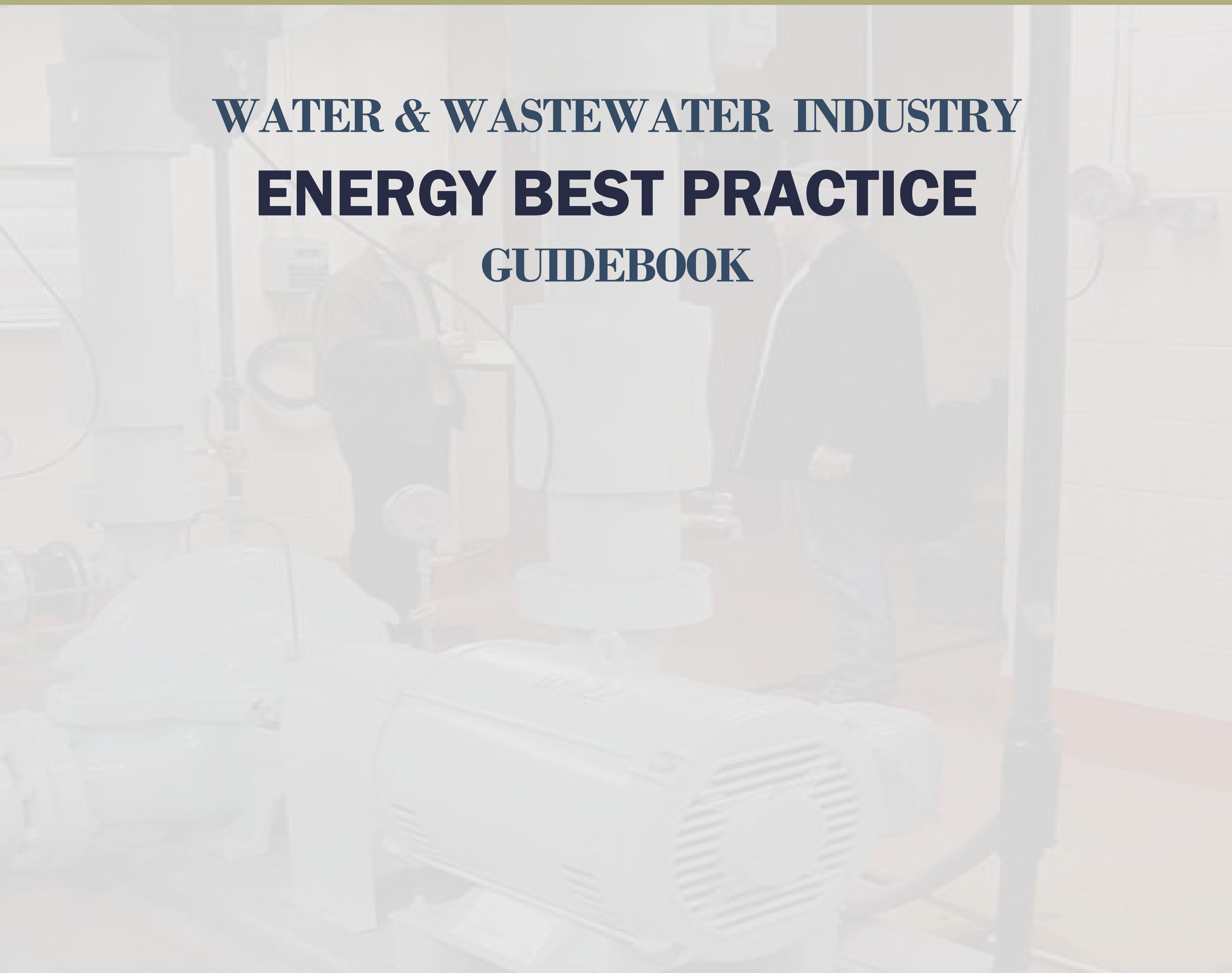
WATER & WASTEWATER INDUSTRY

ENERGY BEST PRACTICE

GUIDEBOOK



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The power is within you.

Water and Wastewater
Energy Best Practice Guidebook

Provided By:

focus on energy℠
The power is within you.

Funding for this guidebook was provided by Focus on Energy.
Focus on Energy is a public-private partnership offering energy information and services to energy utility customers throughout Wisconsin. The goals of this program are to encourage energy efficiency, use of renewable energy, enhance the environment and ensure the future supply of energy for Wisconsin.

Prepared by:

Science Applications International Corporation (SAIC)

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FORWARD

"As the cost of energy escalates it is even more imperative that [we} evaluate and implement available technologies for reducing energy consumption. In the end it is our customers who will benefit."

Kevin Breit
City of Mosinee

Are You a Leader in Saving Energy?

As energy costs continue to rise, knowledge of energy efficient technologies and best practices is becoming more valuable. While these practices have slowly gained acceptance within the water and wastewater industries, increasingly strained budgets coupled with aging infrastructure make energy efficiency a feasible option to save money.

Energy efficiency projects can vary in complexity from very simple – operating process equipment on a different schedule, to complex – changing the type of treatment system or replacing critical process equipment. Regardless of complexity, the benefits are numerous and typically include cost savings, improved treatment and increased system reliability. Industry leaders have already taken advantage of the energy savings at their facilities. These leading energy savers have:

- Compared their energy consumption to that of other, similar facilities
- Performed assessments to identify best practices to save energy
- Established a capital improvement program to generate funds to implement energy-efficiency projects
- Appointed an energy advocate among facility staff to champion energy-efficiency projects
- Instituted a program to continuously monitor, review and assess energy consumption on a monthly and yearly basis
- Developed and maintained communications with management to increase awareness of the value of energy management

If your facility lacks any of these essential ingredients, this Best Practice Guidebook will help you identify ways to incorporate energy efficient practices and equipment into your facility. You can become a leader in understanding the value of energy management and in initiating your own energy management program. This guidebook can serve as your starting point.

What Others Say About Energy Management

Peter Conine, City of Waukesha

> *"Energy awareness and energy management are very important aspects of daily operations. Sometimes it is difficult to see the benefit of an energy savings project if it comes with a formidable price tag. Often the pressure from upper management or elected officials to keep taxes or rates low has intimidated managers to the point where they are very hesitant to propose projects that will cost money. It is imperative that managers begin to look to the future and step beyond the "sticker shock" of projects. Reduction of energy use must be included in the evaluation of projects and many managers will be amazed at how quickly some projects will pay for themselves."*

Tom Vik, P.E., McMahon Associates, Inc.

> *"As a consulting engineer, and resident of this planet, I am an energy saving advocate … as good stewards, one should use our resources wisely and efficiently, minimizing waste….[W]e can accomplish water quality objectives and public safety while using energy management and conservation techniques. … saving operations expense, ultimately reducing costs to the consumer."*

Al Larson, Madison Water Utility

> *"Controlling and reducing our energy consumption is an efficient and effective means of controlling the increases in our operating costs… and to provide a high quality service to our customers."*

Please see Appendix A for additional testimonials to energy management.

The **Wisconsin Department of Natural Resources (WDNR)** recognizes the importance of increasing energy efficiency at water and wastewater facilities and generally endorses the goals and recommendations of the **Water and Wastewater Energy Best Practice Guidebook.** Although the Department strongly supports energy conservation, providing necessary treatment (with a reasonable factor of safety to ensure reliability) and attainment of all regulatory requirements must not be sacrificed as a result of seeking energy savings. See **Appendix B** for more information on **WDNR Regulations and Energy Considerations**.

Development of this Guidebook

Funding for this best practice guidebook was provided by Focus on Energy. The following Focus on Energy Water and Wastewater Cluster team members contributed to the development of this guidebook:

- **Joseph Cantwell,** Focus on Energy Advisor and Senior Engineer with SAIC, has over 30 years experience in water and wastewater system design and five years energy efficiency experience.
- **John Nicol,** Industrial Program Manager for the Focus on Energy's Business Program, has more than 25 years of experience in industrial energy efficiency.
- **Craig Schepp,** an Energy Advisor with SAIC, has over 25 years of experience in energy efficiency programs.
- **Kristi Kezar,** an engineer with SAIC has 6 years experience in incorporating energy efficiency into water/wastewater facilities.

Special Acknowledgements

We wish to give special thanks to the following people who contributed their time and expertise toward reviewing this guidebook and helping to make it a truly valuable tool for the Water and Wastewater Industry:

Oliver Lawal	***WEDECO, Inc.***
Lee Boushon	***Wisconsin Department of Natural Resources***
Tom Gilbert	***Wisconsin Department of Natural Resources***
Dave Lefebvre	***Green Bay Metropolitan Sewerage District***
Larry Landsness	***Wisconsin Department of Natural Resources***
Jack Saltes	***Wisconsin Department of Natural Resources***
Don Voigt	***Energenecs***
Tom Vik	***McMahon Associates, Inc.***
Dale Marsh	***Ayres & Associates***
Randy Chann	***Environmental Dynamics, Inc.***
Tim Dobyns	***Turblex, Inc.***
Bob Salmi	***City of Darlington***

Executive Summary

The objective of this **Water and Wastewater Industry Energy Best Practice Guidebook** is to provide information and resources to assist water/wastewater management and staff in identifying and implementing opportunities to reduce energy use.

The information in this guidebook will help managers, administrators and/or operators to identify opportunities to significantly reduce energy requirements at their facilities without affecting production. It also provides the user with information on the value and need for proactive energy management with water and wastewater systems.

Contents include:

- Benchmarking results from selected Wisconsin wastewater facilities
- Best practice approaches to on-going management of energy use
- Documentation of technical best practices for planning, designing and operating water/wastewater system treatment and for conveyance and distribution
- Best practice funding and financing opportunities
- References for further opportunities in water/wastewater system energy efficiency and power demand reduction

The **Guidebook** binder format provides a living document that can be updated continually with new Best Practices and Case Studies provided by the Focus on Energy program (and others) with direct input from water/wastewater industrial leaders. Focus on Energy also provides technical assistance and possible financial incentives to support the implementation of your energy efficiency measures. See the testimonial, below. We encourage you to call us at 800-762-7077 for more information on how Focus on Energy can help you reach your energy efficiency goals.

> *"In the past, energy was taken for granted and the prevailing thought was that "we can't do without it, so why spend time trying to manage it". That is not true today. Programs like Wisconsin's Focus on Energy are there to help us evaluate how we can manage energy usage and cost. We implemented energy efficient modifications because they proved not only to be a way to manage energy costs, but also, to the public, that we are using our financial resources wisely."*
>
> ***Daniel Busch***
> ***Green Bay Metropolitan Sewerage District***

INTRODUCTION

The primary goal of the water and wastewater industry has always been environmental stewardship to meet all applicable water quality standards. The industry has focused on earning and maintaining public trust by protecting the health and welfare of its communities. New, innovative, alternative technologies are approached cautiously within the water and wastewater industry for this reason. Likewise, incorporating energy efficient technologies and concepts into treatment processes usually is not a priority.

> ***"Working for a public entity, I am entrusted by the public to do my job cost effectively. We can cut our costs and not jeopardize effluent quality."***
>
> ***Bob Salmi***
> ***City of Darlington***

This challenge is often compounded by a general lack of knowledge about energy use and energy billing. Rarely do water or wastewater utility personnel even see their see their energy bills, let alone use the valuable information that detailed billing provides. Typically, energy bills are received and paid by the utility clerk or treasurer without facility staff who are responsible for energy use ever seeing them.

Since energy costs are a major component of a utility's operating budget, energy management should be a priority. Normally a utility reviews its energy costs annually and makes adjustments to meet the next years' rate increase without exploring ways to control or decrease energy costs. Energy costs are viewed as uncontrollable – a business cost that cannot be questioned or changed. However, if operation and management personnel become familiar with how their facility uses energy and get charged for it, they can find ways to manage and reduce energy costs.

> ***"An important part of successfully operating a WWTF is the management of energy. It should be a priority to have a good understanding of how you are billed and to run that facility in the most efficient and cost-effective way possible."***
>
> ***Jeremy Cramer***
> ***City of Adams &***
> ***City of Stevens Point***

The Focus on Energy Water and Wastewater Program was developed to support the industry because of the enormous potential to reduce energy use without compromising water quality standards. Through the program, numerous water and wastewater personnel have learned that energy use ***can be managed***, with no adverse effects on water quality. ***Most locations that have saved energy have found improved control and treatment.***

All water and wastewater treatment facilities can save energy. The improvements are often economically attractive – water and wastewater facilities typically see shorter paybacks on energy efficiency projects than their industrial counterparts due to their longer hours of operation. Also, these facilities are necessary public infrastructure and, therefore, have stable financial commitment for long-term viability. In addition, they will not (cannot) close or move to another community or country as can happen in private industry.

Energy Use in Wastewater Treatment and Collection Systems

Wisconsin has approximately 650 public and 360 private wastewater treatment facilities. A summary of the public facilities' sizes is presented in **Table 1** below.

Note that Wisconsin has many small facilities – approximately 85% of facilities treat less than one million gallons per day (MGD). Though they treat only 12% of the total flow, these numerous small facilities use about 24% of the total energy used to treat wastewater in the state, making them excellent candidates for energy efficiency projects.

The remaining facilities, over one MGD, process 88% of the wastewater. Because of their sheer size, even simple energy efficiency projects at these facilities can lead to tremendous savings.

Table 1

Flow Profile of Wisconsin Wastewater Facilities

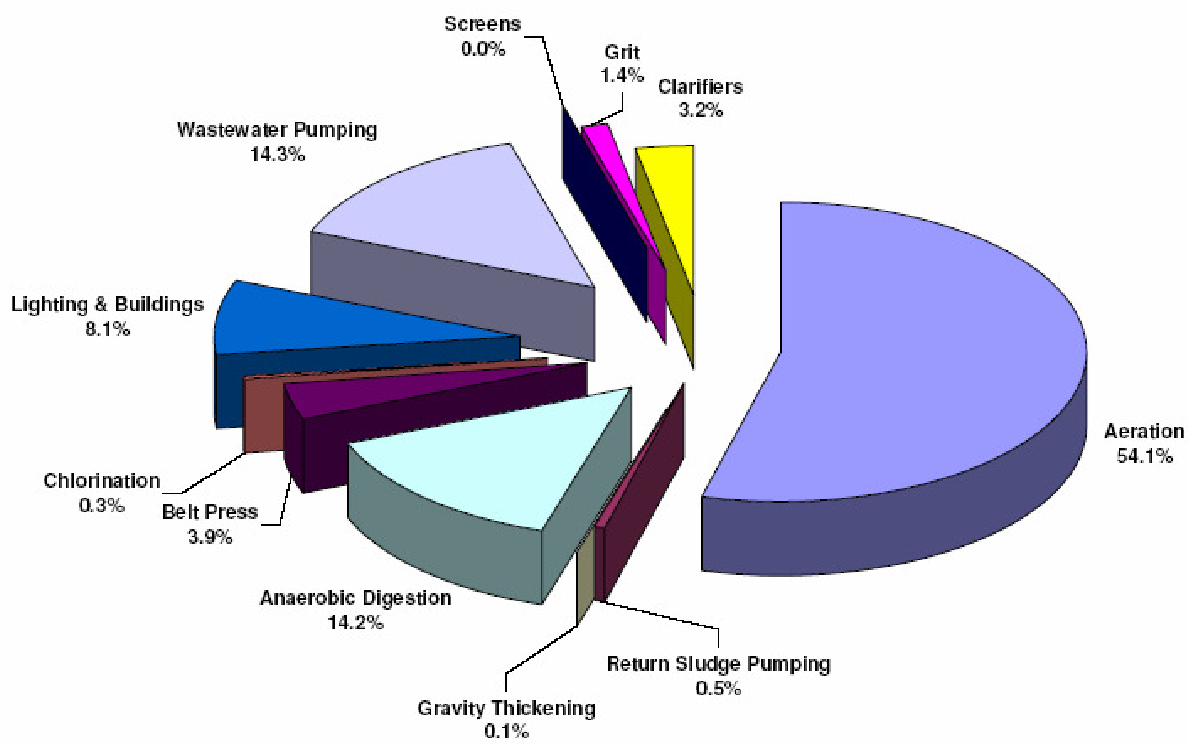
MGD	Number of Facilities	% of Facilities	Cumula-tive %	% of Average Design Flow	Cumula-tive %	Total Average Design Flow MGD
0 - 0.25	402	61.8	61.8	3.7	3.7	33.7
0.26 - 0.5	93	14.3	76.1	3.8	7.5	35.3
0.51 - 1.0	55	8.5	84.6	4.1	11.6	38.0
1.01 - 2.0	34	5.2	89.8	5.7	17.3	52.0
2.01 - 5.0	37	5.7	95.5	12.2	29.5	112.1
5.01 - 10.0	11	1.7	97.2	8.2	37.7	75.5
10.01 - 20.0	11	1.7	98.9	18.0	55.7	165.5
20.01 - 50.0	5	0.8	99.7	18.6	74.3	171.4
> 50	2	0.3	100.0	25.7	100.0	236.0
Total	**650**	**100**		**100**		**919.5**

On average, wastewater treatment facilities spend seven percent of their operating budgets on energy, according to the American Water Works Association Research Foundation (AwwaRF).[1] Regardless of size, the breakdown of energy end-uses at a wastewater facility remains consistent. All facilities have at least secondary treatment. **Figure 1** on the following page shows how energy is consumed at an activated sludge wastewater treatment facility, which represents the majority of Wisconsin wastewater systems.

[1] Manager's Guide for Best Practices for Energy Management, AwwaRF, 2003

The major energy user is the secondary treatment process, partially because this treatment component in this type of facility must operate continuously. Secondary treatment systems are often a good place to start to improve system energy efficiency since even small percentage efficiency improvements will result in significant savings.

Figure 1



Electricity Requirements for Activated Sludge Wastewater

Derived from data from the Water Environment Energy Conservation Task Force *Energy Conservation in Wastewater Treatment*

Energy Use in Water Treatment and Distribution Systems

Wisconsin consumes almost 400 million kilowatt-hours per year to produce drinking water (about $30 million).[2] Wisconsin's 581 drinking water systems, like their wastewater counterparts, vary greatly in size and process components. The 76 largest systems account for 75% of the energy used to treat water in Wisconsin, while the remaining 505 small facilities use 25%. On average, water treatment facilities spend 11% of their operating budgets on energy, according to the American Water Works Association Research Foundation (AwwaRF).[3]

Table 2 presents the average energy use rates for the various classes of drinking water utilities in Wisconsin[45]. It should be noted that one-fourth of Wisconsin's drinking water utilities use less than 1.0 kWh per 1000 gallons.

Table 2
Energy Use Rates at Drinking Water Utilities

Type	kWh/1000 gallons
Class AB (>4000 customers)	**1.51**
Class C (1000-4000 customers)	**1.85**
Class D (<1000 customers)	**1.89**
Surface water source (US)	**1.4**
Groundwater source (US)	**1.8**

Note: The energy rates for the three classes of utility include distribution losses and delivery to customers. The average water loss for the state is 11% of the water produced.

The magnitude of energy savings available will vary depending on the type of treatment and delivery system in use, the age and condition of the equipment in use and the capital available to implement major changes, if necessary. Surface water treatment systems typically have more available energy savings since more equipment is required for treatment. Also, they have extended hours of operation compared to groundwater treatment systems. However, both types of water treatment systems have the potential to save significant amounts of energy, largely due to the aging infrastructure of the industry. It is not unusual to find 40 and 50 year old pumps, motors and controls still in use. Over 90% of energy use for producing and delivering drinking water is for pumping.

Factors such as aging infrastructure, well recharge, well maintenance, well draw-down, local water quality and national/local security are likely to increase the need for improved treatment technologies, such as ozonation, membrane filtration and ultraviolet irradiation. These technologies are typically more energy intensive than conventional treatment. It is essential to address energy efficiency in planning and designing new plant and equipment.

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[2] Source for Class AB,C and D utilities in Wisconsin - "*Energy Use at Wisconsin's Drinking Water Utilities,*" Elliot, T., Zeier, B., Xagoraraki, I., and Harrington, G.; University of Wisconsin, 2002.
[3] Manager's Guide for Best Practices for Energy Management, AwwaRF, 2003.
[4] Same as #2.
[5] Surface and groundwater energy rates for the US derived from "*Water and Wastewater Industries: Characteristics and Energy Management Opportunities,"* Burton, F.L., Electric Power Research Institute, 1996.

ENERGY BASELINE

Focus on Energy conducted on-site surveys, established baseline energy use and recommended best practices for 85 wastewater treatment facilities in Wisconsin. Data derived from site surveys established **current energy use** (billing data from current operations) and **projected energy use** (projected consumption after recommendations are implemented) by the following indices:

- kWh/million gallons/year
- kWh/1,000 lbs BOD/year
- kWh/1,000 population equivalence/year

Baseline energy use is the actual energy use under current operating conditions, i.e., ***before*** new best practices are implemented. **Table 2**, below, shows the average baseline energy use per million gallons (kWh/MG) by treatment type and flow range from the facilities surveyed. Since some facilities like to see their performance in terms of pounds of biological oxygen demand (BOD) or population equivalents, these values are also included.

Table 2
Average Energy Use at Wisconsin Wastewater Facilities[6,7]

Treatment Type	Flow Range (MGD)	Number of Facilities Surveyed	kWh per Million Gallons	kWh per 1,000 lb of BOD	kWh per 1,000 Population Equivalent
Activated Sludge [8]	0 - 1	26	5,440	3,178	242,032
	1 - 5	14	2,503	1,426	88,465
	> 5	11	2,288	1,505	93,365
	All AS	51	3,954	2,258	162,934
Aerated Lagoon	0 - 1	15	7,288	4,232	262,569
Oxidation Ditch	0 – 1.2[9]	19	6,895	3,696	229,316

6 For a more detailed look at the variation of energy use across a given flow range and treatment type, see **Appendix C**, **Figures C1 – C5**.

7 The sample of facilities surveyed by Focus on Energy was not randomly selected and is not necessarily representative of all state facilities. The sampling included facilities that participated in Focus on Energy.

8 "Activated sludge" refers to diffused aeration, as differentiated from aerated lagoons and oxidation ditches which also rely on activated sludge treatment.

9 Eighteen of these facilities are under 0.7 MGD; the remaining facility was at 1.2 MGD.

ENERGY BENCHMARK

Typically an energy benchmark is an energy use target that a facility could achieve by implementing enough energy efficiency measures. There are many different types of benchmarks or targets for energy use such as the energy use of the best 25% or top quartile of all the facilities. The following illustrates how benchmarks are viewed within the industry and the benchmark approach that Focus on Energy uses.

Benchmarking is a term commonly used by energy managers. It has a variety of meanings including:

American Water Works Association Research Foundation (AwwaRF):

> *"**Benchmarking** is the process of identifying, sharing, and using knowledge and best practices. It focuses on how to improve any given business process by exploiting topnotch approaches rather than merely measuring the best performance. Finding, studying and implementing best practices provides the greatest opportunity for gaining a strategic, operational and financial advantage."*

American Water Works Association (AWWA):

> *A **benchmark** is "something that serves as a standard by which others may be measured or judged"*

Both definitions address the measurement of how well a system operates and how it compares to other similar systems. In this guidebook, we define a ***best practice benchmark*** as:

> ***"…the target energy use achieved after implementing all practicable energy best practices."***

Best Practice Benchmark

A special type of benchmark is a ***best practice benchmark***. Once a facility assessment that reviews the existing equipment and operations has been completed, a best practice benchmark can be estimated by subtracting the recommended best practice energy savings from the current energy use.

Focus on Energy performed an assessment of the sample facilities and determined the energy savings from applying best practices. Subtracting the average best practice energy savings from the average energy use values for each facility type and flow range provides the **Best Practice Benchmarks. Table 3** on the following page highlights these benchmarks for the three common Wisconsin treatment types: activated sludge systems for three different flow ranges, aerated lagoon systems and oxidation ditch systems. The values in the far right column show the amount of savings attainable from best practices, expressed as a percent.

Table 3
Best Practice Benchmarks and Top Performance Quartiles for Wisconsin Wastewater Facilities

Facility Type	Flow Range (MGD)	Average Energy Use (kWh/MG)	Top Performance Quartile (kWh/MG)	Best Practice Benchmark (kWh/MG)	Average Potential Savings [10]
Activated Sludge	0 - 1	5,440	< 3,280	3,060	44%
	1 - 5	2,503	< 1,510	1,650	34%
	> 5	2,288	< 1,350	1,760	23%
Aerated Lagoon	< 1	7,288	< 4,000 [11]	3,540	51%
Oxidation Ditch	< 1.2	6,895	< 4,000 [12]	4,320	37%

The table also shows the Wisconsin wastewater industry ***top performance quartiles,*** in terms of current energy use (see Appendix A for details). Top quartile values show considerable improvement over the industry average for each facility type. Another way to approach energy efficiency planning is by using the industry's top performance quartile as an energy use target. The top quartile represents a reasonable ***quartile target*** for each facility type and flow range. Facility operators can begin by comparing their energy use with the appropriate quartile target for a statewide average derived from Focus on Energy surveys. Doing so asks the question, ***"How do I compare to my peers?"***

When you establish your energy management plan, either the best practice benchmark or the top performance quartile is suitable to use. It is important to note that the top quartile demonstrates that some facilities are already performing at or near (sometimes even better than) the Best Practice Benchmark that was established by facility assessments.

Site data for both baseline energy use and benchmark energy use are graphically depicted in **Figures 2 – 6** on the following pages. These figures illustrate the variability within each type and flow range for both current energy use and energy savings potential. In each chart, the surveyed facilities are ordered from lowest flow to highest flow.

[10] Average Potential Savings % = (Average Energy Use - Benchmark Energy Use) / (Average Energy Use) x 100%
[11,12] These are approximations based on mid-point values between two facilities for each type.

For the following bar charts, use the line color code below:

Green line = average current energy use
Dark blue line = average best practice benchmark
Red line = top performance quartile

Figure 2

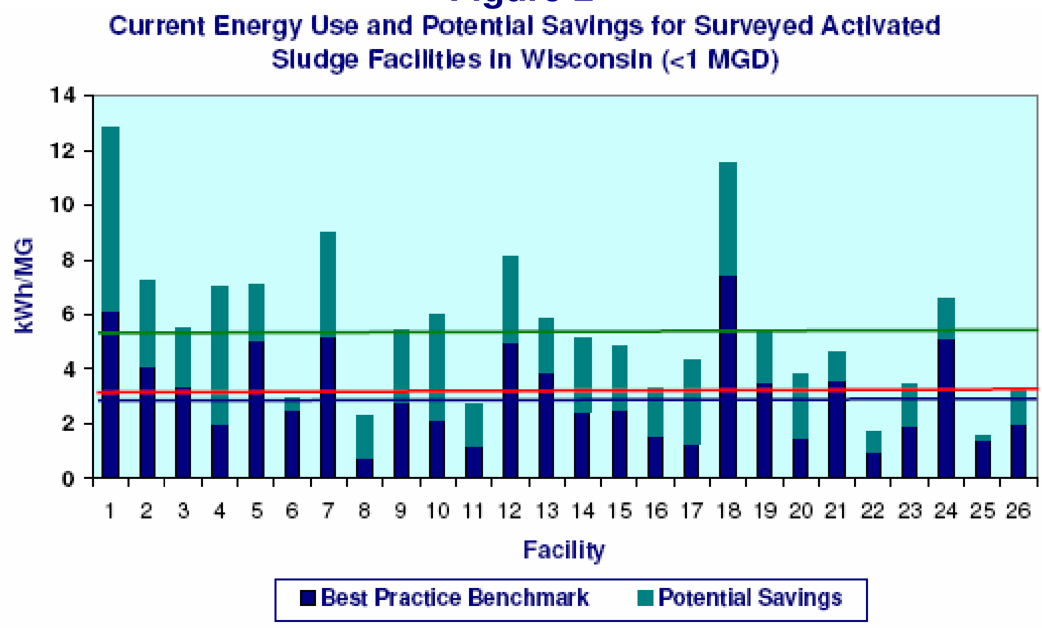
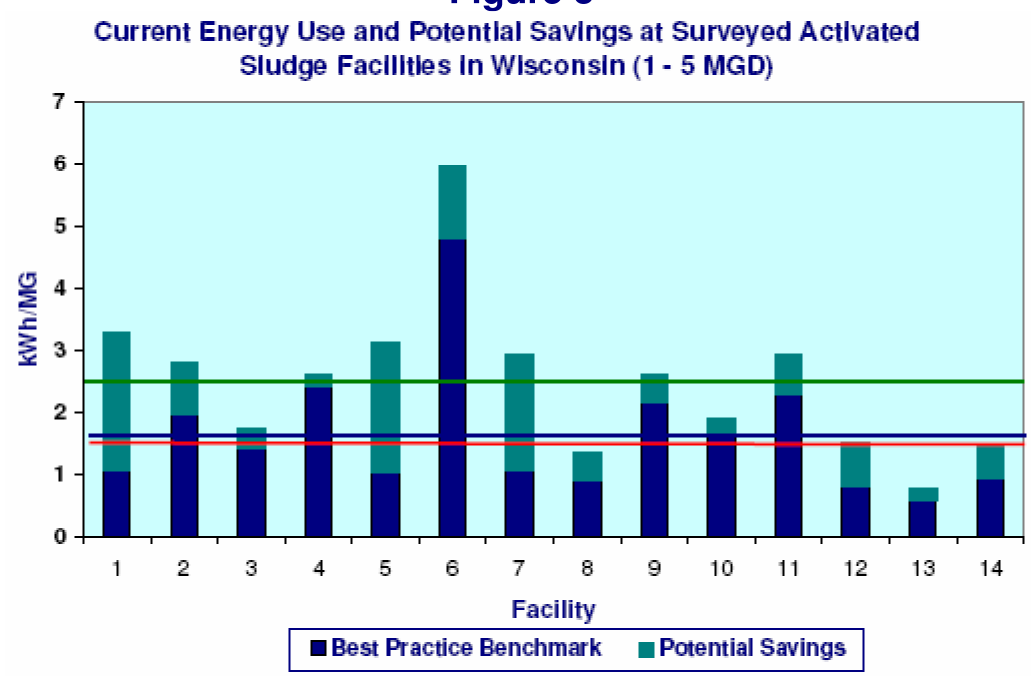


Figure 3



For the following bar charts, use the line color code below:

Green line = average current energy use
Dark blue line = average best practice benchmark
Red line = top performance quartile

Figure 4

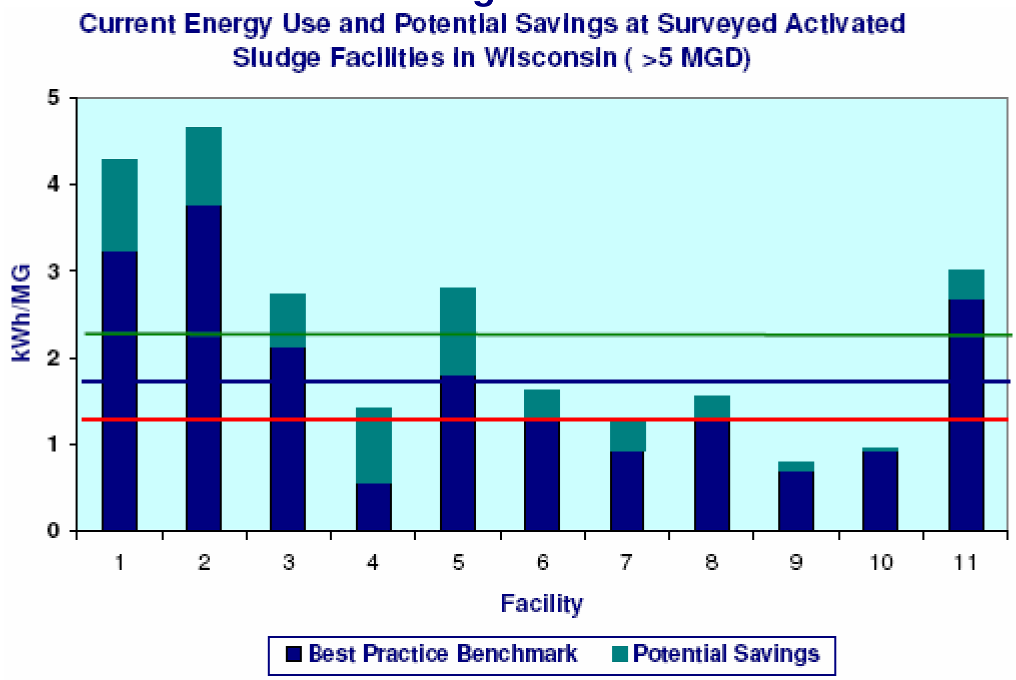
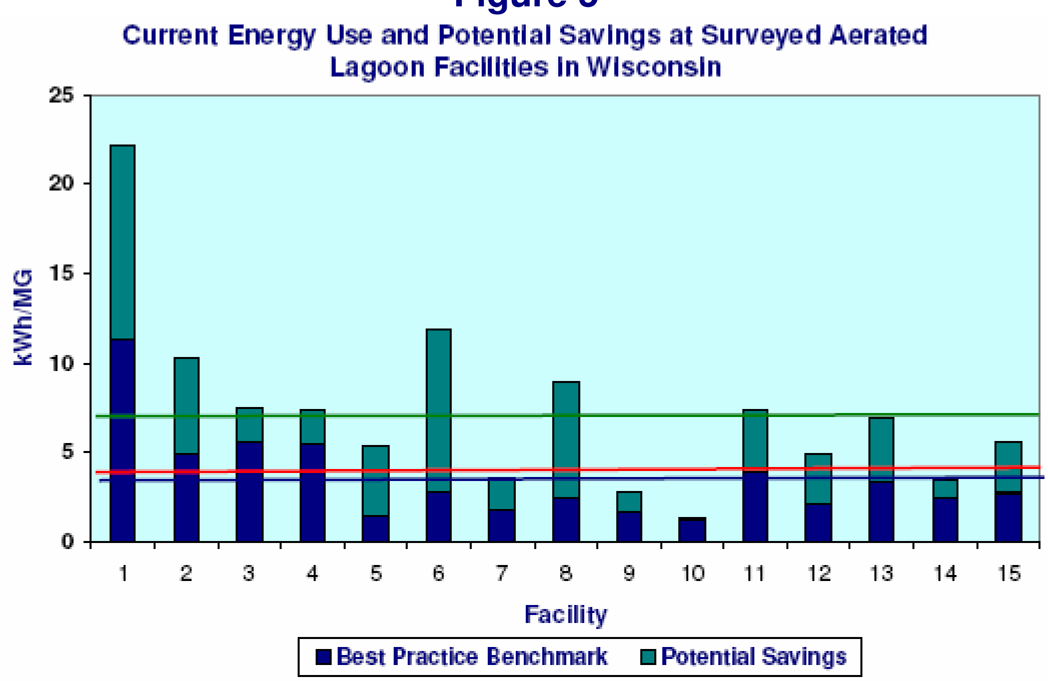


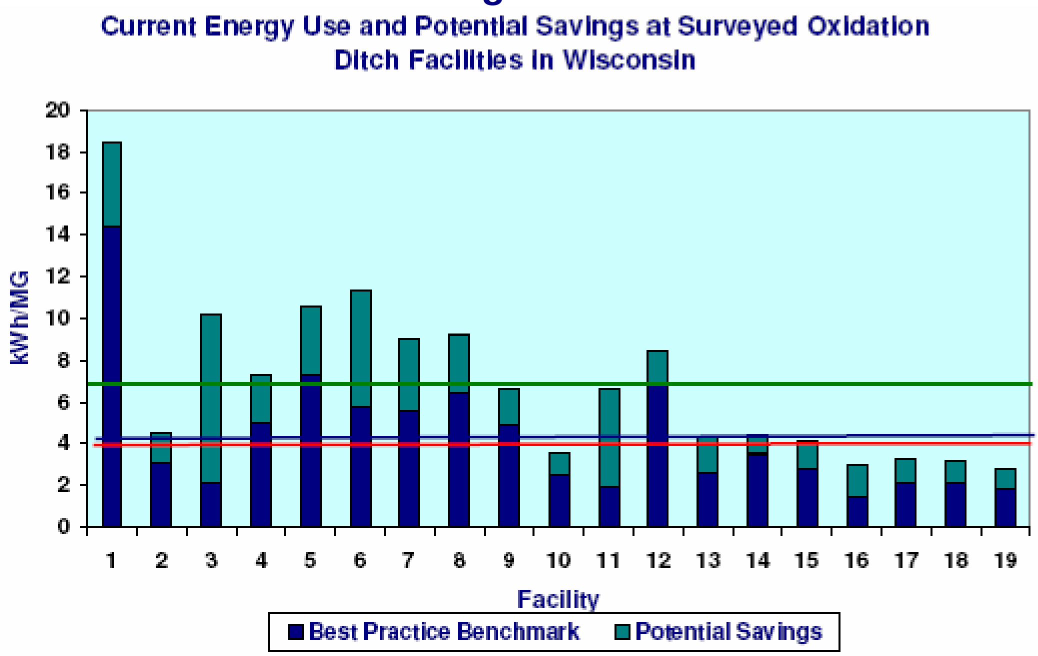
Figure 5



For the following bar chart, use the line color code below:

Green line	=	average current energy use
Dark blue line	=	average best practice benchmark
Red line	=	top performance quartile

Figure 6



MANAGEMENT BEST PRACTICES

A water or wastewater facility can more effectively manage its energy costs by conducting an internal survey, audit or assessment to identify energy saving opportunities and then implementing the best practices that will achieve the available savings. A plan for periodic review and continual improvement will ensure that energy efficiency opportunities are exploited. An energy management program provides a systematic approach to continually assess and reduce energy use and costs of your facility. An energy management program is proactive, not just reliant on "putting out fires" when energy costs increase.

An energy management program is not an energy improvement project (a one-time event), but an on-going process. It can be a standalone effort devoted exclusively to energy management or part of an existing management program such as quality or environmental assurance management. The most successful energy management programs are developed and maintained by a team of individuals from various functions such as administration, engineering, maintenance, operations, finance and management, or if the system is medium- or small-sized, periodic reviews by a specialist would be valuable.

At first glance, creating and implementing an energy management program may seem to be an overwhelming task that pulls your attention away from daily operations. Yet making an effort up front can save you time, money and energy in both the short- and long-term. This chapter will show the steps that will make developing a program easy. Once in place, your energy management program will deliver results year after year.

Energy efficiency is a good investment. Many energy efficiency projects provide a high return on investment (ROI) (as much as 100% or more) and are low risk. When compared to other investment opportunities, these projects can be very attractive. Typically you can achieve 10% to 30% energy cost savings in the first year by implementing a systematic energy management program. The following are the first steps to getting started with a systematic energy management approach and Focus on Energy can assist you with completing any of these steps. Focus on Energy has developed a set of tools called Practical Energy Management© that can make these steps even easier.

All procedures and figures in the following section are included on the CD with the Guidebook and are examples of tools included in the Practical Energy Management approach available for FREE to eligible Wisconsin facilities from Focus on Energy. Call 608-277-2946.

Steps to Begin

Step 1) Establish a Baseline Energy Use: Compile your last 12 to 24 monthly utility bills to develop an overall energy profile of your facility and put energy in the context of overall organizational operations by comparing it to more widely tracked measures such as flow (MGD), BOD or labor costs (see example in **Figure 10**). Next, develop your facility's **Energy Profile Summary**, showing changes in consumption and **Key Performance Indicators (KPI)** such as MWh/MG, by year (**Figure 11**). Then graph KPI for each month. This will set your present baseline for your energy use. Tracking this energy consumption over time provides an indication of the effectiveness of your energy efficiency efforts. Projecting usage forward provides a method to set targets and goals for energy use (see example in **Figure 12**). It can be useful to plot the energy use per month verses MG per month to show how the energy use changes with flow changes (see example in **Figure 13**). The y-intercept of the line fit to the data indicates the constant energy use of the facility with no flow. The slope of the line fit indicates variable energy use as flow changes. Both the constant energy use and variable energy use can be impacted by efficiency measures.

Step 2) Estimate Energy Use for Major Systems: Determine the energy used by major equipment and energy-using systems. This will point the way to your largest energy uses and the best places to focus your attention (similar to **Figure 1** above). Spreadsheets available on the CD under “Energy Use Profile” can also be used to estimate equipment energy use.

Step 3) Identify Best Practice Opportunities: Best practices are techniques or technologies generally recognized as being economical and more energy-efficient than common or typical practices. Review best practices in comparison to your existing equipment and system to identify opportunities for energy efficiency improvement. Recommended best practices for water treatment systems and wastewater treatment systems are provided in the **following sections**. These practices apply to system retrofits as well as to new system designs. A checklist of best practices is provided in each best practice section for your use to copy and “check off” each “best practice” that is deemed as considered, determined feasible or implemented. **Appendix D** includes a list of additional best practices for ancillary end uses, such as lighting and compressed air systems.

Step 4) Quantify Savings and Project Costs of Best Practice Opportunities: Once the best practice opportunities are determined, the next step is to estimate the cost savings associated with each project including energy and maintenance, and the installed cost of the modification. Focus on Energy can provide technical assistance to estimate projected energy savings for projects. Estimating tools for some standard best practices are available on the CD under “Best Practices”.

Step 5) Prioritize Projects: Apply criteria such as ROI, energy savings, associated process improvements or ease of installation to help you prioritize among all the possible energy saving opportunities identified. Select the projects that achieve the energy savings goals within time and budget constraints. The CD contains a spreadsheet to help prioritize projects under “Project Prioritization”.

Step 6) Project Management: Manage each identified energy project as you would any other project within your organization by clearly defining the project parameters, assigning responsibilities for the project implementation and undertaking specific tasks needed to implement the project. The CD also contains a spreadsheet to help manage projects under “Project Management”.

Figure 10
Clearwater Wastewater Treatment Facility

Electric Rate
$0.06

Month	MWh/MG	Consumption (MWh*)	Prod Units MG of Wastewater	Billed Demand (kW)	Total Electric Cost
Jan	6.88	330	48	320	$19,800
Feb	6.42	308	48	320	$18,480
Mar	6.22	336	54	360	$20,160
Apr	6.07	364	60	400	$21,840
May	6.14	387	63	420	$23,220
Jun	6.02	397	66	440	$23,820
Jul	6.06	400	66	440	$24,000
Aug	6.00	414	69	460	$24,840
Sep	5.71	394	69	460	$23,640
Oct	5.52	348	63	420	$20,880
Nov	5.67	340	60	400	$20,400
Dec	5.59	302	54	360	$18,120
AVG	6.02			400	
TOTAL		4,320	720		$259,200
5% GOAL	5.72				-$12,960

* One megawatt-hour (MWh) = 1000 kilowatt-hours (kWh)

Figure 11
Facility Energy Profile - Summary
(Does not include gas, water or other utilities that should also be tracked.)

Clearwater Wastewater Treatment Facility

Electricity	2005	2004	2003	% Change 2004 to 2005
Consumption (MWh)	4,320	4,500	4,872	-4.00%
Electrical Cost ($)	$259,200	$247,500	$243,600	4.73%
$ per MWh	$60.00	$55.00	$50.00	9.09%
Key Performance Indicators				
Millions of Gallons(MG/Yr)	720	740	761	-2.66%
MWh per MG	6.00	6.08	6.40	-1.37%
Electric $ per MG	$360.00	$334.60	$320.19	7.59%
Business Indicators				
Operating Costs	$2,700,000	$2,750,000	$2,800,000	
Electricity as % Oper. Costs	9.60%	9.00%	8.70%	

Figure 12
Electric KPI Goal and Tracking

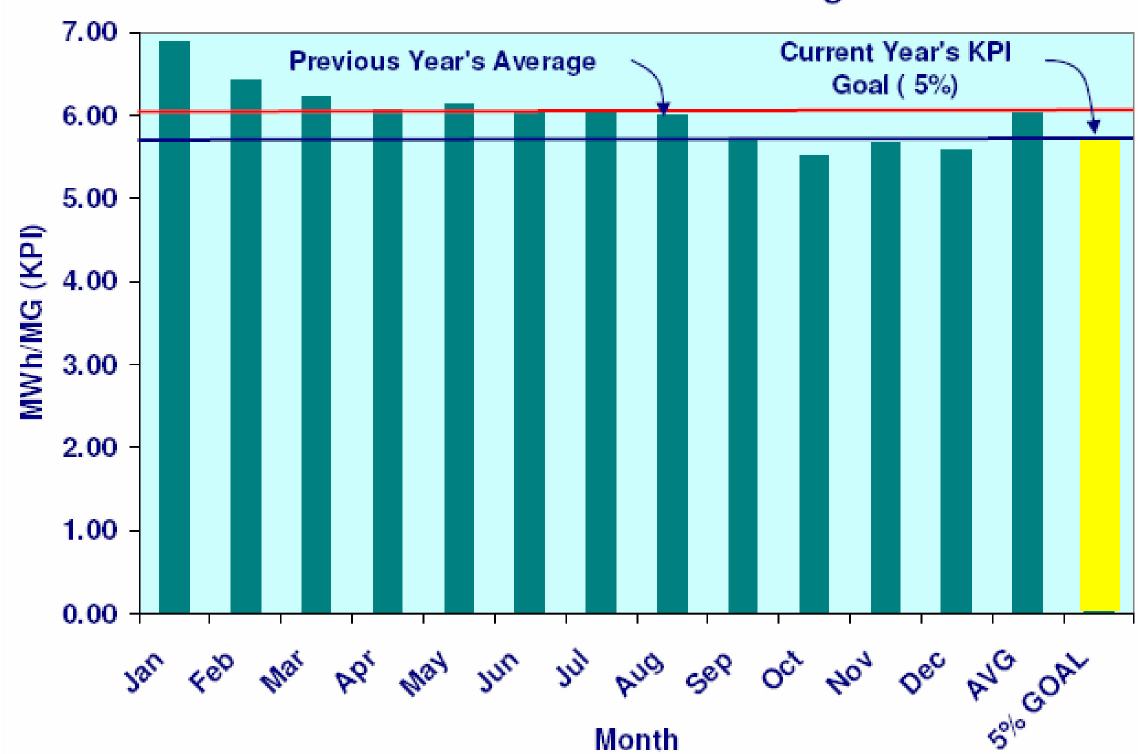
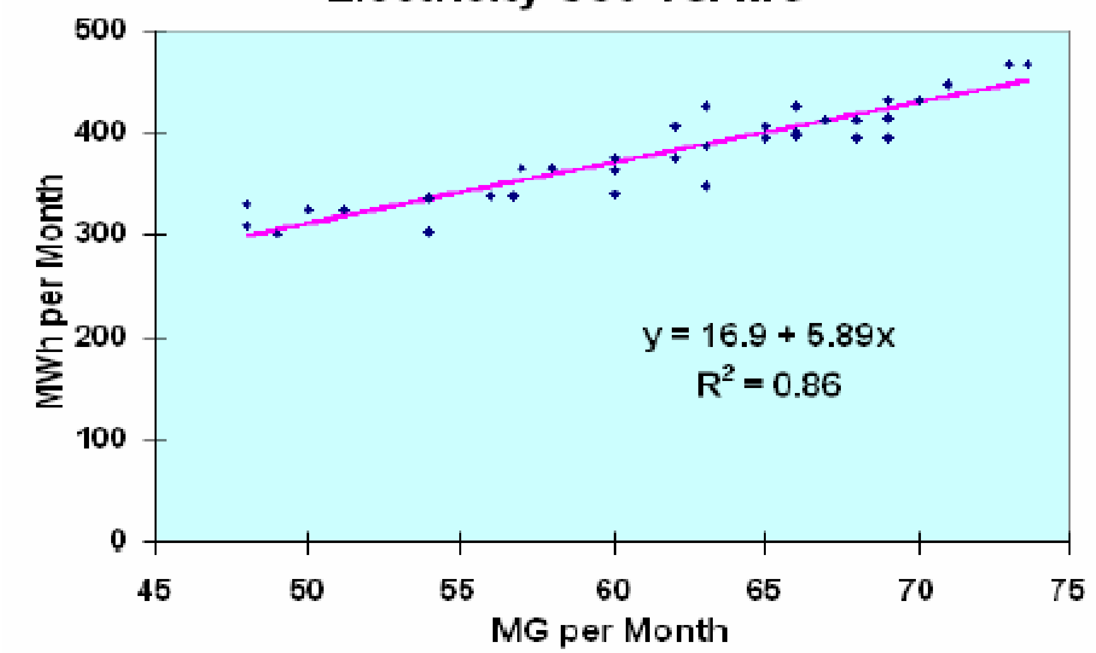


Figure 13
Electricity Use vs. MG



Steps for Ongoing Energy Management

Step 1) Strong commitment from Management: Critical to the success of long-term energy management is a strong commitment from the operations, administration, management and governing personnel. Without this, the time spent on other steps may not significantly enhance energy efficiency.

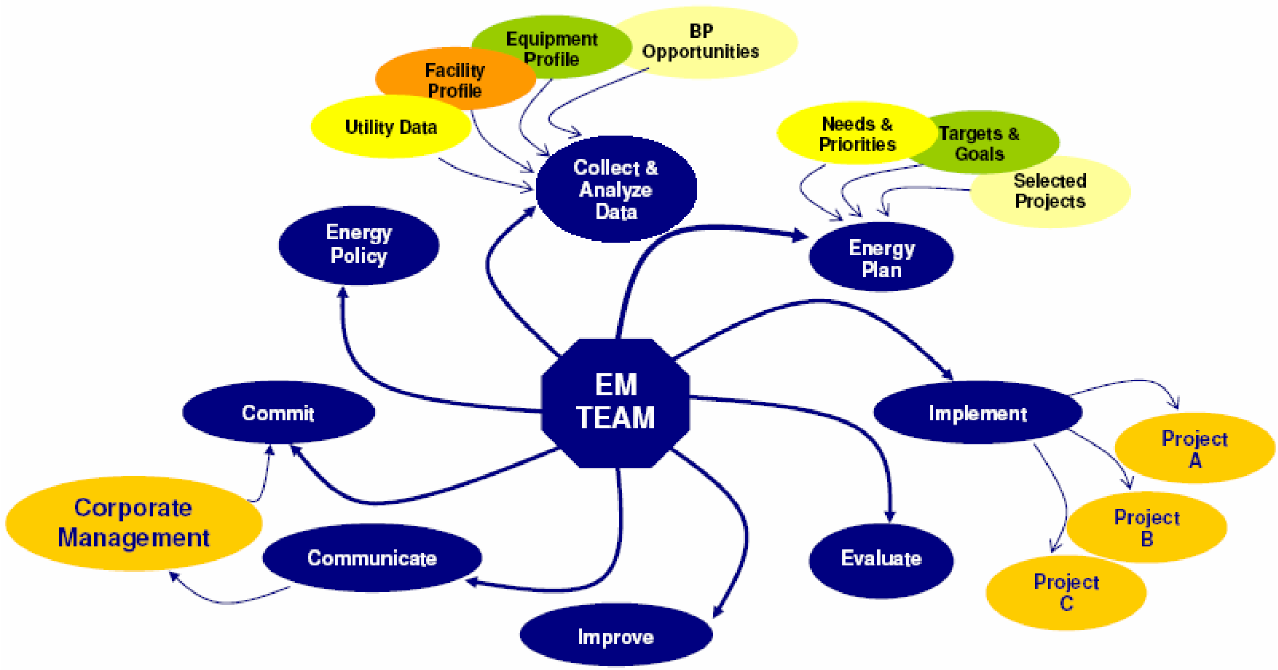
Step 2) Track Energy Saving Performance: An energy usage value per unit (flow, BOD, PE) provides you a measure of energy use per a critical factor. Tracking these values over time provides an indication of the effectiveness of your energy efficiency efforts. Projecting your forecasted savings forward provides a method to set targets and goals for energy use.

Step 3) Form an Energy Team: An energy team formed from personnel in operation, maintenance, administration, management, financing and governing. This team should meet periodically as needed to review progress on the energy management plan and set new direction as necessary to reach established goals.

Step 4) Develop a Long-Term Energy Management Plan: The first task for the Energy Team will be to develop a long-term Energy Management Plan. The plan should define the goals, tasks and responsibilities for implementing and operating an energy management program within your facility. You can use the best practice benchmark or the top quartile value from **Table 4** of the **Benchmarking** section for your type of facility and flow range as a benchmark target for your energy management plan. The values in the right hand column represent reasonable benchmark targets for the highest achievable energy savings for each type and size of facility. You should also inform project and facility designers of your energy use goals to ensure consistency with the plan. Proper design and installation up front are less expensive that after-the-fact retrofits. Your specific energy management plan should define the necessary level of performance for all processes and show how all treatment processes will work together to achieve effective and efficient treatment. In addition, Focus on Energy suggests that you review the **Wisconsin Department of Natural Resources Code's Energy Considerations** in **Appendix B** for additional information to help you with your energy management plan.

Step 5) Establish a System for Continual Improvement (Figure 14) Maintaining an effective energy management program requires management commitment, ongoing project planning and implementation, and communication of program and project results. To the extent possible, integrate the administration of the energy management program with existing management programs such as quality control and safety or environmental management.

Figure 14 – Continual Improvement Cycle



Energy Management in the Real World

Wisconsin's water and wastewater industry has abundant opportunities for saving energy 24 hours per day, 365 days per year. However, many managers, operators and designers of water/wastewater systems are skeptical about energy savings potential, especially at their own facilities. Typical comments are:

> "*I bet you can't find any energy savings at my facility.*"
>
> *"I know there are no energy savings available at my facility because I already have fine bubble diffusers."*
>
> *"When I became Superintendent that motor was running, so I keep it running even though I don't know what it does."*
>
> *"The Mayor told me I have to use the equipment we already have because we paid for it."*
>
> *"Why modify anything? The system has run this way since start up and we are meeting our discharge limits."*
>
> *"Energy management is not required, why bother?"*

In spite of these sentiments, the Focus on Energy Program has been able to identify tremendous energy saving potential and help facilities receive grants for project implementation. Focus on Energy currently has approximately 150 water and wastewater partners representing a variety of facility sizes – from 30,000 gallons per day to 32 million gallons per day. These treatment systems have a range of characteristics as shown in **Table 6**.

Table 6
Characteristics of Wisconsin Wastewater Treatment Facilities Served by Focus on Energy

FUNCTION	CHARACTERISTICS
Activated Sludge	▪ Fine-Bubble Aeration ▪ Coarse-Bubble Aeration ▪ Package Plants ▪ Custom Designs ▪ Manually Controlled Aeration ▪ Municipalities ▪ Industrial Sites ▪ New Facilities (< 1 year old) ▪ Existing Facilities (last upgrade 30+ years ago)
Oxidation Ditches	▪ Disk Aerators ▪ Paddle Aerators ▪ Brush Aerators
Aerated Lagoons	▪ Surface Aeration ▪ Subsurface Aeration
Rotating Biological Contactors (RBCs)	▪ Mechanical Drive ▪ Air Drive ▪ Mechanical Drive with Air Assist
Aerobic Digestion	▪ Diffused Aeration (Coarse- and Fine-Bubble) ▪ Mechanical Aerators ▪ Surface Aerators ▪ Submersible Mixers
Anaerobic Digestion	▪ Gas Mixed ▪ Mechanically Mixed ▪ Single-Stage ▪ Two-Stage
Biogas	▪ Beneficial Utilization ▪ Power Generation ▪ Heating ▪ Biogas Analysis ▪ Biogas Conditioning
Pumping	▪ Raw Sewage ▪ Final Effluent ▪ RAS/WAS (Return Activated Sludge/Waste Activated Sludge) ▪ Constant Speed ▪ Variable Speed

Energy savings generally range from 20% to 40%. However, some facilities have been more aggressive and have cut nearly 75% from their pre-program participation energy use. General findings from facility surveys completed by Focus on Energy include:

- All facilities have energy saving opportunities regardless of size
- Savings generally ranged from 20% to 40%, even reaching 75%
- Aeration systems provided opportunities for the greatest savings
- Simple modifications to equipment and/or operation can result in significant demand savings
- Proactive operations can achieve additional savings
- Beneficial use of biogas is available
- When facility operators become aware of energy, energy management follows
- Continuing education and training in energy management are necessary and useful

A few of the common energy saving measures have included:

<u>Aeration Systems</u>
- Blowers
- Diffusers
- Controls
- Motors

<u>Pumps</u>
- Capacity
- System Assessment
- Motors
- Drives

<u>Miscellaneous</u>
- VSDs
- Automatic Controls
- Operation Changes

Examples of Energy Management Results

Sheboygan Regional Wastewater Treatment Facility:

The Sheboygan Regional Wastewater Treatment Facility has undertaken several energy efficiency projects over the past several years, often using the many resources available through the Focus on Energy program. According to Dale Doerr, Manager of the utility:

> *"When it comes to energy use and energy conservation, we do control our destiny. While we do not control what the power companies charge, we can control the quantity we use or when we use it. We approach all projects with that thought in mind – is there an opportunity to reduce our energy requirements. It may cost more upfront, but if we can reduce our use at a reasonable cost we will take advantage of that opportunity.*
>
> *Our energy conservation program began several years ago when we decided to make improvements to one of our wastewater pump stations. Since we were going to replace pump motors and drives, we decided to look at the project from an energy management perspective. The energy savings opened our eyes to the savings available in future projects if we decide from the beginning to include energy savings as a primary consideration when defining the project's scope. Projects that we implemented and the energy savings are listed below.*

- **Kentucky Wastewater Pump Station – energy efficient motors and VFDs**
  Completed: December 2004
  Project Cost: $150,000 (2 – 125 hp Premium Efficiency Motors @ $8,945 each)
  The Focus on Energy grant of $6,142 helped offset the higher cost for the premium efficiency motors. The energy savings for the first year exceeded $12,000. The average monthly reduction in kilowatt hours for the first 10 months of operation was 6,595 kWh.

- **Wastewater Treatment Plant Aeration System Blower Replacement – two high efficiency blowers and motors**
  Completed: December 2005
  Project Cost: $750,000 (2 – high efficiency blowers and premium efficiency motors @ $454,000 total) The Focus on Energy grant for this project was $17,000. The new blowers and motors reduce energy use by 752,000 kWh (about $26,000 in energy cost savings) per year.

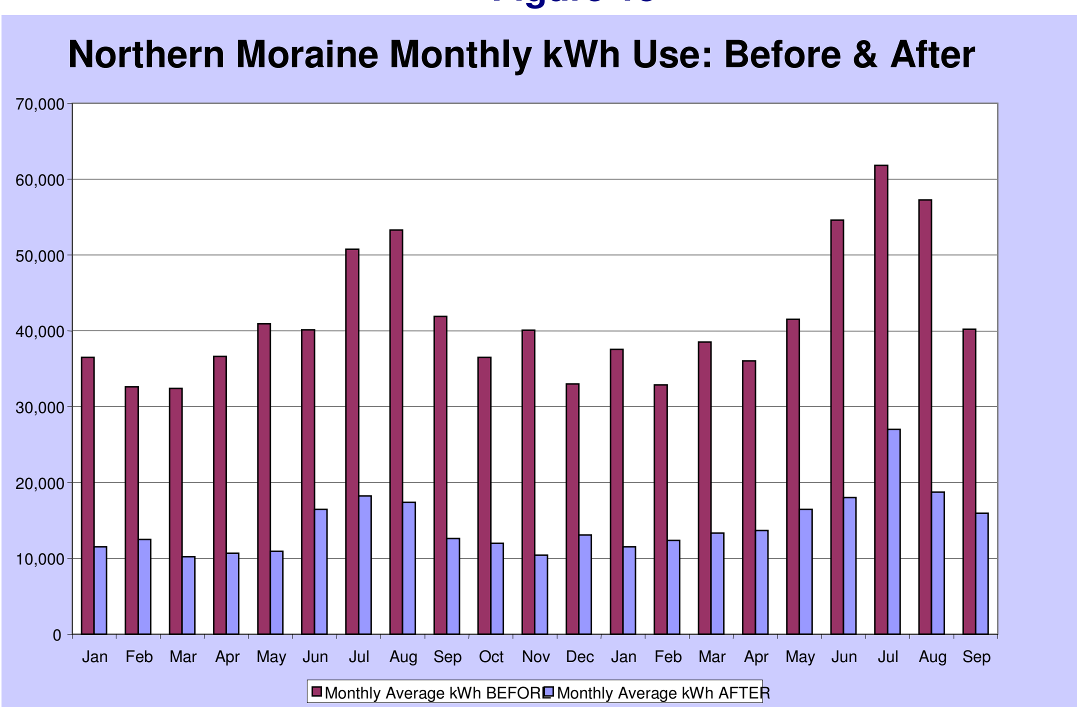
- **Wastewater Treatment Plant Influent Pump Station Motor Replacement – two premium efficiency motors with VFDs**
  Completed: January 2006
  Project Cost: $170,000 (2 – 200 hp Premium Efficiency Motors @ $22,882 each) The Focus on Energy grant for this project was $3,861. The new blowers and motors reduce energy use by 157,000 kWh (over $5,300 in energy cost savings) per year.

- ***Wastewater Treatment Plant Cogeneration Project – 10 – 30 kW Capstone micro-turbines to produce electricity using methane from anaerobic digestion***
  Completed: January 2006
  Project Cost: $1,100,000 (10 – 30 kW micro-turbines with heat recovery)
  The Focus on Energy grant of $65,000, including $45,000 for the electricity savings and $20,000 for thermal energy savings. The electrical cogeneration portion of the project produce 2,300 megawatt-hours of electricity annually (about $78,000 in energy cost savings per year). The thermal energy portion of this project produces 84,000 therms of heat, valued at over $60,000 per year at today's rates.

Northern Moraine and Other Facilities:

Many other water and wastewater utilities throughout Wisconsin have undertaken energy efficiency projects and energy management planning. **Figure 15** provides a graphic before and after comparison of one utility's (Northern Moraine) energy use that shows how much energy can be saved through energy efficiency. See **Appendix E, Figures E-1 through E-6** for more examples of utilities that have saved significantly on their energy costs since working with Focus on Energy.

Figure 15



TECHNICAL BEST PRACTICES

The water and wastewater industry best practices included in this document were compiled and/or developed by the members of the Energy Guidance Committee responsive to literature reviews, personal experience and interviews with facility personnel.

The following subsections divide the currently identified best practices into:

- **Water Supply**
- **Wastewater Treatment**
- **General Facility** (both Water and Wastewater)

An index to the best practice summaries is provided at the beginning of each best practice section. The number assigned to an individual best practice has no significance as a ranking or priority. In most cases resources for additional information are provided.

A **checklist** for the best practices currently identified for each category is found following the index at the beginning of each best practice section. The checklists provide a way for you to ensure proper consideration of each. The checklist indicates the area of the facility and provides a rough estimate of the payback period for each best practice. The best practices in this section deal primarily with process energy use as typically implemented in the water and wastewater industries.

Additional best practices for common support systems found at most facilities, such as heating, ventilation, lighting and compressed air systems, are located in **Appendix D**.

Water Supply Energy Best Practices

#	TITLE
1	Automate to Monitor and Control
2	Integrate System Demand and Power Demand
3	Computer-Aided Design and Operation
4	System Leak Detection and Repair
5	Pump Discharge Throttling
6	Manage Well Production and Draw-down
7	Sequence Well Operation
8	Promote Water Conservation
9	Sprinkling Reduction Program
10	Manage High Volume Users

Checklist for
Water Supply Energy Best Practices

Best Practice Analyzed? (Date)	Further Review Needed? Yes/No	Best Practice Possible? Yes/No	Area	#	Title	Typical Payback
			All	1	Automate to Monitor and Control	Variable
			All	2	Integrate System Demand and Power Demand	Variable
			All	3	Computer-Aided Design and Operation	Variable
			Distribution	4	System Leak Detection and Repair	Variable
			All	5	Pump Discharge Throttling	Variable; ~ 1 year
			Wells	6	Manage Well Production and Draw-down	Short; with VSD- longer
			Wells	7	Sequence Well Operation	Short
			Customers	8	Promote Water Conservation	Variable
			Customers	9	Sprinkling Reduction Program	Short
			Customers	10	Manage High Volume Users	Short

Water Supply 1 – Automate to Monitor and Control

Best Practice	Use automatic controls where possible to monitor and control system functions to optimize energy consumption and production demands.
Primary Area/Process	Automatic controls apply to many aspects of water and wastewater treatment processes.
Productivity Impact	Minimum impact after installation. In many cases control systems can improve system performance.
Economic Benefit	Payback varies significantly depending on the complexity of the controls added.
Energy Savings	Typically, energy savings result from the ability to match equipment performance to the demands on the system. Variable frequency drives are an example of this.
Applications & Limitations	Control technologies vary from simple applications, such as time clocks to prevent large equipment from operating during peak rate periods, to complex systems like filter backwash monitoring, that controls equipment operation based on a number of variables, or automatic monitoring of dissolved oxygen integrated with controlling blower speed.
Practical Notes	Care should be taken in the design and installation of any automatic control system to ensure that the system will operate as necessary to meet operational requirements, especially in emergency situations. Make sure that system components needed for emergency situations are available. Look for vendors with process and controls experience to optimize the entire system.
Other Benefits	The use of automatic control systems to monitor a facility may lead to a more in-depth understanding of facility operations.
Stage of Acceptance	Acceptance of automatic controls in the water and wastewater industry is increasing with simple applications being viewed as "safer" and more complex applications slowly gaining acceptance.
Resources	American Water Works Association Pump Systems Matter, Hydraulic Institute, http://www.pumpsystemsmatter.org/ Europump, http://www.europump.org/ Water Environment Federation

Water Supply 2 – Integrate System Demand and Power Demand

Best Practice	Evaluate current system demand (user water consumption) and electric power demand. The analysis should address residential, commercial, institutional, and industrial usage and required fire flow. Utility staff should direct new system designers to incorporate energy best practices to reduce electric demand for well pump systems and booster pump stations. Consider the feasibility of applying variable speed drives and electric power monitoring and demand controls to keep power demand charges low.
Primary Area/Process	All components of water treatment and distribution systems.
Productivity Impact	Production is assumed to improve for either a new system or retrofit.
Economic Benefit	The estimated payback will vary with improvements and comparison with a base alternative.
Energy Savings	The potential savings will vary with the type of modifications being considered.
Applications & Limitations	There are no limitations on this practice because comprehensive planning should occur prior to the development of any improvement project.
Practical Notes	Careful planning can decrease capital costs by ensuring that system improvements are appropriate and new/retrofit equipment is compatible with existing system components.
Other Benefits	Improved production scheduling. Potential for environmental compliance. Lower utility costs mean lower customer bills and more satisfied customers.
Stage of Acceptance	Careful planning of system improvements has long been a hallmark of the water industry. This practice merely builds on this idea by incorporating the goal of energy efficiency.
Resources	A number of consultants to the water industry are available to assist with analysis and design. Also, consult with your local electricity provider.

Water Supply 3 – Computer-Assisted Design and Operation

Best Practice	Develop a computer model of the water utility to demonstrate the impacts of proposed improvements to the distribution system. A model can evaluate the impacts on the distribution system from changes in pipe size, pumping rates, pump operating point, system pressure, location of booster pumps, location of storage and variable flow rates. Adjusting system pressures, pump rates, pump operating points and operational sequence can cut energy use.
Primary Area/Process	All water distribution systems.
Productivity Impact	No impact on operation or production. Tests may be necessary to calibrate the model to actual field conditions.
Economic Benefit	Payback will be a direct function of the identified opportunities for energy savings. Payback benefits begin when the model is used to select energy efficient practices.
Energy Savings	The potential energy savings will vary with type of modifications being considered.
Applications & Limitations	This measure can benefit even for small systems with minimal infrastructure. System pressure must always be high enough to meet customer demand and fire flow.
Practical Notes	Many computer models are available. The model should address both static and dynamic conditions. The analysis should include the startup flows and progress to the design flow capacity, usually a 20 year projected flow with a peaking factor to identify the range of flow(s) and head conditions required to efficiently meet design conditions. Look for user friendliness and expandability to allow the model to change and grow with the system. Perform analyses prior to new construction to minimize capital costs and ensure the best long-term decisions.
Other Benefits	Helps document and justify infrastructure and operations decisions to management. Also provides data for annual reports and information needed for asset management.
Stage of Acceptance	Use of modeling technology for operations optimization is well received and widely accepted by the industry.
Resources	American Water Works Association US DOE, Hydraulic Institute, Pump Systems Matter http://www.pumpsystemsmatter.org/ Europump, http://www.europump.org/

Water Supply 4 – System Leak Detection and Repair

Best Practice	Review your facility's annual Public Service Commission water reports to determine the amount of water that is unaccounted for. If the amount exceeds "typical" losses for similar facilities, use leak detection and repair to reduce pumping energy requirements and save water.
Primary Area/Process	Throughout all water distribution systems.
Productivity Impact	There may be minor disruptions during repair and disinfection of the section to be repaired before placing it back into operation.
Economic Benefit	Payback varies considerably depending on the size and complexity of the distribution system and the extent of any required repairs. Payback periods tend to be longer than for many energy efficiency projects since the energy savings may be small compared with the cost to repair the leak. The economics should also consider the value of lost water.
Energy Savings	Potential energy savings will vary with number and severity of leaks, and with system pressure.
Applications & Limitations	All distribution systems.
Practical Notes	The amount of energy saved is small relative to the cost of repairing leaks in water mains because excavation in paved areas is expensive.
Other Benefits	Saving water, a limited resource.
Stage of Acceptance	Leak detection and repair is standard practice in the industry, but viewed as routine maintenance rather than as an energy efficiency practice.
Resources	American Water Works Association

Water Supply 5 – Pump Discharge Throttling

Best Practice	Modify operation of system to eliminate the use of throttling valves to control the flow rate from pumps. Consider energy efficient variable speed drive technologies, such as variable frequency drives (VFDs). See also **General Facility 2 – Variable Speed Technologies** and **Appendix F**.
Primary Area/Process	This technology is most often applied to well and booster pump discharges.
Productivity Impact	None.
Economic Benefit	Payback varies by application and may be less than one year if pump run time is high and valve closure is significant. However, the savings can be as low as 15% of total energy consumption if the pump has low hours of operation and the throttling valve is minimally closed.
Energy Savings	Energy savings can exceed 50% of pumping energy in some cases. Actual savings depend on the amount of closure of the throttling valve.
Applications & Limitations	All locations currently using valves to control flows.
Practical Notes	A detailed evaluation should be completed to identify the potential energy savings for each installation considering a variable frequency drive.
Other Benefits	Ability to quickly and easily adjust flow as changes they occur in the distribution system. Reduced pump wear, longer service life, and lower maintenance.
Stage of Acceptance	The industry accepts the use of variable speed drives to replace throttling valves in order to save large amounts of energy.
Resources	Hydraulic Institute, Pump Systems Matter, http://www.pumpsystemsmatter.org/ Drive manufacturers' websites.

Water Supply 6 – Manage Well Production and Draw-down

Best Practice	Monitor, compile and review the physical characteristics and operations of each well, including pumping rates, recharge capabilities, draw-down and recharge areas. Develop a performance chart that presents historic and current conditions. Use this information to optimize the operation and planning of pumps, motors and the control system. Particularly, monitor well draw-down during pump operation to detect any production changes over time. Diminishing production may expose pump failure, which may lead to additional major mechanical problems. The water level may also drop to a point where pumping is inefficient.
Primary Area/Process	All water systems with wells.
Productivity Impact	Impact only during installation, if new equipment is necessary. Failure of pumps or excessive draw-down would eventually lead to impact on production anyway.
Economic Benefit	A short payback is possible if equipment is in place and only requires adjustment. If new equipment, such as VSDs are required, the payback period will increase.
Energy Savings	Varies widely with the characteristics of each specific site.
Applications & Limitation	Monitored operations data helps establish the "best point" for operation and makes the system more efficient. Some utilities may require the assistance of an external consultant.
Practical Notes	A strong maintenance program, coupled with monitoring and review, will always provide energy savings. Keeping a log of changes will also support system planning.
Other Benefits	Many additional benefits may accrue: ▪ Lower stress on system ▪ Reduced pumping rate ▪ Reduced electric peak demand charge ▪ Allows for scheduled, rather than emergency maintenance, of well pumps ▪ Makes fluctuations in the aquifer more predictable ▪ Fewer surprises and emergencies
Stage of Acceptance	Widely accepted in the water industry; however, many utilities do not realize the value of monitoring the condition of equipment and how it supports planned, preventive maintenance and avoids emergency maintenance.
Resources	American Water Works Association

Water Supply 7 – Sequence Well Operation

Best Practice	Compile and review all information available on each well. Observe the functional characteristics and the production capability of each well, noting that many wells are brought on line with equipment sized to achieve full capacity production, which may not be necessary. From this data identify the proper sequence of operations, beginning with the most energy efficient well and ending with the least energy efficient.
Primary Area/Process	Water supply and distribution systems that are served by groundwater (wells).
Productivity Impact	This practice should have no impact on productivity.
Economic Benefit	Paybacks are typically short because the practice requires a low-cost adjustment in procedures, rather than a capital investment.
Energy Savings	Savings vary from system to system depending on the condition of existing equipment and current operations.
Applications & Limitations	None, except for where potential water quality and/or distribution differences may require using one well instead of a more energy efficient one.
Practical Notes	This practice is easy to address since the data required to perform the analysis is already required for the annual Public Service Commission report.
Other Benefits	Utility personnel can more accurately gauge the upper limits of well production and system flexibility.
Stage of Acceptance	Widely accepted by the industry. However, only a small number of utilities have adopted this practice. Its value is not yet generally understood.
Resources	American Water Works Association

Water Supply 8 – Promote Water Conservation

Best Practice	Reducing water consumption on the customer side reduces the energy needed to treat and distribute water. Assess water conserving plumbing fixtures and appliances and promote them within the community. Target all customer classes - residential, commercial, institutional and industrial.
Primary Area/Process	All water utility customers, especially new construction and renovations requiring permits.
Productivity Impact	None.
Economic Benefit	Payback depends on campaign effectiveness and the number of fixtures replaced.
Energy Savings	Savings will depend on the number and types of fixtures and appliances that are replaced.
Applications & Limitations	All new construction and any renovations requiring permits.
Practical Notes	Develop a list of manufacturers that make water conserving fixtures and appliances and make it available to all that inquire. The utility could also consider providing incentives to encourage water conservation.
Other Benefits	Saving water, a limited resource. Also, helps consumers adjust to long-term water conservation without major impact on their lifestyle.
Stage of Acceptance	Water conserving fixtures and appliances are widely accepted in the industry and by consumers.
Resources	American Water Works Association Water Environment Federation Focus on Energy Residential Program

Water Supply 9 – Sprinkling Reduction Program

Best Practice	Establish a customer program that manages lawn sprinkling to avoid peak time water consumption and minimize duration of sprinkling. Automatic sprinkler systems have been shown to have a major impact on water use. Promoting this technology may help win public support.
Primary Area/Process	Residential water consumption/water distribution systems.
Productivity Impact	None. May have beneficial impact by reducing well draw-down during dry times.
Economic Benefit	Payback period will be very short, if not immediate, and begins when customers reduce their consumption.
Energy Savings	Potential energy savings, derived from reduced pumping costs, will vary with customers' lawn sprinkling habits.
Applications & Limitations	While there are no physical limits regarding sprinkling regulations, gaining customer cooperation and enforcing the regulations are real challenges.
Practical Notes	The utility must assess summer use and the potential to affect peak summer water consumption through rules that regulate time and duration of lawn sprinkling. The effort requires an information campaign backed up with enforcement. . The water utility can also consider providing guidance for landscaping practice to reduce irrigation requirements (xeriscaping).
Other Benefits	Saving water, a limited resource. Reduce well draw-down.
Stage of Acceptance	The effectiveness of this practice is widely understood and accepted. However, public approval can be a challenge since restricting lawn sprinkling may be viewed as an infringement of personal rights.
Resources	American Water Works Association

Water Supply 10 – Manage High Volume Users

Best Practice	Meet with the top four water users in your system to identify potential modifications to their operations that may reduce their water consumption and, consequently, save energy.
Primary Area/Process	Water distribution system.
Productivity Impact	No impact on the water utility. Any disruption during implementation would take place at the customers' facilities.
Economic Benefit	The payback for the water utility is nominal, since the cost is for promotion of the program. Customer payback varies with the amount of water conservation and the complexity of the measures needed to achieve the savings.
Energy Savings	Energy savings are proportional to the reduction in water consumption.
Applications & Limitations	Every water utility system has an economic limit on the amount of reduced consumption and the corresponding loss of revenue which can impact water utility rates.
Practical Notes	Take care to minimize water utility rate impacts by balancing reduced consumption with the potential reduction in utility revenues. Also, determine if customer peak usage of water can be shifted to off peak times for both electric and water provision. Peak shifting of both electric and water consumption to off peak demand periods, such as evening and night time hours, may benefit both customer and water utility.
Other Benefits	This practice may extend the life of water supply and distribution systems and may also postpone costly future expansions.
Stage of Acceptance	Not widely accepted due to the potential reduction in utility revenue. Typically, customers respond favorably to this concept as long as the suggested measures do not negatively impact production or operation.
Resources	American Water Works Association Focus on Energy

Wastewater Treatment Energy Best Practices

#	TITLE
1	Variable Frequency Drive Applications
2	Reduce Fresh Water Consumption
3	Optimize Flow with Controls
4	Operational Flexibility
5	Staging of Treatment Capacity
6	Manage for Seasonal/Tourist Peaks
7	Flexible Sequencing of Tank Use
8	Recover Excess Heat from Wastewater
9	Cover Basins for Heat Retention
10	Optimize Aeration System
11	Fine-Bubble Aeration
12	Aerobic Digestion Options
13	Biosolids Processing Options
14	Biosolids Mixing Options: Aerobic
15	Variable Blower Air Flow Rate: Aerobic
16	Dissolved Oxygen Control: Aerobic
17	Biosolids Mixing Options: Anaerobic
18	Ultraviolet (UV) Disinfection Options
19	Final Effluent Recycling

Checklist for
Wastewater Treatment Energy Best Practices

Best Practice Analyzed? (Date)	Further Review Needed? Yes/No	Best Practice Possible? Yes/No	Area	#	Title	Typical Payback
			All	1	Variable Frequency Drive Applications	0.5 to 5 yrs
			All	2	Reduce Fresh Water Consumption	Variable
			All	3	Optimize Flow with Controls	Variable
			All	4	Operational Flexibility	<2 yrs
			All	5	Staging of Treatment Capacity	<2 yrs
			All	6	Manage for Seasonal/Tourist Peaks	4 to 6 yrs
			Basins	7	Flexible Sequencing of Basin Use	2 to 5 yrs
			All	8	Recover Excess Heat from Wastewater	<2 yrs
			Basins	9	Cover Basins for Heat Retention	Variable
			Aeration & Digesters	10	Optimize Aeration System	3 to 7 yrs
			Aeration & Digesters	11	Fine-Bubble Aeration	Variable
			Digesters	12	Aerobic Digestion Options	Variable
			Digesters	13	Biosolids Processing Options	Variable
			Digesters	14	Biosolids Mixing Options: Aerobic	1 to 3 yrs
			Aeration & Digesters	15	Variable Blower Air Flow Rate: Aerobic	<3 yrs
			Aeration & Digesters	16	Dissolved Oxygen Control: Aerobic	2 to 3 yrs
			Digesters	17	Biosolids Mixing Options: Anaerobic	Variable
			Final Effluent	18	Ultraviolet (UV) Disinfection Options	Variable
			Final Effluent	19	Final Effluent Recycling	2 to 3 yrs

Wastewater 1 – Variable Frequency Drive Applications

Best Practice	Variable frequency drives (VFDs), one type of variable speed technology, match motor output speeds to the load requirement and avoid running at constant full power, thereby saving energy.
Primary Area/Process	VFDs apply to most processes in a wastewater system. They can replace throttling valves on discharge piping, control the pumping rate of a process pump, control conveyance pressure in force mains, control air flow rates from blowers and control the speed of oxidation ditch drives. When coupled with adequate storage volume, they can also be used to match influent flow with raw sewage pumping rate.
Productivity Impact	No impact on operation except during installation.
Economic Benefit	Now more available and affordable, paybacks for VFDs range from six months to five years. Payback depends on the existing level of control and annual hours of operation.
Energy Savings	Many wastewater treatment applications, currently using fixed speed drives, can substantially increase efficiency with VFDs. Replacing a throttling valve with a VFD can save 10% to 40%. Applied to a secondary treatment process, a VFD can save more than 50% of that process's energy use.
Applications & Limitations	The primary limitation is the time required to identify, design and install the drives.
Practical Notes	VFDs allow operators to fine tune their collection, conveyance and treatment processes. Matching drives to loads also puts less stress on equipment and reduces maintenance. Be cautious when applying VFDs on centrifugal blowers and pumps. Check with an expert.
Other Benefits	Reduced emissions from the power source directly related to the reduced consumption of electrical power. The ability to match influent flow with treatment requirements enables more effective system operation.
Stage of Acceptance	Widely accepted and proven in the wastewater industry. New and upgraded wastewater systems are commonly equipped with VFDs for most treatment applications.
Resources	Drive manufacturers Websites. USDOE, Pump Systems Matter, Hydraulic Institute, http://www.pumpsystemsmatter.org/

Wastewater 2 – Reduce Fresh Water Consumption

Best Practice	Reducing the consumption of potable water through the use of final effluent (FE) in process applications may save energy by limiting the volume of water treated and/or pumped. The FE system should include a pressure tank and pump control system, where appropriate, and direct pumping where consistently high pressure is required (belt press).
Primary Area/Process	Typical applications are in the recycle system for tank wash down, gravity belt thickener belt wash water, belt press belt wash water, cooling water for a compressor, etc.
Productivity Impact	No impacts are expected, other than minor interruptions during the installation of any required equipment.
Economic Benefit	Payback will vary depending on the volume of potable water currently used, the volume that can be saved by recycling efforts and the extent of modifications required to install a recycle system.
Energy Savings	Savings will vary with the application and will result from the reduced volume of potable water treated and/or pumped.
Applications & Limitations	One common limitation is where a facility does not have strict effluent limits.
Practical Notes	This best practice is implemented where there are requirements for large volumes of wash water, usually for biosolids process needs or facility wash down needs.
Other Benefits	Other potential benefits include reducing well water consumption; reducing operation of booster pumps, where applicable, and possibly eliminating the need of two water distribution systems throughout the facility.
Stage of Acceptance	Reducing the volume of potable water used in the wastewater treatment process is widely accepted throughout the industry.
Resources	A number of consultants to the wastewater industry are available to assist with analysis and design.

Wastewater 3 – Optimize Flow with Controls

Best Practice	Assess variations in facility flows and apply control systems to address minimum, average and peak design flows. Equipment must be designed to pump for peak flows. However, these designs are often not energy efficient at average existing flow conditions. Therefore, it can be beneficial to apply control strategies or equipment that more precisely meets low - and average - flow conditions and can shift system demands to off-peak power periods.
Primary Area/Process	The primary focus of this practice is on piping and channels throughout facilities.
Productivity Impact	There may be a brief interruption in facility operation during installation of any necessary equipment.
Economic Benefit	Payback depends on the cost of the control mechanisms implemented.
Energy Savings	Energy savings will vary with the flow control needed at a facility and to the range of flows that a facility must satisfy.
Applications & Limitations	Flow rates through all facilities should be controlled to assist in more consistent operation of the facility.
Practical Notes	Having smaller pumps operate for longer times will convey flows through the facility more consistently than having larger pumps that are sized for peak flows discharging high rates of flow periodically.
Other Benefits	One possible benefit is lower demand (kW). The facility will also experience a more constant flow through the treatment processes, resulting in more effective treatment and less opportunity for upsets in the system.
Stage of Acceptance	Flow control technology is widely accepted throughout the industry.
Resources	Water Environment Foundation

Wastewater 4 – Operational Flexibility

Best Practice	Evaluate facility loadings and become familiar with the treatment systems in order to identify, plan and design the most efficient and effective ways to operate your system. This may include: - operating fewer aeration tanks - installing variable frequency drives so equipment operation can match system loadings - installing dissolved oxygen monitoring and control equipment - idling an aeration tank during low-flow periods - reducing air flow to the aeration tanks during low-load periods (usually nights and weekends) - waiting to recycle supernatant during lower-flow periods, avoiding periods of high organic loading - operating diffusers or recycling backwash water during off-peak power demand periods.
Primary Area/Process	This practice applies to secondary treatment processes, all pumping operations and biosolids management.
Productivity Impact	Implementation usually involves changes to operations so there should be little or no impact on production.
Economic Benefit	Payback is generally within two years since most of the modifications are operational and will not incur capital costs.
Energy Savings	Energy savings will vary depending on the adjustment. A typical range is from 10% to 25%.
Applications & Limitations	All facilities should implement this practice to save on operating costs.
Practical Notes	This practice is best implemented with a committed energy management plan as described in the **Management Best Practices** section of this guidebook and where the flexibility of facility operations is feasible.
Other Benefits	Operations personnel will gain a better understanding of the capabilities of the multimillion dollar system they control.
Stage of Acceptance	Many facilities accept the need to adjust operations responsive to loadings after learning the magnitude of savings available.
Resources	Information available through Water Environment Foundation.

Wastewater 5 – Staging of Treatment Capacity

Best Practice	When planning improvements, wastewater system personnel and designers should develop a team approach wherein they determine how modifications will effectively and efficiently meet current and projected conditions. Staging upgrades in capacity can help optimize system response to demand and also reduce energy costs.
Primary Area/Process	Staging is most applicable to the major energy users in a system, typically the secondary treatment process, pumping and biosolids management.
Productivity Impact	Usually a system will operate most efficiently when loaded nearer to its design load; therefore, staged systems will generally function more efficiently as the system grows.
Economic Benefit	The simple payback period will usually be less than two years because minimal modifications are required to implement staging.
Energy Savings	Proper staging of treatment capacity can achieve a savings of 10% to 30% of the total energy consumed by a unit process.
Applications & Limitations	Staging is applicable to all systems.
Practical Notes	Usually staging is a minor impact on construction and scheduling in exchange for the energy savings realized.
Other Benefits	Improved control of the system.
Stage of Acceptance	Staging of treatment capacity is gaining acceptance within the wastewater industry; however, it is not readily adopted because of the belief that the entire system must be constructed immediately, rather than efficiently staging a system and bringing components online as needed.
Resources	Consultants can provide the expertise you do not have in house for planning and strategy development.

Wastewater 6 – Manage for Seasonal/Tourist Peaks

Best Practice	Flexible system design allows a utility to adjust and operate more efficiently during peak tourist loadings as well as during the "off season." In many areas tourism-related loadings versus off season may reach as high as 10:1. This may require removing tankage that is used during tourist season from service during the off season.
Primary Area/Process	Primary area of focus is the secondary treatment process, aeration system.
Productivity Impact	No productivity impact other than brief interruptions while new equipment is installed or placed into operation, if needed.
Economic Benefit	Most retrofit aeration modifications have paybacks of four years to six years. If the concept is integrated into the design of new construction, the payback should be less.
Energy Savings	Savings can vary, but it can reach 50% during the off season.
Applications & Limitations	Application is appropriate for systems that have highly differentiated seasonal loading conditions and where it makes economic sense. The physical sizing of an aeration tank may limit feasibility.
Practical Notes	This strategy needs to be carefully analyzed to ensure that adequate treatment can be provided during the tourist season. The aeration tanks must be sized so that they can be taken off line during the off season. It helps to have several years' of facility loading data and utility bills to assess seasonal variation to define the on- and off-peak seasons and their respective peak loadings for proper sizing of equipment.
Other Benefits	If the secondary treatment process is improved, generally the functions of other processes improve.
Stage of Acceptance	These concepts are well known, understood, and widely accepted.
Resources	Many technical papers are available on the application of this technology.

Wastewater 7 – Flexible Sequencing of Basin Use

Best Practice	The selection of basin sizes can have a large impact on the energy consumed at a facility during its lifetime. The facility design team should review the existing and projected organic loadings to identify the best selection of tank sizes. Typically, the use of smaller sized basins is beneficial so that initial loadings can be near the capacity of a smaller basin. The remaining basins can then be loaded sequentially until design capacity is met. This approach allows for energy efficient operation from start up to design flow conditions.
Primary Area/Process	Secondary treatment processes, particularly activated sludge treatment facilities.
Productivity Impact	None.
Economic Benefit	Payback for constructing multiple tanks will depend on space availability at the site. Implementation can be as simple as adding an interior wall to subdivide an existing tank; this can provide a two year to three year payback. Payback may take three years to five years for major site modifications.
Energy Savings	Energy savings of 15% to 40% are common if multiple smaller tanks are available to step the system into operation, compared with having only two large tanks.
Applications & Limitations	All facilities should consider operational flexibility to be sure they can manage their ever-changing facility loads.
Practical Notes	Facility personnel should work closely with designers throughout the design process. Information on the sizes and operation of basins required for a treatment process is invaluable. Operating more fully-loaded smaller tanks versus operating larger, under-loaded tanks is preferable. Using - intermediate tank walls (division walls) may be a simple, acceptable solution.
Other Benefits	Improves overall operation of the facility.
Stage of Acceptance	Acceptance varies from site to site based on facility staff attitudes and experiences with maintenance of empty tanks.
Resources	Water Environment Federation American Society of Civil Engineers

Wastewater 8 – Recover Excess Heat from Wastewater

Best Practice	Recover excess heat from wastewater prior to its treatment and/or discharge to use at or near the wastewater treatment facility. Some industrial wastewater systems have a large volume of low grade heat available in their wastewater (typically able to provide 20°F to 25 °F).
Primary Area/Process	Wastewater stream processes where heat recovery is feasible, especially where the demand for additional heat is nearby.
Productivity Impact	There are possible minor disruptions during installation of piping and equipment and during start up.
Economic Benefit	The payback period is typically short (less than two years) but varies and is a direct function of the distance between the heat source and where it is used.
Energy Savings	The total value of heat energy available varies depending on site characteristics. The heat value available can be in the millions of therms per year.
Applications & Limitations	Use of low grade heat is a challenge. In many applications it can be used to preheat influent river or well water to a tepid temperature (preheating influent raw water). Even if the available heat is insufficient to completely heat process streams, partial heating can reduce heating fuel costs and yield significant benefits. The distance between the heat recovery source and the application determines the economic feasibility.
Practical Notes	In order to optimize the use of waste heat, assess the locations within the facility where the waste heat could be captured at higher temperatures before mixing it with other wastewater streams to maximize the overall temperature differential and heat transfer potential.
Other Benefits	Warming raw water usually decreases the amount of pretreatment chemicals required for conditioning.
Stage of Acceptance	This process is accepted, but often not utilized, because the heat source is low grade. Operators perceive that partial heating, as opposed to complete heating, is insufficient and not worth it.
Resources	U.S. Department of Energy Web site

Wastewater 9 – Cover Basins for Heat Retention

Best Practice	In northern climates, basins are often covered to prevent the contents from freezing. This practice reduces, or possibly eliminates, the energy used to thaw equipment or tanks.
Primary Area/Process	This practice may be applied to any open tank treatment process including grit removal, comminution, clarification, aeration, gravity thickeners, aerobic digesters, biosolids holding tanks and disinfection tanks.
Productivity Impact	Installation of covers would interrupt the use of a tank for a limited time during installation.
Economic Benefit	Payback depends on the number of tanks and the fuel used to thaw any frozen items. The payback period will increase with the amount of equipment needed to implement this practice.
Energy Savings	Savings vary depending on the number of open tanks on site and the total storage volume.
Applications & Limitations	Limitations are related to weather conditions. The colder the climate, the better the application.
Practical Notes	Many enclosure materials are available. Information on these materials can be found on manufacturers' Web sites.
Other Benefits	Reduced odor and aerosol control are auxiliary benefits from covering a structure. Operations will improve as a result of maintaining a more consistent temperature.
Stage of Acceptance	Covering open tanks is a widely accepted practice throughout the industry. However, in most instances the tanks are being covered for odor or aerosol control. Covered storage as an energy efficiency measure is gaining acceptance.
Resources	Water Environment Federation, Ten States Standards

Wastewater 10 – Optimize Aeration System

Best Practice	Determine whether the aeration system is operating as efficiently as possible for the required level of treatment. Assess present loading conditions and system performance through a comparison of kWh/MG and other key performance indicators with those of other similar facilities. Consider the potential benefits and costs of improvements such as fine-bubble aeration, dissolved oxygen control and variable air flow rate blowers. See also, **Wastewater 11 - Fine Bubble Aeration.**
Primary Area/Process	Secondary treatment process, activated sludge and aerobic digestion are the principal treatment processes where this energy saving practice can be implemented.
Productivity Impact	Modified aeration systems have also resulted in savings for other treatment unit processes. Savings have materialized in biosolids processing, particularly in reducing the polymer dosage for biosolids thickening and dewatering. Treatment capabilities have been increased at most facilities.
Economic Benefit	The payback period is generally three years to seven years for retrofits and about one year for new construction.
Energy Savings	Savings of 30% to 70% of total aeration system energy consumption are typical.
Applications & Limitations	All aerated, activated sludge treatment systems.
Practical Notes	This best practice should be implemented at all facilities unless there is an overwhelming reason to avoid it.
Other Benefits	Improvement in other unit treatment processes on site and reduced maintenance at some installations.
Stage of Acceptance	Fine-bubble aeration methods are widely accepted, as are dissolved oxygen control systems and various methods of controlling the flow rate of air to the treatment process.
Resources	Water Environment Federation Design Manuals

Wastewater 11 – Fine-Bubble Aeration

Best Practice	Assess the feasibility of implementing fine bubble aeration at activated sludge treatment facilities. This practice provides energy efficient treatment of wastewater. It can be installed in new or existing systems. The technology usually improves operations and increases the organic treatment capability of a wastewater treatment facility. For optimum performance, combine this practice with dissolved oxygen monitoring and control, and a variable capacity blower.
Primary Area/Process	Primary application for this practice will be on aeration tanks and aerobic digesters.
Productivity Impact	A minor impact on production during installation.
Economic Benefit	Economic benefits vary from new facilities to retrofit applications. A new system may pay back in as little as one year. Payback on a retrofit will vary depending on the inefficiency of the existing system and the amount of new equipment required.
Energy Savings	Energy savings range from 20% to 75% of the aeration or aerobic digestion unit's energy consumption.
Applications & Limitations	This practice applies to all aeration systems. A limit exists for aerobic digestion - if the system operates at a solids concentration of 2.5% or greater, further review must be done.
Practical Notes	Fine bubble technologies have applications for all sizes of wastewater treatment facilities. The proportion of energy savings will be similar regardless of facility size.
Other Benefits	Most sites that have implemented this practice report improved biosolids management, reduced polymer use, better clarification and better overall effluent.
Stage of Acceptance	This technology has gained a high level of acceptance within the industry.
Resources	Water Environment Federation Ten States Standards American Society of Civil Engineers

Wastewater 12 – Aerobic Digestion Options

Best Practice	Assess your aerobic digester operation to determine if a smaller blower would provide better control of airflow using fine-bubble diffusers and equipment with adjustable airflow rates. Many facilities operate aerobic digesters with surface aerators or coarse-bubble diffusers with limited ability to modify or control air flow delivered to the process. First, consider fine-bubble diffusers, which allow for variable airflow rates, for digester applications. Second choose equipment and/or controls with adjustable airflow rates. Often, air for the digestion process is bled from the aeration system, allowing little or no control over the airflow delivered.
Primary Area/Process	Applies to biosolids treatment and management.
Productivity Impact	Conversion to fine-bubble diffuser technology may improve reduction of volatile solids.
Economic Benefit	Payback varies with the modifications required.
Energy Savings	Application of fine-bubble diffusers in an aerobic digestion system can reduce energy consumption for the process by 20% to 50%.
Applications & Limitations	The key limitation is the final concentration of total suspended solids (TSS) in the digester. Operators may want to be involved in control of the concentration of TSS to maintain applicability of fine-bubble. Mixing concerns are limitations.
Practical Notes	This best practice is applicable to most systems, but will typically require that the diffusers and blowers be replaced. Some piping modifications may also be required.
Other Benefits	Fine-bubble aeration reportedly improves biosolids dewatering, reduces polymer demand when the digested biosolids are dewatered or thickened, results in less pin floc in the biosolids processing, improves reduction of volatile solids, improves decanting from the digester and reduces the volume of biosolids to be disposed.
Stage of Acceptance	This technology is readily available and widely accepted except in situations where the solids concentration within the digester exceeds 2.5% of total solids.
Resources	Water Environment Federation Design Manuals Diffuser manufacturer design and application manuals

Wastewater 13 – Biosolids Processing Options

Best Practice	When planning new facilities or expansion, assess the energy and production impacts of various biosolids process options. Standard **aerobic** digestion of biosolids is energy intensive compared with fine-bubble diffusers with dissolved oxygen control and a variable air-flow rate blower. Some locations currently turn off the air-flow to the digester over extended periods of time to further reduce energy costs. **Anaerobic** digestion requires detailed assessment. While the capital cost of an anaerobic system is considerably greater than for an aerobic system, an anaerobic system can produce biogas for energy production and can help offset capital costs. Both types of system should be considered.
Primary Area/Process	This practice applies to biosolids treatment and management.
Productivity Impact	The energy impact of recycling supernatant by each process should be assessed.
Economic Benefit	Payback will vary considerably from site to site and should be determined on a system specific basis.
Energy Savings	Both aerobic and anaerobic systems should be considered to determine the most energy efficient option. One of these processes should be selected.
Applications & Limitations	Each system must identify the class of biosolids it wants to produce which will affect the type of biosolids treatment selected.
Practical Notes	Operators should include all site specific parameters for the assessment, particularly the amount of energy both consumed and produced by each process.
Other Benefits	Each type of treatment process affects the characteristics of the solids product which, in turn, affects production rates and thickening and dewatering capabilities.
Stage of Acceptance	Both aerobic and anaerobic biosolids treatment are readily available and widely accepted treatment processes.
Resources	Water Environment Federation Design Manuals

Wastewater 14 – Biosolids Mixing Options: Aerobic

Best Practice	Biosolids mixing is an energy intensive task that should be addressed in aerobic digestion. Mixing is generally provided by aeration, mechanical mixing, pumping or a combination of these methods. Aeration of the biosolids mass is required to destroy volatile solids and control odor. However, aeration may not be the most energy-efficient way to provide complete mixing in a digester, especially if constant aeration is not required. Evaluate the energy costs of available options to identify the best technology for the site. A combination of mixing methods that will permit the system to be completely turned off periodically may be most practical.
Primary Area/Process	This practice applies to all aerobic digestion systems.
Productivity Impact	No impact on productivity. A disruption should only occur during installation and start up.
Economic Benefit	The payback period for a retrofit condition will take one year to three years. A new installation payback may only take one year.
Energy Savings	The potential energy savings will vary by application but can be as high as 50%.
Applications & Limitations	The limiting factor is the solids concentration in the aerobic digester.
Practical Notes	The solids concentration of the digester contents should be controlled to an approximate maximum suspended solids concentration of 2.5%.
Other Benefits	Improved volatile solids reduction.
Stage of Acceptance	Mixing technologies, including a combination of a mixing regime and an aeration methodology, are accepted by the wastewater industry.
Resources	Water Environment Federation Design Manuals Equipment manufacturers

Wastewater 15 – Variable Blower Air Flow Rate: Aerobic

Best Practice	Require that aeration system and aerobic digester blowers have variable air supply rate capability. The range of variability should respond to the specific requirements a site needs to precisely match system demands. The blower system should be able to supply the minimum air flow required to meet existing low-load conditions and to meet the high loads of design conditions.
Primary Area/Process	This practice applies to activated sludge aeration tanks and aerobic digestion systems.
Productivity Impact	Interruption in production should only occur during installation.
Economic Benefit	Payback is usually under three years.
Energy Savings	Energy savings depend on site conditions and which parameter, mixing or organic loading, dictates the lesser amount of air flow. Savings will range from 15% to 50% of the energy consumed by this process.
Applications & Limitations	This practice can be applied wherever blowers are installed.
Practical Notes	Variable air flow rate blowers should be integrated with fine-bubble aeration and dissolved oxygen monitoring and control for optimum energy efficiency. Also consider the potential advantages of replacing two blowers and staging loadings with three, four, or five smaller units that can both meet today's and tomorrow's demands.
Other Benefits	When teamed with fine-bubble diffusers and dissolved oxygen (DO) control technologies, effluent quality and biosolids processing are usually improved.
Stage of Acceptance	Technologies for varying air flow rates are well received. Variable speed positive blower arrangements and variable capacity centrifugal blowers are becoming more available and well known.
Resources	Water Environment Federation Blower manufacturers

Wastewater 16 – Dissolved Oxygen Control: Aerobic

Best Practice	Consider dissolved oxygen monitoring and control technology which will maintain the dissolved oxygen (DO) level of the aeration tank(s) at a preset control point by varying the air flow rate to the aeration system.
Primary Area/Process	The primary applications are aeration tanks at activated sludge facilities and aerobic digestion and post aeration systems.
Productivity Impact	Installation of most systems can be accomplished without interfering with normal operation.
Economic Benefit	Paybacks from improved monitoring and controls using DO control are two years to three years.
Energy Savings	Savings vary depending on the efficiency of the present system. Generally, energy savings for the aeration system are in the 20% to 50% range.
Applications & Limitations	Limitations will vary with characteristics of the waste being treated. If the waste has characteristics that would easily foul the DO probe then the system will not be readily applicable.
Practical Notes	This control should be employed wherever activated sludge is utilized as the secondary treatment process. Variable flow may be established with variable frequency drives (VFDs).
Other Benefits	Waste biosolids from a DO controlled system have reportedly better dewatering characteristics. Also, a DO controlled system usually will have fewer problems treating a fluctuating influent load.
Stage of Acceptance	DO control is a well accepted control methodology. The primary factor affecting acceptance is the reliability and associated maintenance associated with DO probes.
Resources	Environmental Protection Agency Water Environment Federation

Wastewater 17 – Biosolids Mixing Options: Anaerobic

Best Practice	The contents of an anaerobic digester must be mixed for proper operation, the destruction of volatile suspended solids and the production of biogas. Mixing is generally accomplished by injecting biogas into the bottom of the digester and having it pass through the contents of the tank. Some sites also continually pump the contents to provide mixing. Mechanical mixing can also be used to achieve a higher level of volatile solids destruction and greater biogas production.
Primary Area/Process	This practice applies to the anaerobic digestion of biosolids.
Productivity Impact	Disruption in production should only occur during installation and while the biological environment evolves to make the anaerobic system function.
Economic Benefit	Payback depends on whether the system is new construction or a retrofit of an existing system. Payback for a retrofitted system will take longer.
Energy Savings	Energy savings will vary substantially depending on the specific site conditions.
Applications & Limitations	Mixing should be employed by all anaerobic digestion systems to maximize volatile solids destruction and maximize biogas production.
Practical Notes	The various methods of mixing must be evaluated to identify the best option. It is important to assess the production and beneficial use of biogas.
Other Benefits	Maximizing the production of biogas may provide a lucrative renewable energy opportunity.
Stage of Acceptance	Various mixing technologies are widely accepted throughout the industry.
Resources	Water Environment Federation Mixer manufacturers

Wastewater 18 – Ultraviolet (UV) Disinfection Options

Best Practice	Consider various ultraviolet disinfection (UV) system redesign options that can be configured by reducing the number of lights, bulb orientation, bulb type (pressure and intensity), turn-down ratio (bank size and lamp output variability) and dose-pacing control (system output automatically controls to disinfection requirement).
Primary Area/Process	Limited to systems that can use UV disinfection systems.
Productivity Impact	Minor impacts on productivity during the installation of any improvements, if necessary, because installation should be planned to occur when disinfection is not required.
Economic Benefit	Paybacks will vary depending on the type of UV system in use and the extent of renovations required.
Energy Savings	UV disinfection system design should include flexibility to allow a reduction in the number of lamps and the turn down ratio of the lamps to match low flow conditions, which can save energy. Energy savings from UV result when lamps "on" and lamp output are paced based on flow and transmissivity. Sleeve wiping, alone can save 10% of energy costs.
Applications & Limitations	Energy savings may be lower for systems that operate seasonally, due to limited annual hours of operation.
Practical Notes	Medium pressure lamps convert a lower percentage of the power they consume into useful light, compared with low-pressure, high-output lamps. Additionally, medium pressure lamps offer much lower turn down capabilities. Consequently, a medium pressure system may use significantly more energy, despite having fewer lamps. Including an automatic wiping system ensures that the quartz sleeves stay clean and that the maximum amount of UV can be transferred.
Other Benefits	Installation of an ultraviolet (UV) system usually replaces a chlorination system, thereby eliminating the need to store chlorine, a hazardous gas, on site.
Stage of Acceptance	All varieties and configurations of UV disinfection systems are accepted and in use throughout the wastewater industry.
Resources	"*Evaluation of Ultraviolet Radiation Disinfection Technologies for Wastewater Treatment Plant Effluent,*" New York State Energy Research and Development Authority, Dec 2004. (Final Report in April, 2007) Major manufacturers offer plant optimization assistance.

Wastewater 19 – Final Effluent Recycling

Best Practice	Reuse final effluent to replace potable water use for wash down of tanks and process related applications. The installation should include a pressure tank so the recycle pump will not operate continuously. Additional applications are possible with an inline filter prior to each application.
Primary Area/Process	Typical applications are recycle systems for tank wash down, gravity belt thickener belt wash water, belt press belt wash water and cooling water for a compressor.
Productivity Impact	No impact on production should be expected, other than minor interruptions during any necessary installation.
Economic Benefit	Payback periods for this best practice are typically two years to three years and will vary with the volume of potable water currently used.
Energy Savings	Savings may reach 50% of the total system energy if an installed system does not already utilize a pressure tank system to regulate supply.
Applications & Limitations	Application is limited by the quality of effluent available for recycling.
Practical Notes	This best practice is usually implemented when the final effluent quality is sufficiently high so that its use will not hamper the function of pumps, hoses and nozzles used in its distribution. The practice is also cost effective when large volumes of wash water are required, such as for biosolids processing or facility wash down.
Other Benefits	Other potential benefits associated with this measure include reducing well water consumption, reducing operation of booster pumps, where applicable, and possibly eliminating the need of two water distribution systems throughout the facility.
Stage of Acceptance	Reducing the volume of potable water used in the wastewater treatment process is widely accepted throughout the industry.
Resources	Water Environment Federation

General Facility Energy Best Practices

#	TITLE
1	Facility Energy Assessments
2	Real Time Energy Monitoring
3	Energy Education for Facility Personnel
4	Electric Peak Reduction
5	Manage Electric Rate Structure
6	Idle or Turn Off Equipment
7	Install High Efficiency Motors
8	Variable Speed Technologies
9	Optimize Pump System Efficiency
10	Comprehensive Planning Before Design
11	Design Flexibility for Today and Tomorrow
12	Renewable Energy Options

Checklist for
General Facility Energy Best Practices
(Water and Wastewater)

Best Practice Analyzed? (Date)	Further Review Needed? Yes/No	Best Practice Possible? Yes/No	Area	#	Title	Typical Payback
			All	1	Facility Energy Assessments	Variable
			All	2	Real Time Energy Monitoring	Variable
			All	3	Energy Education for Facility Personnel	Variable
			All	4	Electric Peak Reduction	<1 yr
			All	5	Manage Electric Rate Structure	Variable
			All	6	Idle or Turn Off Equipment	Immediate
			All	7	Install High Efficiency Motors	<2 yrs
			All	8	Variable Speed Technologies	Variable
			All	9	Optimize Pump System Efficiency	0.25 – 3 yrs
			All	10	Comprehensive Planning Before Design	Variable
			All	11	Design Flexibility for Today and Tomorrow	1 to 5 yrs
			All	12	Renewable Energy Options	3 to 7 yrs

General Facility 1 – Facility Energy Assessments

Best Practice	An annual energy survey should be a common practice for all water and wastewater systems to determine any opportunities to improve energy efficiency. The survey should review all energy consuming processes.
Primary Area/Process	This practice should be completed for the entire facility, with emphasis on the major energy using processes such as pumping, aeration and solids management.
Productivity Impact	The only possible impact may be a short disturbance during implementation of the recommendations.
Economic Benefit	Payback period will vary with the complexity of the modifications and the required capital investment, if any.
Energy Savings	Energy savings will vary depending on the existing equipment and the opportunities identified. Savings range from 10% to 50% of the total system energy consumption. Several projects have resulted in energy savings of as much as 65%.
Applications & Limitations	None.
Practical Notes	Energy can be saved at every site, regardless of treatment process, age or size of facility.
Other Benefits	More attention is given to operations because of the desire to save money resulting from saving energy.
Stage of Acceptance	Acceptance of the value of energy assessments is growing and getting more attention. The acceptance of various energy efficient technologies and practices varies.
Resources	American Water Works Association Hydraulics Institute – Pump Systems Matter American Water Works Association Research Foundation US Department of Energy Water Energy Research Foundation Water Environment Federation

General Facility 2 – Real Time Energy Monitoring

Best Practice	An accurate, real-time energy monitoring system will permit the collection and analysis of 15-minute energy data for each treatment process and pump installation. This support tool enables utility staff and management to establish energy use reduction goals and monitor/verify demand consumption.
Primary Area/Process	This technology can be applied to all process treatment units and is most beneficial to high energy users. High energy users may include large facilities and facilities that use an inordinate amount of energy or demand per unit of water or wastewater conveyance and treatment.
Productivity Impact	No impact on a facility's capability to meet treatment limits.
Economic Benefit	Payback depends on the cost of the monitoring system and on the system capability to adjust.
Energy Savings	The achievable range of energy savings is typically 5% to 20% where energy efficiency is viewed as a daily performance goal.
Applications & Limitations	Each site must be individually assessed to identify which processes can benefit the most from monitoring.
Practical Notes	The most common barrier to implementation is acquiring management approval and commitment for the capital expenditure. Be sure to include the potential savings from energy management in payback calculations. This practice has been suggested through benchmark studies.
Other Benefits	Monitoring also can support other functions, such as maintenance and the identification of failing equipment.
Stage of Acceptance	This concept is well known but not widely practiced since it is usually not necessary for meeting system performance goals (effluent limits).
Resources	Check with your local electric provider.

General Facility 3 – Energy Education for Facility Personnel

Best Practice	All water and wastewater system personnel should understand the relationship between energy efficiency and facility operations. Information can be found in various publications, such as this guidebook and through training sessions offered through industry support organizations, such as Focus on Energy.
Primary Area/Process	This practice focuses on personnel, especially those who make both long- and short-term decisions that affect energy use (including Board or Council members). All parties involved in the operation of a water treatment and distribution system and a wastewater conveyance and treatment facility can benefit from understanding their system's energy use.
Productivity Impact	None.
Economic Benefit	There is no direct return on investment for this practice. The return will be a function of actual process changes made in response to recommendations.
Energy Savings	The energy savings for this practice will vary substantially depending on what measures are implemented.
Applications & Limitations	None.
Practical Notes	It is useful to establish an annual schedule for energy training to keep facility management and personnel up to date on available technology and management practices.
Other Benefits	Staff members and colleagues within the industry typically share and discuss the information they gain from attending education classes and reading publications.
Stage of Acceptance	Education and training is common and widely accepted throughout the industry.
Resources	American Water Works Association US Department of Energy Environmental Protection Agency Focus on Energy Water Environment Foundation

General Facility 4 – Electric Peak Reduction

Best Practice	Management of peak demand (shifting to off-peak or shaving peak power usage) can substantially lower energy costs. The following can be done to optimize power use and reduce electric peak demand: • Assess the typical and peak operation of your water and wastewater system to identify areas where peak power demand can be trimmed or shifted. • Develop an operation strategy that meets overall system demand and minimizes pumping and specific treatment processes during peak power demand periods. Consider adding storage capacity or simply delaying the time of operation. • Assess electric bills to understand peak demand charges and examine facility operations to determine ways to avoid or reduce peak demand.
Primary Area/Process	All energy-using components of water and wastewater systems, with a focus on the supply side. Candidates for off-peak operation in wastewater include biosolids management (operate sludge presses in off-peak demand times); shifting recycling to off–peak periods; loading or feeding anaerobic digesters off-peak so supernatant does not recycle on-peak; operating mixers or aerators in aerobic digesters off–peak; reducing recycling during on-peak; and accepting or treating hauled in wastes during off–peak.
Productivity Impact	None.
Economic Benefit	Paybacks are typically less than a year because the modifications are generally procedural and do not have significant costs.
Energy Savings	Energy savings (kWh) are generally minor. Savings result from reduced demand for peak power.
Applications & Limitations	Application may be limited by the amount of storage available and by the absolute minimum power requirement for necessary operations. Substantial savings are more likely with a time of use (TOU) rate. Smaller facilities may not be charged separately for demand.
Practical Notes	An understanding of the relationship between peak power demand and the demands of water supply and wastewater treatment are also necessary to make the application effective. The facility must also meet WDNR requirements.

Other Benefits	Improved utilization of system components.
Stage of Acceptance	Electric utilities provide information to assist customers optimize their consumption according to their specific rate structures. Most water and wastewater utilities are aware of this but may not be optimizing their operations to fit the rates.
Resources	American Water Works Association Water Environment Federation Your local electric power utility

General Facility 5 – Manage Electric Rate Structure

Best Practice	Work with your utility account manager to review your facility's electric rate structure. The review process should determine if the current structure is the most appropriate pricing structure for your facility based on peak demand and overall energy consumption.
Primary Area/Process	Facility wide, with special attention to accounting and purchasing.
Productivity Impact	None
Economic Benefit	There is no direct return on investment for this practice. However, economic benefit can result from actual process changes made in response to recommendations.
Energy Saving	The energy savings will vary with site and rate structure.
Applications & Limitations	All facilities should apply this practice.
Practical Notes	All personnel should be aware of how their facility is charged for energy consumption.
Other Benefits	Management will give more attention to the operation of a system if energy awareness is made available to everyone.
Stage of Acceptance	The practice of reviewing utility bills and rate structures is becoming more common as its value becomes recognized. As water and wastewater personnel are becoming more aware of energy costs and methods of billing, modifications to operations are also being made.
Resources	The best resource is the facility's account representative from the electric provider.

General Facility 6 – Idle or Turn Off Equipment

Best Practice	Idle or turn off non-essential equipment when feasible, especially during periods of peak power demand. Review operations and schedules to determine if any equipment is not required for the proper operation of the facility.
Primary Area/Process	This technology can be applied to almost all areas in a water or wastewater system.
Productivity Impact	None.
Economic Benefit	Paybacks are typically short, if not immediate, because the modifications are low or no-cost changes in procedures.
Energy Savings	Savings depend on the amount of non-essential equipment currently operating. Reduced power demand will also result if shut off occurs during periods of peak power demand.
Applications & Limitations	Care must be taken to not turn off an essential piece of treatment or monitoring equipment or warning system device. Provide as much automatic control, such as timers, as is feasible to reduce the need for operator attention and the potential for operator error. Facilities subject to Wisconsin WPDES discharge permits are generally expected to operate as efficiently as possible with regard to pollutant removal. WDNR staff should be contacted if there is any question about whether turning off equipment would be unacceptable in accordance with permit requirements.
Practical Notes	It can be useful to ask why each piece of equipment is operating and if the equipment is critical to operation. This is of particular value when trying to reduce peak power demand charges.
Other Benefits	Increased equipment life, reduced maintenance and, possibly, fewer spare parts required.
Stage of Acceptance	Water and wastewater utilities are increasingly more willing to turn off equipment once they understand that system requirements can still be met.
Resources	The best resources available are knowledgeable, seasoned staff members who can walk through the facility and identify what equipment is and is not necessary for basic operations.

General Facility 7 – Install High Efficiency Motors

Best Practice	Survey existing motors for possible replacement with new, high efficiency motors and specify the most energy efficient motors on all new installed and inventoried equipment. Include an emergency motor replacement program that specifies energy efficient motors.
Primary Area/Process	Can be applied to all electric motors, especially on well and booster pumps for water systems, and on those wastewater facility motors with high annual operating hours and those that operate during peak demand, e.g., aeration blowers, disinfection systems (seasonal), pumps and clarifiers.
Productivity Impact	None, except for a possible short shutdown time for removal of the existing motor and installation of the new motor.
Economic Benefit	The simple payback is generally short, often less than two years, if the motor operates continuously; however, if the equipment's annual hours of operation are minimal, the simple payback period can become extended.
Energy Savings	Savings will vary, but should be minimally 5% to 10% of the energy used by the lower efficiency motor to be replaced.
Applications & Limitations	None. However, physical characteristics and location of the existing motor must be considered when replacing a motor. For example, the new motor may have to be explosion proof, spark resistant or have immersion capability (flooding conditions).
Practical Notes	Typically, this best practice is implemented when an existing motor is replaced or needs to undergo major repairs. However, in certain situations, such as high annual hours of operation, it may be worthwhile to replace a working motor. A program to determine whether it is economically justifiable to replace older motors instead of repairing them may be beneficial. Note that a premium efficiency motor may require a longer lead time than a standard or high efficiency motor of the same size. Allow extra time in the project schedule.
Other Benefits	Reduced emissions from the power source directly related to the reduced consumption of electrical power.
Stage of Acceptance	This is well known, proven and accepted technology.
Resources	U.S. Department of Energy website: www.energy.gov ; Pump Systems Matter, Hydraulic Institute, http://www.pumpsystemsmatter.org/

General Facility 8 – Variable Speed Technologies

Best Practice	Apply variable speed drives for most water and wastewater pumping installations, particularly where peak demand is significantly higher than average demand and where the motor can run at partial loads to save energy.
Primary Area/Process	Pump installations and other continuously operating processes.
Productivity Impact	Impact should only be short term with interruption of service during installation, start up and fine tuning.
Economic Benefit	The payback period will vary with application depending on size of drive, hours of operation and variation in load. Large drives, long hours and high load variability yield the highest savings.
Energy Savings	Savings vary with application and technology. Many variable speed drive retrofits have saved 15% to 35%. In some installations, particularly where throttling is used to control flow, savings of 10% to 40% is possible.
Applications & Limitations	Applications for variable speed drives include controlling pressure, daily demand (gpm), fire flow, and well recovery and replenishment. Other applications include controlling aeration blowers, the pumping rate of raw sewage and sludge processing.
Practical Notes	Many variable speed drive options are available. See **Appendix F – Variable Speed Technology Options** - for the various variable speed technology configurations. Calculations that account for load variation can help justify the cost. The system must be reviewed by an expert before selecting and installing the variable speed technology to ensure system compatibility and cost-effectiveness.
Other Benefits	Associated benefits include better control of system flow-rate and pressure, more consistent supply and increased flexibility to meet demand requirements with minimum energy use.
Stage of Acceptance	Most utilities are very receptive to installing variable speed drive technology.
Resources	American Water Works Association Drive manufacturers' Websites. USDOE, Pump Systems Matter, Hydraulic Institute, http://www.pumpsystemsmatter.org/

General Facility 9 – Optimize Pump System Efficiency

Best Practice	Identify the optimum operational conditions for each pump and develop a system analysis. This analysis should include the start up flows and progress to the design flow capacity, usually a twenty year projected flow with a peaking factor to identify the range of flow(s) and head conditions required to efficiently meet the conditions and specifications of the system design.
Primary Area/Process	This technology should be applied to all pumping applications.
Productivity Impact	Optimizing pumping systems can reduce unscheduled downtime, reduce seal replacement costs and improve unit process treatment efficiency and effectiveness.
Economic Benefits	The payback period depends on site specifics and whether it is new or retrofit. With a new facility, the payback period should be less than two years; in retrofit conditions three months up to three years is a typical range.
Energy Savings	The energy saved will vary with the installation; 15% to 30% is typical, with up to 70% available in retrofit situations where a service area has not grown as forecasted.
Applications & Limitations	No limit to application possibilities.
Practical Notes	Many computer models can help with the analysis; the model should address both static and dynamic conditions.
Other Benefits	Generally, improved pumping systems provide better treatment system control.
Stage of Acceptance	The technologies used to analyze pumping systems are readily available and their use is widely accepted.
Resources	American Water Works Association Water Environment Federation Pump Systems Matter, Hydraulic Institute, http://www.pumpsystemsmatter.org/ Europump, http://www.europump.org/

General Facility 10 – Comprehensive Planning Before Design

Best Practice	Clearly define utility goals and objectives and set the design criteria for system improvements. Incorporate all appropriate energy efficiency best practices into capital and operations improvement plans. This helps the utility address the critical needs of the future system and optimizes capital and operating budgets.
Primary Area/Process	All components of water treatment/distribution and wastewater treatment systems.
Productivity Impact	No impact.
Economic Benefit	Payback will vary by facility and by project, depending on the energy benefits and costs of alternative designs and operations. Payback may vary from a few months to several years.
Energy Savings	Future energy savings are derived from the incorporation of energy efficiency practices in the capital and operations improvement plans.
Applications & Limitations	There are no limitations on this practice because comprehensive planning should occur prior to project development.
Practical Notes	Proactive and open communications promote the success of capital and operations improvement planning, including energy management planning. Aggregating energy efficiency measures into a capital improvement project and justifying them in the aggregate, helps avoid lost opportunities for future energy savings. Energy saving improvements should be evaluated on a life-cycle cost basis.
Other Benefits	Well conceived and planned projects result in the highest value to the utility.
Stage of Acceptance	Increasingly, utilities are seeing the value of energy management. Its acceptance is growing, especially as a means to stretch limited budgets.
Resources	American Water Works Association Water Environment Federation

General Facility 11 – Design Flexibility for Today and Tomorrow

Best Practice	Operation, administration and management personnel need to be involved with the planning and design of any improvements and/or expansions to their system. Plan and design improvements or expansions that have the flexibility to serve both current system and future system needs, taking into account any significant anticipated changes.
Primary Area/Process	All components of a water or wastewater system.
Productivity Impact	Impact should be negligible.
Economic Benefit	The selected design of any improvements or expansions should reflect the best quality for the most reasonable cost. The simple payback for installing smaller operating units and storage that can follow current system demand, compared with a larger, single unit operating at reduced capacity, can be from one year to five years.
Energy Savings	Energy savings will vary by project, but are directly related to a system's ability to closely meet demand at all points throughout its lifetime, as opposed to being designed only for 20 year peak flows.
Applications & Limitations	None.
Practical Notes	An assessment of the size and space needed to install multiple smaller units, as compared to only two large units, needs to be completed. Also, the continuous operation of a smaller unit will put less stress on a system than a large unit operating periodically.
Other Benefits	Having a system that operates effectively as well as efficiently through the life of its design, not only at its future design condition, is a value to the system operations.
Stage of Acceptance	Designers and owners are becoming more knowledgeable and accepting of equipment sized to match existing conditions, as opposed to only considering projected peak design needs.
Resources	American Water Works Association Pump Systems Matter, Hydraulic Institute, http://www.pumpsystemsmatter.org/

General Facility 12 – Renewable Energy Options

Best Practice	Assess the availability of renewable energy resources (wind, solar, biogas or hydro) at the facility site. If available, investigate the technical and economic feasibility of installing equipment to harvest these resources to meet part or all of the facility's electric and heating needs.
Primary Area/Process	Traditionally, renewable energy in the wastewater industry has meant the use of biogas to heat buildings and processes. Technological advancement in other renewable resource areas has lead to their cost effectiveness for certain applications and under certain conditions. Now more consideration is given to the use of wind and/or hydro power resources for electric generation and solar energy for space and process heating.
Productivity Impact	No impact beyond construction and commissioning.
Economic Benefit	Typically payback periods for renewable energy technologies range from three to seven years.
Energy Savings	Energy savings will vary with location. Renewable energy benefits will increase by using cascading energy streams (e.g., first using recovered biogas to fuel an engine and then capturing the heat from the engine and exhaust systems to serve low grade heat applications, such as space or process heating).
Applications & Limitations	The site must be assessed to identify the best match of the renewable resource to the application.
Practical Notes	A renewable resource must be available at the facility to be beneficially used.
Other Benefits	Renewable energy may offset electric utility demand. Their use avoids the use of dirtier, non-renewable fuels, such as coal for electricity or gas for heating, providing a favorable environmental impact. Operations may run smoother because more attention is given to operate them correctly.
Stage of Acceptance	The use of renewable energy sources within the wastewater industry is widely accepted, but not often implemented, due to lack of knowledge and experience.
Resources	Water Environment Federation ASCE Focus on Energy Renewables Program

APPENDIX A

Additional Quotes in Support of Energy Management at Water and Wastewater Facilities

"As the cost of energy escalates it is even more imperative that the entities responsible for supplying water and treating wastewater evaluate and implement available technologies for reducing energy consumption. In the end it is our customers who will benefit."

Kevin Breit
City of Mosinee

****

"As a consulting engineer, and resident of this planet, I am an energy saving advocate … as good stewards, one should use our resources wisely and efficiently, minimizing waste….[W]e can accomplish water quality objectives and public safety while using energy management and conservation techniques. … saving operations expense, ultimately reducing costs to the consumer."

Tom Vik, P.E.
McMahon Associates, Inc.

****

"The program that we have implemented is intended to not only reduce energy consumption at the Prairie du Chien Wastewater plant, but also to direct the dollars we save on energy into money that we can use to improve our collection system, lift stations and the WWTF itself. What this means is that the ratepayers in the City of Prairie du Chien are getting better service for the money they spend. [We are] excited about the opportunities to protect our natural resources by reducing energy consumption and producing a higher quality effluent that we discharge into the Mississippi River through more efficient treatment."

Terry Meyer
Prairie du Chien Wastewater Facility

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"Controlling and reducing our energy consumption is an efficient and effective means of controlling the increases in our operating costs. Madison Water Utility is committed to energy management to control operating costs, to conserve resources, and to provide a high quality service to our customers."

Al Larson
Madison Water

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"Energy awareness and energy management are very important aspects of daily operations. However, all of us have to fit both into ever tightening budgets and schedules. Money for projects and man hours needed to implement those projects become less available as time goes on. Sometimes it is difficult to see the benefit of an energy savings project if it comes with a formidable price tag. Often the pressure from upper management or elected officials to keep taxes or rates low have intimidated managers to the point where they are very hesitant to propose projects that will cost money. It is imperative that managers begin to look to the future and step beyond the "sticker shock" of projects. Reduction of energy use must be included in the evaluation of projects and many managers will be amazed at how quickly some projects will pay for themselves"

Peter Conine
City of Waukesha

****

"An important part of successfully operating a Wastewater Treatment Facility, often overlooked, is the management of energy. A large portion of the overall cost to run a Wastewater Treatment Facility will go towards paying the electric bill, therefore, it should be a priority to have a good understanding of how you are billed and to run that facility in the most efficient and cost-effective way possible. I have had the opportunity to be involved at two different facilities where Wisconsin Focus on Energy has performed energy audits and has made recommendations on where and how to save energy. At both facilities energy saving measures were implemented with great success…"

Jeremy Cramer
City of Adams and City of Stevens Point

****

"With rising fuel and power prices, salary increases, levy limits imposed on property taxes it has become more important to reduce costs wherever possible. Energy management in water supply and wastewater treatment systems is an extremely efficient tool in reducing the cost of operation."

Bob Mommaerts, P.E.
City of Oconto

****

"Energy awareness is something that we all have become tuned in to. The City of Burlington is currently looking at microturbines as a means of electricity and heat. Grant money is available and easily applied for, making a win-win situation."

Connie Wilson
City of Burlington

****

"Working for a public entity, I feel I am entrusted by the public to do my job cost effectively. By watching what we are doing, we have proven we can cut our costs and not jeopardize effluent quality. I have found that high electric bills for pumping of water to our city water system have shown that it was time to do a leakage survey. Again, we save costs to the consumers and lowered the generating needs of the utility supplying us."

Bob Salmi
City of Darlington

****

"The City of De Pere Wastewater Treatment Plant has made efforts to install energy saving equipment and processes for the past twenty years. A few years ago I was making plans to upgrade our aeration system with new blowers and fine bubble diffusers. Our supplier of fine bubble diffusers informed me of the Focus on Energy group [and] *told me that they would work with me to determine the amount of energy savings, and possibly be eligible for some grant money through the program for applicable projects.*

I have found that the group is wonderful to work with. In fact, they study the project and present the report, which includes the amount of energy savings and time frame for pay back. So far I have worked with them on three projects that have generated $87,550 in grant monies to us from the Focus on Energy group.

Power costs make up a high percentage of our total yearly budget. Because of energy saving installations and replacements in our facility, I have been able to maintain or decrease our wastewater treatment rates. Ultimately, savings are realized by our residential customers, small business and industry. When serving the public sector, it is important to do the best job, while offering the lowest possible cost to our customers."

Michael Kersten
De Pere Wastewater Treatment Plant

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APPENDIX B

Department of Natural Resources Regulations and Energy Considerations

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary

101 S. Webster St.
Box 7921
Madison, Wisconsin 53707-7921
Telephone 608-266-2621
FAX 608-267-3579
TTY Access via relay - 711

DEPARTMENT OF NATURAL RESOURCES REGULATIONS AND ENERGY CONSIDERATIONS

September 8, 2006

The Wisconsin Department of Natural Resources (WDNR) recognizes the importance of increasing energy efficiency at water and wastewater facilities and generally endorses the goals and recommendations of the **Water and Wastewater Energy Best Practice Guidebook.** Although the Department strongly supports energy conservation, providing necessary treatment (with a reasonable factor of safety to ensure reliability) and attainment of all regulatory requirements must not be sacrificed as a result of seeking energy savings.

WDNR regulations for public water systems are addressed chapter NR 811, Wis. Administrative Code and municipal wastewater systems are addressed in chapter NR 110, Wis. Adm. Code.

Water Systems

Chapter NR 811 does not include requirements or recommendations to evaluate energy consumption in the design or equipment selection processes. While there are no regulations to do so, the Department encourages water systems to consider energy savings measures when designing new facilities, replacing existing equipment, and in daily operations.

Wastewater Systems

Municipal (and privately owned domestic) sewerage system designs are primarily subject to the requirements in NR 110, Wis. Adm. Code. Industrial wastewater systems are subject to WDNR approval as required by NR 108, and, because of variable wastewater characteristics, are based on standard engineering practice.

Planning requirements for new or modified municipal wastewater facilities are contained in s. NR 110.09, Wis. Adm. Code. An analysis to demonstrate that a proposed project is cost-effective must be provided. The cost-effective analysis must identify both capital and operation and maintenance costs, including electrical power costs. Although the Department has not historically required an extensive evaluation of potential energy saving measures, such considerations are encouraged as part of the overall determination of cost-effectiveness.

Various requirements in NR 110 refer to conducting the planning analysis over a 20 year planning period and using the 20-year design flow and loading projections as the basis for design. Although NR 110 generally emphasizes the 20-year design basis, it is actually an over-simplification to say that "a facility should be designed for the 20 year flow and loading". Good design practice includes looking at the range of operating conditions expected from the initial operating year up to the twentieth year, and making design accommodations to enable effective and efficient operation throughout the planning period.

DEPARTMENT OF NATURAL RESOURCES REGULATIONS AND ENERGY CONSIDERATIONS

One method to accomplish this is to design treatment processes with multiple treatment units such that certain units can remain out of service until needed. Another method is to provide equipment that can operate over ranges rather than only one set rate. This applies to pumping systems in particular. Under s. NR 110.14 (2) (b) 3, the DNR may require the use of variable speed pumps or multiple constant speed pumps where large fluctuations in flow are known to occur. Aeration equipment is also a large energy consumer, and similarly, variable speed blowers, paced off of in-line dissolved oxygen sensors, can result in good process control and energy efficiency by providing oxygen amounts based on the specific biological needs of the plant.

Chapter NR 110 also allows staging of construction over time periods shorter than 20 years if that is demonstrated to be cost-effective. This could be applied to the facility as a whole, or possibly to just one unit process or system within a facility where the remainder of the facility is designed for the 20 year condition.

Basing design on a shorter time period may be beneficial for a variety of reasons, including the creation of an energy efficient design. The need for this consideration is supported by the findings of numerous assessments performed for the Focus on Energy program which show that many municipal wastewater treatment facilities are treating less than 50% of their design loads, while operating all of their available equipment.

Staging, or otherwise operating in a range more in accord with current loadings, can provide various benefits, including energy savings, but this must be carefully implemented to ensure that adequate treatment will still occur at all times. One of the most challenging aspects of designing and operating municipal wastewater facilities is to accommodate a wide variability in flow and loadings. Operating with a conservative safety factor is a normal and necessary practice. The WDNR encourages the attainment of efficiency, but at the same time will hold permittees fully accountable for permit compliance. Operators should contact WDNR staff if they are considering making significant operational modifications that may affect treatment levels or that relate to permit compliance questions.

Many wastewater facility managers and operators take great pride in producing an effluent quality that is substantially better than the minimum required by their WPDES permit. These exceptional quality effluents can provide important water quality benefits and these efforts are fully supported by the WDNR. The Department endorses the attainment of energy efficiency, but only in conjunction with maintaining high treatment performance levels.

Wastewater facility modifications will normally require a review and approval by the WDNR. Certain improvements may be considered "maintenance" work and do not need to be submitted to the WDNR for plan review. The following Internet link leads to the Department's guidance on what is a "reviewable project" .

http://dnr.wi.gov/org/water/wm/glwsp/facilities/submittalrequired.htm

Additional Department guidance on "Wastewater Systems Plan Review", including links to DNR administrative rules, can be obtained from:

http://dnr.wi.gov/org/water/wm/glwsp/facilities/

APPENDIX C

Wastewater Treatment Facilities from Low Efficiency to High Efficiency by Flow Range

Figures C1 – C5 in the following pages illustrate the variation in energy use at various Wisconsin wastewater treatment facilities grouped by different hydraulic flow rates and treatment processes. Focus on Energy conducted site visits to gather data from these facilities. Each graph shows quartile lines with the top performers falling into the far right quartile. Note: "Activated Sludge" refers to diffused aeration, as differentiated from aerated lagoons and oxidation ditches which also rely on activated sludge treatment.

Figure C1

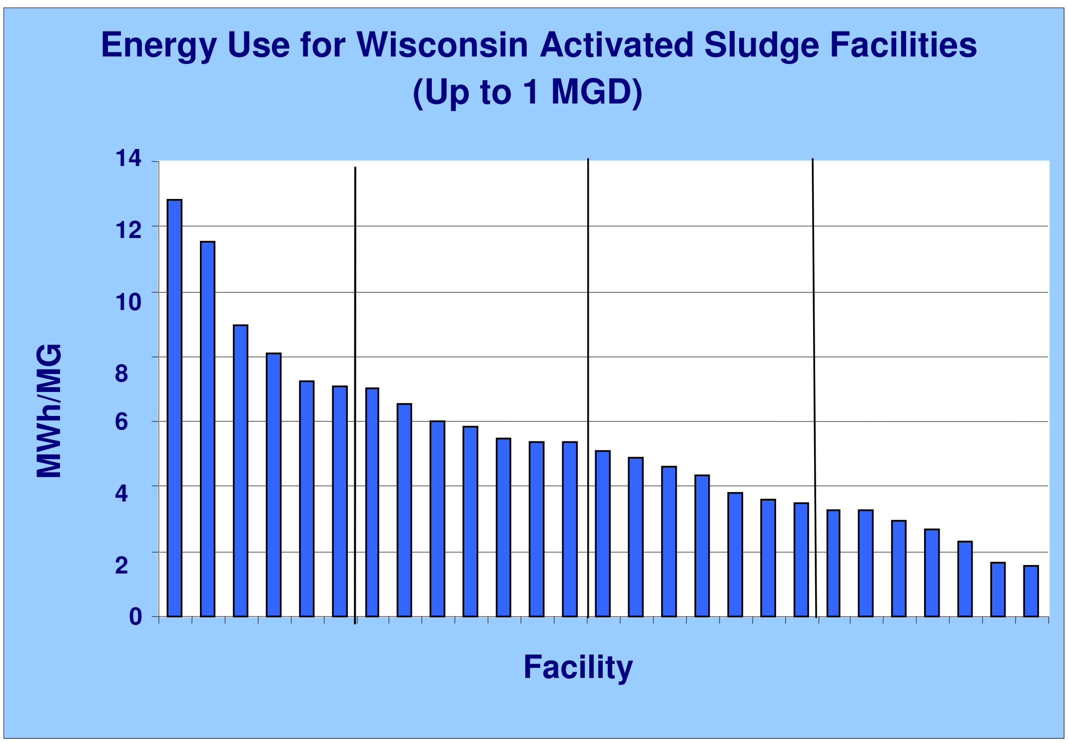


Figure C2

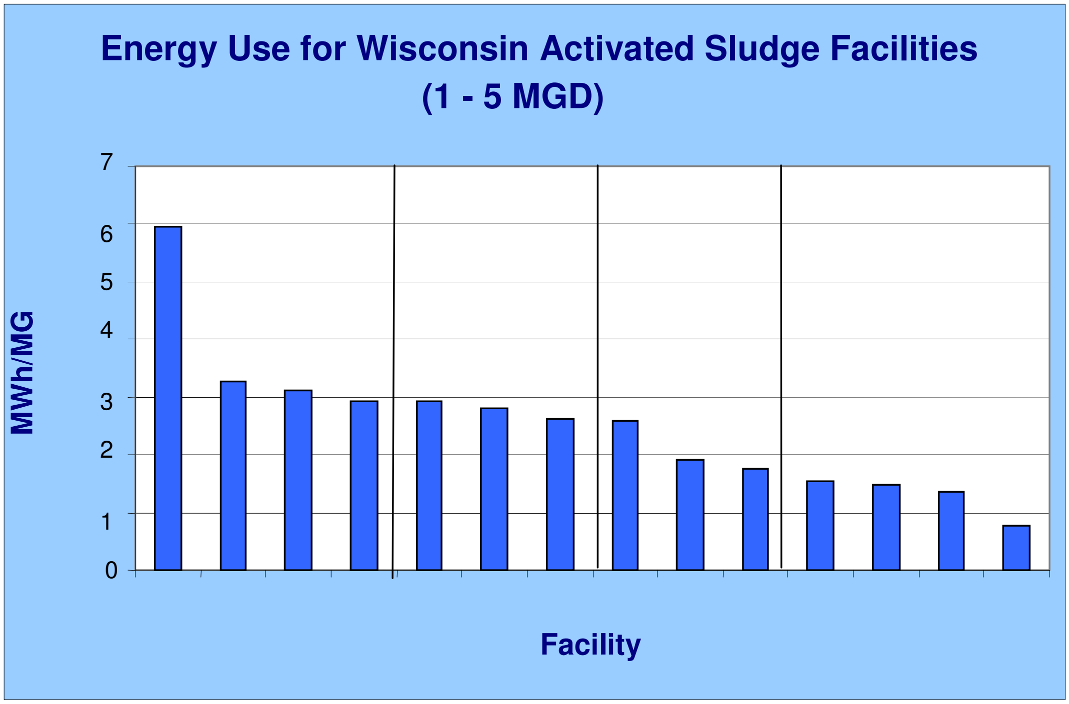


Figure C3

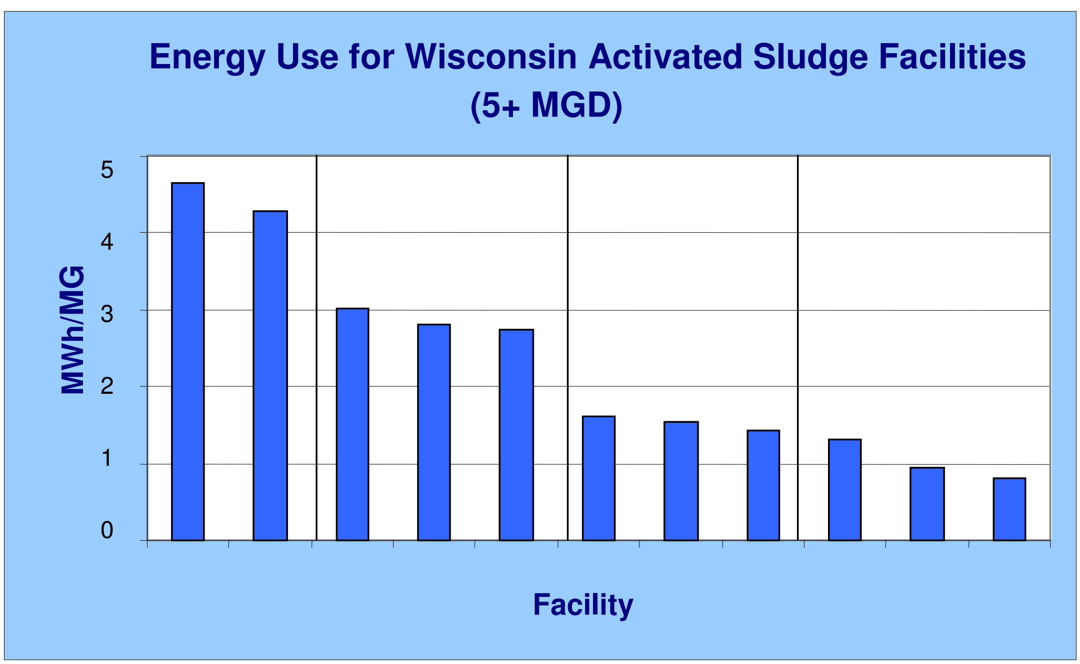


Figure C4

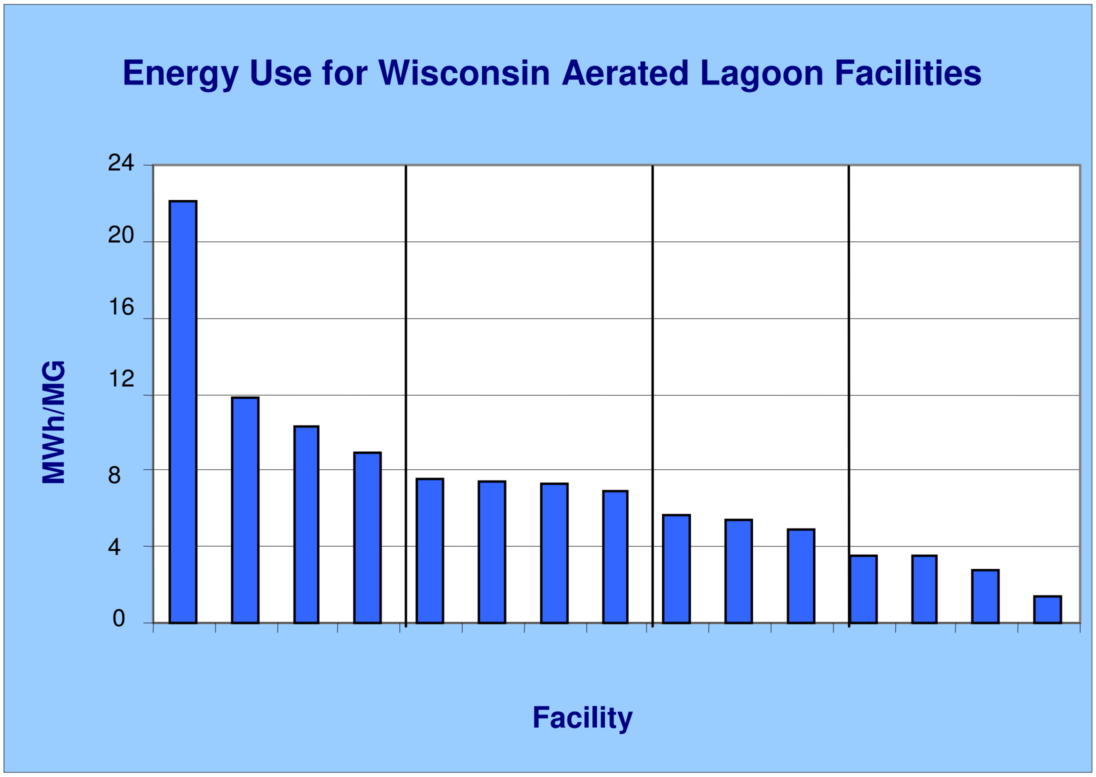
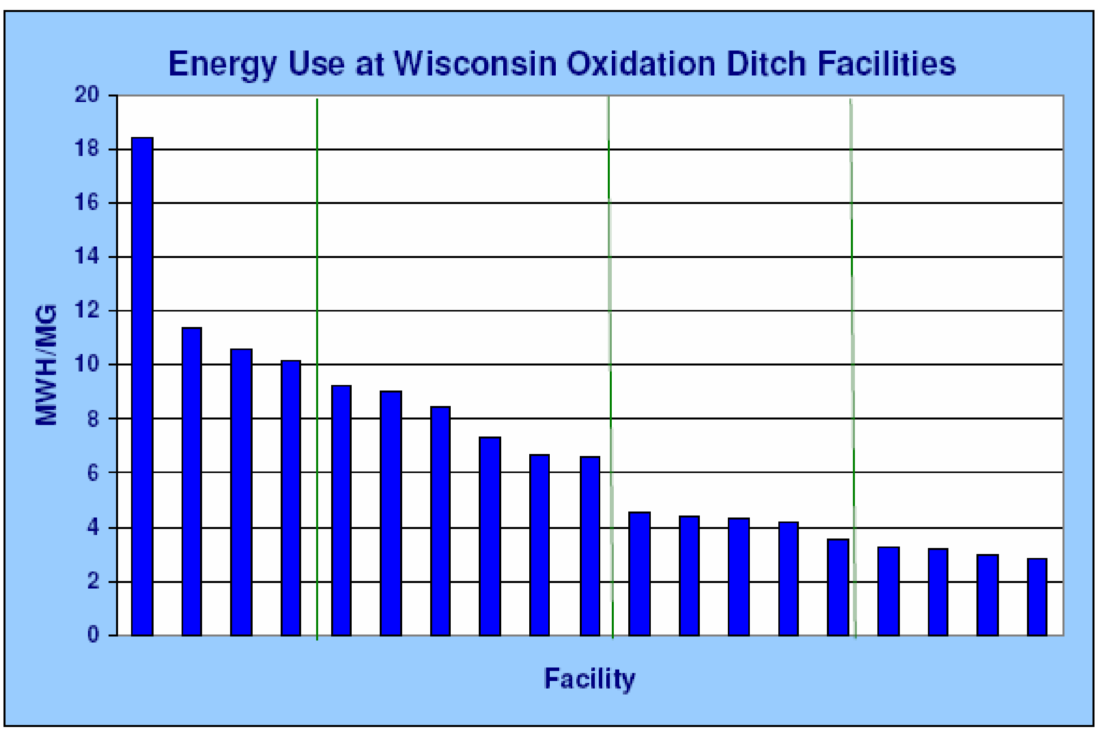


Figure C5



APPENDIX D

Best Practices for Common Systems

The following are key energy best practices within common systems in industrial facilities. For more information on these best practices, free technical support to estimate the best practice energy savings for your systems and possible financial incentives call the Focus on Energy - Industrial Program at 800-762-7077.

System	Best Practices	System	Best Practices
Compressed Air		**Area Comfort Heating**	
	Reduce system pressure		Reduce waste heat
	Repair leaks		De-stratify heated air
	Single vs. two stage		Control heating to desired temperature
	Variable inlet volume		Use infrared heating
	Variable speed control		Optimize CFM air exhausted
	Energy efficient motor		Automatic temperature control
Lighting			Minimize heat to storage areas
	Light meter used to verify levels	**Comfort Cooling**	
	T8 or pulse start MH lighting are considered		Install removable insulation
	Occupancy sensors		Minimize unnecessary ventilation
	Lights off during process shutdown		Minimize moisture released
	Task lighting is maximized		Higher efficiency AC
	Night lighting is turned off		Optimize room air temperature
	LED lamps in exit signs	**Dehumidification**	
Motors			Reduce humidity load
	Premium efficiency motor vs. repair		Accurately controlling humidity
	Cogged belts vs. V-belts		Optimize ventilation
	Premium efficiency motors specified		Desiccant dehumidification
Pumps			Minimize reheat energy
	Trim impeller to meet maximum Load		
	Use VSD instead of throttled control		
	Use VSD instead of bypass control		

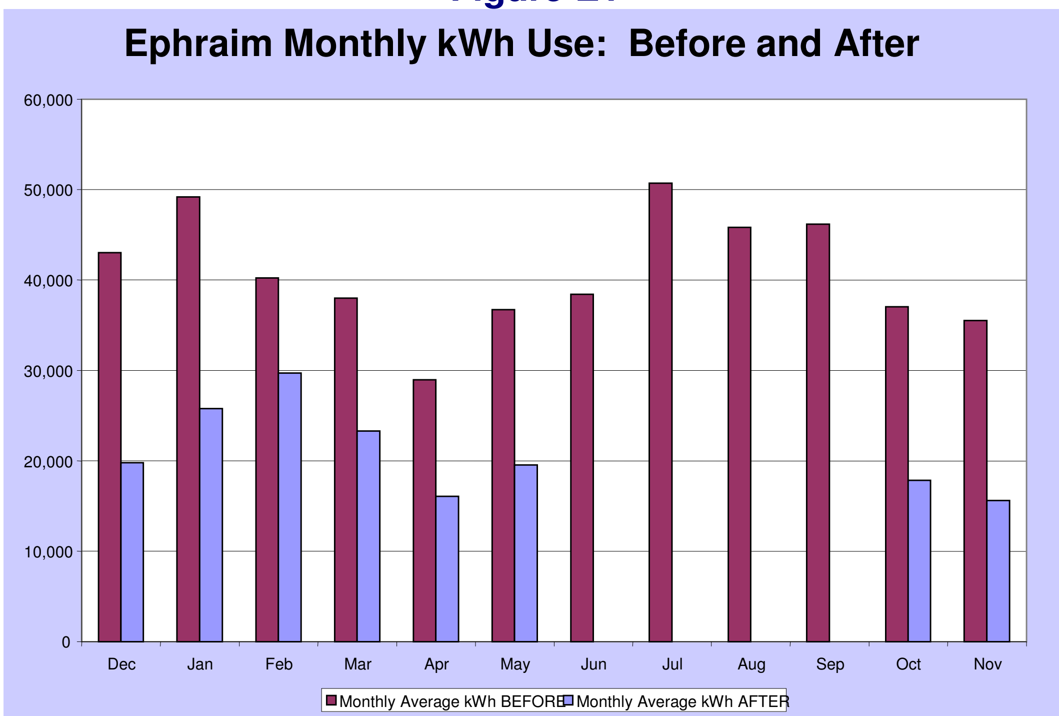
Best Practices for Common Systems – continued

Refrigeration		**Fan Systems**	
	Thermosiphon		Reduce excess flow
	Evaporator fan control		Eliminate flow restrictions
	Floating head pressure		Correct poor system effects
	Scheduled maintenance		Optimize efficiency of components
	- Clean filters		Correct leaks in system
	- Low refrigerant charge		Optimize fan output control
	Automatic air purge	**Process Cooling**	
Steam Systems			Use VSDs
	Reduce steam pressure		Float head pressure
	Steam trap maintenance		Use of free cooling - fluid cooler
	Minimize blowdown		Use of free cooling - cooling tower
	Insulate pipes		Match chilled water pumps
	Improve boiler efficiency		Insulate pipes and vessels
	Heat recovery for boiler blowdown		Process to process heat recovery
	Increase condensate return	**Process Heating**	
	Stack economizer		Optimize combustion air fuel ratios
	Recover flash steam		Preheat combustion air
Ventilation			Insulate pipes and vessels
	Direct fired make-up units		Schedule cleaning of heat exchangers
	Better ventilation management		Condensing heat recovery
	De-stratified air		Process to process heat recovery
Wastewater			Ultra filtration for condensation
	Fine bubble diffusers	**Vacuum**	
	Automatic controlled DO sensors/VSDs		Optimize total cost for conveying
	Heat recovery on anaerobic digester		Choose appropriate vacuum pump
	Unneeded aeration basins are shut off		Optimize vacuum pressure
			Eliminate vacuum leaks

APPENDIX E

Examples of water/wastewater utilities that have saved energy through energy efficiency projects and working with Focus on Energy

Figure E1



"Energy savings is a real important part of our daily routines. In 2004, an energy reduction program was implemented with the help of Focus on Energy. We switched from coarse-bubble in the aeration basins to fine bubble, implemented use of one aerator instead of two, replaced blower motors from 75hp to 40hp and installed variable frequency drives for blower motors which are controlled by a dissolved oxygen (DO) meter in the aeration basin. Also removed all the T12 fluorescent bulbs and retrofitted with T8's. The energy consumption dropped dramatically saving us roughly around $10,000 the first year. We continue to look for ways to save energy and we think anyone considering taking the step to reduce their energy consumption should do so with the help of Focus on Energy."

David L. Alberts
Ephraim Wastewater Treatment Facility

Figure E2

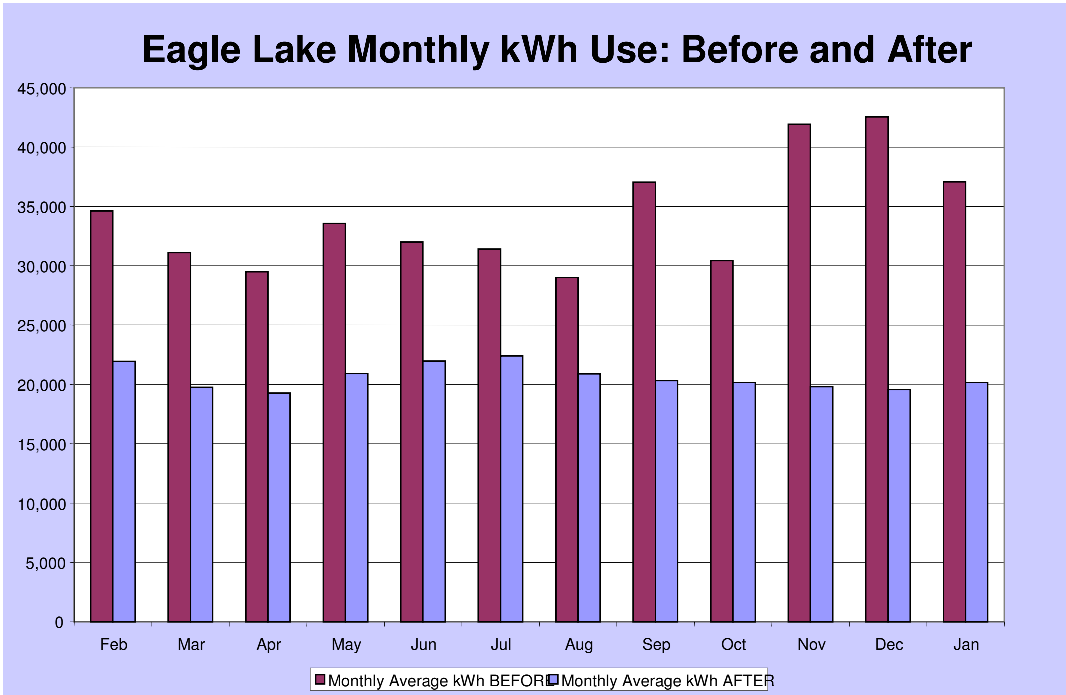


Figure E3

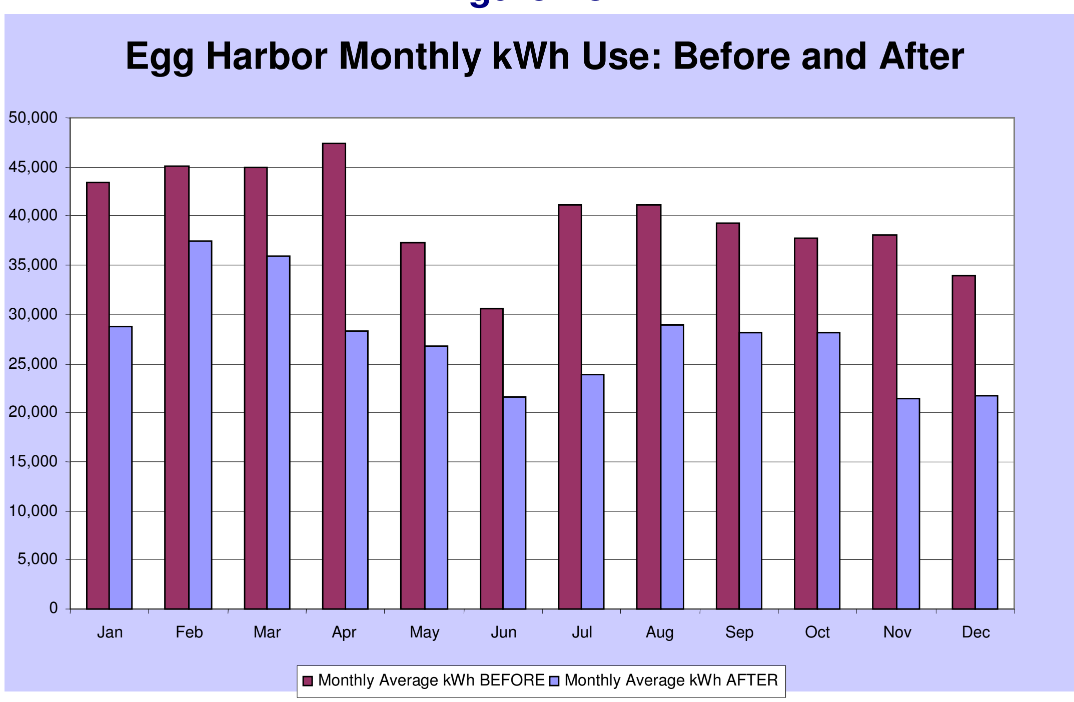


Figure E4

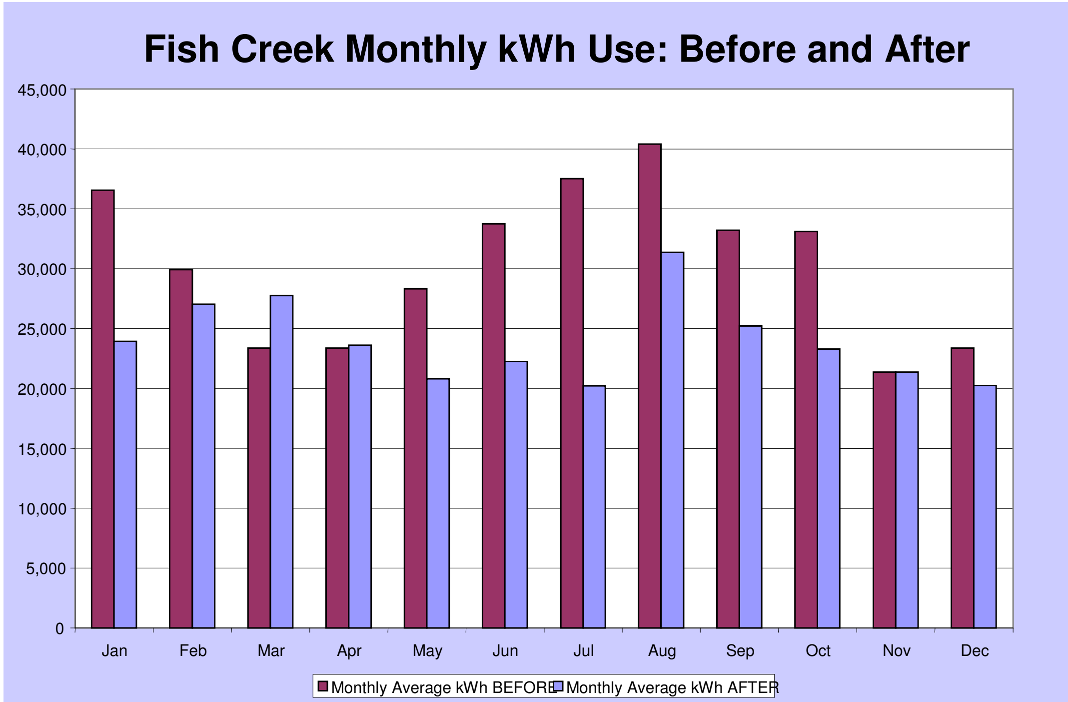


Figure E5

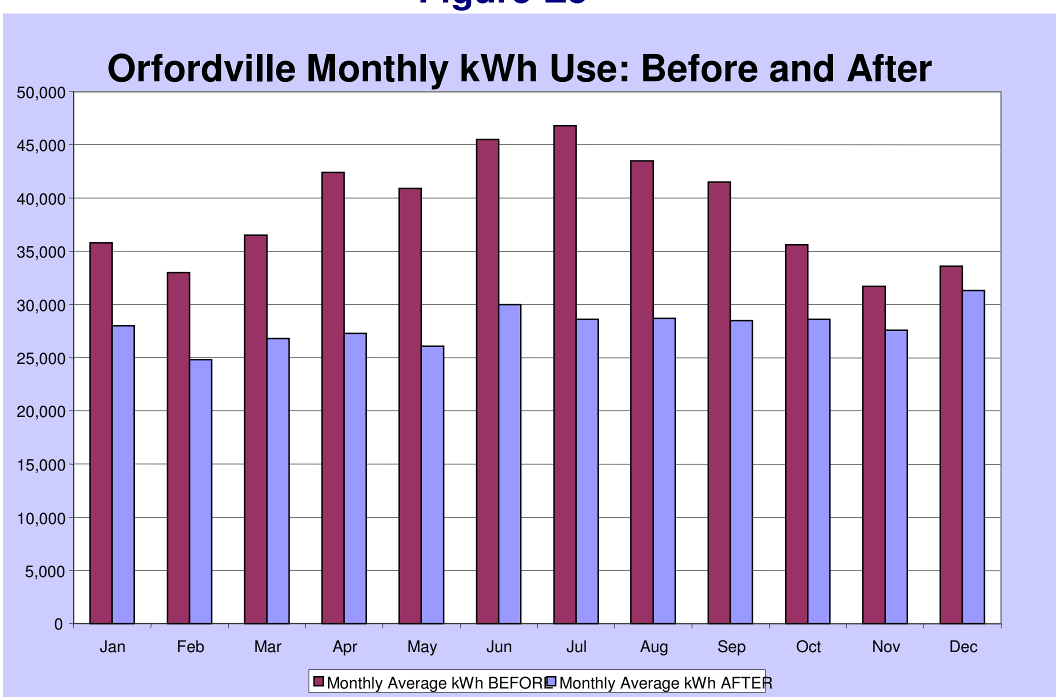
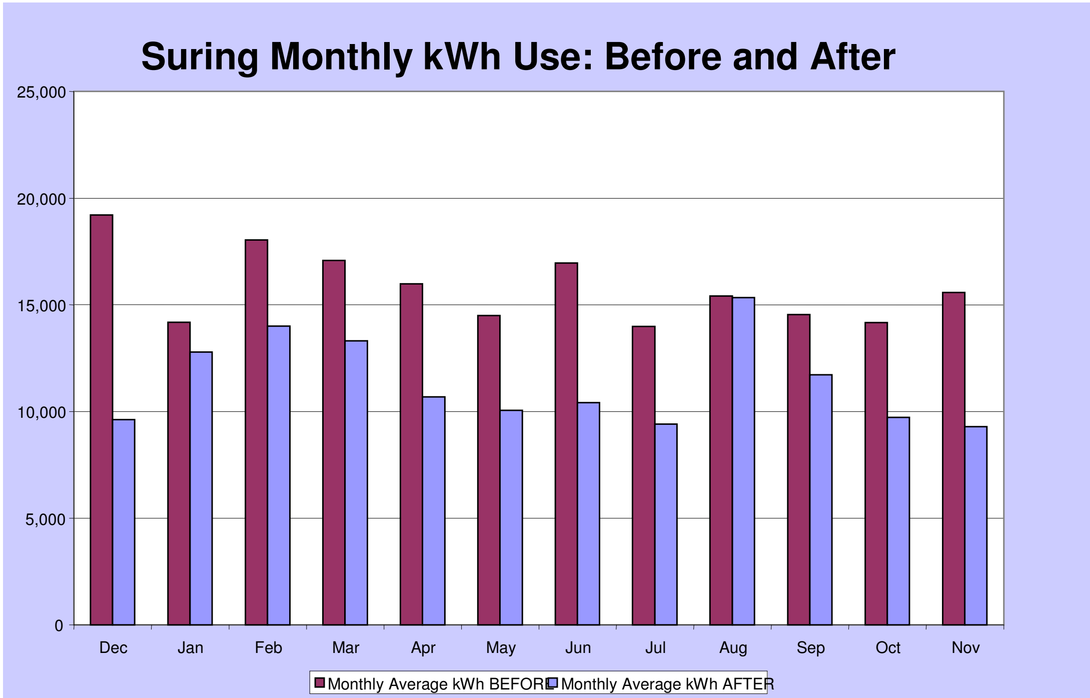


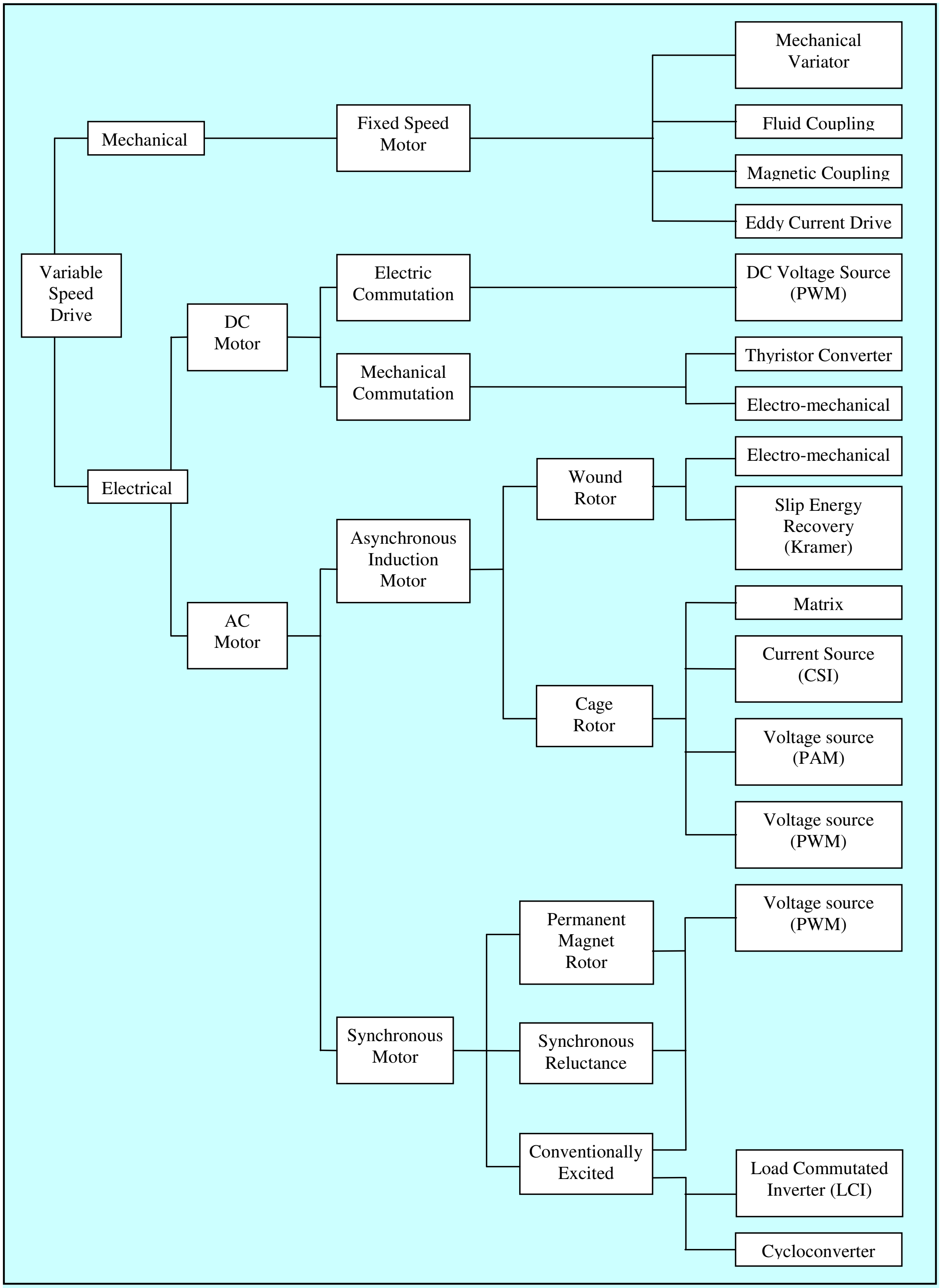
Figure E6



Suring Monthly kWh Use: Before and After
25,000
20,000
15,000
10,000
5,000
0
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Monthly Average kWh BEFORE
Monthly Average kWh AFTER

APPENDIX F

Variable Speed Technology Options



APPENDIX G

Water/Wastewater Energy Guidance Committee

Agencies	
Tom Gilbert	Wisconsin Department of Natural Resources Wastewater Review
Jack Saltes	Wisconsin Department of Natural Resources Wastewater Operations
Preston Schutt	CleanTech Partners, Inc.
Lee Boushon	Wisconsin Department of Natural Resources Water
Dave Lawrence	Wisconsin Rural Water Association
Joe Cantwell	Focus on Energy
Consultants	
Tom Vik	McMahon & Associates
Jim Smith	Applied Technologies, Inc.
Rocky Raymond	Short, Elliot, Hendrickson, Inc.
Dale Marsh	Ayres & Associates
Equipment Representatives	
Don Voigt	Energenecs
Rich Gannon	
Superintendents/ Operators	
Pete Conine	Waukesha Wastewater
Bob Salmi	City of Darlington
Dave Lefebvre	Green Bay Wastewater
Jeremy Cramer	Stevens Point Wastewater
James Carter	Sheboygan Water
Alan Larson	Madison Water
Terry Meyer	Prairie du Chien Wastewater

APPENDIX H

Water and Wastewater Best Practice Guidebook
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APPENDIX I

RESOURCES

Alliance to Save Energy (ASE) – Watergy Website
http://www.watergy.org/

American Council for an Energy Efficient Economy (ACEEE)
http://www.aceee.org

American Water Works Association (AWWA)
www.awwa.org
Also, **American Water Works Association Research Foundation (AwwaRF)**
http://www.awwarf.org/research/TopicsAndProjects/topicSnapshot.aspx?topic=EnrgyMgm

California Energy Commission (CEC)
http://www.energy.ca.gov/process/water/index.html

Consortium for Energy Efficiency (CEE)
For Water and Wastewater Committee Resources and other valuable links, see:
http://www.cee1.org/ind/mot-sys/ww/cr.php3
Energy Benchmarking Project for Water and Wastewater Utilities – Surveys for Water and Wastewater Utility Benchmarking:http://www.cee1.org/ind/mot-sys/ww/awwarf-surveys.php3
For industrial program energy efficiency see: http://www.cee1.org/ind/ind-main.php3

Environmental Protection Agency
www.epa.gov
Also, includes Best Practices for Small Water Systems,
www.wpa.gov/safewater/smallsys/ssinfo.htm

Europump
http://www.europump.org/

Focus on Energy
For technical and financial resources for Wisconsin businesses, both general industrial customers and water/wastewater customers, go to:
http://www.focusonenergy.com/page.jsp?pageId=1626

Pump Systems Matter (Hydraulic Institute)
http://www.pumpsystemsmatter.org/

U.S. Department of Energy – Best Practices (USDOE)
http://www1.eere.energy.gov/industry/bestpractices/

Water Environment Federation
www.wef.org
Also, **Water Environment Research Foundation** – www.werf.org