U.S. Department of Energy - Energy Efficiency and Renewable Energy
Advanced Manufacturing Office

Case Study - The Challenge: Improving Sewage Pump System Performance

- Summary
- Background
- Project Overview
- Project Team
- Project Implementation - The Systems Approach
- The Old System
- The New System
- Results
- Lessons Learned

Project Profile

Industry:	Municipal Sewage System
Process:	Sewage Pumping
System:	Pump System
Technology:	Downsized pump, direct on-line pump controls

Summary

The Town of Trumbull was looking for a way to increase the energy and operating efficiency of its Reservoir Avenue sewage pump station. With the help of ITT Flygt Corporation, the town altered the existing pump system by adding a smaller pump and modifying the system control scheme. The changes reduced annual electricity consumption by almost 44 percent, or nearly 31,900 kWh, saving more than $2,600 per year. This Motor Challenge Showcase Demonstration project, which cost $12,000, has a simple payback of 4.6 years. The project demonstrates that an innovative pump selection and operating scheme can significantly reduce the operational costs of a sewage pumping station. The lessons learned from this successful project can be applied to Trumbull's other sewage pumping stations, further reducing the town's electricity consumption and costs, and to similar pumping stations throughout the United States.

Background

Located just north of Bridgeport in southwestern Connecticut, the Town of Trumbull has a population of 32,000 and, with ten sewage pumping stations, a total raw sewage handling capacity of 3.3 million gallons per day. Each of the stations pump sewage to a main lift station where it is then pumped to a sewage treatment plant in Bridgeport.

Project Overview

Built in 1971, the Reservoir Avenue Pump Station consisted of twin sewage handling pumps vertically mounted approximately 17 feet below the ground. The pumps were each equipped with a 40-hp direct drive, wound-rotor motor. Running at reduced speed, the pumps operated at a system duty point of approximately 850 gallons per minute (GPM) at 50.3 feet of total dynamic head (TDH). A control system using a wound rotor and variable resistance circuit technology was used to reduce pump speed to a constant 1320 revolutions per minute (RPM). To turn the pumps on and off based on the level of liquid in the sump, a bubbler-type level control system was used. The system used two continuously running compressors which supplied a small amount of air through a dip tube into the wet well. A pressure transducer mounted on the air supply line measured the pressure needed to overcome the wet well level.

The pump station handles approximately 0.34 million gallons (MG) of raw sewage per day. The original pumping processes consumed approximately 72,500 kWh of electricity annually, costing the Town of Trumbull $5,495.

Project Team

Town of Trumbull

SIC:	4952
Products:	Sewage Pumping
Location:	Trumbull, Connecticut
Showcase Team Leaders:	Paul Kallmeyer, Town of Trumbull Three employees in the wastewater treatment department.

In addition to the engineers employed by the Town of Trumbull, this Showcase Demonstration project team included several consultants from ITT Flygt Corporation, the manufacturer of the new pump used in the project. ITT Flygt was also involved in the provision of pumping methodology, engineering and design of all modifications, data collection and analysis, and report writing.

Company Energy Philosophy:	All efforts should be made to ensure that energy saving measures are employed, as long as they do not reduce reliability and the payback period is reasonable. Never stop looking for those steps that save energy.

Project Implementation - The Systems Approach
To identify potential energy saving opportunities at the pump station, a test plan was undertaken by team engineers. A systems approach was used to determine how to increase the efficiency of the entire sewage pumping station. Rather than focusing on the individual elements and functions of the pumping system, total system performance was the focal point of the analysis. Following a thorough investigation of the pumping system, engineers decided to add a smaller pump that could handle the same volume as the original pumps during non-peak periods. The lower outflow rate reduces friction in the piping system, lowering the required head and energy consumption.

The Old System
The sizing of the pumps in the original system was designed to allow one pump to handle the entire peak inflow to the station under normal operation, which is usually less than 800 GPM. Both pumps were inactive until the level meter reached 57 inches. At that time, the primary pump would begin operating and would pump until the water level fell to 32 inches. The second pump was designed only to be used during extreme flood conditions. If the water level reached 60 inches on the level meter, the second pump would begin to operate. In flood conditions, both pumps would remain running until the water level fell to 32 inches, at which time both pumps would simultaneously shut down. Each pump rarely operated for more than five minutes at a time.

Test data for the original system indicated a normal operating point of 850 GPM at 50.3 TDH for the single operating pump. With an overall pump efficiency level of 74 percent, the pump's efficiency was not a problem. Years of use, however, had begun to take its toll on the system, resulting in frequent breakdowns, occasional flooding, and sewage spills.

Engineers categorized four energy use sources in the original system: the bubbler level control system, lights, circulating pumps for the motor control system cooling water, and miscellaneous station energy use. Analysis of the pump system determined that much of the overall energy use consisted of auxiliary electrical system loads and miscellaneous point loads. Engineers found that the existing speed control system did not vary the pumps' flow handling capacity. As a result, the pumps were operating at a reduced constant speed. In addition to reducing the efficiency of the pumps' electric motors, the inefficient control system also required the constant operation of two circulating cooling water pumps. The level control system was also equipped with two continuously running compressors, further increasing electricity consumption. Finally, because of a broken automatic light switch, the three 200-watt light fixtures were constantly on.

The New System
To increase energy efficiency of the pump station, engineers installed an additional 10-hp pump with direct on-line motor starters and a level control system with float switches. The new pump handles the same volume as the original pumps during non-peak periods, but runs for longer periods of time. The lower outflow rate reduces friction and shock losses in the piping system, which lowers the required head and energy consumption.

In addition, the ineffective existing pump speed control was eliminated and the motors were wired for direct on-line start. Because the speed control was eliminated, the motors powering the existing pumps ran at 1750 RPM instead of 1320 RPM, so their impellers were trimmed from 11.25 inches in diameter to 10 inches. The existing pumps are still used for the infrequent peak flows that the new smaller pump can't handle. The two compressors for the bubbler level control system and the two circulating pumps for the old motor control system were also eliminated.

Results
Under normal conditions, the operating point for the new pump is

Performance Improvement Summary

Energy and Cost Savings

450 GPM at 40.7 TDH, compared to 850 GPM at 50.3 TDH for the pumps in the original system. The specific energy of the optimized system was measured at 325 kWh/MG, a 255 kWh/MG decrease from the original system. In addition to the 17,643 kWh of energy savings achieved by modifying the pump unit, significant energy savings also resulted from changes made to other energy use sources in the station. Annual energy consumption by the lighting system was reduced from 5,256 kWh to 78 kWh, while energy consumption of the bubbler level control (7,300 kWh/yr) and the cooling water pumps (1,752 kWh) was entirely eliminated. In all, 31,875 kWh was saved, a reduction of almost 44 percent, resulting in $2,614 in annual energy savings.

Project Implementation Costs	$12,000
Annual Energy Cost Savings	$2,614
Simple Payback (years)	4.6
Demand Savings	12.2
Annual Energy Savings (kWh)	31,875
Total Annual Emissions Reductions	
CO_2	40,200 lbs
Carbon Equivalent	11,000 lbs
SO_x	230 lbs
NO_x	54 lbs
PM-10	5 lbs
CO	6 lbs
VOC	1 lbs

In addition to energy savings, the modifications reduced the system's cleaning and maintenance requirements as well as the control subsystem's maintenance requirements. Together, these reductions significantly decreased the labor needs of the station. Finally, the expected life of the operating equipment and electrical switch gear increased with the longer operating times and reduced power input of the new system.

Lessons Learned

Several lessons were learned from this Showcase Demonstration project which can be applied to other similar energy efficiency projects in the future: (1) rethinking the pump selection and operating methodology for pumping equipment can result in significant savings; (2) in systems with static head, stepping of pump sizes for variable flow rate applications can decrease energy consumption; (3) a "systems approach" can identify sources of energy consumption other than pumps that can be modified to save energy.