Barriers to the Implementation of Energy-Related Technologies in Water Treatment Plants

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Opportunities for water treatment plants to reduce their net energy consumption were identified through interviews with experts, stakeholders, and participants in the water treatment industry. Recommendations on how barriers to the implementation of energy-related technologies in water treatment plants can be mitigated were made. Emphasis was placed on water treatment technologies, funding availability, communication, and energy management.

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Acknowledgements

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Table of Abbreviations

ARRA	American Recovery and Reinvestment Act of 2009
CEPT	Chemically enhanced primary treatment
CHP	Combined heat and power
CWA	Clean Water Act of 1972
CWNS	Clean Watershed Needs Survey
CWSRF	Clean Water State Revolving Fund
DEP	Department of Environmental Protection
DO	Dissolved oxygen
EPA	Environmental Protection Agency
ESCO	Energy service company
FOG	Fats, oils, and grease
FW	Food waste
kWh	Kilowatt hour
LIFT	Leaders Innovation Forum for Technology
MGD	Millions of gallons per day
NSF	National Science Foundation
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and maintenance
ROI	Return on investment
SCADA	Supervisory control and data acquisition
SRF	State Revolving Fund
SULI	Science Undergraduate Laboratory Internships
THP	Thermal hydrolysis process
U.S. DOE	United States Department of Energy
U.S. EPA	United States Environmental Protection Agency
VFD	Variable-frequency drive
WERF	Water Environment Research Foundation
WPCF	Water pollution control facility
WQA	Water Quality Act of 1987
WRA	Wastewater Reclamation Authority
WRF	Wastewater reclamation facility
WRP	Water reclamation plant
WTP	Water treatment plant
WWTF	Wastewater treatment facility
WWTP	Wastewater treatment plant
ZNE	Zero-net energy

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Introduction

The necessity for the betterment of the United States' water treatment infrastructure is manifested in the American Society of Civil Engineers' 2013 Report Card for America's Infrastructure, in which America's wastewater infrastructure received a letter grade of "D" [1]. 298 billion dollars may be required over the next twenty years to assuage the condition of the United States' wastewater sector. Water and wastewater treatment can account for as much as 4% of the national energy consumption and on average energy consumption constitutes thirty percent of a water utility's operational costs [2, 3]. The United States Department of Energy's Office of Energy Policy and Systems Analysis has interest in reducing the net energy consumed by water treatment plants as doing so would meet the United States Department of Energy's mission by addressing the country's energy and environmental needs. Since nearly 300 billion dollars' worth of upgrades will be needed over the next twenty years, the Office of Energy Policy and Systems Analysis and the rest of the United States Department of Energy are presented with the opportunity to encourage the implementation of energy-conscious technologies and processes in water treatment plants during these upgrades.

In this paper leading personnel from the water industry, highly ranked members of private organizations, and government officials were collaborated with to identify opportunities for water treatment plants to reduce their net energy consumptions. Water treatment plants in the United States exist in a diverse range of climatic and political environments, so industry professionals from across the country were interviewed. This eclectic approach allowed for the identification of barriers to the reduction of net energy consumption that are pervasively applicable to many water treatment plants. Auspicious opportunities for net energy reduction in water treatment plants include the further development of key energy consuming and producing technologies and the expansion of energy and management training programs across the water sector.

Methodology

Government officials, personnel in the water treatment industry, and agency leaders from various regions in the United States were interviewed to identify challenges within water treatment plants (WTPs) to reducing net energy consumption. This was accomplished by first requesting interviews with government and private agency leaders in order to acquire insight into the state of the water treatment industry from experts who have spent years working in the field. Organizations from which representatives agreed to be interviewed include the United States Environmental Protection Agency (U.S. EPA), the New York State Energy Research and Development Authority (NYSERDA), New York City's Department of Environmental Protection (NYCDEP), Minnesota's Metropolitan Council Environmental Services, Water Environment Research Foundation (WERF), and WERF's Leaders Innovation Forum for Technology (LIFT) program. Once a better understanding of the challenges that the wastewater sector is faced with was obtained from these interviewees, we extended our invitations for interviews to those in the sector that work directly with WTPs such as plant managers. WTPs were selected to contact based on location and daily water treatment volume in millions of gallons per day (MGD). After the initial interviews, follow-up interviews were conducted with all interviewees from private and government agencies who were willing to participate. These follow-up interviews were held in order to share the challenges experienced by the WTP personnel with the agency representatives and see if they found these challenges to be common throughout the water treatment sector. In one case during a second round interview, two additional WTP managers were recommended to us to interview because they faced challenges similar to some of our other interviewees.

Selection Process

The government and private agency selection was straightforward. Randomness was only desired amongst the WTPs since bias was not a concern for the agency interviews. A simple literature review allowed us to identify the most prominent agencies within the wastewater industry. For the other interviews, 3 WTPs were selected from each of the ten EPA regions.

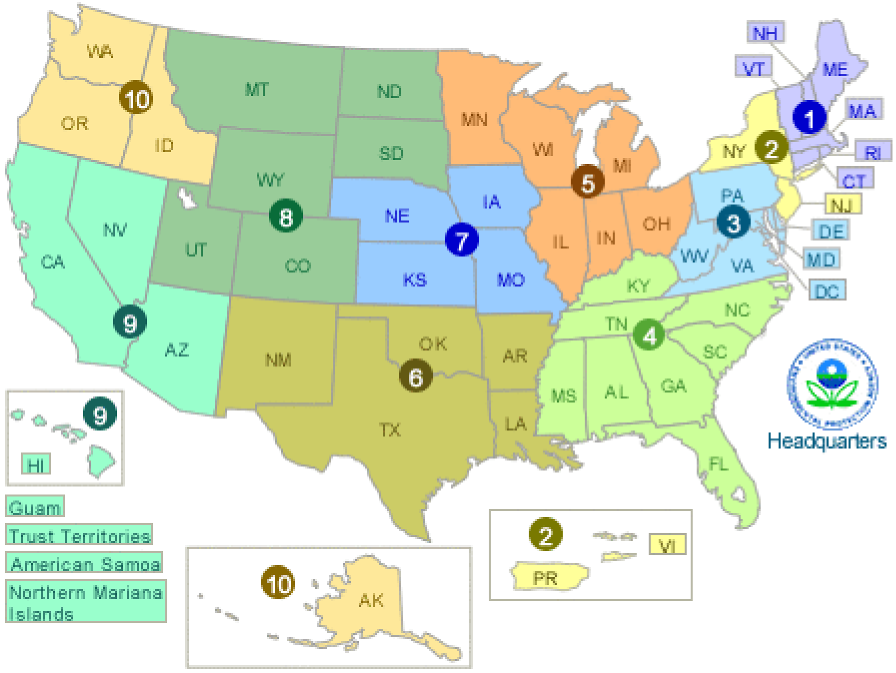

Figure 1 The United States divided into 10 EPA regions [4]

The selections were made such that at least seven WTPs fell into each of the four water intake ranges: 0-1 millions of gallons per day (MGD), 1-10 MGD, 10-100 MGD, and 100+ MGD. This was done simply to increase the diversity of the WTPs interviewed and was accomplished using the U.S. EPA's 2008 Clean Watershed Needs Survey (CWNS), which was the most recent CWNS available at the time. Not all of the agencies and WTPs that were contacted agreed to be interviewed. The representatives of agencies that were interviewed for this study are shown in Table 1 and the representatives of WTPs that were interviewed are shown in Table 2.

Table 1 Interviewees from government and private agencies

Agency	Interviewee's Name	Interviewee's Position
Minnesota Metropolitan Council Environmental Services	Removed by request	Removed by request
New York City Department of Environmental Protection (NYCDEP)	Anthony Fiore	Office of Energy Director
New York State Energy Research and Development Authority	Kathleen O'Connor	Project manager, environmental research and development
United States Environmental Protection Agency, Office of Wastewater Management	James Horne	Project manager, Environmental Management Systems
United States Environmental Protection Agency Region 1	Jason Turgeon	Energy and Water Specialist
Water Environment Research Foundation	Lauren Fillmore	Senior Program Director
Water Environment Research Foundation's Leaders Innovation Forum for Technology Program	Jeff Moeller	Director of Water Technologies

Table 2 Interviewees from water treatment plants

Facility	Water intake volume (MGD)	State (EPA region)	Interviewee Name	Interviewee Position
[redacted]	[redacted]	[redacted]	[redacted]	Director of Resource Recovery
City of Boulder WWTF	12.5	CO (8)	Chris Douville	Manager
Roberto Bustamante WWTP	39	TX (6)	Manuel Perez	El Paso Water Utilities Energy Management Coordinator
Deer Island WWTP	380	MA (1)	Kristen Patneaude	Program Manager of Energy Management
Des Moines WRF	59	IA (7)	Bill Miller	Reliability and Sustainability Manager
Encina WPCF	22	CA (9)	Kevin Hardy	Chief Executive
Fred Hervey WRP	12	TX (6)	Vic Pedregon	Superintendent
[redacted]	[redacted]	[redacted]	[redacted]	Operating Officer
Gloversville-Johnstown Joint WWTF	13.8	NY (2)	George Bevington	Manager
City of Gresham WWTP	13	OR (10)	Alan Johnston	Program Manager, Senior Engineer
South Shore WRF	300	WI (5)	Kevin Shafer	Milwaukee Metropolitan Sewerage District Executive Director
Victor Valley WRA	13	CA (9)	Logan Olds	Manager
West Point WWTP	90-440 (seasonal)	WA (10)	Carl Grodnik	Energy Program Manager

Not every entity that was contacted agreed to take part in this study. In total, representatives from seven agencies and thirteen WTPs participated in the first round of interviews. After the initial interviews, four of the seven interviewed agency representatives agreed to partake in follow up interviews, them being Kathleen O'Connor, James Horne, Jason Turgeon, and Lauren Fillmore. During the second interview with Jason Turgeon we were directed towards two additional WTP representatives to interview. These two WTPs are of interest to this study because they have recently had issues with their aeration turbo blowers—the largest consumers of energy in most WTPs [3]. The details regarding these two WTPs are summarized in Table 3.

Table 3 Additional interviewees from water treatment plants

Facility	Water Intake Volume (MGD)	State (EPA region)	Interviewee Name	Interviewee Position
Lowell Regional Wastewater Utility	25	MA (1)	Mark Young	Executive Director
Warwick Wastewater Treatment Facility	7.7	RI (1)	Janine Burke	Warwick Sewer Authority Executive Director

A short summary of each interview is located in the appendices. Recommendations were made based on the interviews conducted.

Treatment Processes

The majority of WTPs utilize a combination of preliminary treatment, primary treatment, secondary treatment, disinfection, tertiary treatment, and solids treatment before reclaiming or releasing the water back into the environment. A simple diagram of a typical treatment process is shown in Figure 2.

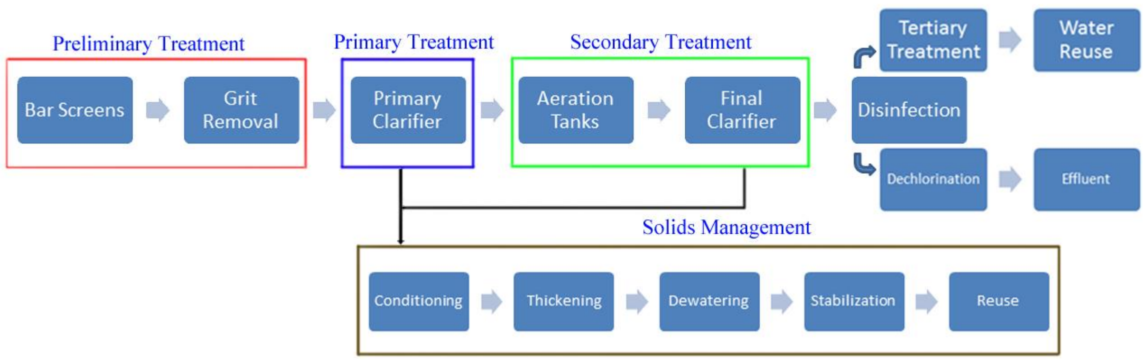

Figure 2 Illustrative fundamental water treatment and biosolids handling process. Adopted from [5].

While the basic water treatment process shown in Figure 2 is utilized in some fashion by many WTPs, variations of this process are often used based on the specific needs of each plant. Some of the technical opportunities for energy reduction and generation within each step of the typical water treatment process are given in Table 4.

Table 4 Upgrades that can be made to widely used process technologies that can reduce net energy usage in WTPs [6-8]

Process	Purpose	Standard Technologies	Energy Reduction and Generating Opportunities
Preliminary treatment	Remove large objects, grit, and grease	Screening, grit basins, vortex grit removal	Heat recovery
Primary treatment	Remove suspended solids and other floatables, such as oil and grease	Sedimentation or primary clarification, fine screens	Finer screens, chemically enhanced primary treatment, ballasted flocculation, nanofiltration
Secondary treatment	Reduce organic waste	Activated sludge aeration, final clarifiers, dissolved air flotation	Fine bubble diffusers, membrane diffusers, turbo blowers, automatic aeration blowers, dissolved oxygen probes, aerator filter domes, supervisory control and data acquisition systems (SCADA), high efficiency motors, gravity belt thickeners, rotary drum thickeners
Tertiary/Advanced Treatment	Remove harmful nutrients	Sand filters, chlorination, nitrification, denitrification	Algae bioreactors
Disinfection	Remove pathogens	Chlorination, ultraviolet treatment, ozone treatment	Micro-hydro water turbines
Solids management	Prepare solids for reuse	Anaerobic digestion, aerobic digestion, composting, alkaline stabilization	Combined heat and power, incineration, pyrolysis, gasification, steam reformation, co-digestion

By acting upon these opportunities, it is possible to reduce net energy consumption of the whole wastewater industry and in some cases improve the treatment processes with newer technologies. Table 5 shows each of the WTPs that we interviewed, along with the processes that each plant used for each treatment step as of 2008.

Table 5 The processes used by the interviewed WTPs as of 2008. Information obtained from the 2008 CWNS and through interviews.

Plant Name	Preliminary Treatment	Primary Treatment	Secondary Treatment	Advanced Treatment	Disinfection	Solids Handling
[redacted]	Bar screen, aerated grit chamber	Sedimentation	Sedimentation	Nitrification	Chlorination	Gravity thickening, centrifuge dewatering, lime stabilization
City of Boulder WWTF	Bar screen, aerated grit removal	In-channel clarification	Trickling filter, rock media, activated sludge, extended aeration, flocculation	Biological nitrification	Chlorination	
Roberto Bustamante WWTP	Bar Screen	Aerated grit removal	Mixed media filter	Activated sludge, extended aeration		
Deer Island WWTP	Bar screen, grit removal	Clarification	Activated sludge, anaerobic/anoxic/ oxic treatment		Chlorination	Mechanical dewatering (centrifuge), Gravity thickening
Des Moines WRF	Bar screen, grit removal	Sedimentation	Trickling filter, Rock media	Activated sludge, biological denitrification	Chlorination	Anaerobic digestion, centrifuge dewatering, land treatment (spreading)
Encina WPCF	Bar screen, aerated grit removal	Sedimentation	Clarification			
Fred Hervey WRP	Bar screen	Aerated grit removal	Clarification	Activated sludge, extended aeration		
[redacted]	Built in 2012	Built in 2012	Built in 2012	Built in 2012	Built in 2012	Built in 2012
Gloversville-Johnstown Joint WWTF	Bar screen, aerated grit removal	Clarification, intermediate treatment	Activated sludge clarification	Biological nitrification		Anaerobic digestion, gravity thickening, dewatering, chemical addition
City of Gresham WWTP	Bar screen, spiraling vortex grit removal	Clarification	Clarification, aeration basins,		Chlorination	Anaerobic digestion
South Shore WRF	Bar screen, grit removal	Clarification	Activated sludge	Ferric chloride addition	Chlorination	Anaerobic digestion, heat drying
Victor Valley WRA	Bar screen, grit removal	Clarification	Clarification, flocculation	Activated sludge, extended aeration	Ultraviolet disinfection	Dissolved air flotation thickening, anaerobic digestion
West Point WWTP	Bar screen, grit removal	In-channel clarification	Pure oxygen activated sludge, clarification		Chlorination	Gravity thickening, anaerobic digestion

The WTPs shown in Table 5 utilize a wide range of technologies and combinations of processes. Each WTP is unique in its treatment process, which makes reducing the energy consumption of the wastewater sector as a whole difficult. However, improving on specific technologies can be an effective way to reduce energy consumption within wastewater treatment facilities.

Energy Reduction Opportunities

By applying the energy reduction strategies shown in Table 4 to plants such as the ones shown in Table 5, it is possible to reduce net energy consumption of the wastewater industry. A WERF presentation given in 2014 provides examples of ten hypothetical "model" WTPs and the percentage of electrical and primary energy that can be saved or produced on-site. "Primary" energy refers to energy sources such as biomass, natural gas, hydropower and wind power that can be transformed into "secondary" energy such as heat and electricity [9]. These hypothetical facilities can be seen in Figure 3.

	10 Model High Performance Facilities	Electric Energy	Primary Energy
1	Basic Secondary (*CEPT*); Anaerobic Dig. (*THP, FOG and FW co-digestion*); CHP; Dewatering	139%	139%
2	Basic Secondary (*CEPT*); Dewatering (satellite to #9 or #10)	0%	0%
3	Nitrification (*CEPT, pre-anoxic*); Anaerobic Dig. (*THP, FOG and FW co-digestion, sidestream deammonification*); CHP; Dewatering	110%	110%
4	BNR (*CEPT, fermenter*); Anaerobic Dig. (*THP, FOG and FW co-digestion*); CHP; Dewatering	61%	61%
5	BNR (*CEPT, fermenter*); Fluidized Bed Incineration (*steam turbine energy recovery*)	13%	11%
6	ENR (*CEPT, fermenter*); Anaerobic Dig. (*THP, FOG and FW co-digestion*); CHP; Dewatering	49%	39%
7	Reuse-MBR (*CEPT, simultaneous N/DN*); Anaerobic Dig. (*THP, FOG and FW co-digestion, sidestream deammonification*); CHP; Dewatering	80%	80%
8	BNR (*CEPT, fermenter*); Anaerobic Dig. (*THP, FOG and FW co-digestion*); CHP; Dewatering; Fluidized Bed Incineration(*energy recovery*)	69%	59%
9	Regional – Anaerobic Dig. (*Imported solids, THP, FOG and FW co-digestion*); CHP, Dewatering – System includes #2	103%	99%
10	Regional – Fluidized Bed Incinerator (*imported solids, steam turbine energy recovery*) System includes #2	52%	41%

Water Environment Federation — the water quality people

WERF

Figure 3 Model WTP Theoretical Energy Production, in percent of energy consumed [10]

Many WTPs today utilize some of the same technologies as these model facilities, and are working on maximizing their on-site energy generation capabilities and minimizing net energy consumption. The potential electricity savings of widely used technologies is shown in Table 6.

Table 6 Potential electrical savings for various technologies [11]

Technology	Treatment Process Type	Potential Electricity Savings (kWh per million gallons water treated)
Primary clarifiers	Primary	215
Chemically Enhanced Primary Treatment (CEPT)	Primary	507
Shortcut-Nitrogen Removal (SNR, market readiness in 20 years)	Advanced	151
Combined heat and power system	Solids Handling	785
Co-digestion	Solids Handling	116
Gasification with CHP (Market readiness in 20 years)	Solids Handling	50

From Table 6 we can gather that an area of the treatment process with high potential for energy savings is solids handling. Specifically, the adoption of anaerobic digestion allows for the production of energy through combined heat and power (CHP) and co-digestion systems, leading to a significant decrease in the net energy consumption of a facility. We identified another opportunity for large energy reductions in WTPs through Figure 4, which shows the percentage of total energy consumption within various areas of WTP operation.

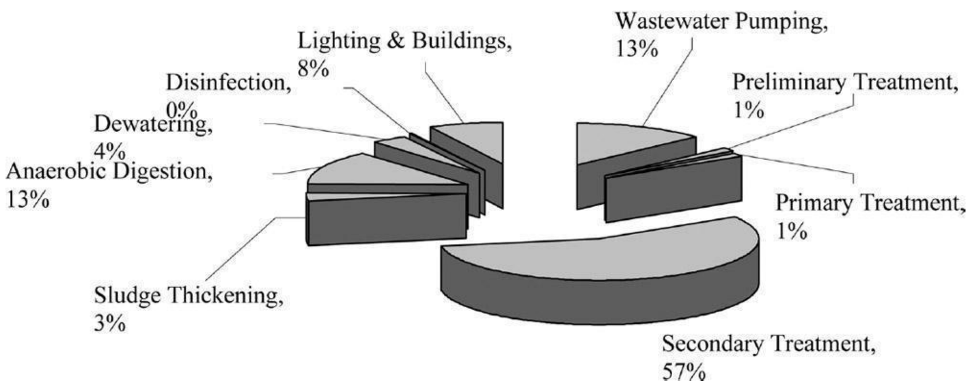

Figure 4 Typical percent energy consumption of each treatment step in WTPs [6]

Based on Figure 4, we can conclude that secondary treatment processes consume the most energy within WTPs. We investigated the recent technological upgrades made by the WTPs that we interviewed in order to draw correlations between the upgrades made and our target areas of improvement.

The WTPs that we interviewed have made renovations and updates to their processes and technologies since 2008. Many of the plants that we interviewed have adopted anaerobic digestion, started using CHP and co-digestion to convert biogas from anaerobic digesters to energy, and made upgrades to diffusers and pumping systems. These upgrades correlate strongly to the target areas of improvement drawn from Table 6 and Figure 4. Recent upgrades made by interviewed plants are shown in Table 7.

Table 7 Recent upgrades made by interviewed plants since the 2008 CWNS that can help the plants reach energy neutrality

Facility Name	Recent energy saving and generating upgrades
[redacted]	Anaerobic digestion
City of Boulder WWTF	Updated CHP system, variable-frequency drives (VFDs), high efficiency motors
Roberto Bustamante WWTP	Co-digestion, membrane diffuser
Deer Island WWTP	Co-digestion
Des Moines WRF	CHP, pump and blower optimization, SCADA
Encina WPCF	CHP, investigating co-digestion of fats, oils, and greases (FOG)
Fred Hervey WRP	CHP, investigating co-digestion
[redacted]	SCADA, low dissolved oxygen aeration mode
Gloversville-Johnstown Joint WWTF	CHP engines installed, enhancements made to anaerobic digesters, storage built to save whey for future co-digestion, working on selling power back to grid
City of Gresham WWTP	CHP, high efficiency pumps and blowers, co-digestion of yogurt, milk, cheese, and FOG
Victor Valley WRA	Omnivore project (new process that removes more moisture from sludge), gas equalizer bladder, membrane diffusers
West Point WWTP	VFDs

Of the thirteen plants that we initially interviewed, ten plants have adopted anaerobic digestion or upgraded their anaerobic digestive system in the past six years, and seven plants have made upgrades to their secondary aeration blowers. We explored the barriers that our interviewed plants had faced in making these upgrades.

Co-digestion

In our interview with WERF's Lauren Fillmore, it was suggested to us that the lifespan of an anaerobic digester is between thirty and forty years. This correlates strongly with what we have observed from our plant interviews. Many construction projects, including digesters, were built in the 1970s and 1980s under the 1972 Clean Water Act (CWA), and ten of the thirteen plants that we interviewed upgraded their digestion systems in the last six years, which is between thirty and forty years after the passing of the CWA in 1972 [12].

One possible upgrade that can be made to digestion systems is the utilization of co-digestion. Co-digestion is a method of increasing biogas production by feeding materials such as FOG and dairy products through digesters. Despite having the capacity to decrease grid dependency, co-digestion can be expensive and time consuming to perfect, as indicated from our interviews and research. For instance, co-digestion operation and efficiency can vary with influent quality and type, climate, FOG composition, and temperature [13]. The Gloversville-Johnstown Joint WWTF and the City of Gresham WWTP are two of the earlier plants that pioneered the use of co-digestion. Due to the existence of many complications, most of these plants' advancements in co-digestion were based on trial and error over a period of a few years. The Gloversville-Johnstown Joint WWTF's studies were possible due to its close ties with a nearby yogurt facilty, and Gresham's WWTP received a 40 thousand dollar grant from the Oregon Economic Development Department for a feasability study on co-digestion. Our interviewees from these facilities said that they can easily understand why a plant would chose to not adopt co-digestion due to the testing required for its implementation. They stressed that a plant cannot always look to previous studies since those studies may have been carried out in different climates or under different conditions.

Half of the plants that we initially interviewed have adopted co-digestion during the last six years, as evident from Table 7. This roughly alludes to a statistic from the American Biogas Council: of the 1500 hundred WTPs that have operational anaerobic digesters in the United States, about 250 utilize the biogas produced in a useful way [14]. This suggests that as of 2011, a maximum of 16.7% of the United States' WWTFs utilized co-digestion, and that there is a large collective improvement that can be made with how the United States' treatment facilities utilize the energy contained within bio-waste.

We recommend that the United States Department of Energy (U.S. DOE) partner with the National Science Foundation (NSF) to promote the adoption of co-digestion in WTPs. Studies on co-digestion can be NSF funded to mitigate the risk associated with its adoption. The U.S. DOE can assist WTPs with applying for these NSF grants and with publishing the results of the studies. The information gathered by plants regarding co-digestion can also be disseminated throughout the water sector by a partnership with WERF's LIFT program. WERF's subscription base consists of two-thirds of the sewage treatment population in the U.S., and can be reached via emails, newsletters, and press releases. It may be beneficial for WERF to start a new database, similar to ScienceDirect.com, where WTPs and independent researchers can post the results of their studies on co-digestion and other technologies to be shared with the rest of the WERF subscribers.

Additionally, we suggest that the U.S. DOE sponsor undergraduate students who want to study the use of technologies such as co-digestion and publish their results. The groundwork for such a program already exists in the U.S. DOE's Science Undergraduate Laboratory Internship (SULI) program. Finally, we recommend that the U.S. DOE gather as much information about co-digestion use and modeling as possible by roughly the year 2040. Since the lifespan of a digester is about 30 years, and the first wave of mandatory digester upgrades recently swept the country, it stands to reason that many plants will require their next digester upgrades starting in the year 2040. The decade between 2040 and 2050 may be a unique time for the U.S. DOE to offer technical assistance and be able to make a huge impact on energy production at WTPs.

TURBO BLOWERS

Of the thirteen plants that we interviewed, seven have upgraded the blowers of their aeration systems. It is clear that upgrading the aeration system is of high priority for many plants because of a large possible reduction in energy consumption. However, factors exist that inhibit the implementation of these upgrades despite being long-term financial benefits. Our plant interviews suggest managerial and communication barriers to upgrading aeration systems, but we suspect that there may be technical barriers as well, as there similarly is for the implementation of anaerobic digesters. In an interview we asked Jason Turgeon of Massachusetts EPA if he knew of any WWTFs that have had technical difficulties with upgrading the turbo blowers in their aeration systems, and he directed us to the Lowell Regional Wastewater Utility in Massachusetts and the Wastewater Treatment Facility of Warwick in Rhode Island.

The Warwick Wastewater Treatment Facility has recently undergone upgrades and repairs due to damages caused by a flood in 2010. Their newly built [redacted] turbo blowers are currently operational, but the plant managers and technicians experienced difficulty getting the turbo blowers to communicate with their SCADA system, which acquires and monitors data about the dissolved oxygen (DO) output of the blowers. Coupled with this software issue, the plant struggled with the blowers' poor turndown ratio, defined as the electrical power range over which the blowers can operate. Below the turndown capability of a blower, catastrophic failure can arise due to hydraulic instability. Most blowers automatically switch off when approaching this threshold, but the Warwick Treatment Facility's staff could only reduce DO levels by ten percent before the blowers automatically shut down. Additionally, the increased levels of DO can have a negative effect on the anoxic (requiring no DO) portions of the treatment process, as the excess DO can enter these areas when recycling water, decreasing treatment efficiency [15]. Together, these two issues resulted in the blowers outputting much more DO than required, since the SCADA system could not accurately measure the DO output and the engineers could not manually turn down the blower DO.

The issues that the Warwick Wastewater Treatment Facility faced persisted until they were able to meet with both the SCADA and turbo blower vendors at the same time to work out all the bugs. It took the Warwick plant two years from their initial purchase to see a reduction in kWh cost. To see if their case was unique, the Warwick Treatment Plant informally surveyed surrounding Rhode Island WTPs to see if they had similar problems. The responses are tabulated in Table 8.

Table 8 Informal survey performed by Warwick WWTF regarding the state of aeration blowers in Rhode Island [16]

Plant	MGD	Superintendent, Project Manager	Brand	Problems
Cranston	20.2 maximum 13.2 average	[redacted]	[redacted]	None, their current blowers were installed in 2000
Warwick	7.7 maximum 4.5 average	Patrick Doyle	[redacted]	Controls, turn-down, mechanical failures; no energy savings
Woonsocket	16.0 maximum 9.3 average	[redacted]	[redacted]	Control issue with blower turndown
East Providence	14.2 maximum 6.7 average	[redacted]	[redacted]	No issues; replaced surface aerators at same time so tough to gauge energy savings
Westerly	3.3 maximum 2.5 average	[redacted]	[redacted]	Controls, turn-down, mechanical failures
South Kingstown	5.0 maximum 2.4 average	[redacted]	[redacted]	Installed 2010, seeing savings, no issues
Fields Point	65.0 maximum 45.5 average	[redacted]	[redacted]	No particular issues

Roughly forty three percent of the plants listed in Table 8 have experienced costly quandaries with their turbo blowers. There appears to be no correlation between MGD and blower effectiveness, as we initially expected there to be. However, an unexpected trend arises: turbo blowers that utilize air foil bearing technology seem to have a higher dissatisfaction rate than those that use traditional mechanical bearings. It is interesting that such a large number of plants have had issues with turbo blowers that have air foil bearings, considering that the Lowell Regional Wastewater Utility in Massachusetts has also had issues with this technology.

In 2011, the Lowell Regional Wastewater Utility in Massachusetts acquired [redacted] turbo blowers to replace their relatively more expensive and less efficient centrifugal blowers. Executive Director Mark Young lauds the turbo blowers' energy efficiency and quietness, but these positive features cannot make up for the repeated mechanical failures that the turbo blowers have experienced due to the air foil bearings. Mark Young and his staff have observed that the air foil bearings severely limit the number of times that the turbo blowers are able to start and stop before experiencing failure. Since DO demand can drastically change over time, the plant is left with two choices—either leave all the turbo blowers running at all times to meet the required DO concentration but spend more money on kWh, or turn some blowers off to meet the current DO demand and spend less money on kWh, but risk mechanical failure. At the time of writing, each of the four turbo blowers that the Lowell Regional Wastewater Utility originally purchased have been replaced at least twice due to mechanical failure in the air foil bearings, and only two turbo blowers are currently operational. Despite being much less energy efficient than the new turbo blowers, the plant's centrifugal blowers had lasted for twenty years before needing to be replaced, while the new blowers are being replaced multiple times per year.

There are a limited number of cases where turbo blowers have failed due to air foil bearing technology, but we suspect that this is because its use in the water industry is relatively new. Turbo blower technology can give WTPs the opportunity to reduce energy consumption and increase pecuniary savings, but many plants avoid the implementation of this technology due to stories such as these shared throughout the industry. We recommend that the U.S. DOE seize the opportunity to make this effective technology even better and more widely used. Kathleen O'Connor, one of NYSERDA's project managers, feels that there is a lack of consistent protocol for measurements and verification for turbo blowers—stricter manufacturing and product testing requirements can promote the use of this technology by decreasing the risk associated with its implementation, promoting energy reduction and environmental friendliness. The U.S. DOE can also assist treatment facilities with choosing the blower that best fits their needs. For instance, a small WTP might be advised to use air foil bearing technology since fewer starts and stops are required by blowers in small plants, while larger plants may be advised to use some different technology.

The implementation of the new turbo blowers at the Lowell Regional Wastewater Utility was American Recovery and Reinvestment Act (ARRA) funded. In an effort to promote American industry, the ARRA requires that the funds can only be applied to blowers that are assembled in the U.S. The Lowell Regional Wastewater Utility originally purchased their new turbo blowers from a [redacted] company called [redacted]. However, [redacted] sent a set of already assembled turbo blowers to the Lowell Regional Wastewater Utility. Consequently, these turbo blowers were not able to be implemented using ARRA funding. At this point, the Lowell Regional Wastewater Utility had gone a long time without supplying DO to their saprotrophic bacteria, so the management at the plant was rushed into purchasing new turbo blowers without fully assessing their options. It may be beneficial in the long run to promote American industry by putting policies in place to improve the quality of the products produced, instead of adding international complications to an already complex process. While competition between turbo blower manufacturers should be the main driving force behind improving product quality, national energy consumption can be negatively affected if at least a reasonable minimum standard is not set.

Technology implementation

The implementation of some energy reducing or producing technologies can be daunting for many WTP managers, and mechanical issues can make using many technologies risky. Meeting effluent regulations was cited as one of the top priorities for every plant manager that we interviewed. Getting approval to implement a new technology is a very involved process that requires attention and dedication from plant managers and staff. It can be difficult for plant staff to focus on exploring new technologies, especially when other issues such as effluent regulations and public health take precedence. In this section we discuss financial and communication related barriers to the implementation of technologies and explore possible strategies for mitigating these obstacles.

Funding

A major barrier to the implementation of new technologies in WTPs is finding sufficient funding. Funding for a new project must be approved by a water facility's governing body—such as a public or private board or an elected town council. Additional funding for projects of various calibers can also be provided to WTPs in the form of grants, loans, rebates, or partnerships by government and private organizations. Receiving a source of additional funding greatly increases a plant's chances of getting a project approved by its governing body.

Of our thirteen initial interviewees, nine of them claimed that the availability of project funding from the federal government has significantly decreased over the last thirty years. These interviewees are referring to the amendment of 1972's CWA with the Water Quality Act (WQA) in 1987. Under Title II of the CWA, grants were given to the water sector for the purposes of construction and expansion. However, the WQA of 1987 amended the CWA and the initial Title II grants were replaced by the Clean Water State Revolving Funds (CWSRFs), which takes the form of low interest loans rather than grants [17]. Jason Turgeon of EPA Region 1 pointed out that SRFs are typically used for funding construction projects, not for installing and testing out new technologies. However, he also stresses that some larger technological projects, such as digester implementation, can be funded using CWSRFs. If a facility desires to acquire grants for non-construction, grants and public-private partnerships can be—and often are—sought from sources like energy service companies (ESCOs). SRFs, grants, and partnerships can be competitive, time consuming to apply for, and difficult to find due to their disjointed nature, as pointed out by Jason Turgeon and our contacts from the City of Gresham, Des Moines, Metropolitan Council Environmental Services, and Milwaukee. WTP staff must be able to effectively communicate amongst themselves and with governing bodies in order to be granted the necessary funding for new energy-related projects. WERF's Lauren Fillmore suggests that for these reasons, many plants are discouraged from actively seeking out funding opportunities, especially for smaller projects.

Communication and Energy Management

Effectively communicating with stakeholders is an ongoing challenge for plant staff and managers across the water sector, as stated by our contacts from the cities such as Gresham and Washington, D.C. As the U.S. EPA's James Horne points out, it is often arduous to persuade decision makers of the benefits of implementing energy conscious technologies. Nearly all of the facility managers that we interviewed are under governance of decision making bodies that are elected onto councils by city residents, appointed by city council members, or appointed by governors or mayors. In some cases, the city mayor can be a member of the governing body that oversees water-related projects. Those who look over the operations of water treatment in their cities—board members, mayors, and city council members—can be preoccupied with other issues and are not always fully educated about water treatment since they are often newly elected or appointed every few years. For these reasons, when proposing a new technological implementation to decision makers, WTP staff must have good presentation skills: it is often necessary to portray a large amount of information quickly, concisely, and articulately.

Water or wastewater treatment can account for up to twenty five percent of a town's electricity usage, depending on size, but many WTPs operate solely on rates and municipal budgets [18]. Staff is limited in some plants, as was noted by James Horne, since income from ratepayers can be limited and municipal budgets are shared with police, fire, and other departments. It may be difficult for a treatment facility with limited staff to focus on performing return on investment (ROI) and operations and maintenance (O&M) analyses and preparing presentations, so third parties are sometimes hired. This, however, is an issue because it can be expensive to hire a full-time consultant to assist with all project proposal presentations. In an interview with Jason Turgeon, we learned that Massachusetts EPA is considering a program that funds consultants to temporarily work with a few plants that do not have enough money to hire one. Mr. Turgeon suggested that he would be willing to work with the U.S. DOE to pilot such a program in New England.

Properly communicating with the surrounding community and rate payers is also of high importance for WTPs. Public perceptions influence decision makers, and in many cases the public chooses decision makers through the power of the vote. Some common ways a treatment plant can interact with its surrounding community are through websites, press releases, tours, bill inserts, social media, and grease collection [19]. Many of the plant managers that we interviewed used some or all of these techniques in order to improve public relations. It is commonly believed that size is the primary factor that dictates a treatment plant's ability to communicate with its decision makers and community, though our interviews provide evidence that communication and technological implementation is more related to management than to plant size.

Table 9 Community outreach and energy management initiative by interviewed WTPs [20-22]

Plant, MGD, Percent Energy Generation	Energy Leader	Advanced Communication Method	Energy Management Initiatives
[redacted]	[redacted]	-Website	-Energy is currently a secondary focus
City of Boulder WWTF, 12.5 MGD, 35%	Chris Douville	-Bill Inserts -Surveys -Website -Newspaper features	-No team dedicated to working with energy -Energy management is Chris Douville's secondary responsibility -Supplies monetary rewards for energy-related ideas
Roberto Bustamante WWTP, 39 MGD	Manuel Perez	-Uses media outlets to keep in touch with community leaders	-Utilizes consultant firms to manage energy
Deer Island WWTP, 380 MGD, 50%	Kristen Patneaude	-Tours -Website -Brochures -Supplies educational teacher resources	-Monthly energy management team meetings - Joined numerous funding-related mailing lists -Actively seeks relationships with utility companies such as NSTAR
Des Moines WRF, 59 MGD, 35%	Bill Miller	-Publications -Website -Media Announcements -Communicate ROIs of less than 5 years	-Monthly energy management team meetings -ROI analysis team - Joined numerous funding-related mailing lists
Encina WPCF, 22 MGD, 80%	Kevin Hardy	-Public tours -Tours for students of all ages -Hosts booths at fairs and other public events -Brochures -Newsletters -Social Media -Website	-Monthly energy management team meetings -Separates from grid during peak hours -Utilizes consultants when needed
Fred Hervey WRP, 12 MGD, 2%	Vic Pedregon	-Financially supports public education on water conservation	-Periodic plant-wide review of electrical usage
[redacted]	[redacted]	-Flyers -Makes appearances on local news	-1 of 4 staff members involved with energy -Power meter to monitor energy use -Works with a local organization to improve energy efficiency in things such as lighting
Gloversville-Johnstown Joint WWTF, 13.8 MGD, 94%	George Bevington	-None -Feels he has too little staff for effective public outreach	-Entire staff aware of plant's monthly energy consumption -Created a board that meets monthly to identify funding opportunities
City of Gresham WWTP, 13 MGD, 60%	Alan Johnston	-Stays in touch with community using media outlets -Appeal to decision makers by presenting projects with ROIs of less than 10 years	-Has a team of 3 or 4 that investigates new energy related projects and presents them to decision makers -The same energy team meets monthly to monitor energy use, set energy goals, and delegate tasks to the appropriate staff members - Joined numerous funding-related mailing lists -Participate in grant feasibility studies
South Shore Water Reclamation Facility, 300 MGD, 50%	Kevin Shafer	-Communication manager stays in touch with policy makers -Appeals to decision makers by presenting many projects with ROIs of less than 10 years -Social media -Community meetings -Website	-Monthly energy management team meetings -Attends conferences to discover new funding opportunities
Victor Valley WRA, 13 MGD, 100%	Logan Olds	-Speaking events -Public hearings -Publications -Email services -Tours	-Staff members trained to monitor energy use
West Point WWTP, 90-440 MGD (seasonal), 55%	Carl Grodnik	-Tours -Advertise surrounding attractions such as hiking trails, beaches, and lighthouses	-Created an energy management team comprised of a variety of types of engineers

As mentioned by Lauren Fillmore and Bill Miller of Des Moines WRF, ROI and O&M analyses are essential for getting a new project approved, but such analyses are time consuming and can be intimidating for smaller plants. However, Table 9 and our discussions with these interviewees suggest the individual manager has a greater influence on a plant's ability to perform these analyses and communicate the results with stakeholders, as opposed to number of staff available.

A strong focus on energy within a plant stems from a strong focus on energy within plant management. Despite being relatively small in terms of water intake capacity, plants such as Gresham, Gloversville, Encina, and Victor Valley produce a large percentage of the energy that they need on site; the capacity of these plants to investigate and implement new energy efficient and energy generating technologies stems from a collective staff wide energy consciousness that is instituted by some "Energy Champion." The U.S. EPA's James Horne, NYSERDA's Kathleen O'Connor, and WERF's Lauren Fillmore also stress the importance of having a strong managerial focus on energy. Relatively larger plants that were interviewed, such as Deer Island, South Shore, and West Point also produce a large amount of energy due to their managements' energy-related initiatives.

The [redacted] in [redacted], a large plant with a capacity of [redacted] MGD, currently treats energy consciousness as a secondary concern, according to the our contact from this WWTP, [redacted]. Despite having a staff of over one hundred, there is little energy awareness among operators because there have been few energy-related initiatives from higher up management in recent years. [redacted] was overseeing energy consumption at the plant at the time of the interview, but his main job title was "Director of Resource Recovery." [redacted] has said that he believes there should be a new position instated that focuses solely on energy. Although successfully installing projects such as an underground rain collection system, he has had difficulty dedicating time towards energy conscious projects, promoting energy awareness in the plant, assessing new technologies, achieving funding for new technologies, and putting together effective presentations.

[redacted] in [redacted] is the smallest plant that we were in contact with. Regardless of being built only three years ago, and having only four staff members, this plant is poised to start its journey towards zero-net energy (ZNE) operation. Although limited in staff, the new plant's manager [redacted] is energy conscious, constantly monitoring plant energy consumption and is planning on installing solar panels in the future. [redacted] employs a

SCADA system to monitor energy use, a low DO mode to conserve energy, and a glycol system to recover energy. The main barriers for implementing energy conscious technologies at [redacted], according to [redacted], are lengthy permit renewal processes. The data from our interviews with other plants suggest that a greater emphasis on energy awareness for the other three employees at the [redacted] may significantly assuage the barriers to implementing energy reducing and energy generating technologies. Interviews with other plants of not much greater staff size suggest that it is the awareness and effort to have monthly energy meetings that counts more than the number of people available to attend the meetings.

These WTPs and many more have systems in place that can allow for large strides towards ZNE operation. A small amount of assistance is likely all that is necessary to initiate plant-wide energy awareness. One program that we recommend the U.S. DOE investigate is one from Rhode Island. This program, known as Wastewater Management Boot Camp, provides mandatory yearlong training to upcoming managers for each of the nineteen treatment plants in Rhode Island in the fields of media relations, budget preparation, collaboration with regulatory agencies, and wastewater sciences and engineering [23]. While this program does not exclusively teach courses on energy management, the skills that it teaches are indirectly important to energy management. This program is the first of its kind in the nation; if its methods and results were to be investigated and recorded by the U.S. DOE or another institution such as WERF, other states might follow suit.

A program such as the Rhode Island Wastewater Management Boot Camp could prove useful to cities such as [redacted] and [redacted]. Providing similar, personal energy management training to a staff member at [redacted] may serve as a good indicator for the effectiveness of such a program, and is feasible since the U.S. DOE HQ and the [redacted] are located within relative proximity to each other. For instance, a designated employee of the [redacted] can receive personal training a few times a month on finding grants, energy monitoring, raising awareness, and presentation building from the U.S. DOE's highly knowledgeable staff. If such a small, personal training program was to prove successful, and the [redacted] was to become significantly closer to ZNE operation in the years following the training, then promoting such training for the future will be reasonable. It is also convenient, since during the time of our interview, [redacted] stressed the plant's need for a new energy manager. Such ideas could be useful to organizations such as the U.S. DOE, WERF, and state EPAs, because, as Jason Turgeon stresses, there is a dearth of energy management training programs in the water treatment industry.

These ideas are mirrored closely by some previously published studies. One in particular, WERF's "Demonstrated Energy Neutrality Leadership: A Study of Five Champions of Change," explores case studies showing how having a managerial focus on energy in WTPs affected the facilities. Plants to note from this study are Northeast Philadelphia Water Pollution Control Plant in Pennsylvania, Joint Water Pollution Control Plant in California, Douglas L. Smith Middle Basin Water Treatment Plant in Kansas, and Ithaca Area Wastewater Treatment Facility in New York. Through an increased focus on energy, these facilities were able to increase their energy production and grant obtainment using techniques that match what we found from our interviews [24]. If energy management training programs become more utilized in the future it may be useful to look at these plants and others with similar success stories as models, and even try to recruit some close-to-retirement "Energy Champions" to work for the training programs to teach the next generation of managers in the water treatment industry.

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Appendix A Water Treatment Plant Interview Summaries

Plant name: [redacted]
State: [redacted]
MGD: [redacted]
Contact name(s) and position(s): [redacted], Director of Resource Recovery
Staff: 100+
Priorities: Meeting effluent regulations, replacing aging equipment and infrastructure
ZNE Progress: 20%
Barriers to ZNE: There is some lack of demonstrations done on certain technologies and processes.
Notable technologies used as of 2008: Gravity thickening, centrifuge dewatering, lime stabilization
Recently adopted technologies: Anaerobic digestion
Governance: The governing board consists of members from [redacted] and serviced counties in [redacted] and [redacted]. The board members from [redacted] are appointed by the mayor while the board members from [redacted] and [redacted] are elected.
Public Outreach: Website
Funding: Grants and loans are not used frequently.
Energy management: [redacted] currently oversees energy consumption at the facility because the previous energy manager was promoted to a new position. Energy management is currently a partial responsibility of his and he believes that there should be a new energy manager at the facility.

Plant name: City of Boulder Wastewater Treatment Facility
State: Colorado
MGD: 12.5
Contact name(s) and position(s): Chris Douville, Wastewater Treatment Manager
Staff: 28
Construction year: 1968
Renovation years: 1972, 1980, 1987, 2007
Priorities: Meeting effluent regulations, expanding plant capacity, replacing aging infrastructure
ZNE Progress: 35%
Barriers to ZNE: Budget limitations and the level of confidence with new technologies
Notable technologies used as of 2008: None known
Recently adopted technologies: Updated CHP, VFDs, high efficiency motors
Governance: Members of the Water Resources Advisory Board are appointed by the City Council. The City Council sets goals and the Water Resources Advisory Board provides input on energy-related projects.
Public Outreach: Bill inserts, surveys, a website, and newspaper features
Funding: Projects at the facility were funded by the USEPA. The plant also was one of 66 facilities that participated in a citywide performance-contracting project on energy efficiency where opportunities for energy efficiency were identified along with ways to take advantage of these opportunities. The plant was awarded $1,080,000 to reduce the levels of nitrogen and phosphorus in the treated water.
Energy management: Energy management is Mr. Douville’s secondary responsibility. He supplies monetary rewards to his employees for energy-related ideas.

Plant Name: Roberto Bustamante Wastewater Treatment Plant
State: Texas
MGD: 39
Contact Name(s) and position(s): Manuel Perez, El Paso Water Utilities Energy Management Coordinator
Construction year: 1991
Renovation years: 2003
Priorities: Expanding their current system and addressing water shortage
ZNE Progress: 15%
Recently adopted technologies: Co-digestion, membrane diffuser
Governance: Public service board that meets monthly. Invitations are issued to the public for open positions on the board, with some positions requiring specific qualifications. The City Council ultimately selects the candidates for the board.
Public outreach: Board members are easily accessible to the community leaders and are responsive to their concerns. The board expresses these concerns through media outlets.
Funding: Grants are advertised, and low-interest funding is available from the state. Utilities have always tried to leverage grant money. Most of the money obtained is used primarily for water treatment processes. Some grants were used for energy-related pilot projects, such as leak detectors.
Energy management: Mr. Perez is the Energy Management Coordinator servicing all divisions of El Paso Water Utilities, and works to propose new projects to the chief technical officer. Mr. Perez believes that energy management is not yet recognized as an area requiring resources and incentives should be given to facilities that exhibit good energy management.

Plant name: Deer Island Sewage Treatment Plant
State: Massachusetts
MGD: 380
Contact name(s) and position(s): Kristen Patneaude, Program Manager of Energy Management
Staff: 400+
Construction year: 1968
Renovation years: 2000
Priorities: Keeping waterways clean, meeting permits, maintaining low rates
ZNE Progress: 26% electrical and 50% total
Barriers to ZNE: The payback period is an important factor for the plant to even consider a particular technology. New projects must be researched to ensure that they do not negatively affect the quality of effluent water or gas, and all operational impacts must be considered before installing these technologies.
Notable technologies used as of 2008: Mechanical dewatering, gravity thickening
Recently adopted technologies: Co-digestion
Governance: The plant is overseen by a public board. The plant's energy-related projects were influenced by Massachusetts Governor Deval Patrick's Executive Order 484, which required state-owned buildings to meet energy reduction goals.
Public Outreach: Tours, a website, brochures, and supplying educational teacher resources all raise public awareness.
Funding: Deer Island was granted this money from NSTAR on a three year memorandum of understanding, pledge to reduce purchased electricity by 5% kWh in return for a cash reward. They also received funding through stimulus packages, and various state and federal programs, such as the Massachusetts Clean Energy Center and SRFs from the Massachusetts Department of Environmental Protection.
Energy management: An energy task force meets monthly to discuss energy-related issues. Decisions are not made within these meetings, but senior management does participate in them.

Plant name: Des Moines Wastewater Reclamation Facility
State: Iowa
MGD: 59
Contact name(s) and position(s): Bill Miller, Reliability & Sustainability Manager
Staff: 104
Priorities: Reducing operational costs and hence rates, meeting effluent standards
ZNE Progress: 35%
Notable technologies used as of 2008: Anaerobic digestion, centrifuge dewatering, land treatment (spreading)
Recently adopted technologies: CHP, blower optimization, SCADA systems
Governance: A board which consists of members from the 17 different communities of the Des Moines metropolitan area. The board is receptive to energy-related projects as long as they have a low return on investment (usually between 2 and 5 years) and all the details of the projects are effectively and convincingly communicated.
Public Outreach: Publications, websites, announcements, and energy-related awards all raise public awareness.
Funding: Grants have been used for many energy-related projects, but are becoming more challenging to locate.
Energy management: Mr. Miller is the energy champion of the Des Moines Wastewater Reclamation Facility. He raises awareness of the plant's energy consumption among the rest of the staff.

Plant name: Encina Water Pollution Control Facility
State: California
MGD: 22
Contact name(s) and position(s): Kevin Hardy, Chief Executive
Construction year: 1965
Renovation years: 1975, 1992, 2009
Priorities: Protect surrounding waterways, protect public health, costs, rate reductions
ZNE Progress: 80-85%
Barriers to ZNE: There is data on technologies out there, but it can be difficult to find.
Notable technologies used as of 2008:
Recently adopted technologies: Expanded CHP, co-digestion
Governance: Members of the board are appointed by a joint power agency. Two board members are appointed by each of the three cities and special districts served by the treatment facility. Politicians who are elected into office appoint the board members. Communicating efficiency tends to convince the board to approve new projects.
Public outreach: Public tours, tours for students of all ages, hosts booths at fairs and other public events, brochures, newsletters, social media, a website
Funding: An employee is dedicated to searching for grant opportunities.
Energy management: An energy management team focuses on the power production aspects of the facility. When time is limited, outside consultants are sometimes used. The chief plant operator identifies areas that the facility can improve in energy efficiency. An energy management program is in place where the plant separates from the electric grid during the plant's peak energy production time.

Plant Name: Fred Hervey Water Reclamation Plant
State: Texas
MGD: 12
Contact Name(s) and position(s): Vic Pedregon, Superintendent
Staff: 30
Construction year: 1985
Priorities: Permit compliance, maximizing water sustainability and energy efficiency
ZNE Progress: 2%
Barriers to ZNE: Meeting regulations and cost of new technologies. The return on investment for new technologies is often not desirable. Focus is typically on conserving water, since it is scarce in the area.
Recently adopted technologies: CHP, currently investigating co-digestion
Governance: Public board which includes the mayor is partially autonomous from the city. Members are appointed by the City Council.
Public outreach: Strong proponent of public education towards water conservation. Mr. Pedregon expends significant resources on public education, leading to greater community support of water-saving endeavors.
Funding: A coordinator searches for available grants and writes grant applications. Extensive effort is required to seek out funding opportunities, and the application process can be cumbersome.
Energy management: Electricity consumption is periodically reviewed, and ways to achieve better energy efficiency are brainstormed during these reviews.

Plant name: [redacted]
State: [redacted]
MGD: [redacted]
Contact name(s) and position(s): [redacted], Operating Officer
Staff: 4
Construction year: 2012
Priorities: Costs, budget planning, meeting effluent regulations
Barriers to ZNE: Overregulation
Recently adopted technologies: SCADA, low dissolved oxygen aeration mode
Governance: City Council members are elected.
Public Outreach: Flyers, makes appearances on local news
Funding: A lot of assistance from the state and from grants was used to construct the plants.
Energy management: [redacted] oversees energy onsite using a wide variety of monitoring tools.

Plant name: Gloversville-Johnstown Joint Wastewater Treatment Facility
State: New York
MGD: 13.8
Contact name(s) and position(s): George Bevington, manager; Tyler Masick, engineer
Staff: 25
Construction year: 1972
Renovation years: 1990
Priorities: Effluent standards, cost reduction, and energy production
ZNE Progress: 94%
Barriers to ZNE: Staff is limited. Gloversville and Johnstown have relatively low populations (15,315 and 8,479 in 2013 respectively), meaning that money from ratepayers is somewhat limited.
Notable technologies used as of 2008: Anaerobic digestion installed in 1990 renovation
Recently adopted technologies: CHP, co-digestion, digester enhancements
Governance: Board members are appointed by the cities of Gloversville and Johnstown and have three-year terms. Staff can make investment decisions, but is limited by budget set by the board.
Public outreach: The plant has too little staff for effective public outreach.
Energy management: An energy management board meets monthly to discuss energy production, energy reduction, and external funding opportunities. All staff members actively seek out external funding opportunities.

Plant name: City of Gresham Wastewater Treatment Plant
State: Oregon
MGD: 13
Contact name(s) and position(s): Alan Johnston, Program Manager and Senior Engineer
Staff: 20
Construction year: 1954
Renovation years: 1970, 1980, 1990, 2000, 2005, 2010, 2012
Priorities: Effluent standards, cost reduction, energy efficiency, and energy production
ZNE Progress: 60%
Barriers to ZNE: Return on investment for new projects and convincing the governing body and community of the importance of new projects.
Notable technologies used as of 2008: Anaerobic digestion installed in 1990 renovation
Recently adopted technologies: CHP, high efficiency pumps and blowers, and co-digestion of yogurt, milk, cheese, and fats, oils, and greases, digester enhancements
Governance: Energy management team presents projects to the City Council for approval.
Funding: New funding and grant opportunities are always being sought. The staff is signed up for various funding opportunity-related mailing lists, attend seminars, and perform grant feasibility studies.
Energy management: An energy management team meets once per month to monitor energy use, set energy goals, discuss new projects, and assign tasks to appropriate staff members.

Plant name: South Shore Water Reclamation Facility
State: Wisconsin
MGD: 300
Contact name(s) and position(s): Kevin Shafer, Executive Director
Staff: Not known
Priorities: Meeting effluent regulations, replacing aging equipment and infrastructure
ZNE Progress: 50%
Barriers to ZNE: Finding funding for projects, especially those with a large return on investment time.
Construction year: 1968
Notable technologies used as of 2008: Anaerobic digestion, co-digestion, heat drying
Recently adopted technologies: Investigating using thermal energy from wastewater.
Governance: The Milwaukee board is comprised of 11 members.
Public Outreach: Communication manager stays in touch with policy makers, appeal to decision makers by presenting many projects with ROIs of less than 10 years, social media, community meetings, a website
Funding: Grants and loans are not used frequently. Obama's stimulus plan and SRFs assisted with projects. Funding opportunities are advertised through the Milwaukee Water Council, conferences, and seminars such as those sponsored by WEFTECH. Loans are now more common than grants.
Energy management: An energy management team meets monthly and makes recommendations to the governing body.

Plant Name: Victor Valley Water Reclamation Authority
State: California
MGD: 13
Contact name(s) and position(s): Logan Olds, Manager
Construction year: 1978
Renovation years: 2007, 2008, 2011
Priorities: Meeting effluent regulations, saving money through efficient operations and generating revenue from alternative resources
ZNE Progress: 100%
Barriers to ZNE: The California energy Commission, in conjunction with electrical utilities, has a program that requires an energy audit from a private entity. Private entities are innumerous, and require a portion of the long-term cost reduction for their services. This cost is high and unfair to ratepayers. This barrier was bypassed by a free energy audit offered by the EPA. Energy costs in CA are high, creating a burden for utilities. The energy permit process is lengthy and involved.
Recently adopted technologies: Modified version of the typical primary treatment process. Technologies include anaerobic digestion, gas equalization bladder, gas conditioning system, 400 horsepower turbo blowers, internal combustion engines, UV disinfection system, membrane style diffusers, Omnivore system. LED UV bulbs and reliable biogas fuel cells are being investigated.
Governance: Joint power authority represents local government entities of three cities and one county. Officials are elected by communities and appointed to the joint power authority. Appointments are typically made out of convenience or for other political reasons, but these policymakers generally support the interests of their communities.
Public Outreach: Mr. Olds engages politicians and the public through speaking functions. Community support is crucial for projects, making the topic of water treatment more approachable makes the speaking functions more effective.
Funding: Grants are not difficult to obtain. Finding private partners was difficult at first, but became easier as the plant became more successful. Plant budgets are designed to incorporate a buffer to prevent rates from increasing.
Energy management: Mr. Olds was originally in charge of energy management. Recently more staff members have been trained to monitor for energy issues. Typically if an innovation is shown to be capable of improving operational efficiency or possesses a strong return on investment (good ROI's are typically seven years or less) a board can be convinced to pass it.

Plant Name: West Point Wastewater Treatment Plant
State: Washington
MGD: 90-440 (seasonal)
Contact name(s) and position(s): Carl Grodnik, King County Wastewater Treatment Division Energy Program Coordinator
Staff: All facilities under the King County Wastewater Treatment Division have an average of 100 employees
Priorities: Low cost implementation of efforts and process tweaks, formerly replacing and upgrading equipment. City council has efficiency goals including 15% energy reduction by 2015 and 20% reduction by 2020. City council requires that 50% of King County's energy come from renewable energy sources.
Barriers to ZNE: Due to seasonal changes in water intake, a large amount of data is needed before attempting to implement new technology. There is also a lack of demonstrations of new technologies.
Recently adopted technologies: Variable-frequency drives
Governance: Officials are elected to the King County Council.
Public Outreach: King County wastewater treatment plants communicate energy reducing and generating goals with community members through signs, displays and plant tours.
Funding: Most funding acquired through utilities with some state and federal grants.
Energy management: Energy management team comprised of employees with mechanical, operational, and electrical expertise.

Appendix B Additional Water Treatment Plant Interview Summaries

<u>Plant name</u>: Lowell Regional Wastewater Utility--Duck Island Wastewater Treatment Facility
<u>State</u>: Massachusetts
<u>MGD</u>: 25
<u>Contact name(s) and position(s)</u>: Mark Young, Executive Director
<u>Staff</u>: 48
<u>Aeration blower upgrade year</u>: 2011
<u>Technology before 2011</u>: Centrifugal blowers
<u>Technology after 2011</u>: Turbo blowers ([redacted])
<u>Advantages of purchased turbo blowers</u>: Quiet, energy efficient
<u>Disadvantages of purchased turbo blowers</u>: The air bearings in the turbo blowers often lead to catastrophic failure. The turbo blowers are limited in the number of times they can start and stop before the air bearings failed. The blowers have a difficult time meeting the correct dissolved oxygen levels.
<u>Replacement of turbo blowers</u>: Mr. Young and his staff have had to replace their turbo blowers 11 times since 2011.
<u>Funding</u>: A State Revolving Fund was used for plant upgrades including purchasing new aeration blowers.
<u>Final thoughts</u>: Air bearing technology has been seen to be more successful in smaller treatment plants because these plants do not need to stop and start their aeration blowers as often as large treatment plants. The basic air bearing technology is good but needs more development before it can become a viable choice for large water treatment plants.

<u>Plant name</u>: Warwick Wastewater Treatment Facility
<u>State</u>: Rhode Island
<u>MGD</u>: 7.7
<u>Contact name(s) and position(s)</u>: Janine Burke, Warwick Sewer Authority Executive Director; Patrick Doyle, Warwick Sewer Authority Superintendent
<u>Aeration blower upgrade year</u>: 2010
<u>Technology after 2010</u>: Turbo blowers from [redacted]
<u>Advantages of purchased turbo blowers</u>: High turndown ratio, energy efficient
<u>Disadvantages of purchased turbo blowers</u>: Had a difficult time getting the blowers to communicate with the SCADA system. It was necessary to meet with the SCADA vendors and the blower vendors at the same time to work out the bugs.
<u>Funding</u>: U.S. Department of Energy grants were used to purchase new aeration blowers.
<u>Final thoughts</u>: Reductions in energy use and cost finally decreased after a year or two or trying to get the new blowers to work.

Appendix C Assistance Programs and Agencies Interviews

Agency/organization name: Minnesota Metropolitan Council Environmental Services
Contact name(s) and position(s): Contact requested that his name be removed
Program functions: Oversee metro-wide public services in the Twin Cities Metropolitan Area in Minnesota. Technical, administrative, construction, and engineering services are provided.
Views on technology in the water treatment sector: The mechanical engineering department offers technical expertise and training. The Metropolitan Council considers approving and assisting in energy-related projects that save ratepayers money in the long run (with an ROI of up to 25 years). The council promotes the use of digesters, wind energy, and solar energy.
Views on funding in the water treatment sector: Funding can be very competitive among treatment plants in the water treatment industry. The contact would like to see more incentives for water treatment plants to focus on energy conservation and energy production.
Views on communication with stakeholders in the water treatment sector: The Metropolitan Council encourages the press to view water treatment plants in a more positive light.
Views on energy management in the water treatment sector: Energy goals set within the city encourage the implementation of energy-related technologies in water treatment plants.

Agency/organization name: New York City Department of Environmental Protection (NYCDEP)
Contact name(s) and position(s): Anthony Fiore, Office of Energy Director
Program functions: Sets strategic energy and carbon management goals for the agency. NYCDEP develops metrics and quality assurance programs for tracking consumption, energy costs, and carbon emissions. In coordination with other bureaus, leads the advancement of energy conservation, generation and renewable energy projects and the management of the capital priorities for energy and carbon management projects.
Views on technology in the water treatment sector: There is a preference for the utilization of current technology that is guaranteed to be successful rather than try new technologies. Long payback periods for energy projects can also act as a barrier to ZNE progress.
Views on funding in the water treatment sector: Obtaining funding for projects is competitive, and at times not worth the effort in applying. Some grants require a 1-2 year turnaround time from when the money is received to when the project is implemented, which is not ideal for long-term projects. More projects could be accomplished if funding was available earlier in the project planning process. There is a tension between spending capital on solids handling and liquid handling.
Views on communication with stakeholders in the water treatment sector: There is a strong communication between the NYCDEP and constituent treatment plants. NYCDEP primarily engages the community through community boards and monitoring committees for larger scale projects. The community is concerned with environmental changes that come with new projects, as well as trucking and odor management. Projects should be framed to the community in a way that relates it to air emissions and energy.
Views on energy management in the water treatment sector: A focus on energy efficiency and generation was caused by local legislation that requires a 30% reduction in carbon emissions by 2017. The law will soon be updated to require 35% reduction by 2025 for city government agencies. Projects under development at water treatment plants need to have a baseline for how much energy would be used and how it will affect air emissions. There is a centralized energy group that has a strong influence on projects relating to greenhouse gas mitigation and energy conservation and efficiency projects.

Agency/organization name: New York State Energy Research and Development Authority (NYSERDA)
Contact name(s) and position(s): Kathleen O'Connor, Project Manager
Contact responsibilities: Offers analysis, research, programs, technical expertise, and funding for energy-related projects.
Views on technology in the water treatment sector: There is a lot of good information on various technologies available to water treatment plants. However, this information is not readily accessible. For example, information that is easily available in EPA Region 9 might not be easy to access by a plant located in EPA Region 1 and information available overseas might not be easy to access in the United States. There is also a lack of consistency in the protocol for testing certain technologies such as turbo blowers.
Views on energy management in the water treatment sector: Most plant managers who are successful at implementing new technologies often go to conferences such as WEFTEC. Having an Energy Champion is often more important than having a large staff size. NYSERDA would like to develop some sort of mentor program where great retiring energy managers are hired to mentor aspiring managers.

Agency/organization name: Office of Wastewater Management, United States Environmental Protection Agency

Contact name(s) and position(s): James Horne, Project Officer; Kelly Kunert Tucker, Environmental Protection Specialist

Program functions: Mr. Horne is involved in the National Pollutant Discharge Elimination System (NPDES) permit program and the state revolving fund (SRF) program, promotes sustainability, and runs training workshops.

Views on technology in the water treatment sector: There is a lot of information about new technologies available to water treatment plants, though most of this information is geared towards more sophisticated, larger treatment plants. However, smaller treatment plants can effectively treat water using less complex technologies. Good management in a small plant can easily offset a lack of the use of cutting edge technologies.

Views on funding in the water treatment sector: Funding in the water treatment sector is not necessarily geared towards energy efficiency. Instead, it is mostly awarded for infrastructure upgrades. However, it still can be used for energy-related projects at times. The problem is that many treatment plants do not understand exactly what funding opportunities are out there or how to get them.

Views on communication with stakeholders in the water treatment sector: Communication between water treatment plants and decision makers is a problem in the sector, especially for smaller communities. Plant staff must effectively address costs and rates in a limited amount of time to leaders and decision makers. Leaders and decision makers are not always educated on water treatment and sometimes have limited attention span. Providing presentation training to plant staff can be beneficial in some cases. Large treatment plants experience these problems but to a lesser degree. Plants with larger staff and more resources sometimes hire external consultants to do research and presentations.

Views on energy management in the water treatment sector: It is very important for each water treatment plant to have an "energy champion" who is in constant contact with all staff. An energy priority among managers can trickle down and become the priority of each staff member. This is most important in smaller plants. Even if a person cannot commit to energy full time, a general awareness or monthly meetings can help greatly.

Agency/organization name: United States Environmental Protection Agency Region 1
Contact name(s) and position(s): Jason Turgeon, Energy and Water Specialist
Contact responsibilities: Provide energy and financial related advice to water treatment facilities and policy makers, spread ideas through public speaking events and roundtables.
Views on technology in the water treatment sector: The water treatment industry is very conservative with regards to new technologies. Programs such as energy star programs and consumer reports can take some guesswork out of the water treatment industry.
Views on funding in the water treatment sector: There are fewer available federal grants than in the recent past. State Revolving Funds, however, exist in the form of loans. State Revolving Funds are awarded for construction purposes, but it is important to keep in mind that the implementation of some energy-related technologies and processes is categorized as construction.
Views on communication with stakeholders in the water treatment sector: Websites, newsletters, tours, and regular meetings all raise public awareness of wastewater treatment and diminish the stigma that wastewater treatment plants possess. Mr. Turgeon is in favor of energy management programs to improve the communication skills of treatment plant staff so that they can more effectively engage ratepayers and policy makers. Mr. Turgeon points to the Wastewater Management Boot Camp in Rhode Island as an example program that trains upcoming treatment plant managers.
Views on energy management in the water treatment sector: Huge energy-related changes can be made within a water treatment plant without significant funding if the plant's management has a strong focus on energy. Currently programs are being considered in which a consultant works with multiple water treatment plants that do not have enough money to hire outside consultants.

Agency/organization name: Water Environment Research Foundation (WERF)
Contact name(s) and position(s): Lauren Fillmore, Senior Program Director
Program functions: Provides subscribers with publications and data on demonstrations.
Views on technology in the water treatment sector: New technologies have a hard time being accepted because failure can result in jail time or fines. Many site demonstrations are needed before there is sufficient data to use some technologies on a large scale. WERF is currently looking into making digesters more efficient. The proportion of organic food in a digester needs to be perfected to maximize its efficiency. The asset life of an anaerobic digester is about 30 years. Many digesters were installed in WWTPs in the 1970s and the 1980s. Modern digesters are quite different from the older digesters that many WWTPs currently use.
Views on funding in the water treatment sector: There are fewer grants available than there were in the past. State Revolving Funds are low interest loans that are currently used for construction purposes, but pursuing these loans may not be worth it for smaller treatment plants.
Views on communication with stakeholders in the water treatment sector: Properly communicating with the audience is key. When proposing a new project to a decision making board, life cycle, operational and maintenance costs must all be addressed. In addition, these things must be communicated concisely and quickly in order to convince decision makers to approve a new project.
Views on energy management in the water treatment sector: Having an Energy Champion is more important than having a large staff or getting a lot of funding in many cases. Energy management can come from within a plant or externally from people such as mayors.

Agency/organization name: Water Environment Research Foundation (WERF)
Contact: Jeff Moeller
Position: Director of Water Technologies
Associated Program: Leaders Innovation Forum for Technology (LIFT)
Associated Program Mission: A combined WERF and WEF initiative aimed at efficiently and effectively bringing new water technologies into practice.
Age of Associated Program: 2 years.
Type of Assistance: LIFT uses a four-step approach to accelerate innovation and the use of new technologies in WWTPs.

1. **Technology Evaluations:** New technologies are identified, screened, and evaluated. A new website is going to be implemented soon that allows WWTP employees and managers to share the results of pilot programs and tests with LIFT. Research needs are identified through surveys.
2. **People and Policy:** Benchmarking the accomplishments of how individual WWTPs and utilities identify the policies and resources needed for research and development and go about accomplishing the research and development.
3. **Communication/Outreach:** Ideas are spread through education, training, newsletters, workshops, press releases, and focus groups.
4. **Informal Forum for R&D:** Managers share experiences and results of pilot programs and research.

Incentives: WWTPs involved in the LIFT program and members of the LIFT working group can more easily learn about new technologies. It also allows for facility owners to collaborate with each other.
Working Group: The LIFT working group consists of facility representatives. It has quarterly meetings (some virtual and some personal) and reviews utility reports, data, and survey answers to determine the focus areas of LIFT. Currently LIFT has seven focus areas:

1. Green Infrastructure
2. Digestion Enhancement
3. Biosolids to Energy
4. Energy from Wastewater
5. Collection Systems
6. Shortcut Nitrogen Removal
7. Phosphorus Recovery
8. Future Focus Area

There are currently about 300 facility representatives in the working group.
Collaboration with DOE: The LIFT program collaborates with the Pacific Northwest National Laboratory. LIFT is funding a bench scale biosolids to energy conversion technology.