

White Paper

The Efficient Utility: From the Source to the Tap and Back

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Introduction

In a time when funds are scarce, staffs are stretched and infrastructure needs are great, water and wastewater utilities need to find new ways to upgrade, rather than react with emergency repairs or temporary fixes. Today's technologies can bring significant efficiency gains at every stage, and innovative financial tools make it possible to undertake bundles of projects – with no up-front capital outlay.

Up-to-date equipment and systems could cut operating costs significantly, but that takes a major investment at a time when budgets are tight and tax or rate increases are unpopular.

Today's water and wastewater utilities face the fundamental challenge of trying to do more with less – not an easy endeavor when treatment plants and piping and pumping systems are aging.

While fulfilling their charter to protect public health and the environment at affordable costs, and striving to operate sustainably, many utilities must deal with equipment that is both inefficient and failure-prone. Up-to-date equipment and systems could cut operating costs significantly, but that takes a major investment at a time when budgets are tight and tax or rate increases are unpopular.

Fortunately, as progressive utilities have shown, it is possible to undertake wholesale improvements in a short time – not piecemeal over a number of years – without burdening customers. In essence, savings from the future pay for improvements today. The financial tool that makes it possible is performance contracting.

In this model, proven in many private- and public-sector facility upgrades, a third party puts up capital to complete a slate of improvements that will deliver a contractually guaranteed level of energy and operating cost savings over a specified term. The owner then uses those savings to make payments against the project costs. Often, contracts are structured so that the annual savings are greater than the annual payments and the owner sees immediate positive cash flow. In addition, current debt sometimes can be restructured to reduce interest rates. After a typical 10- to 15-year term, the payments end and the owner reaps the full amount of savings for the remaining equipment life.

As part of the program, new equipment and maintenance scheduling software can help owners get beyond reactive approaches and put in place an operational plan that is predictable and easier to budget.

An efficiency imperative

Utility leaders need no instruction on the state of the nation's water and wastewater infrastructures. The 2013 edition of the American Society of Civil Engineers' Report Card on America's Infrastructure gave each a D.

Meanwhile, budget pressures remain at all levels, and utility officials are anxious about it. A 2012 report from the Black & Veatch consulting firm explored how utility leaders felt about the condition of their infrastructure. They cited capital costs and funding as their top concerns, and "the vast majority of survey respondents doubt the sufficiency of their future funding to manage and maintain their systems," according to the report.[1]

At the same time, leading industry groups are encouraging utilities, especially wastewater agencies, to expand their roles and spheres of influence. According to a 2013 article, *The Water Resources Utility of the Future: A Blueprint for Action:* "Instead of solely collecting and transporting wastewaters as far downstream as possible to central treatment plants where

1. 2012 Strategic Directions in the U.S. Water Utility Industry, ©2012, Black & Veatch.

wastes are cleansed to meet permit limits prior to discharge to waterways, the Utility of the Future transforms itself into a manager of valuable resources, a partner in local economic development, and a member of the watershed community seeking to deliver maximum environmental benefits at the least cost to society."[2]

On the drinking water side, utilities are increasingly challenged by drought and extreme stress on water supplies.

Dealing with these issues and rising to higher expectations takes investment and aggressive action; small, incremental steps no longer suffice. There are efficiency gains to be made at every step of the water and wastewater process. The most sensible approach is to target the largest ones first according to a clear set of priorities and a plan that delivers the greatest and fastest return on investment.

The rewards can be substantial: In the operations of mid-sized cities, 30 to 40 percent of electricity is used by water utilities (mainly for pumping) and wastewater utilities (mainly for aeration).[3]

Treating drinking water

On the potable water side, moving water from the source to treatment and from treatment to distribution presents the great savings potential. Aging constant-speed vertical turbine or horizontal split-case pumps can be replaced by high-efficiency pumps with premium-efficiency motors and variable-frequency drives. Simply rebuilding old pumps to original specifications can increase the efficiency of the old degraded pumps although nameplate factory efficiency is not achievable.

Utilities can take advantage of electric companies' time-of-use rates by shifting pumping from high-cost peak hours (daytime) to lower-cost off-peak hours (overnight).

Because pumping is so essential, it is advisable to perform an asset management review of all pumps and identify those that would benefit most from rebuild or replacement. This review can include a detailed cost analysis showing the remaining economic useful life of each pump. This can serve as a guide to planning rebuilds and replacements over the next 10, 15 or 20 years.

In addition, optimized pumping schemes or additional storage can drive down energy consumption. Utilities can take advantage of electric companies' time-of-use rates by shifting pumping from high-cost peak hours (daytime) to lower-cost off-peak hours (overnight). This saves on both the energy (kilowatt-hour) and demand (kilowatt) sides of the electric bill. Other ways to optimize efficiency include:

Generating power. The movement of water can help produce rather than just consume energy. For example, utilities that draw water from high elevations can install hydroturbines in the pipeline to generate electricity. For large utilities, turbines with capacities up to 500 kW have proven feasible. On the distribution side, small turbines (50 to 100 kW) can be deployed downstream of water towers and reservoirs. They can also replace pressure-reducing stations, a benefit especially in remote locations where the electricity can help directly power a local building.

Optimizing membranes. Membrane treatment is much more energy-intensive than conventional treatment. Manufacturers continuously improve their systems' overall efficiency. As existing polymeric membranes age and degrade (typical life is seven to 10 years) it is worth exploring replacements that operate at lower transmembrane pressure and therefore use less energy. In addition, new control features are being developed that could lengthen membrane life and minimize the use of chemicals.

2. The Water Resources Utility of the Future: A Blueprint for Action. ©2012, Water Environment Federation, Water Environment Research Foundation, National Association of Clean Water Agencies.

3. U.S. EPA, http://water.epa.gov/infrastructure/sustain/water efficiency.cfm

Optimizing chemical use. Many water treatment plants can benefit from alternative coagulants that improve treatment and save on chemicals. Chemical savings can also be found through controls that tailor chemical dosing based on raw water quality or parameters from downstream processes.

Updating disinfection. Ultraviolet light (UV) disinfection can be updated to newer systems that achieve more energy and operational efficiency through better cleaning systems, longer-life lamps and better access to lamps for service or replacement.

Improving residuals processing. Efficient dewatering of treatment process residuals with the latest technologies can substantially reduce volume, hauling costs, and disposal fees.

Efficient distribution

Many water utilities waste significant energy and forfeit a great deal of revenue through deficiencies in metering and distribution. The U.S. Geological Survey has estimated that as much as 6 billion gallons per day is unaccounted for nationwide due to leakage, poor accounting and other unbilled consumption.[4]

Optimizing efficiency means taking a two-pronged approach: Reducing real losses (pipe leaks, pipe breaks and storage tank overflows) and apparent losses (water that reaches customers but is not accounted for and not billed). Sources of apparent loss are inaccurate meters, errors in meter reading, and errors in the billing system.

One such technology uses sensors permanently mounted on specified numbers of customers' service lines immediately upstream of the water meters (spacing depends on pipe material).

Programs to reduce real losses are especially valuable in times of drought. Such losses can be attacked with condition assessment for large pipes such as transmission mains and with leak detection and repair for distribution lines.

Condition assessments deploy video inspection cameras or acoustic sensing devices that traverse the line and capture data on defects. One acoustic technology is a free-swimming foam ball with an instrument-filled aluminum alloy core, able to detect and locate very small leaks in large diameter mains while they remain in service. It can travel with the water flow for up to 12 hours, collecting data over many miles of line in a single deployment. The data helps show which large pipes are most in need of repair so that the utility can plan capital improvements wisely instead of replacing pipes based solely on age.

Leak detection on distribution pipes relies on vibration-sensing devices. One such technology uses sensors permanently mounted on specified numbers of customers' service lines immediately upstream of the water meters (spacing depends on pipe material). The sensors record vibrations caused by leakage, and the data is uploaded to a proprietary website for analysis. The utility then has access to a system map showing the locations of probable leaks and a spreadsheet that suggests repair priorities based on leak severity. The data in turn can be exported to a work order management system so that field teams can use noise correlators to pinpoint the leaks and repair the leaks that represent the largest losses.

On the apparent loss side, a first step is to ensure that the proper meter size is deployed at each customer site and to test all meters for accuracy. Another essential step is water bill reconciliation, which uses proprietary software to re-calculate every bill for a baseline year based on the water and sewer rate schedule. The calculated bills are then compared to the actual bills and discrepancies are flagged. Among more than 100 utilities on which Johnson Controls has used the system, it has found errors in all except one.

Meanwhile, metering technologies help ensure accurate meter reads with minimal labor. Mobile and fixed-base automated meter reading (AMR) systems are widely accepted and deliver fast payback by eliminating manual reading. Advanced metering infrastructure (AMI),

4. Alliance for Water Efficiency http://www.allianceforwaterefficiency.org/Water_Loss_Control_Introduction.aspx which provides incremental data on each customer's water usage, has gained favor in recent years. A few customer service benefits of AMI include:

- Prompt detection of leaks in customers' homes or businesses that might otherwise go undetected for an entire 30- to 90-day billing cycle.
- Quick detection of reverse flow or meter tampering.
- Data that helps customers understand their usage patterns and adopt better habits.

AMI also helps utility managers track usage among the largest users, who account for a large share of revenue. Daily reports show any notable changes in usage so that a technician can be sent to check for a faulty meter or other reasons usage has declined. Before such data was available, identification of these losses fell to billing departments, who might easily fail to detect them while working on tens of thousands of customer accounts.

Energy saved, energy created

The wastewater treatment side brings opportunities to save significant energy as well as create it through the beneficial use of biogas.

Many wastewater treatment plants suffer from aging equipment. In some, the inefficiency is compounded because the plants were built for projected population growth that never occurred and are now oversized.

In this sector, the biggest energy-saving opportunity lies in the control of aeration for the activated sludge (secondary treatment) process. Old constant-speed, mechanical aerators and coarse-bubble diffusers are highly inefficient and may account for more than half a plant's energy usage.

One part of the remedy is high-efficiency, high-speed turbo blowers combined with fine-bubble diffusers that enhance oxygen transfer in the aeration basins. The other part is an electronic feedback loop that allows for control of dissolved oxygen (DO) content in the mixed liquor. Without this control, basins tend to be aerated beyond what the process requires – especially overnight when wastewater flows and oxygen demand are lower. The control typically consists of an oxygen sensor in the basin that communicates with a programmable logic controller (PLC). The system automatically adjusts blower output to maintain a preset DO concentration. With this configuration, energy savings can range from 10 to 15 percent or more, depending on basin depth and geometry and other factors.

Other strategies for enhancing treatment plant efficiency include:

Pumping. As on the drinking water side, aging influent pumps and other high-volume pumps can be replaced with high-efficiency pumps and motors with variable-frequency drives. Replacing traditional floats with sonic devices for water-level control in wetwells can help reduce pump cycling, thus saving energy and reducing wear and tear.

Renewable energy. Many treatment plants flare biogas from anaerobic digesters, in some cases because boilers or engine-generators that once used it fell into disrepair from lack of fuel treatment to remove impurities. This equipment can be rebuilt, or replaced, and pretreatment added, allowing biogas to be used productively. Ideally, the gas fuels an engine or turbine that generates electricity, and heat from the unit is captured for facility or digester heating. In some cases it is feasible to increase biogas production by feeding dairy waste, food waste, fats/oils/grease or other organic substrates to the digesters. Well-designed biogas-to-energy projects have enabled treatment plants to produce a majority of their heat and electricity, saving hundreds of thousands of dollars per year.

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Performance contracting allows water and wastewater utilities to take bold steps to improve their most basic operations without burdening customers with new taxes or higher rates.

Bundling projects

Performance contracting makes it possible to bundle multiple improvements like these and finance them all at once instead of undertaking smaller initiatives year by year. The owner realizes immediate savings that fund the upgrades and avoid future cost increases. Furthermore, utility operation improvements can be combined with traditional efficiency measures for administrative and other buildings: interior and exterior lighting retrofits, boiler and chiller upgrades, HVAC control automation, window replacements, insulation, renewable energy, and others.

In a typical performance contract, an energy service company works closely with utility leadership, and its engineering consultants, to develop a package of projects that offers the optimum return on investment in keeping with the utility's business strategy. The process includes a detailed assessment of equipment, process, water loss, and facilities, followed by an investment grade audit that provides an accurate projection of the project costs and the savings to be generated.

The utility does not simply take a "leap of faith" that the savings will materialize. The cost and savings projections are based on years of experience with similar projects and a close analysis of the utility's electricity and fuel prices and rate structures. Most important, the savings are guaranteed by contract. If a given year's savings exceed the projection, the utility pockets the excess. If the savings fall short of the guarantee, the energy service company must write a check to cover the difference.

Time for action

Fiscal times seldom have been more challenging than today, yet the need for infrastructure improvements perhaps never has been more acute. Performance contracting allows water and wastewater utilities to take bold steps to improve their most basic operations without burdening customers with new taxes or higher rates.

A well executed program delivers immediate savings by adding the latest technologies and by replacing aging equipment with new equipment that is more efficient, less prone to downtime, and less costly to maintain. In the immediate and long term, it adds up to enhanced customer service, improved operations, and predictable outcomes at highly competitive prices.

Cases in Point

Savings from new meters and automation

The City of Colby, Kan. (population approximately 5,400) saw an estimated $750,000 in savings and increased revenue over a 15-year performance contract by upgrading all water and electric meters and replacing an older AMR system with an up-to-date technology. On the water side, the $1.7 million project replaced more than 2,000 outdated meters and added a permanently installed leak detection system. The project also included water bill reconciliation that identified and corrected several areas that increased annual revenue.

New meters, better service

Savings from an AMR system and 35,000 accurate new water meters helped the City of Olathe, Kan., repay a $12 million investment in 11 years through savings and increased revenue. All told, the city (population approximately 125,000) was also able to fund other energy efficiency improvements including solar panels for the city car wash, a waste oil heating system, and variable frequency drives on large pump motors at the wastewater treatment plant. The savings helped the city invest in further efficiency improvements including a solar hot water system, a new boiler and radiant heaters, and variable-frequency drives on large motors at the wastewater treatment plant.

Biogas to energy – and savings

Upgrades to the Ithaca (N.Y.) Area Wastewater Treatment Facility completed in 2013 mean $9 million in guaranteed savings on energy and operations over 20 years to the city of approximately 30,000. The work included modernizing of aging infrastructure, an upgrade to the digester-gas-fueled cogeneration systems, and improvements to the biosolids digester and boiler. After project implementation, 64% of the plants electric and thermal energy is projected to be supplied by renewable sources. The projects have helped reduce greenhouse gas emissions by 961 tons per year, generated $15 million in economic activity, and created 80 green-collar jobs in the region.

A boost for treatment

The city of Rome, N.Y, and its approximately 34,000 residents benefited from a $6.5 million performance contract that expanded capacity and improved efficiency at the wastewater treatment plant without a rate or tax increase. The project installed an aeration system with energy efficient variable-vane blowers, dissolved oxygen controls and fine-bubble diffusers. Variable-speed drives were installed at the water filtration plant. The City of Rome will obtain benefits totaling $8.6 million over the 15 year contract term. An earlier performance covered $2 million of lighting, energy management and other improvements to city buildings.

Funding system renewal

A three-phase, $14.8 million performance contract helped the City of Mt. Vernon, Ind., (approximately 8,000 population) make wholesale improvements to its water treatment and distribution systems and receive an expected $22 million in savings and increased revenue over 15 years. The first phase replaced all 2,375 meters and added an AMR system and installed a new booster station. Phase two included new filtration units at the 4.0 mgd water treatment plant. Phase three covered new water intakes, new storage and pretreatment facilities, solar panels and a wind turbine. All work was done at no up-front cost.

Greater accuracy, more revenue

The City of Bedford, Ind. (population approximately 13,500) used a performance contract to change out 6,000 water meters and install a drive-by AMR system. The $3.2 million project also included citywide automated leak detection, integration of meter data with the billing systems, operational training and troubleshooting, insertion valves, and meter box rehabilitation. The project improved metering accuracy and lower operating costs, bringing an annual average over $385,000 per year in guaranteed savings and new revenue over a 15-year term.

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