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Managing Energy Costs in Wastewater Treatment Plants

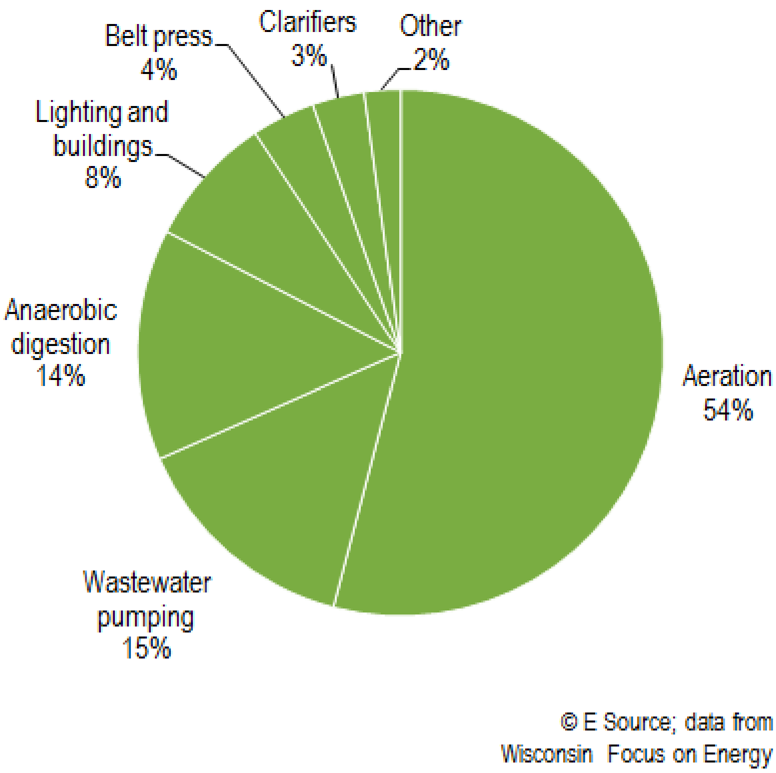
There are approximately 17,000 municipal wastewater treatment facilities in the US. Wastewater and municipal drinking water treatment systems account for about 3 percent of total US energy consumption and approximately 35 percent of the total energy consumed by municipalities.

A breakdown of electricity consumption at a typical municipal activated-sludge wastewater treatment facility is shown in **Figure 1**. Electricity accounts for 90 to 95 percent of the total energy consumed by these facilities; the remainder is fuel (fuel oil or natural gas) used for back-up electricity generation or natural gas used to heat buildings.

Average energy use data

Figure 1: Electricity consumption by end use

Aeration accounts for more than 50 percent of wastewater treatment plant electricity consumption.



Top technology uses

- Drivepower
- Lighting
- Ventilation & air handling

QUICK FIXES

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Wastewater treatment plants typically have one or more administration buildings that could benefit from the following energy-efficiency measures. These measures cost nothing or only a little, are easy to implement, and utilize proven technologies.

Turning things off

Turning things off seems simple, but remember that for every 1,000 kilowatt-hours (kWh) you save by turning things off, you'll save $100 on your utility bill (assuming average electricity costs of 10 cents per kWh).

Computers and monitors. Computers and other electronic equipment can contribute up to 20 percent of overall energy consumption. You can gain significant energy savings by verifying that computer power-management settings are enabled on individual computers and monitors, forcing them to enter sleep mode after a specified period of inactivity. Effective power-management settings can cut a computer's electricity use roughly in half, saving up to $75 annually per computer. Although most computers are now shipped with some sort of power management settings enabled, those settings can be disabled or made less effective, or they can be made more rigorous to maximize energy savings. For more information, the US Environmental Protection Agency (EPA) offers detailed instructions on Energy Star's The Business Case for Power Management page.

Other office equipment and plug loads. Like computers, devices such as printers, fax machines, and coffeemakers often have energy-reduction settings that can yield substantial energy savings. Additionally, consider using smart power strips with occupancy sensors, which are an easy way to shut off often-forgotten energy users such as printers, monitors, desk lamps, and radios.

Lights. Lights should be turned off when not in use, but many people forget to take this step. When properly installed, occupancy sensors and timers can do this for you. A no-cost option is to simply train staff to turn off lights as part of their closing procedures (you can also help by posting a notice that identifies the locations of light switches).

Chilled-water drinking fountains. Water fountains generally don't need to provide ice-cold water 24 hours a day unless it's required for health reasons. In most cases, you can turn off the cooling systems in drinking fountains.

Vending machines. Refrigerated vending machines typically operate 24/7, using 2,500 to 4,400 kWh per year and adding to cooling loads in the spaces they occupy. Timers or occupancy sensors can yield significant savings because they allow the machines to turn on only when a customer is present or when the compressor must run to maintain the product at the desired temperature.

Walk-through audits. For facilities that don't operate constantly, one method to identify energy-efficiency opportunities is a walk through the facility after hours. Much of the equipment that is left on overnight or over the weekend in an empty building is a good candidate for saving energy by switching it off. Consider recruiting volunteers from each shift as monitors.

Motors. Identify motors that are operating unnecessarily and shut them down. This could be as simple as ceiling fans running in unoccupied spaces or as complicated as cooling tower fans still running after target temperatures have been met.

Turning things down

Some equipment cannot be turned off entirely but can be turned down to save energy.

HVAC temperature setbacks. During closed hours, turn down temperature settings during heating seasons and turn them up in cooling seasons. Programmable thermostats make temperature setbacks a reliable option.

Peripheral and back rooms. Make sure that HVAC settings in rarely used offices and other peripheral rooms are at minimum settings.

Window shades and blinds. During warm weather, blinds can block direct sunlight and reduce cooling needs; in the winter, opening the blinds on south-facing windows will let in sunlight to help heat the space.

Optimizing operations and maintenance

Given all the moving mechanical parts in a wastewater treatment plant, it’s very important to remember that regularly scheduled operations and maintenance (O&M) can keep equipment running smoothly and delivering energy savings.

Check motors. Mechanical problems are the main cause of premature failures of electric motors. Routinely lubricating motors, checking for clean and adequate ventilation, and ensuring that motors aren’t suffering from a voltage imbalance will help them achieve their full-life potential while simultaneously minimizing their energy consumption.

Inspect fans, bearings, and belts. A thorough inspection of fan blades, bearings, and belts at least once a year can prevent failure and maintain efficiency. During the inspection, fan blades should be cleaned, bearings should be checked for adequate lubrication, and belts should be adjusted and changed if needed.

Conduct a recommissioning audit. Professionals who are trained in identifying wastewater treatment O&M and capital opportunities offer audits similar to the walk-through audit described above, but focused on identifying a broader set of opportunities (not just turning equipment off). The audit typically lasts up to a day, and ends with the delivery of a report detailing potential savings measures, plus estimated costs and benefits. The audit is often done in conjunction with benchmarking, which involves collecting facility energy use data, billing data, and facility comparison data. Recommissioning audits identify efficiency measures that will restore the overall plant performance to original design levels, but they do not delve into specifics about the performance of process systems.

LONGER-TERM SOLUTIONS

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Longer-term solutions are energy-saving measures that require more investment of capital or longer payback periods, but they may also result in larger energy and cost savings.

Monitor energy usage

For many wastewater treatment facilities, improved energy monitoring is a great place to start when trying to reduce energy consumption. Many utilities will provide access to 15-minute interval data from the facility's main meter. Installing additional submeters, such as for the pumps or blowers, can also be worthwhile. And there are many energy-information software products that can help facilities gather and display energy and process data in a way that helps operators optimize performance and save energy. According to EnerNOC, which has conducted research on energy monitoring and information systems for the Northwest Energy Efficiency Alliance (NEEA), industrial facilities (including wastewater treatment plants) can save between 5 percent and 20 percent of their total energy consumption by installing energy-management and energy-information systems and by training facility staff to use the information.

The wastewater treatment facility in Greeley, Colorado, installed a new system in 2014 to gather and display its electricity information in a way that is useful for plant operators. The city publishes the information online , so that the public can to see how much energy the facility is saving on a daily basis.

Audit aeration and pumping systems

The two largest energy-consuming end uses for wastewater treatment facilities are the aeration and pumping systems, and adding better controls to these systems can save energy. Often, your local utility will offer free or subsidized energy audits, and there are many consultants who have expertise in these systems.

Aeration system controls. Upgrading the controls on the blower system can be a significant energy-saving opportunity. Improved controls can significantly reduce energy consumption when the aeration system is operating at less than full capacity.

We spoke with a facility engineer at the Fort Collins, Colorado, wastewater treatment facility. He told us that in 2012, his facility upgraded the controls on its blower system, installing an automated control system with much better turndown capabilities and a blow-off valve to improve system performance. Along with other blower upgrades, the improved controls helped reduce energy consumption from the aeration system by about 30 percent.

ASDs on pumps. Pumping systems are the next-largest energy consumers at wastewater treatment facilities. An energy audit will reveal any pumps that are consistently operated at partial loads; those may be good candidates for adjustable-speed drives (ASDs). ASDs can achieve significant energy savings in the right applications, and simple payback periods can be as low as three years. Utility incentives can help make these projects even more cost-effective.

Upgrade to LED lighting

Outdoor lighting fixtures at wastewater treatment plants are especially good candidates for LED upgrades. In addition to reducing lighting energy costs by about 70 percent, LEDs result in significant maintenance costs savings due to their longer life. In 2013, the city of Greeley completed a comprehensive upgrade of its outside lighting, switching from metal halide and high-pressure sodium lights to LEDs, spending a total of $47,000. After the utility incentive, the estimated payback period was about 5.7 years.

Use turbo blowers

There are several alternative technologies for providing process air to the aeration system (**Table 1**). The turbo blower is a newer and highly efficient alternative, offering high efficiency over a wide range of air flows in addition to low maintenance costs. This technology has become increasingly popular since its introduction to the wastewater treatment market in 2007, and there are seven or more competing manufacturers in the US, according to a report from Carollo Engineers, Overview of Blower Technologies and Comparison of High-Speed Turbo Blowers (PDF).

Table 1: Typical blower efficiencies

Turndown capability is an indication of the blower's ability to meet a range of airflow requirements.

Blower type	Nominal blower efficiency (%)	Turndown capability (% of rated flow)
Multistage centrifugal (inlet throttled)	50–70	60
Multistage centrifugal (variable speed)	60–70	50
Positive displacement	45–65	50
Single-stage centrifugal, integrally geared (with inlet guide vanes and variable diffuser vanes)	70–80	45
Single-stage, high-speed turbo	70–82	50

© E Source; data from Carollo Engineers

The Greeley wastewater treatment facility installed six 300-horsepower high-speed turbo blowers in 2011. The installation resulted in cost savings of about $100,000 per year and reduced the facility's total electricity consumption by about 15 percent. The simple payback period for investment in the turbo blowers, after rebates from Xcel Energy, was about 6.6 years.

Take advantage of combined heat and power

Most midsize or large (greater than 1 million gallons per day) wastewater treatment facilities have anaerobic treatment processes. These processes produce biogas, which typically consists of about 65 percent methane and 35 percent carbon dioxide and impurities, according to the American Council for an Energy-Efficient Economy (ACEEE) report Reduce Grid Required Energy to Utilize Your Wastewater Treatment Facility (PDF). Rather than flaring the biogas, it can be captured and used for on-site electricity generation through an internal combustion engine or combustion turbine. The waste heat from the power generation is used to heat the anaerobic digester, enhancing its performance, especially during cooler months. The waste heat can also be used to heat buildings in cooler months. Generating electricity and using the waste heat on-site is called combined heat and power (CHP).

The potential benefits of CHP include energy cost savings, improved electrical reliability, and reduced greenhouse gas emissions (from reductions in purchased electricity, flared methane, and possibly natural gas consumption). Depending on the amount of solids being treated through the anaerobic process and their organic loading, the wastewater treatment facility may need to collect supplemental food wastes in order to generate an adequate and consistent quantity of biogas to supply the CHP system. The biogas also needs to be pretreated to remove the impurities.

Add solar PV

Another option for clean, renewable electricity generation is through a solar photovoltaic (PV) system. This option is attractive to wastewater treatment facilities in cities that have greenhouse gas emission reduction goals. In addition, many facilities are surrounded by open space that could potentially be used for PV arrays. With the price of PV systems coming down and financing options readily available (such as a ten-year lease), an increasing number of wastewater treatment facilities are installing PV systems to provide a portion of their electricity needs.

For more information

These are some of the most common energy-saving measures for wastewater treatment plants. A more comprehensive list of measures and strategies can be found in the Water & Wastewater Industry Energy Best Practice Guidebook (PDF) from Wisconsin Focus on Energy, and in Energy Efficiency Strategies for Municipal Wastewater Treatment Facilities (PDF) from National Renewable Energy Laboratory.