http://dx.doi.org/10.5991/OPF.2016.42.0057

James J. Chelius, PE, and Michael E. McDonald, PE, are with American Water (www.amwater.com), Voorhees, N.J.

Expand Utility Efficiency to Save Energy and Water

A multifaceted approach can help water and wastewater utilities maximize energy efficiency, improve operational reliability, and conserve water in a time of increased concern about limited water supplies, energy consumption, water quality, and climate change. BY JAMES J. CHELIUS, PE, AND MICHAEL E. McDONALD, PE

THE PRESSURE ON WATER and wastewater utilities to improve operational efficiency is greater than ever for this energy-intensive industry. Fortunately, efficiency programs across the United States and elsewhere in North America are helping utilities save substantial amounts of water. These programs translate into cost savings for water supply and wastewater operations but still deliver an unchanged or an improved level of customer service.

EXPANDING WATER–ENERGY MANAGEMENT PROGRAMS

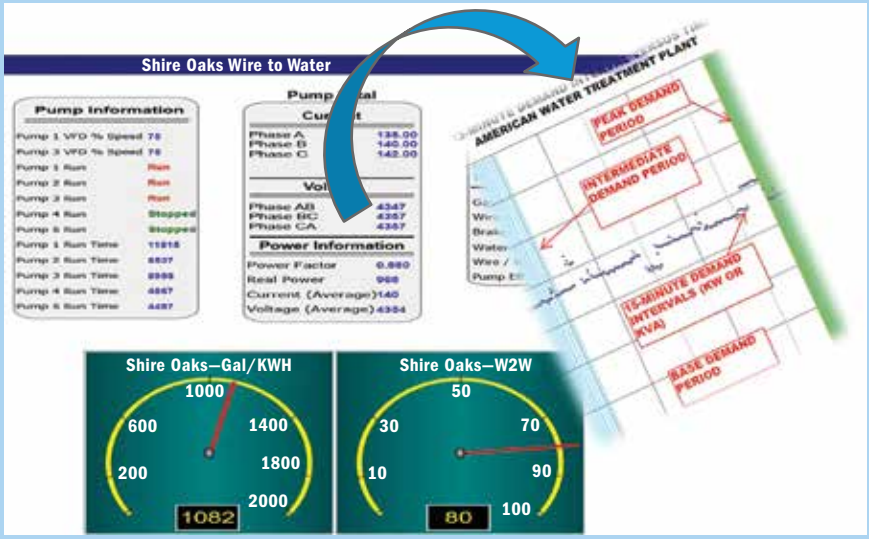
Drinking water and wastewater systems account for about 4 percent of total US energy use, according to the Electric Power Research Institute in a 2013 report titled *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries* (http://bit.ly/2bK6NbN). Some 52,000 water systems produce 42 bil gal/day of water, and 16,320 wastewater treatment facilities treat 34.8 bil gal/day.

The majority of energy consumed by water utilities is used to pump water. For example, American Water subsidiary facilities consume approximately 1 million MWh/yr of electricity, with more than 95 percent used to pump water. Because of the importance of this energy–water nexus, the company actively manages its fuel and power usage through energy- and water-efficiency programs; alternative energy supplies; energy audits; and pump, motor, and pipeline renewal programs. These energy-management programs save energy and water and yield environmental benefits, including lower greenhouse-gas emissions.

American Water also is reducing electricity demand at several of its facilities, which helps electric providers during peak-demand loading events and, in turn, saves energy and greenhouse-gas emissions. In addition, the company has incorporated an energy and optimization program into its planning process. Energy optimization studies are conducted at the system level, engaging operations, management, and

Real-Time Energy and Demand Monitoring

Cost savings and operational efficiency can be obtained by monitoring electric demand charges and minimizing large equipment usage during peak interval pricing.



PHOTOGRAPH AND GRAPHICS: AMERICAN WATER

Because most of the energy consumed by water utilities is used to pump water, much of a utility's energy-efficiency work should focus on improving pump efficiencies through refurbishment or replacement.

engineering staff as well as the electric utility to identify ways to optimize energy use and enhance system resiliency.

PUMP PERFORMANCE

Much energy-efficiency work concentrates on improving pump efficiencies through refurbishment and replacement. American Water programs include the following:

Energy Usage Index (EUI). This metric is derived by dividing total power usage in MWh by the volume of water sold in mil gal during a discrete period of time. The company's current baseline is 2.86 based on 2011–2013 operating data. The EUI data are collected and monitored to serve as a barometer for the pump fleet's condition. Specifically, as pumps age, they wear and become less hydraulically efficient, requiring more power to deliver the same volume of water. American Water's pump fleet comprises about 7,500 centrifugal pumping units. Of this, it's estimated that about 20 percent of the largest pumps consume 80 percent of the company's total power usage.

Wire-to-Water Pumping Efficiency Tests. Wire-to-water efficiency tests are conducted every year to monitor pump and motor efficiency. Even a small efficiency increase can yield energy savings. Research has shown the average wire-to-water efficiency of typical pumping equipment is about 55 percent.

Pump Refurbishment. It's important to maintain, repair, and replace pumps, motors, and variable-frequency drive (VFD) equipment. The cost of pump replacement and refurbishment to recover capacity and improve efficiency is weighed against the typical decline in efficiency and capacity over time. New pump installations can achieve efficiency ratings of 76–82 percent. In replacing or refurbishing older pumps, studies have shown pumps can be restored to their original efficiencies, which often means a 10–20 percent or more improvement. These efficiency improvements can significantly reduce energy consumption and costs while reducing a utility's carbon footprint. Vibration analysis helps extend pump service life through predictive maintenance. Also, VFDs are used to vary pump speed. In appropriate conditions, variable speed pumping can reduce electrical consumption.

Real-Time Energy and Demand Monitoring. Real-time energy and demand monitoring provides operations personnel with the data required to understand and act on events and situations affecting the efficient operation of pumps and processes while providing transparency to stakeholders throughout the organization. In addition to energy efficiency, cost savings and operational efficiency can be obtained by monitoring electric demand charges and minimizing large equipment usage during peak interval pricing. The figure on page 14 illustrates several demand pricing intervals superimposed with 15-min power interval data from one of American Water's water treatment facilities.

Hydraulic Modeling. Distribution systems are modeled to analyze current and future hydraulic conditions to enable efficient pump selection and operation while optimizing system performance under various demand conditions.

Alternative Fuels. Natural gas- and diesel-powered engines are used to provide power for pumping water at several sites. Auxiliary power supplies can also prove critical in maintaining system resiliency and recovery during emergency conditions.

RENEWABLE ENERGY

Renewable energy technologies can help utilities reduce emissions that contribute to greenhouse-gas emissions while improving energy reliability and system resiliency. American Water maintains a portfolio of alternative energy supplies, including solar, wind, and biomass facilities, to reduce greenhouse-gas emissions.

American Water maintains several solar power installations that provide auxiliary power to facilities and save more than 2,500 metric tons of carbon dioxide annually. The plants generate electricity without producing harmful greenhouse gases, producing maximum output during peak demand, when electricity's value is highest. Solar energy can be purchased from a third-party supplier or owned outright. Financial incentives are typically available in the form

of rebates and tax credits from local utilities and local, state, and federal government sources.

American Water has installed more than 3 MWdc of solar-generating capacity at 12 facilities across four states (New Jersey, Illinois, Hawaii, and Missouri), with plans for more facilities. The company's first solar installation was a 500-kW facility constructed in New Jersey in 2005 that celebrated 10 years of continuous "green" service in 2015. Today, the same expanded facility (698 kWdc) generates 818,000 kW•h/yr of clean energy and provides 20 percent of the water treatment plant's peak usage power.

In 2011, the company's New Jersey subsidiary installed solar panels on a Canoe Brook Water Treatment Plant reservoir in Millburn, N.J. The installation, shown in the photo at right, is the first East Coast solar array on a body of water designed to withstand a freeze/thaw environment. The 400 110-ft × 110-ft solar panels rest on a docking station made to float on the water's surface. The array produces 135,000 kW•h/yr of energy, saving more than 56 tons of carbon emissions and $16,000 per year in energy costs.

The company also uses solar power in smaller applications, including solar panels with batteries at various remote supervisory control and data acquisition monitoring sites where access can be difficult during storm events. To promote safety and conservation, solar-powered utility carts are used at several large treatment facilities, and solar-powered arrow boards are used at some construction sites.

The company also operates a 300,000-gpd industrial anaerobic wastewater treatment and biogas recovery system in Texas, which provides 100,000 ft^3/day of biogas, on average, replacing 15 percent of the facility's natural gas demand.

SMART-GRID TECHNOLOGY

American Water was also an early adopter of smart-grid technology to manage the way treatment plants and pumps use electrical power. Instead of adjusting electrical generation to match changes in electrical demand, the network adjusts demand, enabling electrical equipment to consume more energy when demand is low and less when it's high. This approach provides grid balance to electricity system operators.

Solar panels on a reservoir near New Jersey's Canoe Brook Water Treatment Plant produce 135,000 kW•h/yr, saving the facility approximately $16,000 per year in energy costs.

A successful pilot program at the Shire Oaks (Pa.) Pumping Station offset 2–3 percent of the site's total energy bill. The program has led to a larger partnership between American Water and the smart-grid service provider that will bring this technology to several large water treatment facilities.

CONTROLLING WATER LOSS

For water utilities, detecting and repairing leaks is a main component of water conservation. Aging infrastructure, fluctuating water temperatures, soil movement, vibrations, and water pressure changes are some of the factors contributing to water leakage.

During the last several years, many studies have been undertaken to estimate water loss. US nonrevenue water levels average just over 20 percent. Finding and stopping leaks quickly reduces repair costs, chemical use, and energy consumption along with its associated greenhouse-gas emissions.

Continuing its work with acoustic leak-detection systems and improved metering techniques, American Water has intensified efforts to find leaks more rapidly in its systems and reduce water lost from leaks. The company has built on an Israel–US Binational Industrial Research and Development Foundation grant and is working with the California Energy Commission to further develop the Stream Control Advanced-Pressure Management System. The two projects will demonstrate the feasibility of modifying existing distribution system pressure controls that could reduce pressure in a system as a function of leaks and reduced customer demand. International efforts to reduce leakage have confirmed that reducing excessive pressure reduces the volume of leaks through pipes and the frequency of pipe failures.

ONGOING EFFORTS

Water and wastewater utilities are faced with many challenges, and efficiency remains a top priority. All utilities and utility companies are challenged to find innovative ways to operate efficiently to benefit themselves and their customers. Through continued progress at the system and operational level, along with engagement at the electric service provider level, American Water will continue enhancing its energy efficiency and optimization program.