Energy Efficiency in the Water Industry

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ABSTRACT

While there are energy efficiency programs targeting the water & wastewater utility industry, implementation of energy efficiency has been uneven within the industry. The water & wastewater utility industry faces a number of challenges when implementing energy efficiency measures due, in part, to its capital intensive nature and the interaction of public interests on water treatment. Because of these capital limitations many water & wastewater utilities have not invested in their infrastructure and water delivery assets in as many as thirty years, with the result that many water & wastewater utilities are currently served by aging and sometimes inefficient equipment.

As water becomes scarcer due to drought conditions in some parts of the United States and water treatment regulations become more stringent and energy-intensive, improving efficiency in water and energy use will become indispensible for water and wastewater utility managers and end use customers across a variety of economic sectors.

This paper will provide valuable insights into the Watergy approach to tackle the issues and opportunities faced by water and wastewater utilities. Based on a successful Watergy project at a utility in Pennsylvania that improved energy efficiency at several pumping stations and waste water treatment plants, other water & wastewater utilities and municipalities will learn how they can implement similar projects and achieve significant water and energy efficiency gains, thereby addressing both water scarcity and energy costs simultaneously. This paper will also help funding entities design programs that take into account the unique characteristics of the water utility industry. The authors conclude with policy and technical recommendations for future energy efficiency efforts in the water and waste water industry.

Introduction

Water and energy costs are inextricably linked and can be significant. In the U.S., the energy required to supply, treat, transport, and heat water accounts for an estimated 13% of the country's total electricity consumption. In some municipalities, drinking water and wastewater treatment can account for up to 35 percent of their annual energy use (Consortium for Energy Efficiency 2001, 1). Recently, Federal and state funding has increased substantially for energy efficiency while funding for the *Drinking Water State Revolving Fund* (DWSRF) has decreased (EPA 2010). Federal and state and rate-payer energy efficiency grants are now greater than funds available through the Federal water revolving loan funds. Moreover, the U.S. Environmental Protection Agency's (EPA) and state regulation of greenhouse gases may incentivize private utilities and major companies to fund hundreds of millions of dollars in energy efficiency projects (Barbose et al. 2009).

This paper examines energy use in water and wastewater utilities, and opportunities for energy efficiency gains in this sector. For those who are not familiar with the sector and the opportunities present there, this paper provides background on the water industry and the characteristics of energy savings opportunities that can be found in it. We then follow the background with some more details on the challenges this industry faces and how these challenges can be overcome. The paper will also explain the Watergy approach and how its practitioners are implementing an innovative portfolio of services to enable water and wastewater utilities to manage energy continuously and maximize implementation of energy efficiency opportunities. We conclude with an example of our current work at the Bucks County Water and Sewer Authority.

Water and Wastewater Utilities

Water and wastewater utilities across the country present numerous opportunities for energy savings. According to a 2007 report from the Consortium for Energy Efficiency, water and wastewater utilities, on average, account for 35 percent of a municipality's energy usage. That same report estimated annual potential savings of 31 billion kWh in municipal water & wastewater agencies (Consortium for Energy Efficiency 2007, 1). However, this energy use is not uniform across all water utilities. A report from the Energy Center of Wisconsin (2003, xiii, 12) found that energy use is concentrated with large water utilities (13.1 percent of water utilities use 74.1 percent of the energy) with the utilities in the state using an average of 1,400 to 1,800 kWh per million gallons of delivered water. Another report by the EPA shows that just 8% of the approximately 52,000 community water systems in the U.S. or 4,132 serve 82% of the U.S. population (EPA 2009b).. While the opportunities exist, the culture and mission of water utilities can often make it difficult to implement new, energy efficient measures.

Water utilities exist in three main forms: wholly private (e.g., American Water), as municipal departments (e.g., Philadelphia Water Department), or as a quasi-governmental non-profit entity (e.g., Tampa Bay Water) often covering multiple political jurisdictions. As with electric utilities, the ownership structure may limit borrowing capacity and ability to retain capital for investments.

No matter what form the governing structure takes, water utilities are highly regulated entities trying to balance a large number of constraints. Water utilities are mandated to meet certain water quality standards while providing low-cost service to their customers. Water utilities also have distribution systems that can be 100 years old or more, and face difficulty in rapidly updating their distribution systems. Water systems also typically have a smaller and less interconnected electric distribution grid, minimizing opportunities for efficient planning. Furthermore, as water quality mandates become more stringent, treating water will require more technology and will become more energy intensive, increasing capital and operation costs for utilities (EPA 2009a). The U.S. EPA estimates that upgrading the nation's water and wastewater infrastructure would cost approximately $500 billion (EPA 2009b, page 14). Many communities have not made substantial investments in their infrastructure in 40 years, in some cases longer (EPA 2009b). As population growth extends the distances and increases the volumes of water that needs to be delivered and reclaimed, systems that were designed for given populations and service territories could end up becoming overburdened.

As new drinking water regulations are mandating more energy intensive treatment technology, the vast majority of energy use by water utilities comes from extracting and conveying water using large pumping systems to the end users. Pumping water can be highly energy intensive. An internal report from one of the country's largest utilities found that 98 percent of its energy consumption was electricity and of that, 95 percent was used for pumping water. Moreover, the EPA water utilities report found that globally, energy costs can account for the majority of water utilities' expenses and can represent as much as 65% of a water utility's annual budget (EPA 2009b, 13). In addition, water utilities have to satisfy variable demands much like an electric utility. For wastewater, pumping often spikes with large rainfalls or other influxes of water. Drinking water facilities often see spikes in demand for pumping during the hot, summer months. During these months, people are using more treated water to water the lawn, wash cars, and other warm weather activities. Demand response and peak load are an addition constraint for water utilities. However, unlike industrial plants, water utilities have very different incentives to measure, monitor, and modify their energy use.

For these reasons water and wastewater utilities have fundamental qualities to make them good candidates for energy efficiency investments. The highly regulated aspects mean that utilities have trained personnel that can implement efficiency measures and that operations are closely tracked, monitored, and reported. Water utilities operate 24/7 and almost never go out of business. The improvements are often capital investments that can be measured and verified. As a result, water utilities offer opportunities for real, permanent, and verifiable energy efficiency gains.

Water and wastewater utilities are also ideal candidates for projects and measures that can yield high reductions in energy demand per dollar spent. We looked at pilot programs for energy efficiency in Massachusetts and Hawaii to demonstrate the overall cost effectiveness of upgrades at water utilities.[1] The Massachusetts has a pilot program for energy management at 14 water utilities. This pilot program financed many projects, such as standard lighting and HVAC improvements and utility-specific pumping motor upgrades. Collectively, these 14 projects save more than 15 million kWh per year.[2]

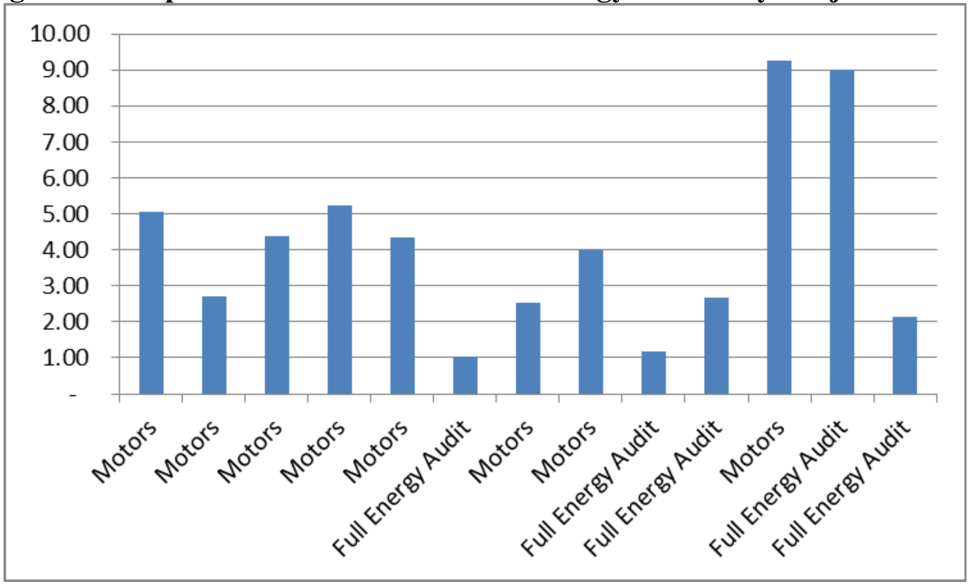
To evaluate the Massachusetts projects, we looked at the costs and results of two types of projects -- upgrade motors and full energy audits. Upgrading outdated motors at water/wastewater utilities returned an average benefit-to-cost ratio of 1.45 over a 10-year lifecycle. Full energy audits of these facilities returned an average benefit to cost ratio of 3.87 (Massachusetts Department of Environmental Protection, n.d.).[3] Figure 1 below further illustrates the benefits of water utility improvements by comparing the simple return on investment for the projects named above.

[1] There are additional programs in California, Wisconsin, and California; however, data from these programs was not readily available.

[2] Other states have programs directed at water utilities. New York State's Energy Research and Development Authority offers programs that focus on water and wastewater utilities. These programs, FlexTech Program and Existing Facilities Program, provide assistance to water utilities implementing capital improvements, but data are not as complete. California also has a pilot project directed at water and wastewater utilities; however, complete data from that pilot was not available at time of writing.

[3] Using a 10 percent discount factor

Figure 1. Simple Return on Invest from Energy Efficiency Projects in MA



Challenges

Implementing energy efficiency at water and wastewater utilities is not a simple process due to institutional challenges present. Institutional challenges at water utilities have often been outlined as five barriers: operational barriers, institutional barriers, political barriers, regulatory barriers, and financial barriers (Water Research Foundation 2011). These challenges rest on the culture of a water utility and the outside constraints placed on water utilities.

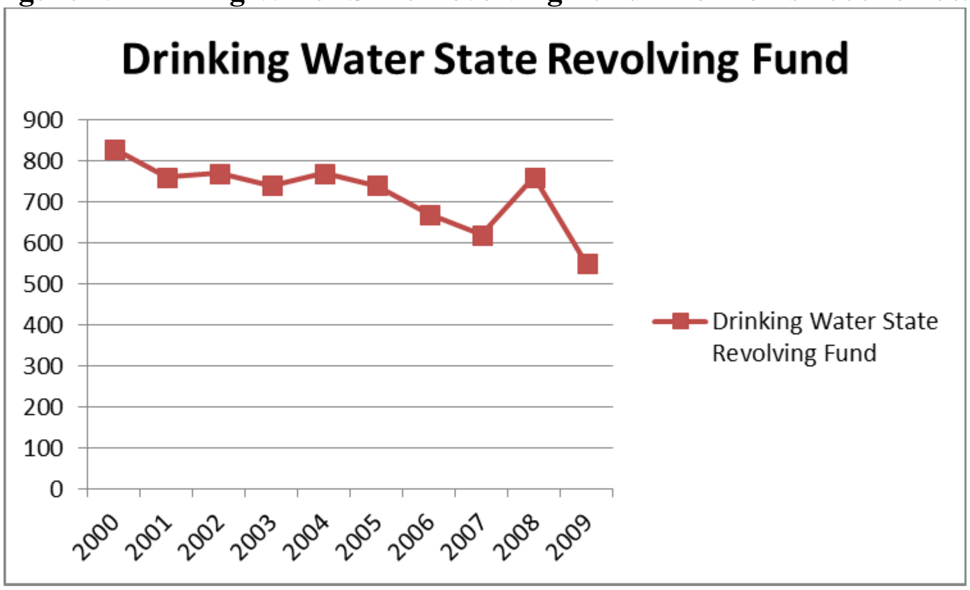
The culture at a water utility centers around the public health aspect of providing high quality drinking water with the lowest possible burden. Utilities take this mandate very seriously, and as a result of that obligation and various regulations utility employees are highly trained in their field. The first issue (or conflict) with energy efficiency arises because expertise in water treatment is not directly translatable to expertise in energy efficiency. As a result, employees may not be able to identify and implement energy efficiency projects.

At the same time, management is often torn between meeting the public demands for low-cost water and the demands from the regulatory agencies to meet quality standards. Rarely will the public welcome a rate increase. While energy efficiency measures can reduce costs over time, the upfront capital investment can often be hard for the public to swallow. Resistance from the public can often dissuade managers from timely implementation of infrastructure improvements. Additionally, the regulatory constraints placed on water utilities are daunting. Failure to meet any of the standards can result in a dramatic loss in public confidence and possibly hefty fines from regulatory agencies. Federal fines for some infractions can cost utilities thousands of dollars a day. As a result, utilities often take a more risk-averse approach by implementing oversized equipment or by not wanting to alter a process that works.

The financial constraints revolve around the nature of utilities providing what is seen as a public good. Utilities operate on very tight margins. In many situations, utilities must ask for approval from customers before undertaking new capital expenditures or raising rates. Taken together, this creates an environment where non-essential capital expenditures often sit on the shelf until resources are available. It is not uncommon for pumps to operate for 30 years, well below the efficiency curve, and still not be scheduled for replacement until they fail completely.

To highlight the capital constraints placed on water utilities we point to a series of studies by the EPA. EPA estimated that water utilities will need an investment of over $334 billion in the 20 years between 2007 and 2026 to maintain and expand infrastructure (EPA 2009, i). Other entities have looked at previous needs surveys (reporting needs of $255 billion) and reported funding shortfalls of over $100 billion (American Society for Civil Engineers 2009). As water utilities are facing this need for infrastructure investments, they are also seeing a decline in traditional sources of funding. The DWSRF has seen a 30 percent decrease in funding levels in real terms since 2000 (U.S. Environmental Protection Agency 2010). Figure 2 shows the decline in DWSRF funds since 2000.

Figure 2. Drinking Water State Revolving Fund Allotments 2000 to 2009



As a result of these challenges, the industry is generally conservative when adopting new technologies or concepts. This culture can make it difficult to tap into the opportunities for energy savings at utilities. A targeted effort from many different stakeholders will be necessary to overcome these challenges.

These institutional challenges present a number of issues for those trying to work with water & wastewater utilities. Entities like electric utilities or state governments looking to implement programs with water & wastewater utilities will face these institutional challenges. These hurdles can often discourage formation of programs or implementation of specific energy efficiency projects. To address the challenges programmatic and policy mechanisms are needed to enable greater implementation of energy efficiency to the water and wastewater utility sector.

Interest in Energy Efficiency

As noted earlier, one of the largest constraints on water utilities is the availability of capital to invest in infrastructure upgrades. However, programs for funding energy efficiency are growing in number and in size. This growth in energy efficiency funding signals the importance society is placing on energy efficiency and can serve as a needed tool for water utilities looking to implement energy efficiency measures.

Possible funding for energy efficiency projects generally comes from three main sources: Federal programs, state programs, and electric utilities. Federal programs and state programs are often lumped together due to the Federal funding mechanism. Federal funding for energy efficiency is most often seen through grants to state energy programs; however, funding may also come through tax credits and (more rarely) direct grants. State funding is more limited and generally administered by the same state agencies that administer Federal funding. While these sources of funding saw large increases under the *American Reinvestment and Recovery Act of 2009*, most state energy offices have seen large decreases in funding in the most recent budgets from both state and Federal sources.

Although the potential for funding energy efficiency projects from government sources seems rather limited, electric utilities are showing more promise as a source of funding. Varying states are mandating electric utilities establish ratepayer-funded programs (also known as a public benefit fund) to promote energy efficiency and renewable energy. Essentially, public benefit funds leverage small charges from a large pool of ratepayers to fund projects that would not otherwise be funded. This type of funding mechanism is expected to save ratepayers over the long run by delaying or reducing the need to expand electricity infrastructure (Brown 2009). These programs have seen substantial increases over the recent years. In 2008, 28 states had ratepayer-funded programs with a total budget of $3.1 billion (Barbose et al. 2009, i).

These ratepayer-funded programs are expected to increase dramatically over the next nine years. While the programs in 2008 had a budget of $3.1 billion, estimates place 2020 budget projections at over $12 billion (Barbose et al., 2009, 10). As these programs are a result of public policy and are funded directly by the public they are often heavily scrutinized. Ratepayer-funded programs must show that they are responsibly using public funds. In some instances, they must report to state legislatures how much money they spent and the result of that spending in demand reductions or implementation of renewable energy.

Additional growth in utility spending on energy efficiency may result from efforts by government to address climate change. Possible methods such as cap-and-trade or carbon taxes will raise costs to electric utilities. These utilities may be willing to pay customers to reduce electricity usage up to the amount imposed by legislation. While this source of funding is more theoretical at the time, ratepayer-funded programs are real and offering incentives for energy efficiency.

Ratepayer-funded programs have significant amounts of money at their disposal, but relatively few are looking at targeting water utilities and even fewer have dedicated programs. Through our research we identified New York, the Energy Trust of Oregon, and the Wisconsin Office of Energy Independence as having an established effort to promote energy efficiency at water utilities while California and Massachusetts had established pilot programs. This lack of attention to the water sector may provide an opportunity for funding programs to continue to meet legal mandates. Ratepayer-funded programs have an opportunity to capitalize on the efficiency gains available from the water sector to effectively meet mandates for energy reduction. By focusing on a (relatively) few larger entities with high potentials for energy savings, these funds can achieve the same if not greater reduction in energy use than by focusing on a large number of small entities.

The Watergy Approach

One approach that has helped many municipal water utilities not only implement water and energy efficiency measures, but manage their energy continuously is the Watergy program. Begun in 1997, Watergy addressed energy efficiency and water losses in more than 100 municipal water delivery systems in nine developing countries. The Watergy approach involved assessing water and energy consumption throughout all parts of the municipal water delivery systems and addressing opportunities found throughout these systems. These opportunities included:

- Pumping system improvements
- Leak detection, repair and pressure reduction
- Automation of system operations
- Regular monitoring & metering of energy and water end uses

Many of the projects that were identified had rapid payback periods; often within one year. Rates of return depended on local conditions, but approximate paybacks for various energy efficiency measures are as follows:

- Immediate to several months: using capacitors to optimize electric installation power factors, improving operations and maintenance (O&M) procedures; managing pressure within the system.
- 1 – 2 Years: installing metering equipment; retrofitting worn pumps, configuring system controls to operate equipment during off-peak demand periods.
- 2 - 3 Years: installing new automation systems, variable speed drives, or premium efficiency motors.

The projects that were undertaken in these systems resulted in immediate improvements in water service, increased water delivery and reduced water and energy consumption. In many cases the energy cost savings allowed the municipalities to undertake other needed improvements and add new customer connections. As a result of these projects, the aggregate energy savings totaled approximately 20.8 million kWh with annual energy and water cost savings of $5.3 million (Allen 2008, 1).

Lessons Learned

The Watergy projects yielded some important conclusions that can inform other and future programs that seek to address the nexus between water and energy efficiency. The first conclusion is that a quality energy assessment is a foundational element of an energy efficiency program. Assessments were conducted by subject matter experts in energy and water who understood the municipal water utilities' constraints. This yielded assessment recommendations that were realistic given the utilities' resources. Another important component is energy efficiency training for the water utility technicians. This component is often overlooked, but integral to energy efficiency implementation because energy efficiency is not often taught in many educational systems. Once the value of continuous improvement is understood by the human infrastructure, the stage is set for persistent energy savings. A third important conclusion is that access to capital is essential in order for capital intensive measures to be implemented. In many cases, the Watergy projects paired the local utility with an energy service company that was able to fund the up-front costs of projects involving equipment replacement. Finally, recognition through targeted outreach materials not only celebrated the achievements of the utilities that implemented projects, but showed other utilities what they could do to save energy and water.

An Example in the U.S.: Bucks County Water and Sewer Authority

As a result of these successes, experience, the Watergy approach was proposed for the U.S. water utility industry. In 2010, the Bucks County Water and Sewer Authority (BCWSA) in Bucks County, Pennsylvania, commissioned a Watery in the U.S. project to validate their existing approach and see if there were other opportunities to improve energy efficiency. The Watergy project at BCWSA began with an energy assessment of the main energy applications in three pumping stations and four wastewater treatment plants. The assessment was performed in a manner that was consistent with the ASME *Pumping System Assessment Standard* and best practices in energy management (ASME 2009).

The assessment recommended several measures including establishing an energy management policy, some simple energy conservation measures and some more complex capital equipment upgrades. The identified projects have a total estimated cost of $778,000 and would save more than 4 million kWh of electricity per year, or roughly 20 percent of BCWSA's annual energy usage. With estimated implementation costs of just $361,000 the aggregate simple payback is 2.2 years (BCWSA 2011).

Because the implementation costs are not a small investment, the project partners looked into what can be done to enable the water utility to invest in energy efficient infrastructure when the industry as a whole sees such a large gap in infrastructure funding. Part of the project therefore involved research into the financing mechanisms and policy considerations available in Pennsylvania. On the basis of energy saved alone, the benefit to cost ratio (BCR) is rather attractive at 2.81. In the case of BCWSA, the incentives from the utility's power company (PECO) and the state were found to significantly reduce the burden of the investment. The incentives from Pennsylvania come in the form of a low-interest loan for energy efficiency. This loan has a 1 percent annual interest rate over a 10-year term, much lower than market rates that BCWSA would pay. We estimated the benefit of using this funding option over market rates at $184,700 over the course of the loan. The PECO incentives were found to be even more beneficial than the loan option from the state of Pennsylvania. The PECO rebate is estimated to be worth $330,900. With these two sources counted as benefits, the BCR increases to 3.29.

In addition to a sound energy assessment and energy management training, access to expertise on finding financing mechanisms and policy analysis can catalyze implementation of energy efficiency recommendations. BCWSA has already indicated that they plan to establish and energy management policy with a cross-functional team and are looking to obtain the impending ISO 50001 *Energy Management Standard* to ensure that their energy management approach is in keeping with best practices in energy management. BCWSA also plans to implement many of the recommended measure in the energy assessment, partly because the financial analysis and research into the financing mechanisms found greater incentives than had been anticipated. This project at BCWSA has highlighted the need for financing in implementing energy efficiency projects.

Conclusion

Water and wastewater utilities are an industry with potential for extensive energy saving opportunities. Estimates place the national potential savings at 31 billion kWh. The example of BCWSA demonstrates how a relatively small investment can return large reductions in energy usage ($778,000 can result in more than 4 million kWh in annual energy savings).

However, there are institutional challenges that can impede implementation of energy efficiency projects at water and wastewater utilities. The cultural and financial challenges associated with providing a public good, regulations protecting human health, and financing models means water utilities often play by a different set of rules. These institutional challenges can prevent entities like electric utilities from taking advantage of the high-value energy efficiency projects in the water sector. Through careful planning and the use of partners familiar with the challenges of the water sector, electric utilities and other proponents of energy efficiency can develop targeted programs for energy efficiency at water utilities.

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