Innovations Solutions Within The Water Industry: Desalination

The world’s population is expected to increase by 50 percent by 2050, but only one percent of the earth’s water is freshwater that is ready for drinking, and the number of regions experiencing droughts and water shortages is growing.¹ Considering these facts, one of our most critical questions for the future centers on how all people will have access to clean drinking water. With 97 percent of the earth’s water consisting of seawater, one viable solution is desalination.

Desalination, the removal of salt from brackish (saline) water or seawater, has been successfully implemented around the world and has proven to meet the needs of residents that would otherwise have no local access to drinking water. Though not widely used at a large scale in the U.S., desalination is beginning to make headway across the country, particularly in arid coastal regions. Seawater “desal” is now playing an increasingly important role in the U.S., which is why it is critical to understand what it involves and how it will affect us on an environmental, economical and practical level.

BACKGROUND

The need for water supply solutions in the U.S. becomes clear when laying out some of the challenges facing our country:

- The U.S. is the only industrialized nation whose population is growing significantly. Whereas the population of Europe is expected to decrease by 10 percent by 2050, that of the U.S. is expected to increase by one third.²

- The population is growing fastest in areas where water is scarcest.³

- The U.S. water supply system is threatened by population growth and climate change. A report from the Government Accountability Office in 2003 anticipates that by 2013, about 36 states will experience water shortages.⁴

³ Grumbles, Benjamin H. Congressional Testimony. 21st Century Water Commission. 8 Nov. 2007
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Innovation Solutions Within The Water Industry: Desalination

- The U.S.’s largest sources of freshwater – the Great Lakes, the Ogallala Aquifer and the Florida Everglades – are under increasing pressure. The Everglades, for example, has shrunk to one-half its original size in the past century.5

Some experts note that “America’s relatively high population growth and high rates of resource consumption and pollution make for a volatile mixture resulting in the largest environmental impact per capita…in the world.”6. It is clear that in order to meet rising demand for a dwindling resource, water providers must find new sources of supply to increase capacity while remaining environmentally sensitive.

Desalination, though not intended to address all water scarcity issues, provides one solution in addressing these supply concerns. With 58 percent of the source water for desal plants based on seawater, desal is primarily used in coastal communities.7 While current global output of desalinated water is only about 0.1 percent of total drinking water, a report by Global Water Intelligence noted that the worldwide desalination industry is expected to grow 140 percent over the next decade.8 It is estimated that increased construction of desalination plants will generate cumulative capital investment of $87.8 billion worldwide during the period from 2010 to 2016.5 GWI predicts that contracted desalination capacity is expected to rise from 68 million cubic meters of water per day to 130 million cubic meters per day as the demand for desalination in response to water scarcity grows steeply.10

EXPLAINING DESALINATION

It is clear that desalination is effectively supplying communities across the globe with their drinking water and that this technology will continue to grow. But further explanation is needed as to what exactly desal is and how it works. There are different methods and technologies employed, depending on the type of desal process at hand. Two-thirds of all desal plants use thermal technology, a process predominantly employed by plants in the Middle East, where heat is easily harnessed.11 However, this paper will focus on explaining membrane technology, as the vast majority of plants in the U.S. and elsewhere outside the Middle East use this process.

When discussing membrane technology, the most commonly used process for desalination is reverse osmosis (RO). Prior to RO treatment, particles and other compounds must be removed from the sea or brackish water source. This partially treated water is then pumped at high pressure through a semi-permeable RO membrane, which allows water molecules to pass through while trapping the salts within. Two things result from this process: clean drinking water and brine, a leftover concentrate of salty water that is typically released into the ocean. The clean drinking water will undergo a post treatment disinfection and stabilization process before being delivered to customers for consumption.

It is important to note, while relying on the same technology, reverse osmosis desal plants are not all the same. Variable factors such as feedwater salinity, logistical outlay and the surrounding environment require tailored pretreatment solutions in order to produce drinking water. While the solution vary, many of the challenges raised by desal remain the same.

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7 Latteman, Sabine & Thomas Hoepner. Environmental impact and impact assessment of seawater desalination. Institute for Chemistry and Biology of the Marine Environment. 2006
9 Pike Research “Desalination Technology Markets” 2010
10 Global Water Intelligence: Desalination Markets 2010
UNDERSTANDING THE CHALLENGES

There are a series of questions regarding the viability of desal, but many of these result from dated or contradictory information. This section will examine and address some of these challenges.

Energy Use

The general concern is that desalination plants consume vast amounts of energy to produce drinking water, rendering them inefficient. While energy consumption was an obstacle in the past, newer, improved technologies have addressed this problem in two ways. First, membranes today are more efficient, meaning they can do the same task with lower energy input. Second, the energy used can also be leveraged. Water is still under a lot of pressure after it passes through the membrane, so the pressure can be harvested and recycled back to the plant as energy. Whereas it used to take an osmotic pressure of 700 psi (pound per square inch)\(^{12}\) to produce drinking water, today the average is at about 420 psi.\(^{13}\)

Membrane technology improvements coupled with the ability to recover energies in the treatment process and use energy efficiently means that the cost of desal is actually converging with the cost of other water treatment options.\(^{14}\) See table, below.

<table>
<thead>
<tr>
<th>Costs of Water by Source</th>
</tr>
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<tbody>
<tr>
<td><strong>Convergence of Costs</strong></td>
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<tr>
<td>$/1,000 gal</td>
</tr>
</tbody>
</table>

**Source:** American Water, 2007

One significant development involves linking desal plants [Note: this is potentially true for all types of water treatment] to renewable energy sources such as hydroelectric, solar and wind. This is unique to the water industry, as drinking water can be stored for future use. There is no efficient storage mechanism for electricity, for example. Thus, if the wind blows at night (a time of low energy consumption), the energy generated can be used to power a desal plant and the resulting water can be stored in a reservoir. As a result, desal plants can become even more energy efficient.\(^{15}\)

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\(^{12}\) Pound per square inch: pressure resulting from one pound-force applied to an area of one square inch.


Note: 420 psi refers to the average. The range can greatly differ depending on the salinity level of the water as well as other factors.

\(^{14}\) Young, John. Chief Operating Officer, American Water. Interview. 11 Nov. 2007.


\(^{15}\) It is important to note that the energy use of any desal plant correlates with the salinity of the feedwater, with more saline water requiring more filtration and thus, more energy.
Environmental Impact

Another concern regarding desal involves the overall impact desal plants have on the environment - specifically, whether the discharge of brine back into the ocean negatively affects the environment. In this case, it is important to explain what is being discharged. Desal generally operates at 50 percent efficiency. That means that two gallons of seawater yields one gallon of potable water and one gallon of brine. With the average salinity of water at 3 percent, an efficiency of 50 percent would yield brine twice as salty, or with 6 percent salinity. However, desal plants in North America and in Europe are required to dilute this mixture with regular seawater prior to discharge. In the U.S., the dilution ratio is in the range of 10 to 20 gallons of seawater for every gallon of brine, bringing the salinity down to 3.1 percent to 3.2 percent. As such, most desal plants are returning water that is only marginally more saline than the original water. In addition, the plants are careful to discharge the diluted brine in areas where the mixture can be quickly integrated into the ocean, so as to have minimal impact (i.e. in deep waters or near currents).

To make the discharge process even more efficient, desal engineers try to build their operations near energy plants. Since energy plants use seawater as a cooling mechanism and already have the infrastructure in place to draw and return seawater, desal plants located nearby can use this water to dilute the brine before sending it back into the ocean and thus, minimize additional energy and infrastructure requirements.

In some cases, desal plants can actually help ward off negative environmental impacts. In Monterey, California, a desal plant was approved by the California Public Utilities Commission so that the community can minimize the use of a local river as a water source, thereby protecting an important habitat for fish and other species. In this situation, environmentalist were among the proponents of the desal plant, as continuing to draw from the river during low flow conditions would jeopardize its ecosystem. In this instance, desal helped a community minimize its environmental impact.

FINDING SOLUTIONS

Water industry experts are always motivated to find solutions that work for the community both on an economical and environmental level. If a community is considering a desal plant, it is usually because there are very few or no cost-effective alternatives for supplying potable water, aside from significantly decreasing water consumption or curbing community growth.

As with any solution, it is critical to assess the net impact and cost. Desalination is just part of the solution to our nation’s water challenges. Ensuring adequate supply in America also requires making people aware of just how essential water is to our everyday life, educating people about conservation and promoting water saving methods. Becoming more informed about our water use habits will enable us to make better and more conscious decisions about our water use in the future.

Likewise, desalination, as a solution, needs to make sense for the community it serves. One should always “encourage a community to look at all of its options first and critically assess if desalination is the most cost effective, sustainable and environmentally friendly solution for a community,” notes John Young, Chief Operating Officer of American Water. Since desal is very site-specific, it requires a thorough examination of a community’s needs and options as well as careful planning to determine whether desal can provide the best possible solution both for the current and expected future population. One challenge to this is the water industry’s fragmented nature with over 52,000 systems across the U.S. If each system focuses solely on its own local solution, it is sometimes challenging to build a desal plant that can meet the needs of all the systems in a region. Better cooperation and consolidation of these systems can enable us to develop plants that meet a region’s needs and not just those of isolated communities. For any community considering desal, it is critical to evaluate the options and issues with relevant stakeholders before making a decision.
CONCLUSION

All solutions have their critics, and desalination is no exception. With the nation's first large-scale seawater desalination plant fully operating in Tampa and plants being planned for San Antonio and Laredo in Texas, as well as Carlsbad and Monterey in California, desal will very soon become a mainstay of the U.S. water industry. As has been demonstrated, there is a pressing need in this country to find ways to both increase sustainable capacity and conserve water. Desalination technologies can provide a water supply solution that can best serve local and regional needs. Therefore, it is essential that more people understand and focus on the benefits of desalination.
The Water-Energy Nexus: Challenges and Opportunities

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.

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...
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.

**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 needs.
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

**one water**

**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.  

(continued)
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 WaterReuse 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 groundwork 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.

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.

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.

Water Reuse

Introduction

Meeting water demand and supplying water for future generations is a significant challenge for the water industry. Although water scarcity is an issue of critical importance in drier areas, communities across our nation are increasingly experiencing water shortages, calling into question the longevity of a national water supply that is threatened by droughts, consumption patterns and continued population growth. By the year 2013, it is estimated that 36 states will face serious water shortages, and water demand is expected to soon outpace water supply in megacities like Los Angeles. Water reuse offers an essential, viable and drought-proof solution for managing our critically limited natural resources.

Background: Applications and Treatment

The water cycle is a natural process that recycles water, but with advancements in treatment technologies, water can now be recycled more efficiently to meet our needs. Water reuse is a term describing the reclamation, treatment and recycling of wastewater (sewage derived from industrial use, washing or toilet flushing) or stormwater collected from homes, commercial buildings and industrial facilities. Reused water is not used for drinking, which accounts for only one percent of overall consumption. As such, tremendous opportunity lies in reusing water for a variety of other non-potable (non-drinking) purposes.

Water is reused in two main ways: non-potable (non-drinking) reuse, which involves taking treated wastewater to use for agriculture and landscape irrigation, industrial use (such as cooling processes), toilet flushing and fire protection; and indirect reuse, which involves using wastewater to recharge ground water supplies. Indirect reuse, also called land application, allows treated wastewater to percolate down to aquifers to replenish water sources. Non-potable reuse is already a widely accepted practice that will continue to grow, and indirect potable reuse is becoming an increasingly favored and applied method of reuse over discharging water into surface water, which ultimately evaporates or runs off into the ocean.

Since the vast majority of water goes toward industrial use or irrigation, using wastewater as an alternative supply for such applications can help protect existing supplies. Water reuse also helps

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1 Refer to the American Water White Paper: Meeting Demand in the West for more information.
3 This paper will refer to wastewater or stormwater reuse as simply water reuse.
4 Zinkevich, Andre, Vice President American Water Applied Water Management. Personal interview. 28 Nov. 2007.
the environment by decreasing the amount of wastewater discharged into bodies of water, which has long been considered a pollutant and problem, and by beneficially utilizing the nutrients in the discharge as fertilizers in irrigation applications. Water reuse can also be an economical long-term water management solution, since treating water to non-potable, versus potable, standards is energy efficient, and it precludes the need to purchase from or draw upon new water sources.

The table below shows how reused water is subject to differing levels of treatment and quality criteria, as determined by its end use. As a means of ensuring public safety, water that is more likely to come into contact with human beings is subjected to further treatment and more stringent standards.

### Suggested Water Recycling Treatment & Uses*

<table>
<thead>
<tr>
<th>Water Collection System</th>
<th>Primary Treatment: Sedimentation</th>
<th>Secondary Treatment: Biological oxidation or Disinfection</th>
<th>Advanced Treatment: Chemical coagulation, filtration, or advanced disinfection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No uses recommended at this level</td>
<td>Irrigation of orchards and vineyards</td>
<td>Landscape or golf course irrigation</td>
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<tr>
<td></td>
<td></td>
<td>Non-food crop irrigation</td>
<td>Toilet flushing</td>
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<td></td>
<td></td>
<td>Restricted landscape watering</td>
<td>Vehicle washing</td>
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<tr>
<td></td>
<td></td>
<td>Groundwater recharge of non-potable aquifer</td>
<td>Food crop irrigation</td>
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<tr>
<td></td>
<td></td>
<td>Industrial cooling</td>
<td>Indirect potable reuse (i.e. groundwater recharge of potable water source)</td>
</tr>
</tbody>
</table>

*Suggested uses are based on Guidelines for Water Reuse, as developed by US EPA

### Technology in Practice

Water reuse in the United States is a growing practice, with more than 2 billion gallons per day reused, and reused water volume is growing at an estimated 15 percent per year. With so many communities experiencing a reduction in water supply, wastewater reuse is increasingly being explored to meet water demand in an environmentally friendly as well as an economically feasible way. Utilities, municipalities and the industrial private sector are now, more than ever, seeking ways to implement such solutions as a way to reserve water resources and meet demand. Additional drivers of putting water reuse systems in place include: alleviating stress on our nation’s water infrastructure by reducing water volumes; implementing water reuse systems while repairing or updating pipes and facilities; regulatory mandates and incentives, such as water rate and tax subsidies; and shifting expectations toward sustainability.

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Recycling nearly two billion gallons of water annually, American Water’s Applied Water Management Group has a long history of designing, implementing and operating water reuse systems across the United States. Notable projects include:

- **Residential buildings** – Five high-rise buildings in Battery Park City, Manhattan employ underground double 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.

- **Community developments** – The Homestead at Mansfield in New Jersey is an active adult, residential development connected to a dedicated wastewater treatment plant. The water reuse system provides up to 250,000 gallons per day of reclaimed water to irrigate landscaped spaces at personal residences and open common areas.

- **Sports facilities** – Gillette Stadium, the home of the New England Patriots, would not have been in Foxboro, Massachusetts, a town with limited water supplies, had it not been for the stadium’s water reuse system. 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.

- **Commercial complexes** – Wrentham Mall has undertaken the first commercial water reuse project in Massachusetts. Facing space and environmental constraints for wastewater discharge, an onsite water recycling and disposal system was necessary. Now the mall can meet its water requirements, supporting the operation of the facility’s 130-store outlet center, office complex, hotel, movie theater and restaurant.

- **Schools** – The Copper Hill School in Raritan Township, New Jersey recycles wastewater from school toilets, the cafeteria and gym showers to be used for toilet flushing, saving the elementary school about 12,000 gallons of wastewater each day. The 20 percent of treated wastewater that is not used in the recycling process is recharged to groundwater.

- **Golf courses** – The Hawk Pointe Golf Course in Washington, New Jersey reclaims and treats wastewater to supply the significant volumes of water required to irrigate the course.

**Implementation**

While the benefits of water reuse are clear, only a small percentage of American communities have implemented such systems and technologies. In order to successfully implement water reuse projects, communities need to prioritize the financing of wastewater infrastructure projects. Public-private partnerships, as well as the Clean Water State Revolving Fund, offer solutions for funding such investments. Collaboration between wastewater and water agencies is also needed to set policies and develop system and facility plans that optimize water recycling opportunities. Community leaders must also perform public outreach to educate consumers about water reuse and mitigate any public safety and cost concerns.

**Conclusion**

As discussed in this paper, water reuse will play an increasingly important role in safeguarding our long-term water supply as water demand grows. While water reuse cannot solve scarcity issues alone, it is an essential part of a sustainable approach toward water resource management.
The Water Energy Nexus: Benefits & Innovations

The Water Energy Nexus is a topic of much discussion lately. You may have been wondering what exactly it is. Well, a nexus is simply a relationship, and the relationship between water and energy is deeply intertwined. In the simplest terms, you can’t produce energy without an abundance of water, and you can’t deliver water and wastewater service without consuming lots of energy. A few numbers help to illustrate this:

- **Water for Energy:**
  - Approximately 40% of all fresh water withdrawn from the environment in the United States is withdrawn to cool thermoelectric power plants.

- **Energy for Water:**
  - Nationally, between 2 and 4% of all power produced in the United States is for the operation of water and wastewater systems.
  - It is estimated that the water and wastewater industry can realistically achieve an 8% baseline energy savings by 2030.
  - It is estimated that efforts by the water and wastewater industry can deliver on 1-2% of the nations’ total amount of realistic, achievable energy efficiency savings by 2030.

The interdependent nature of water and energy thus provides many opportunities for synergy and greater efficiency.

**The Nexus: A Win-Win-Win**

Nearly everyone can “win” when water - energy efficiencies are achieved.

- **Customers** benefit from lower utility costs and more efficient services.
- **Utility companies** benefit from energy savings and becoming more efficient utilities.
- **State policymakers** benefit by facilitating delivery of better and more affordable service.
- **Current and future generations** benefit from the improved stewardship of water, air, and fossil fuel resources.
- **Communities** benefit from growth in jobs and increases in tax base. Indeed, when investments are made in water and wastewater infrastructure, as many as 27,000 jobs are created for every $1 billion spent. These include not only jobs in construction, but also jobs in supporting fields such as architecture, engineering, industrial machinery, and truck transport.

**The Means: Investment and Innovation**

There are many ways the water and wastewater industries can be more energy efficient. Investing in the replacement of aging infrastructure is one key way. Examples include:

- **Aging Pipe Replacement:**
Nearly 1 of every 4 gallons of treated water is lost in the distribution system due to leaks, meaning 25% of the water industry’s energy use is likewise “lost” due to leaks. The American Society of Civil Engineers states that pipe replacement needs in the coming decades “could reach more than $1 trillion.” Completing this work can translate not only into energy efficiency gains but also a tremendous number of jobs.

- Replacement or refurbishment of aging pumps:
  - It is estimated that improving water pump efficiency by 55-80% across the entire sector will yield a savings of 10 million megawatt-hours per year. That’s enough electricity to light a city the size of Chicago for over 2 years.

Beyond these efforts, there are many other cutting-edge ways that the water and wastewater industry can achieve energy efficiency. These include:

- Demand Side Management & “Intelligent” Customer Communication:
  - Advance Meter Infrastructure ("AMI") & “Intelligent” Communications: American Water’s affiliate in Monterey, California, is just beginning an AMI pilot program. Participating customers will be able to request text or email alerts if they have a likely leak, if they are about to break into the next rate block, or if their total bill is approaching a certain dollar value. This pilot is especially well-suited to the Monterey area, where revenue stabilization policies are used in conjunction with steeply inclining rate block as a way to manage critical water supply issues. The AMI program allows the company to help customers keep their bills low and limit unwanted usage, which is what every stakeholder in the area wants.
  - ENBALA Partnership: American Water is the first U.S. water utility to use the Smart Grid technology of ENBALA Power Networks. The technology manages the way American Water’s treatment plants and pumps use electrical power, and it allows us to offer capacity to the electric regulation market.

- New Treatment Methods:
  - NPXpress: American Water has developed energy efficient NPXpress technology, which reduces aeration energy consumption in the wastewater treatment process by up to 50 percent. The process has been implemented at seven full-scale wastewater treatment plants in New Jersey and New York.

- Alternative energy sources:
  - Solar: A solar electric system at New Jersey’s Canal Road Water Treatment Plant is used to supplement up to 20% of peak usage.
  - Wind: Pennsylvania’s Yardley Water Treatment Plant Facility runs entirely on wind-generated energy, purchased from local electricity service provider PECO.

The Support: Policies and the Nexus

State and federal legislators and regulators are key players in helping to unlock further progress towards realizing the many benefits of the water energy nexus. A recent resolution adopted by NARUC, for example, provides a forward-looking framework for state regulators looking to “proactively explore the
water-energy nexus and pursue regulatory reforms that might be needed to unlock further progress toward enhanced water and energy efficiency." At the federal level, policymakers can leverage the water-energy nexus by taking a holistic approach to policies. For example, if the EPA adopts its proposed rule limiting greenhouse gas emissions from existing generation units, having clarity that states may account for measures taken across industries would be important. If this were done, it would allow the water and wastewater sectors to help states fulfill their Clean Air Act Section 111(d) plans. Reduction of energy usage in the water sector could have a measurable and lasting impact on carbon output. American Water has submitted comment to the EPA suggesting this flexibility.

At American Water, we support pursuing water energy nexus opportunities to achieve energy security and environmental sustainability. We look forward to working with customers, partners in other industries, policymakers, and other key stakeholders in order to find innovative solutions.

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