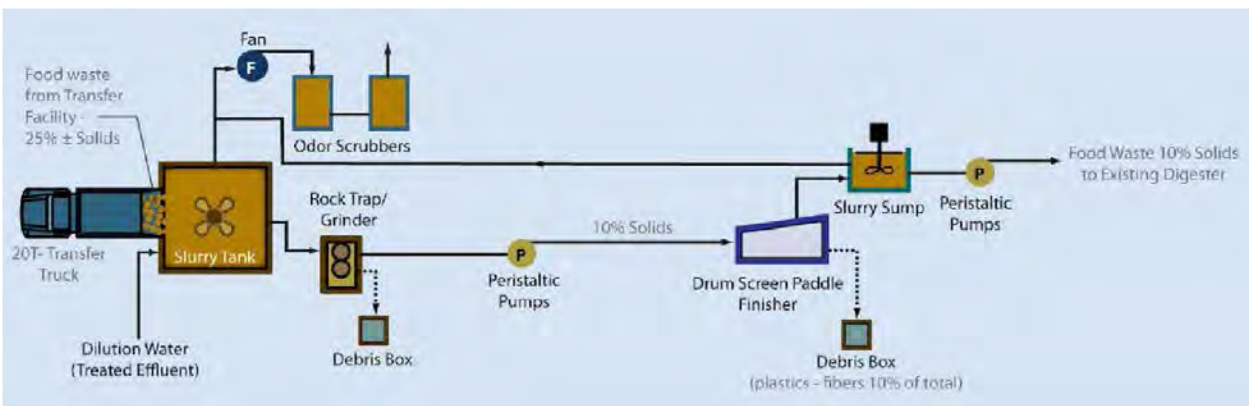
CMSA follows a similar protocol to EBMUD: the MSS hauls food waste collected from commercial customers to its transfer station, where the contaminants are manually removed and the food waste is chopped into 1-inch solids. Then the MSS hauls the waste to CMSA (Figure 6).

Figure 6: **Marin Sanitation Service process schematic**



At CMSA, the food waste, at approximately 25% solids, is combined with FOG in a large, underground storage tank. The FOG/food waste slurry is further diluted with treated effluent, and then further processed with, as with EBMUD, a rock trap/grinder followed by a drum screen paddle finisher. The resultant 10% solids slurry is then pumped into the digester (Figure 7).

Figure 7: **Central Marin Sanitation Agency process schematic**



The food waste that the West Lafayette WRRF receives from the Purdue University cafeteria is preprocessed on campus. The University had originally purchased equipment to collect, macerate, and transport cafeteria food waste so that it could be composted (Kennedy/Jenks Consultants). However, the composting program never materialized. When the West Lafayette operator read about the failed compost program in the local paper, he called the University and asked to tour the cafeteria's new system. He observed "baby food for the digesters" and promptly offered to take the University's waste. The images below show the techniques used to preprocess Purdue's cafeteria food waste.

Figure 8: **West Lafayette's partnership with Purdue University**

Food waste is scraped from plates at the kitchen cafeteria.

Water conveys food waste to an industrial grinder.

A classifier deposits ground food waste into a toter.

During the school year, Purdue delivers 15-20 toters to the WRRF each day.

At the West Lafayette WRRF, an operator stands by as the cart tipper empties a toter into the hopper.

To accommodate the food waste from the cafeteria, the West Lafayette WRRF constructed a receiving station: a platform with a cart tipper that empties the University's toters into a hopper. From the hopper, the food waste passes through a grinder and then into repurposed wet and dry wells (now one big tank with 16,000 gallons of storage capacity). FOG passes through a "heavy object trap" before entering the repurposed wet and dry wells. The food waste/FOG slurry is mixed with warm sludge before being pumped to the digester. Many of the facilities mix the slurry with warm sludge to decrease viscosity. The facilities feed the slurry into the digesters at different rates, and different solids concentrations. Table 4 summarizes the processing techniques of each of the facilities.

Table 4 Food waste storage and processing

	CMSA	**EBMUD**	**Hill Canyon**	**Sheboygan**	**West Lafayette**	**Janesville**
Digester conditions	Mesophilic	Thermophilic	Mesophilic	Mesophilic	Mesophilic	Mesophilic
Storage (gallons)	20,000	40,000 for solid wastes; 81,000 for liquid wastes	20,000 (expanding to 50,000)	500,000	16,000	7,000
Pre-processing	**Hauler** Sorts & grinds into 1-inch solids **On-site** Grinder & Paddle finisher	**Haulers** Remove large objects & metals Grind into ~2-inch solids **On-site** Grinder & Paddle finisher	**On-site** Cleaned for contaminants then chopped and mixed. Fed through manually raked bar screen before entering digester	**On-site** Screen at unloading Grind effluent sometimes added to decrease acidity or chloride content	**Campus** *Food waste* Separated & ground **On-site** *Food waste* Grinder *FOG* Heavy object trap	**On-site** Mechanical bar screen
Feed Rate (GPM)*	30	550	10-20	35-55	30	25
% total solids**	10%	35%	5% (FOG)	3%	~20%	4.5%

*Gallons per Minute (GPM) **Varies greatly with the material.

5 How much biogas is produced? How is it used?

The interviewed facilities reported that co-digesting with food waste and FOG has greatly increased biogas production. For at least three of the facilities, it has more than doubled biogas production. All of the interviewed facilities would like to co-digest more. EBMUD, for example, actively seeks out new sources of waste for their trucked waste program: a full-time business development representative identifies and recruits potential customers.

As with the volume of food waste received (section 2), biogas production, correspondingly, varies throughout the day and throughout the year. Table 6, row 2, shows **average** daily biogas production for each of the six facilities.

Every one of the interviewed facilities uses a co-generation, or Combined Heat and Power (CHP), system to manage their biogas. CMSA runs biogas through a 750 kW Internal Combustion Engine-generator (ICE). Before CMSA started co-digesting, they produced enough biogas to meet 40% of the plant's electricity needs. If the current amounts of FOG and food waste (10,000 gallons of FOG and 1,100 gallons of food waste per day) continue to be delivered, the Agency will generate at least 60% of its energy needs. As additional food waste is delivered, which is desired and expected, the percentage will continue to increase. Assuming the current amounts of FOG and food waste continue to be co-digested, CMSA expects the system will produce 3,460 MWh per year and 150,612 therms/year.

EBMUD is already energy positive. The facility currently generates about 129% of its energy needs on on-site, using 3 ICEs—capable of producing 2 to 2.5 MW each —and a new 4.5 MW gas turbine. With a total energy capacity of 11 MW, the ICEs and turbine can meet 100 to 200% of the facility's demand. Of the 52,561 MWh generated in 2013, the WRRF used 40,782 MWh. The surplus is exported and sold. EBMUD established a Power Purchase Agreement[2] (PPA) with the nearby Port of Oakland. The PPA is a contract that guarantees EBMUD will provide the Port with a certain amount of energy at a fixed rate. If EBMUD generates more than what the agreement stipulates and the Port declines it, that electricity can be sold to others.

In 2013, Hill Canyon produced an average of 450,000 cubic feet of biogas per day; the biogas was directed to two 250 kW and one 295 kW ICEs to generate 4,600 MWh of electricity and 3,000,000 therms of heat. The electricity generated by the engines replaced what would have otherwise been drawn from the grid. The waste heat was used to the warm the digesters and the administration building. Hill Canyon flared about 275,000 cubic feet of biogas per day because it lacked the engine capacity to combust it. Now, with an updated system comprised of two ICEs (the 295 kW and a new 630 kW engine), the facility will soon meet or exceed its power needs.

At the Sheboygan WRRF, biogas is used in boilers to produce heat to warm the digesters. Biogas is also used to power ten 30 kW microturbines and two 200 kW microturbines (Figure 9). In 2006, the facility installed the ten 30 kW microturbines, which are capable of producing a combined 300 kW of electrical power and recovering 10 therms of heat per hour. In 2008, the facility began co-digesting with high strength organic wastes and biogas production jumped 150%, prompting the CHP system's expansion. In 2010, Sheboygan installed two 200 kW microturbines. The two 200 kW microturbines are capable of producing 400 kW of electricity and 14 therms per hour. Most of the year, the Sheboygan WRRF is energy positive.

[2] PPAs are finance contracts between the signatory (e.g. the port) and a third-party renewable energy developer (e.g. EBMUD). The third party owns, operates, and maintains the renewable energy system. In exchange for upfront costs and maintenance, the signatory commits to buying the energy at a predetermined rate over a predetermined time period.

Figure 9: **Microturbines at the Sheboygan WRRF**
Source: Sheboygan Regional Wastewater Treatment Facility 2011

WRRFs can sell excess electricity to the grid. To do so, the facilities must meet **interconnection** standards, which can include complex and costly technical and contractual considerations. EBMUD, for example, spent $1.3 million to upgrade their interconnection to Pacific Gas and Electric's (PG&E) distribution lines. Whether a WRRF sells to a third party (e.g. EBMUD's PPA with the Port) or to the local electric utility, the facility must interconnect. In most states (DSIRE 2013), WRRFs can sell electricity back to the grid by establishing a **net metering** agreement with their electric utility. Net metering credits renewable energy generators that deliver to the grid. The local utility tracks each kwh consumed and received. When a WRRF generates more electricity than it consumes, the electric utility credits the excess delivered to the grid. These credits can, in turn, be used to offset power purchased from the utility when the WRRF consumes more than it generates.

Different states have different interconnection and net metering policies, some more supportive than others (Freeing the Grid 2014). In California, for example, the major electric utilities must offer net metering to all eligible facilities (one MW or less solar, wind, fuel cell or biogas systems) until they reach a legislated limit (DSIRE 2014). Larger capacity systems are eligible for other renewable energy procurement programs. Systems under three MW may participate in California's Feed-in Tariff (FIT) program (CPUC 2014a); systems greater than three MW and less than 20 MW may participate in the Renewable Auction Mechanism (RAM) program (CPUC 2014b). Unlike net-metering, the FIT and RAM programs do not commit utilities to purchasing the electricity at full retail value; rather, as with PPAs, the utilities commit to buying electricity at a predetermined rate over a predetermined time period.

For some WRRFs, selling excess electricity back to the grid can be prohibitively burdensome — not only because it requires familiarity with concepts heretofore peripheral to wastewater operations; but also because interconnection costs can affect project economics. Interconnection costs can be as much as 5-10% of the installation cost of new generation.

The West Lafayette WRRF also generates heat and electricity with microturbines and a boiler. The facility relies on two 65 kW microturbines to produce an annual average of 679 MWh. When Purdue is in session, the waste heat from the microturbines is used to warm the digesters; when not in session (i.e. when the facility is not receiving cafeteria waste), biogas production drops and the digesters must also be heated with a natural-gas fired boiler. Overall, waste heat warms the digesters 90-95% of the time. The West Lafayette CHP system meets less than 20% of the facility's electricity needs. The facility would like to increase biogas production, but the plant operators face two challenges: 1) the facility possesses no biogas storage capacity (and so all excess biogas is flared) and 2) the microturbines are fully utilized (except when school's out). The facility is considering adding another microturbine.

The Janesville WRRF has been generating heat and power since 1985. They started with two 150 kW ICEs, and have progressively invested in a larger, more efficient, and diverse system. Currently, biogas is used to generate heat, power, and vehicle fuel, specifically, compressed natural gas (CNG). Using one 200 kW and four 65 kW microturbines, the facility produced 1,717 MWh in 2013, meeting 27% of its electricity needs. Roughly 65,000 therms of waste heat were recovered from the microturbines and used to warm the digesters. On average, Janesville produces 120,000 cubic feet per day of biogas with about 90% dedicated to the microturbines. The remaining goes to fuel (CNG) production. However, this allocation fluctuates. As the operator explained, the relative amount of electricity and fuel produced "…depends on demand. We adjust accordingly. During on-peak hours, we produce more electricity; during off-peak, we produce more CNG."

Janesville can produce as much as 275 Gallons of Gasoline Equivalent (GGE) per day of BioCNG. In 2013, the facility produced 1,982 GGE. To produce the CNG, the biogas runs through a proprietary gas conditioning system. The CNG is stored and dispensed on-site. At the time of the interview, the CNG was used to fuel four facility vehicles: a dual-fuel Ford F-250 truck, two dual-fuel Ford F-150 trucks, and a dual-fuel Ford Fusion Sedan and one lawn mower, a CNG Dixie Chopper. Within the next ten years, Janesville hopes to produce enough CNG to fuel 40 vehicles.

Table 6 summarizes how the six interviewed facilities produce, store, and use biogas.

As a producer of BioCNG, Janesville could participate in the national Renewable Fuel Standard (RFS) program. Managed by the U.S. EPA, the RFS program mandates that 36 billion gallons of renewable fuel be blended into the nation's transportation fuel by 2022 (U.S. EPA 2014d). The RFS obligates producers of gasoline (including refiners, importers, and blenders) to meet the mandate, and established a trading program to ensure compliance (U.S. EPA 2007a). The trading program allows obligated parties to comply by producing or purchasing Renewable Identification Numbers (RINs).

A RIN is a 38-digit number generated by the production or import of one gallon of renewable fuel; it uniquely identifies the fuel, providing, among other details, information about the fuel category (U.S. EPA 2007b). RFS fuel categories include cellulosic biofuel, biomass based diesel, advanced biofuels, and renewable fuel. The obligated parties must produce or purchase a specified volume of fuel in each category. These Renewable Volume Obligations (RVOs) change each year. Table 5 shows the 2013 RVOs associated with each fuel category (U.S. EPA 2013, U.S. EPA 2014e).

Table 5 2013 Renewable Volume Obligations (U.S. EPA 2013, U.S. EPA 2014e).

Fuel category	2013 RVO Volumes (gallons)	2013 RVO Percentages (of total U.S. fuel produced)
Cellulosic biofuels	810,185	0.0005%
Biomass based diesel	1,280,000,000	1.13%
Advanced biofuels	2,750,000,000	1.62%
Renewable fuel	16,550,000,000	9.74%

WRRF biogas had been classified as an advanced biofuel, but was reclassified to be a cellulosic feedstock in the July 2014 Pathways II Final Rule (U.S. EPA 2014f). WRRF-derived fuels and electricity used in the transportation sector (to, for example, power an electric car) can now generate cellulosic RINs. RINs are traded in an open marketplace, and prices are controlled by supply and demand. Cellulosic RINs may become more valuable for two reasons: 1) They have been relatively rare, and obligated parties must meet RVOs; and 2) Cellulosic fuels are the "one-stop-shop" of the RIN marketplace, as they can be used to meet the RVOs of any RFS fuel category. While Janesville has not yet registered under the RFS, the WRRF is now considering generating RINs for their BioCNG.

Table 6 Biogas production, storage, and use at interviewed facilities

Facility	CMSA	EBMUD	Hill Canyon	Sheboygan	West Lafayette	Janesville
% increase w/ co-digestion	60%	Over 100%	250%	150-300%	N/A**	40%
Biogas production (cubic feet/ day, averaged)	252,000	2,400,000	450,000	560,000	92,160	120,000
Biogas Use	CHP ICE Boiler*	CHP ICE Boiler Turbine	CHP ICE Boiler*	CHP Microturbines Boilers	CHP Microturbines	CHP Microturbin es CNG
Electricity (MWh/year)	3,460	52,000	4,600	2,300	679	1,717
Heat (therms/year)	150,612	2,300,000	3,000,000	84,000	Not measured	>65,000
Fuel (GGE/year)	N/A	N/A	N/A	N/A	N/A	1,982
Biogas Storage	Flexible membrane covers	Membrane dome over 1 digester	Excess flared	Minimal storage in 1 digester	Excess flared	Flexible membrane covers
Storage capacity (cubic feet)	200,000	200,000	None	Negligible	None	102,000
% of electricity demand generated on-site (annual average)	60%	128%	80-85% (soon to be 100%)	90%	16-18%	27%

* Used to heat digesters if CHP system is offline
** The facility started co-digesting as soon as the CHP system went into place. There is no baseline which to compare it.

6 How much biosolids are produced? How are they managed?

Biosolids are the nutrient-rich organic materials resulting from the treatment of domestic sewage in a WRRF. There are several beneficial uses for biosolids, including landfill alternative daily cover (ADC), composting, land application (to manage forests, fertilize farmland, etc.), mine reclamation, or energy generation (e.g. gasification). Biosolids may also be incinerated, disposed of in landfills, and/or stored for future use.

The interviewed facilities produce varying amounts of biosolids, dedicating the biosolids to a mix of uses, depending on quality, quantity, time of year, and affecting regulations. When used for land application, biosolids are classified as class A or class B depending on the level of treatment. Class A biosolids are treated to inactivate pathogens and are subject to fewer regulations, while class B biosolids are treated to remove 99 percent of pathogens and are subject to greater regulation (Water Environment Federation 2010).

In California, the land application of biosolids is heavily regulated, and, in some counties, effectively banned. Some counties only prohibit land application at certain times of the year. CMSA, for example, transports its class B biosolids to Sonoma County, where farmers can land apply from June to October (the dry season); the rest of the year, CMSA sends biosolids to a landfill for use as ADC. EBMUD, on the other hand, sends biosolids to farms for use as fertilizer and to landfills for use as ADC year-round.

In 2013, EBMUD produced 14,716 dry metric tons of class B biosolids, dedicating approximately 40% of that to agricultural land application, 59% to use as ADC, and 1% to two stand-alone food waste digesters. As the immediately surrounding counties have prohibited year-round application, EBMUD transported 5,942 dry metric tons of biosolids over 100-miles to Merced County, where farmers can land apply throughout the year. By sending 8,664 dry metric tons of biosolids to local landfills for use as ADC, EBMUD substantially reduced hauling distances and the associated costs. The two stand-alone food waste digestion projects (Hillmar Cheese and Zero Waste) used, respectively, 100 and 10 dry metric tons of EBMUD biosolids as a “starter,” co-digesting to develop the desired metabolic activity.

Hill Canyon is located in Ventura County, a jurisdiction which has effectively banned the land application of biosolids. The WRRF currently sends 100% of its class B biosolids to the Toland landfill, where they are heat dried (to meet class A standards). In the future, the landfill operators hope to sell the treated biosolids as a soil amendment; currently, it’s used as ADC. In order to reduce the amount sent to landfills, Hill Canyon will soon enter into “biosolids transformation” arrangement that will generate energy and reduce hauling volumes. The facility is considering a range of technologies, including pyrolysis, gasification, supercritical water oxidation, and hydrothermal processing.

West Lafayette land applied 348 dry metric tons of biosolids in 2013, and was able to do so year-round because the Indiana Department of Environmental Protection permitted the land application of the WRRF’s biosolids onto snow-covered or frozen ground. When West Lafayette cannot immediately land apply (e.g. because farmers’ schedules unexpectedly shift), the biosolids are either stored on-site or — if the on-site storage capacity is exceeded — sent to a regional facility, where the biosolids are stored until they can be land applied.

Janesville land applies 100% of its class B biosolids between spring and fall (the exact timing depends on when the growing season begins and ends). During the winter, the facility stores biosolids on-site, and begins land applying when the growing season starts again. Similarly, Sheboygan land applies 100% of its biosolids from April to October; as with Janesville, the WRRF stores them on-site during the winter months.

Co-digesting at WRRFs that land-apply biosolids contributes to the creation of a valuable soil amendment used to grow crops, manage forests, and restore land. Of the six interviewed facilities, half of these land-applied **all** of the biosolids they produced. The Sheboygan (WI), Janesville (WI), and West Lafayette (IN) WRRFs hauled biosolids to nearby farmland to fertilize fields and increase soil moisture. Both CMSA and EMUD land applied a portion of their biosolids. Only Hill Canyon sent everything to a landfill. The biosolids management strategies of the interviewed WRRFs reflects national trends. In the U.S., 55% of biosolids are applied to soils for agronomic, silviculture, and/or land restoration purposes (NEBRA 2007).

Table 7 Biosolids management

	CMSA	EBMUD	Hill Canyon	Sheboygan	West Lafayette	Janesville
Quantity produced (dry metric tons per year)	1,302	14,716	2,011	3,278	370	1,277
Biosolids use	Dry season: Land applied ADC Wet season: ADC	Dry season: Land applied ADC Wet season: ADC Disposal	Year-round: ADC Disposal	Spring-Fall: Land Applied Winter: Stored on-site	Year-round: Land Applied	Spring-Fall: Land Applied Winter: Stored on-site
Percent to each use	Land Applied: 31% ADC: 69%	Land Applied: 40% ADC: 59% Other: 1%	Landfill disposal or ADC: 100%	Land Applied: 100%	Land Applied: 100%	Land Applied: 100%

Table 7 shows how the interviewed facilities manage their biosolids. The interviewed facilities did not quantitatively describe how co-digestion has affected the volume of biosolids production. Instead, EBMUD, West Lafayette, and Sheboygan indicated “commensurate” or “proportional” increases in production of biosolids with co-digestion.

7 How much did the facilities invest in co-digestion infrastructure?

All but one of the interviewed facilities received some amount of grant funding to help finance their co-digestion efforts. However, the grants represented relatively small portions of overall project costs. For the interviewed facilities, money saved by reducing energy use and the money earned from tipping fees have made these projects economical.

In 2008, CMSA received $20,000 in seed funding from their local utility, PG&E, to complete a methane capture feasibility study (Marshall 2014). The PG&E grant represented a very small portion of the total project costs. Over the course of six years, CMSA will have spent $7.65 million on digester upgrades and the co-digestion project, investing not only in the construction of the new solid and liquid waste receiving station, but also in the installation of other critical project components, such as a more effective and energy-efficient digester mixing system, new flexible membrane covers (to replace the digesters' 25 year-old floating steel covers), and a new hydrogen sulfide removal system. Of the $7.65 million, $1.9 million was used to construct the FOG and food waste receiving facility.

Having only started co-digesting in February 2014 CMSA has not realized major savings, but the agency is optimistic. By reducing the consumption of—and, eventually, no longer purchasing—natural gas, they expect to save as much as $396,900 per year. Once CMSA exports electricity back to the grid, the agency will also realize electricity savings. At present, there are none. CMSA also generates revenue via tipping fees. CMSA charges $.10/gallon, $.08/gallon, and $20/ton for FOG, septic, and food waste, respectively. Based on the annual percentage change of the greater San Francisco Area All Urban Consumer Price Index (CPI) index, CMSA's food waste tipping fee will very likely increase 1-3% annually (CMSA 2013).

If all of the area's food waste generators were to participate in the organics collection program, CMSA could receive as much as 20 tons of food waste per day. With a tipping fee as low as $20/ton, CMSA could make as much as $144,000/year from food waste tipping fees. While the program is in its infancy, the agency will nonetheless earn a fair amount this year. Assuming CMSA continues to daily receive 10,000 gallons of FOG and four tons of food waste through 2014, the associated tipping fees should generate roughly $400,000. If CMSA receives as much as 20 tons of food waste per day, the agency estimates the project will be paid back in 2.89 years; if they never receive more organic material than what is currently co-digested, the agency estimates the project will be paid back in 7.82 years.

EBMUD received funding from numerous sources, including a 2002 grant awarded through California Senate Bill (SB) 5X, a one-time grant program funding peak-load reduction and supply augmentation projects; a 2004 California Energy Commission (CEC) grant for $0.5 million; and a 2006 EPA grant for $50,000 (EBMUD 2012b). While grant funding helped kick-start the project, the system is paying for itself (EBMUD 2012b). EBMUD generates millions of dollars each year in revenue from tipping fees and energy sales. Tipping fees range from $0.03/gallon for liquid organic material to as much as $65/ton for solid organic material (See Table 8). In 2012, EBMUD brought in $8 million through tipping fees (Day 2012). Energy savings and sales yield, on average, an additional $3 million a year.

EBMUD heavily invested in the infrastructure needed to support this system: $5 million to construct the food waste receiving station, $1.3 million in interconnection fees, and another $30 million for the new gas turbine. Additional costs include operating and maintaining the system, managing a greater volume of biosolids (and hence purchasing more polymer, hauling more biosolids, etc.), and staffing the Materials Management program, which consists of five full-time employees. EBMUD considers co-digestion a very beneficial investment, for the agency and for their customers. As the interviewed representative explained, EBMUD pursued co-digestion "…to create a net benefit for our ratepayers." By finding a creative way to use their excess digester capacity, EBMUD has increased the agency's revenue, securing funding for capital improvements that otherwise would have been obtained by raising rates.

Table 8 FY13-14 rates for EBMUD tipping fees

Septage	\$0.07/gal
FOG	\$0.11/gal non-concentrated \$0.15/gal concentrated
Liquid Organic Material	\$0.03/gal
Protein Material	\$0.06/gal up to 10% Total Solids \$0.08/gal over 10% Total Solids
Solid Organic Material	\$30/ton - \$65/ton

Source: EBMUD 2014

Partially funded by the California Public Utilities Commission's Self Generation Incentive Program (SGIP), Hill Canyon's engines will soon provide at least 100% of the facility's energy needs. The remaining funding was contributed by a third party. Hill Canyon forged a PPA with CHP Clean Energy (CHPCE). Hill Canyon pays \$.07/kWh to CHPCE, rather than 0.16/kWh to Southern California Edison. The WRRF estimates they save roughly \$300,000 a year on avoided energy costs. While very little of the utility's funds were used to finance the CHP system, Hill Canyon invested \$400,000 to construct a FOG and liquid waste receiving station. In total, the receiving station cost \$800,000; the American Reinvestment and Recovery Act (ARRA) funded the difference. The WRRF's renewable energy initiatives, along with energy efficiency and process optimization projects, have kept the monthly sewer service charge for a single-family residence stable for nearly a decade. They have also advanced their local Energy Action Plan.

In 2012, the City of Thousand Oaks adopted an Energy Action Plan. The plan identified "energy standards and policies to guide the City in achieving its long-term objectives in energy efficiency, renewable energy, and carbon emission reductions" (City of Thousand Oaks 2012). The Hill Canyon WRRF has been a driving force in helping City attain its 2017 goals to reduce energy use by an additional ten percent. In 2011, City facilities consumed over 11 million kWh. By committing to reduce energy use by 10% from the 2011 baseline, the City of Thousand Oaks committed to reducing 1,344,938 kWh (City of Thousand Oaks 2014).

Between 2011 and 2013 the Hill Canyon WRRF reduced energy by 715,483 kWh. Between 2011 and 2013, the Hill Canyon WRRF increased onsite renewable energy generation by 1,890,101 kWh. Through energy efficiency, process optimization, and on-site renewable energy generation, Hill Canyon had, by 2013, exceeded the City's 2017 goal.

Communities across the country are setting targets to reduce energy use. Typically the largest energy consumers in municipalities and often possessing the existing infrastructure to generate renewable energy onsite, WRRFs are critical partners in helping cities advance energy reduction and renewable energy generation efforts.

Both Sheboygan and Janesville received grant funding (\$225,960 and \$138,421 respectively) from Wisconsin's Focus on Energy, a statewide energy efficiency and renewable resource program funded by the state's electric utilities.

Initially, Sheboygan entered into a PPA, and the third party absorbed the remaining installation and maintenance costs for the first phase of the CHP system (i.e. the ten 30 kW microturbines). Eventually, the facility purchased the microturbines and installed the two 200 kW microturbines (phase two). In total, Sheboygan invested $301,000 for the first phase and $1,295,000 for the second phase. Additionally, the city invested $75,000 in infrastructure to blend and mix the food waste (i.e. an in-line strainer, a mixing pump, and a feed pump) and another $350,000 to upgrade the boiler. In total $2,021,000 in city funds were invested in the CHP and co-digestion system. In 2012, Sheboygan earned $366,000 through reduced electricity costs, $75,000 in reduced natural gas costs, and $290,800 through tipping fees. Increased competition for high strength food waste, however, is affecting earnings. In 2013, Sheboygan received more waste and earned less in tipping fees. The WRRF is now accepting the majority of food waste for free.

There were also two distinct phases to Janesville's (most recent) biogas initiatives (Botts and Zacovek). During the first phase, Janesville upgraded its biogas-to-energy system (i.e. installed the dual membrane gas storage system, the conditioning and compressor system, the four 65 kW microturbines, etc.). These upgrades cost $1,196,752, and were partially funded by the Focus on Energy grant. Once Janesville installed the microturbines, the facility entered into a net metering agreement with the local energy provider, Alliant Energy. During the second phase, Janesville added the 200 kW microturbine and the BioCNG system. These upgrades cost $880,000, and were partially funded with a $125,000 grant from the WI State Energy Office. The biogas-to-energy system improvements were part of a broader $30,000,000 expansion project, which Janesville helped fund by increasing rates (by 7.5%). With $9,000/year earned in tipping fees and an estimated $257,801/year saved in heat, electricity, and fuel costs, Janesville estimates the projects will be paid back in 7 years.

The West Lafayette "digester renovation and alternative power source" project cost $10.4 million. The facility drew from the general fund to pay for the food waste receiving station. The FOG collection and CHP systems were financed with a low-interest loan from the Indiana Finance Authority's State Revolving Fund (SRF) program. By saving $80,000/year in reduced energy costs and generating an average of $10,000/ year in tipping fees (from FOG only; Purdue is not charged), the WRRF estimates the investment will be paid back in 12 years. While West Lafayette moderately increased wastewater rates to pay back the SRF loan, the money saved on energy and earned in tipping fees will ultimately help minimize future rate increases.

Table 9 summarizes sources of funding, project earnings, and estimated payback periods.

Table 9: Cost, savings, and revenue

	CMSA	EBMUD	Hill Canyon	Sheboygan	West Lafayette	Janesville
Funding Assistance	PG&E	U.S. EPA CEC SB 5X	SGIP ARRA	Focus On Energy	None	Focus On Energy State Energy Office
Capital Investment (million $)	$1.9	$35	$.4	$2.02	$10.4	$2.07
Tipping Fees ($/year)	≤ $400,000	$8,000,000	$307,000	$296,800	$10,000	$9,000
Energy-derived savings ($/year)	Gas: $396,900 Electric: n/a	Gas & Electric: $3,000,000	Gas & Electric: $3,000,000	Gas: $296,800 Electric: $366,000	Gas: $30,000 Electric: $50,000	Gas: $28,000 Electric: $224,801 Fuel: $5,000
Estimated Pay-Back (years)*	2.9 - 7.8	3.2	0	2.7	12	7

* These estimates were provided by the interviewed WRRFs and incorporate factors not discussed in this report.

8 Summary & Conclusions

This report has described the co-digestion practices and performance of six WRRFs: the Central Marin Sanitation Agency (CMSA), the East Bay Municipal Utility District (EBMUD), and the Hill Canyon Treatment Plant in California; the Sheboygan and Janesville facilities in Wisconsin; and the West Lafayette Wastewater Treatment Utility in Indiana. They have shared information about the food waste material, receipt, storage and processing; biogas and biosolids production and use; and program costs. The interviewed facilities relied on different materials, technologies, management strategies, and funding mechanisms, yet their responses to the question "Would you recommend that other facilities pursue co-digestion?" were unanimously affirmative. Each of the six organizations agreed that, although co-digestion presents challenges, the benefits outweigh the difficulties.

Even the Sheboygan (WI) WRRF— which is not only making less money in tipping fees than it has in previous years, but must also repair and coat the concrete walls and floors of their receiving tank and install new stainless steel piping throughout so that the system can tolerate the acidity of trucked in FOG and food waste— is determined to realize "complete energy self-sufficiency…" and so is "…planning to diversify (their) high strength waste loading to include more sources…" (City of Sheboygan Regional Wastewater Treatment Facility 2014). For WRRFs with excess capacity, co-digestion can be a fundamental feature in plans for energy independence. Revenue earned through tipping fees and costs reduced through energy savings (electricity, heat, **and** fuel) can be used to help finance repairs and upgrades, tempering rate increases and adapting municipal budgets to shortfalls in public infrastructure funding.

Although traditional sources of federal funding for public infrastructure have declined, federal incentives for renewable fuels are increasing. In July 2014, EPA's Renewable Fuel Standard (RFS) recognized biogas as a transportation fuel feedstock, designating the resulting fuel as "cellulosic," likely conferring greater value to the associated RINs. Some states are also incentivizing renewable fuels production. In May 2014, the California Air Resources Board (CARB) announced a Low Carbon Fuel Standard (LCFS) pathway for WRRF-derived biogas (CARB 2014). Both the RFS and the LCFS have set renewable fuel targets. Obligated to meet the mandates, refiners can generate RINs and LCFS credits to comply; they can also trade them. While the renewable fuels market has been volatile, experts expect that generating credits will prove lucrative. In conjunction with co-digestion, state and federal renewable fuel incentives may enable many WRRFs to initiate or expand biogas to energy projects.

With the ability to not only offset their own large energy requirements but to generate surplus heat, electricity, and/or fuel, WRRFs are uniquely equipped to advance local climate change mitigation efforts. For example, the City of Thousand Oaks' (CA) 2011 Energy Action Plan identified renewable energy and energy efficiency efforts at the Hill Canyon Treatment Plant—which, of all its municipal facilities, had the biggest electricity bill and second biggest emissions load—as central to attaining the City's greenhouse gas reduction goals (City of Thousand Oaks 2012). As Hill Canyon co-digests more food waste and generates more renewable energy, the City of Thousand Oaks will likely revise their targets.

Co-digestion can also facilitate waste diversion goals. For example, San Francisco is committed to diverting 75% of its discards from landfills by 2010, and 100% by 2020. Diverting organics (food and yard material) is a major component of the City's "zero waste" strategy. San Francisco currently collects an average of 600 tons of source-separated organic material each day. While the majority is composted, the EBMUD has— as part of an eight-year pilot program— received 20 to 40 tons per day. San Francisco has pursued co-digestion as a way to reduce the volume of hauled organic waste, improve handling, and control emissions[3] (Sullivan 2011). To reach its diversion goals, San Francisco plans to increase the

[3] Anaerobically digesting food waste stabilizes it, mitigating the volatile organic compounds (VOCs) that would otherwise be emitted at composting operations (California Integrated Waste Management Board 2008, Mata-Alvarez, Macé, and Llabrés 2000).

volume of anaerobically digested food and yard material—although source-separated organics will no longer be **co-**digested.

The majority of EBMUD biosolids are used for ADC. For San Francisco, co-digesting source-separated organics at a WRRF that sends its biosolids to a landfill is not “the highest and best use.” This has lead EBMUD, San Francisco, and Recology to explore alternatives that will advance both the City’s waste diversion and the WRRF’s renewable energy goals. Other West coast cities (e.g. Seattle and Portland) and Northeast states (e.g. Massachusetts, Connecticut and Vermont) have banned food waste from landfills (Henricks 2014). Concurrently, many communities, particularly in California, restrict the land application of biosolids. As local and state ordinances simultaneously advocate for diverting organics and restricting biosolids use, WRRFs with excess digester capacity present an attractive solution (i.e. co-digestion) with an— in some places —unwelcome byproduct (i.e. biosolids).

Of the interviewed facilities that produce biosolids used as ADC, one, the Hill Canyon (CA) WRRF, sends 100% to landfill. Hill Canyon is located in and surrounded by counties with such restrictive permit requirements that the land application of biosolids has effectively been banned. EBMUD (CA) and CMSA (CA), respectively, land apply 40% and 31% of their biosolids, a result of nearby county requirements which either prohibit land application or prohibit it during the rainy season. In areas with very restrictive permit requirements, WRRFs such as Hill Canyon are evaluating “transformation” options; these technologies would respect permit provisions while maximizing energy generation and minimizing solids production.

While technologies such as pyrolysis and gasification may one day become standard, the interviewed facilities, in the meantime, generate energy as wastewater treatment facilities have since the 1920’s: with *sewage gas* (Figure 3). Running biogas through internal combustion engines, microturbines, and/or turbines, all of the interviewed facilities used CHP systems to keep their digesters warm and to power their operations. Only one, the Janesville (WI) WRRF, additionally produces CNG to fuel vehicles. Emerging national and state incentive programs such as the RFS and LCFS will likely prompt more projects, as may prohibitively expensive interconnection fees and relevant air quality regulations[4].

Streamlined waste management regulations may also facilitate more projects. To receive, process and co-digest food waste in California, a WRRF is required to hold two permits from two state agencies: A NPDES permit from the SWRCB, and a solid waste permit from CalRecycle. State agencies and the California Association of Sanitation Agencies have been working to resolve this issue. CalRecycle is proposing an exclusion for direct injection of “anaerobically digested materials” (ADM) into WRRF digesters regulated under a NPDES or Waste Discharge Requirement (WDR) permit. The CalRecycle exclusion would require that the WRRF develop proper Standard Operating Procedures to manage the ADM (Appendix B).

While supportive regulations facilitate co-digestion, more significant to the interviewed facilities were supportive partnerships. Whether an unplanned collaboration—such as repurposing Purdue’s grinding and pulping equipment to make “baby food” for the West Lafayette digesters— or more formal partnerships—such as the arrangements between the WRRFs and the waste haulers—the interviewed facilities indicated that leveraging the expertise and resources of other organizations can be very beneficial. This was particularly true of the facilities that executed PPAs. Maximizing renewable energy production requires focus and skills outside the traditional scope of wastewater treatment utilities (WERF 2012b). By partnering with an organization that specializes in renewable energy generation, WRRFs can attain energy independence without developing exhaustive in-house expertise.

[4] Biogas-to-fuel may become an attractive option for WRRFs in extreme non-attainment areas (for criteria air pollutants such as ozone), where local air districts have promulgated rules that complicate the permitting of stationary engines (e.g. California’s South Coast Air Quality Management District's rule 1110.2).

Two of the interviewed facilities, the Hill Canyon (CA) and Sheboygan (WI) WRRFs, forged PPAs with third-party renewable energy developers. PPAs ensure stable and often lower electricity rates, efface maintenance costs, and provide the expertise WRRF operators may lack. Operators can, however, develop the necessary expertise, and the facilities may eventually choose to purchase equipment they once leased. Sheboygan, for example, originally partnered with Alliant Energy, but eventually purchased the 10 microturbines Alliant managed—and then installed 2 more. Now, Sheboygan carries the burden and the benefit, assuming the maintenance costs and the savings.

WRRFs are accustomed to changing economic, regulatory, and biological conditions. Whether balancing budgets, meeting more stringent discharge requirements, or responding to an unexpected peak in BOD, WRRFs know how to adapt. Skills essential to operating a WRRF lend themselves to initiating and maintaining co-digestion programs. As the Hill Canyon operator explains, it takes "…equal amounts of FOG, frappo, determination, technology, joy, disappointment, teamwork and, an American trait we should all appreciate, a belief in the power of self-reliance." In other words, excess digester capacity is not the only existing asset a co-digestion program relies on.

Navigating unfamiliar regulations, investing in new equipment, and/or adjusting facility processes to accommodate different waste streams can be challenging. But, for many WRRFs, increasing biogas production will be a worthy incentive. Co-digestion has more than doubled biogas production at the EBMUD, Hill Canyon, and Sheboygan; at CMSA and Janesville, it has increased biogas production by 60% and 40%, respectively; at West Lafayette, it propelled investment in the plant's first CHP system. Because co-digestion markedly increases biogas production, it is and will continue to be a strategic component of many WRRF renewable energy projects. Today, almost as many WRRFs co-digest (216) as co-generate (270) (Qi, Beecher and Finn 2013). These numbers will likely rise concurrently as energy and operating costs increase, waste diversion ordinances gain popularity, and climate change mitigation and adaptation efforts advance.

9 Appendices

Appendix A: Survey questions for WRRFs

Facility Information:

1. What is your facility design flow? What is your average dry weather flow?
2. What is your digester design capacity?
3. How have you estimated excess capacity? Do your estimates vary by season?

Food waste collection information:

4. Does the WRRF digest food waste? If so, what are they?
5. How far away are these sources?
6. Is there an issue with seasonality (especially from agricultural waste)?
7. What systems are in place to accept and store the various types of food waste?

Food waste processing information:

8. Does the WRRF pre-process the food waste before it enters the digester? If so, how does it pre-process?
9. What volume of food waste is processed in a year?
10. At what rate does unprocessed food waste enter the facility?
    - Average/min/max rate?
11. At what rate does processed food slurry enter the anaerobic digester?
    - Average/min/max rate?
12. What is the percent total solids and ratio of volatile solids to total solids is the food waste before it is mixed with the municipal sludge?
    - What about for the combined food waste/municipal sludge feedstock?
13. How has co-digestion of food waste affected the biogas generated?
    - What quantitative measures demonstrate this change? (Volume of biogas, electricity generated, increased revenue, etc.)
    - What other qualitative changes have been observed?
14. How sensitive are the digesters to feedstock variations?
    - How have issues been remediated?
15. How has co-digestion affected biosolids production, and hauls?
16. Have there been odor problems from handling and digesting food waste?

Biogas Production

17. Are digesters operated under mesophilic or thermophilic conditions?
    - At approximately what temperature?
18. Has the WRRF been able to determine the mean cell residence time or volatile solids reduction since the 2008 report?

Biogas Storage and Utilization Information:

19. Does excess biogas need to be stored? How is excess managed?
20. What fraction of the WRRF's power needs are generated onsite?
21. How much power is produced on site annually?

Cost, Savings, and Revenue Information:

22. What are the operation and management costs?
23. What were the equipment costs?
24. Were there any other revenue or cost savings as a result of co-digestion? Such as:
- electricity sold to the grid
- cost savings on biosolids disposal
- tipping fees

25. How have tipping fees affected the economics of the project?
26. What was the payback period? The return on investment?

Building Future Relationships

27. What were the most significant factors that led this WRRF to start co-digesting?
28. Overall, would this WRRF recommend that other facilities pursue co-digestion?
29. Are you willing to mentor other facilities considering food waste co-digestion projects?
30. Is the WRRF planning to sell the engineering designs?

Appendix B: Example Standard Operating Procedures to Manage Anaerobically Digestible Material (Curtsey of CSMA)

FOG/Food to Energy Receiving Facility Operations Document
Fats, Oils, and Grease, and Food Waste Receiving Station

April 2013

Purpose
This operating procedure (SOP) is intended to ensure that the delivery and processing of Fats, Oils, and Grease (FOG) and Food Waste (FW) brought to the CMSA Treatment Plant are conducted in a safe, efficient manner that protects the physical facilities, maintains adequate treatment capacity, ensures proper overall operation, maximizes beneficial reuse, and maintains acceptable effluent quality. This procedure is designed to comply with the requirements in Special Provisions section C, subsection 5d. Fats, Oils, and Grease in CMSA's NPDES permit.

Description
The FOG/FW Receiving Station (the Receiving Station) is located on the south western side of the Agency's Solids Handling Building (1). The Receiving Station consists of a slurry tank, a FOG receiving connection and FW receiving hatch opening into the slurry tank, and various processing equipment. It is designed to receive and process FOG and FW, mix it with digested sludge, and transport it to the Agency's Anaerobic Digesters (the Digesters). During normal operation, methane gas (biogas) is produced (2) in the Digesters and used as a fuel source along with natural gas to operate a cogeneration engine and generator that produces electricity and waste heat. The electricity produced is used to power the Agency's facilities which offset's the purchase of natural gas for engine fuel, and in the future electricity from Marin Clean Energy. Captured waste heat is used to produce hot water for heating the Digesters and for other uses throughout the Treatment Plant and Agency facilities.

Unlike typical wastewater treatment plant process equipment, the receiving station does not receive raw wastewater from a collection system. The Receiving Station's slurry tank has a working volume of 20,000 gallons and can accept up to 20 tons of FOG and/or FW per day, both coming primarily from Food Service Establishments within the central Marin service area. These wastes are delivered to the receiving station by FOG tanker and/or specialized food waste hauling trucks. The received FOG and FW are processed by screening, grit/rock removal, mixing with heated digested sludge, and holding for processing into the Digesters. Following the anaerobic digestion process, the biosolids are dewatered by centrifuges and beneficially reused as land applied soil amendments or utilized as alternative daily cover at a local landfill.
This facility includes integrated instrumentation and control systems for manipulating and monitoring various aspects of the receiving station operation.

Definitions
Authorized Waste Haulers: Companies which have obtained access cards issued by CMSA and are authorized to transport and dispose of FOG and Food wastes into the receiving station for processing.

Biosolids: Refers to treated municipal wastewater sludge that meets federal (EPA) pollutant and pathogen requirements for land application and surface disposal.

Commercial Food Waste (FW): Food preparation wastes from commercial food service establishments.

Fats, Oils and Grease (FOG): Oily organic compounds, derived from animal and/or plant sources, that are generated during food preparation and cooking, and that are captured in grease traps and interceptors at Food Service Establishments.

Food Service Establishment: Those establishments primarily engaged in preparing, serving or otherwise making foodstuffs available for purchase and consumption.

FOG/FW Receiving Station: The facility at CMSA which receives, stores, and processes FOG/FW from waste haulers with the purpose of introduction of the FOG/FW into the Digesters and to increase biogas production.

FOG Delivery Sequence: The automated sequential steps required to receive and process FOG deliveries.

Food waste Delivery Sequence: The automated sequential steps required to receive and process food waste.

Hauled Waste: A non-hazardous liquid waste, as defined by the USEPA, which is prohibited from discharge into:
(a) a sanitary sewer; or
(b) a storm sewer or watercourse.

Human Machine Interface (HMI/PLC): The user interfaces in a Treatment Plant's process control system. They provide a graphics-based interface for controlling the process control and monitoring system.

Interference: Discharges which, alone or in conjunction with a discharge from other sources would:

1. Inhibit or disrupt the Treatment Plant, its treatment processes or operations, or the processing, use, or disposal of its sludge processes; and

2. Therefore would a cause, or have the potential to cause, a violation of any permitted requirement.

Liquid Waste Hauler: Any person, firm, corporation or other entity that collects, pumps, transports and/or disposes of liquid wastes.

Odor Control System: A system to contain and remove odors from air in process environments.

The Receiving Stations' odor control system includes air ducts, fans, and an activated carbon media vessel. The carbon adsorbs volatile organic carbons (VOCs) and converts hydrogen sulfide (H2S) to water soluble sulfur compounds by oxidation.

Treatment Plant: For the purpose of this SOP, these are any of the, facilities, structures, devices, equipment or works owned by the CMSA for the purpose of the transmission, storage, treatment, recycling and reclamation of municipal wastes.

Unacceptable Materials: Materials of a type, quality, or quantity that would adversely impact the Food Waste receiving facility operations (e.g. clogging pipelines or damaging equipment).

Conditions of Acceptance of FOG/FW
CMSA has the right, but not the obligation, to inspect each load of hauled waste to confirm that no unacceptable materials are contained therein. Lack of inspection of any load does not relieve an authorized waste hauler from the obligation to not discharge any unacceptable materials into the Receiving Station. The Receiving Station will receive FOG and/or FW from haulers six days per week. The hours of operation are M-F 6:00 a.m. to 4:00 p.m., Saturdays 9:00 a.m. to 12:00 p.m., excluding Agency Holidays. Authorized waste haulers will fill out a *Trucked Waste Record* (3) at CMSA's Administration Building prior to entering the Treatment Plant and proceeding to the Receiving Station. The white line striped on the plant road provides visual direction to the receiving station for first time users and emergency responders. CMSA reserves the right to refuse or require scheduled delivery of any hauled waste, if doing so would be in the best interest of the operation of the Treatment Plant to avoid process disruptions. Wastes that contain heavy metals, toxic chemicals, and extreme pH, flammable or corrosive materials in concentrations harmful to the treatment operation will not be accepted.

Unloading
The Receiving Station's equipment has been designed for receiving both FOG and FW waste streams. Material is screened by a Rock Trap Grinder (FOG) and a Paddle Finisher (FW). These machines are designed to prevent interference by screening the waste and removing materials that could clog downstream equipment and/or cannot be anaerobically digested. The screenings are directed to special debris bins for off-site disposal. FOG delivery is designed to be fully automated after the delivery driver inserts an Agency issued access card into the card reader. Prior to accepting FOG deliveries, the station's HMI will shut down all operating equipment and valves feeding the Slurry Tank that could disturb or change the liquid level in the tank. The Slurry Tank has a working volume of 20,000 gallons, based on a low operating level of 4.0 feet and a high operating level of 11.0 feet. Food Waste Deliveries will be performed by Marin Sanitary Service (MSS) with CMSA staff observing the deliveries. The Slurry Tank can accept a single truck load of up to 20 tons of food waste every day. Guide posts and a concrete tire stop are located to assist the MSS delivery drivers in properly positioning the truck so it will dump its contents into the Slurry Tank without spilling onto the plant road. If a material spill needs to be cleaned up, it can be rinsed to a nearby drain sump that is connected to the slurry tank, identifiable by "Drains to Slurry Tank" marked drain sumps.

Processing
After the Hauled Waste has been received and the slurry tank filled to the pre-established level, an operator will initiate the slurry tank mixing sequence (4) from the FOG/FW HMI. The station PLC sets the amount of mixing time needed (based on source and amount) to create the slurry. After appropriate slurry mixing, the receiving station goes into an automatic mixing mode using the mix pumps, the paddle finisher, and/or the rock trap grinder.

Feeding
Feeding the slurry to the digesters is permitted only when the following conditions exist:
1. The FOG Delivery Sequence is not active
2. Food Waste Slurry Sequence is not active
3. Slurry Tank level is above the operator adjustable low level setting. (Initially set at 4.0 feet.)
4. Station recirculating pumps are operating.
5. Digester Gas Volume is less than 116,000 cubic feet
6. Digester liquid levels are less than 25 feet

Spill Prevention and Containment
The FOG and FW delivery areas are designed to drain rainwater directly into the Slurry Tank via 4-inch drain piping. There are no valves in this piping, so drainage will occur without operator action. To prevent possible odor emissions from the Slurry Tank, each 4-inch tank connection contains a P-trap. A 6-inch interconnected drain pipe with a buried plug valve is provided to drain any FOG or FW spillage from either receiving pad directly into the slurry tank. The buried plug valve should be closed at all other times to avoid the potential for odor emission through the 6-inch drain piping.

If the Slurry Tank needs to be drained (5) rapidly, two feed pumps and a recirculation pump can be utilized. The pump discharges can be manually valved to the existing plant process waste return sump in the Solids Handling Building and recycled to the plant Headworks. Pipe cleanouts are located in the suction and discharge piping of the Receiving Station mixing pumps and the feed pumps. CMSA's Emergency Response Plan (6) provides a detailed response in the event that spilled waste makes its way into the Treatment Plant's storm drain system and cannot be contained and pumped back to the treatment plant.

Vector and Odor Control
The Slurry Tank delivery hatch and Paddle Finisher sump hatch are two potentially significant access points for vectors (rats, mice, insects, birds) into the receiving tank. These access points shall be closed at all times except for during deliveries and maintenance activities. Fine mesh screens have been attached to the tanks air intake and exhaust vents to exclude vectors from those entry points.

The Odor Control System (OCS) has a gas detection meter that monitors for oxygen, hydrogen sulfide, and flammable gases and vapors. The OCS draws air from the Slurry Tank and removes the contaminants in the air stream before the air is released into the atmosphere. The fan for the OCS can be started manually as needed to prevent emissions from the Slurry Tank. The media in the OCS vessel is high quality activated carbon. When odor or hydrogen sulfide breakthrough occurs, the media can be regenerated in place.

Separate from the OCS, exhaust fans are included to minimize the potential for harmful gases to accumulate in the lower equipment area. These fans are also designed to provide ventilation so that the equipment area does not need to be designated as a hazardous area per the National Electrical Code. Fans will be in operation at all times.
A chlorine solution can be sprayed into the Slurry Tank if needed to reduce odors that may be present after FW is dumped into the slurry tank. This chlorine solution spray can be controlled manually or by initiating the Chlorine Solution Spray Timer on the FOG/FW Screen at the HMI. Spray nozzles within the Slurry Tank direct the spray to the area below the food waste delivery hatch where the FW is expected to mound.

Operations and Maintenance
It is expected that daily removal of rocks from the rock trap/grinder will be required. Operators will be expected to perform daily general cleanup of the Receiving Facility. The bins with rejected material from the rock trap/grinder and/or the paddle finisher will require periodic pick-up and removal for disposal on an as yet to be determined frequency. Annually, grit removal from the Slurry Tank will be required, the hose pump hoses will be inspected and replaced depending on wear, and annual preventive maintenance will be performed on the rock trap grinder, mixing pumps, and paddle finisher. O&M staff members will maintain appropriate technical certification levels and possess the experience required for operating anaerobic digesters and appurtenant equipment. Equipment-specific procedures are contained in the *Digester Improvements and FOG/Food to Energy Facility Operations Document* dated January 2013.

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