# Water is a Finite Resource, with Hidden Energy Savings Floating Just Below the Surface


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## ABSTRACT

Municipal water systems are major energy users where savings float just below the surface. This paper summarizes an effective strategic energy management (SEM) approach—combining industrial energy efficiency, water resources engineering, and people-centered action—to capture those hidden energy savings. The approach has been used on some 60 water utilities in the United States under programs sponsored by multiple power companies. The process is described along with specific examples and successes.


## What is the Opportunity?

Municipal drinking water systems require significant amounts of energy to extract, treat, and deliver high-quality drinking water—about 2,500 kWh/MG on average, but some as high as 12,000 kWh/MG (Sowby and Burian 2017). While providing a vital public service with strict water quality and pressure standards, these systems can almost always use less energy and still perform well (AWWA 2016; Jones and Sowby 2014; Liu et al. 2012; EPA 2008). Figure 1 illustrates the factors that, when combined, contribute to an optimized water system. An optimized water system operates in the "sweet spot" where water quality, hydraulic performance, and energy efficiency overlap. Water quality and hydraulic performance (pressure) are the primary goals of any reliable water utility, and achieving them takes energy—but not as much as one might think. In the water industry, energy savings float just below the surface and are major opportunities for power utilities.

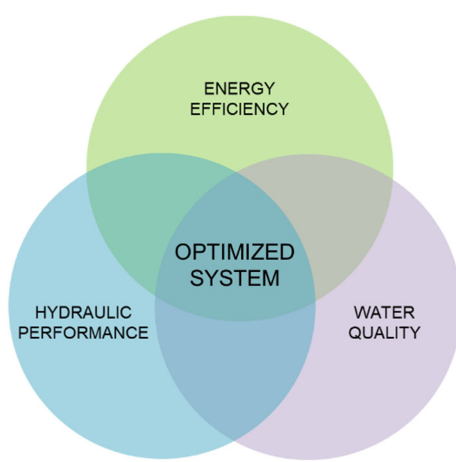


Figure 1. Optimized water system. Figure courtesy of Hansen, Allen & Luce, Inc.

The challenge, however, is multifaceted. First, while energy efficiency is gaining momentum in the water sector, some technical solutions are still being developed and are unfamiliar to many water system operators. Further, water systems and power companies—though both deal with finite and indispensable resources—rarely speak the same language and struggle to connect due to differing operating objectives, business models, and cultures within each type of organization. Finally, water system operators are naturally risk averse and resist energy efficiency changes that they fear could adversely affect water quality or pressure. In public water supply, the cost of failure is high, often involving some public health crisis. If something starts to go wrong—poor treatment outcomes or low pressure, for example—the default reaction is to throw more energy at it.

Over the past several years, consultants Cascade Energy and Hansen, Allen & Luce, working together as Aquafficiency, have developed a successful method to overcome these challenges and capture those hidden energy savings in the water sector. By combining industrial energy efficiency, water system engineering, and a people-centered approach, Aquafficiency has succeeded with some 60 water systems throughout the western United States.

The approach and results, documented in various forms elsewhere (Jones and Sowby 2014; Jones et al. 2015; McWilliams et al. 2017; Sowby et al. 2017; Sowby et al. 2019), are described here in the context of power utility programs under which many of them occurred. The technical solutions, while important, are not the focus of this paper and may be found in the references provided at the end.

## What is Aquafficiency and SEM?

In recent years, water systems have increasingly embraced energy efficiency as a means to reduce operating costs or environmental footprints. Several conventional approaches have been variously successful, such as building audits, pump equipment upgrades, analytics software, smart controls, automation, and performance contracts. However, while important, these technical solutions lack a fundamental, underlying feature.

Aquafficiency is based on the principles of strategic energy management (SEM), applied specifically to public water systems. At its heart, SEM is an *organizational commitment to managing energy.* This commitment is what ties everything together, including the elements mentioned above. *People*, not technologies, make the difference. Without this commitment, technical solutions are not likely to stick; with it, energy savings are achieved and sustained.

The Aquafficiency engagement is a series of structured activities typically occurring over 12 to 24 months, though the actual length may vary. A process overview is presented in Figure 2.

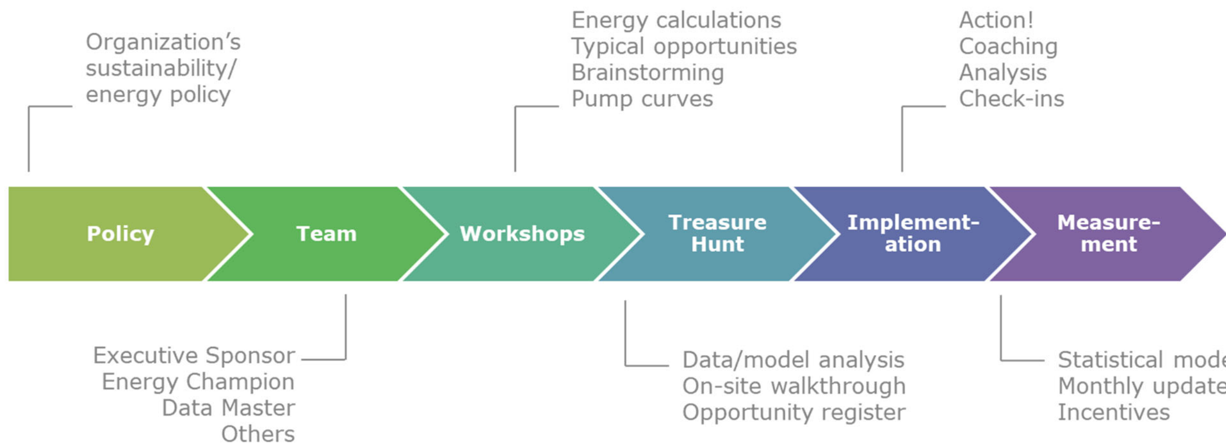


Figure 2. Aquafficiency process overview. Figure courtesy of Hansen, Allen & Luce, Inc.

## Policy Development

First, water utilities develop an energy policy and set a goal. Recent research (Sowby 2018) found that water utilities with a documented commitment to energy management, such as a policy or SEM program, will use, on average, 30% less than those that do not, even after normalizing energy footprints for their sizes, water sources, and climate settings. A policy alone, of course, does not save energy, but it does establish a commitment and sets the direction that will lead to energy savings through SEM and other means. Effective policies will outline goals, metrics, standards of behavior, and accountability. Once established, the policy influences all subsequent Aquafficiency activities.

## Team Development

While the primary objective may be energy savings, SEM takes a people-first approach. The formation of a motivated and well-defined team is critical to SEM success. While energy teams may be of various sizes and involve water operators, engineers, office staff, and IT personnel and supported by anyone interested in saving energy, three key positions are critical to the success of the engagement. The "executive sponsor" authorizes work and provides resources to the effort. The "energy champion" leads the team, conducts meetings, and follows up on assignments. The "data master" provides information necessary to evaluate opportunities and measure progress.

Because every employee of a water system has different insights into system operation, involving diverse team members early and often creates better ideas and execution throughout the Aquafficiency process. SEM coaches encourage executive sponsors and energy champions to invite seasoned operators, junior operators, staff and consulting engineers, mechanics, and any other individuals whose inclusion might broaden the understanding of the water system to participate.

## Workshops

Energy issues are mostly unfamiliar to those working in public water systems. Historically, energy was a cheap means to an end and the goal to "provide clean water, no matter the cost" still prevails in some organizations. Even in the rare case that the civil engineers who designed the facilities were adequately trained in energy analysis, it may not have been part of the design scope for those facilities. Where the focus is water, it is easy to miss energy.

For these reasons, the Aquafficiency program includes several training workshops. In these interactive workshops, each lasting at least half a day and spaced over several months, the consultants cover basic energy literacy, pump calculations, persistence strategies, and typical opportunities for saving energy in a water system. Participants follow along and complete exercises in a custom workbook. In addition, the workshops provide opportunities for team members to discuss issues and brainstorm energy-saving ideas to be implemented later. A picture of a previous workshop is presented in Figure 3, in which several water systems' energy teams are discussing how to reconfigure pressure zones.

Figure 3. An Aquafficiency workshop. Photo Courtesy of Hansen, Allen & Luce, Inc.

## Treasure Hunt

The "meat" of the Aquafficiency engagement is the so-called "treasure hunt," an on-site activity designed to help the water system staff generate and prioritize specific energy-saving ideas. By this time, the energy team is well established, well trained, and has established a relationship with the consultants. Before the treasure hunt, building on best practices from industry resources (AWWA 2016; EPA 2008; World Bank 2012), the consultants analyze the hydraulic model, system operations, and facility-level energy data for insights into energy savings. At the treasure hunt, the team reviews this information, visits selected facilities and processes, discusses ideas to save energy, and ultimately generates an "opportunity register," a prioritized list of energy-actions, assignments, and due dates. Some actions are strictly operational, while others require capital investment.

**Implementation**

Guided by the opportunity register, the energy champion oversees implementation of the energy-saving actions. Some actions may be implemented immediately, such as modifying the setpoints for certain water tanks and pump stations; some require longer-term planning and investment, such as upgrading treatment equipment or installing new pipelines. Regular team meetings, in which the energy champion reviews the team's progress and follows up on assignments, occur over several months as action items are completed. Common barriers to implementation include lack of information, lack of funding, and risk uncertainty. The consultants help the water system staff address these on a case-by-case basis: for example, by arranging to submeter certain pumps within a water treatment plant, facilitating power company incentives, or modeling the distribution system to assess the pressure and water quality impacts of certain operational adjustments.

**Measurement**

At the beginning of the Aquafficiency engagement, the consultants develop a baseline energy model. Usually, three years of historic monthly energy and water use, by facility, are compiled into a spreadsheet-based regression model that characterizes past energy use and predicts future energy use (assuming business-as-usual). Other important factors affecting water or energy use, such as air temperature or precipitation, are also considered. After the baseline period, the data are updated monthly with observed water and energy use and actual performance is compared against the energy use predicted by the regression model. The consultants provide monthly progress updates during energy team meetings and/or workshops. The final savings may be verified by a third party if needed.

## What are the Results?

Aquafficiency has delivered SEM engagements to over 60 water utilities in both direct and power-company-sponsored engagements. Table 1 through Table 4 present selected results and highlights.

Table 1. Jordan Valley Water Conservancy District's SEM results

| Organization | Jordan Valley Water Conservancy District |
|---|---|
| Location | Salt Lake City, UT, area |
| Service Population | 630,000 |
| Main Opportunity | Source Selection |
| Engagement Length | 35 months |
| Energy Savings | 34,513,000 kWh (25%) relative to baseline |

*Source:* Sowby et al. 2017; power company reports

Table 2. City of North Salt Lake Water Department's SEM results

| | |
|---|---|
| Organization | City of North Salt Lake Water Department |
| Location | North Salt Lake, UT |
| Service Population | 21,000 |
| Main Opportunity | Pressure-reducing valve settings |
| Engagement Length | 35 months |
| Energy Savings | 3,700,000 kWh (25%) relative to baseline |

*Source:* Sowby et al. 2019; power company reports

Table 3. City of Blackfoot Water Department's SEM results

| | |
|---|---|
| Organization | City of Blackfoot Water Department |
| Location | Blackfoot, ID |
| Service Population | 12,000 |
| Main Opportunity | System pressure control |
| Engagement Length | 12 months |
| Energy Savings | 225,000 kWh (11%) relative to baseline |

*Source:* Joint Utility Eastern Idaho Water Cohort Year 1 Report

Table 4. Roy City Public Works' Water SEM results

| | |
|---|---|
| Organization | Roy City Public Works |
| Location | Roy, UT |
| Service Population | 37,000 |
| Main Opportunity | Prematurely breaking pressure |
| Engagement Length | 12 months |
| Energy Savings | 827,000 kWh (55%) relative to baseline |

*Source:* power company reports

## Case Study Specifics

**Jordan Valley Water Conservancy District.** Jordan Valley Water Conservancy District's (JVWCD's) participation with SEM was sponsored by Rocky Mountain Power. Serving the greater Salt Lake City area, JVWCD is a large wholesaler with three water treatment plants and more than 20 wells. With an average energy use of about 4,000,000 kWh/mo, Rocky Mountain Power and Aquafficiency agreed that JWVCD was a good candidate for an SEM engagement.

JVWCD's initial engagement had an eight-month measurement period that recorded 3,887,000 kWh of savings. During this time, Aquafficiency helped JVWCD compare the energy intensity of each of its water sources and prioritize the use of the most efficient ones. The resulting energy intensity map is presented in Figure 4. Before this analysis, JVWCD's team had assumed that the newest facility was the most efficient, but the results gave them new insight into how each water source contributed to the district's overall energy profile.

The whole experience prompted a culture shift for JVWCD in which the staff formed an in-house energy team to prioritize the best opportunities and seek ongoing savings. Rather than asking, “How can we make this pump more efficient?” the team asked the deeper question, “How can we optimize our whole water supply?”

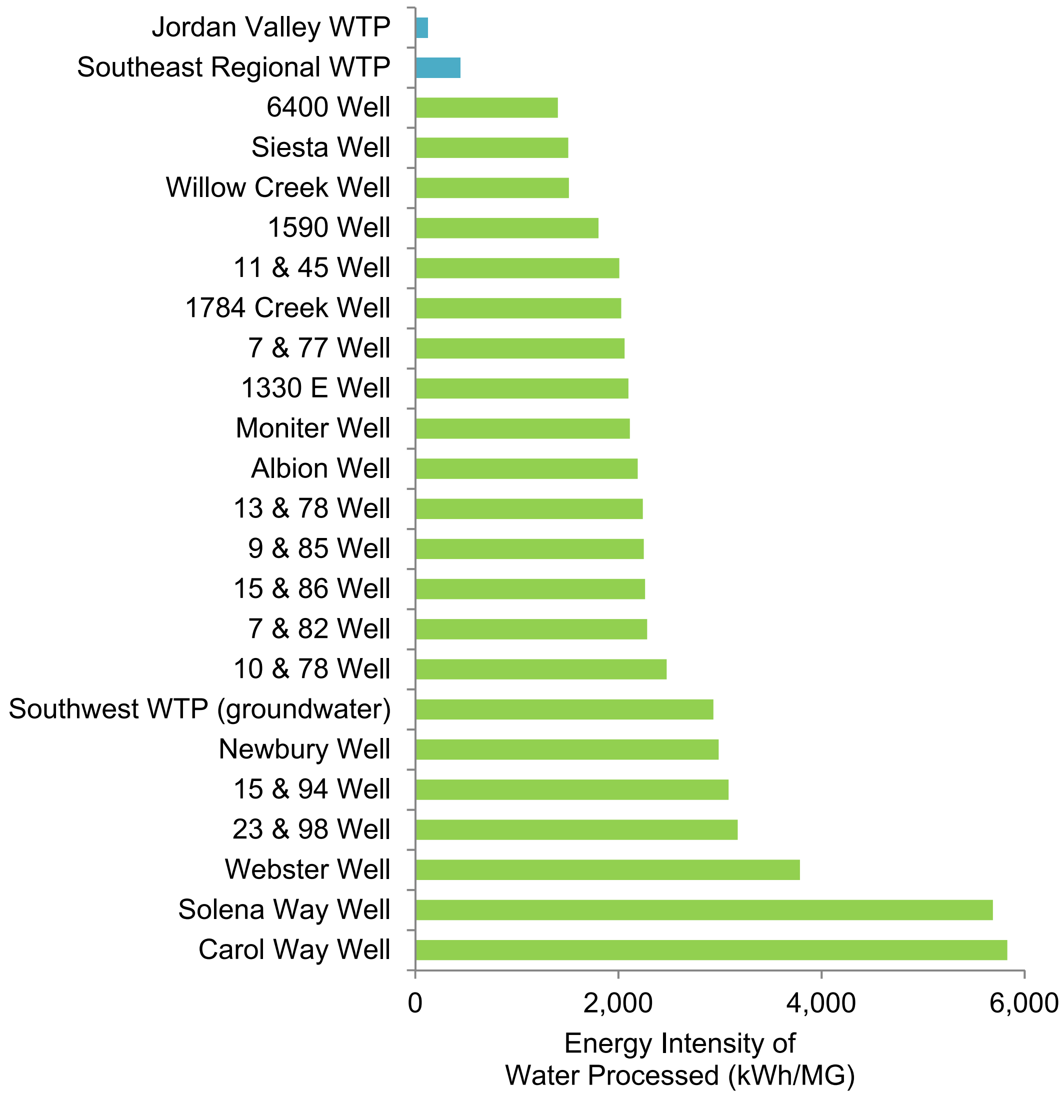


Figure 4. JVWCD drinking water energy intensity. Figure courtesy of Hansen, Allen & Luce, Inc.

Because JVWCD was only able to complete a portion of the actions identified in the first engagement, Rocky Mountain Power authorized a second engagement of 15 months. Continuing down the opportunity register, the water district achieved an additional 8,644,000 kWh of unique savings beyond the first engagement. The district’s experiences in the first two engagements are documented by Sowby et al. (2017).

With such success, Rocky Mountain Power agreed to fund a third and final SEM engagement of 12 months. During this time JVWCD sustained the ongoing savings from the first two phases and saved an additional 1,951,000 kWh. While not the solution for every water system, this phased, multi-engagement approach worked well for all involved. JVWCD’s staff became comfortable discussing energy issues and making changes, Rocky Mountain Power was pleased with the results and confident in the approach, and the consultants and JVWCD personnel were able to come up with new opportunities that did not surface earlier.

In addition to the SEM savings, the water district completed seven energy-efficiency capital-improvement projects. Those projects were identified as part of the SEM engagement. After completion, the capital projects were verified and reported separately from the SEM savings, totaling 1,619,000 kWh savings in the first year.

**The City of North Salt Lake.** The City of North Salt Lake participated in the very first SEM water engagement funded by Rocky Mountain Power. That engagement consisted of three water systems selected because of their high energy use. The city's water system had a very high energy intensity because a large portion of its residents live in the foothills and its wells are all located on the valley floor.

Over the course of the engagement, Aquafficiency engineers and city staff, working together, found that the boundary valves between the pressure zones going up the hill were not configured properly. Designed to open in emergency for fire flow only, the boundary valves were actually allowing water to descend regularly from higher zones into lower zones, where it was then pumped back into the higher zones. By adjusting the boundary valve settings, the city was able to significantly reduce the energy intensity of its water services and reduce its peak demands on the power company. During the 35-month engagement, the energy savings amounted to 3,700,000 kWh, or 25% of the baseline energy use. Pressures also improved and the water department received fewer pressure-related customer complaints, illustrating the other benefits that can occur when energy issues are addressed.

**City of Blackfoot Water.** The City of Blackfoot Water participated in an eight-member, three-utility SEM cohort that was offered in Eastern Idaho. The first of its kind, this SEM engagement was funded by Bonneville Power Administration, Idaho Power, and Rocky Mountain Power. The three-way arrangement allowed these power utilities to engage with their customers in a region where SEM was otherwise cost prohibitive due to the small size of most participating water utilities when considered individually. Idaho Power identified Blackfoot as a potential participant and invited Aquafficiency to contact them about the opportunity.

Among other things, Blackfoot had implemented automatic pressure control of its water system that was not properly tuned. This caused the pressure in the water system to swing radically as pumps were cycled on and off. While this operation was hard on the water system and the equipment, it also caused higher energy use and erratic demands on the power company. By tuning the control system, the city was able to dramatically reduce the pressure swings and stabilize water delivery and power demand. A time series graph of cumulative savings is presented in Figure 5.

In that figure, the baseline period, the section with the grey background, is used to create the regression model; in this section of the graph, the actual energy use and the predicted energy use mirror each other. After a two-month implementation period which included the first two workshops, the performance period began, indicated by the blue background. In this portion of the graph, the regression model, indicated by the red line, is used to predict the energy the system would have used without making energy-efficiency changes, and the blue line is their actual energy use. The cumulative sum of the difference between the predicted energy use and the actual energy use is their energy savings.

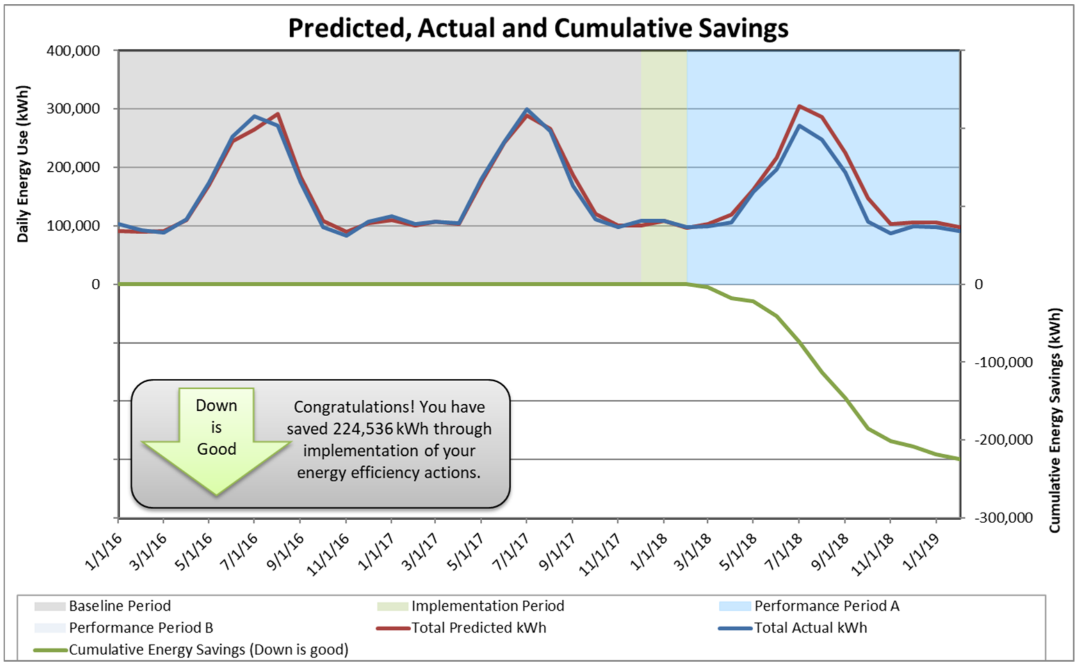


Figure 5. Blackfoot City Water's Energy Performance for Year 1. Photo courtesy of Cascade Energy Inc.

**Roy City Water.** Roy City Water was invited by Rocky Mountain Power to participate in a five-member water cohort in Northern Utah. Roy City's topography is unique in that it receives most of its water from a wholesaler in its highest-pressure zone. Water was gravity fed into a large tank, where additional water could be added from a well, before it was boosted into the two lower pressure zones. After discussing this operation with the consultants during the treasure hunt, Roy's staff determined that by opening the pressure-reducing valves between their pressure zones to continuous flow, they could avoid boosting from the large tank into the lower zones. This change allowed them to eliminate over half of their annual energy use.

## How Does Aquafficiency Fit with Power Utility Programs?

Many power companies already offer energy efficiency programs to industrial customers and could extend this offering to municipal water systems; municipal water systems are a largely untouched segment of industrial energy efficiency. However, it can be difficult for power companies to find the best ways to connect with water systems and to help them understand how to save energy. Aquafficiency fills the role of a "translator" who speaks both water and energy in order to engage water utilities in energy efficiency programs.

Aquafficiency acts in a consulting role to deliver the program to selected customers. Power company representatives may attend the workshops and treasure hunts to observe progress and interact with their customers. Energy savings updates are provided throughout the engagement and verified at the end of the engagement.

### Conclusions

Almost all municipal water systems have opportunities to save energy. Each one is different, however, and there is no universal solution that will allow them to operate more efficiently. By implementing strategic energy management programs focused on the people and their commitment to savings energy, power companies can positively engage with their water utility customers and help them find operational improvements that will improve water quality, hydraulic performance, and energy efficiency.

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