The Water-Energy Nexus: Challenges and Opportunities

AMERICAN WATER

Department of Energy water-energy Nexus

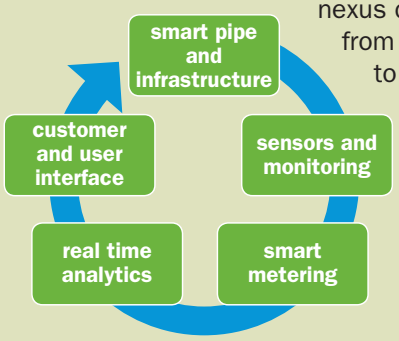
The Department of Energy's Water-Energy Tech Team issued a new report in 2014 called ***The Water-Energy Nexus: Challenges and Opportunities***. The report frames an integrated challenge and opportunity space around the water-energy nexus for the Department and its partners, laying the foundation for future efforts.

The report offers six strategic pillars to address the Water-Energy Nexus:

- Optimize the energy efficiency of water management, treatment, distribution and end use systems
- Enhance the reliability and resilience of energy and water systems
- Increase safe and productive use of nontraditional water sources
- Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts
- Exploit productive synergies among water and energy systems
- Optimize the freshwater efficiency of energy production, electricity generation and end use systems

As the first US water or wastewater utility to join EPA's Climate Leaders program, American Water already has several efforts underway that address the Department of Energy's pillars.

From investing in smart water management to pioneering a smart water grid, this paper highlights a few examples of what we're doing to address the water-energy nexus challenge from source to tap and beyond.



Optimize the energy efficiency of water management, treatment, distribution and end use systems

NPXpress

American Water has been awarded three patents for a technology called NPXpress to reduce aeration energy consumption, which uses the most energy during wastewater treatment, by up to 50 percent and supplemental carbon source by 100 percent. This technology has been implemented at seven full-scale wastewater treatment plants in New Jersey and New York, and is currently being implemented at a system in California as part of the company's overall initiative to achieve sustainable, energy-neutral wastewater treatment.

NPXpress produces high quality treated effluent while using much less oxygen and minimal or no additional carbon. The unique operating condition of the NPXpress promotes growth of certain microorganisms that remove nitrogen and phosphorus in wastewater. These microorganisms require much less oxygen and carbon to convert ammonia nitrogen to nitrogen gas compared to conventional bacteria found in wastewater treatment systems.

Pressure Management Research

Increasing operational efficiency by reducing main breaks, interruptions of service and leakage are major priorities at American Water and for many utilities around the world. Each year, upwards of 2 trillion gallons of treated water are wasted due to leaks in water systems across the United States. Reducing water pressure is a key approach recommended in the water industry to reduce leakage.

On-going research on pressure management using devices to automatically reduce water pressure during low flow (typically at night) will demonstrate the feasibility of installing modifications on existing distribution system pressure. International efforts to reduce leakage have confirmed that reducing excessive pressure not only reduces the volume of leaks through pipes but reduces the frequency of pipe failures. The expected outcome of the project will be a significant reduction of water leakage. American Water is a partner in a two-year award from the Israel-U.S. Binational Industrial Research and Development (BIRD) Foundation along with Stream Control Ltd., an Israeli start-up company, for the development of this advanced pressure management system.

Pump Efficiencies

Much of American Water's energy efficiency work concentrates on improving pump efficiencies through refurbishment and/or replacement. Programs include:

Energy Usage Index (EUI) metric

American Water manages its energy program using this metric derived by dividing total power usage in

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megawatt-hours (MWh) by the volume of water sold in million gallons (MG) during a discrete period of time. The current baseline for this metric is 2.89 based on 2011-2013 operating data. The EUI data is collected and monitored to serve as a barometer for the condition of the pump fleet.

Specifically, as pumps age, they wear and become less hydraulically efficient, which translates to more power required to deliver the same volume of water. American Water's pumping inventory is comprised of about 7,500 centrifugal pumping units. Of this, it is estimated that about 20 percent of the largest pumps consume 80 percent of American Water's total power usage.

Wire-to-Water Pumping Efficiency Tests

American Water conducts wire-to-water efficiency testing to monitor the efficiency of pumps and motors. We deliver over a billion of gallons of water each day, so even a small increase in efficiency can yield energy savings. Research has shown that the average "wire-to-water" efficiency of existing "in-field" water utility pumps is about 60 percent. New installations are designed to achieve efficiencies of between 76 percent and 82 percent. American Water sees this as a major opportunity to decrease its carbon footprint. By replacing or refurbishing older pumps, studies have shown that pump efficiencies can be restored to their original efficiencies of 76-82 percent. This efficiency gain may yield energy savings of 10-20 percent at facilities that have completed pump improvements.

Pump Refurbishment

American Water programs maintain, repair and replace pumps, motors and variable frequency drive (VFD) equipment. The cost of pump replacement/refurbishment to recover capacity and improve efficiency is weighed against the typical decline in efficiency/capacity over time. American Water has vibration analysts on staff to extend pump service life through predictive maintenance. A total of 52 pump refurbishments/replacements were completed from 2011-2013, at a cost of approximately $6 million, and provided an estimated energy reduction of 8 million kWh/year.

Variable Frequency Drives (VFD)

American Water has installed numerous variable frequency drives to vary pump speed/output. Variable speed pumping can reduce electrical consumption where a throttling valve would otherwise be used to control pumping rate.

Hydraulic Modeling

Distribution systems are modeled to analyze current and future hydraulic conditions to enable efficient pump selection. Maintaining updates and calibrated models allow engineers to evaluate a variety of options to continuously improve system operations.

Enhance the reliability and resilience of energy and water systems

DEMAND-SIDE ENERGY MANAGEMENT Shire Oaks Pumping Station, Penn.

American Water is the first U.S. water utility to use the Smart Grid technology of ENBALA Power Networks. This innovative technology manages the way American Water's treatment plants and pumps use electrical power and allows us to offer capacity to the electric regulation market. The regulation market provides short term grid balance service critical to the integrity of the electric grid. American Water earns revenue from participating in this market which helps to reduce operating costs at the participating locations. A successful pilot program at Pennsylvania American Water's Shire Oaks Pumping Station offset 2-3 percent of the site's total energy bill and has led to a larger partnership between American Water and ENBALA Power Networks that will bring ENBALA's Grid Balance technology to large treatment facilities throughout American Water.

Managing Risk

A systematic approach to assess the vulnerability of its water supply to climate variability is embedded into American Water's engineering planning studies. The engineering and operations team examines every facility and regional water availability to develop a capital plan—how much investment is needed, based on a five-year planning cycle, to meet future infrastructure

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needs—as well as a 15-year outlook. Business continuity and emergency response plans are also developed or updated to increase preparedness to address risk factors including climate related scenarios. The company conducts sensitivity analyses of its historic water variability record with future predictions and safety factors that can consider accelerated impacts such as, for example, a 100-year flood occurring every 20 years or a 20-year flood occurring every five years.

The engineering planning studies drive American Water's capital needs assessments, business planning, and financial forecasting. Planning studies include, for example:

- Historic water variability records;
- Regional urbanization trends;
- Expectations about population growth;
- Local and regional per capita use of water;
- Regional availability of water supply; and
- Current and future regulations impacting the quantity and quality of water supplies.

Saving Water to Save Energy

American Water was awarded a new research project from the Illinois Sustainable Technology Center. Utilizing an advanced leak monitoring technique, this project will achieve measurable water savings in a water distribution system within a year and show the potential for significant water savings for other water systems.

Advanced continuous acoustic monitoring technology can be installed within a pipe network to alert the utility to leaks when they first begin, rather than once the leak is large enough to be seen bubbling out of the ground. The process involves placing sensors throughout a water system that 'listen" for the vibrations from water leaks carried by the pipe and track the sound through a sophisticated communication network.

This project, funded by the Illinois Sustainable Technology Center, includes a partnership with the Canadian company, Ecologics, to evaluate the next generation of technology to track and pinpoint the leak. Besides the wasted resource, leaking water represents wasted energy in pumping and treatment. The project will examine the economic analysis of water production cost savings but also the added secondary benefits of reduction of leak repair overtime and damage caused by leaks.

Increase safe and productive use of non-traditional water sources

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Desalination

Membrane desalination is the process of removing salts from seawater by passing the water through a reverse osmosis membrane. The process is typically the most efficient means of producing large volumes of freshwater, however, fouling of the membrane can increase energy and operational costs. American Water developed a novel method for measuring one of the key factors contributing to the biological fouling (called biofouling) of the membrane. In a project funded by the WateReuse Research Foundation, American Water scientists have used the method to examine various steps of the desalination process to determine the impact on biofouling. For example, some chemicals used in the pretreatment can change or contribute compounds

that increase the amount of biofouling. Understanding these factors can improve the overall efficiency of the process. The high level of salt in seawater interferes with the removal of natural organic matter and can also lead to increased fouling. American Water is partnering with researchers from Washington State University to examine heated metal oxide particles (HMOPs), a novel coagulant for removal of organic material in membrane systems. The WateReuse Research Foundation sponsored project anticipates improved efficiency in desalination systems, but the coagulant could also be useful for many wastewater reuse processes.

In addition, to establish a safe drinking water supply for years to come, American Water is the operator of the country's largest seawater desalination plant in Tampa, Florida, as well as a smaller desalination plant in Sand City, CA. Additionally, we are in the process of developing and constructing a desalination plant, which we will own and operate, that will serve customers in California's drought-stricken Monterey Peninsula for generations to come. We are helping to ensure the safe and environmentally sound conversion of ocean water to drinking water.

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Reuse/Recycle

Over 90 percent of the treated wastewater in the U.S. is not recycled. American Water sees this water as a valued resource and has been at the forefront of research to study and promote reuse. Since 2006, American Water has conducted 11 research projects sponsored by the WateReuse Research Foundation valued at over $4 million.

These projects have examined issues dealing with water quality and public health safety, to best management practices, treatment process, and energy efficiency. These studies support the approximately 40 reuse systems owned or operated by American Water and provide the strategic ground work for future growth in this area.

- **Battery Park City, Manhattan**

American Water also operates reuse systems in five high-rise buildings in Battery Park City, Manhattan. It employs segregated piping systems to collect, treat and recycle wastewater and storm water for a variety of purposes, including toilet flushing, air conditioning and irrigation for rooftop gardens and an adjacent park. By reusing wastewater for non-potable applications, these buildings' potable water needs are reduced by nearly half. Together, these five buildings save approximately 56 million gallons of water per year.

- **Gillette Stadium**

In addition, American Water operates the water reuse system at Gillette Stadium, the home of the New England Patriots. The facility's double piping system treats recycled wastewater from the stadium, as well as from adjacent office complexes and stores, saving 250,000 gallons of water for every major event.

- **The City of Fillmore**

The City of Fillmore, California also contracted with American Water to build a new, state-of-the-art water recycling plant that would end the practice of river discharges and enable development of a full-scale water reuse system to benefit many areas of the town. The result is a facility that meets the stringent requirements of federal and state regulations as a zero-discharge facility and recycling program for irrigation and groundwater recharge.

The plant's current irrigation system provides 200,000 gallons per day to two public schools, the Two Rivers Park, and other green areas in Fillmore. About 800,000 gallons per day are discharged to percolation ponds and an underground effluent disposal system that provides groundwater recharge. The irrigation system has reduced the use of potable water sufficiently enough to allow the city to postpone drilling a new well and has helped preserve its limited supply of quality potable water.

Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts

SHALE GAS PRODUCTION

Our American Water subsidiary in Pennsylvania is in the heart of the Marcellus shale gas activity. As a water provider to approximately two million people in the state, we have two objectives:

- to protect the safety of the drinking water resources that we manage
- to support the economic opportunity that shale activity provides for our communities in terms of jobs and resources, as well as the contribution it makes to our nation's energy independence.

Over the past few years, American Water has entered into multiple agreements with shale gas production companies to build water pipelines to support drilling operations in the Marcellus Shale area. At the same time, we're able to provide the communities along the new pipeline route with needed clean water service.

There are also significant environmental benefits to using our treated water in shale drilling activity. It has been estimated that just three of these pipeline extensions will reduce the number of water truck hauls in a single western Pennsylvania county by over 500,000 over the next five years. This will reduce emissions, protect infrastructure and reduce traffic on the roadways. Plus, using our treated water eliminates or significantly reduces the need to add chemicals and biocides, which are needed to treat the raw water supply. (continued)

Given that 2-4 percent of the nation's electricity is used for water and wastewater systems* and that power is one of the top three costs for American Water, reliable and affordable energy is an important matter for the company and the water industry as a whole.

Exploit productive synergies among water and energy systems

FLOATING SOLAR POWER

Canoe Brook Water Treatment Plant, Millburn, N.J.

In fall 2011, New Jersey American Water installed the East Coast's first solar array on a body of water designed to withstand a freeze/thaw environment – weather conditions that are common to a northern New Jersey winter. Featuring a unique mooring system that allows the 538 solar modules to rise and fall with the water level of the reservoir, the array will generate approximately 2 percent of the water treatment plant's power. Annually, the solar field will produce 135,000 kilowatt hours for an estimated energy cost savings of $16,000. The pilot project was designed and built by ENERActive Solutions of Asbury Park, New Jersey. Solar tax rebates obtained through the American Recovery and Reinvestment Act may offset some of the costs of the project, to the benefit of customers. "Solar bees," also at Canoe Brook Treatment Plant, are employed to improve water quality by constantly circulating reservoir water.

The company will monitor the effectiveness of the solar station during changes in weather, and consider adding more solar panels on the 735-million gallon reservoir. This is New Jersey American Water's fourth solar project.

Solar Electric Systems

American Water supplements power at 11 facilities located in New Jersey, Illinois and Missouri. Combined, with a 3.1 megawatt (MW) capacity, these systems are expected to generate approximately 3.7 million kilowatt-hours of green energy per year. This annual reduction in energy usage prevents 2,551 metric tons of carbon dioxide from being emitted into the air. This savings in carbon dioxide pollution is equivalent to planting and growing 65,419 tree seedings for 10 years.

RENEWABLE POWER

Pennsylvania

American Water enrolled in a wind power program in Pennsylvania in 2005 for its Yardley plant through local electricity service provider PECO. Today, the plant runs on 100 percent wind-generated energy, purchasing 1.4 million kilowatt-hours of wind power annually. While the move has not been a money-saving one, its environmental benefits are substantial – the equivalent of not driving nearly 2.3 million miles each year. In 2014, Pennsylvania American Water will be purchasing an additional 3.2 million kWh of renewable energy in PA.

ABOUT AMERICAN WATER

Founded in 1886, American Water is the largest publicly traded U.S. water and wastewater utility company. With headquarters in Voorhees, N.J., the company employs approximately 6,600 dedicated professionals who provide drinking water, wastewater and other related services to an estimated 14 million people in more than 40 states and parts of Canada.

LEARN MORE

Visit us online at www.amwater.com

* Environmental Protection Agency, *Strategies for Saving Energy at Public Water Systems*, July 2013; and Electrical Power Research Institute and the Water Research Foundation (WRF), *Electric Use and Management in the Municipal Water Supply and Wastewater Industries*, November 2013.

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