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# Reducing Energy Usage in Water and Wastewater Treatment Facilities : A Tale of Two Cities

“It was the best of times; it is now one of the worst of times,” is not only the opening line of a novel, but also could be an accurate description of the current economic condition of many communities in Illinois and throughout much of the United States.

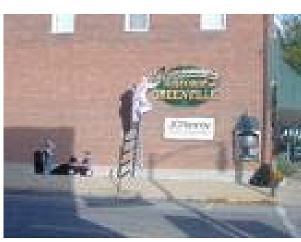
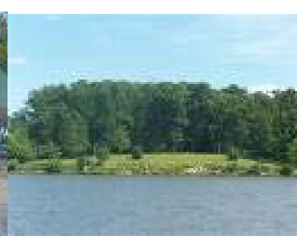
The current economic climate is characterized by rising unemployment, increasing foreclosures, shrinking business bases and declining tax revenues. It has become a significant challenge for municipalities to provide city services, maintain existing infrastructure, meet payroll, and pay creditors. To deal with these challenges, municipalities are turning to previously overlooked opportunities for energy efficiency to reduce their operating costs. Cities are closely scrutinizing energy use at water and wastewater treatment facilities because such facilities are typically the largest energy consumers in municipal government.

## The Research Initiative

This fact sheet was developed as part of the Strategic Energy and Water Reduction research initiative funded by a grant from the U.S. Environmental Protection Agency. This funding, in part, allowed ISTC to assist small municipalities in Central Illinois with reducing their water production and wastewater treatment costs. During this project, ISTC worked with several municipalities to identify opportunities to reduce energy use. This fact sheet identifies opportunities within two of these communities.

## About the Two Communities

The City of Greenville is a rural community in Bond County with approximately 7,000 residents. It operates a water treatment plant north of the city on Governor Bond Lake and a waste treatment facility south of the city.


The City of Bushnell is a small community in McDonough County with approximately 3,200 residents. It operates a water treatment plant within the city, which draws from the St. Peters aquifer, and two wastewater treatment lagoons.


## Research Stakeholder

Illinois Electric Works (IEW) of Granite City agreed to partner with ISTC to provide technical assistance in identifying energy-saving opportunities at the participating municipalities' treatment facilities. IEW's core competencies are blower, pump and motor efficiency, with specialization in motor controls, variable frequency drives, and load balancers.

## Energy…A major expense at treatment facilities

Water treatment facilities incorporate a variety of techniques when processing drinking water. No matter what individual techniques they use, all processes involve a series of pumps and motors to move water from a source (lake, stream, aquifer), through the treatment facility, into storage vessels to the public distribution system. Wastewater treatment facilities also use motors, pumps and fans to move the wastewater from the community to the facility, and to process and treat the wastewater once it enters the facility. These pumps, blowers, and motors require substantial amounts of energy, which makes them expensive to operate.

## Motor Efficiency…Paying close attention to the efficiency %

Motors can have a 30 to 40 year service life. The average integral motor consumes 4 to 10 times its initial cost in electricity per year. Energy-efficient motors only save money when they're running. The more the motors run, the more energy and money they save. Efficiency is a measure of how much total energy a motor uses in relation to the rated power delivered to the shaft.

$$\text{Efficiency \%} = \frac{\text{Watts (output)}}{\text{Watts (input)}} \times 100$$

Over the service life of the motor, upgrading motor efficiency by just a few percentage points can produce significant energy savings and return on investment. Paying attention to the motor ratings Standard → EPAct → NEMA Premium saves both energy and money. These operational savings offset the additional purchase price of higher efficiency motors.

## Affinity Laws and Variable Frequency Drives…Energy savings are more than a theory.

Fan, pump and blower power consumption is equal to the cube of the speed. Two times the speed will consume eight times ($2^3$) the power. Speed is expensive. The penalty for running a motor faster than necessary is severe. Conversely, one half the speed requires one-eighth ($.5^3$) the power to drive a fan, pump or blower (see Table 1). This means significant energy savings are available by reducing motor speed.

| Speed | Flow | Required Power |
|---|---|---|
| 100% | 100% | 100% |
| 90% | 90% | 72.9% |
| 80% | 80% | 51.2% |
| 70% | 70% | 34.3% |
| 60% | 60% | 21.6% |

| | | |
|---|---|---|
| 50% | 50% | 12.5% |
| 40% | 40% | 6.4% |
| 30% | 30% | 2.7% |

**Table 1 Numeric Description of the Affinity Laws**

A Variable Frequency Drive (VFD), also known as an Adjustable Speed Drive (ASD), is a system that controls the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor (Figure 1). It converts incoming 60Hz AC power into other desired frequencies, which allows for AC motor speed control. VFDs enhance process control and provide energy savings by matching motor speed with load requirements. Pump, fan and blower applications at water and wastewater facilities are excellent candidates for retrofits because VFDs match motor speeds to fluctuating loads at these facilities, which is more economical than running motors at a constant speed.

***Scenario 1***: *100 HP motor running 24/7 at 100% speed and 75% Flow with mechanical flow control.*
*Cost of Operating at Fixed Speed= $50,000 per year*

***Scenario 2***: *100 HP motor running 24/7 at 75% speed, 75% Flow, and VFD at 75% speed 24/7.*
*Cost of Operating with a VFD= $21,094 per year*
***Annual Savings: $28,906***


**Figure 1 Variable Frequency Drive**

## Load Balancers…Sharing the work evenly.

Problems occur when multiple pumps or blowers are tied into a common header (Figure 2). Some of these problems include pumps and blowers that vary slightly; asymmetrical piping; impellers that wear over time; unbalanced loads; and motors that constantly cycle on and off. These problems cause uneven loads and inefficient load sharing, which wastes both energy and money.

**Figure 2 Common header application**


**Figure 3 Load balancer**

Load balancers (Figure 3) are controls that take advantage of a VFD's ability to control motor torque (load). Instead of only controlling speed, the load balancer forces the pumps or blowers to spin at the speed that produces the proper load. When tied into a common header, the pumps work evenly share the work. This operating efficiency also optimizes energy use and saves money. Load balancers are a sensible complement to VFDs because they offer up to 30% energy savings if the pumps are in good working order. The energy savings is even greater if the pumps are worm or operating at less than peak efficiency.

***Advantages***

- *Energy savings*
- *Quiet*
- *Easy installation using existing motors and pumps*
- *No starting and stopping, equipment runs continuously*
- *Eliminate mechanical shock*
- *Pump the proper mass*

**Water treatment facility applications:**

- Well pumps, intake pumps, high service pumps and booster pumps

**Wastewater treatment facility applications**:

- Lift station pumps, influent station pumps, aeration blowers, sludge return pumps and effluent pumps

## Back to the Communities…What are the opportunities?

### City of Greenville

The research team identified significant energy saving opportunities at both treatment facilities. The greatest opportunity at the water treatment facility involved installation of a VFD on a 60HP lake recirculation pump that runs twenty four hours per day/seven days per week.

The wastewater treatment facility treats wastewater with activated sludge and 280HP disc aeration running at either idle or full speed. By retrofitting the aeration disc motors with VFDs coupled with a load balancer, facilities can save energy through efficient load sharing and matching aerator motor speed to the system's dynamic dissolved oxygen load requirements. Table 2 summarizes these opportunities.

| Location | Description | Annual Projected Savings | Projected Payback (Years) |
|---|---|---|---|
| Water Plant | Lake Recirculation Pump VFD | $9,800 | 0.9 |
| Sewer Plant | VFD Retrofit of Aeration Rotors | $28,375 | 1.5 |

**Table 2 Summary**

### City of Bushnell

The research team identified several motor, pump and blower opportunities at both treatment facilities. The water treatment facility draws its water from three deep wells and is processed by reverse osmosis (RO). The well pumps range from 20HP to 65HP, running either independently or in pairs for 16 hours each day. The facility had a new RO backup NEMA Premium high efficiency 50 HP motor sitting in a box. Two high service pumps (25HP each) transport water to the water tower and run individually 10 hours each day. Installation of VFDs or VFDs coupled with a load balancer would produce significant energy savings, balance the pumps, even the flow, and reduce cavitations and pump wear.

At the wastewater facility, aeration is provided to the two lagoons by three 15HP (east) and three 20HP (west) positive displacement compressors, with one or more running continuously 24/7 regardless of dissolved oxygen levels. Simple timers offer a low cost alternative. Table 3 summarizes some of the opportunities.

| Location | Description | Annual Projected Savings | Projected Payback (Years) |
|---|---|---|---|
| Water Plant | High Service Water Pumps VFDs | $2,400 | 3.8 |
| Water Plant | Well Pumps VFDs and Load Balancer | $8,300 | 2.5 |
| Water Plant | Reverse Osmosis System Motor Upgrade (92.4% to 94.1%) | $256 | 2.0 |
| Sewer Plant | Aeration Blower Timers (20% run time reduction) | $3,000 | 0.3 |

**Table 3 Summary**

## Conclusion

Municipalities must balance budgets as revenues decline. Energy is a major component in producing drinking water and in treating wastewater. Reducing energy consumption at treatment facilities makes good business sense. Treatment facilities can save money by upgrading to more energy-efficient motors, incorporating variable frequency drives and load balancers where feasible.

Additional ISTC fact sheets covering energy efficiency, water conservation and pollution prevention are available at www.istc.illinois.edu. You may also contact:

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