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Minnesota Wastewater Facilities

Final Project Report:

Energy Efficiency Implementation in Minnesota Wastewater Treatment Facilities

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Submitted By:

MnTAP Minnesota Technical Assistance Program
University of Minnesota

mn Commerce Department
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mn Minnesota Pollution Control Agency

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Abstract:

The Minnesota Department of Commerce (Commerce), the Minnesota Technical Assistance Program (MnTAP), and the Minnesota Pollution Control Agency (PCA) engaged municipal wastewater treatment plants (WWTP) to participate in training and assessment activities for the purpose of identifying significant energy efficiency projects.

Key outcomes of this project include:

- Developed an energy benchmarking protocol, incorporated it into the State B3 Benchmarking platform[1], and used it to engage facilities in the assessment activities.
- Identified a total of 5.5 million kWh annual energy savings opportunity with an estimated value of $423,000 across eleven assessed facilities through on-site technical energy efficiency assessments.
- Implemented 40% of the 5.5 million kWh of recommended energy savings to date with an additional 39% planned.
- Developed an Action Plan that can serve as the basis for replication activities at other wastewater facilities within Minnesota and can be adopted by service providers in other states.
- Defined a project payback period of 4-9 years for site investment in combined heat and power based on Level 1 assessments of site energy use and generation opportunity.

Future efforts seek to expand on the strategies developed throughout this work to deliver a cohort based energy efficiency program at a scale and level appropriate for small to medium sized WWTPs within Minnesota. A regional energy efficiency cohort model can make use of the strong culture of education and knowledge sharing within the operations community to magnify the impact of site based technical assistance resources and to equip site operations staff with tools needed for continuous improvement.

[1] "Wastewater Treatment Benchmarking." The Weidt Group. <https://mn.b3benchmarking.com/WastewaterTreatmentPlants>.

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Executive Summary

Project Goal

Cities are under constant pressure to deliver improved services and at the same time manage operating costs. Delivering wastewater treatment services to communities can be a high cost effort due to the energy intensity of the operating equipment and the need to meet increasing effluent quality requirements for positive public health and environmental outcomes. Across the U.S., the water and waste water treatment sectors account for as much as 3% of total electricity use.[2] Energy is a large component of facility operating cost accounting for 25-40% of the operating budgets of most wastewater utilities.[3] U.S. EPA has supported studies of energy efficiency in water and wastewater facilities and lists numerous benefits of improving energy efficiency such as reducing energy cost, reducing air pollution and GHG emissions, improving energy and water security, supporting economic growth, and protecting public health.[4]

The primary goals of this project were to decrease energy use in Minnesota municipal wastewater facilities and scope opportunities for renewable energy generation at suitable facilities. To accomplish this goal the Minnesota Department of Commerce (Commerce), the Minnesota Technical Assistance Program (MnTAP), and the Minnesota Pollution Control Agency (PCA) provided technical assistance to selected wastewater treatment plants (WWTPs) to identify significant energy savings through improved efficiency in the operation of wastewater treatment systems.

Project Activities

Target outcomes of this project's technical assistance activities included improved operational efficiency of WWTP aeration systems and other major energy consuming operations in these facilities. Operational cost analysis was used to help justify the implementation of changes to capture identified savings. Additionally, facility-level performance benchmarking, onsite technical assessments and training facility operations staff in energy conservation measures were key project activities. An objective of these facility assessment activities was to identify operational changes that could be made with no or low capital investment to enable site staff to rapidly engage in energy efficiency activities and realize energy reduction impacts within a short timeframe.

An additional target of the team's technical assistance was to identify opportunities for distributed energy generation at wastewater facilities – specifically opportunities for combined heat and power (CHP). Due to the relatively few facilities within Minnesota that fit typical evaluation criteria for favorable CHP implementation, the project team broadened the scope of project screening activities and included facilities treating high strength waste streams to support development and implementation of

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[2] U.S. EPA State and Local Climate and Energy Program: Water/Wastewater, Forum 1/15/2009 Background Paper. Available: http://www.epa.gov/statelocalclimate/documents/pdf/background_paper_wastewater_1-15-2009.pdf

[3] Municipal Wastewater Treatment Plant Energy Baseline Study, Pacific Gas & Electric, 2003, http://www.scribd.com/doc/62799540/Waste-Water-Treatment-Plant-Energy-Baseline-Study

[4] Energy Efficiency in Water and Wastewater Facilities, U.S. EPA, 2013 and references therein, http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf

distributed energy generation. Significant project effort was dedicated to engagement of local and regional partners to increase support for implementation of energy saving recommendations.

Project Outcomes

The financial support from the Department of Energy (DOE) through this grant allowed the project team to complete a comprehensive program to scope effective strategies to identify and implement energy efficiency at wastewater treatment facilities in Minnesota. Considerable untapped energy efficiency potential in this sector was identified over the course of this work through engagement activities with various industry stakeholders, performance benchmarking and energy focused site assessments. Additionally, DOE's support enabled more detailed introduction to the opportunity potential for CHP energy generation from biogas at Minnesota wastewater facilities through screening studies. Energy generation through CHP is not common within typical Minnesota facilities, so identification of opportunity potential at moderate size plants was a critical first step to more broad based adoption. The information gained during this project will serve as the basis for replication activities at other wastewater facilities within Minnesota and can be adopted by service providers in other states.

The primary impacts and outcomes of this project were decreased energy use in Minnesota municipal wastewater facilities and identified opportunities for energy generation. Overall results include:

Outreach and Training

- Engaging Minnesota municipal wastewater treatment sector through outreach activities, including 23 local, regional and state wide meetings and presentations engaging 1,139 wastewater affiliated stakeholders.
- Convening 11 regional discussions of impact of wastewater energy efficiency opportunity implementation.
- Providing training on energy efficiency tools and methods at 3 events reaching 108 wastewater treatment personnel.

Energy Efficiency Assessments

- Conducting 11 energy efficiency assessments at municipal wastewater treatment facilities across Minnesota resulting in 5.5 million kWh/year of recommended energy efficiency improvements, representing over $423,000 in annual savings with nearly 70% of the total feasible through site operational changes.
- Supporting regional implementation plans resulting in 2.2 million kWh/year energy efficiency measures implemented worth over $168,000 annual savings and an additional 2.1 million kWh/year energy efficiency measures planned worth $163,000 in annual savings.

Distributed Generation Assessments

- Screening 25 Minnesota municipal wastewater treatment facilities for energy conservation opportunity through renewable energy generation and engaged 4 facilities in a first level assessment.
- Defining simple payback for combined heat and power implementation at 4, Level 1 assessed facilities to be 4-9 years .
- Setting the stage for at least one investment grade assessment under consideration at the end of the grant period.

As summarized in in the table below, by the end of the project grant period, 79% of the recommended energy savings were implemented or planned to be implemented. Twenty-one recommendations were implemented or partially implemented, and of the implemented recommendations to date, 20 were operational changes and one required capital investment.

Recommendation Status	Number	Energy Savings (kWh)	% of Total Energy Opportunity	Cost Savings ($)
All	54	5,502,000	100%	$423,000
Implemented	21	2,207,000	40%	$168,000
Planned	8	2,158,000	39%	$163,000
Proposed	14	970,000	17%	$81,000
Not Planned	11	251,000	5%	$20,000

Total energy savings is higher than recommended due to higher than estimated implementation value

Introduction

Project Goals

The Minnesota Department of Commerce, Division of Energy Resources and its partners provided technical assistance to selected wastewater treatment facilities. The purpose of this assistance was to determine the opportunity potential for energy efficiency in the municipal wastewater sector and identify significant energy savings through improved efficiency in the operation of wastewater treatment systems.

The primary goals of this project were to decrease energy use in Minnesota municipal wastewater facilities and scope opportunities for energy generation at suitable facilities.

The goals of this program were achieved by implementing the following activities:

- Develop partnerships among municipalities operating wastewater treatment facilities and technical assistance providers, technology providers, and state/regional resources to assess operations for improved energy efficiency opportunities
- Conduct energy efficiency opportunity assessments at sites with sufficient energy efficiency opportunity potential and interest in capitalizing on identified opportunities
- Facilitate site investment in identified proposed project concepts to decrease site energy consumption
- Provide detailed opportunity assessment for renewable energy generation

Wastewater Treatment in Minnesota

Cities are under constant pressure to deliver improved services and at the same time manage operating costs. Delivering wastewater treatment services to communities can be a high cost effort due to the energy intensity of the operating equipment and the need to meet increasing effluent quality requirements for positive public health and environmental outcomes. Across the U.S., the water and waste water treatment sectors account for as much as 3% of total electricity use.[5] Energy is a large component of facility operating cost accounting for 25-40% of the operating budgets of most wastewater utilities.[6] U.S. EPA has supported studies of energy efficiency in water and wastewater facilities and lists numerous benefits of improving energy efficiency such as reducing energy cost, reducing air pollution and GHG emissions, improving energy and water security, supporting economic growth, and protecting public health.[7]

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[5] U.S. EPA State and Local Climate and Energy Program: Water/Wastewater, Forum 1/15/2009 Background Paper. Available: http://www.epa.gov/statelocalclimate/documents/pdf/background_paper_wastewater_1-15-2009.pdf

[6] Municipal Wastewater Treatment Plant Energy Baseline Study, Pacific Gas & Electric, 2003, http://www.scribd.com/doc/62799540/Waste-Water-Treatment-Plant-Energy-Baseline-Study

[7] Energy Efficiency in Water and Wastewater Facilities, U.S. EPA, 2013 and references therein, http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf

WWTPs operate in over 700 communities throughout Minnesota with over 200 communities operating more energy intensive mechanical facilities. Effective and efficient wastewater treatment is critical to community health and economic development. According to the Minnesota State Auditor's Office, the age of wastewater facilities across the state ranges from less than 10 years to greater than 40 years[8] in communities ranging in size from some of the largest such as those in and around the Twin Cities and other high population areas to cities and towns with 2,000 people or less. It is critical for continued growth of state and local economies to extend the useful life of this infrastructure, meet permitted effluent quality and reduce the cost burden for residents and businesses.

While technology practiced at WWTP operations is well established, facilities are highly customized to meet individual community needs and deliver effluent water discharge meeting regional permit requirements. This site specific, customized performance means that while facility staff can be trained generally on operational best practices, many do not feel equipped to address the specific optimization requirements presented by their facility operations.

Site specific technical assistance has been successful in identifying WWTP energy efficiency in facilities across Minnesota. In 2013, MnTAP completed a project to assess energy use and operational benchmarks for ten WWTPs under an EPA Region 5 Water Quality Cooperative Agreement.[9] This project, identified between 5 and 30% energy conservation opportunity for aeration processes across the eleven assessed wastewater treatment facilities. Forty-eight recommendations were made ranging from two to seven recommendations for each plant. The total energy conservation potential of the recommendations was over 4 million kWh/yr, with a total value over $270,000. Seven recommendations were identified as having low to no cost for implementation. Five recommendations had been implemented by the end of the project.

Over the course of the EPA project, MnTAP developed internal experience and knowledge around energy efficiency opportunities in wastewater treatment facilities. Important factors from this work that motivated interest in pursuing additional focused technical assistance to this sector include the vital service these facilities provide to their communities, the significant energy efficiency opportunity remaining in many operations, and the ability to impact the cost efficiency of operations for communities around the state. The following observations made over the course of that project informed the design and focus of the work reported here.

- Wastewater treatment was a large part of a city's operating costs so there was value to the community in optimizing these operations.
- Energy benchmarking showed the amount of energy consumed by plants for treatment activities varied by a factor of 2-3 between the most and least efficient plants but facility staff had no way to know this.
- Many plants were not operating at peak design efficiency due to lower than design treatment flows and minimal capability to turn down operations.
- Aeration costs were typically 50% of the electrical operating costs for treatment plants using activated sludge processes.
- Automation could help optimize treatment required for varying loads levels.

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[8] Minnesota Office of the State Auditor, Civil Infrastructure Project http://www.osa.state.mn.us/maps/

[9] EPA-R5-WQCA-2010, CP-00E00758-0, Energy Efficiency Demonstration Projects and Audits for Minnesota's Wastewater Treatment Plants, final report, 2013

Increased attention to energy efficiency in the wastewater treatment sector was considered a way to extend the useful life of invested infrastructure, help communities reduce cost associated with this critical infrastructure, as well as provide a mechanism for Minnesota to meet key energy performance goals.

State Energy Office Overview

Minnesota was well positioned to execute this project based on strong State energy policies and tools that promote energy efficiency. Commerce has a long-standing history of developing and implementing energy efficiency initiatives and setting renewable energy standards through a progressive regulatory framework. The efficient use of energy in all sectors is vital to the health of Minnesota's economy and environment.

The primary goal of Minnesota's energy program is to accelerate market acceptance of high-efficiency and renewable energy technologies and practices. Since the early 1980s, Minnesota has developed a strong regulatory framework around energy conservation and efficiency through utility demand-side management. These efforts ensure that efficiency is viewed as a supply-side resource for consideration in the integrated resource planning process. The state legislature has placed a priority on diversifying fuel sources that are not imported into Minnesota and consuming less energy across all sectors.

The Next Generation Energy Act of 2007 established energy-saving goals for electric and gas utilities that operate in the state of Minnesota, through the Conservation Improvement Program (CIP). Utility CIPs are a significant source of energy efficiency activity in Minnesota and a cornerstone for achieving the state's energy savings goals. Commerce oversees the $200M CIP programs for over 180 electric and natural gas utilities to ensure that ratepayer dollars are used effectively and energy savings are reported as accurately as possible. As a result of the electric and natural gas savings achieved through CIP in 2013-2014, nearly 1,700,000 tons of CO_2 emissions were avoided over this two year period, equivalent to removing approximately 325,000 cars from the road for one year.[10]

Barriers to Energy Efficiency in Wastewater Treatment

There is considerable energy efficiency opportunity at wastewater treatment facilities of all sizes within Minnesota. Through observations made over the course of this and previous projects, several key barriers to energy efficiency at WWTPs have been identified:

- *Engagement* - Local knowledge of facility energy use and comparative energy performance with peer facilities is often unknown and limits justification to look for energy savings.
- *Finance* - Perception that energy efficiency efforts require large capital investments that are typically not available to facilities limits interest in identifying savings.
- *Assistance* - Highly customized plant designs require more tailored energy efficiency solutions to equip site operations staff to implement large energy conservation projects.
- *Support* - Uncertainty with risk if facilities are operated outside historically prescribed set points results in maintaining high energy use operating strategies and limits continuous improvement.

[10] The Minnesota Conservation Improvement Program Energy and Carbon Dioxide Savings Report for 2013-2014 may be viewed at: https://www.leg.state.mn.us/docs/2017/mandated/170154.pdf

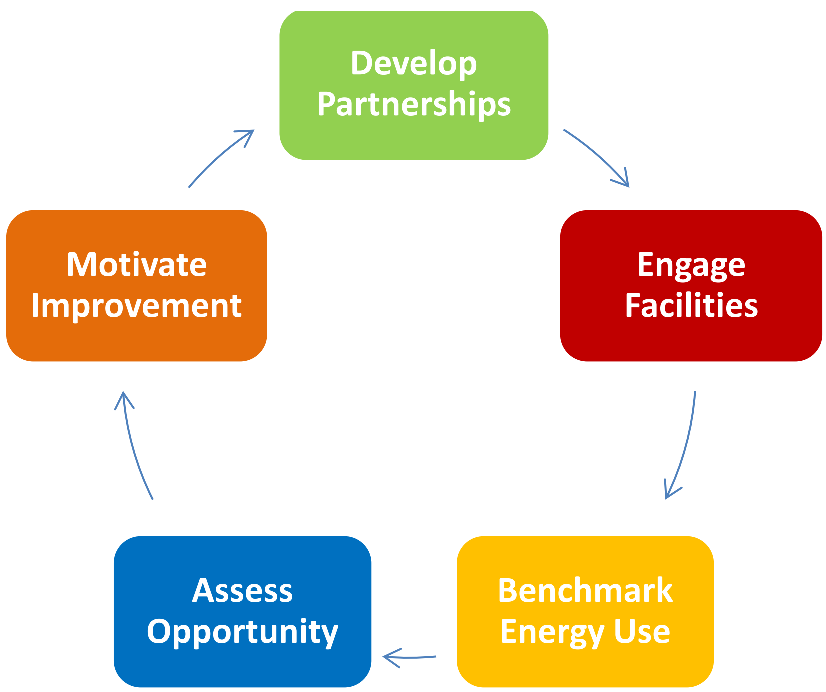
This Minnesota based DOE funded project sought to capture the significant energy efficiency opportunity at wastewater treatment facilities by addressing the root causes behind these barriers and providing tools and assistance to overcoming them.

Summary of Project Strategy

The project team proposed to engage municipal wastewater treatment facilities to participate in training and assessment activities for the purpose of identifying significant energy efficiency projects. The team identified opportunities, worked with key stakeholders to develop implementation plans, engaged interest and support to motivate execution of the implementation plans, and measured and tracked results to demonstrate impact. As an additional stage of this effort, the project team identified and engaged facilities that were ready to scope the opportunity for systems to capture renewable energy sources.

A summary of the key process activities required to develop and execute energy efficiency and renewable energy generation activities for Minnesota WWTPs is outlined in Figure 1. Details of the major components of the process are discussed through this report.

Figure 1 - Key Process Activities



Program Activities and Outcomes

The key project tasks and a brief discussion of key implementation actions are summarized in this section.

Task 1: Strategic Planning

The objective of this first phase was to strategically plan coordination of the project partners and DOE to finalize the scope of work, establish timelines and expectations, and to establish an ongoing communications and management plan in order to achieve the goals set out in the subsequent phases of this project.

Subtask 1.1 **-** Establish Project Plan
Subtask 1.2 **-** Establish Communications Plan
Subtask 1.3 **-** Establish Stakeholder Engagement Plan

Key Project Partners

Commerce

Commerce was the primary grantee and is the State agency responsible for developing and managing Minnesota's state energy plan. Commerce provided detailed knowledge of state energy policy and energy financing tools and relationships with state electric energy utilities. Commerce scheduled and facilitated project calls, developed reporting templates, facilitated communications with the primary project sponsor and managed overall program finances. They were the primary link with contracted services to generate the state wastewater energy benchmarking module for the Buildings, Benchmarks and Beyond (B3) program.

PCA

PCA is the state agency responsible for regulation and compliance management for the wastewater treatment sector. MPCA provided publicly available data on the state's wastewater treatment facility operations, insight on opportunities to motivate energy efficiency through public funding mechanisms, introductions to key industry partners and a forum to share energy efficiency training and topics with industry operations staff through annual meeting forums. MPCA provided key insight to balance energy management and facility treatment compliance.

MnTAP

MnTAP is a state technical assistance provider based at the University of Minnesota. MnTAP served as the client facing organization for the project and provided primary technical expertise in energy efficiency at wastewater facilities which included program promotion and communications, outreach and training activities, site energy benchmarking, technical site assessments to identify energy efficiency opportunities, as well as measurement and verification of energy efficiency recommendations and implementation. MnTAP developed and managed the program website, using this as a tool for outreach and communication as well as publishing wastewater energy efficiency information and project case studies. MnTAP staff members also utilized their successful intern program to provide additional assistance to facilities where needed.

Combined Heat and Power Technical Assistance Partnership (CHP TAP)

CHP TAP promotes combined heat and power through market analysis, education, outreach and technical assistance. The project partnered with the CHP TAP based out of the University of Illinois, Chicago. This organization provided education to Minnesota wastewater facility managers and operations staff through presentations and a booth at a regional meeting. The key activity was no-cost, first level CHP screening assessments at several facilities pre-screened for participation. The assessments serve to give sites a first-look at the cost-benefit analysis associated with using the gases generated in anaerobic digestion processes for electric energy generation and heat for their plants, reducing their need for externally generated electricity and natural gas from the grid.

The availability of this suite of technical and agency expertise and services added scope and capacity to the program effort and helped convince wastewater treatment facility stakeholders to expend the effort to engage in the assessment and implementation phases of the project as well as increasing the interest in seeing the projects move to full implementation.

Task 2: Develop Partnerships

The objective of this task was to engage municipal wastewater treatment facility managers and operations staff, inform key stakeholders of program opportunities and provide energy efficiency training. Additional partnership activities were focused on aligning regional utilities and assistance providers, technology providers, and state/regional resources to assess operations for improved energy efficiency and finance opportunities.

Subtask 2.0 – Engage Partners
Subtask 2.1 – Outreach Activities for WWTP Staff
Subtask 2.2 – Training Activities for WWTP Staff

Partnership activities focused on aligning with existing wastewater assistance providers and industry networks across the state. The initial purpose of these partnership activities was to share information about the program opportunities and solicit input on approaches and strategies to introduce these resources at the facility level. Ultimately these relationships were critical to reporting results from the project activities back to the wastewater operations community. Partnerships included industry partners, commercial partners, regional partners and utility partners as outlined in Figure 2.

Figure 2 – Key Project Partners

Industry Partners

Minnesota Rural Water Association (MRWA) is a non-profit association staffed with full-time personnel trained to offer professional on-site technical assistance and training to water and wastewater system personnel in managerial, financial, and operation and maintenance of systems, as well as source water protection. An initial meeting with MRWA staff members serving as an advisory team helped the project team confirm the need for services and develop the initial outreach plan. MRWA convenes an annual conference and provided the project partners with an annual forum to present the project opportunities and results to wastewater operations staff and engage sites interested in pursuing energy efficiency. A final report of the program impacts to the wastewater community is planned for the 34th Annual MRWA Water & Wastewater Technical Conference, March 6-8, 2018 in St. Cloud, MN.

Minnesota Wastewater Operators Association (MWOA) is an organization of professional operators, laboratory technicians, regulatory agencies, collection system specialists, maintenance personnel, engineers, and marketing consultants from all areas of Minnesota. MWOA is run through a volunteer board and convenes meetings in six regions that cover Minnesota as well as a state wide meeting annually. The organization shares information with members and nonmembers through conferences, training sessions, and section meetings. MWOA has been generous with invitations to project staff to present on energy efficiency at both regional and state meetings as well as publishing articles on wastewater energy efficiency written by MnTAP and Commerce. [11,12]

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[11] Summer 2016 – Energy Efficiency Best Practices in Wastewater Treatment, The Wastewatcher, Vol 63, No 2, page 28

[12] Fall 2017 – Understand your Wastewater Treatment Energy Use: How Benchmarking Can Help Identify Cost Savings, The Wastewatcher, Vol 64, No 3, page 18

Commercial Partners

Commercial partners were also engaged in this process. Specifically vendors such as Hach Company who loaned a meter to measure dissolved oxygen to complete an assessment at one facility; Drueger/Violia provided information on BAF design and operation; General Electric provided information on MBR setup and control; Aerzen provided technical information on blower design, confirming blower capabilities could be expanded through a motor change as opposed to a blower replacement; Great Northern Environmental/Roots Blowers provided blower design information related to maximum turn-down limits and blower sizing.

Consultants, engineering firms and other service providers were engaged to provide information and review of technical recommendations. WHKS reviewed an assessment and added an energy conservation measure to their design proposal. Bolton and Mink engineers provided background information and vendor contacts for the 3 BAF plant assessments. SHE invited MnTAP to participate in design review meetings in late 2017 for a new plant upgrade. Brown and Caldwell, provided some early background reference reports and invited MnTAP to an MCES E2 project summary meeting. People's Service regional managers have encouraged their operators to participate in efforts to disseminate results of work done at plants they manage and have approached MnTAP about an assessment at another of their plants.

Regional Partners

Minnesota GreenStep Cities (GSC) is a voluntary challenge, assistance and recognition program to help cities achieve their sustainability and quality-of-life goals operated out of the Minnesota Pollution Control Agency. This free continuous improvement program is based upon implementation of actions within 29 best practices. These actions focus on cost savings and energy use reduction, and encourage civic innovation. GSC helped launch awareness of the Minnesota effort through a series of webinars supported by Clean Energy Resources Team (CERTs) and League of Minnesota Cities. This outreach was geared toward city managers and operations staff on wastewater energy efficiency, state financial resources for project implementation and the value of benchmarking/B3.[13,14,15] CERTs also provided information on the program to rural communities through their traditional outreach efforts and provided city referrals to MnTAP for site assessments.

Utility Partners

Additional partnership activities target energy utility providers who, along with individual site operations staff, are the primary source for facility energy data. As indicated in the State Energy Office Overview section, utility partners are responsible for managing conservation improvement programs which can be helpful in motivating implementation of projects that help save energy. Energy utilities who worked with MnTAP on this project included Xcel Energy, Southern Minnesota Municipal Power Association, Ottertail Power and Minnesota Power. Utility partners provided approved energy information for benchmarking wastewater facilities in their territories to identify sites that had energy efficiency potential, introduced

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[13] December 8, 2015 – GreenStep Cities Workshop Webinar, Energy Efficiency and Renewable Energy Opportunities at Minnesota Wastewater Treatment Plants, https://youtu.be/lawMMC2tV4E

[14] January 13, 2016 – GreenStep Cities Workshop Follow-Up Session, Financing Energy Efficiency and Renewable Energy at Wastewater Treatment Plants, https://www.youtube.com/embed/Hep4pwyey_Y

[15] December 2017 – GreenStep Cities Workshop, Wastewater Treatment Facility Energy Efficiency, https://youtu.be/0ixCEsLGj8s?t=1429 https://youtu.be/0ixCEsLGj8s?t=2418

the program to key accounts and provided financial support for in depths site studies through the MnTAP Intern Program.

Outreach

MnTAP has developed and maintained the project website[16] as a means to present general project information, case studies and outreach materials. The website was critical to engaging facilities and sharing results. Case studies developed were important tools to demonstrate the opportunity potential for wastewater energy efficiency activities. The most significant outreach occurred through presentations at industry focused events. Project partners presented information on project assessment opportunities, energy efficiency best practices, benchmarking, financing opportunities as well as results and case studies throughout the project period. Overall 25 event activities were conducted reaching 1250 wastewater staff, partners and project stakeholders. A list of events and activities is compiled in Table 1.

Training

Training activities were conducted throughout the program to develop a baseline for engagement and participation. Energy efficiency training was conducted by a hired consultant Thomas Jenkins from JenTech Inc. the 79th and 80th Minnesota Wastewater Operations Conferences held in 2016 and 2017. Energy efficiency training was conducted by MnTAP staff at the Minnesota Wastewater Operators Association Central meeting in April 2016. Overall, 108 operations staff were formally trained in energy efficiency techniques. Informal energy efficiency training was conducted by MnTAP staff members at regional and state meetings as well as individual sites through the assessment and reporting activities. In addition to efficiency, training in energy benchmarking was conducted by MnTAP and The Weidt Group on the wastewater benchmarking module in the State B3 program. Training activities are also summarized in Table 1.

[16] http://www.mntap.umn.edu/industries/facility/potw/wwtp/

Table 1 – Training and Engagement Activities

Wastewater Outreach Event	Topic	Date	Type	Attendees	Status
MRWA	Project Overview	Mar 4, 2015	Presentation	25	Complete
St. Paul Port Authority	Project Overview	Mar 24, 2015	Presentation	10	Complete
Minnesota WW Operations Conference	Energy Efficiency Opportunities	Mar 26, 2015	Presentation	50	Complete
Engineering Firm	Energy Efficiency Opportunities	Oct 2015	Presentation	2	Complete
Green Step Cities	Energy Efficiency Opportunities	Dec 8, 2015	Webinar	67	Complete
Green Step Cities	Funding Mechanisms	Jan 13, 2016	Webinar	22	Complete
MRWA	Energy Efficiency Opportunities	Mar 2, 2016	Presentation	50	Complete
MRWA	Combined Heat and Power	Mar 2, 2016	Presentation	50	Complete
Minnesota WW Operations Conference	Energy Efficiency Training	Mar 24, 2016	Training	38	Complete
MWOA Central	Energy Efficiency Opportunities	Apr 12, 2016	Training	29	Complete
MWOA 40th Annual Conference	Energy Efficiency	Jul 28, 2016	Presentation	35	Complete
Clean Energy Community Awards	Energy Efficiency	Nov 10, 2016	Presentation	70	Complete
34th Innovative Approaches to Wastewater Operational Problems	Energy Efficiency	Feb 7, 2017	Presentation	120	Complete
Pretreatment Delegated POTWs	Energy Efficiency	Feb 16, 2017	Presentation	38	Complete
MRWA	Energy Efficiency Opportunities	Mar 8, 2017	Presentation	20	Complete
MWOA Northeast Section Meeting	Benchmarking and Energy Efficiency	Mar 22, 2017	Presentation	30	Complete
MPCA Wastewater Operators Conference	Benchmarking and Energy Efficiency	Mar 29, 2017	Presentation	122	Complete
MPCA Wastewater Operators Conference	Industrial Source P2	Mar 30, 2017	Presentation	35	Complete
MPCA Wastewater Operators Conference	Energy Efficiency	Mar 30, 2017	Training	41	Complete
MWOA 41st Annual Conference	Benchmarking and Energy Efficiency	Jul 25-28, 2017	Presentation	40	Complete
MPCA Permit Engineers	Energy Efficiency	Oct 3, 2017	Presentation	20	Complete
MWOA Southeast Meeting	Benchmarking and Energy Efficiency	Oct 11, 2017	Presentation	55	Complete
Water Resources Conference	Energy Efficiency	Oct 18, 2017	Poster	200	Complete
CEE Technology Forum	Energy Efficiency	Nov 8, 2017	Poster	50	Complete
32nd Conference on the Environment	Benchmarking and Energy Efficiency	Nov 8, 2017	Presentation	28	Complete
Green Step Cities	Energy Efficiency Opportunities	Dec 6, 2017	Webinar	50	Complete
MRWA	Energy Efficiency Opportunities	Mar 7, 2018	Presentation	TBD	Planned
MPCA Annual Operators Conference	Energy Efficiency Opportunities	Mar 22, 2018	Presentation	TBD	Planned

Energy Benchmarking a Key to Site Engagement

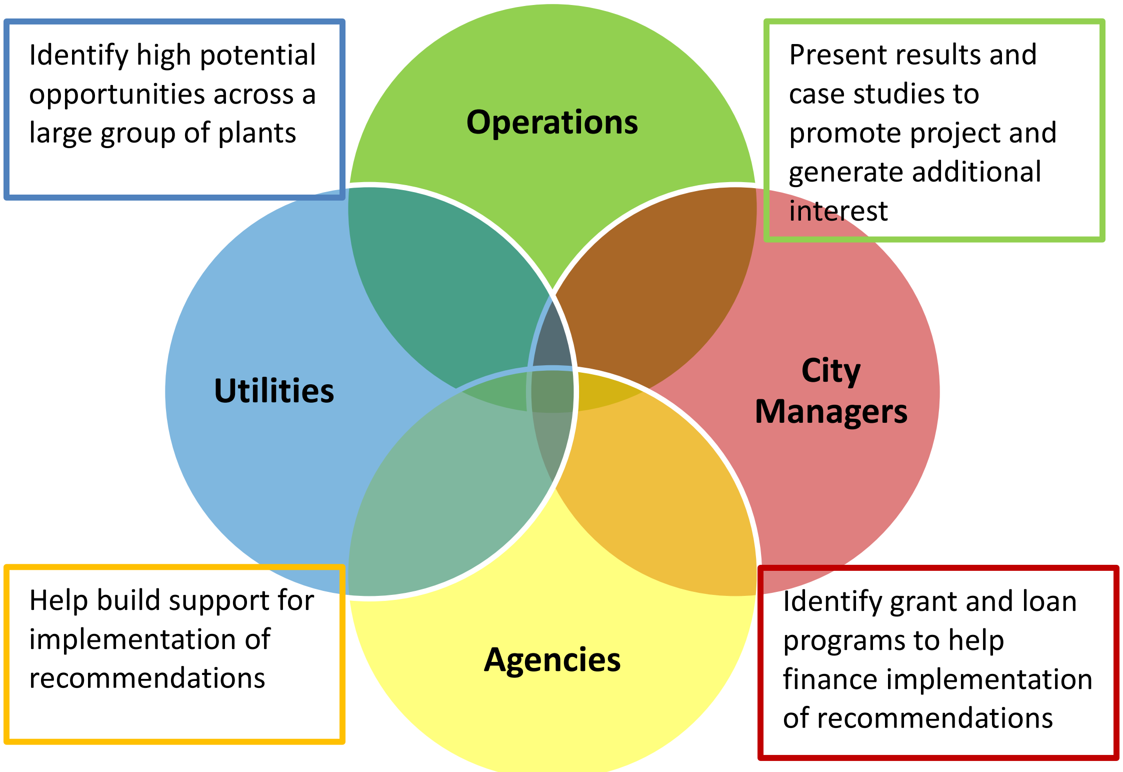
While not in the original project scope of work, it was found that the most significant engagement tool and launch point for site energy assessments identified over the course of this project was the introduction of facility benchmarking within the wastewater sector. As outlined in Introduction section, a key barrier to facility engagement with energy efficiency assessments and implementation was local knowledge of site energy use and energy performance relative to other facilities. Benchmarking allows the energy use and the potential for improvement to become clearer to site staff, city managers and energy utility representatives and serves as a focus for conversations around identification and implementation of energy efficiency measures and evaluation of advanced energy technologies.

A variety of benchmarking strategies were employed over the course of this work depending on the type of facility and the amount of data available. Simple benchmark strategies such as energy use per million gallons processed or per unit biological oxygen demand (BOD) processed were effective to convey the concepts of benchmarking to operations staff but often lack sufficient detail to allow site staff to evaluate their energy performance relative to peer facilities.

Benchmarking was key to quickly identify and communicate energy efficiency opportunities to a variety of sector stakeholders. The benchmark scores were an important part of the overall process to identify sites with energy savings opportunity, engage the facilities in assessment activities and aggregate support resources to encourage and enable implementation. Figure 3 illustrates how stakeholders and facilitating relationships between stakeholders can help support assessment activities, identify financing resources, and motivate implementation of energy efficiency recommendations.

It was found that receiving the energy performance as a ranking relative to other facilities resulted in a high level of site engagement with the assessment process. This was the case for facilities with both high and low benchmark indicators, with low scoring sites actively seeking technical assistance to identify opportunities to improve. Once the benchmarking analysis was completed, site based energy performance based on the energy benchmark indicator value was discussed with site personnel to assist with interpretation of the analysis.

Figure 3 - Benchmarking as a Program Engagement Tool



To provide the comparative capacity the project team looked to improve the B3 Benchmarking tool already used by public facilities to track energy performance and utility cost based on building envelope criteria. While the existing B3 system included WWTPs, the facilities were benchmarked like other public buildings based on square foot area and utilization of the building. Revisions to include process energy use provide more useful measures of energy use in these facilities.

Over the course of the Minnesota DOE project, new functionality was added to B3 so the platform can now provide a wastewater benchmark score based on operational factors not just building size. For facilities treating >0.6 million gallons per day flow, the Minnesota B3 system provides data to EPA to generate ENERGY STAR® Portfolio Manager scores.[17,18] For smaller facilities a similar score is calculated within B3 to generate an equivalent benchmark value. The ENERGY STAR® Portfolio Manager score is the percentile ranking of plant energy performance against a national sampling of facilities, with a higher value being more efficient. With the newly added WWTP benchmarking functionality, cities can compare their plant energy performance to other WWTPs throughout Minnesota, and the nation, to determine how efficiently their plant is operating.[19]

[17] https://www.energystar.gov/buildings/tools-and-resources/energy-star-score-wastewater-treatment-plants

[18] https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/eligibility

[19] http://mn.b3benchmarking.com/WastewaterTreatmentPlants

Key features of this tool include:

- B3 branding to for recognition and alignment with the State program
- Discharge Monitoring Report (DMR) data uploaded from the State quarterly
- Energy data can be added manually or uploaded automatically from some utility providers
- Scores for facilities >0.6 MGD are provided from Portfolio Manager
- Performance indicators for facilities <0.6 MGD are calculated from Portfolio Manager standards

Upon full implementation and site utilization, the State B3 benchmarking for wastewater treatment will allow facilities to track implementation and resulting energy use impact. Site energy performance will be recorded and visualized in the software reporting package for easy retrieval and comparison with site goals. B3 data tracking offers sites a way to track energy use performance over time and provide feedback to sites engaged in continuous improvement programs. Data tracking will also allow stakeholders, such as energy utilities, funding partners and technical assistance providers, to tailor program outreach activities for facilities that need the most assistance.

Task 3: Conduct Energy Efficiency Assessments

Conduct energy efficiency opportunity assessments at sites with sufficient energy efficiency opportunity potential and that are positioned to implement resulting opportunities. Provide site specific report summary of energy efficiency recommendations.

Subtask 3.0 – Assessment Site Selection
Subtask 3.1 – Prepare for Site Visit
Subtask 3.2 – Conduct Site Assessment
Subtask 3.3 – Assessment Results
Subtask 3.4 – Follow up with site on report

A number of mechanisms for identifying plant assessment sites were used: an email broadcast produced one assessment; a mailing produced one assessment and two unsuccessful leads; a third party (partner) referral produced one assessment and one unsuccessful lead; and benchmarking produced eight assessments and three unsuccessful leads, making benchmarking the most productive strategy for engaging projects. In addition to greater contact quantity, the benchmarking efforts provided broader information about the energy performance of the sector.

Once benchmarking of wastewater plants was complete, analysis of the results showed a range of energy performance. Facilities that had low benchmark indicators were generally interested in technical assistance to identify options to improve performance. Table 2 provides an overview of actions and recommendations made to facilities based on their benchmark scores. Facilities with lowest scores were contacted first and offered site assessments. This was to test if low scoring facilities had significant accessible energy efficiency opportunity as well as to provide improvement opportunities for the lowest performing plants.

Table 2 - Energy Benchmark Indicator Recommendation Plan

Relative Performance	Project Action

Lowest quartile	Energy assessment whole facility recommended
	Implementation plan developed
	    Operational changes for high energy uses
	    Outlined list of next steps available
	Follow up for technical support

Third quartile	Energy assessment whole facility often recommended
	Implementation plan developed
	    Operational changes for high energy uses
	    Capital change opportunities discussed
	Follow up for technical support

Second quartile	Energy assessment targeted operations on request Implementation plan for continuous improvement Discussion about advanced technology screening Possible request for best practices case study
Top quartile	Possible site visit for unique operations Review of continuous improvement plan Discussion about advanced technology screening Request for best practices case study

The assessment visits were scheduled as soon after site identification as possible to maintain interest and site momentum. A detailed site assessment procedure has been developed which includes data sheets and checklists which is included as Appendix A. Figure 4 provides a brief overview of the site visit process steps.

In preparation for an assessment, staff reviewed Discharge Monitoring Reports (DMRs) from the MPCA which reduced data requests needed from the plants. Assessments started with a meeting to clarify the plant's motivations, understand the flow and general operation, and identify areas plant staff thought were opportunities. Assessment staff toured the plant focusing on aeration processes and other priority areas identified by the plant– taking photos and notes for future reference. Staff constructed energy footprints for aeration and priority processes. Staff identified likely opportunities by looking for departures from generally optimal performance, such as: high Dissolved Oxygen (DO) levels; equipment running at steady output while loads varied; footprint slices that seemed unusually large; and historically data suggesting more efficient operation in the past. In most cases, key opportunities became apparent and were analyzed, most commonly through an aeration model, or blower calculations. In a few cases, where opportunities were suspected but not specifically identified, staff had detailed discussions with operators about how equipment operated, what changes were possible and what impacts might be expected. For more complex, proprietary processes, staff studied operating manuals and spoke with vendor representatives.

Upon completion of the assessment, analysis staff:

- discussed the findings with the plant
- created an implementation plan for opportunities of interest
- identified clear signals that would show whether the change performed as expected.

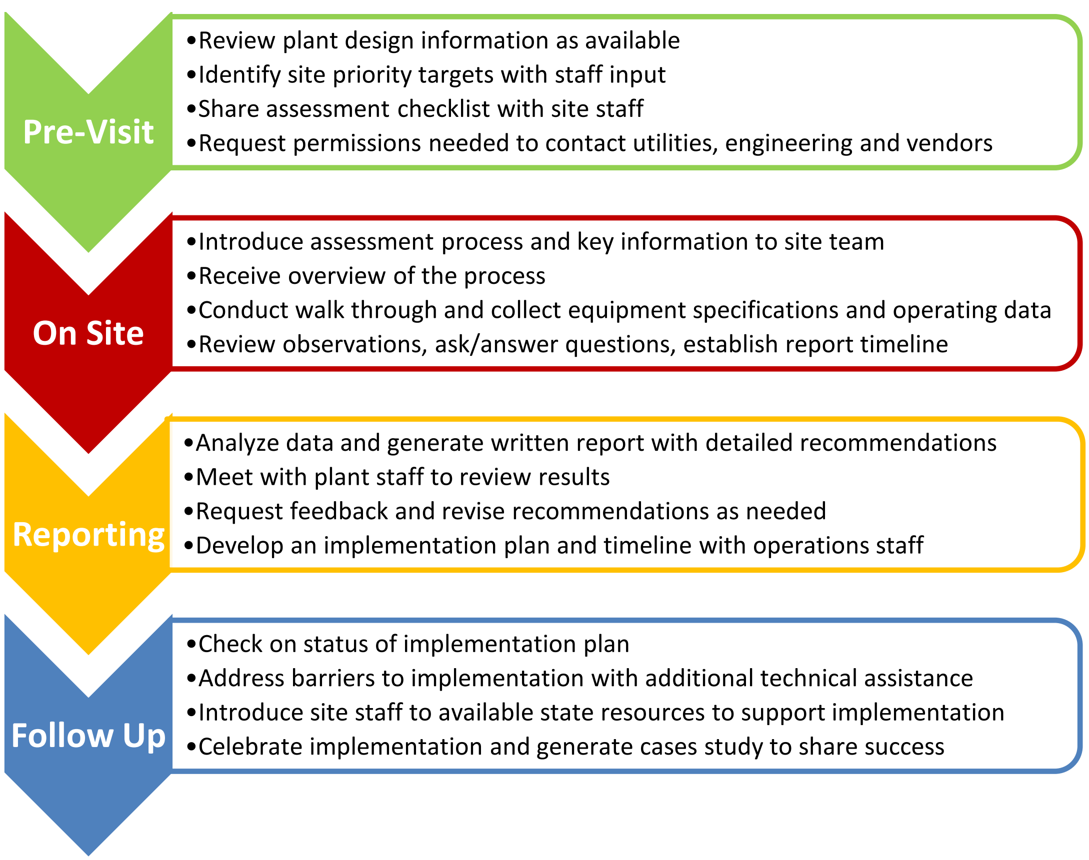
In a few cases, based on the initial discussion, staff further refined proposed changes or investigated a new approach and then had a second discussion and planning session. The last assessment stage was to check back periodically according to the implementation plan to learn what was implemented, what impacts had been seen, what adjustments to original plans might have been made and what further changes were being planned or considered.

Assessment results show energy use in WWTPs depends on fundamental plant design choices. Facilities have been designed to run most efficiently at full capacity and many have limited ability to tune operations for energy efficiency at intermediate flow, which is where most plants operate. The overarching theme addressed in the energy efficiency assessments conducted in this work was improved use of plant capacity. Within this theme there were three important aspects:

- Optimize operation of existing equipment for plant loading
- Add capabilities to better match treatment to load
- Take plant capacity off line

Site assessment activities identified 54 energy efficiency recommendations across eleven wastewater treatment facilities. A summary of the recommendations made, energy savings estimated and resulting potential cost savings on implementation is summarized in Appendix B. Of the recommendations made from the assessments, 38 were operational changes (SCADA adjustments, reducing number basins used, and timed aeration) and 16 are likely to require capital investment (VFDs and blowers).

Figure 4 - Site Assessment Process Summary



Task 4: Facilitate Site Implementation

Identify barriers to implementation of facility energy efficiency recommendations. Connect project implementation decision makers with program partners such as technology vendor, utility and economic development resources to develop strategies to overcome technical and financial barriers to implementation, engage state agency staff to determine options to manage regulatory issues that create barriers to implementation.

Subtask 4.0 – Barriers to Implementation
Subtask 4.1 – Develop Implementation Plan
Subtask 4.2 – Measure and Verify Implemented Savings
Subtask 4.3 – Record Results

The true measure of an energy efficiency program is how effectively it motivates implementation of recommended energy conservation measures and encourages continuous improvement. Follow up with facilities has been a key to measuring success over the course of this work. Connecting with facility managers after the initial assessment activities have been completed and the report and recommendations delivered is a critical piece to ensuring the site staff understand the opportunities presented and are engaged in testing operational strategies to support implementation. These conversations offer the opportunity to support and encourage site efforts toward implementation, revisit concerns site staff may have over suggested activities and provide additional information or resources that may help facilitate implementation or identify additional opportunity. Follow up activities offer an important opportunity to test recommendations, measure the impact of implemented recommendations and verify the electric energy conserved and cost savings achieved.

Table 3 provides a summary of the status of energy savings recommendations for the eleven facilities. At the end of the project period, 79% of the recommended energy savings are implemented or planned to be implemented.

Table 3 - Energy Recommendations and Status

Recommendation Status	Number	Energy Savings (kWh)	% of Total Energy Opportunity	Annual Cost Savings ($)
All	54	5,502,000	100%	$423,000
Implemented	21	2,207,000	40%	$168,000
Planned	8	2,158,000	39%	$163,000
Proposed	14	970,000	17%	$81,000
Not Planned	11	251,000	5%	$20,000

Total energy savings is higher than recommended due to higher than estimated implementation value

Twenty-one recommendations were implemented or partially implemented at the end of the grant period. Some recommendations involve staged improvements with testing required between changes to document performance. Of the implemented recommendations to date, 20 are operational changes and one required capital investment. Assessment protocols intentionally sought operational improvement recommendations to engage facility staff to implement energy savings activities within their control. This was an attempt to empower site staff to take the lead in energy efficiency activities rather than assume a passive role waiting for the capital investment process. The distribution of implemented, planned, proposed (no decision made to implement or not) and not planned recommendations for both operational changes and proposed changes as of the end of the grant period is shown in Table 4.

Table 4 - Frequency of Implementation by Type

	Capital Recommendations	Operational Recommendations
Implemented	1	21
Planned to be implemented	5	3
Proposed no decision	4	10
Not planned	6	4

Some facilities had complex operation changes or unclear implementation pathways identified during site assessments. Supplying additional resource support was used as a tool to maintain progress on opportunity identification, testing and implementation at these sites. Student intern projects, supported in part through grant funds and facility utility providers as part of the MN CIP program, supplied the manpower needed to refine the process improvement suggestions and launch implementation.

On occasion, facility implementation progress stalled due to lack of knowledge on how to best proceed or out of concern for what might happen to facility effluent quality performance. Reconnecting with the project sites allows for added input to the implementation process. This type of facilitation included connecting facility staff with other sites that have experience with similar operations for peer to peer training. Additionally it may be necessary to clarify operational standards with site staff and regulatory inspection staff to develop common understanding among the partners to optimize both wastewater treatment aeration performance and energy efficiency.

In addition to the operational recommendations, there were 15 recommendations that would require capital investment for implementation. Of these only one capital project was completed during the grant period. The implemented investment recommendation was one of the first assessments done in the program illustrating the longer timeframe required to capture implementation of recommendations that require capital investment. Capital projects require resources beyond the facility walls for implementation which can take considerable time in public facilities. Numerous options are available for financing capital energy efficiency projects in Minnesota. These can range from utility rebates to grants to loan programs. Table 5 provides an overview of many of the common financing program options in the state. One of the Green Step Cities webinars presented early in the program was dedicated to project financing options.[9]

Table 5 - Minnesota Implementation and Financing Programs

	Implementation & Financing Programs			**Financing Programs**	
Method	Clean Water Project Priority List (PPL)**	Guaranteed Energy Savings Program	Local Energy Efficiency Program	Energy Saving Partnership	Rev It Up Program
Eligibility (recipient)	Cities, Counties, Sanitary Districts and other Municipals Entities Borrowers Must have authority to issue General Obligation debt	State Agencies, Higher Ed, Local Governmental Units, K-12	Local Governmental Units, K-12 buildings	Local Governmental Units, K-12	Local Governmental Units, Commercial and industrial Businesses, Small Businesses (<50 employees), Health Care Facility's, MHFA
Type	Build, repair and improves wastewater and stormwater collection and treatment systems Low interest loans and either affordability or pollutant based grants	State Assisted Energy Savings Performance Contracting (ESPC) Program with Guaranteed Savings	State Assisted Energy Study using Design-Bid-Build for implementation	Municipal Leasing program-tax-exempt	Revenue Bonds - tax-exempt or taxable (project dependent)
Project Size*	Min. Historical of under $100k (additional requirements may not off set interest saved under $300k) Max. none	Min. $300k Max. none	Typically between $50k and $350k	Min. $50k Max. none	Min. $1M Max. $20M
Term (years)	20 years, up to 30 years for some projects if demonstrated financial hardship. Loan term cannot exceed useful life of project	Up to 25	Up to 15	Up to 15	Up to 25
Interest Rate*	Below market rate, less annual discount approved by the PFA Board. Cities under 2,500 may quality for additional discounts. Rates cannot go below 1%	Dependent upon financing instrument – eligible for lease purchase financing	Dependent upon financing instrument – eligible for lease purchase financing	Dependent upon issuance	Dependent upon Project Security
Administrator	MN Pollution Control Agency, Bill Dunn (MPCA) 651-757-2324Public Facilities Authority, Becky Sable (PFA) 651-259-747	MN Department of Commerce Peter Berger 651-539-1850	MN Department of Commerce Peter Berger 651-539-1850	St. Paul Port Authority Peter Klein 651-204-6211	MN Department of Commerce Peter Berger 651-539-1850

Site Implementation Summary

On-site technical energy efficiency assessments identified a total of 5.5 million kWh annual energy savings opportunity with an estimated value of $423,000. This is an average energy savings of 500,000 kWh per year per facility with an actual range from 69,000 to 1.2 million kWh/year across the eleven assessed sites. Approximately 70% of the recommended energy efficiency opportunities identified in this work could be achieved through operational changes requiring no or low capital investment. Approximately 40% of the 5.5 million kWh of recommended energy savings has been implemented to date with an additional 39% planned. A summary of project objectives and outcomes has been outlined in Table 6 below. A summary of the status of recommendations is shown in Figure 5. A summary of facility level recommendation status is shown in Figure 6.

Table 6 - Project Objectives and Outcomes

Project Objective	Project Target	Project Outcome
Engage MN WWTP in E2 and DG	-	26 presentations/events
Attendees at events	-	1139 attendees
Operators Trained in E2	50	108
E2 Assessments	10	11
Identified annual energy efficiency	2-5 million kWh	5.5 million kWh
Implemented annual energy efficiency	-	2.2 million kWh
Planned implementation	-	2.1 million kWh
Case studies generated	-	6
Discussions on E2 planning	10	11
MnTAP Intern Projects	2-3	2
CHP Screening Analysis	5	5 launched, 4 completed
CHP Assessment	1-2	1 under consideration

Figure 5 - Program Energy Recommendation Status

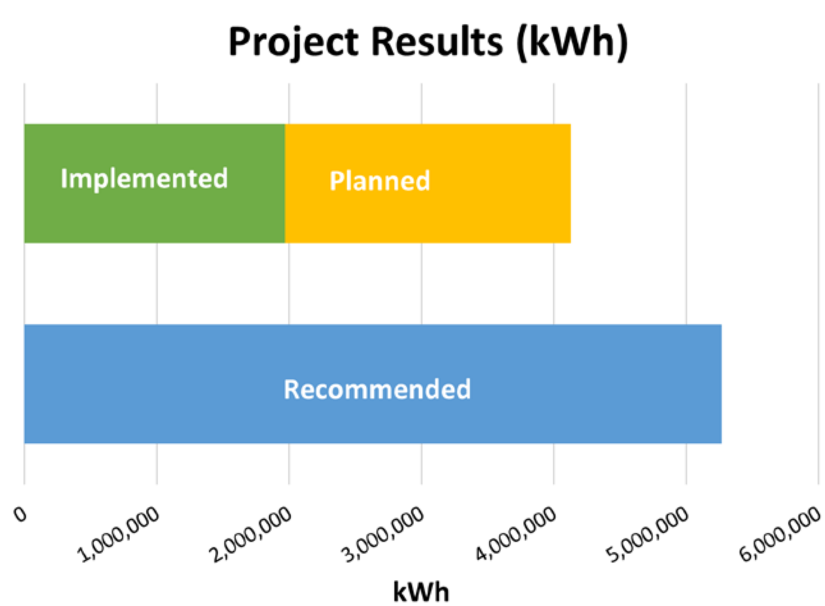
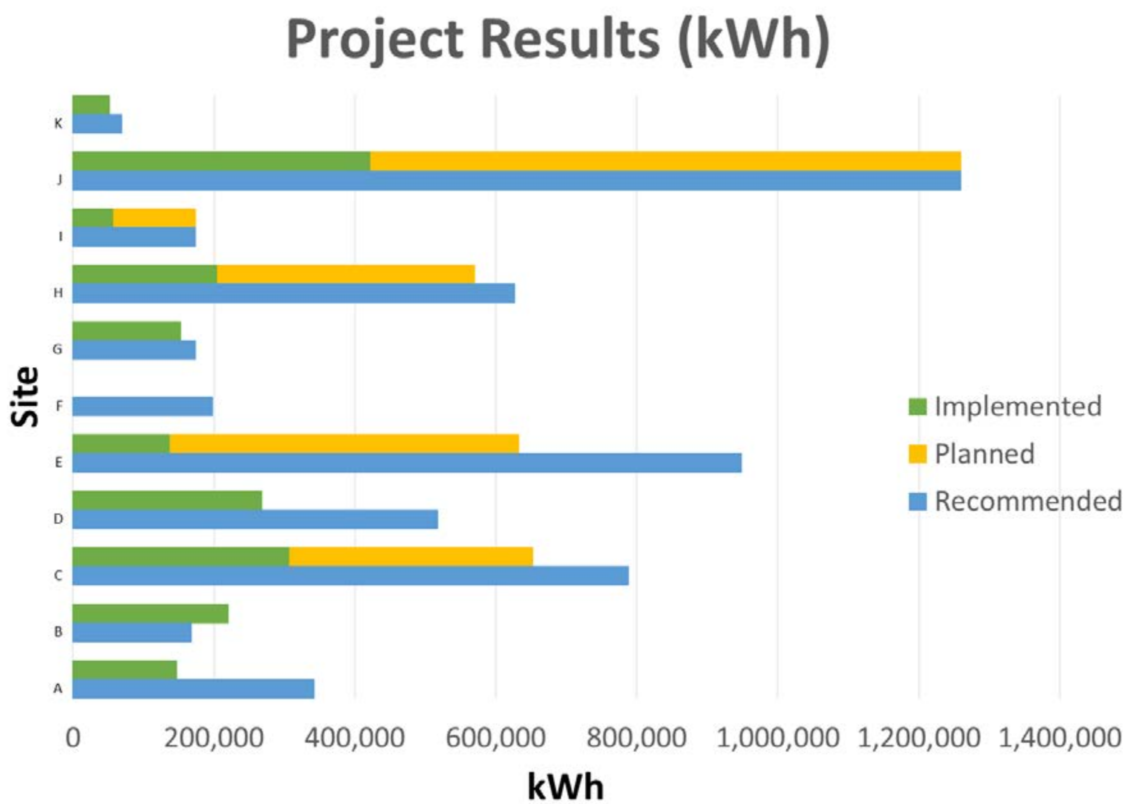


Figure 6- Facility Level Energy Efficiency Recommendations and Implementation



An additional opportunity that came from building these relationships with facilities was the ability to promote sites' energy stories through case study development. As facilities pursued implementation of the recommended energy measures, there was an increasing investment in the process and awareness of energy use opportunity. Celebrating the site by promoting their participation in the program and the efficiency activities that were identified and implemented was a good opportunity to positively reinforce their work and encourage continued improvement. Additionally, creating case studies can served to generate teaching materials used to engage other facilities, government leaders and utilities as they seek to improve energy performance and operating costs.

In addition to direct energy savings, six case studies were produced providing public facing summaries of energy efficiency measures recommended to various facilities and best practices at high performing facilities. These case studies can be used as tools for outreach and education to additional facilities that would like to capture energy efficiency beyond the grant period. Appendix C compiles the case studies developed throughout this project.

Task 5: Identify Renewable Energy Opportunities

The goal of this task is to identify and advance opportunities for renewable energy generation at wastewater facilities. Such opportunities may be available at facilities that manage high load effluent streams or that have clients that generate such streams.

Subtask 5.0 – Identify Sites with Renewable Fuel Generation Opportunity
Subtask 5.1 – Distributed Generation Opportunity Assessment
Subtask 5.2 – Distributed Generation Opportunity Report
Subtask 5.3 **–** Develop Distributed Generation Implementation Plan

This project also served to connect WWTPs with information and site scoping for CHP opportunities. Wastewater plants that practice anaerobic digestion may be good candidates, as the process is in place to break these wastes down into methane that can be used as fuel. An additional attribute of strong candidates for CHP are those wastewater facilities with moderate to high BOD loading or with access to compatible high-load industrial waste.

This part of the project was conducted in collaboration with the Combined Heat and Power Technical Assistance Partnership (CHP TAP) based out of the University of Illinois, Chicago. This organization provides no-cost first level CHP screening assessments throughout the Midwest. The assessments served to give sites a first-look at the cost-benefit analysis associated with using the gases generated in anaerobic digestion processes for electric energy generation and heat for their plants, reducing their need for externally generated electricity and natural gas from the grid.

MnTAP conducted site screening evaluations based on suggestions provided by CHP TAP[20] including facility attributes such as having anaerobic digestion operations and a flow of >5 MGD. There were few facilities in Minnesota that met those criteria. To increase the number of facilities for consideration, MnTAP staff chose to look at potential sites with lower flow but with high organic load. The level of organic material treated is the source for biogas generation. The thinking behind this was that higher load facilities may be able to produce more gas for lower volume treated. State discharge monitoring report (DMR) data were analyzed and MN sites practicing anaerobic digestion with >1 MGD flow and high BOD load were identified. Twenty-five facilities were approached for CHP screening, having BOD loadings between 2500 and 25,000 lb/day. Of these, five facilities were engaged in the screening assessments.

Of the five sites engaged in the screening evaluation, four completed the feasibility assessment by providing operations data that were analyzed by the Chicago CHP TAP. The feasibility assessments showed investment payback periods for site CHP investments ranged from four years to ten years. This return on investment period, while likely too long for most private investment, is within the range of many wastewater facility investment projects. A report summarizing the results of the CHP evaluations and Level 1 assessments is included in Appendix D. It was encouraging to see that a reasonable investment opportunity appears to be available even to smaller facilities, which comprise most of the Minnesota wastewater infrastructure. Of the four facilities completing the feasibility assessment, one site may be interested in proceeding to an investment grade analysis to further refine the site CHP opportunity.

[20] http://www.midwestchptap.org/support/documents/CHP_TAP_Technical_Assistance_Offerings.pdf

While renewable energy generation at wastewater facilities has been practiced at a few sites throughout the state for many years, it is still relatively rare. A local example of CHP implementation in wastewater treatment is seen in southern Minnesota.[21] Albert Lea, Minnesota has a population of approximately 18,000 based on the 2011 census. The Albert Lea Wastewater Treatment Plant operates a 120kW microturbine CHP system that was highlighted in the 2011 U.S. EPA CHP Partnership report.[22] This system saves the plant approximately $100,000 annually with 70% of the savings coming from reduced fuel purchases and the remaining 30% from reduced maintenance costs. The Albert Lea CHP system project was a joint development with the State of Minnesota and the local utility covering approximately two-thirds of initial installation and maintenance costs.[23] The local utility managed operation of the CHP for five years before turning it over to the wastewater operations group. This was considered a key to help the facility learn how to operate the system before taking full responsibility for managing the unit. Clearly significant investment and support was needed for this implementation.

Most wastewater operations managers and staff as well as support services such as engineering firms and utility providers do not have extensive knowledge about the opportunity appropriately applied implementation of renewable energy generation technologies can bring to a site or region. This general lack of familiarity can present barriers to consideration of technologies such as CHP that may manifest as inability to invest time to explore the opportunity potential, lack of support from service providers and lack of willingness to explore the technology and cost implications. This project provided an important introduction to CHP to Minnesota wastewater facilities and provided data that can be utilized to educate industry stakeholders and promote the potential for renewable energy generation in this sector.

Task 6: Action Plan/Implementation Model

The objective of the sixth task is to develop an Action Plan/Implementation Model that would present a detailed step-by-step process that other wastewater treatment facilities can follow to identify and implement onsite energy efficiency and renewable energy opportunities.

Subtask 6.0 – Manage Action Plan
Subtask 6.1 – Draft Plan
Subtask 6.2 – Prepare Final Action Plan
Subtask 6.3 – Present Final Action Plan
Subtask 6.4 - Final report

Two summary documents have been prepared based on the work accomplished in this project. An Action Plan was developed to provide a high level overview of the opportunity potential for energy efficiency activities and distributed energy generation in municipal wastewater treatment facilities and outline key steps to develop a successful program. The action plan developed from this project is included in this report as Appendix E. The second document is this report itself. This compilation of activities, resources, results and key learning can be used to replicate the successful outcomes realized

[21] http://www.midwestchptap.org/profiles/ProjectProfiles/AlbertLea.pdf

[22] U.S. EPA CHP Partnership, Opportunities for Combined Heat and Power at Wastewater Treatment Facilities, October 2011, http://www.epa.gov/chp/documents/wwtf_opportunities.pdf

[23] Energy Efficiency in Water and Wastewater Facilities, U.S. EPA, 2013 and references therein, http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf

in the Minnesota effort. The report and associated Appendix materials summarize engagement activities, assessment procedures and tools, recommendations and opportunity potential for combined heat and power implementation.

Task 7: Dissemination of Results

The objective of the seventh phase is to promote the resources that were developed under this project to key stakeholders. To foster change, it is critically important for wastewater treatment facilities to have clear, actionable items (i.e. strategies and best practices) as a result of the previous six phases of this project.

Subtask 7.0 – Present Results to MN WWTP Operations Staff
Subtask 7.1 – Present Results to Other MN Stakeholders
Subtask 7.1 – Implementation Model

Wastewater treatment purpose and function are quite similar where ever it is practiced. While facilities all may have unique implementation of the basic stages of the treatment process, many commonalities exist. The process for assisting municipal wastewater treatment facilities across the state put forward in this proposal has strong replication potential across Minnesota and in other regions of the United States as well as in the private wastewater treatment sector. In addition, methodologies could easily be adopted by utility efficiency programs, private consultants, and equipment vendors to speed replication and adoption.

Immediate dissemination of results will be accomplished through two invited presentation activities. MnTAP will be convening a panel discussion on wastewater treatment energy efficiency activities at the 34th Annual Minnesota Rural Water Association Water and Wastewater Technical conference on March 7, 2018 in St. Cloud MN. The focus of this panel will be for wastewater operations staff who have participated in energy efficiency assessments conducted in this work to tell their energy stories to their peers. A second invitation has been received to present the results of this work at the 81st Annual Wastewater Operations Conference scheduled for March 21-23, 2018. Details for this presentation are in progress.

Future Effort - Cohort Training Model

While technology for WWTP operations is well established, facilities are highly customized to meet individual community needs and deliver effluent water discharge meeting permit requirements. Due to this customization, general solutions for energy efficiency are limited in equipping site operations staff to implement significant energy conservation projects. Site specific technical assistance model described in this document has been effective in identifying significant WWTP energy efficiency opportunity and motivating implementation in facilities across Minnesota. However, given the large number of facilities across the state and country, site based technical assistance will require significant resource investment to capture the full energy potential within this sector and may not equip site operations staff with the tools needed for continuous improvement.

Future efforts seek to deliver a cohort based energy efficiency program at a scale and level appropriate for small to medium sized WWTPs within Minnesota. A regional energy efficiency cohort model can make use of the strong culture of education and knowledge sharing within the operations community to magnify the impact of site based technical assistance resources. A cohort energy efficiency model is expected to increase peer learning, motivate group participation for the identification and implementation of energy efficiency measures and reduce program transaction costs over individual site assistance efforts. MnTAP was awarded a Conservation Applied Research and Development (CARD) grant from DER to develop curriculum and delivery models for a small to mid-size wastewater treatment facility cohort training program. This program, scheduled to start in January 2018 and run for 18 months, will seek to apply the information gained from site based technical assistance at small to mid-size wastewater facilities and transform it into a cohort energy efficiency training model that would help overcome many of the remaining engagement, assistance, and support barriers to energy efficiency outlined in the Background Section.

Municipal wastewater treatment is an ideal sector to demonstrate the value of a cohort model for energy efficiency. There are few issues with proprietary operations. Workforce licensing in this sector fosters a culture of continuing education. There are strong regional and state networks that enable and encourage peer interactions, technical training and collaboration. Similar approaches have been used on a national level by DOE focused on very large facilities to improve energy performance of critical infrastructure across the United States through programs such as, Superior Energy Performance Water and Wastewater Pilot Project and Sustainable Wastewater Infrastructure of the Future Accelerator. This program would seek to understand best practices identified in this effort and use similar methods at smaller treatment facilities where appropriate.

Once the curriculum is developed a second phase will be to utilize the developed training tools in a technical demonstration of a regional WWTP cohort assessment model to achieve energy efficiency. When a pilot cohort training is conducted, the process will be documented to facilitate replication as a utility program. Recommended and implemented energy efficiency measures will be assessed in order to estimate opportunity potential upon program replication. Benefits of the program will result from the site based energy efficiency opportunities identified by cohort participants. A cost/benefit analysis of this cohort model is critical to justify the approach as a cost effective energy efficiency program. In addition the time, operational and capital commitments from the cohort members will be documented to better assess the site investment required to achieve outcomes within a cohort framework. An additional outcome of this effort will be the implemented energy reduction achieved by the cohort member facilities.

Conclusions

The Minnesota partnership associated with this grant was successful in meeting all the objectives established early on. Results indicate significant energy efficiency opportunity available in this sector. This energy saving opportunity is generally untapped by most energy efficiency programs and is typically unknown by facility operations staff. Several key findings include:

1) Increasing awareness of energy use and relative energy performance compared with peer sites by wastewater facility operations staff resulted in a high level of motivation to improve operations and get energy use in control.
2) Benchmarking is an effective way to measure site performance and present those results to facility decision makers for action. An accessible energy benchmarking tool such as Minnesota B3 will be valuable in engaging more facilities of all sizes with their relative energy use.
3) The greatest opportunity for improved wastewater plant energy efficiency is better use of plant capacity to match current load. This can include: optimizing the operation of existing equipment; adding capabilities to better match treatment to load such as smaller equipment or VFDs; and take plant capacity off line such as removing an aeration basin, digester or pond aerator from service.
4) Motivating energy efficiency actions at wastewater facilities requires supporting short term operational changes that can be made by facility staff engaged with the process through benchmarking and site assessment activities. Enabling quick energy efficiency gains help build commitment to implementation of identified savings and future continuous improvement.
5) Introducing the concept of CHP to moderate size facilities is an important first step in expanding this technology broadly in the wastewater sector. Much of current investment has been focused on large facilities. This work has demonstrated economically feasible opportunity potential for combined heat and power at moderate size facilities, practicing anaerobic digestion with access to high strength wastewater.

Appendix A

Assessment Process Outline

Challenge: How is this type of project started? How do researchers lay a strong foundation for a successful project?

1. Spread awareness and engage stakeholders.
    a. Engage electric utilities.
        i. Reach out to electric utilities to explain the goals of the project, how it will benefit them, and how they can help to support the project.
            1. Utilities will benefit from a WWTP outreach and assistance program because they have a strong stake in the identification and implementation of energy efficiency measures through conservation improvement programs (CIP).
            2. Utility partners can help support the project by:
                a. providing electric energy consumption information required for benchmarking
                b. sharing information on rebates and incentives with clients
                c. promoting implementation of efficiency projects.
    b. Engage wastewater associations, like the Minnesota Wastewater Operators Association (MWOA), and the Minnesota Rural Water Association (MRWA).
        i. Engage stakeholders, explaining the goals of the project, how it will benefit them, and how they can support the project.
            1. Members in these groups stand to gain through individual energy efficiency assessments. These assessments help operators and plants to save energy and money for the city, which reflects well on them and on the plant.
            2. These associations can support the project by:
                a. broadly sharing project information
                b. identifying sites with strong potential for energy savings opportunity
                c. broadly sharing project results to promote widespread implementation.
        ii. Present results and case studies at conferences and at both state-wide and chapter meetings to promote energy efficiency.
        iii. Provide continuing education opportunities with energy efficiency trainings
        iv. Solicit interest in participating in an assessment or intern project
    c. Engage City Managers
        i. Engage city administrators, explaining the goals of the project, how it will benefit them, and how they can help to support the project.
            1. City contacts serve to gain directly through energy and cost savings associated with implementing opportunities identified in the assessments or from ideas generated from other assessments.
            2. City contacts can support the project by building support for assessments, managing local government relationships, and promoting city support for energy efficiency implementation that requires funding, especially in cities where WWTP personnel may not have this authority or expertise.

ii. Ensure city managers are copied on assessment findings as their buy-in is typically required to promote plant upgrades that require financial investment.

d. Engage Regulators

i. Engage the state regulating authority, explaining the project, its benefits for the state, and how they can help to support the project.

1. The project will benefit the state by reducing the state's overall energy generation and consumption, helping to make individual cities more efficient. Less energy consumption directly correlates to fewer CO_2 emissions. The project will also help bring city wastewater plants closer to net-zero-energy status.
2. State regulating authorities can assist the project by sharing up-to-date, publicly available, state-wide discharge monitoring report (DMR) data that will facilitate the benchmarking and assessment processes.
3. Regulators may also provide insight into facility positions on revolving fund lists which may help to prioritize assessments to allow efficiency opportunities to be identified ahead of major plant reconstruction efforts.
4. Regulators may also help to identify grant and loan programs available as financing options available for identified energy efficiency investments.

Challenge: How do researchers identify sites with a high likelihood for impactful savings opportunity?

2. Complete benchmarking; sites with lower scores typically have higher potential for savings.

a. Benchmarking requires two sources of information:

i. publicly available discharge monitoring report (DMR) data.

1. This information should be obtainable from the local state regulatory agency.

ii. wastewater treatment plant site energy consumption data.

1. Each electric utility should have records for each of the treatment plants in their service areas.

Challenge: Typically these records are confidential between the utility and their client.

a. An engaged utility partner that understands the value of this project may be willing to reach out to their wastewater clients for permission to share this information for the purposes of benchmarking.

b. Researchers can create a customized benchmark calculator for engaged utility sites that utility contacts can fill in with energy data to get the benchmark scores for themselves. [Appendix A] The utility can then reach out to specific, low scoring sites and connect them with the researcher's assessment project.

2. If electric utility engagement is unsuccessful, researchers can reach out to wastewater plants individually to collect electric utility information on a site-by-site basis to perform benchmarking.

b. Three basic types of benchmarking can be completed:

i. Hydraulic Flow Benchmarking (kWh/MG)

1. This is measured in kilowatt hours per million gallons (kwh/MG).

a. Hydraulic Flow Benchmarking is a metric that accounts for the amount of fluid processed, but disregards the level of contaminants that require treatment in the wastewater.

ii. Strength Benchmarking (kgBOD/MG)

1. This is measured in kilograms of biological oxygen demand (BOD) per million gallons flow (kgBOD/MG)

   a. This is a basic metric that accounts for the amount of contaminants processed, but disregards the amount of flow through the plant.

iii. Energy Star Portfolio Manager Benchmarking (ESPM)

1. Energy Star Portfolio Manager Benchmarking accounts for flow, some contaminants, temperature, and some other plant features to provide a percentile rank (1-100) score for treatment plants.

   a. Energy Star does not consider this score valid for plants with hydraulic flow less than .6 million gallons per day (MGD).

   b. For smaller sites, hydraulic flow and strength benchmarking should be given more weight when considering site efficiency, but an unofficial ESPM score can still be generated and will also provide a sense for how these smaller plants compare to the larger plants assessed in the ESPM study.

c. How to complete benchmarking:

   i. A complete guide to calculating an Energy Start Portfolio Manager (ESPM) scores for wastewater treatment plants is available from the department of energy.[24]

   ii. Additionally, sites can be encouraged to use B3 Benchmarking for Wastewater Treatment Facilities, a resource that will perform benchmark calculations for the site[25]. That database can be used to identify sites for assessment.

d. As utilities are engaged and share energy data, benchmark all of the WWTFs their service area to prioritize conservation efforts. Plants with lower scores are more likely to have large energy savings opportunities. Benchmarking:

   i. provides an opportunity to discuss the program and engage utilities. (MnTAP worked with Xcel, MN Power, Ottertail Power and SMMPA.)

   ii. provides an efficient mechanism for gathering energy data; a utility has access to data for all wastewater plants in their territory.

   iii. creates options for obtaining either raw energy data or benchmark scores. MnTAP generated a tool for utilities to enter energy data and generate the benchmark score, avoiding need for client release of utility data. The utility was then able to recommend low-scoring plants for assessment. An example of this tool can be found in Appendix A.

      1. gives researchers an opportunity to request access to prior utility funded conservation studies on WWTFs; most of these focused less on process and more on lighting and building energy use.

      2. helps to support funding for efficiency projects or intern assessments.

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[24] How to calculate an Energy Star Portfolio Manager (ESPM) score for wastewater treatment plants: https://www.energystar.gov/sites/default/files/buildings/tools/ENERGY%20STAR%20Score%20for%20Wastewater%20Treatment%20Plants.pdf

[25] B3 Benchmarking Webpage: http://mn.b3benchmarking.com/WastewaterTreatmentPlants

Challenge: How do researchers schedule sites for assessment?

3. Engage individual sites; schedule and prepare for the assessment.
    a. Site selection is completed by first reviewing available data on target sites.
        i. Prioritize wastewater plants with poor benchmark scores that are likely to have significant savings opportunities.
        ii. Assess information in Environmental Assessment Worksheets (EAW) and Environmental Impact Statements (EIS) typically required for major plant reconstruction and expansion; the reports can offer insight into current plant equipment and operations.
        iii. If possible, leverage utility, association, or city contacts to make the introduction to the project team.
        iv. Call the plant manager to explain the project, their benchmark score, and the opportunity in order to gauge his/her interest in an assessment. If the site contact seems interested, schedule an assessment and talk through the basic operations of the plant to get a sense for which areas will be significant to focus on.
            1. Confirm accuracy of information used in benchmarking.
            2. Identify priority process equipment and key assessment opportunities
                a. What is the Dissolved Oxygen (DO) level in the secondary aeration basins?
                b. How does the plant control DO? (examples include automated DO controls, manual VFD adjustment, or none)
                c. Does the plant have VFDs for blowers and pumps?
                d. Are dampers and throttling valves being used to control flow?
                e. Is there anything the plant manager sees as being a significant opportunity that he/she would specifically like information on?
        v. Email the plant manager a site assessment checklist of information the team will be planning to collect during the site visit. This gives the site contact some time to gather any data that might not otherwise be readily available. An example checklist is in Appendix B, although individual site checklists are variable and based upon plant operation and the initial discussion with the plant manager.

Challenge: How do researchers complete the site assessment process? How are opportunities identified?

4. Complete the site assessment.
    a. Meet with site contact at the wastewater treatment plant at the designated time.
    b. Ask site contact to verbally describe the processing processes used to treat wastewater and sludge from influent to effluent. The goal is for the researcher to ensure he/she has a basic understanding of how the plant is operating and to gain as much basic information as possible.
    c. After collecting basic overview information, complete a walkthrough with the plant manager as an opportunity to physically look for potential cost savings opportunities, and in order to take photos of blower, motor, and other relevant equipment nameplates.
        i. Typical information to be collected is included in the **Site Assessment Checklist in Appendix A**.
    d. Obtain additional information from third parties, if required.

i. With plant approval, utilities will be able to release electric bill records if the plant staff did not have records of their own.
   1. The design engineer is sometimes a useful resource if site contacts don't have answers to why things are running a certain way, or if manuals are missing.
   2. Equipment vendors sometimes need to be contacted to provide information on specific equipment, such as curves needed for analysis.
   3. Equipment vendors are also sometimes contacted for information on specialized equipment and operations, such as biological aerated filters (BAFs) or Membrane Bioreactors (MBRs). This is required for rare treatment systems where other sources of information are not readily available.

Challenge: How do researchers complete the site analysis process? How are opportunities identified?

5. Complete the analysis.
   a. Create a selective process energy footprint
      i. Use the information gathered during the site assessment to calculate the estimated energy consumption for the secondary aeration blowers, digester blowers, pumps, and any other relevant items
         1. For blowers, calculate or estimate blower cfm, blower efficiency, motor power, motor efficiency, vfd efficiency, and overall energy consumption.
         2. For pumps, calculate current operating point, efficiencies, and overall energy consumption
      ii. Compare the calculated values to the actual utility bills to ensure that the values seem reasonable.
         1. For most plants, secondary aeration uses the most energy, followed by digester aeration.
      iii. The footprint is used to frame the importance of secondary aeration and digester aeration, as it is not uncommon for over 50% of a plants energy consumption to be due to aeration.
   b. Energy efficiency for secondary aeration systems
      i. Steven Bolles developed an aeration model that can be used to estimate the aeration requirements for a plant based on its current system set points. Its use is explained in "Modeling Wastewater Aeration Systems to Discover Energy Savings Opportunities" linked below[26]. [LINK]
         1. The aeration model uses information on flow, BOD, TKN (Total Kjeldahl Nitrogen), secondary aeration basin DO, and aeration blower airflow along with temperature data to estimate the Standard Oxygen Transfer Efficiency (SOTE) of the system.
            a. Temperature data can be easily found using one of many weather databases. One such example is weather underground.[27]

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[26]"Modeling Wastewater Aeration Systems to Discover Energy Savings Opportunities" by Steven Bolles: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.539.9955&rep=rep1&type=pdf

[27]Weather Underground Resource for Weather Data: https://www.wunderground.com/

2. This SOTE can then be used as a known value, and the required airflow can be modeled as a function of system DO.
3. By setting the desired plant DO between .5 and 2 ppm in the model, (optimal DO range from literature), the plant's required airflow can be calculated.
4. Researchers can then use this airflow estimate to estimate the energy and cost savings associated with:
    a. implementing blower VFD control.
    b. adjusting blower VFD setpoints
    c. installing a smaller blower
    d. allowing the blower to cycle on and off.
5. Compare the cost, benefit, and energy savings of these options to help quantify and justify the best option for the plant.

c. Energy efficiency for aerated digestion systems
    i. The Ten State Standards contains recommended airflow for aerated sludge digestion[28].
        1. 30 CFM / 1000 ft^3 recommended
    ii. Compare plant airflow per 1000 ft^3 of sludge to the Ten State Standards.
    iii. Typically there is an opportunity to adjust VFD speed based on the depth of sludge within the digesters.
    iv. Calculate energy and cost savings associated with reducing airflow to match 10 State Standard recommendations by either reducing VFD speeds, taking digesters offline, or using time cycling to reduce digester energy use.
    v. Researchers should also consider whether shorter detention times or using fewer cells can reduce aeration requirements.
    vi. Compare the cost, benefit, and energy savings of these options to help quantify and justify the best option for the plant.

d. Pump optimization
    i. Is there opportunity to increase pump station water level to reduce pressure on the pump?
        1. Can calculate savings using pump curves.
    ii. Model pump operation scheme and recommend optimal operating ranges
    iii. Review pump curves and operating points – optimize for design

e. Energy efficiency for other systems
    i. In general, for other systems, the researcher must determine how much and how fast equipment should be required to run and compare that to current operating points.
    ii. Identify old equipment that can be replaced with more efficient options or set to run with more efficient operating strategies.
        1. Motors
        2. Compressors
        3. Lighting
        4. UV disinfection
    iii. The equipment that will be worth assessing will vary from plant to plant. The researcher will need to use discretion to determine which of these smaller areas are worth putting effort into on a plant-by-plant basis.

[28] 10 State Standards Resource: http://10statesstandards.com/wastewaterstandards.pdf

Challenge: How do researchers transfer the information developed during the analysis process to site contacts with supporting information to promote implementation?

6. Share Findings with site contacts, promote implementation, and schedule follow up.
    a. Share savings opportunities with primary plant contact via written report.
        i. Plant Benchmarks, Annual Energy Use, Annual Energy Cost
        ii. Opportunity A ($, kWh)
        iii. Opportunity B ($, kWh)
        iv. Opportunity C ($, kWh)
        v. Conclusion with overall savings table
    b. Schedule a meeting (in person or online web conference) to discuss the opportunities in the letter. Share a slideshow presentation highlighting the main points from the report.
        i. Solicit feedback on the recommendations and any perceived barriers
        ii. Revise recommendations with additional information (if required)
        iii. Ask the plant contacts which recommendations they will plan to move forward with, and schedule a date within the next one or two months to follow up on whether implementation has been successful. (ask your contacts to develop an implementation plan)
            1. Identify target outcomes
            2. Suggest means to test (internal staff, interns, consultants)
            3. Set timeline for testing, implementation, and follow-up
        iv. Ask plant for approval to share report with stakeholders, and for approval to make a case study showcasing the project.

Challenge: How do researchers track savings opportunities?

7. Record results
    a. Use a spreadsheet to track sites, opportunities, energy and cost savings recommendations, implementation, and status. An example 'Summary of Recommendations' spreadsheet can be found in Appendix B.

Challenge: How do researchers improve implementation rates?

8. Follow-up, connect contacts to stakeholders, and help to resolve additional barriers to implementation.
    a. Follow up on the scheduled date to learn whether testing and implementation has been successful. Once again, ask the plant contacts which items they will be focusing on next, and for a reasonable follow up date.
        i. Refer to the reported list of recommendations
        ii. Identify changes made at the facility
            1. Determine what, where, and how changes occurred.
            2. Determine what impacts were seen regarding:
                a. treatment performance.
                b. energy performance.
                c. equipment performance & reliability.
        iii. Identify any additional difficulties that were seen and how they were resolved.

iv. Confirm or quantify the energy conservation achieved through:
    1. equipment measurements.
    2. plant bill changes.
    3. estimation from report recommendations.
v. Are there barriers to implementation that the researcher can help to overcome at this point?
    1. Additional Technical Assistance
        a. Equipment vendors
        b. Engineering firms
        c. MnTAP resources, publications, or other experts
    2. Additional Financial Assistance
        a. Utility programs and rebates
        b. ESCO financing opportunities
        c. State grants or revolving loan funding

Challenge: How do researchers promote energy efficiency findings and opportunities more broadly?

9. Share Outcomes
    a. Draft case studies[29] on process approach and recommendations, highlighting:
        i. implemented outcome.
        ii. barriers to implementation
        iii. key learning points.
    b. Share outcomes with:
        i. key project stakeholders
        ii. MnTAP website and newsletters
        iii. association publications
        iv. conference and meeting presentations.

[29] An example Case Study is in Appendix C.

Site Assessment Checklist

Pre-Assessment Data Questionnaire

WWTP Name:

Availability of:

Plant schematic / flow diagram

Plant age

Motor list (>10hp) hp; FLA; nameplate V; rpm; hz; eff; age; size margin?

Pump list - brand; model; impeller if modified, performance curves, rpm @ 60hz

Blower list - brand, model, turndown (possible, method), performance curves, rpm @ 60hz

Diffusers - brand, model, flux rate, number, minimum air flow

Large equipment from survey:	amps	kw	pressure	flow	log	elect	Tot hours	interval	how far back?
Blowers									
Pumps									
Plant flow				flow	log	elect	Tot hours	interval	how far back?
digester									
Mixer									
Gas production									
Gas flare									

DO reading	daily	continuous	interval	log	elect	historical length
Aeration						
Effluent						
Sludge						
other						

Data for other significant uses.

<u>Energy Star inputs</u>

DMR data:

- 12 month Average Influent Biological Demand (mg/l)
- 12 month Average Influent TKN (mg/l)
- 12 month Average Effluent Biological Demand (mg/l)
- 12 month Average Effluent TKN (mg/l)
- Average Influent Flow (MGD)
- Plant Design Flow rate (millions gallons per day)

Fixed Film Trickle Process Y/N

Nutrient Removal Y/N

Whole plant Energy (Electric & Gas):

Energy Meter ID

Energy Type

Energy Unit - kwh or mbtu

Energy Start Date

Energy End Date

Energy Consumption

Energy Cost

Annual Heating Degree Days

Annual Cooling Degree Days

Wastewater Equipment Data Sheet

Please fill in data for larger, continuously run motors and electrical end uses (>5 - 10hp; operate >20hour/day). The applications listed are intended as a guide to what large electrical uses might be present; please adjust as appropriate for your facility. Contact Karl DeWahl (dewah001@umn.edu or 612.624.4645) with questions regarding this data sheet.

Facility Specific Information		
Facility Name		
12-month electrical consumption (kWh/yr)		*Example: 950,000 kWh*
Months included in consumption data reported		*Example: February 2011—February 2012*
Typical plant flow (MGD)		*Example: 1.4 MGD*

	Application	**Nameplate motor hp or amp & volt draw**	**Number of units**	**Number typically operating**	**Typical hours of operation per day**	**Blower or pump curve is available?**	**Comments**
Examples	*Raw water lift pumps*	*50*	*4*	*1.5*	*1st: 24hr* *2nd: 12hr*	*yes*	
	UV disinfection	*480V / 40A*	*2*	*2*	*24/7; Apr-Nov*	*NA*	
Primary Treatment	Grit pump						
	Primary clarifier						
	Primary sludge pump						
	Pre-aeration blower						
	Raw water lift pumps						
	Ventilation fan						
Secondary Treatment	Main aeration blowers						
	Secondary clarifier						
	RAS pump						
	WAS pump						
	Mixing pump						
	Trickle filter pump						
	Lift pump						
	Ventilation fan						
	Aeration rotor /brush						

Application		Nameplate motor hp or amp & volt draw	Number of units	Number typically operating	Typical hours of operation per day	Blower or pump curve is available?	Comments
Examples	*Raw water lift pumps*	*50*	*4*	*1.5*	*1^{st}: 24hr* *2^{nd}: 12hr*	*yes*	
	UV disinfection	*480V / 40A*	*2*	*2*	*24/7; Apr-Nov*	*NA*	
Final Treatment	Backwash aeration blower						
	Filter backwash pump						
	Lift pump						
	UV disinfection						
	Effluent aeration blower						
	Ventilation fan						
Sludge Processing	DAF compressor						
	Thickened sludge pump						
	Digester mixer						
	Sludge heating circulation pump						
	Sludge aeration blower						
	Digester gas pressurization blower						
	Sludge storage mixer						
	Ventilation fan						
Other	Air compressor						

Data Availability Survey

Please fill in what type of data you have available for equipment in your facility. We are specifically interested in data that indicates the degree of motor or unit loading, where load is either variable or less than full load. Contact Karl DeWahl (dewah001@umn.edu or 612.624.4645) with questions regarding this survey.
***Note:** If your SCADA system collects load data listed in this table, but you are not sure if it is exportable, please check with your SCADA system maintenance contractor on whether data can be exported.*

	Which readings do you record?				What format is the data in?					
Load	Energy Use (amp or kW)	Flow (cfm or gpm)	Speed (rpm or % speed)	Other	What is included in your SCADA trend charts?	What data set can you export?	What is the meter display?	What is recorded on a manual log sheet?	Log interval	No load data is available
Example *Variable speed aeration blower*	*amps*	*cfm*	*% speed*	*none*	*cfm, % speed*	*% speed*	*amps*	*amps*	*daily*	

The example above indicates the following:

- A number of indicators of blower load are available (amps, cfm & % speed of the variable speed drive)
- There is a meter display (instantaneous readout) for blower amps and this reading is logged daily on a manual log sheet
- cfm and % speed are available through the SCADA system as a trend chart; % speed can be exported from the SCADA system

Dissolved oxygen (DO) Data Availability

		DO data format availability					
DO probes	Number of DO probes	SCADA trend chart	Is the data set exportable?	Meter display	Is there a manual log sheet?	What is the log interval?	No DO data is available
Example: activated sludge	*2*	*yes*	*Excel file*	*yes*	*no*	*NA*	
Example: effluent aeration	*1*	*no*	*no*	*Portable meter*	*yes*	*Twice weekly*	
Pre-aeration							
Activated sludge aeration							
Nitrification							
Effluent aeration							

Appendix B

Summary of Recommendations

Site	Recommendation	Recommended Energy (kWh)	Recommended Savings ($)	Type	Status
1	DO Control	143,000	$12,700	Capital	Implemented
1	UV Pacing	4,000	$750	Operation	Implemented
1	Biosolids Cycling	195,000	$18,000	Capital	Proposed
1	Biosolids VFD + Setpoint	0	$0	Capital	Planned
2	Run 68 URAI at 50% with 2 basins	136,000	$12,000	Operation	Implemented
2	Smaller Blower Purchase with 1 basin	31,800	$3,000	Capital	Proposed
2	Run 711 URAI @ 70% with 3 basins	0	$0	Operation	Not Planned
2	Run 711 URAI at 50% with 2 basins	0	$0	Operation	Not Planned
3	SCADA Adjustment (TCV reduced to 1 from 2 gpm/ft2) and allowed below three cells (1A)	153,600	$12,300	Operation	Implemented
3	SCADA Adjustment (TCV down to 1.5 from 2 gpm/ft2) and allowed below three cells (1D)	153,550	$12,300	Operation	Implemented
3	SCADA Adjustment (TCV to 1.5 from 2) AND Install VFDs on BAF blowers (1E; = 1B&1D)	98,340	$7,840	Capital	Planned
3	Biosolids Blower: Install VFD with manual control (2B)	246,500	$19,700	Capital	Planned
3	SCADA Adjustment (TCV to 1 from 2) AND Install VFDs on BAF Blowers (1C; = 1A&1B)	116,000	$9,300	Capital	Not Planned
3	Install VFDs on BAF blowers to reduce effluent DO to target 7 mg/l (1B)	20,000	$1,600	Capital	Not Planned
3	Biosolids Blower: Install VFD and control on tank level (2A)	0	$0	Capital	Not Planned
4	Keep TCV at 1, allow SCADA to go to 1 BAF cell	93,024	$7,442	Operation	Implemented
4	Increase TCV to 1.5, allow SCADA to go to 1 BAF cell	14,908	$1,193	Operation	Implemented
4	Increase TCV to 1.7, allow SCADA to go to 1 BAF cell	894	$71	Operation	Not Planned
4	Reduce BAF scrubber & MAU flow rates	106,157	$8,068	Operation	Implemented
4	SCADA TCV set point adjustment for BAF	38,783	$2,512	Operation	Implemented
4	Seal compressed air leaks	13,820	$1,050	Operation	Implemented
4	Switch BAF & Biosolids scrubber exhaust fans and reduce flow rates	21,035	$1,600	Operation	Proposed

Site	Recommendation	Recommended Energy (kWh)	Recommended Savings ($)	Type	Status
4	Install VFDs on BAF blowers, following SCADA set point adjustment	107,133	$8,142	Capital	Proposed
4	Install LED retrofits for interior lighting and LED wall packs for exterior lights	28,613	$2,174	Capital	Proposed
4	Reduce biosolids storage tank level to between 4-8 ft, instead of 5-9 ft	23,173	$1,854	Operation	Not Planned
4	Install VFD on biosolids blower (while continuing to operate between 5-9 ft)	36,415	$2,913	Capital	Not Planned
4	Install VFD on biosolids blower AND reduce tank level to between 4-8 ft	33,105	$2,648	Capital	Not Planned
5	Increase Flow to MBR to Maintain Single Ditch Operation	138,000	$10,200	Operation	Implemented
5	Use Aerzen Blowers for Aeration=860cfm	495,000	$35,300	Operation	Planned
5	Use Aerzen Blowers for Aeration=731cfm	41,000	$4,500	Operation	Proposed
5	Use Aerzen BLowers for Aeration=650cfm	27,000	$2,000	Operation	Proposed
5	Use Aerzen BLowers for Aeration=285cfm	318,000	$24,000	Operation	Proposed
5	Eliminate Aeration venting	83,000	$6,100	Operation	Proposed
6	Wastewater Aeration Blower Optimization (cycle to maintain DO range of 1 to 3 ppm)	128,000	$10,000	Operation	Proposed
6	Biosolids Blower Optimization (continue reducing cycle on time to reduce energy and maintain a more neutral pH)	56,000	$4,500	Operation	Proposed
6	Raise Lift Station Water Level (10 ft)	14,000	$1,100	Operation	Proposed
7	Reduce first biosolids VFD speed from 45 Hz to 30 Hz.	106,000	$8,500	Operation	Implemented
7	Increase the decant time in D2	18,000	$900	Operation	Implemented
7	Reduce biosolids blower cycle times (req. testing)	47,100	$2,300	Operation	Implemented
7	Turn off biosolids aeration for 36 hours after emptying biosolids tanks (once every two weeks) [Changed to 48 hours for settling / decant)	21,200	$1,100	Operation	Not Planned
8	Switch to One Digester / Reduce Aeration Time / Reduce VFD frequency	84,000	$7,200	Operation	Implemented
8	Reduce Waste Tank Aeration by Leaving Blowers off with Low Tank Volumes and by reducing VFD frequency	142,400	$12,200	Operation	Implemented
8	Reduce Secondary Aeration with a Smaller Blower	364,900	$21,850	Capital	Planned

Site	Recommendation	Recommended Energy (kWh)	Recommended Savings ($)	Type	Status
8	Reduce Secondary Aeration Power by Reducing Pressure (most open valve)	35,000	$3,000	Operation	Proposed
9	Run just one aerator in each pond section.	173,400	$14,300	Operation	Implemented
10	Troubleshoot Primary Clarifier and Reduce BAF Cells from Eight to Four.	853,000	$62,000	Operation	Implemented
10	Reduced Filter Pressing	218,800	$10,940	Operation	Implemented
10	Time Cycle Digester Blowers	156,900	$11,300	Operation	Planned
10	Install and Use VFDs on BAF Blowers	250,000	$20,000	Capital	Planned
10	Re-use filter media lost in backwash, rather than sending it to landfill.	0	$5,333	Operation	Planned
11	Cycle Digester Blowers to Match Air Needs	50,000	$4,000	Operation	Implemented
11	Run Oxidation Ditch at DO = .5	19,000	$1,500	Operation	Implemented
-	**Total**	**5,501,550**	**$423,180**	-	-

Plant Assessment Summaries:

Plant 1 is an oxidation ditch being modified to accept wastewater from a small neighboring community. This plant was in the middle of an upgrade design and was identified by the design engineer as the result of an email description of the project. The design engineer was interested in learning what they might be able to incorporate into the design changes. The design engineer was considering adding dissolved oxygen (DO) control for treatment improvement. The assessment showed there was poor DO control currently and aeration modelling showed DO control could reduce energy consumption for aeration by 30%, which would make this change eligible for Green Project Reserve funding. This strengthened the decision to install DO control. The assessment also determined that UV disinfection was operating at full capacity even though the plant typically operated around 50% of design, and that the UV system had the un-utilized capability for flow pacing which would reduce the light intensity when flow was below a setpoint. Wiring to bring the flow signal to the UV control was needed to make UV pacing active. DO control and UV pacing are currently in the final stages of installation. The final opportunity identified was that the biosolids storage tank was aerated at a rate greater than required for a full tank even though the actual practice was to fill the tank from 50 to 100% over a 3 day period, decant, and transfer half of the biosolids to reed beds. The recommendation was to install a VFD and control the blower speed on the height of biosolids (pressure) in the tank. Given funding availability biosolids blower modifications will wait until the next planned upgrade slated for about five years out.

Plant 2 uses a diffused air, extended aeration activated sludge process. The plant operator requested assistance, at a project presentation, because secondary treatment DO was near saturation levels. Analysis showed the plant had a very large basin volume for their load and that minimum mixing and minimum diffuser air requirements would limit possible air reductions. The plant took 2 of 5 basins out of service early on and later removed a third basin from service, and also adjusted blower header valves to utilize one of the smaller biosolids blowers for secondary aeration. These changes have reduced aeration energy by 75%.

Plant 3 is a Biologically Aerated Filter (BAF) plant that is totally enclosed with significant odor control systems. The plant was identified with a very low (inefficient) ENERGY STAR score, through a Southern Minnesota Municipal Power Association (SMMPA) benchmarking effort on plants in the SMMPA service territory. SMMPA made introductions to the plant and MnTAP conducted an intern assisted assessment of the plant. Cell DO's were near saturation levels. One opportunity identified was a control setting – the target cell velocity (TCV) determines the number of cells required to operate. The plant had initially set a high TCV, but because that had resulted in high effluent TSS, staff overrode the TCV with a requirement that at least two cells operate at any one time. Tests were run demonstrating that lowering the TCV and eliminating the cell minimum requirement reduced the number of cells operating – this change has become permanent and saves 38% of secondary aeration energy at no cost. Barriers to additional change includes: this is a complex, proprietary plant design with a control system that is difficult to modify; single speed aeration blowers, each dedicated to a single BAF cell, with the speed set for backwash aeration (results in high cell DO). Current plans are to add VFDs to the aeration blowers so they will adjust to generate the DO required during treatment. The most difficult part of the change will be programming the proprietary controls. Blower VFDs are expected to reduce aeration energy by another 13%.

Plant 4 is the second BAF plant (totally enclosed with significant odor control systems), identified with a very low ENERGY STAR score through the SMMPA benchmarking effort. Cell DO's were near saturation levels. TCV lessons from plant 4 were transferred and implemented resulting in a 45% reduction in aeration energy. Additional reduction is planned and budgeted by adding VFD's to the aeration blowers to allow them to adjust DO as needed – this should result in an additional 32% reduction in aeration energy. An intern assisted assessment focused on a second large energy use in the totally enclosed BAF plant – odor control. The primary opportunity identified was over-ventilation in one section of the plant – reducing the air flow in that section has been implemented and save 21% of the process ventilation costs. Repair of identified compressed air leaks and a lighting upgrade have been started – these are cost effective improvements but savings are small compared to the process energy changes.

Plant 5 is a hybrid plant with oxidation ditches in parallel with an MBR. City staff contacted MnTAP after seeing outreach materials describing the project. The MBR was running with DO close to saturation levels and they were looking for ways to reduce this. Previous work had recommended operating a single ditch but with staff changes the plant had returned to two ditch operation. The assessment documented that with two ditch operation the plant was below the recommended minimum ditch flow more than 90% of the time, resulting in the decision to operate a single ditch and save 40% of ditch energy. The assessment found that the MBR scour blowers are 40% more efficient than the large secondary aeration blowers operating at maximum turn-down, and that at current high aeration rates the plant is on the edge of minimum mixing and minimum diffuser flow. The plant has made physical modifications to the header so one scour blower can be dedicated to secondary aeration while the second serves scour needs. Trials with the scour blowers are planned for February 2018. Using the scour blower for aeration at current air volume should reduce aeration energy by 56%. The scour blower can reduce air flow at the risk of mixing and diffuser issues – at minimum speed expected average DO=7 and energy should be reduced by 67%. Going to a smaller blower and DO=3 should reduce energy by 84%. The plant is investigating options that would reduce air requirements for mixing and diffusers.

Plant 6 is an oxidation ditch that has been converted to diffused air, extended aeration process, with a low average ENERGY STAR score from the SMMPA benchmarking effort. The plant uses 53% of their electricity for aeration (40% for secondary treatment, 13% for biosolids). It was obvious the secondary aeration blower was over-sized because it runs at its minimum speed and also part of the air generated is vented to atmosphere. The recommendation was to intermittently aerate, somewhat like a sequencing batch reactor, which would save 50% of secondary aeration energy. This is not being implemented because of operator concern about solids settling in the basin. Adjusting biosolids aeration cycles was recommended. The first adjustment, 90min on 45 min off, resolved biosolids pH issues and saves 32% of biosolids aeration energy. Plant staff are hesitant to make additional changes for fear of pH issues returning if they make change.

Plant 7 is a plant using a moving bed bio-reactor (MBBR) and aerated biosolids digestion. The plant was identified as having a low ENERGY STAR score through a benchmarking effort with Ottertail Power. Secondary aeration DO was at 2, but the plant energy footprint found biosolids aeration was 50% of the plant total and a dedicated blower was used for each digester (both were unusual for the typical plant). Discussion with operators lead to their trying and ultimately implementing the permanent slowing of the digester 1 blower (75% to 50%), shutting the blower off during the initial filling stage (three days out of two weeks, when the digester is nearly empty), and ultimately also cycling on five hours and off one hour. SOUR testing verified that biosolids stability improved as did the ability to thicken the biosolids which also saves transportation energy. Modifications to blower use reduced biosolids aeration energy by 46% so far, with further refinements being tested.

Plant 8 uses a diffused air, extended aeration activated sludge process, which was identified with a moderately low ENERGY STAR score through the Xcel Energy benchmarking effort. DO in secondary treatment was close to saturation levels with the blower throttled as much as possible, and the plant operates at 50% of design load. The blower is oversized for the current load but minimum mixing requirements would limit air reduction. Test showed that treatment is complete in 2/3 of the basin volume so installing smaller blowers has been budgeted for 2018 and the plan is to take one basin out of service to deal with mixing concerns. This is expected to reduce secondary aeration energy by 42%. Using the full plant capacity for biosolids digestion resulted in a 60 day average digestion period (27 days is a default assumed requirement). On recommendation the plant has taken one digester out of service and reduced the retention time to 30 days – this reduces digestion energy by 50%. A waste storage tank accumulates solids for digestion and while blower speed increased with solids volume, air levels were universally higher than needed. An improved aeration plan was devised and implemented and blowers are left off for the first 3 days while the tank builds volume from 0 – this strategy saves 30% of solids storage energy.

Plant 9 is an aerated pond plant in a very small town. The town felt they could not afford a consultant to solve this problem. An energy conservation organization with broad contacts in greater Minnesota made the referral to MnTAP to see if we might be able to help them even though MnTAP had no previous experience with aerated pond systems. MnTAP visited the plant and learned the town had lost the one significant industrial load to the ponds, which was 90% of the total pond load, but continued to operate the ponds as if the industrial load was still present with 10 of 14 aerators operating. MnTAP determined the amount of air theoretically needed for the load and recommended conservatively to remove 60% of the aerator power from service. The city has been very concerned about compliance with effluent limits so they have removed 20% of aerator power so far and plan to gradually reduce power further over time to assure compliance.

Plant 10 is a third BAF plant (totally enclosed with significant odor control systems) looked at, which was identified with a very low ENERGY STAR score through the Xcel Energy benchmarking effort. While the total plant load is moderately down since 2002, load removal by the clarifier is much less, which increases the load for secondary treatment. This requires utilization of more treatment cells and energy. The plant is currently investigating why clarifier removal efficiency has degraded, but the initial solution was to use a second clarifier (a low energy operation) to be able to use fewer cells for treatment. The plant later optimized their clarifier chemistries and returned to running only one clarifier. Improving clarifier TSS removal has reduced secondary aeration energy by 20%. Savings will increase to up to 40% if plant staff are able to modify a BAF cell programming error that is causing a load imbalance when they reduce their cells in filtration.

Plant 11 is an oxidation ditch, identified with a moderately low ENERGY STAR score through a benchmarking effort with Minnesota Power. The energy footprint was evenly split between biosolids aeration, secondary aeration and other uses. The biosolids blower was operated 2 hours on and 1 hour off because it was thought to be oversized, but with the plant operating at 50% hydraulic capacity combined with the a long (45day) biosolids retention time biosolids aeration was evaluated further. The plant slowly increased the blower off time, before running into biosolids stability issues and settling on maintaining 1 hour on and 2 hours off as the ideal cycle for their biosolids. The plant has implemented 40% blower operation time resulting in a savings of 40% of the blower energy consumption. Secondary aeration was controlled through manual DO readings. The operations manual for the plant suggested operating with a 0.5 DO setpoint for water going into the rotor. This recommendation has been implemented with savings of 21% of secondary aeration energy.

Plant 12 is an oxidation ditch with biological phosphorous removal that was the very first plant identified through ENERGY STAR benchmarking with a very high (efficient) score (94). We did not conduct an assessment here but we did visit the plant to try to learn why this plant is as efficient as it is. While no differences stood out as “everyone should be doing X”, there were a number of small differences that seem to add up: low Inflow & Infiltration (I&I) from rain events, so plant load variations are greatly reduced; operational DO is controlled below 1.2mg/l; intermittent biosolids aeration; continuous improvement effort to identify most efficient operating points for specific equipment (aerator, blowers & pumps).

Appendix C

Case Studies

Northfield

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WASTEWATER TREATMENT EFFICIENCY – NORTHFIELD, MN

Challenge

Operators at the Northfield Wastewater Treatment plant understood that they were spending a lot of money on energy – roughly $310,000 per year. The team at Northfield is passionate about sustainability, and in 2017 they chose to address their energy challenge head-on.

Approach

Northfield contacted MnTAP about an energy assessment for some help in finding energy savings opportunities. After extensively digging through spreadsheets, sifting through data, and performing analysis, valuable information was uncovered that gave the team at Northfield what they needed to make changes to save significant energy in their wastewater treatment process.

Results

Potential Savings
1,259,900 kWh / yr
$93,300 / yr

Tune primary clarifier and take four BAF cells out of filtration

Time cycle digester blowers

Install and use VFDs on BAF Blowers

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Findings

BAF Treatment

Comparing treatment data from 2002 to data collected in 2017 showed that something was wrong. Influent BOD, TSS, Ammonia, and Phosphorus were very similar between the two time periods. However, in 2002, the plant was able to function with just four BAF cells in filtration – in 2017, the plant was running with eight.

Continued analysis showed that the main difference was the waste removal within the primary clarifiers. The primary clarifier TSS removal percentage had dropped from roughly 90% to 50%. The difference was being made up within the BAF cells in secondary treatment, at the cost of running four additional cells ($62,000 per year in energy).

Northfield operators were able to partially resolve this issue by turning their backup primary clarifier online, reducing the number of necessary BAF cells from 8 to 6. Operators are now studying their coagulant and mixing procedures to look for additional ways to get their primary clarifier to run at optimal efficiency. When the primary clarifiers are performing well, fewer BAF cells are needed to treat the wastewater. The two BAF cells taken offline so far will save the plant $30,000 per year. Operators are looking at options to take two more offline, which will result in a total savings $62,000 per year in energy.

Digester Aeration

The air being generated by Northfield's digester blower was compared to the Ten State Standards recommended digester aeration. This standard declares that air should be sent to the digesters at a rate of 30 scfm / 1000 ft^3 of sludge. That means that as the digester tank fills with sludge, the amount of air being sent to the tanks should increase, allowing the supplied airflow to match the required airflow throughout the sludge stabilization process. The assessment showed that, given the air generated by the digesters at Northfield, the blowers should run from 9 minutes per hour for a nearly empty tank to 42 minutes per hour for a full tank. Switching to this operating procedure from simply running the blower constantly will save Northfield 115,000 kWh, or $8,300 per year. Due to some piping issues, this change is scheduled for 2021.

VFDs

The blowers within the BAF cells at Northfield are run without VFDs. MnTAP was able to use an aeration model to determine what speed the blowers would need to run to maintain a Dissolved Oxygen (DO) level between .5 and 2 within the BAF cells. It was found that with four cells in filtration, the blowers could be turned down to roughly 50% speed and still maintain adequate DO within the cells. For the four remaining cells in filtration, this change will result in an overall energy savings of 250,000 kWh, or $20,000 per year. This upgrade is budgeted and scheduled for 2024.

Getting Started with Energy Efficiency

Benchmarking your wastewater plant is a great way to get a sense for the magnitude of savings potential for your plant. B3 Benchmarking for Minnesota Wastewater Plants can be completed here: http://mn.b3benchmarking.com/WastewaterTreatmentPlants

For more information on wastewater treatment efficiency, please give us a call (612) 624-1300, email mntap@umn.edu, or visit our website: http://mntap.umn.edu/POTW/wwtp.html

Special thanks to our project partners at the Minnesota Department of Commerce and the Minnesota Pollution Control Agency for making this project possible.

Montevideo

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SAVING ENERGY IN WASTEWATER CITY OF MONTEVIDEO

Challenge

Prior to this project, the city of Montevideo's Wastewater Treatment Facility was paying over $124,000 per year for electricity. The plant was identified as having high energy use through an energy benchmarking effort done in conjunction with the plant's electric utility. The city's Utilities Superintendent was interested in opportunities available for energy savings at his plant. He knew that dissolved oxygen (DO) levels were high in his basins, and wanted more in depth information on his options to save energy.

Approach

MnTAP analyzed the equipment and airflow being used for treatment in order to find solutions. The largest opportunities were found in tuning airflow, capacity, and detention time in secondary aeration, waste tank aeration, and digester aeration.

Results

Energy Savings: 626,300 kWh / yr

Cost Savings: $44,000 / yr

Reduce digester aeration and detention time

DO reduced to 2 ppm

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Results

Secondary Aeration: DO = 2 ($35,500, 412,800 kWh – Planned)

Montevideo is currently running three secondary aeration basins in series. The dissolved oxygen within the basins ranges from 9-11 ppm. This is very high, and is a sign that reducing aeration would save a lot of energy. Through additional testing, Montevideo staff was able to determine that there was no further treatment occurring between the second and third basins and that the third basin was unnecessary. Taking that basin offline will reduce the plant's day-to-day aeration needs. The VFD on the large centrifugal blower can't be turned down below 56 Hz before the blower starts surging. Because the blower can't be tuned any further to reduce aeration, the solution here is to take one basin offline and to install a smaller blower which will be able to generate the proper aeration for the two remaining basins. Maintaining a DO of 2 with a smaller blower will save the plant $35,500 per year in energy. This project is being planned for implementation in 2018.

Waste Tank Aeration: Staggered and Reduced ($12,200, 142,000 kWh - Implemented)

Biosolids from the clarifiers are sent to a waste holding tank prior to being thickened and then sent to the aerobic digester. Before the assessment, this tank was being aerated 24/7, with a blower speed ranging from 35 Hz when the basin was empty to 55 Hz when the basin was full. While this type of automated VFD speed change is good, the assessment was able to identify areas for improvement. MnTAP outlined a variety of strategies to reduce airflow and save energy.

Staff tested reducing airflow to the waste tanks to save energy. They found that they can turn the waste tank aeration off for a few days after emptying it, and then can leave the VFD frequency at 40 Hz for the rest of the time. By using this strategy, operators are saving $12,200 per year in energy.

Digester Aeration ($5,400, 65,000 kWh – Partially Implemented)

The Montevideo Wastewater Plant was running two digesters in parallel on offset schedules so that one tank would fill while the other tank was holding and digesting biosolids. Both tanks were being aerated on a 30 minute cycle. The study found that this strategy required enough air to be generated to serve both tanks while full and at design capacity. Additionally, overall detention time of the biosolids was much higher than is recommended in the Ten State Standards.

A plan was developed involving filling and aerating using only one digester, allowing biosolids to aerate as the tank fills and while the prior waste tank fills. Using only one digester reduces the minimum sludge detention time from 45 days to 15 days while reducing the required treatment volume from two tanks to one. The volume reduction should allow the blowers to run for only 15 minutes per hour, down from 30 minutes. Currently, the blowers are being tested at 20 minutes per hour, and they will be brought down slowly to ensure there are no adverse effects on treatment quality resulting from this change. This cycling reduces energy consumption and will save the plant roughly $5,400 per year in energy costs.

Getting Started with Energy Efficiency

Benchmarking your wastewater plant is a great way to get a sense for the magnitude of savings potential for your plant. B3 Benchmarking for Minnesota Wastewater Plants can be completed here mn.b3benchmarking.com/WastewaterTreatmentPlants

For more information on wastewater treatment efficiency, please give us a call (612) 624-1300, email mntap@umn.edu, or visit our website: mntap.umn.edu/POTW/wwtp.html

Special thanks to our project partners at the Minnesota Department of Commerce and the Minnesota Pollution Control Agency for making this project possible.

Pine River Area Sanitary District

Results

Energy Savings:

51,000 kWh / yr

Cost Savings:

$4,100 / yr

Time cycle digester blowers to match required airflow

Maintain a DO of .5 behind the oxidation ditch rotors

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WASTEWATER EFFICIENCY – PINE RIVER AREA SANITARY DISTRICT

Challenge

Staff at the Pine River Area Sanitary District were interested in reducing their operating costs. The plant manager, Andrew Schwartz, was aware that his oxidation ditches and aerobic digestion process used a lot of energy. Andy wanted to quantify that observation and to learn how he could operate more sustainably. He scheduled a MnTAP energy assessment to get these questions answered.

Approach

MnTAP staff came out to the plant to gather information on blowers, rotors, setpoints, and dimensions. This information was used to identify opportunities to optimize operations to save energy.

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Findings

Adjust digester blower operation to match recommended airflow (33,000 kWh, $2,650 per year)

At the time of the energy assessment, the digester blower was cycling to run for two hours on, and one hour off. This type of cycling is a very good practice for wastewater plants looking to reduce aeration costs. MnTAP was able to determine that the airflow generated by the digester blower averaged to 397 scfm over the full blower cycle. This number was compared to the Ten State Standards airflow for the sludge, which recommended running between 151 and 252 scfm, depending on the sludge depth. MnTAP recommended that the plant reduce their aeration cycle times to better match the Ten State Standards values. Pine River staff made the change gradually over the course of several weeks. After weeks of testing, the plant reached a point where the digester started to develop some minor odors. The plant operators turned the cycle times back up to the last working test point (60 minutes on, 90 minutes off, 238 scfm averaged over the cycle). This testing allowed plant staff to optimize their digester blower cycling, resulting in savings of 33,000 kWh per year, worth $2,650 annually.

Reid Priedhorsky, English Wikipedia

Reduce Dissolved Oxygen Level in Oxidation Ditches (18,000 kWh, $1,450 per year)

The staff at Pine River had already been maintaining a dissolved oxygen level of approximately 2 ppm within the oxidation ditches. This is very close to ideal, but there is some small opportunity for further optimization. Typically the dissolved oxygen level should be kept within the .5-2 ppm range to ensure that the microorganisms performing treatment stay healthy. For oxidation ditches, this value can be measured and maintained just behind the rotors that add oxygen to the water. This is the optimal way to maintain a healthy and efficient oxygen range within the ditches. By switching the standard operating point from 2 ppm to .5 ppm, the plant staff are reducing their annual energy usage by 18,000 kWh, worth $1,450 per year.

Getting Started with Energy Efficiency

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http://mn.b3benchmarking.com/WastewaterTreatmentPlants

For more information on wastewater treatment efficiency, please give us a call (612) 624-1300 or visit our website:
http://mntap.umn.edu/POTW/wwtp.html

Special thanks to our project partners at the Minnesota Department of Commerce and the Minnesota Pollution Control Agency for making this project possible.

Pelican Rapids

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ENERGY EFFICIENCY AT THE PELICAN RAPIDS WASTEWATER PLANT

Challenge

Energy efficiency is a noble goal at any wastewater treatment plant. When a plant can be run more efficiently, it saves energy and reduces operating costs. Unfortunately, it isn't always obvious what to change in order to find these savings. Operators at the Pelican Rapids Wastewater Plant were ready to test changes in order to save energy. With some help from MnTAP, the operators were able to identify, test, and implement savings opportunities resulting in large scale savings for the plant and the city.

Results

Reduce Digester Blower Speed

Turn off Digester Blowers after Emptying Basins

Save Energy 145,000 kWh / yr

Reduce Costs $11,600 / yr

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Findings

Reduce Digester Blower Speed from 45 Hz to 30 Hz (112,500 kWh, $9,000)

The Pelican Rapids wastewater treatment plant is running two digesters in series. The identical blowers serving these digesters are run with VFDs. Initially, the first was set at 75% speed (45 Hz), while the second was at 50% speed (30 Hz). The team was curious as to whether turning down the speed of the first blower would provide adequate aeration for treatment.

The operators tested turning the first digester to 50% speed to match the second, and found that treatment quality was not adversely affected by the change. The treatment quality actually improved, although whether that was due to this change or because of lurking variables is unknown at this time. The $9,000 in annual cost savings was a nice bonus.

Turn off Digester Blowers for 36 Hours after Emptying Basins (32,500 kWh, $2,600)

Through discussions relating to plant operations, it was discovered that the digester blowers are running 24/7. This means that after sludge is sent to storage and digesters are emptied, any air being generated is being sent into an empty tank, and is effectively being wasted. The operators decided to do some testing and determined that they are able to leave the digester blowers off for 36 hours after emptying the tanks with no adverse impact on treatment quality. The $2,600 per year savings made this no-cost operational change well worth their time.


Bernard Spragg. Pelican. Flickr.

Getting Started with Energy Efficiency

Benchmarking your wastewater plant is a great way to get a sense for the magnitude of savings potential for your plant. B3 Benchmarking for Minnesota Wastewater Plants can be completed here: http://mn.b3benchmarking.com/WastewaterTreatmentPlants

For more information on wastewater treatment efficiency, please give us a call (612) 624-1300 or visit our website: http://mntap.umn.edu/POTW/wwtp.html

Special thanks to our partners at the Minnesota Department of Commerce and the Minnesota Pollution Control Agency for making this project possible.

Altura

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WASTEWATER POND EFFICIENCY ALTURA, MINNESOTA

Challenge

Altura is a small town of 491 people in Southeastern Minnesota. The town has an aerated pond system to treat wastewater. The wastewater plant manager is also the plant's only operator and also serves as the town's mechanic, first responder, and general problem solver. He suspected there was opportunity to save energy by removing aerators, but he didn't have the time to invest in figuring out the details. Instead, he contacted Clean Energy Resource Teams (CERTs) for help. CERTs had heard about MnTAPs work with wastewater treatment plants, and reached out on Altura's behalf to request an energy assessment.

As a result of that call, the City of Altura has the potential to save $14,000 per year in energy.

Results

Save Energy
173,000 kWh / yr

Save Money
$14,000/yr

Match O_2
Supply and Demand

Take Six
Aerators Offline

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Approach

Staff from Altura, CERTs, and MnTAP met for an on-site assessment to identify the opportunity for energy savings. The wastewater pond aeration was designed to handle large industrial loads from a large turkey plant. When that plant left town, the aerators stayed. These aerators use energy, which places an unnecessary economic burden on the town. At the time of the assessment, Altura was running 10 aerators for treatment. After digging through boxes of old files, the critical design information was pieced together. By comparing the current BOD loading of the plant to the design specifications, the solution became clear.

Results

The plant is expected to adequately treat wastewater with only four of the ten aerators online. This change will save Altura 173,000 kWh, or roughly $14,000 per year in energy.

The aerators are being removed from the pond system slowly to ensure that the change has no adverse effects on the effluent quality of the wastewater. As of this publication, two aerators have been removed from service, for approximately $4,680 in annual energy savings.

McGhiever, Whitewater River, CC3.0

Getting Started with Energy Efficiency

According to Energy Best Practices Guide: Water & Wastewater Industry, average pond benchmark scores for Wisconsin are 7,288 kWh / MG and 4,232 kWh / 1000 lb BOD; how do your ponds compare?

For more information on wastewater treatment efficiency, please give us a call at (612) 624-1300, email mntap@umn.edu, or visit our website: http://mntap.umn.edu/POTW/wwtp.html

Special thanks to our project partners at the Minnesota Department of Commerce, the Minnesota Pollution Control Agency, and Clean Energy Resource Teams for making this project possible.

Appendix D

Combined Heat and Power

Executive Summary

The payback period on combined heat and power projects for Minnesota wastewater treatment plants varied from 3.9 to 9.1 years for the four facilities screened in this project. Electricity savings estimates resulting from these projects ranged from 393,000 kWh per year to 5,700,000 kWh per year. Change in natural gas use was estimated to vary from -13,300 MMBTU to +4,700 MMBTU per year. The cost savings for these wastewater treatment plants was estimated at $15,900 to $306,700 per year as a result of installing combined heat and power. Minnesota has approximately 115 wastewater treatment plants currently using anaerobic digestion. Of the sites that do not yet have CHP, 23 are believed to remove over 2000 lb BOD/day, and are expected to be among the sites where CHP will be the most cost effective.

Methodology

The first two CHP screening assessment sites reached out to MnTAP and volunteered as a result of outreach with regards to the opportunity to learn about the cost-effectiveness of CHP. The following two assessment sites were identified through targeted outreach from MnTAP. MnTAP reached out to a total of 10 sites expected to benefit from CHP with regards to a no-cost screening assessment. A total of four CHP screening assessments have been completed through the US DOE Midwest CHP TAP through the Energy Resources Center at the University of Illinois at Chicago. Plant contacts were called and emailed with regards to the opportunity for a no-cost CHP screening assessment. MnTAP received interest from a total of five facilities, four of which moved forward with the screening process (the fifth site claimed that they had completed something similar within the last 5 years and decided against proceeding). The first step was for plants to fill out a short survey to provide information on energy consumption, power demand, thermal load, fuel consumption, boiler efficiency, and energy costs.

MnTAP sent this data to CHPTAP to complete a screening assessment report which lays out a first level cost-benefit analysis of implementing CHP. MnTAP and CHPTAP then scheduled meetings with site contacts to explain the findings and learn which steps staff are planning to take next. CHPTAP strongly recommends following up the screening assessment with an investment grade analysis (IGA) that is more thorough and uses more details to better estimate cost effectiveness. Investment grade analyses requires plants to pay a cost-share to complete through CHPTAP. Unfortunately, due to funding issues, CHPTAP lost the ability to offer investment grade analyses over the course of this project, but can still assist sites with completing the process through other consultants. Site three is planning to move forward with an IGA and is likely to ultimately install CHP as a result of this project.

Results

Four screening assessments have been completed. The following tables lays out the key findings from the screening reports:

Table 1 - CHP Cost Benefit Screening Results

Site #	CHP System Cost	Annual Savings	Simple Payback Period (yr)	Flow (MGD)	BOD Removal (mg/L)	BOD Removal (lb/d)
Site 1	$115,000	$32,096	3.9	3.2	413	12,436
Site 2	$144,575	$15,906	9.1	1.5	187	2,549
Site 3	$1,282,850	$306,665	4.2	3.39	341	9,649
Site 4	$259,900	$54,032	4.8	1.21	121	1,221
Total	$1,802,325	$408,699	4.4	9.3	265.5	25,855

Table 2 - CHP Electricity, Natural Gas, and Operation and Maintenance Screening Results

Site #	Change in Electricity Purchased (kWh)	Change in Natural Gas (MMBTU)	Electric Energy Purchases	Fuel Purchases	Change in O+M
Site 1	(428,215)	(3,207)	($29,119)	($12,827)	$9,849
Site 2	(393,045)	404	($28,299)	$2,960	$9,433
Site 3	(5,743,745)	(13,300)	($330,839)	($90,700)	$114,875
Site 4	(970,082)	4,703	($113,500)	$37,155	$22,312
Total	(7,535,087)	(11,400)	($501,757)	($63,412)	$156,469

Simple payback periods for these systems range from 4 to 9 years. Three sites had payback periods ranging from 4-5 years, while one had a payback period of 9 years. The plant with a 9 year payback period is due to very high natural gas prices from the site's natural gas provider. There may still be opportunity to reduce this payback period if there is available high strength industrial waste that the plant can use as a fuel source. Wastewater plants tend to have stable operation year in and year out, which strengthens the case for moving forward with a project with a payback period in the 4-5 year range. To date, none of these plants have implemented CHP, but site 3 is planning to move forward with an investment grade analysis.

At the beginning of the project, CHPTAP stated that the best payback periods for CHP at wastewater treatment plants occurs within the daily flow ranges of 5 MGD to 15 MGD. Most wastewater treatment plants in Minnesota fall well below this flow range, and yet the payback periods still seem reasonable for the sites screened in this effort.

Minnesota Opportunity

Minnesota has roughly 115 wastewater treatment plants with anaerobic digestion. Five have CHP systems installed (Winona, Rochester, St. Paul, Albert Lea, St. Cloud). The smallest lb BOD/day screened so far in this study removed 2549 lb BOD per day, and had a 9.1 year payback period for CHP. Minnesota has 23 plants believed to have anaerobic digestion that remove over 2000 lb BOD/day (that don't already have CHP):

Met Council – Blue Lake WWTP
Grand Rapids WWTP
Met Council – Empire WWTP
Mankato Water Resource Recovery Facility
Litchfield WWTP
Faribault WWTP
Moorhead WWTP
Austin WWTP
Owatonna WWTP
Bemidji WWTP
Brainerd WWTP
Red Wing WWTP
Monticello WWTP
Elk River WWTP

Met Council – St Croix Valley WWTP	Zumbrota WWTP	Fergus Falls WWTP
Met Council Hastings WWTP	Willmar WWTF	Melrose WWTP
Alexandria Lake Area Sanitary District	Hibbing WWTP South Plant	Plainsview Elgin Sanitary District

These sites are believed to have some of the best potential for CHP systems in Minnesota. This list is based off of historical data on anaerobic digestion, and is therefore not expected to be perfect, but does provide a sense for potential locations that may have cost effective CHP project opportunities.

Barriers

Lack of basic information is the first barrier to CHP. Many of the sites that were contacted over the course of this project were not initially familiar with the term CHP or with the purpose of Combined Heat and Power. None of the sites that were contacted initially expressed familiarity with CHPTAP and their no-cost screening assessments. Spreading awareness that CHP is a process that can help wastewater treatment plants to reduce electricity purchases and operating costs would be a useful campaign to break down this "lack of awareness" barrier.

Some electric utilities have not fully engaged in the opportunity presented by CHP. One claimed that CHP doesn't "work well" for smaller plants. It is possible that replacing utility produced electricity in part with electricity produced by burning natural gas (both from anaerobic digestion and purchased) may require additional policy adoption. Framing this as a strategy to help electric utilities to meet CIP goals may help to overcome some of these barriers.

Payback period is another barrier to CHP at wastewater treatment facilities. Without a lower payback period, it may difficult for treatment plants and cities to justify CHP installation over other potential projects. Accounting for additional local industrial loads that can help to increase gas production during initial screening assessments would be one method to help reduce the payback period and may help to make projects more cost effective at first glance, rather than waiting for a follow-up screening. (As an example, the Saint Cloud wastewater plant accepts brewery wastes, fats and greases, and nutrient rich food processing wastes to bolster their methane production within their on-site anaerobic digesters.)

Aerobic digestion is more common than anaerobic digestion. Aerobic digestion is very similar to secondary aeration; blowers are typically set to run at a setting that will provide enough oxygen for treatment. Unfortunately, aerobic digestion does not produce methane for CHP. Anaerobic digestion tends to be more difficult, requiring precise temperatures and bio-solids compositions to ensure that microorganisms can treat waste and produce methane to full-effect. Encouraging plants with aerobic digestion to consider anaerobic digestion and CHP during plant upgrades is a way to counteract this barrier.

Appendix E

Action Plan/Implementation Model

Minnesota Action Plan/Implementation Model

Energy Efficiency and Renewable Energy Generation
Minnesota Wastewater Facilities

Energy Efficiency and Renewable Energy Generation at Minnesota Wastewater Treatment Facilities

Benchmarking, Assessments and Training

Recommendations Prepared for:
Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Submitted by:

MnTAP Minnesota Technical Assistance Program
University of Minnesota

mn COMMERCE DEPARTMENT
DIVISION OF ENERGY RESOURCES

mn MINNESOTA POLLUTION CONTROL AGENCY

Goal

To provide comprehensive technical assistance program for energy efficiency at wastewater treatment facilities

Barriers

Awareness of energy efficiency opportunity within wastewater sector is uneven across facilities and resources for assessments and support are not coordinated

Solution

Increase sector awareness of energy efficiency through coordinated outreach and assistance incorporating facility benchmarking, site assessments, technical and financial support to encourage identification and implementation of efficiency opportunities and continuous improvement planning

Outcomes

- Incorporate facility benchmarking as a starting point for site based energy assessments focused on operational efficiency measures for site engagement
- Develop and launch an energy benchmarking module for wastewater treatment facilities within the Minnesota Buildings Benchmarking and Beyond (B3) program based on ENERGY STAR Portfolio Manager®
- Capture synergies with benchmarking, technical assistance and state financing opportunities to motivate implementation

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Special Thanks: The Department of Energy, Office of Energy Efficiency and Renewable Energy for awarding our project team this State Energy Program grant, and to the many wastewater treatment plant staff and affiliated organizations who contributed to this project and helped us develop a program to scope, identify, and implement energy efficiency improvements at plants throughout Minnesota.

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Background

Cities are under constant pressure to deliver improved services and manage operating costs. Wastewater treatment service can be a high cost effort due to the high capital and maintenance costs, the energy intensity of operating equipment and the need to meet increasing effluent quality requirements for positive public health and environmental outcomes. Nationally, the U.S. Environmental Protection Agency (EPA) estimates that wastewater treatment plants (WWTPs) account for 1.5-2% of all U. S. energy use.[30] Energy is a large component of facility operating costs, accounting for 25-40% of most wastewater utility operating budgets.[31,32] WWTPs reduce environmental impacts in receiving water, but create other life cycle impacts mainly through energy consumption.

Given the critical nature of WWTPs to community health and economic development, the sector's large energy consumption and the widespread distribution of facilities within Minnesota, highly effective programs to improve operation and energy use may serve as a cornerstone for communities seeking continued growth and improved community resilience. A variety of strategies will be needed to identify improvement opportunities across the spectrum of plant sizes and designs to optimize performance and operating cost.

This action plan/implementation model meets the objectives of the project to present a detailed that other wastewater treatment facilities can utilize to identify and implement onsite energy efficiency and renewable energy opportunities. By summarizing the resources and best practices gathered over the course of the project tasks, this Action Plan will present explicit strategies and tactics that can be employed by wastewater treatment facilities across Minnesota and in other states.

Wastewater Treatment in Minnesota

With wastewater treatment facilities operating in over 600 communities throughout Minnesota it is critical for state and local economies to improve the efficiency of operations to extend the useful life of this public infrastructure, meet permitted effluent quality and reduce the cost burden for residents and businesses. According to the Minnesota State Auditor's Office the age of wastewater facilities across the state ranges from less than 10 years to greater than 40 years[33] in communities ranging in size from some of the largest to cities and towns with 2,000 people or less. The cost to operate and maintain these systems can be high, which may limit the ability of some communities to reinvest in their systems to upgrade performance. Optimizing the operations and energy use of wastewater facilities can increase the working lifetime of equipment as well as help communities save money to put toward future infrastructure investment and other critical community needs.

While technology for WWTP operations is well established, facilities are highly customized to meet individual community needs and deliver effluent water discharge meeting regional permit requirements. Site specific technical assistance has been successful in identifying WWTP energy efficiency in facilities across Minnesota. In 2013, the Minnesota Technical Assistance Program (MnTAP) completed a project

[30] U.S. EPA – *State and Local Climate and Energy Program: Water/Wastewater*, 2012

[31] Municipal Wastewater Treatment Plant Energy Baseline Study, Pacific Gas & Electric, 2003 https://www.scribd.com/document/62799540/Waste-Water-Treatment-Plant-Energy-Baseline-Study

[32] NYSERDA – Statewide Assessment of Energy Use by the Municipal Water and Wastewater Sector, 2008

[33] Minnesota Office of the State Auditor, Civil Infrastructure Project https://www.auditor.state.mn.us/maps/

to assess energy use and operational benchmarks for ten WWTPs under an EPA Region 5 Water Quality Cooperative Agreement.[34] A collaborative effort between the Minnesota Department of Commerce Division of Energy Resources (DER), the Minnesota Pollution Control Agency (MPCA) and MnTAP was supported with a State Energy Program grant from U. S. Department of Energy (DOE) and provided energy assessments at eleven small to mid-sized facilities across the state.[35]

Barriers to Energy Efficiency in Wastewater Treatment

Over the course of these projects, several key barriers to energy efficiency at WWTPs have been identified:

- *Engagement* - Local knowledge of facility energy use and comparative energy performance with peer facilities is often unknown and limits justification to look for energy savings.
- *Finance* - Perception that energy efficiency efforts require large capital investments that are typically not available to facilities limits interest in identifying savings.
- *Assistance* - Highly customized plant designs require more tailored energy efficiency solutions to equip site operations staff to implement large energy conservation projects.
- *Support* - Uncertainty with risk if facilities are operated outside historically prescribed set points results in maintaining high energy use operating strategies and limits continuous improvement.

This Minnesota based DOE funded project sought to capture the significant energy efficiency opportunity at wastewater treatment facilities by addressing the root causes behind these barriers and providing tools and assistance to overcoming them. Minnesota was well positioned to execute this project based on strong State energy policies and tools that promote energy efficiency.

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Minnesota Energy Policies and Tools

Next Generation Energy Act

Minnesota has a history of energy policy-making through collaboration among stakeholders, resulting in consistent achievement of aggressive carbon emission reduction and energy savings goals supported by programmatic offerings in technical assistance, education and outreach. The State has implemented policies that support energy efficiency at all levels from households and municipalities to large and small business enterprises. One of the cornerstones of State policy supporting energy efficiency is the 2007 Next Generation Energy Act (NGEA) which set a 1.5% Energy Efficiency Resource Standards (EERS) beginning in 2010 for electric and natural gas utilities. Each utility is required to develop a Conservation

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[34] EPA-R5-WQCA-2010, CP-00E00758-0, Energy Efficiency Demonstration Projects and Audits for Minnesota's Wastewater Treatment Plants, final report, 2013

[35] Grant project MN Department of Commerce – 90103 – UofM (MNTAP Sub DE6888)-G, http://www.mntap.umn.edu/POTW/wwtp.html

Improvement Program (CIP) plan to achieve energy savings of 1.5% of gross annual retail sales,[36] unless adjusted by the Commissioner of Commerce.

Conservation Improvement Program

The Conservation Improvement Program (CIP) is a statewide program funded by ratepayers and administered by electric and natural gas utilities to help Minnesota households and businesses lower their energy costs by using electricity and natural gas more efficiently. CIP helps to conserve these important resources while reducing harmful emissions and the need to build new utility infrastructure. Utility CIPs are a significant source of energy efficiency activity in Minnesota and a key part of achieving the statewide EERS. Electric and natural gas CIP savings have grown significantly since the advent of NGEA, however, development of new and innovative CIP programs are needed to help utilities continue meeting their energy savings goals going forward. The *Energy Efficiency and Renewable Energy Generation at Minnesota Wastewater Treatment Facilities* program, which is focused on collaborating with Minnesota utilities to target and implement cost-effective energy efficiency measures at WWTPs, represents a CIP program concept that would help Minnesota continue to be recognized as a national leader in energy efficiency.

Buildings, Benchmarks and Beyond

Buildings, Benchmarks and Beyond[37] (B3) is a public building energy benchmarking system that provides data to support energy use planning by owners of public buildings. The Minnesota B3 was developed to meet legislative requirements[38] that energy use be benchmarked in Minnesota public buildings for the purpose of meeting State energy conservation goals. The Minnesota B3 platform has been developed under contract with The Weidt Group® (TWG) and is managed by the Department of Commerce.

Implementation and Financing Tools

Minnesota has developed a suite of financing tools to help motivate identification and implementation of energy efficiency projects at facilities throughout the state. These tools are available to wastewater facilities to minimize barriers of capital funding for improvement projects. A brief description of these programs is outlined in the Appendix.

Process

A summary of the key process activities required to develop and execute energy efficiency and renewable energy generation activities for Minnesota WWTPs is outlined in Figure 1. Details of the major components of the process are discussed in sections below.

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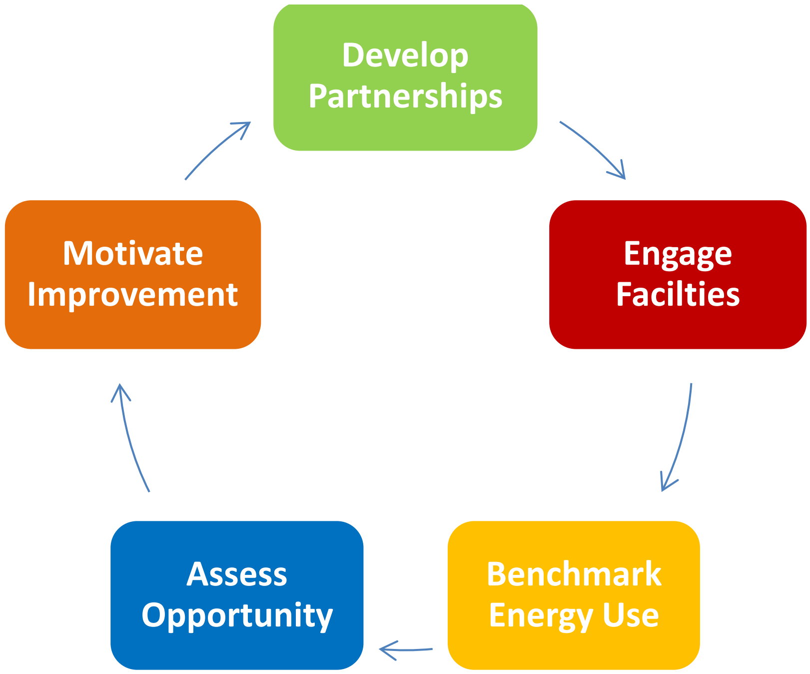
[36] As defined in Minn. Stat. §216B.241 subd. 1 (g), "gross annual retail sales" excludes sales to CIP-exempt customers.

[37] https://mn.b3benchmarking.com/

[38] https://mn.b3benchmarking.com/MN-session-law

Figure 1 – Key Process Activities

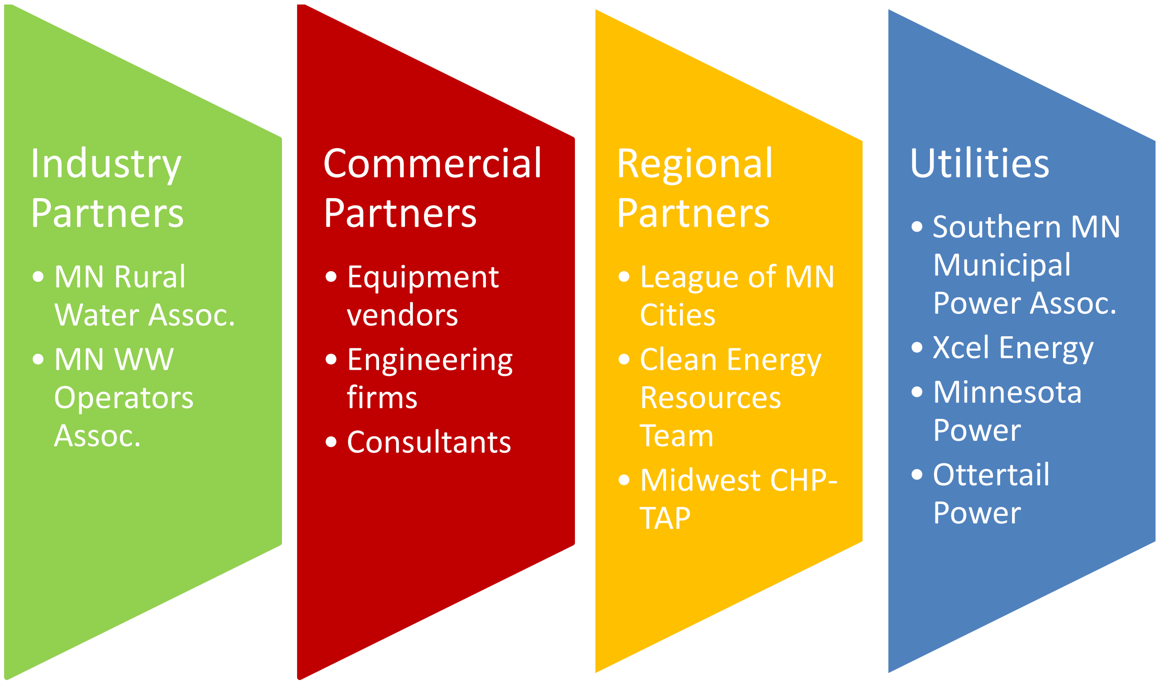


Step 1 - Develop Partnerships

There are multiple stakeholders associated with WWTPs, Figure 2 lists many of those identified in Minnesota with responsibility for engineering design, management, operation, regulation, support services, technical assistance, training and project financing. Each stakeholder can provide a unique input to the process from technical and financial support to site specific program introduction and engagement. It is necessary to identify these key stakeholders and invite them into the process to contribute to the overall success of the program.

Partnership activities focused on aligning with existing assistance providers and industry networks across the state with the primary mission to serve the WWTP community. The initial purpose of these partnership activities is to share information about the program opportunities and solicit input on approaches and strategies to get these resources to the facility level. Ultimately these relationships were critical to reporting results from the project activities back to the wastewater operations community. Commercial partners were also engaged in this process. Specifically vendors, consultants and engineering firms were engaged to provide tools, training and review of technical recommendations. Other state/regional resources were engaged as available and needed to provide specific services for outreach and engagement, efficiency assessments, tool development and training. Additional partnership activities target energy utility providers who, along with individual site operations staff, are the primary source for facility energy data. As indicated in the Policy section, utility partners are responsible for managing CIP which can be an important source of financing for site assessment and efficiency implementation activities. The Tools and Resources section provides an overview of many additional resources available to facilities in Minnesota.

Figure 2 – Key Project Partners



Step 2 - Engage Facilities

Development and promotion of case study examples created from early grant funded technical assistance efforts with WWTPs was necessary to illustrate the program approach and the energy efficiency opportunity potential that could be achieved.[5] Newsletter articles, website content and promotional presentations crafted for the WWTP community were continuously developed and revised throughout the program to reflect the breadth of facility operations across the state and engage additional facilities with the program.

One highly effective engagement strategy was to present program results at state and regional meeting focused on wastewater topics. Minnesota has a very strong network of training and technical assistance for wastewater treatment personnel through MPCA, Minnesota Rural Water Association (MRWA) and the Minnesota Wastewater Operators Association (MWOA). Presenting energy efficiency training, benchmarking discussion and case study examples to operations staff attending these meetings proved to be a highly effective way to engage facilities. Benefits of this approach include:

- Alliances with industry affiliated partner organizations
- Access to staff from many wastewater facilities at one time, in one location
- Opportunities to visit sites and demonstrate best practices through regional meeting activities
- Repeated exposure to operations staff through recurring meeting activities

Energy efficiency training and informational presentations were well received by operations staff at these meetings. Early stage engagement of facility staff and stakeholders often occurred at these events.

Step 3 - Benchmark Energy Use

The most significant engagement tool and launch point for site energy assessments identified over the course of this project was the introduction of facility benchmarking within the wastewater sector. As outlined in the Background section, a key barrier to facility engagement with energy efficiency assessments and implementation is that local knowledge of site energy use and energy performance relative to other facilities is limited. Benchmarking allows the energy use and the potential for improvement to become clearer to site staff, city managers and energy utility representatives and serves as a focus for conversations around identification and implementation of basic energy efficiency measures through opportunity scoping and evaluation of advanced energy technologies.

A variety of benchmarking strategies were employed over the course of this work depending on the type of facility and the amount of data available. Simple benchmark strategies such as energy use per million gallons processed or per unit biolochemical oxygen demand (BOD) processed were effective to convey the concepts of benchmarking to operations staff but often lack sufficient detail to allow site staff to evaluate their energy performance relative to peer facilities. To provide the comparative capacity the project team looked to improve the B3 Benchmarking tool already used by public facilities to track energy performance and utility cost based on building envelope criteria.

Over the course of the Minnesota DOE project, new functionality was added to B3 so the platform can now provide a wastewater benchmark score based on operational factors not just building size. For facilities treating >0.6 million gallons per day flow, the Minnesota B3 system provides data to EPA to generate ENERGY STAR® Portfolio Manager scores.[39,40] For smaller facilities a similar score is calculated within B3 to generate an equivalent benchmark value. The ENERGY STAR® Portfolio Manager score is the percentile ranking of plant energy performance against a national sampling of facilities, with a higher value being more efficient. With the newly added WWTP benchmarking functionality, cities can compare their plant's energy performance to other WWTPs throughout Minnesota, and the nation, to determine how efficiently their plant is operating.[41]

Key features of this tool include:

- B3 branding to for recognition and alignment with the State program
- Discharge Monitoring Report (DMR) data uploaded from the State quarterly
- Energy data can be added manually or uploaded automatically from some utility providers
- Scores for facilities >0.6 MGD are provided from Portfolio Manager
- Performance indicators for facilities <0.6 MGD are calculated from Portfolio Manager standards

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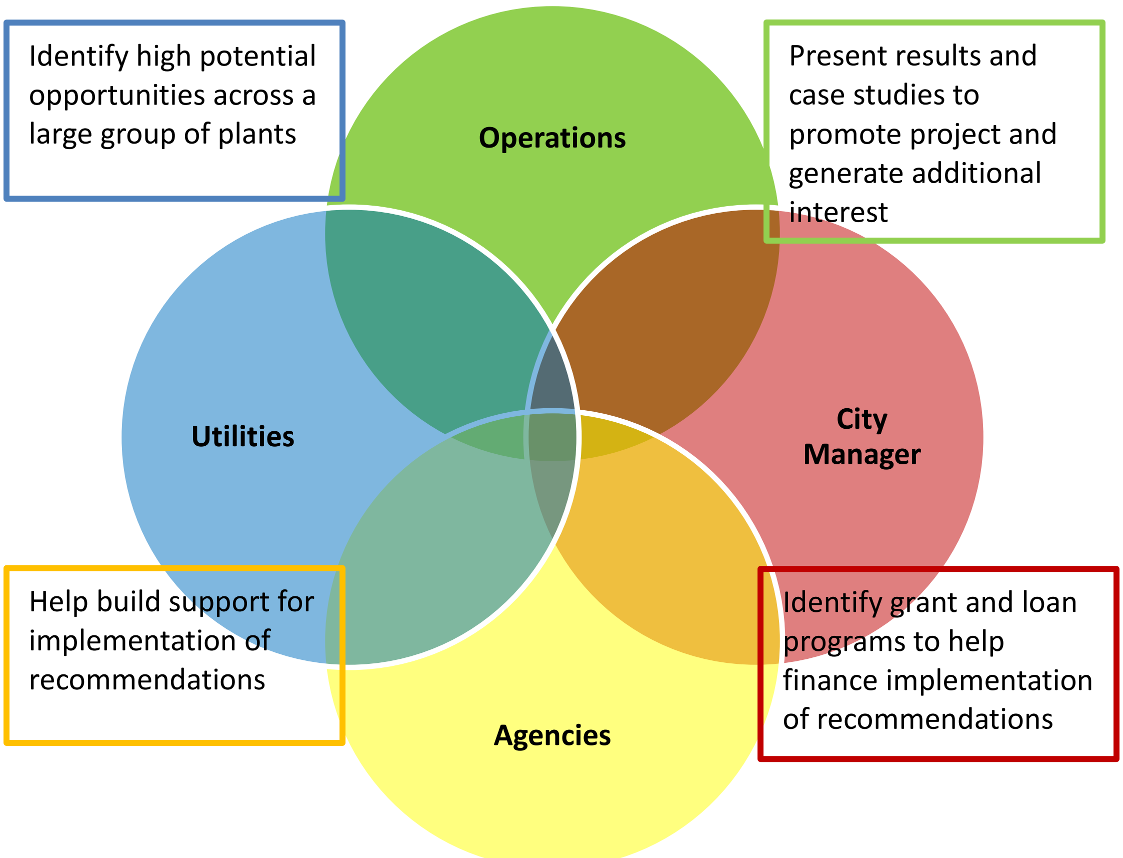
[39] https://www.energystar.gov/buildings/tools-and-resources/energy-star-score-wastewater-treatment-plants

[40] https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/eligibility

[41] http://mn.b3benchmarking.com/WastewaterTreatmentPlants

Benchmarking was key to efficiently identify and communicate energy efficiency opportunities to a variety of sector stakeholders. The benchmark scores were an important part of the overall process to identify sites with energy savings opportunity, engage the facilities in assessment activities and aggregate support resources to encourage and enable implementation. Figure 3 illustrates how stakeholders and facilitating relationships between stakeholders can help support assessment activities, identify financing resources and motivate implementation of energy efficiency recommendations.

Figure 3 – Benchmarking as a Program Engagement Tool



It was found that receiving the energy performance as a ranking relative to other facilities resulted in a high level of site engagement with the assessment process. This was the case for facilities with both high and low benchmark indicators, with low scoring sites actively seeking technical assistance to identify opportunities to improve. Once the benchmarking analysis was completed, site based energy performance based on the energy benchmark indicator value was discussed with site personnel to assist with interpretation of the analysis. Facility energy use was classified as shown in Table 2.

Table 1 - Energy Benchmark Indicator Recommendation Plan

Relative Performance	Project Action
Lowest quartile	Energy assessment whole facility recommended Implementation plan developed Operational changes for high energy uses Outlined list of next steps available Follow up for technical support
Third quartile	Energy assessment whole facility often recommended Implementation plan developed Operational changes for high energy uses Capital change opportunities discussed Follow up for technical support
Second quartile	Energy assessment targeted operations on request Implementation plan for continuous improvement Discussion about advanced technology screening Possible request for best practices case study
Top quartile	Possible site visit for unique operations Review of continuous improvement plan Discussion about advanced technology screening Request for best practices case study

The success in engaging WWTPs in energy efficiency activities based on process benchmarking results and the lack of an available tool to generate these results for all the mechanical facilities in the state encouraged the DER to revise the wastewater treatment module in the current state B3 system. While the existing B3 system included WWTPs, the facilities were benchmarked like other public buildings based on square foot area and utilization of the building. Revisions to include process energy use provide more useful measures of energy use in these facilities.

As additional incentive for communities to participate in B3 for wastewater treatment, entering facility data into B3 will be required for all applications for State Revolving Fund capital funding projects.

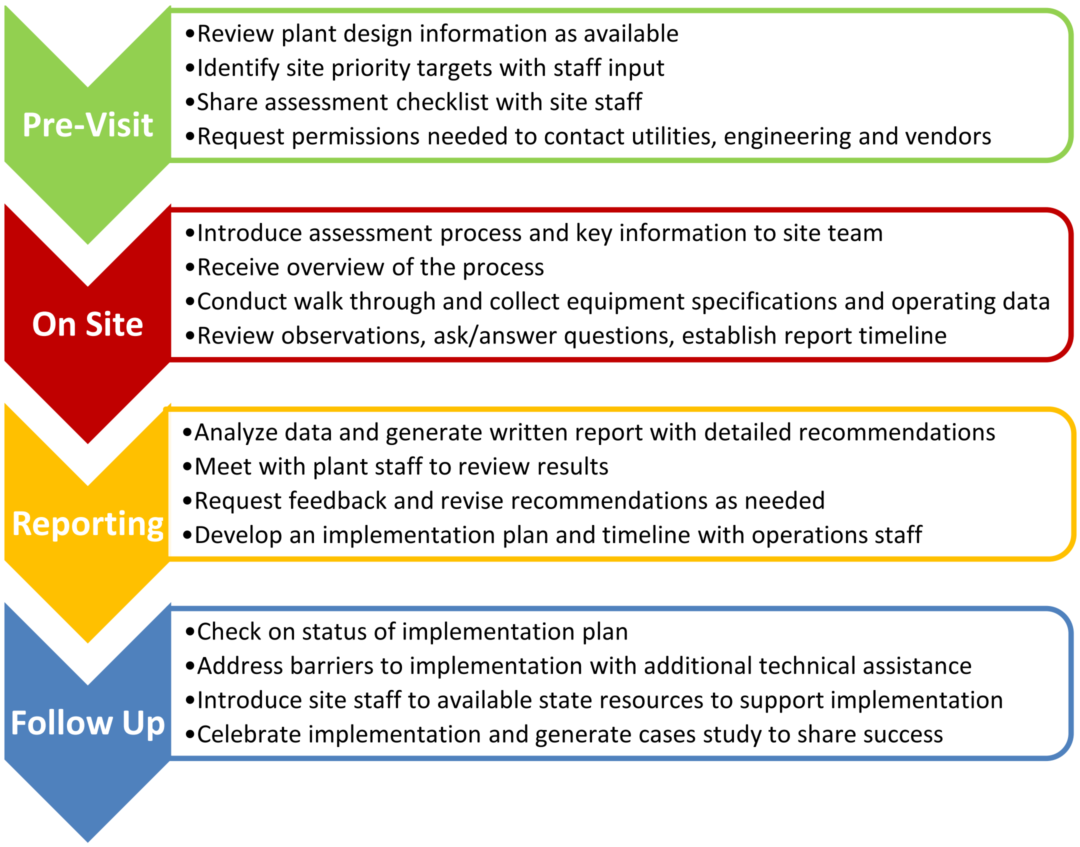
Step 4 - Assess Opportunity

Energy use in WWTPs depends on plant design choices. Facilities have been designed to run most efficiently at full capacity and generally have limited ability to tune operations for energy efficiency at intermediate flow, which is where most plants operate. There were three themes addressed in the energy efficiency assessments conducted in this work.

- Optimize operation of existing equipment for plant loading
- Manage dissolved oxygen (DO) in aerated systems
- Emphasize life cycle cost advantages of energy efficiency equipment choices

Facilities that had low benchmark indicators were generally interested in technical assistance to identify options to improve performance. The assessment visits were scheduled as soon after the benchmarking review as possible to maintain interest and site momentum. A detailed site assessment procedure has been developed which includes data sheets and checklists. Figure 4 provides a brief overview of the site visit process steps.

Figure 4 - Site Assessment Process Overview



Step 5 - Motivate Improvement

The true measure of an energy efficiency program is how effectively it motivates implementation of recommended energy conservation measures and encourages continuous improvement. Follow up with facilities has been a key to measuring success over the course of this work. Connecting with facility managers after the initial assessment activities have been completed and the report and recommendations delivered is a critical piece to ensuring the site staff understand the opportunities presented and are engaged in testing operational strategies to support implementation. These conversations offer the opportunity to support and encourage site efforts toward implementation, revisit concerns site staff may have over suggested activities and provide additional information or resources that may help facilitate implementation or identify additional opportunity. Supplying additional resource support was used as a tool to maintain progress on opportunity identification, testing and implementation for facilities with complex operational changes or unclear implementation pathways as identified during initial assessment activities. In these cases, student intern projects, supported in part through grant funds and facility utility providers as part of the MN CIP program, supplied the manpower needed to refine the process improvement suggestions and launch implementation. Follow up activities offer an important opportunity to test recommendations, measure the impact of implemented recommendations and verify the electric energy conserved and cost savings achieved.

On occasion, facilities may become stalled during the implementation phase due to lack of knowledge on how to best proceed or out of concern for what might happen to facility performance. Reconnecting with the project sites allows for added input to the implementation process, discussion on additional opportunities or limits identified and awareness of unintended outcomes that may have been observed. An additional opportunity that often comes from building these relationships with facilities is the ability to share the site energy story through case study development. As facilities pursue implementation of the recommended energy measures, there is an increasing investment in the process and awareness of energy use opportunity. Celebrating the site by promoting their participation in the program and the efficiency activities that were identified and implemented is a good opportunity to positively reinforce their work and encourage continued improvement. Additionally, creating case studies can serves to generate teaching materials used to engage other facilities, government leaders and utilities as they seek to improve energy performance and operating costs.

Upon full implementation and site utilization, the State B3 benchmarking for wastewater treatment will allow facilities to track implementation and resulting energy use impact. Site energy performance will be recorded and visualized in the software reporting package for easy retrieval and comparison with site goals. B3 data tracking offers sites a way to track energy use performance over time and provide feedback to sites engaged in continuous improvement programs. Data tracking will also allow stakeholders, such as energy utilities, funding partners and technical assistance providers, to tailor program outreach activities for facilities that need the most assistance.

Outcomes

On-site technical energy efficiency assessments identified a total of 5.5 million kWh annual energy savings opportunity with an estimated value of $423,000. This is an average energy savings of 500,000 kWh per year per facility with an actual range from 69,000 to 1.2 million kWh/year across the eleven assessed sites. Approximately 70% of the recommended energy efficiency opportunities identified in this work could be achieved through operational changes requiring no or low capital investment. Approximately 40% of the 5.5 million kWh of recommended energy savings has been implemented to date with an additional 39% planned. A summary of project objectives and outcomes has been outlined in Table 3 below. A summary of the status of recommendations is shown in Figure 5. A summary of facility level recommendation status is shown in Figure 6.

Table 2 – Project Objectives and Outcomes

Project Objective	Project Target	Project Outcome
Engage MN WWTP in E2 and DG	-	26 presentations/events
Attendees at events	-	1139 attendees
Operators Trained in E2	50	108
E2 Assessments	10	11
Identified energy efficiency	2-5 million kWh	5.5 million kWh/year
Implemented energy efficiency	-	2.2 million kWh/year
Planned Implementation	-	2.1 million kWh/year
Case studies generated	-	6
Discussions on E2 planning	10	11
MnTAP Intern Projects	2-3	2
CHP Screening Analysis	5	5 launched, 4 completed
CHP Assessment	1-2	1 under consideration

In addition to direct energy savings, 6 case studies were produced providing public facing summaries of energy efficiency measures recommended to various facilities and best practices from high performing facilities. These case studies can be used as tools for outreach and education to additional facilities that would like to capture energy efficiency beyond the grant period.

Figure 5– Program Energy Recommendation Status

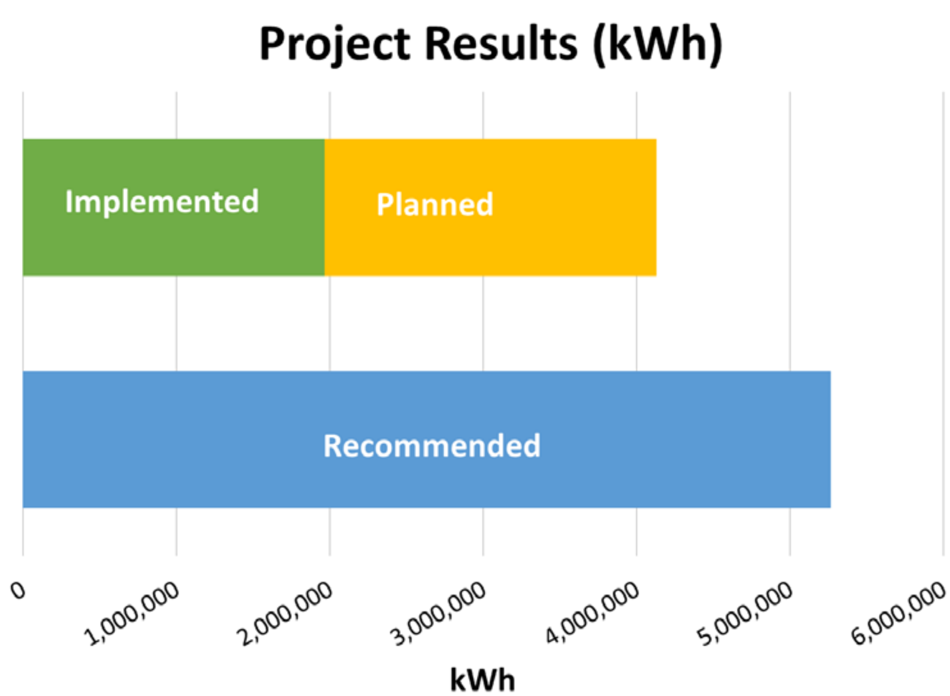
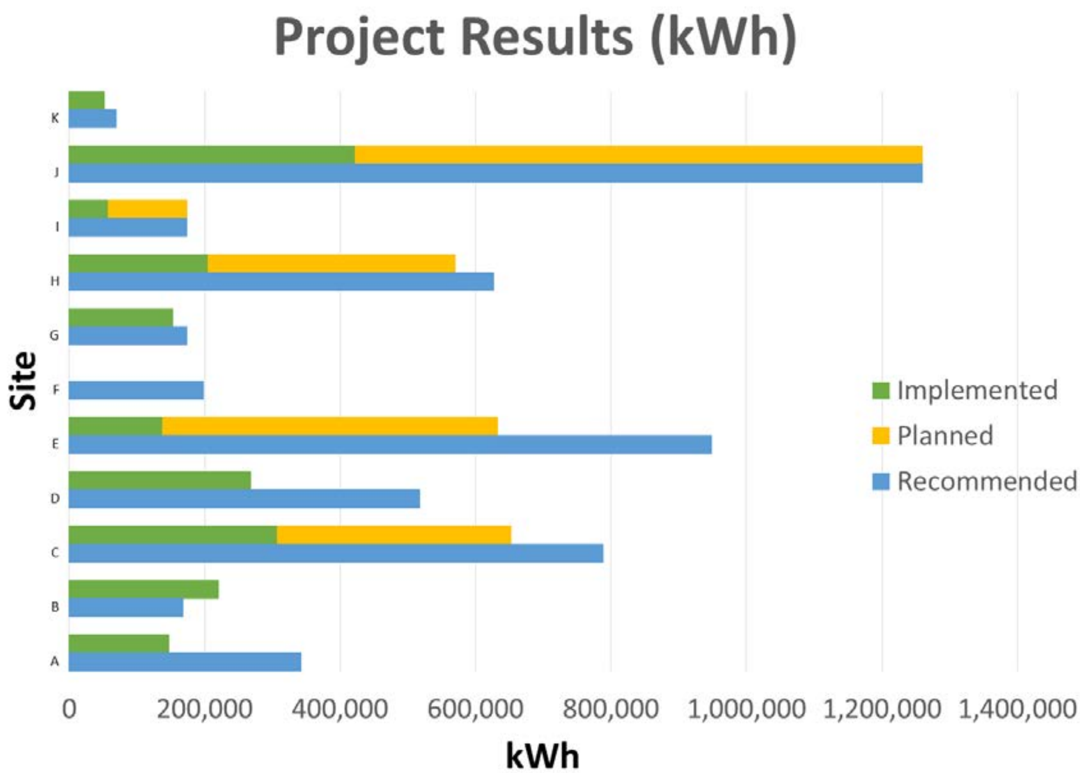


Figure 6 – Facility Level Energy Efficiency Recommendations and Implementation



Additional Opportunities

Distributed Energy Generation

This project also served to connect wastewater treatment plants with information and site scoping for combined heat and power (CHP) opportunity. Wastewater plants that practice anaerobic digestion may be good candidates, as the process is in place to break these wastes down into methane that can be used as fuel. An additional attribute of strong candidates for CHP are those wastewater facilities with moderate to high BOD loading or with access to compatible high-load industrial waste.

This part of the project was conducted in collaboration with the Combined Heat and Power Technical Assistance Partnership (CHP TAP) based out of the University of Illinois, Chicago. This organization provides no-cost first level combined heat and power (CHP) screening assessments throughout the Midwest. The assessments serve to give sites a first-look at the cost-benefit analysis associated with using the gases generated in anaerobic digestion processes for electric energy generation and heat for their plants, reducing their need for externally generated electricity and natural gas from the grid.

MnTAP conducted site screening evaluations based on suggestions provided by CHP TAP[42] including facility attributes such as having anaerobic digestion operations and a flow of >5 MGD. There were few facilities in Minnesota that met those criteria. To increase the number of facilities for consideration, MnTAP staff chose to look at potential sites with lower flow but with high organic load. State discharge monitoring report (DMR) data were analyzed and MN sites practicing anaerobic digestion with >1 MGD flow and high BOD load were identified. Twenty-five facilities were approached for CHP screening, having BOD loadings between 2500 and 25,000 lb/day. Of these, five facilities were engaged in the screening assessments.

Of the five sites engaged in the screening evaluation, four completed the feasibility assessment by providing operations data that were analyzed by the Chicago CHP TAP. The feasibility assessments showed investment payback periods for site CHP investments ranged from four years to ten years. This return on investment period, while likely too long for most private investment, is within the range of many wastewater facility investment projects. It was good to see that a reasonable investment opportunity appears to be available even to smaller facilities, which comprise most of the Minnesota wastewater infrastructure. Of the four facilities completing the feasibility assessment, one site is interested in proceeding to an investment grade analysis to further refine the site CHP opportunity.

While renewable energy generation at wastewater facilities has been practiced at a few sites throughout the state for many years, it is still relatively rare. Most wastewater operations managers and staff as well as support services such as engineering firms and utility providers do not have extensive knowledge about the opportunity appropriately applied implementation of renewable energy generation technologies can bring to a site or region. This general lack of familiarity can present barriers to consideration of technologies such as CHP that may manifest as inability to invest time to explore the opportunity potential, lack of support from service providers and lack of willingness to explore the technology and cost implications. This project provided an important introduction to CHP to Minnesota wastewater facilities and provided data that can be utilized to educate industry stakeholders and promote the potential for renewable energy generation in this sector.

Continued Impact - Cohort Energy Efficiency Model

While technology for WWTP operations is well established, facilities are highly customized to meet individual community needs and deliver effluent water discharge meeting permit requirements. Due to this customization, general solutions for energy efficiency are limited in equipping site operations staff to implement significant energy conservation projects. Site specific technical assistance model described in this document has been effective in identifying significant WWTP energy efficiency opportunity and motivating implementation in facilities across Minnesota. However, given the large number of facilities across the state and country, site based technical assistance will require significant resource investment to capture the full energy potential within this sector and may not equip site operations staff with the tools needed for continuous improvement.

Future efforts seek to deliver a cohort based energy efficiency program at a scale and level appropriate for small to medium sized WWTPs within Minnesota. A regional energy efficiency cohort model can make use of the strong culture of education and knowledge sharing within the operations community to

[42] http://www.midwestchptap.org/support/documents/CHP_TAP_Technical_Assistance_Offerings.pdf

magnify the impact of site based technical assistance resources. A cohort energy efficiency model is expected to increase peer learning, motivate group participation for the identification and implementation of energy efficiency measures and reduce program transaction costs over individual site assistance efforts. MnTAP has won a Conservation Applied Research and Development (CARD) grant from DER to develop curriculum and delivery models for a small to mid-size wastewater treatment facility cohort training program. This program, scheduled to start in January 2018 and run for 18 months, will seek to apply the information gained from site based technical assistance at small to mid-size wastewater facilities and transform it into a cohort energy efficiency training model that would help overcome many of the remaining engagement, assistance, and support barriers to energy efficiency outlined in the Background Section.

Municipal wastewater treatment is an ideal sector to demonstrate the value of a cohort model for energy efficiency. There are few issues with proprietary operations. Workforce licensing in this sector fosters a culture of continuing education. There are strong regional and state networks that enable and encourage peer interactions, technical training and collaboration. Similar approaches have been used on a national level by DOE focused on very large facilities to improve energy performance of critical infrastructure across the United States through programs such as, Superior Energy Performance Water and Wastewater Pilot Project and Sustainable Wastewater Infrastructure of the Future Accelerator. This program would seek to understand best practices identified in this effort and use similar methods at smaller treatment facilities where appropriate.

Once the curriculum is developed a second phase will be to utilize the developed training tools in a technical demonstration of a regional WWTP cohort assessment model to achieve energy efficiency. When a pilot cohort training is conducted, the process will be documented to facilitate replication as a utility program. Recommended and implemented energy efficiency measures will be assessed in order to estimate opportunity potential upon program replication. Benefits of the program will result from the site based energy efficiency opportunities identified by cohort participants. A cost/benefit analysis of this cohort model is critical to justify the approach as a cost effective energy efficiency program. In addition the time, operational and capital commitments from the cohort members will be documented to better assess the site investment required to achieve outcomes within a cohort framework. An additional outcome of this effort will be the implemented energy reduction achieved by the cohort member facilities.

Appendix - Tools and Resources

Minnesota Implementation and Financing Programs

	Implementation & Financing Programs			**Financing Programs**	
Method	Clean Water Project Priority List (PPL)**	Guaranteed Energy Savings Program	Local Energy Efficiency Program	Energy Saving Partnership	Rev It Up Program
Eligibility (recipient)	Cities, Counties, Sanitary Districts and other Municipals Entities Borrowers Must have authority to issue General Obligation debt	State Agencies, Higher Ed, Local Governmental Units, K-12	Local Governmental Units, K-12 buildings	Local Governmental Units, K-12	Local Governmental Units, Commercial and industrial Businesses, Small Businesses (<50 employees), Health Care Facility's, MHFA
Type	Build, repair and improves wastewater and stormwater collection and treatment systems Low interest loans and either affordability or pollutant based grants	State Assisted Energy Savings Performance Contracting (ESPC) Program with Guaranteed Savings	State Assisted Energy Study using Design-Bid-Build for implementation	Municipal Leasing program-tax-exempt	Revenue Bonds - tax-exempt or taxable (project dependent)
Project Size*	Min. Historical of under $100k (additional requirements may not off set interest saved under $300k) Max. none	Min. $300k Max. none	Typically between $50k and $350k	Min. $50k Max. none	Min. $1M Max. $20M
Term (years)	20 years, up to 30 years for some projects if demonstrated financial hardship. Loan term cannot exceed useful life of project	Up to 25	Up to 15	Up to 15	Up to 25
Interest Rate*	Below market rate, less annual discount approved by the PFA Board. Cities under 2,500 may quality for additional discounts. Rates cannot go below 1%	Dependent upon financing instrument – eligible for lease purchase financing	Dependent upon financing instrument – eligible for lease purchase financing	Dependent upon issuance	Dependent upon Project Security
Administrator	MN Pollution Control Agency, Bill Dunn (MPCA) 651-757-2324Public Facilities Authority, Becky Sable (PFA) 651-259-747	MN Department of Commerce Peter Berger 651-539-1850	MN Department of Commerce Peter Berger 651-539-1850	St. Paul Port Authority Peter Klein 651-204-6211	MN Department of Commerce Peter Berger 651-539-1850