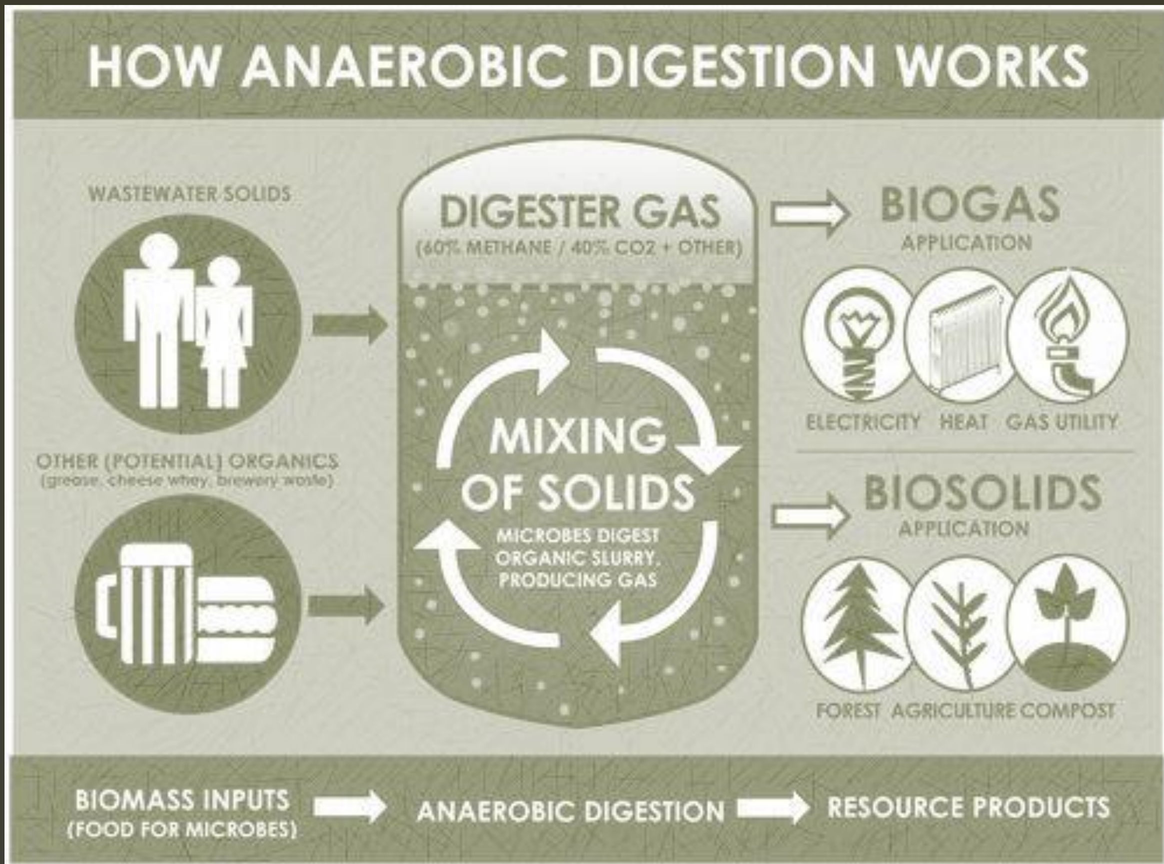

Institutional Barriers to Co-digestion

Case Studies of the East Bay Municipal Utility District and Des Moines Wastewater Reclamation Authority's Co-digestion Efforts

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To my husband, Kevin:

I dedicate this to you, for every sacrifice you've made over the last two years, so I can be where I am today. You've learned more about waste than you ever cared to know, but without you, your opinions, editing, and cheerleading, this would not mean anything.

Cover Photo
Credit: King County

Acronyms

AD	Anaerobic digestion
CCCSWA	Contra Costa County Solid Waste Authority
EBMUD	East Bay Municipal Utility District
EPA	Environmental Protection Agency
FOG	Fats, oils, grease
FSE	Food service establishment
FY	Fiscal year
GHG	Greenhouse gases
PG&E	Pacific Gas & Electric
POTW	Publicly owned treatment works
PPA	power purchase agreement
REC	Renewable energy credit
WRA	Wastewater Reclamation Authority
WEF	Water Environment Federation
WERF	Water Environment Research Foundation
WRF	Wastewater reclamation facility
WWTP	Wastewater treatment plant

Unit Abbreviations

GPD	Gallons per day
MW	Megawatt
MGD	Million gallons per day
MWh	Megawatt-hour
tpd	Tons per day
cf	Cubic feet

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Executive Summary

Waste is a wondrous treasure that provides a source of energy and can easily be incorporated into a practice that's already happening, co-digestion. Co-digestion is a process where wastewater facilities incorporate other forms of organic waste into the anaerobic digestion process they use to treat solids that are generated from the wastewater treatment process. The solids and other organic waste is decomposed to produce biogas which is typically used to heat and power the facility and can be sold to willing buyers. Using co-digestion can address concerns of energy supply, sustainability, and economic efficiency (Hussey & Pittock, 2012). Similarly, regulatory drivers will make co-digestion seem favorable when states aim to divert materials from landfills.

Barriers exist that inhibit innovative projects, co-digestion in this particular situation, and "Numerous methods and technologies for solving water problems seem to be at hand, but at the same time the capacity (for example; skills, experience, financial resources, etc.) to implement these methods and technologies seem to be lacking" (Edelenbos, Bressers, & Scholten, 2013). To better understand these barriers, research is needed on how organizations that use co-digestion have overcome them.

The study analyzed two successful examples of wastewater utilities that are using co-digestion and their relationship with partners and cities, the East Bay Municipal Utility District (EBMUD) in San Francisco, California and the Des Moines Metropolitan Water Reclamation Authority (WRA) in Iowa. Research focused on four institutional barriers, how actors were able to overcome them, and what cities' roles could be in contributing to co-digestion.

Institutional Barriers

Traditional examples of institutions range from administrative structures to customs and practices. This research encapsulates those examples by using four institutional barriers as an evaluation framework: cultural, social, economic, and regulatory/political. Although there is an overall lack of research on institutional barriers for co-digestion, the following are common examples of barriers as indicated by academic and grey literature.

Cultural

Cultural barriers develop externally and internally. External refers to the inter-cultural environment among different professions and governments. Internal refers to the intra-cultural environment that a particular organization/agency has.

External

- Systems thinking and integration of different schools of thought are lacking.
- Networks between different professions and sectors are not fully established, for example, planning and engineering.
- Overlapping responsibilities create administrative inertia as the waste and wastewater regulatory agencies determine pathways that minimize duplicative oversight.

Internal

- A lack of organized leadership inhibits ideas that break from tradition. For example, operators are wary to experiment with new forms of waste.

Social

Social barriers embody the general public and their concerns and awareness about the topic.

- The public lacks complete understanding of infrastructure needs and operations.
- Attention on a topic indicates a problem with the current service due to traditional out-of-sight-out-of-mind public mentalities.
- A lack of open discourse makes the public mistrustful of agencies and government.
- Insufficient communication and outreach can make it difficult to gather community support, especially in regional areas and when renewable energy projects are voluntary and not required and make the public unaware of their role in the project (e.g., proper disposal to avoid contamination)
- Concern for odor and noise can make the public wary of these projects.

Economic

Economic refers to funding, costs, and acquiring revenue for projects.

- Uncertainty and risks outweigh the costs needed to invest in projects.
- Lack of funding, financing, and slow return on investments deters utilities from investing in new projects.
- Available monetary resources need to be invested in projects aimed to address existing regulatory or permit requirements.
- Operation and maintenance can be costly.
- Markets constrict how utilities can sell excess biogas.

Regulatory/political

Regulatory/political represents the regulations and frameworks that impede collaboration between different organizations.

- Policies and regulations fragment and separate resources which doesn't always encourage cross-sector collaborations.
- Permitting processes can be lengthy and complicated which impedes or slows cooperation and partnerships between the waste and wastewater sector.
- Overlapping political and jurisdictional boundaries impede projects and efficient regulatory action.
- Environmental regulations may inhibit new renewable energy projects.

Findings

Through synthesizing the document review and interviews, findings reveal that economic and regulatory/political barriers appear to cause the most prevalent issues to co-digestion efforts. Cultural and social barriers, on the other hand, do not appear to impede efforts as much. The following sections describe these issues in more detail. Table i summarizes these findings and provides some strategies for how to overcome these challenges.

Economic

Consistent with the literature, findings show economics as both an opportunity and a constraint. The potential revenue from taking in feedstock and saving money on electricity costs makes it an opportunity. To elaborate, the facility typically uses tipping fees from hauled waste to maintain the program, and if it produces enough biogas to sell to a willing buyer, the utility generates more revenue. Utilities save on electricity costs by using the biogas with a combined heat and power system at the plant to satisfy the plant's energy demand. Despite these opportunities, several issues still cause economic worries for utilities and their partners, like not having a steady stream of feedstock, dealing with contamination, increased competition for feedstock, and the role of the market for selling excess biogas.

Regulatory/Political

Many actors involved in both case studies experienced regulatory/political barriers during all stages of the co-digestion process. In some cases the barriers impeded the progress of actors when they tried to build new pre-processing facilities, whereas other times they affected utilities' opportunities to sell excess biogas. Local regulations also play a key role in supporting co-digestion efforts, but lack of proper planning or collaboration can undermine efforts. The main regulatory/political barriers discovered in these case studies include, sale of renewable electricity due to state regulations, lack of state/federal funding and tax credits, duplicative permitting processes, and effective fats, oils, and grease (FOG) ordinances.

Cultural

Compared to regulatory and economic issues, cultural barriers do not play an inhibitory role for co-digestion. Findings suggest that utilities do not experience many cross sector (e.g., waste and water) barriers in terms of developing partnerships. The existing regulatory solid waste framework in California is likely instrumental in allowing these cultural relationships to flourish. Instead, most barriers are internal for utilities, such as getting used to a new way of doing things. However, the biggest cultural issue is external: fragmentation between cities and utilities. Cities' involvement in this process has not reached its potential, and their role is still not fully understood. This issue is further discussed in the Role of Cities section below.

Social

Like cultural barriers, social barriers do not readily impede co-digestion efforts. The most prevalent social concern is the odor associated with incorporating the different forms of waste into the digestion process. Odor concerns are present throughout the entire process (i.e., collection through digestion). The most notable barrier is the lack of public involvement or awareness. Perhaps it is not a barrier in itself, but minimal public awareness blankets other public concerns and suppresses the opportunity to gather public support and participation (e.g., food scrap recycling).

The Role of Cities

Cities' key roles center on two main topics: FOG and food waste management. They have the influence to control what happens to both FOG and food waste which have monumental benefits to co-digestion and renewable energy efforts.

FOG

Cities are responsible for their own sewer maintenance before it enters the larger collection system, as is the case for EBMUD and the Des Moines WRA. Any city naturally wants to preserve its sewer system; by prohibiting FOG from entering the system, they have generated a feedstock for their local or regional wastewater utility. Even though several other forms of organic waste also serve as feedstock, FOG is a highly desirable commodity since almost all of it is converted to biogas when digested. Not all organic wastes produce the same amount of biogas, some produce more biosolids than biogas and some produce more biogas than biosolids (Burger, 2003).

Food Waste Management

Cities provide or contract out services to handle municipal solid waste. They also set waste management strategies and policies and therefore, influence how food waste is handled. Research has shown that using food waste for co-digestion has a smaller carbon footprint than other treatment methods cities might use (Parry, 2013b). Not only does using collected food waste for direct anaerobic digestion through co-digestion have a lower carbon dioxide value than other food waste disposal methods, it actually has negative carbon dioxide emissions due to its potential to generate electricity (Parry, 2013b). If cities are looking at ways to reduce greenhouse gas emissions, using co-digestion can be an excellent strategy to consider.

Recommendations

The analysis of the EBMUD and the Des Moines WRA cases is just the start of a conversation about what types of institutional barriers co-digestion projects encounter. This research intended to identify a few aspects of how co-digestion efforts and challenges can be approached when cities, partners, and utilities are considering or are in the early stages of co-digestion projects as well as create an awareness of cities' potential roles. Below are some key recommendations to help facilitate co-digestion efforts.

Develop market assessments of organic waste and training programs for appropriate staff. This helps utilities understand what value they might get from using different types of waste and helps them identify the most beneficial potential partners if competition for feedstock might increase. Apprenticeship programs and hands on training can help operators become more comfortable with co-digestion.

Establish and strengthen communication pathways and collaborative networks between cities and utilities. Cities control valuable resources for co-digestion (i.e., FOG and food scraps) and collaborating with utilities results in a win-win situation. Utilities get prime resources for generating electricity, and cities can reduce GHG emissions and divert waste from landfills. Having champions for both utilities and cities should be a starting point.

Cultivate a strategic public outreach process for the development of a FOG ordinance in collaboration with the wastewater facility. This can address cost and maintenance concerns by involving food service establishments in the process. Compromises such as offering tax-credits, rebates, or flexible design requirements could help both parties reach common ground.

Take a top-down and bottom-up approach to encourage co-digestion efforts. A top-down approach will help iron out regulatory pathways that partners seem to experience during permitting processes and develop a framework to encourage these types of projects. A bottom-up approach is necessary for utilities to implement creative ideas and help strengthen relationships between cities and utilities.

Use creative sources to finance co-digestion efforts when funding lacks. Utilities can consider power purchase agreements to have reassurance that they can generate revenue outside of tipping fees when funding lacks.

Further Research

Literature identified certain barriers that were not present in the two case studies. This does not mean they do not exist, but perhaps they were not a large factor given other variables. For example, literature suggests that air quality regulations can play an impeding role in co-digestion efforts (Parry, 2013a; Willis et al., 2012), but in these case studies air quality issues have not surfaced as a vital roadblock from a social or regulatory perspective.

In the EBMUD case study, the setup of California's and its cities' existing solid waste goals and regulations to achieve zero waste and divert organics from landfills was instrumental in cultivating an environment for successful relationships between the solid waste and wastewater sectors. This is not the case for every state; therefore, further research on how partnerships develop with utilities that receive solid organic waste in other states should be explored. This will provide more information on whether or not the cultural barriers differ from this research's findings.

Table i: Summary of Challenges and Strategies Categorized by Institutional Barriers.

Challenge	Strategy
State regulations constrict renewable energy revenue.	Develop new partnership contracts that satisfy regulations.
Funding and tax credits lack.	Educate higher government.
Waste and water sector oversee permitting processes.	Give jurisdiction to waste or water agencies, not both.
Maintenance and cost for FOG ordinances.	Include maintenance schedule in ordinance. Cost not addressed.

Challenge	Strategy
Fluctuating feedstock amounts make it hard to generate steady energy supply.	Build storage tanks. Keep receiving stations open 24/7.
Contamination raises maintenance costs.	Develop education programs to teach proper disposal.
Increased competition for feedstock detracts revenue and clients.	Acquire long-term contracts and partners within service area.
Regional energy markets can limit revenue options for utilities.	Sell biogas, if demand for cheaper electricity lacks.

Not as prevalent because regulatory framework (e.g., landfill diversion) encourages collaborative partnerships across sectors.

Challenge	Strategy
Operators are cautious about change.	Create training programs.
Cities and utilities don't collaborate.	Have champions for each entity.

Not as prevalent because the public isn't aware of co-digestion efforts. However, this isn't a good thing because if cities decide to use food waste for co-digestion, proper education for disposal methods is important to avoid contamination.

Challenge	Strategy
Residents nearby have odor concerns.	Update infrastructure.

Chapter 1: Introduction

Seldom does the average person think twice about where any of their waste goes. The way we handle it is somewhat ironic since,

> "The advent of modern sewage systems, for example, has given us the luxury of flushing away our waste with clean water, but it doesn't transform the waste into something useful; it simply transports it away from us. We then expend considerable financial and energy resources to treat that water before discharging it back into the same rivers, oceans, and water tables that we gather our fresh water from" (Sarte, 2010)

Unbeknownst to the average person, perceived waste is a wondrous treasure that provides a source of energy and can easily be incorporated into a practice that's already happening, co-digestion.

It's time for everyone to start viewing one man's trash as that man's treasure because as the story is told, the world is undergoing exponential population growth supplemented by rapid urbanization and climate change. Countries and cities have

What is Co-digestion?

Co-digestion is a way to treat multiple types of waste at one facility. The wastes must be organic and treatment typically occurs at wastewater treatment plants (WWTP). The EPA defines co-digestion as, "a process whereby energy-rich organic waste materials (e.g. Fats, Oils, and Grease (FOG) and/or food scraps) are added to dairy or wastewater digesters with excess capacity." Figure 1 provides a visual of the inputs and outputs. During the wastewater treatment process, sludge (i.e. residual solids or semi-solids that settle out of the water) remains and needs further treatment since it can contain pathogens or other contaminants. Anaerobic digestion (AD) is the process that treats the sludge. AD helps accelerate the natural decomposition process where microbes break down organic matter in the absence of oxygen, ultimately producing methane, carbon dioxide, and useable nutrient-rich matter referred to as biosolids. The facility combusts the biogas (i.e. the methane produced) to generate steam that powers a turbine which generates energy. The utility can then use it to power the facility and even become a net producer where it can sell extra biogas or electricity to a willing buyer. Often in this process the digester has extra capacity, so other high strength organic matter can be used to generate larger volumes of biogas which is when co-digestion comes into play.

used resources at a rate and we now are becoming aware of the impacts. With more mouths to feed and public services to provide, growing cities grapple with how to maintain infrastructure and services that not only maintain quality of life and are affordable, but also reduce environmental impact. These challenges require more efficient urban infrastructure that manages resources more sustainably, especially since cities have required considerable resource consumption (Schuetze, Lee, & Lee, 2013). Historically, large, fragmented, centralized systems provided services and developed solutions through a technocratic approach, with little concern for the resource problems we're facing today. This has largely led to siloed practices and resource management, but these growing concerns are encouraging a mindset of integrated resource management that seeks out new innovative solutions and progressive interdisciplinary thinking. One focal point is integration of energy, organic waste, and water. Co-digestion is at this focal point.

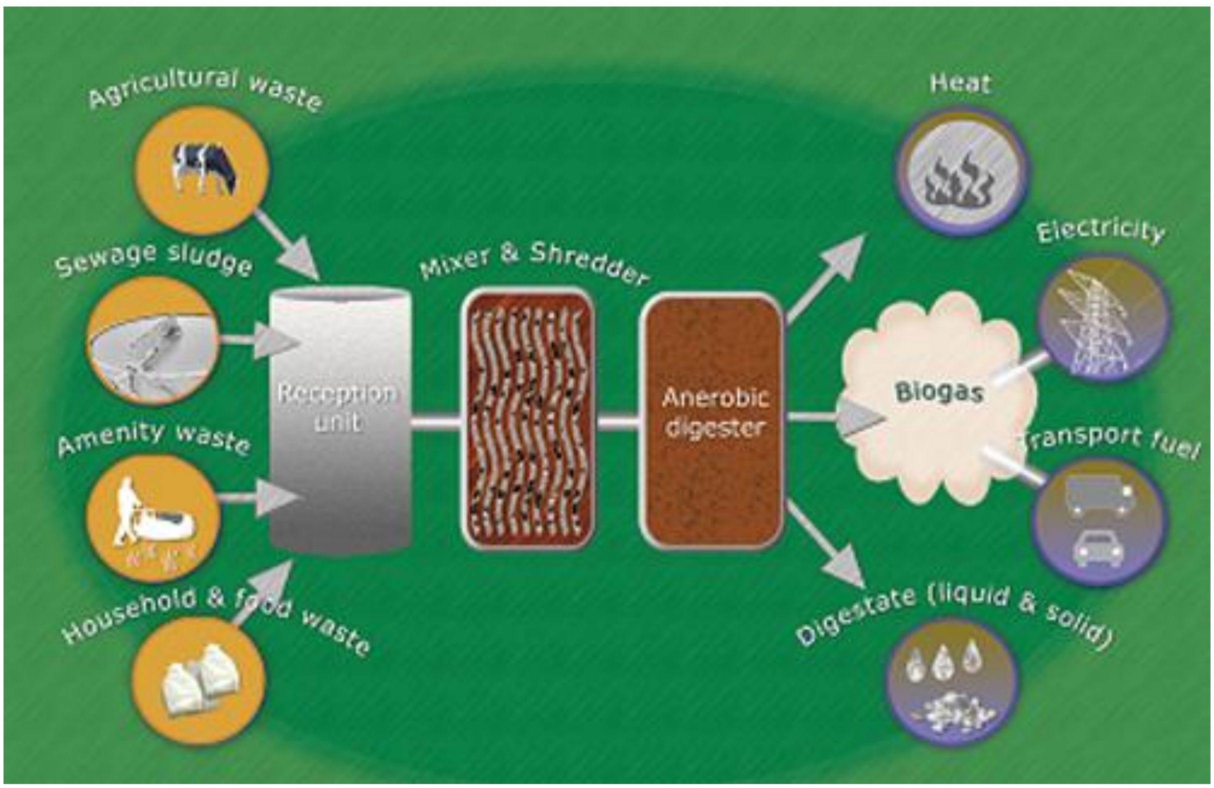


Figure 1: Anaerobic digestion Process Credit: CABI Blogs

Co-digestion is one way to manage multiple resources and address multiple concerns in a productive way by leveraging existing infrastructure. It can reduce non-renewable energy consumption and increase renewable energy production by utilizing waste which people have traditionally viewed as something 'icky' and requiring out-of-sight out-of-mind disposal. Some have concerns about focusing too much on the water-energy relationship, in particular, because each one is vulnerable to the others' failures (Hightower, Reible, & Webber, 2013). However, these concerns largely seem to focus on more water-intensive energy or more energy-intensive water uses. In contrast, co-digestion at treatment plants, is largely recovering existing or untapped resources in the wastewater treatment process, in addition to other waste streams. Others may think this undermines efforts to push for more decentralized systems; however, cities will still need some level of reliance on centralized systems and the transition to decentralized systems can take decades. Therefore, co-digestion requires thoughtful consideration. Given the incalculable list of resource concerns, there is a need for greater integration and collaboration among different sectors to provide flexible solutions and new innovations (Böhm et al., 2011). Overall, such collaboration between sectors can increase resource efficiency and reduce costs associated with maintaining and expanding infrastructure systems; however, there needs to be an awareness of non-technical barriers associated with technological advances that can facilitate this integration and innovation.

Food for thought

What is the difference between power and energy?

Energy is used to do something, in other words the ability to do work. In this paper it is signified by the unit MWh. The amount of energy produced or used can vary at any time.

Power is the rate at which energy is produced or consumed. In this paper it is signified by the unit MW.

Why Co-digestion?

1. **It reduces dependence on other energy sources.** Wastewater treatment processes heavily rely on energy. Producing their own energy by using biogas and converting it to heat and power gives WWTPs an opportunity to become self-sufficient or net producers of energy. Furthermore, if a utility can generate a surplus, it allows the utilities to sell the biogas or electricity (if they convert the biogas to electricity). Overall, this reduces dependence on other unsustainable methods of generating electricity.

2. **It can help reduce sensitivity to electricity price increases.** In 2002 an EPRI report estimated that water and wastewater utilities use almost 4% of the nation's electricity. Of that 4%, utilities use almost 80% of the electricity to treat the water and wastewater (Goldstein & Smith, 2002).[1] This lofty demand can comprise almost 30 to 50% of a municipality's energy bill (Office, 2011) ultimately costing an estimated $7.5 billion per year (Goldstein & Smith, 2002). With stricter regulations for treatment, increasing electricity rates, and aging infrastructures systems, this provides a concerning outlook for cities as the cost of energy rises for utilities (Goldstein & Smith, 2002). In sum, utilities depend on an external source of energy to power treatment processes which is sensitive to increasing prices. Without a change, residents might absorb the increased cost of treating water in their water bills.

3. **It helps reduce concerns about rising energy consumption for the treatment process.** Energy use for treating wastewater has increased 74% since 1996 (Pabi, Amarnath, Goldstein, & Reekie, n.d.) and is expected to increase for a variety of reasons. The increase is due to a growing population and widespread adoption of secondary treatment. If future regulations require more stringent effluent standards, this will likely require more energy during the treatment process. Similarly, newer treatment methods, like replacing chlorine disinfection with ultraviolet systems, require more energy (Hightower et al., 2013).

[1] These estimates are over a decade old and technology has evolved, the energy needed to treat the water has most likely increased (Office, 2011).

4. **It helps close urban metabolic loops.** The United States produced 250 million tons of municipal solid waste in 2011, and out of all that, food waste is the second largest component at 14.5% and only 1.6% of that food waste is recycled, mostly through composting (EPA, 2013). Even after accounting for recycling and composting, food waste is still the largest category of waste discarded at 21.3%. That represents a large amount of waste that could be diverted from landfills. Luckily, it can become an input to an already existing process while closing its loop. Opponents would argue that composting is closing the loop and while that is true, composting requires land and produces uncaptured emissions like methane and volatile organic compounds. AD can use those emissions to generate electricity from the decomposition process and still produce a fertilizer. The EPA partnered with the East Bay Municipal Utility District to study this and found that food waste in an AD process can produce almost three times more methane than wastewater solids (Gray, Suto, & Peck, 2008).

5. **It creates mutually enforcing relationships.** Some states have and are starting to ban organics from landfills which means cities need to find a use for them. Utilities are looking at ways to reduce greenhouse gas emissions and vulnerabilities to climate change. This creates an opportunity to build off of existing infrastructure and help satisfy concerns while creating a central community resource for waste management (Sierral, 2012).

6. **It gives planners a role in resource management.** Utilities are looking for more ways to meet sustainability goals and collaboration with cities will maximize success. Cities can provide financial incentives for utilities, set up organic waste programs, market and gather public support, incorporate utilities in the decision making process, encourage multi-sector or service provider collaboration (e.g. food, energy, water), and provide leadership for co-digestion projects.

Even with the benefits described in the *Why Co-Digestion?* section, co-digestion let alone biogas use is still not prevalent in WWTPs. According to Mo & Zhang (2012), less than 0.6% of WWTPs use biogas for electricity generation, which is typically because facilities require flows greater than five million gallons per day (MGD) to produce a volume of biogas that is cost effective. The threshold originally used to be 10 MGD. However, with treatment plants using alternative feedstock like FOG in their anaerobic digesters it has made combined heat and power (CHP) more cost-effective (Wiser, Schettler, & Willis, 2012). This indicates that co-digestion is slowly being adopted, but the fact that so few have implemented this process suggests barriers to successfully utilizing it may prohibit widespread adoption.

Project Purpose

The water sector has come a long way in technological advancements, which is supported by literature. However, a "valley of death" exists between invention and innovation when it comes to technology (Raven & Geels, 2010). Most often this is because research heavily focuses on technical advancements and not how institutional dimensions could assist in implementing those advancements and facilitate change (Brown, 2008; Saleth & Dinar, 2005; Wong, 2006). Furthermore, cities typically categorize infrastructure into special disciplines that inhibit concepts and actions to integrate systems that can close material or energy groups (Neuman, 2009). With that said, literature has acknowledged the slow pace of change in managing water sustainably due to institutional issues, but not much literature exists on how to overcome these issues because the main effort has been to document the barriers (Brown & Farrelly, 2009; Wong, 2006). A need exists to investigate how perceptions, information, learning, and adaption play out in the process of institutional change for overcoming barriers and facilitating change (Saleth & Dinar, 2005). Raven & Geels (2010) argue that experimental pilot projects in real-life allow for a mutual learning process among stakeholders and the chance for experiences and outcomes to be translated to lessons that can be infused into institutions. In other words, change can't be autonomous but it requires purposeful interventions (Saleth & Dinar, 2005).

It's not only a lack of literature that compels further research, but cities and water utilities are facing practical needs for it. There is more attention on water and energy sectors because of security of supply, sustainability, and economic efficiency (Hussey & Pittock, 2012). Similarly, regulatory drivers will make co-digestion seem favorable. For instance, some states, like California, mandate that municipalities divert organic materials from landfills. Other states are also considering similar mandates, like Massachusetts and Vermont. As cities start to mandate source-separated wastes and require more renewable energy, interest in diverting waste from landfills will grow. Cities and planners might look to AD as an option since as previously discussed it is a method to handle organic wastes while recouping benefits (e.g. soil amendment and energy). However, planners don't have to necessarily consider a full scale launch of AD systems for waste when they can integrate with existing systems that already use anaerobic digestion for waste management (Rapport, Zhang, Jenkins, & Williams, 2008).

Problem Statement

Barriers exist that inhibit innovative projects, co-digestion of sewage and organic matter in this particular situation, and "Numerous methods and technologies for solving water problems seem to be at hand, but at the same time the capacity (for example; skills, experience, financial resources, etc.) to implement these methods and technologies seem to be lacking" (Edelenbos et al., 2013). To better understand these barriers, research needs to address how organizations that have participated in co-digestion projects have overcome these barriers.

The study will analyze successful examples of wastewater utilities that are using co-digestion and their relationship with partners and cities. The two particular cases this research will focus on are the East Bay Municipal Utility District (EBMUD) in San Francisco, California and the Des Moines Metropolitan Water Reclamation Authority (WRA) in Iowa. Research will investigate what institutional barriers each case encountered, if any, and how actors were able to overcome them. By doing so, it may shed light on how these kinds of projects can truly become innovations in sustainable development. This research specifically aims to answer

What institutional barriers have successful cases of co-digestion at wastewater facilities encountered and how were they overcome?

Do these barriers create a role for planners in co-digestion efforts?

The following questions will help guide in answering the previous question:

- How did the actors involved get this project started? What were strengths and weaknesses of the project?
- What were the political/regulatory, social, economic, and cultural barriers they encountered, and how did they overcome them?

The scope of this paper is to look at larger cities that are using co-digestion and how they are overcoming institutional barriers throughout the process. It is outside the scope of this paper to assess the health or environmental impacts that may be associated with co-digestion although it may overlap with barriers.

Organization of this Report

The report has six chapters. Below is a description of the remaining chapters.

Chapter 2: Institutional Barriers Context and Overview – The following chapter explains what institutional barriers are and expands upon four types of barriers that water utilities or cities may face when implementing a co-digestion project. It pulls from academic literature and grey literature.

Chapter 3: Methods – This chapter provides an overview of the research methods employed to evaluate what barriers were present in each case study.

Chapter 4: Case Study Summaries – Chapter four summarizes the organizational characteristics of each utility and actor involved and the general background and history of the co-digestion efforts.

Chapter 5: Case Study Findings – This chapter builds off the case study summaries and delves into further detail about the barriers discussed in chapter two as they relate to the case studies. It also expands upon the cities' role in this process.

Chapter 6: Recommendations – The final chapter provides recommendations to help facilitate co-digestion efforts and discusses further research opportunities.

Chapter 2: Institutional Barriers Overview & Context

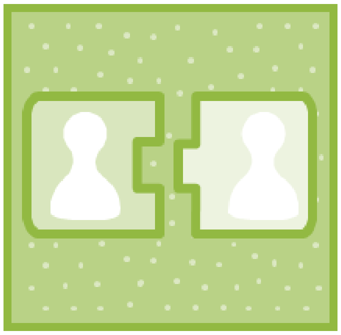
Change is inevitable; it challenges and often breaks from tradition which requires a new form of management and set of values. When new ideas come along and cause this to happen, it means the conventional practices and values that have shaped the institutions of the present have outlived their intended mission and objectives (Cortner, Wallace, Burke, & Moote, 1998). However, because these institutions have not yet been replaced, barriers arise that prohibit innovation from flourishing. Therefore, it is important to look at the institutions that have shaped our values in the past and how they will help or hinder transformations. This section highlights and discusses these barriers to provide more contexts on what they entail.

In general, not much literature exists that discusses institutional barriers specific to co-digestion for wastewater. Outside of academic literature, there is a growing trend in gray literature/working papers to document barriers for biogas and energy projects for facilities. Therefore, each barrier is generally discussed using academic literature pertaining to institutional barriers in the water sector followed by subsequent information obtained from the gray literature. Ultimately, this report will help narrow this research gap.

What is an institutional barrier?

> *Institutions are the expressions of the terms of collective human experience. Institutions reflect the ways people interact with one another and the ways they interact with their environment. Further, they are the means people use to solve social problems. The term institution has been defined in various ways; however, the broadest definitions include both formal institutions, such as administrative structures, and also informal institutions, such as customs and practices.* (Cortner et al., 1998, p. 160)

In the water sector, institutions are nested in cultural, social, economic, and political contexts (Saleth & Dinar, 2005). Although literature for integrated water management has identified several types of barriers within these overarching contexts, this research will distinguish them in the larger cultural, social, economic, and political framework. For the purpose of this research, political barriers will include legislative and regulatory barriers since politics can heavily influence those topics. This research also focuses on all four barriers because they are intertwined and mutually reinforce each other.



Cultural

Achieving sustainable water development will require significant cultural change not only for utilities, but for governments and society (Herrick et al., 2013). New solutions require thinking that expands beyond the technical thought process and integrates social and ecological systems. Juggling these different systems and schools of thought necessitates interdisciplinary collaborations and approaches to new solutions which will give birth to a new culture in the water sector. Culture is developed both externally (i.e. relationships outside of an organization) and internally (i.e. organizational culture) which means cultural barriers can be multifaceted.

External

Holistic approaches require the integration of distinct rules of thought, which means social and natural sciences must be combined to overcome fragmentation, (Brewer, 1999) or at least communicate with one another. Communication and network impasses and lack of strong relationships with external stakeholders, like state and local departments or planners and engineers, can be a barrier to implementing projects (Herrick et al., 2013). Traditionally, the water sector has minimal interaction outside the technical world, which means these network and communication paths are not fully established. This has resulted in a lack of systems thinking for developing integrated solutions and collaborations of all disciplines, which is why decisions and efforts have been focused on one discipline more than others (Healy, 2003). Design of water systems has reduced uncertainty, therefore, avoiding radical alternatives (Ferguson, Frantzeskaki, & Brown, 2013). Furthermore, in other water-related discourses, like stormwater sustainability, research has shown that implementation is problematic due to administrative inertia because of overlapping responsibilities between local governments, state governments, and various other organizations (Brown, 2005). This indicates that co-digestion for sustainable wastewater management practices experiences similar barriers. Issues also arise when dealing with interdisciplinary collaboration and energy. The water sector has not had significant coordination with other resource sectors (e.g., waste) (Grigg, 2008), and historically, energy has not been a performance metric, which does not incentivize renewable energy generation at wastewater treatment plants (Willis et al., 2012).

Internal

Organizational culture refers to mental assumptions in an organization that influences how it thinks, acts, and behaves. When utilities or local governments fragment departments, it can hinder innovations and cross-disciplinary problem solving. Therefore, when new initiatives are brought up, the lack of support from staff or leadership can dampen the progress (Willis et al., 2012). Stagnation occurs because holistic initiatives are new and carry a great deal of uncertainty with them. To move forward in the face of uncertainty, organizations need to have a flexible decision making processes and strong leadership and coordination. Groups or agencies may struggle with this since it often requires them to break away from traditional values (Cortner et al., 1998). Historically, water facilities are conservative and lack strong champions for these new initiatives, which makes breaking away from traditional values difficult (Herrick et al., 2013). Reluctance to deviate from the status-quo has proven to be a barrier for many wastewater treatment plants (WWTPs) when they consider using biogas for renewable energy (Willis et al., 2012).

Social

Over the years, the public has developed certain expectations for the provision of water services. Little awareness exists as to what the behind the scenes operations are, which has cultivated a take-for-granted attitude. Because of this, consumers expect trouble-free delivery of services (Marks & Zadoroznyj, 2005). Likewise, utilities perceive success based on whether or not there is political debate or public attention regarding the services they provide (Gober et al., 2013). Basically, these perceptions and expectations have reinforced the out-of-sight-out-of-mind mentality, and the lack of conversations has led the general public to have minimal understanding of infrastructure needs and operations. This means when conversation does take place, it is about an issue like contamination or raising rates which enables the public to associate any conversation as a problem with the current situation. Unfortunately, this history can make it difficult for new efforts and initiatives to come to fruition.

Along those same lines, the public has developed a lack of trust with agencies over the years in part due to lack of open discourse (Cortner et al., 1998). Minimal discourse makes it hard for the public to understand the need for change. Academic literature in water reuse has shown that trust is based off of structural components, like awareness of regulations and rules, transparency of governance, and accountability supplemented with informal structures like personal and collective characteristics (Marks & Zadoroznyj, 2005). Typically cities and states need strong established regulatory structures to help influence the informal structures associated with trust so when there is a flow of information generated by the public, a false sense of confidence is not established if they misunderstand or misperceive the effort. Basically, "trust has to be actively reproduced and renegotiated in the case of new alternatives for taken-for granted abstract systems" (Van Vliet & Stein, 2004).

Although the barriers discussed above aren't specifically in reference to the water-energy-waste nexus, gray literature has suggested co-digestion initiatives face similar barriers. For example, the Water Environment Federation (WEF) *Energy Roadmap* report stressed the importance of communication and outreach for new collaborative efforts between energy and water to be successful. Another research report sponsored by the Water Environment Research Foundation (WERF), *Barriers to Biogas*, indicated that when utilities have tried to use biogas for renewable energy, lack of community interest or support has been problematic (Willis et al., 2012). Currently, co-digestion and using biogas for renewable energy isn't necessarily required for facilities and is considered voluntary. Voluntary initiatives compared to required initiatives can require lengthy public outreach campaigns, especially when there is concern about odor and noise (Willis et al., 2012). It is especially difficult to get public support for regional plants with multiple jurisdictions.

While out-of-sight out-of-mind mentalities and trust represent barriers to project and policy innovations, behavioral barriers also affect the performance of a project. When the public uses water services, they are in fact participating in the effort because any change in the system may require adjustments of their behaviors. However, behaviors can be difficult to change when the public has developed traditional expectations of their role. A co-digestion project can require multiple actors, like households, restaurants, industries, etc. if proper disposal and collection methods of organic waste are required to provide smooth operations at the treatment facility. Incorrect disposal can require significantly more resources in operations and maintenance due to clogging machinery and undesired contaminants. Therefore, successful efforts require public support and understanding, because without their participation the program will not produce the intended results.

Given these issues, public relationships should be strengthened in the decision making process. The public not only needs to have a say early in the process, but should also have an awareness of what their role would be and a better understanding and appreciation for the services and the challenges utilities and cities face.

Economic

Using co-digestion has proven to be economically feasible (Parry, 2014) which is a major driver for many utilities to even consider it. It is a way to bring in revenue and also reduce sewer maintenance costs due to the harsh effects fats, oils, and grease (FOG) can have on infrastructure, like clogging and reduced capacity. Nonetheless, innovative projects fruitfully bring a magnitude of uncertainty with them and high capital costs naturally make decision makers cautious. Therefore, decision makers want to understand the associated risks and financial and economic impacts. A large deterrent for implementing new projects is lack of funding, lack of financing, and slow return on investments. In the water sector, utilities are already strapped for cash, and the limited monetary resources they do have need to be invested towards meeting regulatory/permit requirements (e.g. mandates for combined sewer overflows). Gray literature in reference to the water-energy nexus has acknowledged that many utilities have not adopted more progressive energy-recovery projects specifically because of the lack funding (WEF, 2013). The WERF *Barriers to Biogas* report indicated that economic barriers are one of the most dominant barriers to biogas production in the wastewater industry (Willis et al., 2012).

Even when utilities can overcome these initial economic barriers and move forward with an energy-generation project, operation and maintenance end up requiring considerable resources and present another barrier (Sierral, 2012). Although this may be considered more of a technical barrier, public outreach and legislation can help ameliorate these concerns. To provide some context on co-digestion specifically, the incoming organic waste must be preprocessed to remove impurities like plastics, silverware, and bones so it doesn't clog or damage the equipment (Hagey, 2011; Pruegel, 2010). Outreach can focus on proper disposal.

Another concern exists regarding quality of the soil amendment produced as a result of anaerobic digestion (AD) if the organic waste is mixed with the sludge, which can contain pollutants like heavy metals. If the quality is low, it can impact selling prices for the amendment. Some utilities can bypass this concern if they have multiple digesters and can digest the sludge and other organic matter separately.

As mentioned earlier, economics is a driver since utilities can generate revenue from the resource products co-digestion produces by selling the biogas or electricity to a willing customer. If they don't have a willing customer to purchase the excess biogas, they have to flare it and do not gain any additional economic benefit. This can happen if a renewable energy market lacks or other energy prices are cheap, which makes utilities concerned about how they will offset some of the costs of the project.

Political /Regulatory

Historically, formal institutions have separated resources into single resource categories when creating policies (Hussey & Pittock, 2012). Because of this, existing laws, policies, and regulations may be fragmented and end up constraining or aiding in the development and implementation of new management strategies or ideas.

Again, gray literature supports this. For wastewater facilities, regulations in general have severely limited utilities' ability to generate renewable electricity (WEF, 2013). This is in part due to the permitting process of energy generation in general (Sierral, 2012). Because wastewater facilities already use AD, adding organic waste to the mix might make permitting easier than proposing a new separate AD facility. However, piggybacking off of wastewater facilities is not devoid of barriers because co-digestion is a process that requires new inputs and outputs that weren't previously included in permits.

Aside from energy generation concerns, these different sectors may face inconsistencies and overlapping political and jurisdictional boundaries. These regulatory regimes bound organizational change because so many agencies and authorities might be impacted by one initiative, and that has given utilities problems with sustainable initiatives (Herrick et al., 2013). The water-waste-energy nexus for co-digestion requires cross-coordination for resource and land management strategies.

Aside from the general messiness and administrative inertia that might result, environmental regulations also pose an obstacle to utilities seeking renewable energy projects at treatment facilities. For example, the WERF *Barriers to Biogas* report indicated that air regulations can be an issue because there is general opposition to new pollution sources (Willis et al., 2012).

Chapter 3: Methods

This research used a qualitative approach to identify barriers and strategies for demolishing them. The following chapter explains the reasoning for choosing the East Bay Municipal Utility District (EBMUD) and the Des Moines Metropolitan Wastewater Reclamation Authority (WRA) and the methods used to obtain information for each case study.

Case Study Selection

The research process started with the identification of large-sized (>10MGD) publicly owned treatment works (POTW)[2] that have a history of embarking on co-digestion. The two cases selected, EBMUD in Oakland, California and Des Moines WRA in Des Moines, Iowa, were selected based on national recognition and awards for leadership in co-digestion. Both examples have a long standing history of co-digestion and are viewed as exemplars by the field.

East Bay Municipal Utility District (EBMUD)

EBMUD, located in Oakland, California, became the first wastewater treatment plant in North America to become a net producer or energy in 2012. It also received a 2013 National Association of Clean Water Agencies Operations and Environmental Performance Award for the Renewable Energy Program. Aside from its success in pioneering co-digestion, it is one of the few large scale utilities that utilize food waste in the co-digestion process.

Des Moines Metropolitan Wastewater Reclamation Authority (WRA)

WRA, located in Des Moines, Iowa, has received acknowledgement for its co-digestion efforts and ability to overcome a variety of barriers as indicated in the Water Environment Research Foundation (WERF) *Barriers to Biogas* study. In 2010 it received special recognition in the Governor's Iowa Environmental Excellence Award for Energy Efficiency/Renewable Energy. Aside from its recognition, WRA has decades of experience using co-digestion and has actively sought partnerships to sell excess biogas.

Case Study Research

Research areas focused on document review and stakeholder interviews.

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[2] The EPA breaks POTWs down into three sizes, small, medium, and large. Small-sized POTWs have flows less than 1 MGD. Medium sizes have between 1 and 10 MGD and large sizes have flows greater than 10 MGD.

Document Review

To gather background information on the utilities, the process of the co-digestion projects, and the key actors involved I reviewed the utilities' websites, working papers, public reports, and documents. This information was used to document potential barriers, gather contact information, and discern remedial steps to these barriers. After conducting interviews, the information was also used to help corroborate findings or identify contradictory information.

Document review for the EBMUD case study included the following sources:

- Sustainability/Energy Committee Agenda and Meeting Minutes
- Project Memorandums
- Biosolids Performance Reports
- News and Journal Articles

Document review for the WRA included the following sources:

- News and Journal Articles
- WRA Technical Committee Meeting Minutes

Semi-structured Stakeholder Interviews

The purpose of interviews was to gather additional information on the project barriers, the actor/group's perception of each barrier, the prominence of one type of barrier over the others, and the methods used to overcome the barriers. A list of potential interviewees was developed through document review and the snowball method led to the identification of additional interviewees. Contacted participants received an informed consent document and all participants were engaged in one-on-one interviews over the phone. During the phone interviews, informed consent was reviewed again before discussing the barriers. The duration of interviews lasted 20 to 40 minutes.

Nineteen people were contacted for interviews. A total of six people were interviewed; three for the WRA case study and three for EBMUD. During the interview, questions were based on the four identified barriers (i.e., regulatory/political, cultural, social, and economic) and were documented through note taking. Audio recording was used to verify notes. Key themes for each specific barrier were identified during analysis.

Chapter 4: Case Study Summaries

Both the East Bay Municipal District (EBMUD) and Des Moines Wastewater Reclamation Authority (WRA) have more than a decade of experience in starting and fine tuning successful co-digestion programs. To identify and narrate the main actors involved, the following chapter portrays the characteristics of each utility and its historical progression of co-digestion efforts.

East Bay Municipal Utility District (EBMUD) – San Francisco, CA

Organization's History & Background

EBMUD's roots run almost a century deep in the San Francisco Bay area. In 1921 California passed the Municipal Utility District Act to ensure the provision of water services to a growing California, which ultimately gave birth to the publicly owned utility, EBMUD, in 1923. However, it wasn't until 1944 that EBMUD added wastewater services to its regime. It started with collection in a subsidiary district and later added wastewater treatment in 1951. Since then, it has provided both drinking water and wastewater services to the eastern San Francisco Bay area, particularly Alameda and Contra Costa counties which include two major cities in the Bay area, Oakland and Berkeley.

Governing Characteristics

Board of Directors

EBMUD has a publicly elected Board of Directors that consists of seven members who serve four-year terms. The board's tasks are to determine overall policies and work with the General Manager to implement them. In addition to policy making, the board is involved in planning, legislative/human resources, and finance/administrative activities.

Departments

The General Manager oversees six departments in EBMUD: water & natural resources, operations & maintenance, engineering and construction, wastewater, finance, and administration. Each of these departments has several divisions. Naturally, the wastewater services fall under the wastewater department. In terms of finance, EBMUD has a bi-annual budget for both the water and wastewater system since they are treated as separate entities (Dudek, 2008).

Co-digestion Initiative

The co-digestion initiative falls under EBMUD's Resource Recovery program. The program accepts liquid and solid

Profile

Service Population:

1,300,000 (drinking water)
650,000 (wastewater)

Service Area:

332 sq. miles (drinking water)
88 sq. miles (wastewater)

Wastewater Capacity: 70 MGD

Treatment Characteristics:

Primary and secondary treatment and disinfection for domestic, commercial, and industrial wastewater

2013 Annual Biogas-Energy Production:
55,000 MWh

Efforts and Initiatives:

Focus on water reuse and energy recovery

Did you know?

The plant is a net producer of energy. This means it produces more energy than needed to power the plant; EBMUD was the first plant in North America to do so in 2012.

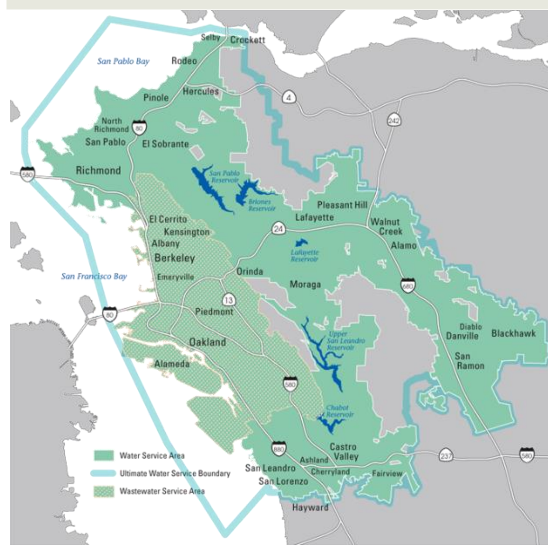

Figure 2: EBMUD's Service Area Credit: EBMUD

waste, such as fats, oils, and grease (FOG), food scraps, and winery wastes. In 2013 EBMUD received a National Association of Clean Water Agencies Operations and Environmental Performance Award for its renewable energy program. In 2011, 5% of the food waste from restaurants and grocery stores in the Bay Area was part of the program.

History of the Program

The following timeline is a summary of the activities that took place throughout the years as EBMUD has worked to develop its co-digestion efforts. The subsequent section, Actors, elaborates on the issues and challenges of the activities themselves.

1951 EBMUD **builds a wastewater treatment plant** in Oakland. It **includes 12 anaerobic digesters**, because the local canning industry is in its prime, and produces an abundance of organic waste.

1986 EBMUD **begins power generation** and starts a purchase power agreement (PPA) with Pacific Gas & Electric (PG&E) and **sells** PG&E **power** on an as-needed basis.

1992 The last cannery in the area finally closes, as the industry declined over the years (Hagey, 2011). This **decline in supply** leaves EBMUD with **extra capacity in the digesters** and decreases EBMUD's amount of wastewater needing treatment by a third. Due to the loss of the canning industry, EBMUD no longer uses some of the infrastructure (e.g., digester, flow tanks), but it still **needs maintenance,** which costs money. Options include raising customer rates or coming up with another solution (Kerr, 2010).

2000 The California **electricity crisis** hits Oakland. Electricity prices are increasing and EBMUD **needs a way to control rates** for their customers (WEF, 2013). EBMUD **looks for ways to utilize the digesters** and starts using processed waste (e.g. oils, portable toilet liquid, and greases from restaurants) for digestion.

2004 EBMUD **experiments with food waste** during anaerobic digestion (AD) and starts collaborating **with Recology** in May. Recology brings about 40 tons per day (tpd) of food waste for EBMUD to use (Gray, Suto, & Chien, 2008).

2007 The Environmental Protection Agency **(EPA) funds a bench-scale study** to learn more about co-digestion, such as **figuring out how much energy food waste generates**. The results indicate that **food waste generates about three times more biomethane than municipal sludge** during anaerobic digestion. Results indicate a promising future for co-digestion.

2008 EBMUD **begins a pilot project with Central Contra Costa Solid Waste Authority** (CCCSWA) and its waste hauler Allied Waste Services. CCCSWA starts bringing commercial food waste to EBMUD in November, and the project starts to deliver 30 tons/week (Pruegel, 2010).

2010 The CCCSWA-Allied Partnership project is supposed to be available to all commercial customers, and Allied is supposed to build a new solid waste facility (Pruegel, 2010).

2011 EBMUD is processing 40 tons of commercial postconsumer food waste every weekday, and receives 240,000 gallons per day (gpd) in food processing waste. **EBMUD is generating 90% of its demand**. In July **EBMUD and Recology form an agreement to develop a pre-processing facility on site**, which will also provide EBMUD with 120 tpd of food waste.

2012 **2012 is a year full of accomplishments and milestones for EBMUD.**

EBMUD **completes an Energy System Master Plan** in October.

EBMUD looks for ways to increase the power generation capacity of its 6.3 megawatt (MW) power generation station (PGS). After research it decides to install a 4.6 MW turbine. Once the new PGS is fully operational, EBMUD averages 1 MW to the grid within the first two weeks (Williams, 2012a). **EBMUD becomes a net producer of energy** because of this new addition and receives CASA's 2012 Outstanding Capital Project Award for the Power Generation Station Renewable Energy Expansion Project.

Food for thought

A Megawatt-hour (MWh) is a way to measure the amount of electricity used over time.

1MWh = The amount of electricity one 100W light bulb turned on for 10,000 hours (~1 year 2 months) uses.

EBMUD ends its PPA with PG&E and starts a new PPA with the Port of Oakland.

EBMUD and Recology face **permitting issues for the pre-processing facility**.

2013 In this fiscal year (FY), EBMUD experiences a slight increase in revenues from 2012. **Organic waste creates $2M in energy value** (Horenstein, 2013) and EBMUD **generates 126% of its own demand**.

With all of its success gaining attention, EBMUD starts to see an **increase in competition for feedstock** (Williams, 2012a).

2014 EBMUD **anticipates biogas to meet 130% of demand** in FY 14.

Figure 3: Pictures of the co-digestion process at EBMUD
(left) Commercial food waste being dumped at EBMUD Credit: Image Slides (center) EBMUD's anaerobic digesters Credit: EBMUD (right) EBMUD's co-generation engines where biogas is turned into electricity Credit: Image Slides

Actors

As indicated in the timeline above, several actors have been pivotal in allowing EBMUD to attain the success it has reached today.

The following section provides more characteristics on these organizations, details their involvement, and highlights challenges.[3] See Figure 6 for a diagram illustrating the actors' involvement and roles.

East Bay Municipal Utility District (EBMUD)

Credit: Alliance for Water Efficiency

EBMUD is the utility that produces the biogas and collects the organic waste from companies, industries and agencies, like Recology and CCCSWA and its partnered waste haulers. Over the years several drivers spurred EBMUD's interest in co-digestion. More recently, energy prices and greenhouse gases (GHG) have been the primary motivator as EBMUD tries to reduce its GHG emissions; co-digestion significantly helps due to energy generation. A series of plans EBMUD has developed supports these efforts, such as its Strategic Plan and Energy System Master Plan. The Strategic Plan, first developed in 2004, contains several strategies to support co-digestion, like, "Minimize impacts to the environment by reducing, recycling, reusing and reclaiming waste, and by conserving natural resources." Similarly, the Energy System Master Plan outlines energy conservation measures, management practices, and ways to increase energy production.

[3] This is not meant to be an all-inclusive list of partners; it is a list of actors that appeared to have a large role in the process.

As indicated in the timeline above, EBMUD has seen an increase in competition, which is one of their biggest current concerns. Between FY12 and FY13, it lost 11% of its revenue from businesses. Nonetheless, the utility views the competition as a good thing because it corroborates EBMUD's success. The competition has increased due to two main reasons. First, neighboring locations have also started to accept items like FOG and winery waste (EBMUD, 2013). Second, other facilities, like Hilmar Cheese, want to construct their own digesters. Naturally, this detracts existing or potential revenue from EBMUD. Growing pains and steep learning curves still give EBMUD an advantage. As these companies/facilities work through these displeasures, EBMUD still receives waste from those sources.

Pacific Gas & Electricity (PG&E)

Credit: PG&E

PG&E is a natural gas and electric utility in California that has been in operation since 1905. It provides services to northern and central California, and EBMUD sold energy to PG&E on an as-needed basis for 16 years.

Although this company no longer has a role in the process, the main issues it encountered involved scheduling energy exports between EBMUD and PG&E. This is because electricity exports require a schedule, and at the time EBMUD struggled with creating a steady stream of energy from the co-digestion process.

Port of Oakland

Credit: Port of Oakland

Port of Oakland is a public agency within the City of Oakland. A board of commissioners governs it and it funds its own operations. Since November 2012 it has been an entity willing to purchase the renewable energy EBMUD produces, through a PPA.

Port of Oakland entered the picture as PG&E was leaving it. The main reason for this change was because EBMUD wanted to be able to sell renewable energy credits (RECs) and existing regulations prohibited that from occurring with EBMUD and PG&E's long-standing PPA. Therefore, EBMUD, in search of a new PPA, submitted a request for expressions of interest and moved forward with Port of Oakland since it had an attractive pricing proposal (Williams, 2012b). The arrangement ended up being a five-year contract where the Port of Oakland pays EBMUD $71/MWh (bundled with REC) when power is available (EBMUD, 2012). Because EBMUD could sell the RECs, this accrued a payment over twice as much as what PG&E paid them ($34/MWh). During the first year of the PPA with Port of Oakland (Nov 2012 –Oct 2013) EBMUD sold a total of 12,465 MWh, generating a revenue of $908,000.

Recology

Recology is an employee-owned company that has provided resource recovery services (e.g., collection, sorting, transfer, recovery) in California since 1920. To provide services, it enters into franchise agreements with agencies (e.g., cities). Throughout the co-digestion efforts, Recology has been a willing partner wanting to bring organic waste to EBMUD.

Credit: Recology

When Recology started to bring food waste to EBMUD in 2004, Recology needed to pretreat the food to avoid contamination. Contamination could be things like metals or bones that can clog the system. When the system was impacted by contaminants it required regular cleaning and caused alarm for what types of materials were actually being sent to the digester. Pretreatment has been an ongoing issue for the organization. Even in FY 13, EBMUD mentioned in a committee update that Recology was bringing in 15 tpd of San Francisco multi-family organic waste, among other sources, but contamination was still a hurdle. It was difficult to obtain information on how Recology is handling this based on lack of interviews from the Organization and documents accessible for review. In January, 2014 Recology was supplying 120-200 tpd to EBMUD.

Years later, in 2011, Recology approached EBMUD with a proposition to bring preprocessing closer to the facility. The idea was that EBMUD would lease some of its land so Recology could construct and operate a pilot-scale pre-processing site for two years and provide additional food waste (Horenstein, 2013). Both parties liked the idea, since it could be an opportunity to attract new materials, like ones that need depackaging. Recology would pay a $37/ton tip fee associated with the proposed pilot. However, this process has required an exhausting regulatory marathon for Recology and EBMUD and has pushed back the project. This is because solid waste agencies still have jurisdiction over the waste being used for co-digestion. To get approval to move forward with the pre-processing facility, Recology needed to go through three steps.

1. List the preprocessing facility on EBMUD's City of Oakland's Nondisposal Facility Element (NDFE)
2. Have StopWaste amend the Alameda County's Integrated Waste Management Plan (CoIWMP)
3. Submit application for a solid waste facilities permit to CalRecycle, the state of California's solid waste management authority, which can take a year to process.

To date, the City of Oakland and StopWaste have approved both of Recology's requests to allow for full-scale facility construction. More information can be found about the timeline in Appendix A (p. 58).

Central Contra Costa Solid Waste Authority (CCCSWA)

Credit: CCCSWA

CCCSWA is an authority created in 1990 that is dedicated to providing solid waste and residential recycling services to its member cities in Contra Costa County. A board of directors (i.e., representatives from member agencies and county authorities) governs the authority. Anyone in the county who has authority to franchise solid waste collection is eligible to become a member. Part of CCCSWA's responsibility is to develop franchise agreements with waste haulers and recycling companies. It currently holds franchise agreements with Allied Waste Services and Valley Waste Management.

Figure 4: CCCSWA's Logo for Program

Credit: CCCSWA

Like Recology, CCCSWA and its franchised hauler, Allied Waste Services, have collaborated with EBMUD to bring organic waste to EBMUD's facility for co-digestion. CCCSWA initially obtained the idea to develop a commercial food waste pilot project in 2007 after it conducted a waste characterization study in 2007. The results indicated organic waste composed a large portion of the waste stream. Aside from the amount of organic waste generated, CCCSWA was looking for ways to reduce GHGs and also received requests to initiate a food waste recycling program. CCCSWA kicked off the program in 2008 and funded it through a Diversion Incentive Fund which consists of commodity sales. For their pilot they recruited100 accounts that regularly generated food waste. Allied Waste Services would collect the food waste and take it to a grinding facility in Milpitas (~40 miles away) before bringing it to EBMUD. With the pilot's success, two years after the project CCCSWA passed the operational costs to the entire commercial base rate (*Food Recycling Project*, 2011). Four years after the project kickoff, CCCSWA had acquired 140 participants. Figure 5 provides a brief timeline of the project. Participants of the program include grocery stores, schools, assisted living facilities, and hotels. The successful program receives national and international attention. This collaboration has been so successful that it won the 2013 Contra Costa Leadership in Sustainability Award.

Table 1: Food waste generated via recycling project

Year	Amount of waste brought to EBMUD	Percent Increase
2011	40 tons per week	-
2013	10 tons per day	175%
2014	20 tons per day	200%

It receives much attention because it is a unique program; CCCSWA-Allied train the generators how to properly dispose of the food so it has little to no contamination, which bypasses the pre-processing step before entering the digesters. The only action taken before it goes to EBMUD is to grind the material to be less than two inches in size. Over the years the program has drastically increased the amount of waste collected and brought to EBMUD as shown in Table 1. CCCSWA has reported positive responses from participants and has saved on tipping fees. When it initiated the pilot, it cost $52/ton to bring the material to a landfill compared to only $45/ton to tip it at EBMUD. Over time, the cost has increased; in March 2014 it was about $55/ton. The one notable concern has been the odor because Allied Waste does not collect food waste daily. Generators use plastic bags to help control odor in addition to retaining liquids. However, plastic bags can get stuck in the equipment at EBMUD. CCCSWA investigated the use of paper bags during a trial run in 2011. Paper bags worked well in the process but they are more expensive; nonetheless, participants have the option of using the paper bags. Allied Waste, CCCSWA's franchised waste hauler, also can switch out bins and steam clean them to address residue or odor.

As CCCSWA considers expanding the program to participants and new materials, EBMUD collaborates with CCCSWA to provide in-kind services for technical inspection to ensure contamination remains low and participation continues to grow (Morsen & Carr, 2014). The franchise agreement with EBMUD will end in 2015, and CCCSWA wants to have a competitive RFP process. Contracts will entail 10-12 years of material collection and processing services.

Figure 5: History of Food Recycling Project

Source: (*Food Recycling Project*, 2011)

City of Oakland

The City of Oakland is in Alameda County and franchises out its waste and recycling services. The City of Oakland is currently working out a new recycling contract, and the City Council has reflected great interest in taking organic waste to EBMUD for energy generation. In September 2012 it put out an RFP for zero waste services. As of May 2014, the City of Oakland is still in the process of selecting a contractor. The City Council expressed interest in collaborating with EBMUD and asked city staff to return to council with more information. To help the Council gather more information about this process, EBMUD has been working with the city and giving them tours of the site.

The partnership between the Oakland and EBMUD could allow the City Council to include a requirement for the contractor to consider bringing some of the food scraps to EBMUD for energy generation. Such an arrangement could potentially bring in 100 tpd of commercial waste and 50 tpd of family food waste. If this came to fruition, the collection would start in 2015.

The City of Oakland has several factors that give the Council reason to take interest in co-digestion. First and foremost, the city has an Energy and Climate Action Plan from 2012 that aims to restructure solid waste management and reduce greenhouse gas emissions. This builds off of the city's 2006 adopted goal to achieve zero waste. The goal requires a 90% reduction in waste sent to landfills by 2020. In addition to the Energy and Climate Action Plan the city has a zero waste strategic plan. These initiatives call on the council to make decisions that support efforts like co-digestion.

However, based on an interview with a City of Oakland staff member, during this contract renewal, recycling contractors have expressed concern about the economic costs of current options and bringing food waste to EBMUD. Their arguments are based on the claim that current arrangements are losing them money with the contract. If Oakland brought food waste to EBMUD they would need to pre-process it, just like Recology and CCCSWA. The city expects it to cost about $3M. StopWaste could provide $1M but that leaves $2M remaining and the City would need to find someone or a way to pay for it. The economic concerns of this issue make City Council cautious in moving forward.

Despite the economic concerns, the council has adopted a resolution to take effect July 1, 2014. The resolution has four standards for the new recycling contract, one is a requirement that the contractor must consider, "sending some of the food scraps to a biowaste-to-energy facility where waste would be used to generate electricity" (Oakland, 2014). To address the economic concerns and the potential extra raise in rates, the City Council would like a cost analysis on this option before they decide to require this method of disposal.

City of Sunnyvale

The City of Sunnyvale is about 40 miles south of EBMUD. However, Sunnyvale has discussed the potential of bringing some organic waste to EBMUD. A potential partnership is still budding and requires future monitoring for opportunities and challenges. If Sunnyvale decides to bring organic material to EBMUD, it could be around 120 tpd (Horenstein, 2014).

Collection/ Pre-Processing

Recology
Helped experiment with performance organic wastes in digestion process; brings in food waste; proposed; operating a pre-processing facility

Central Contra County Solid Waste Authority
Brings in food waste; created collection program to remove contamination at the source

Companies
(e.g., wineries, foster farms)
Bring in multiple forms of organic waste

City of Oakland
Renewing waste hauler and recycler contract and will potentially ask service provider to bring organics to EBMUD

City of Sunnyvale
Has potential interest in trucking some feedstock to EBMUD

Digestion

EBMUD
Takes material and uses it in the anaerobic digesters; biogas is used to heat and power the plant to generate electricity

Resource Products

Port of Oakland
Purchases excess electricity from EBMUD

Pacific Gas & Electric
Purchased excess electricity from EBMUD for 16 years

Figure 6: Snapshot of Actors Involved in EBMUD Co-Digestion

Des Moines Metro Wastewater Reclamation Authority (WRA) – Des Moines, IA

Organizational History & Background

The WRA originated from the Federal Water Pollution Control Act Amendments of 1972 (also known as the Clean Water Act). Because the law emphasized clean up in areas that struggled with water quality, the EPA gave funding to the Central Iowa Regional Association of Governments to conduct a waste treatment management study. The study resulted in the formation of the Des Moines Integrated Community Area which consisted of 12 local governments and two sewer districts. In 1995 ICA was renamed as the WRA. It wasn't until 2004 that WRA became a legal entity and had an organized board along with a budget. At the same time, the City of Des Moines also became the operating contractor for the WRA. Today, WRA consists of 17 metro area municipalities, counties, and sewer districts.

Governing Characteristics

Board of Directors

WRA has a Board of Representatives that comprises one representative from each community. Each community appoints its own member and memberships last for one year terms. An additional member is allowed for every 25,000 people. The board has the responsibility to jointly finance acquisitions and construction improvements to expand, extend, and upgrade the WRA, approve its budget and capital improvement program, contract services, define parameters and benchmarks for services; and employ staff.

Services

The WRA contains a conveyance system which connects each community to the conveyance system that leads to the treatment facility. Additionally, WRA provides finance support, legal support, human resource support, procurement and purchasing, risk management, information technology, and engineering services.

Profile

Service Population:

500,000 people

Service Area:

88 sq. miles

Wastewater Capacity: 59 MGD

Treatment Characteristics:

Primary and secondary treatment, disinfection, solids treatment and biosolids disposal. WRA feeds water back to Des Moines River

2013 Annual Biogas Production: 458,000,000 cubic feet

Efforts and Initiatives: Energy recovery, hauled waste, and FOG program

Did you know?

The plant produces 75% of its own power and uses the treated biosolids from the AD process as soil amendment for farms.

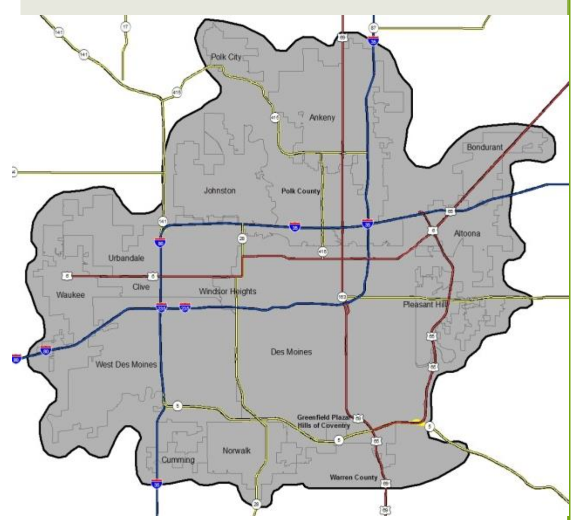

Figure 7: WRA's Service Area Credit: WRA

Co-digestion Initiative

The co-digestion initiative is supported by the FOG and hauled waste program. The Des Moines WRA wastewater reclamation facility (WRF) collects tipping fees for hauled liquid wastes. Tipping fees range from 1.5 to 6 cents/gallon which gave them annual revenues of $337,000 and $200,000 in 2008 and 2009, respectively (Greer, 2011). About 2,000 restaurants and food service establishments (FSE) in the metro area and 60 industrial producers bring waste or FOG to the facility for digestion (Greer, 2011). On an average day, the facility receives anywhere from 25 to 60 trucks, and this hauled waste accounts for 42% of the feedstock entering the digesters (Greer, 2011). This generates about $1.5M annually in hauled waste tipping fees.

History of the Program

1980s The wastewater reclamation facility (WRF) is designed. The **original design** has a 20 year planning timeframe and ends up **overestimating the needed capacity**.

1991 A local dairy has **whey waste** that they want to dispose of. WRA decides to **use it for anaerobic digestion**. This opens up other co-digestion opportunities now that **WRA sees the benefits** (Greer, 2011).

2004 WRA becomes a legally separate entity in July. The WRF constructs a permanent hauled waste receiving station.

2006 WRA starts to **produce excess gas** and must burn the excess methane unless they find another way to use it. They look for other options, like cleaning the biogas and selling it to a natural gas utility, but **natural gas prices are already cheap**. WRA continues to look for other ways to market the excess biogas.

The metro area **adopts a FOG ordinance** that requires FSEs to have grease traps and intercepts.

2007 WRA **creates a bioenergy master plan** and identifies facility improvements.

A **joint partnership between WRA and Cargill** occurs and construction of a biogas delivery system between the two sites begins. Cargill will use the biogas for its grain processing.

2008 WRA completes the Bioenergy Master Plan. WRA **saves about $2.7M in power costs by selling gas to Cargill**.

2009 WRA sells 40% of biogas to avoid flaring excess gas.

2010 WRA starts a $19 million project to **upgrade the digesters and distribution systems**. This project will also add two 1.4 MW cogeneration units to expand power generation to the current 1.8MW.

2011 WRA **approaches a local natural gas utility** to see if they are interested in purchasing biogas. (Willis et al., 2012). Further analysis indicates **nothing came to fruition**.

2012 CH4 Solutions expresses **interest in entering a property lease agreement to develop a compressed natural gas fueling station**. The two parties are **unable to come to leasing terms** for the project (Board, 2012).

2013 WRA releases a **request for proposals for a biogas-based compressed natural gas fueling station**.

2014 WRA has an agreement with Iowa Utility Board to keep rates stable until 2014. WRA expects electricity rates to increase.

WRA expects to complete construction upgrades at the end of April.

Actors

As indicated in the timeline above, a variety of actors have been involved in the process, especially in terms of finding outlets for WRA to handle excess biogas. The following section provides more characteristics on these organizations, details on their involvement, and the challenges they experienced throughout the process. Figure 7 provides a snapshot of the actors' contributions and highlights their roles.

Credit: WRA

Des Moines Wastewater Reclamation Authority (WRA)

WRA is the authority that has treatment facilities to treat the wastewater, FOG, and hauled waste to produce biogas. Several factors influenced the WRA to reach out to industries that were treating waste and discharging it to the facility, like excess capacity in the digesters. With the excess capacity, the facility looked to see what value they could get out of the engines, especially since methane needed to be flared occasionally. Aside from excess capacity, the WRA also formed an energy management team in 2007 and has a champion to promote energy initiatives in the utility.

When the WRF initially started co-digestion, the WRA marketed the effort by attending and speaking at several types of conferences (e.g., ethanol, biodiesel). Eventually word of mouth became a self-sustaining market strategy. In addition to spreading the word, the WRA looked for partners and started with local food processing industries but quickly realized how many biodiesel and ethanol plants were sprouting up in the area. These plants create a byproduct that can be used as feedstock for digestion. Demand from these plants increased especially when the Iowa Department of Natural Resources became stricter with regulations regarding land applications of high strength organic wastes (Greer, 2011). Ultimately, this increased the amount of waste WRA received from biofuel plants.

With growing popularity, WRA wanted to upgrade its power generation capabilities as indicated in the timeline. This helps WRA provide more gas to Cargill and therefore acquire more revenue and become closer to achieving a net zero facility status.

Credit Cargill

Cargill

Cargill is a private global company in the food processing/agricultural industry with a plant in Des Moines, Iowa. The plant produces grain and oilseed and is located adjacent to the WRF. It has purchased the facility's excess biogas since 2007.

The partnership between WRA and Cargill was truly a joint venture. WRA had gas to sell and Cargill needed gas culminating to a fantastic example of being in the right place, literally, at the right time. The two organizations split the cost of the 600 foot pipeline that would send gas over to Cargill. The WRA spent $1.1M and Cargill spent $750,000. Both parties expected fairly quick payback periods (WRA 3.9 years and Cargill 1.5 years) (Greer, 2011). The WRA bills Cargill monthly for the amount of biogas Cargill consumes. In 2007 WRA made $460,000 in revenues selling biogas to Cargill.

Des Moines Metro Area / Restaurants

The Des Moines metro area consists of five counties with a population over 500,000. The WRA developed a committee to develop a FOG ordinance that the metro area cities adopted in 2006. The ordinance affects over 2,000 FSE (e.g., restaurants). A main driver for the ordinance was the EPA's mandate to decrease grease-related sewer blockages, backups, and sanitary sewer overflows. Since its adoption, the metro area has seen a dramatic decrease in the amount of blockages and overflows.

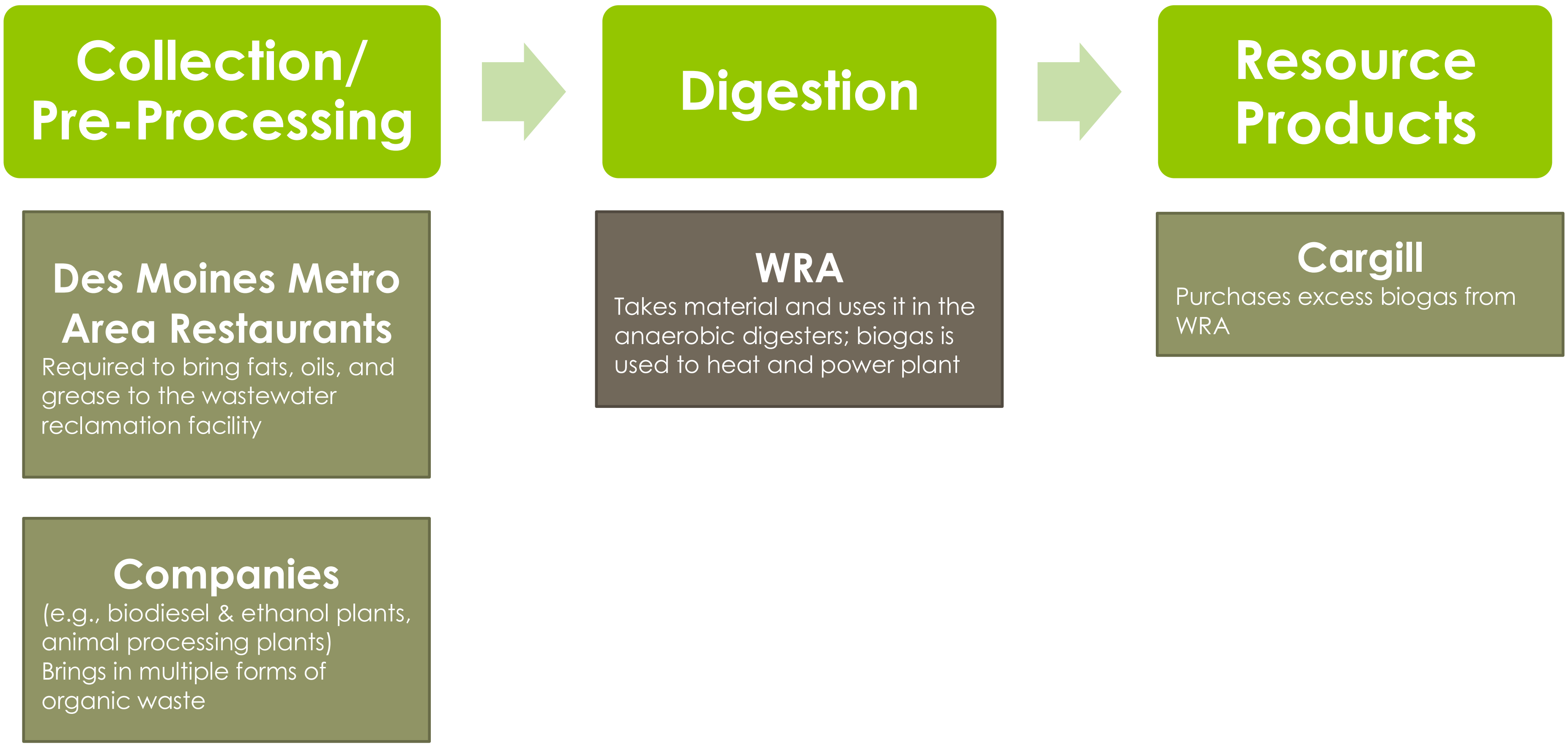

Figure 8: Snapshot of Actors Involved in WRA's Co-digestion

Comparison of EBMUD and WRA

EBMUD and WRA have many similarities, yet many differences that uniquely contribute to the history of their co-digestion efforts (see Table 2). Both are considered a large POTW, but EBMUD is separate from municipal oversight whereas WRA is operated by the City of Des Moines. WRA also focuses on FOG and liquid wastes unlike EBMUD who also accepts forms of solid waste for co-digestion. This difference in feedstock influences the types of partnerships and challenges that each case has faced. Both entities share similar drivers for co-digestion – with excess capacity being a large factor. As the wastewater sector learns more about co-digestion and energy recovery, this initiative helps achieve many of the concerns expressed in the Why Co-digestion? (See page 4).

Table 2 | Comparison of Cases

	EBMUD	WRA
Service locations	Regional	Regional
City relationship	Separate from city	City of Des Moines operating contractor
Feedstock	FOG, food scraps, industrial and animal processing, winery waste	FOG, industrial and animal processing, biodiesel and ethanol byproduct
Drivers for co-digestion	Started due to excess capacity in digesters and rising electricity prices	Started due to farmer with excess whey and facility was also built looking 20 years in the future and overestimated the needed capacity.
Excess Biogas	Converted to electricity and sold to Port of Oakland	Biogas sold and piped to Cargill

Chapter 5: Case Study Findings

This research identified four potential institutional barriers; cultural, social, economic, and political/regulatory (see Chapter 2, p. 9). Based on a synthesis of the document review and interviews, only economic and regulatory/political barriers cause the most prevalent issues to co-digestion efforts. Cultural and social barriers, on the other hand, do not appear to impede efforts as much. The purpose of this chapter is to answer the two main research questions by delving into further detail about those barriers as they relate to the two case studies as well as expand upon the role the cities can have in this process.

Economic

Consistent with the literature, findings show economics as both an opportunity and a constraint. The potential revenue from taking in feedstock and saving money on electricity costs makes it an opportunity. To elaborate, the facility typically uses the tipping fees from hauled waste to maintain the program; if co-digestion produces enough biogas for the facility to sell to a willing buyer, the utility generates even more revenue. Utilities save on electricity cost by using the biogas with a combined heat and power (CHP) system at the plant to satisfy the plant's energy demand. Despite these opportunities, several issues still cause economic worries for utilities and their partners, such as lacking a steady stream of feedstock, dealing with contamination, facing an increased competition for feedstock, and the market's role.

Lack of a Steady Stream of Feedstock

Without a steady stream of feedstock, generating a constant production of biogas is difficult. Facilities desire a constant supply of feed for several reasons. It ensures enough biogas will be produced to heat and power the plant throughout the week, without needing to rely on the grid. Additionally, it increases reliability for a buyer and helps them better anticipate when they can expect to receive the electricity or biogas. Both case studies reveal that the facilities receive the most waste during weekdays, which makes it difficult to generate a constant production of biogas on weekends. This increases difficulty in scheduling exports of energy with buyers, like in the case of Pacific Gas & Electric (PG&E) and East Bay Municipal Utility District (EBMUD).

Aside from generating a reliable supply, fluctuating amounts of feedstock makes it hard to strategically recoup revenue. Electricity prices can fluctuate throughout the day, week, and season, and supply and demand affect prices. If wastewater utilities cannot control when they are able to generate the electricity to sell to electric utilities, the wastewater utilities cannot try to sell when value is highest during the day. WRA has addressed the issue of receiving a constant stream of feedstock by building a holding tank which will help control the rate the feed enters the digesters. However, creating a storage tank will not completely guarantee a steady stream. WRA also keeps its receiving station open 24/7. Overall, utilities may need to consider extending their receiving times, developing infrastructure to store waste, and understanding that maximizing revenue may not always be attainable.

Contamination

Utilities accepting other forms of waste (i.e., outside of sludge) will need to address contamination issues to preserve equipment and address environmental impacts. If they do not, utilities may have to incur costs to fix and frequently maintain the equipment, and partners will have to spend more money to figure out better ways to pre-process the material. Participants, who bring the waste to the facility, are typically responsible for pre-processing the material. As demonstrated in the EBMUD case study, pre-processing occurs off- site and can be expensive. EBMUD's partners, Recology and Central Contra Costa Solid Waste Authority (CCCSWA), used different strategies to approach pre-processing. Recology has a costlier process; they use a pre-processing facility prior to bringing it to EBMUD. This strategy has appeared to cause operational headaches as new materials are introduced. Recology also wanted to open a facility on EBMUD property, and this process had resulted in a lengthy permitting process.

On the other hand, CCCSWA wanted to avoid the capital cost required to develop a pre-processing facility, and instead developed a program where the generators (e.g., restaurants, grocery stores) properly dispose (i.e., pre-process) of the material. Successful participation and disposal practices hinged on mandatory training, monitoring, and outreach materials for prospective and current participants; they are key components of this program (*Food Recycling Project*, 2011). Given the positive responses and recognition of the program, pre-processing at the source offers a promising way for agencies/solid-waste haulers to avoid a costly process. However, such a program requires thoughtful and careful development and should gradually increase its participants. If generators do not have a clear understanding of proper disposal, why proper disposal is important, and what is done with the material, it can still lead to contamination issues. It is not clear what steps Recology has taken with its multi-family waste program, but, as the case study indicates, that source of feed still has problems with contamination. The EBMUD-CCCSWA-Allied partner case study has shown that engaging food waste generators in proper education and outreach can go a long way in addressing contamination concerns and is a great way to increase awareness while minimizing hefty pre-processing costs.

Competition for Feedstock

When a utility embarks on a co-digestion project they are on a path filled with possibilities, making it seem as enticing as an insect flying into a bright light. Ultimately, this creates an increased competition for feedstock. However, both EBMUD and the WRA conflict each other, illustrating that this isn't always the case. Competition is dependent on the region and its industrial economy.

Due to its success, EBMUD has seen increased competition for feedstock. Now that others have seen this process work, their interest in it has grown. Former and current EBMUD industrial customers, as well as other utilities, are starting to embark on these efforts themselves. On the other hand, WRA has its pick of the litter and is almost at capacity. A likely reason for the steady demand is because Iowa is the nation's leading producer of ethanol and biodiesel.[4] Both ethanol and biodiesel create a byproduct that is digestible. Furthermore, a WRA interviewee explained that when the WRA was still emerging its co-digestion efforts, the methane produced from WRA counted toward the biodiesel tax credits for producers who took their waste to WRA. Essentially, this demand has allowed WRA to pick and choose which type of substrates to put in the digesters, because some wastes produce more energy than others.

Food for thought

"They say imitation is the best form of flattery."

- EBMUD Interviewee

Overall, the conflicting data indicates that competition for feedstock is dependent upon the regional industries and economy. In an area where competition is high, EBMUD uses pragmatic thinking and planning. With awareness that they might lose a stream of products, EBMUD constantly looks for new sources and long-term contracts. They have already started doing this, which is a main reason why they've still experienced increases in revenue, aside from the fact that some existing customers have increased the amount of feedstock they provide.

Due to the benefits it would not be a surprise if co-digestion efforts become common practice and naturally increased competition regardless of regional economies. Both WRA and EBMUD have long-distance clients that continue to haul resources to them because it is currently the best option. If this idea becomes mainstream, businesses will likely start bringing waste to nearer facilities for economic savings and environmental benefits of reducing greenhouse gas (GHG) emissions due to travel. An EBMUD interviewee grounded this thought by stating if the utility is using co-digestion to help reduce emissions and improve the environment, pragmatism makes sense and part of the solution is took for sources closer to EBMUD.

[4] Standings are according to the U.S. Energy Information Administration and Iowa Renewable Fuels Association.

Role of the Market

When utilities generate excess biogas they have two options. They can either burn the methane or look for a willing buyer to sell the biogas as gas or converted electricity. The latter option is dependent on the current energy market. For example, when the Des Moines WRF started to produce excess biogas they considered purchasing a generator to produce electricity with the hopes of finding a buyer to purchase the electricity. However, the region already had low prices which made this option uneconomical (Greer, 2011). If market prices are low for electricity, utilities can still attain success by looking for partners that would purchase biogas directly, like the Des Moines WRA- Cargill partnership.

Food for thought

Not doing anything with excess biogas, "is like burning a suitcase full of money!"
-Interviewee

Even if low electricity prices encourage utilities to sell the biogas itself, the use of biogas can be limited as well. Biogas cannot be a direct substitute for natural gas without additional cleaning. Biogas is around 60% methane and 40% carbon dioxide; the composition varies based on the type of waste used for digestion. Natural gas is mostly methane so natural gas utilities typically require methane to make up almost all of the gas (i.e. ~97%). They have specifications on acceptable grades, which also include removing other constituents, especially because if the grade is not similar it can cause corrosion in the pipe along with other issues. Because the process of cleaning and upgrading biogas to a quality that natural gas utilities might use is cumbersome and expensive, it is even difficult to entice natural gas utilities to become a buyer. Biogas can also be converted to compressed natural gas and used as vehicle fuel; however, the challenges to utilizing biogas for that market is outside of the scope of this paper since that was not a major theme for either case study.

Regulatory/Political

Many actors involved in both case studies experienced regulatory/political barriers during all stages of the co-digestion process. In some cases the barriers impeded the progress of actors when they tried to build new pre-processing facilities, whereas other times they affected utilities' opportunities to sell excess biogas. Local regulations also play a key role in supporting co-digestion efforts, but without proper planning or collaboration these regulations can undermine efforts. The main regulatory/political barriers discovered in these case studies include sale of renewable electricity due to state regulations, lack of state/federal funding and tax credits, duplicative permitting processes, and effective fats, oils, and grease (FOG) ordinances.

Sale of Renewable Electricity Due to State Regulations

Depending on states' political environment, regulations may limit what type of benefits utilities can recoup from selling biogas or electricity generated from biogas. For example, utilities may be ineligible from receiving particular credits simply because they already have a long standing power purchase agreement, like in the EBMUD case study. In 2006, California adopted senate bill (SB) 107 which required 20% of total electricity sold to retail customers to be from renewable energy credits (REC) by the end of 2010. Part of the idea was to improve competition for existing in-state renewable electricity generation facilities and accelerate California's Renewable Portfolio Standard (RPS). Therefore, the regulation stated that any electricity generated under a contract prior to 2005 was not eligible to receive RECs. EBMUD ran into issues with this contingency in 2012 when it installed the new generator and became a net producer of energy. This was a time where RECs were worth more than energy prices in wholesale markets,[5] but because EBMUD's power purchase agreement (PPA) with PG&E started in 1986 they could not sell RECs. Therefore, to capitalize on the RECs and their market prices, EBMUD had to seek out a new contract which ended up being with Port of Oakland. Overall, this decision has been a financial success for EBMUD. One year into the PPA with the Port of Oakland, EBMUD had sold 12,465 MWh for a total revenue of $908,000 (Horenstein, 2014), a 67% increase in sales compared to what sales would have been with the old PG&E PPA.

This highlights the economic benefit of selling renewable energy; however, these projects require years of evolution to produce large amounts of biogas. Utilities need to be aware of how regulations can undervalue these efforts. Policy makers should also understand how these processes evolve to hopefully create some flexibility in these regulations.

Lack of State/Federal Funding and Tax Credits

Due to institutional and intergovernmental disconnect, utilities can experience a lack of funding to support co-digestion efforts. One interviewee at WRA said that many state/federal funds make government or municipal entities ineligible and instead focus on private companies producing renewable energy. The interviewee suggested that this occurs because other strategies such as methane recovery at landfills receive more attention, and higher forms of government are unaware of what public utilities consider new progressive ideas (i.e., utilities can create energy from waste more efficiently than from landfills or burning it). Although EBMUD and WRA are larger utilities, interviewees from these entities mentioned that it is likely more cumbersome for smaller utilities to obtain monetary resources to kick off a project, especially when funding lacks. EBMUD and WRA are large and can use other strategies, like issuing bonds. Aside from funding,

[5] During this timeframe RECs were $35/MWh and regional wholesale peak power prices on the market were $24-33/MWh.

tax credits were another concern. The same WRA interviewee mentioned that it is difficult for government agencies to get credit for reducing GHGs and producing biofuels. Unfortunately, these issues are remote barriers that utilities cannot always rectify with direct action. Instead, proper outreach and education to higher forms of government and state and federal agencies will continue to be necessary.

Duplicative Permitting Processes

Contamination, as previously mentioned, can be a big issue for utilities accepting different forms of organic waste. As solid waste partners look at developing pre-processing facilities to treat the waste before bringing it to the plant, duplicative regulatory oversight can slow the process. This slowing process most likely occurs because these projects are the first of their kind in the area or region and require agencies to work out regulatory pathways. For example, Recology has worked with EBMUD to locate a pre-processing facility on the treatment site. In 2012 the application process faced issues with duplicative regulatory oversight of the trucked waste program because the material still fell under solid waste jurisdiction causing project delays. Since Recology approached EBMUD about a pre-processing facility in 2011, it has taken three years to obtain the necessary permits (see Recology p. 23). CCCSWA also experienced similar issues when it wanted to locate a grinding facility[6] closer to EBMUD's facility; additional permitting requirements delayed the process and increased project costs because they needed to continue transporting waste to a grinding facility that was further away.

Aside from dealing with this duplicative oversight on a case-by-case issue for pre-processing or grinding facilities, California has been trying to address this duplicity in a larger context. The state of California has two agencies, CalRecycle and the Regional Water Boards, both of which have been trying to work out a regulatory pathway outlining which agency should be responsible. The two discussed if permit operations at POTWs that accept FOG and other waste used in digesters can be exempt from CalRecycle permitting since the waste stream is already regulated under the wastewater facility's NPDES permit. The overall goal is to only have one agency regulate this activity – preferably the Regional Water Boards (Howard, 2011). A proposed solution that the two agencies discussed was the idea of putting a standard provision in the NPDES permits that requires POTWs to develop and implement standard operation procedures for waste fats, oils, and grease acceptance and digestion operations.

California has a progressive solid waste reduction strategy as highlighted in Appendix B (p. 59), which has caused many counties and cities to adopt zero waste goals or to take progressive action to reduce the amount of waste going to landfills. This

[6] A grinding facility grinds the material to be less than two inches in size. It is different than a pre-processing facility, which removes contaminants prior to grinding.

environment has supported and driven co-digestion partnerships as highlighted in the EBMUD case study. However, with a lack of foresight on what strategies the solid waste sector might take to reduce the amount of material going to landfills, agencies have not been able to establish regulatory pathways to allow for a seamless transition when new methods are executed, as highlighted above. Further research on this issue can establish a better understanding of how cross-sector agency collaborations can help facilitate and anticipate what regulatory pathways should receive attention.

Effective Fats, Oils, and Grease (FOG) Ordinances

Cities are beginning to implement FOG ordinances to prohibit the material from entering the sewers. Sometimes cities voluntarily implement the ordinance but the Environmental Protection Agency (EPA) can also mandate it, like in WRA's case, because FOG can cause blockages in the sanitary sewer system and contribute to overflows. The increase in sanitary sewer overflows has the EPA alarmed, and the agency estimates that almost half of overflows are due to blockages, and of these blockages half are FOG-caused, contributing to 5,000 to 17,000 overflows annually (Tupper & Skoda, 2008). For these reasons, agencies and cities have a growing focus on FOG prevention.

Cities run into problems if they do not fully develop the program prior to adopting the ordinance. One issue is the general maintenance of the grease traps and interceptors at food service establishments (FSEs). If cities expect the FSEs to do it on their own, maintenance may not be frequent enough to prevent FOG from entering the sewers. However, it isn't enough to simply require maintenance; cities need to determine a way to monitor if the maintenance is actually occurring. In the Des Moines metro area, WRA addressed this by requiring the FSE to have a certified hauler bring the FOG to the WRF quarterly or when the grease interceptors reached 25% of their design capacity. This requirement addresses both issues by allowing the WRF to track who is maintaining their traps and interceptors while allowing the WRF to use the FOG for co-digestion. To address political concerns with this requirement, WRA offers a discounted rate so they do not make money off of the tipping fees. Offering a low price helps insure that FSEs don't have an incentive to beat the system.

Even though the Des Moines metro area implemented the ordinance in 2006, interviews indicate that it has only been heavily regulated in the last five years or so. Many restaurants in the Des Moines area have quarrels with the ordinance because of the cost to install grease interceptors. If renovations are needed, some restaurants can expect installation of a grease interceptor to cost $50,000. This has made it cost-prohibitive for restaurants to keep certain parts of their kitchens in operation or from opening new restaurants. Some of the strict regulations also cause restaurants owners and chefs to have issues with the ordinance. For example, in the WRA case, one executive chef interviewee said the ordinance required a grease interceptor at the bar, which only drains beverages. These types of seemingly unnecessary requirements convey inflexibility and distrust. Lastly, the interviewee thought the greater restaurant industry in the area seems to have a loose awareness of what happens to the FOG after it is collected (i.e., used for co-digestion). Regulations often have a negative connotation; explaining the positive benefits of what is done with the FOG can elicit a sense of self pride and a deeper appreciation for the positive impacts of participation. These concerns suggests that outreach and education needs to be an ongoing process, collaboration could be strengthened when developing and amending the ordinance, and other benefits outside of reducing overflows and blockages can be promoted more.

Cultural

Compared to regulatory and economic issues, cultural barriers in the co-digestion realm are not as inhibitory. Based on the research and interviews, utilities do not experience many cross sector (e.g., waste and water) barriers in terms of developing partnerships. The regulatory solid waste framework that is already in place in California is likely instrumental in allowing these cultural relationships to flourish. Most barriers utilities encounter are internal. Despite the positive cultural environment, the biggest cultural issue that emerged is an external one. Cities' involvement in this process has not reached its potential, and their role is still not fully understood.

Internal - Utilities

Both the EBMUD and WRA case studies suggest that cultural institutions are replaced before regulatory and economic for co-digestion. Based on an EBMUD interview, EBMUD's co-digestion efforts were largely staff driven; they were not something that came from the top down. In fact, the role of the Board was to support the staff, and EBMUD's values and goals cultivated an environment to encourage this project. For instance, EBMUD has plans and a sustainability and energy committee. Additionally, when EBMUD wanted to move forward with the project, its constituents were in favor of the idea.

Although both utilities create an open environment for new ideas, cultural barriers are not completely absent when new ideas are developing. At EBMUD, a lot of waste comes from different companies, like Foster Farms, who brings animal processing waste. Early on, one staff member expressed concern about dealing with chicken blood. Although a minor and unique instance, it is a reminder that changes in the process can be unfamiliar and concerning for staff. For WRA, one of the biggest challenges was getting the utility in the mindset of trying something new (Pahl, 2012). Compared to co-digestion, the conventional way of doing things (i.e., flaring excess gas) requires less thought and coordination. For operators in particular, this involves a change in routine and more risk. One interviewee mentioned that operators have an increased risk because they need to learn how to treat these new wastes and still stay in compliance with the plant permit. Part of this requires utilities to decide what types of waste are feasible to even accept. To address these concerns, WRA has a three-year apprenticeship program that requires taking college credit classes and getting hands on experience. Co-digestion is one of the areas required for hands on experience. Operators must pass the co-digestion part of the apprenticeship program to work at the facility.

Overall, both EBMUD and WRA recognize staff for their excellence which facilitates an open environment for innovation. This can largely be due to the identity change wastewater treatment plants have undergone over the past few decades. Wastewater utilities are now more frequently thought of as a business.

> *"The sewage treatment plant was where you put all the rejects, people that didn't get along with anyone, people who didn't do any work. Today we are one of the best paying government positions. We pay high and also have some recruits because of that. We have great new technologies that we are working with. Every day we work with many types of engineering firms. It's gone from being a bad job to being a job that people are proud to work for."*
>
> - *WRA Interviewee*

External - Cities

Public utilities can be municipally owned or cooperatively owned (i.e., owned by their customers), which usually plays into the city's relationship and involvement in the process. When wastewater utilities are not municipally owned, their relationship with the city can be less intimate. For example, EBMUD is a regional utility district that is separate from the cities it provides services for; therefore, maintaining close one-on-one working relationships with the cities is difficult for EBMUD. The nature of the city-utility relationship does have much crossover outside of coordinating maintenance of their systems. This distant relationship makes it hard to develop city champions for co-digestion, more so when cities do not have a large interest in this initiative. An EBMUD interviewee mentioned that for the most part, cities have not expressed significant amounts of interest in co-digestion efforts. However, the interviewee also thought that the District has more responsibility to reach out to the city on these efforts than vice versa.

On the other hand, when cities have some involvement with the WWTP, like in the WRA case, the city has greater potential for direct contact with the utility. However, this potential is not fully developed because municipal departments, like planning or public works, tend to rely on the wastewater organization to carry out activities, as in the case of WRA. This dependence prohibits cities from playing a larger role in these efforts. Throughout the research, a general disconnect or lack of understanding of the city's role in this process became transparent through contacting city staff and officials for potential interviews. When reaching out to various departments in the City of Des Moines, many recommended contacting the WRA to discuss this research. Ultimately, this disconnect makes it hard to establish city champions. WRA has experienced difficulty in obtaining city officials to champion the efforts even though the program has experienced great accomplishments, like generating 75% of its own energy.

Part of the issue is that this type of activity is off of people's radar compared to more visible efforts (e.g., rain garden, low hanging fruit). As the literature states, "wastewater" is a concept that receives little attention. One way WRA continues to work on building city champions is by developing benchmarks and measures. The WRA uses these to evaluate and compares itself to other leading utilities in the country. WRA sends these findings to the City Manager and Mayor to increase awareness.

Although utilities and their partners have overcome several cultural barriers in co-digestion projects, the city-utility role continues to face challenges. City involvement is essential for proper political, economic, and regulatory support. The Role of Cities section on page 45 elaborates on this topic.

Social

Like cultural barriers, social barriers do not readily impede co-digestion efforts. The most prevalent social concern is the odor associated with incorporating the different forms of waste into the digestion process. Odor concerns are present throughout the entire process, starting with collecting the waste all the way through to digesting it. The most notable barrier is the lack of public involvement or awareness. Perhaps it is not a barrier in itself, but it hides what other concerns might be present and inhibits the public's ability to support and participate in this process.

Odor

Odor is the most apparent concern and both utilities and participants bringing waste to the facilities have experienced problems with this. In the San Francisco Bay area, cities near EBMUD are doing lots of development which has resulted in condos and apartments in close enough vicinity for tenants/owners to give odor complaints. An EBMUD interviewee explained that most of the time this is due to problems with the digesters; for example, human error due to new staff or the tops of digesters failing. To rectify the problem, EBMUD is considering installing a new system to prevent that from happening. Similarly, when waste is trucked in everyone involved needs to develop and learn new techniques to minimize odor. Odor is an issue that requires constant improvement, and actors attempt to address it through different disposal methods prior to collection and updating technology.

Public Awareness

Document review and interviews for both the EBMUD and WRA case studies indicate that public awareness about co-digestion is minimal. Even during public review periods for permitting processes or projects, comments were minimal to none. This corroborates the out-of-sight-out-of-mind mentality discussed in Chapter 2: Institutional Barriers . It makes it hard to predict the public's feelings about co-digestion projects. However, when asked about social barriers, several interviewees thought the public has a growing awareness about fossil fuel prices, GHGs, and that the energy economy is in transition, which might make them more accepting of the idea. One of the biggest obstacles, consistent with the literature, is that most people are not technically based; in other words they don't have a solid understanding of how the wastewater process works and what different strategies entail. Instead they rely on preconceived notions. Part of that stems from the conventional way the public has been educated about the water sector (i.e., black box). Nonetheless, it is important to engage the public early on in these initiatives to avoid contributing to any mistrust that might develop as a result of lack of discourse, which literature has pointed out as a social barrier for innovative water projects.

Most importantly, a lack of awareness indicates that the public might not even be aware of what their role in the co-digestion process could be. For example, in the City of Oakland, residents are not required to have a green bin (i.e., yard trimmings and food scraps). They need to contact the contracted solid waste and recycling company to obtain one. If the city moved forward to require a contractor to bring waste to EBMUD to generate renewable energy; the amount of material brought to the facility would be heavily dependent on residents' participation. These issues again stress the importance of outreach and education and how important the role of the city can be. To get residents engaged and aware of these efforts necessitates the city's development of a marketing program for residents. The idea is similar to what the CCCSWA did for the Food Recycling Project; participants are voluntary and are not forced to participate in the program.

The Role of Cities

The cultural, regulatory, and social barriers mentioned above stress the importance of cities' involvement in co-digestion efforts. The previous sections of this chapter focused on answering the first research question, what are the barriers and how are they overcome? This section focuses on answering the second research question, based on the barriers does this give planners a role in co-digestion? The answer is yes. Cities' key roles center on two main topics, FOG and food waste management. They have the influence to control what happens to both FOG and food waste, which have monumental benefits to co-digestion and renewable energy efforts.

FOG

Figure 9: FOG in a sewer
Credit: Georgetown

Cities are responsible for their own sewer maintenance before it enters the larger collection system, as is the case for EBMUD and the Des Moines WRA. Any city naturally wants to preserve its sewer system; by prohibiting FOG from entering the system, they have generated a feedstock for their local or regional wastewater utility. Even though several other forms of organic waste also serve as feedstock, FOG is a highly desirable commodity since almost all of it is converted to biogas when digested. Not all organic wastes produce the same amount of biogas, some produce more biosolids than biogas and some produce more biogas than biosolids (Burger, 2003).

Food Waste Management

Figure 10: Food waste
Credit: Letsrecycle

Cities provide or contract out services to handle municipal solid waste. They also set waste management strategies and policies and therefore, influence how food waste is handled. Research has shown that using food waste for co-digestion has a smaller carbon footprint than other treatment methods cities might use (Parry, 2013b). Not only does using collected food waste for direct anaerobic digestion (AD) through co-digestion have a lower carbon dioxide value than other food waste disposal methods, it actually has negative carbon dioxide emissions due to its potential to generate electricity (Parry, 2013b). If cities are searching for ways to reduce GHG emissions, using co-digestion can be an excellent strategy to consider.

Considering the benefits described above, cities can leverage their position to help catapult co-digestion. In the EBMUD case study, the City of Oakland uses a franchise system for contracting solid waste haulers and recycling companies, which is common in California. The city adopted a resolution for contractors to consider biowaste-to-energy by bringing acceptable waste to EBMUD. A city pushing for their franchise partners to do this solidifies utilities' efforts. It is important to note, not all cities use a franchise system. Some provide their own services, which gives them more control over how they want to dispose of waste and expedite the process. Using the cities' food waste for co-digestion allows the utilities to secure feedstock closer to the plant and opens up another avenue for utilities to obtain a stream of products as competition increases. Obviously, the city's involvement is more influential and beneficial if the utility is municipally owned. However, even if the utility is cooperatively owned, cities can use these strategies to meet landfill diversion goals, resulting in win-win benefits.

One concern that recycling contractors may have is the economic impact that biowaste-to-energy requirements will have on their operations. Cities will need to be patient and work through the contracting process with understanding and identify where they can help. The City of Oakland is addressing this by requiring the potential contractor to do a cost-analysis prior to making a decision. Similarly, if cities provide their own services, they can develop policies and work with the utilities to implement a collection program that will help with co-digestion. In this way cities can become champions of the project since research indicates that cities lack champions for these efforts.

Chapter 6: Recommendations

The analysis of the East Bay Municipal Utility District (EBMUD) and the Des Moines Wastewater Reclamation Authority (WRA) cases is just the start of a conversation about what types of institutional barriers co-digestion projects encounter. This research intended to identify a few aspects of how co-digestion efforts and challenges can be approached when cities, partners, and utilities are considering or are in the early stages of co-digestion projects as well as create an awareness of the potential role cities have. Although the previous chapter alluded to some general conclusions about the types of barriers and suggested strategies to help ameliorate struggles, this section's intention is to provide key recommendations to help facilitate co-digestion efforts in a larger context.

Develop market assessments of organic waste and training programs for appropriate staff.
Who: Wastewater utilities

Utilities will undergo several iterations in refining a new program. Co-digestion is gaining popularity which has increased a demand for research on this topic. Therefore, engineering firms, the Environmental Protection Agency (EPA), and research foundations, like the Water Environment Research Foundation, are conducting research to better understand environmental and economic impacts of handling organic waste. While knowledge develops on this topic, most utilities have figured out a strategy to create a successful program on their own through trial and error and undergoing iterations, which often contribute to operators being wary about new efforts.

Essentially this means that some of the technical details still need ironing out. For example, the wastewater sector continues to learn about loading rates[7], the amount of methane organic substrates produce[8], and greenhouse gas (GHG) emissions for co-digestion. Since different types of organic waste produce different levels of energy, (Parry, Vandenburgh, & Fillmore, 2012) it is important for utilities to evaluate performance and effectiveness for different types of feedstock. While this information is still developing, utilities can perform an analysis of potential types of waste streams in their local and regional area. Based on what is already known about how these different wastes perform, utilities can create a priority ranking and develop a strategy for what type of material will be most useful for them. In turn, this might give utilities a starting point to evaluate economic potential of customers' waste and who they might

[7] The amount of solids and liquids a digester receives each day.
[8] Also referred to as the biochemical methane potential.

want to target as potential partners right off the bat, especially if there is a concern for increasing competition. This not only gives utilities a better understanding of the surrounding market, but also gives cities and companies an idea of the value of their "stock." Performing a preliminary analysis to help utilities develop a plan that will provide the most profit (i.e., the most energy produced) might also give some reassurance to help compensate for the lack of funding and economic woes.

In addition to performing an analysis, training can help ease internal worries about how co-digestion might affect or change standard operating procedures. If more hands on training and site visits are available for operators, like in the case of Des Moines WRA, it will increase confidence and assurance.

Establish and strengthen communication and collaborative networks between cities and utilities.
Who: Wastewater utilities and cities

Cities need to be a bigger promoter of and become familiar with co-digestion, especially because research has identified fats, oils, and grease (FOG) as a desirable source of feed for anaerobic digesters at wastewater facilities, and using food waste for AD greatly reduces GHG emissions. For these reasons, if cities have zero waste goals or a general desire to reduce the amount of material going to landfills, reaching out to its local/regional wastewater utility should be the first step. To address this, cities should dedicate a champion who stays up-to-date on what utilities are doing, identifies ways the city can be involved, and infuses collaborative concepts to city officials and appropriate departments.

It is also wise to have an awareness for what utilities are doing because research has shown that co-digestion at wastewater facilities can be more economically favorable than creating a standalone facility for anaerobic digestion(Parry, 2013a). Therefore regardless of whether a utility is municipal or cooperative, cities should consider a utility's plans because if a utility currently or in the future has plans to open its doors to co-digestion, its tipping fees will most likely be lower than a standalone facility since the standalone would need to cover the capital costs. Infrastructure already is in place at a WRF. Pragmatically, companies will bring their business to the most affordable option.

Cultivate a collaborative strategic public outreach process for the development of a FOG ordinance with food service establishments.
Who: Cities and wastewater utilities

When developing a FOG ordinance, this research indicated that cost and maintenance are two concerns that need attention. Cities need to require a maintenance schedule to ensure that food service establishments (FSEs) do not let grease traps and interceptors overflow, and restaurants should not feel crippled by the cost of adding a grease trap or interceptor. A strategic public engagement process with restaurant owners, chefs, managers, etc. could help address cost concerns. If utilities, FSEs, and cities can build trust and develop proper training methods, ordinances may not need to be so strict. Furthermore, the outreach process can continue to increase the awareness of why there is a need for FOG ordinances while promoting the benefits of how FOG can be used.

One potential way to address cost concerns could be giving out a tax credit or rebate for FSEs to help offset some of the costs of installing grease traps and interceptors. Utilities could set aside a percentage of the revenue generated from co-digestion to be used for this purpose, and cities can also contribute a portion of their budget as well. One example that supports this approach is the FOG program the San Francisco Public Utilities Commission (SPUC) has developed in collaboration with restaurants. The two groups have worked to create a program that will address restaurant needs and the city's concern with FOG. To help offset the cost of installing grease traps or interceptors, the city will reduce sewer rates for the restaurants that install them for two years (Larson, 2010). SPUC suspects that will give restaurants enough time to rebound from the cost, and even though the city may need to compromise temporary revenue, the long term benefits of avoiding sewer repairs to due to blockages and the potential energy generation from utilities outweighs the short term loss. Aside from helping restaurants recoup the costs of adding necessary infrastructure, utilities, restaurants, and cities can collaborate to develop flexible solutions for restaurants or parts of restaurants that do not intend to generate a lot of grease. One example would be to develop a piping system that bypasses the sanitary sewer and disposes into a grease interceptor in the back of the building. These are just a few ideas to help facilitate a more flexible and collaborative process.

Take a top-down and bottom-up approach to encourage co-digestion efforts.
Who: States and cities

All actors involved in co-digestion experience barriers that originate from varying levels of government or organizations. For example, partners bringing waste to facilities seem to experience more regulatory barriers that require top-down attention to sort out regulatory pathways and to address overlapping jurisdictions, both geographically and across sectors (i.e., water and waste). Ironing out these pathways can grant all parties smoother implementation. This requires state and local agencies to be proactive and set up these frameworks to encourage and facilitate these projects instead of waiting for projects to become more popular.

A bottom-up approach is essential to allow these types of projects to come to fruition as illustrated in both case studies. Utilities need to encourage an open-door policy and creativity in their staff to develop that type of environment, and will need to continue to reflect and improve in order to remain innovative and strategic. A bottom-up approach will also help strengthen relationships between cities and utilities. The biggest stepping stone is developing a constant flow of communication and brainstorming that creates a mutually supportive environment. This will allow cities to be more aware of and develop policies to support efforts like co-digestion and encourage utilities to illustrate the benefit of city collaboration and engagement.

Use creative funding sources when funding lacks.
Who: Utilities

From a general perspective, it seems like most funding is geared toward pilot projects and feasibility studies to build knowledge about co-digestion projects. Funding is a remote issue that utilities have little control over; luckily EBMUD and WRA found successful partnerships to sell biogas/energy as part of the process. If utilities are having difficulty in obtaining funding sources, they can start conversations with potentially interested companies or utilities in purchasing excess biogas. For example, they can consider power purchase agreements (PPA) with local electric utilities, assuming the market encourages this partnership, unlike the case of WRA. The EPA has created a helpful fact sheet to explain how a PPA works and the benefits it can provide.[9] Essentially this gives utilities reassurance that they can generate some revenues outside of tipping fees. One interviewee from WRA also recommended that education outreach to get agency buy in is crucial so those agencies can educate others and hopefully advocate for these efforts. By starting conversations early on, it may give utilities a better idea of what to expect.

Further Research

Again, the purpose of this research was to bridge the gap between academic literature and grey literature on what institutional barriers co-digestion projects face. Many of these findings are preliminary in nature and can be corroborated or contradicted with future research. Additionally, investigating these two case studies did not find certain barriers to be a great issue, which is opposite of what the literature suggested. This does not mean that they do not exist, but perhaps were not a large factor given other variables. For example, literature suggests that air quality regulations can play an impeding role in co-digestion efforts along with the quality of soil amendment (Parry, 2013a; Willis et al., 2012), but in these case studies, these issues have not surfaced as a vital roadblock from a social or regulatory perspective.

In the EBMUD case study, the setup of California's and its cities' existing solid waste goals and regulations to achieve zero waste and divert organics from landfills was instrumental in cultivating an environment for successful relationships between the solid waste and wastewater sectors. This is not the case for every state; therefore, further research on how partnerships develop with utilities that receive solid organic waste[10] in

[9] For more information: http://www.epa.gov/region9/waterinfrastructure/docs/water-sector-ppa-factsheet.pdf
[10] Food scraps is an example of solid organic waste compared to FOG which is a liquid organic waste.

other states should be explored. This will provide more information on whether or not the cultural barriers differ from this research's findings.

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Appendix A

Recology's Permit Application Timeline

2011 Recology hoped to have permits by end of 2011.

2012

June — Port approves development permit for construction and operation.

Recology hoped to start construction in 2012 and begin operations between May and August.

2013

Feb — City of Oakland approves amendment to Non Disposal Facility Element.

April — Recology submits info to amend County Wide Integrated Waste Management Plan (COIWMP).

May — Recology seeks extension from City of Oakland for development permit.

July — StopWaste Board meets and discusses Recology's application.

Sep — CoIWMP is amended.

Dec — Recology submits application for registration permit to Department of Health.

2014

Jan — Department of Health approves facility permit

Appendix B

Legislative History on Sustainability Related Resolutions by California and the City of Oakland

Date	Legislation	Outcome
1989	AB 939 "California Integrated Waste Management Act"	Required California jurisdictions achieve a 50% diversion rate by 2000, and reduce reuse, recycle and compost all discarded materials to the maximum extent feasible before any landfilling or other destructive disposal method is used.
1990	Ballot Measure D "The Alameda County Waste Reduction and Recycling Initiative Charter Amendment"	Set requirement for the county to reduce landfilling by 75% by 2010.
1990	Resolution #66253 C.M.S	Established solid waste reduction goals including returning discarded materials to the local economy through reuse and recycling; applying the waste management hierarchy in priority order (reduce, reuse, recycle, and compost) to the maximum extent; and promoting recycling market development.
1992	Resolution #68780 C.M.S	Authorized establishment of a state designated City Recycling Market Development Zone.
2001	Zero Waste Goal by California Integrated Waste Management Board	Zero waste goal in strategic plan for state.
2002	Resolution #77500 C.M.S	Established the goal of 75% reduction of waste disposal by 2010 for the City of Oakland in alliance with the countywide 75% waste reduction requirement.
Mar 7, 2006	Resolution #79774 C.M.S	Public works agency in conjunction with the Mayor's office to provide a Zero Waste Strategic Plan to achieve the City's Zero Waste Goal.

Dec 5, 2006	Resolution $80286 C.M.S	Resolution adopting Zero Waste Strategic Plan to achieve the City Council goal of Zero Waste by 2020 for the city of Oakland.
Jan, 17, 2012	Resolution #83689	Zero Waste System Design Framework to develop new contracts under single franchise for city wide garbage and organics collection services.
Jun 19, 2012	Approved motion	Economic benefit provisions to be included in the contracts/preference point in evaluation proposals.
Jun 7, 2013	Resolution #84461	Resolution authorizing the city administrator to enter into negotiation with the top ranked proposers for the zero waste services request for proposals.

Source: (*Waste Collection Franchise Agreement Policy*, 2014)