MCES improves aeration process to reduce energy use

Wastewater treatment plant MCES completed an aeration reduction process with MnTAP and MCES interns which resulted in first year total electrical savings of $775,000. Another six million kWh/yr reduction may be added in 2010.

Metropolitan Council Environmental Services (MCES) operates seven wastewater treatment plants that serve the seven county metropolitan area surrounding and including Minneapolis and St. Paul, Minnesota. The Metropolitan Wastewater Treatment Plant (Metro Plant) in St. Paul constitutes 70% of the treatment system's capacity and serves 70% of the area's population. This plant is one of the ten largest in the country in terms of the volume of water being treated.

Incentives for change

In 2006, management set a goal to reduce energy consumption by 15% before 2010. Many different projects have contributed toward accomplishing this goal. However, one of the most significant impacts can be attributed to the changes made to the operation of the aeration system of the Metro Plant between 2006 and 2009. The aeration system became a focus for efficiency projects as it accounts for 60% of the plant's total energy use. Aeration is the second stage of wastewater treatment and relies upon large blowers to provide the air needed. These blowers consume 7-8MW of electrical energy at a cost of about $5.4 million per year.

This project was the combined effort of four summer interns and a number of plant staff members. Two of the interns working on the project were sponsored by MnTAP.

Process description

The aeration process includes 16 tanks, which are used to promote microbial growth that consumes nearly all of the organic material, ammonia, and phosphorus in the wastewater. Each tank is divided into 12 aeration zones; zones 1, 5, and 8 have sensors that control dissolved oxygen levels. The zone 1 sensor controls the oxygen levels in zone 1 alone; this zone consumes about 7% of the blower air. The zone 5 sensor controls oxygen in zones 5

2006 Intern Jason Taubel characterizes oxygen profiles in the tank zones at MCES.

and 6, which consume about 31% of the blower air. The zone 8 sensor controls oxygen in zones 7-12, which consume 55% of the air. The remaining zones, 2-4, are typically kept anoxic or anaerobic and require no added air. Also, the remaining 7% of air generated is used in the secondary influent channel and the mixed liquor channel for mixing and keeping solids suspended.

Air for the aeration tanks is generated by two 3000-hp and four 5500-hp centrifugal blowers. There is a third 3000-hp blower, but it has not operated for many years. Generally, two large blowers could supply the required air to the system during the 5-6 colder months. A third smaller blower was brought online to supply air during the six to seven warmer months, when air is less dense and more air needs to be provided to supply the needed oxygen. Compressed air at between 7-8 psi is blown through 8'4" pipe to the aeration tanks where it is metered into the tank zones through a system of control valves and diffusion membranes.

Benefits Overview

Waste Reduction Option	Waste Reduced/ Materials Savings	Annual Cost Savings
Aeration improvements	13.7 million kWh/yr	$775,000

Aeration Energy Reduction Projects

A significant project was developed and conducted by two MnTAP interns and an additional two interns hired directly by MCES. Also, a number

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of MCES staff guided the interns and continued the project to further develop and implement findings by the interns.

The first MnTAP intern, Jason Taubel, characterized oxygen profiles in the tank zones, developed strong evidence that a number of zones were over-aerated, and developed initial estimates of potential savings. Jason's work led to reduced dissolved oxygen (DO) set-point in zone 1 from 2.5 to 2.0 mg/l, saving 400,000 kWh/year. He recommended reducing the air flow used for keeping solids suspended in the mixed liquor channel. He also identified two methods to reduce the DO set-point in zone 8, as well as three methods for cleaning air diffusion membranes to reduce the header air pressure. Jason was unable to determine the possible impact of diffuser cleaning.

An MCES intern, Phil Novak, followed up on Jason's initial work by developing oxygen profiles for the different zones for a range of DO set-points. He demonstrated that the DO set-point in zone 5 could be reduced from 2.0 mg/l to 1.5 and the DO set-point in zone 8 could be reduced from 2.0 mg/l to 1.0. Another MCES intern, Effe Ankrah, extended the work by developing additional profiles at lower oxygen levels. She demonstrated that the DO set-point in zone 8 could be further reduced to 0.5mg/l. At the same time, plant staff determined that the set-point reductions in zones 5 and 8 could only be accomplished during the warmer half of the year.

Laura Fletcher, the second MnTAP intern and fourth intern overall, was assigned to look at conservation opportunities in the operation of the blowers, the supply side of aeration, and to develop an understanding of blower energy consumption and operating costs. Understanding how changes in air demand affect blower operation was important to refining reliable savings estimates for changes. Laura improved the understanding of the blower efficiency curves and how blower costs are affected by the air volume produced. She developed a spreadsheet to guide MCES in making decisions about when to add a blower into production and when to drop a blower for the lowest operating costs as air demands change. In 2009, MCES used this tool and ran three blowers for less than three months. When compared to previous years, where three blowers ran for 6-7 months, MCES was able to save 121,000 kWh.

2008 Intern Laura Fletcher points out conservation opportunities in the operation of blowers to MnTAP Chemical Engineer Karl DeWahl.

Laura also identified blowers 6 and 7 as being slightly more efficient than the similarly-sized blowers 4 and 5. Laura proposed that the more efficient blowers be utilized as much as possible. However, MCES does not plan to move forward with this suggestion as there are concerns about blower maintenance issues. Laura also identified a number of compressed air leaks in the piping system; some leaks have been repaired, but an estimate of the savings from leak repair is not available.

Diffuser cleaning was also investigated further from Jason's initial work. This project was led by plant staff members. Air bumping was tried as a method of cleaning air diffusers in the tanks. While this method was effective at decreasing the pressure drop across the diffuser membrane, it also resulted in increased air leaks due to PVC pipe breakage and was discontinued. High pressure water cleaning of diffusers in the eight tanks on the east side of the plant was completed in October 2008. This cleaning is estimated to have saved 6,000,000 kWh in the first year for a $60,000 cleaning cost. Studies continue to determine how frequently cleaning will need to occur, but it is estimated that the interval will be at least three years. Cleaning of diffusers in the eight tanks on the west side of the plant is planned for 2010; this cleaning will also likely include a chemical cleaning step due to a different form of fouling that occurs in this area of the facility.

Benefits

Aeration improvements have resulted in first year savings of 7.6 million kWh/yr for DO set-point reductions and 6 million kWh/yr for diffuser cleaning for total electrical savings of $775,000 in the first year. Thus far, the energy savings account for approximately 8% of the Metro Plant's total electrical consumption for the year and are a larger reduction percentage of summer electrical use. Another 6 million kWh/yr reduction may be added in 2010 if the west side cleaning has as large an impact as the east side cleaning did.

The only large budgeted cost for achieving these savings was for the diffuser cleaning, which was contracted out for $60,000. There were salary costs for the interns and an investment in staff hours to support and develop the work, but these remained small compared to the impact.

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For More Information

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The MnTAP intern projects were conducted by Jason Taubel, a junior in chemical engineering at the University of Minnesota and Laura Fletcher, a senior in chemical engineering at the University of Minnesota.