City of St. Peter WWTF

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Organization Background

The City of St. Peter Wastewater Treatment Facility (WWTF), established in 1961, discharges clean effluent water to the Minnesota River. In September 2000, the expanded WWTF was built to provide treatment for population and industrial growth projections through the year 2020 at a designed influent flow of 4 million gallons per day. The process contains preliminary treatment, primary treatment, secondary treatment, ultraviolet (UV) disinfection, and biosolids treatment.

"The MnTAP internship program was a unique opportunity that allowed me to gain engineering experience in a wastewater treatment facility, to develop my own project, to work on a collaborative team, and to experience small town life. My experience was extremely rewarding. In addition to sharpening my understanding of wastewater treatment, working in direct contact with the operators, vendors, and city workers, I thoroughly enjoyed working with such a great team of people." ~ MT

Project Background

The City of St. Peter WWTF largely uses electric energy to operate the plant. The plant's annual electric energy usage for 2015 was 2,943,100 kWh. The secondary treatment process consumes about 26% of the total electric energy. The primary components of this system are seven blowers, each 50 horsepower. The main purpose of these aeration blowers is to provide air for the biological aerated filters (BAF). The BAF blowers themselves account for about 24% of the plant's annual electric energy use. The BAF uses biological organisms to remove contaminates such as: ammonia, biochemical oxygen demand, total suspended solids (TSS), and phosphorus.

To remove contaminates, the blower has to provide the right amount of air. Too little air in the aeration basins slows the growth rate of the bacteria, which provides incomplete treatment. No air would make the bacteria consume the entire dissolved oxygen (DO) in the basin and die. On the other hand, too much air is unnecessary for adequate treatment without improving the quality of the effluent water. The sludge handling processes consume 15% of the total electric energy. The system's primary energy-consuming equipment is a single 100 horsepower aeration blower. The biosolids aeration blower consumes about 14% of the plant's total electrical energy use. The blower has to provide the right amount of air to prevent the biosolids liquid from becoming septic

Incentives To Change

The City of St. Peter WWTF expanded in 1994 and improved from a pond system to an advanced technological process in 2000. Since then, it has observed a high DO concentration in the effluent water, indicating over-aeration and an opportunity for aeration energy conservation. Before the intern project, the monthly average effluent DO concentration was 10.52 mg/L. However, the St. Peter facility is only required to maintain at least 5 mg/L DO at the facility effluent to meet their permit. Optimizing the aeration system by reducing DO concentrations through installing variable frequency drives (VFDs) on BAF blowers and changing the supervisory control and data acquisition (SCADA) control set points could save 41% of the BAF blowers' energy use.

The biosolids storage aeration blower was sized for the full tank depth of 17 ft. However, the biosolids storage minimum and maximum liquid levels are typically 3 to 9 ft, respectively, under normal operating conditions. There are no means to control the blower to match aeration output with liquid level. Optimizing the biosolids storage aeration blower through installation of a VFD for control would save 61% of its energy usage.

SOLUTIONS

SCADA Adjustment of Target Cell Velocity

The number of BAF cells in filtration depends on the influent flow and target cell velocity, a user controllable set point in the SCADA system. St. Peter WWTF was operating at a 2 gpm/ft^2 target cell velocity (TCV) and a mandatory minimum number of three cells in filtration at all times due to high TSS concentrations at the effluent. Adjusting the target cell velocity from its prior 2 gpm/ft^2 value to 1 gpm/ft^2 in the SCADA system slows down the wastewater through the filter media, and at this reduced speed, the BAF will more readily filter TSS. Therefore, it is expected that there is no need to override the system to operate with a minimum of three cells in filtration to control high TSS concentrations. This adjustment allows the plant to operate with a lower number of cells during the low influent flow. It reduces the average number of cells in filtration from three cells to two cells under typical flows. The reduction of cells in filtration decreases the BAF blower energy consumption.

Install VFDs to Reduce Effluent DO Concentration to 7 mg/L

Modeling the aeration system to a reduced effluent DO concentration of 7 mg/L by using VFDs significantly decreases the energy usage. In other words, airflow adjustment is made through reduced blower speeds to approach a fixed average effluent DO concentration (7mg/L). An aeration system model was used to quantify energy savings in the aeration system while ensuring wastewater treatment permit requirements were met. Reducing the blower speed using VFDs decreases the average airflow generated by the blower.

Combined Effects of SCADA Adjustment and VFD Implementation

The combined effects of implementing both recommendations above, the SCADA adjustment of TCV to 1 gpm/ft^2 and reduced DO of 7 mg/L using VFDs, results in a 41% energy savings in the BAF blowers.

Anticipated Maximum Savings Achievable Through Continued Testing

Tests conducted during the intern project period on the above recommendations suggest additional savings may be achievable, should the facility respond well to additional testing. The City of St. Peter WWTF staff are still working to identify the optimal TCV setting by slowly increasing the value in the SCADA to further reduce BAF cell runtime. DO requirements at the effluent are only 5 mg/L, allowing room for further energy savings through blower speed reduction. Additional savings are expected to be achievable through blower speed optimization.

Install VFD to Control Biosolids Blower with Tank Level

Currently, the biosolids blower operates at 2,048 RPM, regardless of biosolids tank level. Reducing the blower speed to 636 RPM during the lowest biosolids liquid level (3 ft) and to 1,220 RPM during highest liquid level (9 ft) using a VFD controlled by tank height decreases the blower energy consumption from 407,200 kWh to 160,700 kWh annually, a 61% reduction in energy use.

Recommendation	Annual Reduction (kWh)	Annual Savings	Status
Opportunity 1: Biological Aerated Filter Blower Efficiency			
SCADA adjustment of target cell velocity	153,600	$12,300	Implemented
Install VFDs to reduce effluent DO concentration	173,600	$13,900	Recommended
Combined effects of SCADA and VFD implementation	289,600	$23,200	Recommended
Anticipated maximum savings achievable	405,490	$32,400	Needs testing
Opportunity 2: Biosolids Storage Aeration Blower Efficiency			
Install VFD to control biosolids blower with tank level	246,500	$19,700	Planned