City of Andover, Kansas
Energy Assessment-Wastewater Treatment Plant

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Executive Summary

The city of Andover, Kansas has a wastewater treatment plant that serves the community and is located at 2115 E. Harry St. The initial parts of the plant were built in 1977, with additional treatment units added in 1996. The major components of the plant are a bar screen, lift station, activate sludge basin, final clarifiers, UV disinfection and cascade aeration. The facility also has an extraneous flow basin. The design flow for the plant is 1.2 million gallons per day average daily flow (MGD), which is about 832 gallons per minute. The firm pumping capacity of the lift station (the capacity with the largest pump out of service) is 3,600 gpm, which is about 4.3 times the average daily design flow rate. The current average flow is 0.741 MGD, or about 514 gallons per minute. The peak flow received at the plant is estimated to be 2.25 times the average daily flow, or about 1,156 gallons per minute, which is about the 48% of the "firm" pumping capacity of the influent pumping station. The facility includes several buildings, including a building containing the headworks lift station, a building that contains the office/laboratory, a building that contains the blowers, a storage building and shop building. The plant discharges into the Walnut River via Four Mile Creek and a large portion of the effluent is sent to irrigate a privately owned golf course, and the resultant sludge is land applied by directly pumping the sludge to adjacent city owned land.

A site visit for the purpose of this energy assessment was conducted on March 5, 2013. Staff present for the site visit included Brian Walls, Chief Operator. During the visit the various systems and components of the facility were reviewed to determine if there were potential opportunities to reduce energy consumption at the plant. The city indicated that there has not been an energy efficiency assessment or review of the energy usage at the treatment plant in recent years.

1.0 Energy Use

This assessment will evaluate four forms of energy and water use - natural gas, electricity, motor fuels and potable water.

This wastewater treatment facility does not utilize natural gas for the treatment processes, but does use it to heat the lift station, the blower building, the storage building and the shop building. Last year the total cost for natural gas usage was $2,600.

Electricity is provided to the facility from two different utilities. One is Westar, located at 818 S. Kansas Ave. Topeka, KS 66612-1213, and the other is Butler County REC, located at 216 S. Vine, Eldorado, KS. 67042. There is one electric meter for the site for each utility and no sub-metering on any of the equipment or processes. Therefore, anticipated energy use for the facilities and equipment discussed below is based on anticipated run times of the facilities and equipment. The wastewater utility utilizes a large amount of electricity in motors/pumps and motors/blowers. The annual energy costs for electricity for the facility over the past year was

$118,900, and so the energy cost per million gallons treated ($/MGAL) is $439.24, with an average energy cost of $0.0926/kWh.

The city has one pickup truck assigned to the wastewater utility. There appears to be little opportunity to reduce fuel usage or to improve efficiency of the vehicles. Any consideration of the use of electrical "people mover" vehicles or "utility carts" or alternate fuels for heavy trucks is beyond the scope of this initial energy efficiency assessment.

The city does not utilize potable water in any treatment processes at the wastewater treatment plant, and has a water recycle system for wash down water. Potable water is used to provide water for the laboratory/office use by the plant staff. Potable water usage is considered minimal and was not investigated.

There were several areas that were identified as potential opportunities for reduced energy consumption, which are described in the sections below.

<u>2.0</u> <u>Energy Using Equipment</u>

2.1 Bar Screen

The facility is equipped with a bar screen. Operation of the bar screen is controlled by a depth sensor in front of the screen, and is powered by 1 hp motor. No changes are recommended for this system.

2.2 Lift Pumps

Lift Pump

The pump station has a wet well and an underground dry well for the pumps. It has four lift pumps, each with a pumping capacity of 1,200 gpm and powered by a 15 hp motor. The wet well is equipped with an ultrasonic depth sensor and two of the pumps are equipped with Variable Frequency Drives (VFDs). The speed of the motor is controlled through the SCADA (Supervisory Control and Data Acquisition) system using data from the depth sensor. The normal operating protocol for the system is for one pump with a VFD to be in service, and if the flows exceed the capacity of that pump then a second pump with a VFD is started, and if the flow exceeds the capacity of those two pumps, then the third or fourth pumps, which are constant speed pumps and not equipped with a VFD, are started. No changes are recommended for this system as it appears to be fully optimized for energy consumption.

The dry well also houses two pumps used to pump all of the digester sludge effluent for land application. Each pump has a 60 hp motor, and the pumps are operated approximately 6 hours per day, three days per week. No changes are recommended for this system.

2.4 Aeration Treatment

The facility is equipped with a single activated sludge treatment basin that includes a traveling bridge aerator. The traveling bridge is powered by a 5 hp motor that is always in service, and the traveling bridge also provides mixing in the aeration basin. The basin also has six diffusers located on the perimeter of the basin. All of the diffusers in the basin are fine bubble diffusers. The diffusers on the traveling bridge are powered by blowers located in the blower building. The blower building houses four blowers, each powered by a 30 hp motor. None of the motors are equipped with a VFD. Generally 2 blowers are on at a time.

After the facility was constructed it was determined that the blowers housed in the blower building were not providing enough oxygen to the basin, and six aerators were installed on the perimeter of the basin and three new blowers to supply the aerators were installed in 2011. The new blowers are powered by 75 hp motors. None of the new blowers are equipped with VFDs.

The basin is equipped with a DO probe, and the SCADA system monitors the DO in the basin. The blowers are on timers that were set to optimize treatment, but if the DO exceeds the target DO the SCADA system shuts the blowers down at that time.


Blowers in the Blower Building

New Blowers

The opportunity for energy savings is by providing computerized operational controls to both reduce unnecessary dissolved oxygen in the basin, and also to "recover" oxygen from nitrate (NO3), which is formed as a result of the oxidation of ammonia (NH3). Please note one pound of NO3 is the functional equivalent of 2.9 pounds of D.O. in the activated sludge mixed liquor. A summary of effluent data from this facility for ammonia (NH3), nitrate + nitrite (NO3 + NO2), and total nitrogen (TN) is attached for information. The average nitrate + nitrite in the effluent over the past two years is 1.3 mg/l. Please note that at the average daily actual flow of 0.741 MGD this calculates to only 8.03 lbs per day of nitrogen, and an equivalent of 23.3 pounds per day of D.O. This is an excellent treatment result, and it is doubtful the process could be improved or optimized further to reduce nitrate + nitrite to any lower average value. Effluent total phosphorus (TP) information is also provided and the long term effluent average is about 2.2 mg/l. While this is above the current KDHE recommended concentration of 1.0 mg/l, optimization of the process to reduce TP is beyond the scope of this energy assessment. In similar design wastewater treatment systems in Kansas, optimization of computerized operational controls have not only reduced energy usage but also reduced effluent nitrate to less than 3 mg/l and reduced total nitrogen to less than 5 mg/l, while some systems also significantly reduce total phosphorus. The Andover WWTP is achieving this effluent TN goal.

This plant has provided treatment that ranks it as one of the best in the state.

Because of the operating protocol used at the facility, and the resulting treatment, no changes are recommended for this system.

2.5 Clarifiers

The facility includes two final clarifiers. Each is powered by a 1 hp motor to operate the sweep arms. Each clarifier includes a scum pump which collects scum from the surface of the clarifier and pumps it back to the bottom of the clarifier for additional treatment. No change recommended for this system.

2.6 Waste Pumps

RAS and WAS pumps structure

The facility includes three return activated sludge (RAS) pumps that pump from the clarifier back to the aeration basin. They are all submersible pumps and each is powered by a 5 hp motor. Two pumps are on at all time. There are also two waste activated sludge (WAS) pumps that pump from the clarifiers to the digesters. They are also submersible pumps and housed in the same structure. The WAS pumps are powered by 5 hp motors. No improvements are recommended for these systems.

2.3 Digesters

Digester

The facility has four digesters to process sludge collected from the final clarifiers. Each digester is equipped with a surface aeration system. Three of the digesters are equipped with 15 hp motors, and one is equipped with a 40 hp motor. Each motor is on 24 hours per day, and none of the digesters are equipped with a Dissolved Oxygen probe to monitor DO in the digester, and none of the motors are equipped with a VFD. Without a DO probe and there is no way to discern the oxygen content of the digester and thus reduce operation of the aerator system. The estimated annual energy cost of running the digesters with 15 hp motors is estimated to be $10,085 per year each, and the energy cost of running the one with the 40 hp is estimated to be $26,900 per year, for a total operating cost of $57,155 per year. Based on the current flow conditions in the plant, which is only about 61% of the design flow, it is conservatively estimated that the aerators are running at 30% to 40% more time than is needed to meet the oxygen demands. There are a couple of approaches that could be used to reduce the energy cost of the digesters. The preferable way to enhance the energy use in the basin would be to use the SCADA system and DO probes to monitor and adjust the surface aerator serving the basins. One alternative would be to install DO probes, and feed that information to a SCADA system, which then could use a VFD to alter the speed of the aerator in order to provide adequate oxygen for the basin; however this method may not provide adequate mixing of all solids in the basin. A DO of 1.0 mg/l would be needed to maintain proper aeration of the digester, and the current operation is providing significantly more oxygen. Another alternative that could be considered would be to use a DO probes to monitor the oxygen in the basins, and then shut off the aerator for short periods of time when the DO levels are met. It is estimated the motor might be able to be turned off up to 40% of the time. If that approach is used, nitrification-denitrification will occur in the basin, and phosphorus release is also expected to occur. To adjust to the increased phosphorus released into the supernatant and returned to the activated sludge basin that may occur as the result of the nitrification-denitrification process in the aerobic digester, some chemical addition may be required, such as alum or ferric, added into the aerobic digester contents. This option has very low initial costs, but will require additional staff oversight. Any increase in phosphorus in the land applied sludge should not be a problem.

If a 40% reduction in running time can be achieved on the aerator motors, it would save approximately $22,860 per year. The cost of installing DO probes is estimated to be $1,500 each, for a total of $6,000, plus installation and programing. If VFDs are put on the motors, it is estimated that they would cost approximately $2,500 each for the 15 hp motors, and $3,750 for the 40 hp motor, for a total of $11,250 for the VFDs, and a total upgrade cost of $17,250. If a

40% reduction in energy costs were obtained, the improvements would have a payback period of less than one year (longer when programing and installation costs are included).   If the option of turning off the aerator is preferred, the payback period would be approximately 4 months, but chemical addition to capture phosphorus would possibly also be required to reduce effluent phosphorus concentrations to the 1.0 mg/l goal as established by KDHE.

Recommendation No. 1: Install DO probes in the aerated digesters, and VFDs and/or run time controls for the aeration motor to maintain reduce oxygen levels to 1.0 mg/l in the basins.

2.7 UV Disinfection

The facility includes two UV disinfection units. Each unit has two racks, each containing 8 high intensity bulbs. The units are on constantly, and there is no means to alter the dosage of the bulbs. They clean the bulbs twice a year, and they get approximately 12,500 hours out of the bulbs. No changes are recommended for this process.

After the water leaves the UV units it passes through a cascade aerator before being discharged to Four Mile Creek.

2.8 Compressor

The facility uses a compressor to operate its non-potable water system. The compressor uses a 7.5 hp motor and utilizes a surge tank to reduce energy usage. No changes are recommended for this unit.

2.5 Building Heat and Lighting

While natural gas space heaters are available for use in the lift pump building, staff reports that they are rarely used. Natural gas is used to heat the storage building and the shop. The office/laboratory building and the blower building is all electric.

A service company is recommended to review the HVAC in the buildings.

Recommendation 2: Consider using the services of a private company or the electric utility for an energy conservation assessment of the Process Building and the space heating for the other buildings.

3.0 Finance Opportunities

In addition to direct purchase of the recommended equipment, there are other financial tools that may be utilized to implement the recommended energy-efficiency improvements. One funding source is the low-interest loans from the Kansas Water Pollution Control Revolving Loan Fund (KWPCRF), which is administered by the Kansas Department of Health and Environment. The use of funding from the KWPCRF requires the city hire a consulting engineer.

Another potential funding source is the Facility Conservation Improvement Program (FCIP), which is administered by the Kansas Corporation Commission (KCC), telephone number 785-271-3100. The FCIP involves a financing mechanism called energy performance contracting, which allows a local government to finance energy-saving capital improvements over a multiyear period, with little to no initial upfront investment. The improvements are paid for using money saved through reduced utility expenditures. The FCIP partners with Energy Service Companies (ESCO's), who often provide a guarantee that the savings from the energy-efficiency improvements will meet or exceed the annual payments covering the improvements. If the savings do not occur, the ESCO pays the difference. Another potential funding source is the electric utility or natural gas utility, which may provide rebates or subsidies for equipment upgrades that improve energy efficiency.

4.0 Recommendation Summary

The recommendations for energy efficiency cost saving opportunities made throughout this report are summarized below:

1: Install DO probes in the aerated digesters, and VFDs and/or run time controls for the aeration motor to maintain reduce oxygen levels to 1.0 mg/l in the basin.

2: Consider using the services of a private company or the electric utility for an energy conservation assessment of the Process Building and the space heating for the other buildings.

Attachments:

Influent and Effluent Nitrogen and Phosphorus data