Wastewater Treatment Plants

Nationally, the energy used by water and wastewater facilities accounts for 35% of the typical U.S. municipal energy budget, with electricity usage accounting for 25-40% of operating budgets for these facilities (NYSERDA, 2008).

The good news is that there are lots of ways to substantially decrease energy usage in these facilities. SEDAC has analyzed dozens of wastewater treatment facilities, helping them select the most energy-efficient options, both for their pocketbook and for the environment.

While wastewater treatment plants can benefit from many of the same strategies that make other buildings more efficient (LED lighting, HVAC controls and maintenance), this brochure focuses on the unique strategies wastewater treatment plants can adopt to save energy and money.

ENERGY EFFICIENT EQUIPMENT AND SYSTEMS

VARIABLE-FREQUENCY DRIVES
A variable-frequency drive (VFD) is an electronic controller that continuously adjusts the speed of the motor of a pump, fan, or blower to meet demand fluctuations. VFDs have a “soft start” capability—they slowly bring the motor to the appropriate speed to reduce stress on the motor, and lower maintenance costs. VFDs are reliable, easy to operate, reduce pump noise, and increase the degree of flow control.

Since VFDs work with most three-phase electric motors used by throttled pumps, retrofitting is a viable option. VFDs can also be used on aeration blowers. When integrated with oxygen concentration sensing, they can maintain the desired dissolved oxygen concentration over a range of different flows and biological loading conditions.

VFDs reduce pump energy use by 30-50% and save 20% or more on electric usage (significantly more efficient than throttled valves and impeller trimming). The initial cost of a VFD is relatively high from $45,000 to $70,000, but payback typically occurs within 3 years.

ENERGY EFFICIENT MOTORS
Continuously operated pump and blower motors typically account for 80-90% of total energy cost, but energy-efficient motors are only 2-8% more efficient than standard motors. However, their failure rate is much lower. Since replacement of motors is costly, SEDAC recommends immediate replacement if it is used > 8,000 hours per year. If used between 4,000 and 8,000 hours, replace the motor upon failure. For motors used < 4,000 hours, it is more cost-effective to rewind them.

ENERGY EFFICIENT PUMPS
Unlike motors, a pump’s efficiency is greatly influenced by the system it supplies. To adopt an efficient pump system, size pumps according to usage requirements, choose low-loss components, design a pipe-system layout that reduces pressure drops, and select pumps that perform efficiently with varying flow rates for both high and low head.

COGENERATION
Methane gas produced by anaerobic digesters, which is a by-product produced during wastewater treatment, can be used to power cogeneration engines or fuel cells to produce electricity and thermal energy to heat work spaces. In addition, the waste heat from the cogeneration engine or fuel cell can be used to heat the digesters, thus reducing purchased energy. If it is used during peak hours, the facility can run on electricity generated on site when it would be most expensive to purchase electricity from the grid.

FINE BUBBLE AERATION
Using diffused aeration systems in wastewater treatment reduces the amount of organic compounds found in the water so the effluent is clean enough to discharge into rivers or lakes. Higher oxygen transfer efficiencies also permit increased process flow. Sludge flows into an aeration tank where it is mixed with a concentrated suspension of flocculated microorganisms that feed on the settled sewage. The pollutants found in the activated sludge are biologically oxidized until only clarified effluent and digested sludge remain. The sludge can be transferred to the heated digester to convert into fertilizer. The most efficient systems employ fine-bubble aeration, integrated with a VFD control.
1. PUMP IMPELLER TRIMMING
Impeller trimming is recommended for oversized and throttled pumps that produce excess pressure. The impeller is trimmed to a smaller diameter to add clearance between the impeller and the fixed pump casing. This reduces the impeller’s tip speed and the amount of head the pump produces. See graph to the right to see how a “right-sized” impeller produces the same flow with less head pressure.

The trimming procedure is relatively cheap, simple to implement, and reversible through impeller replacement. A pump that is continuously throttled to 10% less than its design flow rate will benefit from a 25% reduction in electrical demand after undergoing impeller trimming. This process has been shown to have a payback range of 2-5 years.

The only pumps appropriate for impeller trimming are those that require a constant flow rate, have no planned process changes, and have a partially closed discharge valve. Also, you will usually still need to throttle to obtain your target flow. If you are interested in impeller trimming, have an expert quantify your facility’s pumping process requirements and then contact your pump distributor for assistance.

2. METHANE DIGESTION WITH FUEL CELLS
Fuel cells are a type of cogeneration system that use the anaerobic gas (methane) produced as a byproduct of wastewater treatment as a fuel source. Cogeneration uses waste methane from the water treatment process. Fuel cells are costly to install but are efficient, reliable, quiet, require less maintenance and produce much less emissions than reciprocating engines and gas turbines.

The electricity produced by fuel cells is ultra-clean and can reduce purchased electricity while the byproduct heat from the fuel cell can be recycled to heat the sludge for additional anaerobic digestion, resulting in 80% efficiency. Fuel cells can convert 40% of the energy found in digester gas into electricity, while engine generator combinations can only convert up to 32%.

In a reciprocating engine, the digester gas is burned, producing sulfur compounds, but with fuel cells, the gas is neither burned nor released. Although sulfur from natural gases attack the cell’s anode, engineers have developed methods to continuously remove the sulfur and make fuel cells a viable and economic option.

3. VARIABLE AERATION
Wastewater treatment plants typically aerate basins to provide adequate mixing of contents. This aeration often operates continuously at a high level, above the level required for biological processes. An alternative energy-saving method is variable aeration: operate at a lower level for most of the day and increase airflow to the level required for mixing once or twice a day for one hour. This increase may lift solids from the bottom of the tanks, bringing the material back into suspension.

4. DISSOLVED OXYGEN CONTROL
To provide variable aeration, dissolved oxygen (DO) is typically the metric used to determine required airflow. Dissolved oxygen controls may be provided at different levels of DO at different points in the aeration basins as several basins are set up in a serpentine pattern where lower DO targets may be maintained in the first pass and increased in each successive pass.

Illinois Wastewater Treatment Plant Energy Assessment Program

Are the costs of operating your wastewater treatment plant too high? Do you want to find ways to bring cost savings to your community? Illinois EPA Office of Energy, in partnership with the Smart Energy Design Assistance Center (SEDAC) and the Illinois Sustainable Technology Center (ISTC) offer free energy assessments to WWTP in Illinois. An energy assessment will include a facility walk through, utility bill analysis, and an assessment report with:
- Energy efficiency recommendations
- Projected capital cost and payback time
- Projected energy and cost savings.

Find out more at sedac.org/wastewater

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