Feature Article

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Jordan Valley Water Redefines Sustainable Water Supply Through Energy Management

A MAJOR UTAH WATER DISTRICT REDUCED ITS ENERGY FOOTPRINT BY 19% AFTER FOLLOWING A TWO-YEAR ENERGY MANAGEMENT PROGRAM, IMPLEMENTING BOTH TECHNICAL AND ORGANIZATIONAL CHANGE IN PURSUIT OF ITS VISION TO PROVIDE A MORE SUSTAINABLE WATER SUPPLY.

Serving the greater Salt Lake City area, Jordan Valley Water Conservancy District (JVWCD) is one of Utah's largest public water suppliers. Primarily a wholesaler of water to cities and improvement districts, JVWCD serves a population of approximately 680,000. About 75% of its water comes from surface water sources in the Provo River watershed or from local streams of the Wasatch Mountains' east bench. The remaining 25% comes from groundwater deep beneath the Salt Lake Valley.

Sourcing, treating, and delivering high-quality water requires significant energy, which is one of the district's largest operating costs averaging $4 million/year. To improve its sustainability through efficiency, JVWCD realized it needed to optimize its energy use.

MOTIVATION

A water utility's energy footprint plays a role in its financial, environmental, and social impacts. With increasing population, stricter water quality standards, and rising energy costs, energy efficiency in the water sector is emerging as a primary

Layout imagery by Shutterstock.com artists: f11photo, David Litman contributor to its overall sustainability. In recent years, many new resources and best practices have been developed to promote energy efficiency in the water sector (Sowby & Burian 2017, AWWA 2016, Chelius & McDonald 2016, Jones & Sowby 2014, Martin & Ries 2014, UDDW 2014, Liu et al. 2012, NYSERDA 2010, Moran & Barron 2009, USEPA 2008, Barry 2007).

JVWCD's vision is "to provide a sustainable water supply to promote individual and community well-being." However, although energy use was being monitored and considered with operational adjustments, only in recent years has energy management been directly viewed through the lens of sustainability. For water and wastewater utilities, energy management contributes to sustainability's triple bottom line by controlling costs, reducing emissions, and increasing public confidence while providing a vital service.

Engineering consultant Hansen, Allen & Luce had previously worked with JVWCD and its electricity provider, Rocky Mountain Power (RMP), and understood the potential for energy savings in JVWCD's system. Convinced that the optimization effort would pay back quickly through the energy savings, RMP decided to sponsor a strategic energy management (SEM) program for JVWCD, with Hansen, Allen & Luce and another consultant, Cascade Energy, as delivery partners. JVWCD staff were also an important part of the SEM team, which began its optimization efforts in late 2014.

The program contained the following components:

- Energy management workshops to build awareness, engage JVWCD staff, and develop an in-house energy optimization team
- Energy model development, energy performance tracking, and savings verification
- Engineering analysis to identify and help implement energy-saving opportunities
- Financial incentives for operational changes and capital projects leading to energy savings

It was a new experience for all parties. The power company had never engaged a water utility in this type of program before, and JVWCD was just starting to consider ways to further reduce its energy impacts. JVWCD and its consultants had promising ideas but had not attempted this level of engagement. Wanting to under-promise and over-deliver, the team set a modest goal to save 1 million kW·h in one year, or about 2% of JVWCD's usual energy use. At the end of one year, the team would evaluate its performance and determine whether the savings would justify additional focused optimization efforts.

METHODS AND TOOLS

System-wide perspective. While the most touted energy efficiency practices for water systems are limited to equipment and facilities, the team stepped back for a more holistic perspective. Instead of asking, "How can we make this pump or building more energy efficient?" the team asked the deeper question, "How can we provide an energy-efficient water supply?" Looking beyond equipment and facilities to JVWCD's entire system and even to its neighboring water utilities, this literal outside-the-box thinking enabled the team to identify larger, system-level opportunities that otherwise would have been overlooked. JVWCD examined the purpose and performance of each link in its water supply chain to find a better path for water delivery.

Workshops. Knowing that long-term energy savings would require more than just technical solutions, the program included a series of focused workshops. These workshops provided basic energy management training, helped guide JVWCD's newly formed energy optimization team, and disseminated energy efficiency approaches to all parts of the organization. Numerous efficiency ideas emerged from the workshops.

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Energy model. To determine JVWCD's typical energy use, a two-year baseline period (December 2012–November 2014) was defined. Monthly energy use and water production data from this period informed an energy model that related the amount of energy used to the water volume produced by each of JVWCD's water sources. This also eliminated any effects of water demand on the total energy use. Since JVWCD has many facilities and electric meters and had never before linked water and energy data in this way, the energy model was the most difficult part of the process. Once the energy model was complete and the performance period had begun, water and energy data were entered each month. Energy savings (or increases) were determined by comparing the actual and predicted energy use.

Energy map. The team quantified the energy requirements of each water source in what is called an energy map. All other considerations being equal (water rights, water quality, capacity, etc.), an energy map helps prioritize the most efficient use of water sources. It specifies the order in which water sources should be dispatched to minimize the energy required to meet water demands. The energy intensity of each well, booster pump station, and treatment plant, in kilowatt-hours per acre-foot, was computed from historical records and the energy model. Since energy intensity has little meaning for most people, JVWCD expressed the values as costs in dollars per acre-foot based on the average electricity price. The assignment of a dollar amount to the operation of each facility made the energy impacts more apparent. The energy map also considered exchanges and agreements with other water users outside of JVWCD's system.

Hydraulic model. An extended-period hydraulic model (a computer simulation) of JVWCD's system helped the team identify inefficiencies and test alternatives. The hydraulic model offered insight that augmented the operators' immense knowledge, providing a means to visualize how water could be more efficiently distributed. When an operational change or capital project was proposed, its effects on water quality and pressure were evaluated in the hydraulic model.

TECHNICAL CHANGES

The aforementioned methods and tools helped the energy optimization team compile a list of 88 energy-saving ideas across the system. When ideas were prioritized, several actionable recommendations, based on system data, emerged.

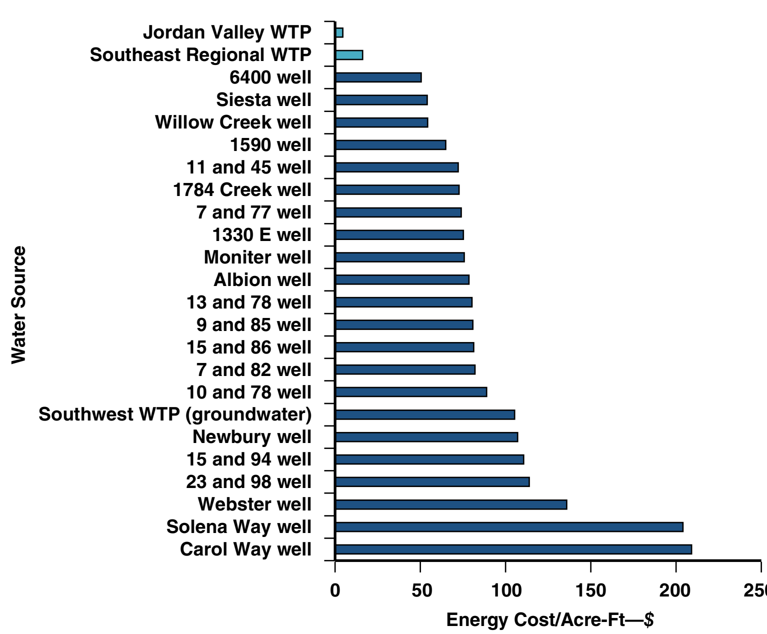
Source prioritization. As expected, JVWCD's two gravity-fed surface water treatment plants had the lowest energy intensities, costing \$4 to \$16/acre-ft, while groundwater resources that relied on pumping cost much more at \$50 to \$209/acre-ft (Figure 1; the gravity-fed plants are indicated by the light-blue bars). The district had always recognized that its surface water treatment plants were less energy intensive, but expressing the data in these terms helped the team fully grasp the magnitude of potential energy savings. Using this perspective, the operational staff understood the financial consequences of their decisions and implemented adjustments to operating protocols accordingly.

While preparing the energy map, the team realized that JVWCD had surface water rights in Echo Reservoir that were underused. Located in the mountains, Echo Reservoir was a gravity-fed supply that only required treatment and could offset much of the district's energy-intensive groundwater pumping. Historically, JVWCD had tried to save this water right for supplemental use in the summer months. This strategy worked, but there were limitations in conveying the Echo Reservoir water in the summer, so the district frequently would not receive its full allocation of this source. The energy optimization team found that if JVWCD used this source earlier in the year, there was a greater probability of maximizing the full yield of the water right.

JVWCD also found that its "favorite" wells were not necessarily the most energy efficient. Until the team examined the data, they had assumed that the newest or most conveniently located wells were the most efficient. In reality, one well could cost four times as much as another to produce the same amount of water. Two wells in particular had unusually high energy intensities. Accordingly, the district chose to promote its best-performing wells and demote worse-performing ones, proceeding down the list as water demands increased through the summer and taking less-efficient wells offline when demands waned. JVWCD applied the same concepts to the booster stations that move water between zones.

Irrigation exchange. Delivery of raw water for irrigation is an important component of JVWCD's energy profile. In the past, JVWCD primarily pumped water from the Jordan River into a canal system. Also nearby was the Provo River Aqueduct, a gravity-fed raw water source. JVWCD has used both sources for many years, but it recently gave specific attention to maximizing the aqueduct source when available. As with Echo Reservoir, this was an opportunity to favor a higher-head water source and avoid pumping. A

FIGURE 1 JVWCD's energy cost for each water source



JVWCD—Jordan Valley Water Conservancy District, WTP—water treatment plant

Left: The development of a focused team was crucial to the energy optimization program's success at Jordan Valley Water Conservancy District. The team meets regularly to review energy performance and act on new opportunities. Right: An extended-period hydraulic model is used to identify and test energy-saving opportunities. *Photos courtesy of JVWCD Photo courtesy of JVWCD*

new valve was installed to more precisely control the flows when bypassing the pump station to convey aqueduct water to the canal system by gravity.

Settings of pressure-reducing valves. Using the hydraulic model, the team identified several locations where pressure-reducing valves and their settings created undesirable operating conditions. JVWCD personnel adjusted these settings to eliminate over-pressurizing and pumping in circles.

Source proximity. JVWCD's water system covers almost the entire Salt Lake Valley, prompting strategies to reduce the overall pumping distance and energy requirements by using the water sources closest to the demand. Combining the energy map and the hydraulic model, the team identified the best options for local water deliveries.

Transmission capacity. The hydraulic model revealed several bottlenecks where transmission capacity was insufficient and caused large pressure fluctuations. The team then explored both capital and operational solutions.

Member agency coordination. JVWCD supplies water wholesale to 17 member agencies throughout the Salt Lake Valley at multiple delivery points. Some of the transmission bottlenecks were associated with these connections. Hydraulic modeling helped determine a more efficient delivery scheme using off-peak capacity, excess capacity, storage, and wheeling in certain areas of the system. JVWCD then coordinated with its member agencies to optimize their deliveries. Shifting the water demand in this manner effectively eliminated a number of bottlenecks and the pumping that was otherwise required to overcome them.

plan involved a single meter station, but by modeling both Midvale City's and JVWCD's systems, the team found that constructing a second meter station feeding a lower pressure zone would result in significant savings. This project is currently in progress.

The 2 mil gal Naniloa Reservoir was removed from service over 20 years ago because of operational restrictions that limited its usefulness.

Quick wins helped the velocity of the program; when employees started seeing positive results from their actions, they gained interest, and program contributions increased.

Capital projects. Although the program focused on operational changes, a few capital projects were identified and completed. JVWCD completed upgrades to its 10200 South Pump Station, which included replacing two pumps and motors and modifying the 36 in. discharge pipeline. The upgrades increased the energy efficiency of the station, which several wholesale customers rely on.

Midvale City, one of JVWCD's wholesale customers, needed to construct a new meter station to accommodate significant new water deliveries from JVWCD. The original

However, using hydraulic modeling, the team determined that making a few adjustments and placing the reservoir back in service would reduce energy consumption and control the pressure fluctuations that occur in that segment of JVWCD's system. The design for this project is currently underway.

Building efficiencies. The team explored several smaller efficiency opportunities in JVWCD's buildings. The ideas included reevaluating thermostat controls, installing efficient lighting and automatic timers, and employees shutting off personal computers and lights when they leave the

Energy Management Guidelines

Similar to a code of ethics, Jordan Valley Water Conservancy District (JVWCD) created energy management guidelines to help its employees understand what is expected of them in the energy optimization program. The primary objectives of these guidelines are to consider energy impacts before action is taken, improve energy consumption efficiency when possible, and reduce operational and maintenance costs. JVWCD recognizes the financial, environmental, and social benefits associated with saving energy, just as it promotes water conservation programs to save water.

JVWCD will implement and maintain the following practices:

- When conditions permit, use the lowest-cost water source first.
- Emphasize energy efficiency as a factor when considering new capital projects.
- Improve energy efficiency by establishing relationships with external customers and agencies to mutually benefit all parties with energy savings.
- Think "outside of the box" when working on routine tasks and daily operations to generate new ideas to conserve energy.
- Review demand charges and rate schedule management to reduce overall power costs expended by the district.
- Drive further development of internal and external energy-efficient, innovative technologies.
- Encourage continuous energy conservation by employees in their work and personal activities.
- Promote a culture of continuous improvement in all aspects of JVWCD's business including energy management.

The district recognizes that some positions have a greater influence on energy consumption, but to develop a culture of energy savings, the energy management guidelines apply to all JVWCD employees.

office. Though not significant in the overall energy profile when compared with water supply operations, these actions strengthened the energy management culture because everyone in the organization could contribute.

ORGANIZATIONAL CHANGE

The new perspective on energy management required a substantial shift in JVWCD's culture. Technical solutions were abundant, but they needed definite support from all levels of the organization.

Typical of many water providers, the district has a decentralized workforce in which employees report to and work from several locations and handle a variety of tasks and responsibilities. It was apparent that a network of key employees would need to be organized to successfully reach the energy savings goal. Modeled after the district's successful safety program, the energy optimization team worked to shift the organizational culture toward efficient energy use.

Multidisciplinary team. The district's energy achievements have been a cooperative effort led by a multidisciplinary team that is strategically staffed with key employees representing all departments within the district. The energy optimization team structure matches the organizational hierarchy of the district and starts at the very top with the district's general manager. Program buy-in from upper management is essential for the success of any program that involves employee resources, operational performance, and output of a water utility.

Of the district's nearly 150 employees, roughly 10% have a role on the energy optimization team. After considering upper management buy-in, the district's energy optimization team was broken down into four distinct groups: project leads, management team, action team, and support team. Each group plays an integral part of the overall program.

- The project leads consist of an executive sponsor, who is one of the district's assistant general managers, and an energy champion, who is the district's senior data analyst. The senior data analyst was chosen as a project lead because of the data demands of the program.
- The management team is primarily staffed by department managers, each representing core functional areas of the district. The role of this team is to allocate appropriate staff time and resources to enable successful program performance.
- The action team is staffed with key employees from each department. The members of this group meet to discuss new ideas, share strategies, and generate involvement from their respective departments.

• The support team helps with administrative and technology needs.

Culture. The district has emphasized adapting the culture of the organization to help employees better understand how their roles affect energy use. This has provided substantial energy savings through the optimization of operations, maintenance, and capital projects. (The sidebar on page 42 lists guidelines that were created for JVWCD employees.)

Historically, JVWCD's operational group had done an excellent job monitoring and managing power demand. This group also monitored the efficiencies of each particular facility, but spent less effort evaluating energy use holistically. The energy optimization team found that the broader view showed a handful of low- or no-cost actions that could reduce energy use, but the team realized there could be several barriers to implementation.

One of these barriers is employee tenure. The district's median tenure is 11 years, which is high compared with the national average of 8.3 years for similar industry (BLS 2016). This was an important consideration because employees who have been doing the same job for several years tend to resist change when exploring ways to improve familiar tasks.

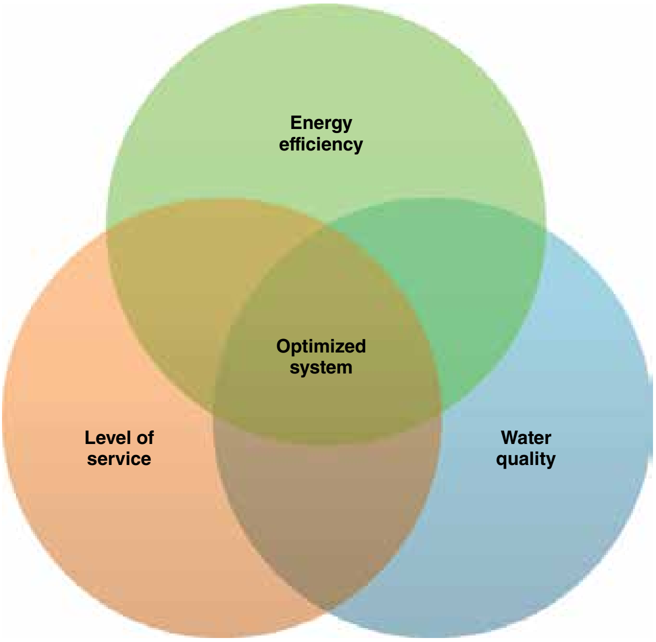
To create program synergy, the district considered motivators for all employees and found that data analytics, employee involvement, and quick wins all contributed to the buy-in and success of the program. Data analyses provided support to change recommendations and gave actual evidence that energy could be saved. Involving employees in finding and recommending solutions and listening to employee concerns helped gain trust in the program and instill ownership. Quick wins helped the velocity of the program; when employees started seeing positive results from their actions, they gained interest, and program contributions increased.

Prioritizing surface water at Jordan Valley Water Conservancy District's 180 mgd plant led to considerable energy savings in phase 1 of the district's energy optimization program. *Photo courtesy of JVWCD*

The district will never sacrifice level of service or water quality to save energy, but it has found that there is often a more efficient way to deliver the total package (Figure 2). In fact, energy efficiency often helps improve level of service and water quality, which results in an optimized system (Jones & Sowby 2014).

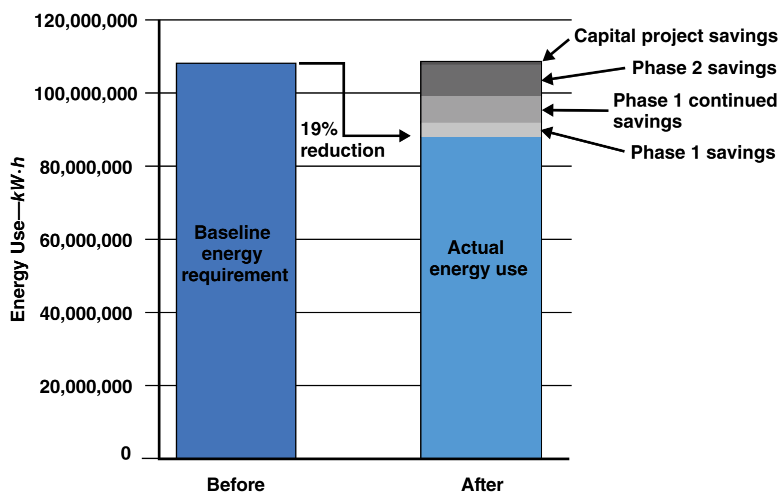
Tracking. The district reports various key performance indicators to its board of trustees every month in a scorecard based on the "Ten Attributes of an Effectively Managed Utility" (USEPA et al. 2017).

FIGURE 2 Energy efficiency as part of an optimized system



Source: Jones & Sowby 2014

FIGURE 3 JVWCD's energy use reduction during the 23-month program



JVWCD—Jordan Valley Water Conservancy District

For energy, the key performance indicator is energy use per volume of water delivered, much like the energy map described earlier, but for the system as a whole. The scorecard compares the district's energy use with the baseline model and is green if actual use is less than the baseline value, yellow if actual use is between 100% and 105% of the baseline value, and red if actual use is greater than 105% of the baseline value. The district also has other reporting tools that are used for data-driven decision-making and operational planning purposes.

Planning and operating protocol. Typically, the energy optimization action team meets every other month to discuss program matters, but the operational group—the group that uses the majority of energy—discusses energy considerations every week or whenever there is a need to start a motor.

RESULTS AND DISCUSSION

In the first eight months of the program (December 2014–July 2015), JVWCD saved 3.9 million kW·h, nearly quadrupling the original goal of 1 million kW·h, with four months to spare. There was no longer any question about whether the effort was worthwhile. With such momentum, the program immediately continued into a previously unplanned second phase (another 15 months: August 2015–October 2016), which logged another 8.6 million kW·h beyond the continued savings attributed to phase 1.

By the end of phase 2, JVWCD had cumulatively saved over 20 million kW·h, or 19% of its baseline energy use predicted for the same period as shown in Figure 3. In the end, most of these savings came from operational adjustments rather than capital projects. The avoided carbon dioxide emissions equated to 21,000 tons from a coal-fired power plant or 4,000 typical passenger vehicles for one year.

Until the team examined the data, they had assumed that the newest or most conveniently located wells were the most efficient.

RMP offered numerous incentives for energy management and capital projects, and even reimbursed the salary costs of the district's energy project manager. At the end of phase 1, JVWCD received over $284,000 in RMP incentives. At the end of phase 2, RMP officials presented JVWCD with a check for the phase 2 incentive of $172,878, the largest strategic energy management incentive RMP has ever offered. RMP estimates that the program saves JVWCD more than $492,000 in electric costs per year. In May 2016, JVWCD earned the top award in the Utah Industrial Energy Efficiency Challenge for the results of its efforts. In July 2017, JVWCD was named a Rocky Mountain Power wattsmart Business Partner of the Year.

Phase 3 of JVWCD's already successful energy management program is underway. The team continues to pursue actions not completed in the first two phases and to generate additional ideas as new insights arise.

CONCLUSION

JVWCD now realizes that efforts to use electricity as efficiently as possible are consistent with its other programs to conserve water resources and strengthen its ability to provide high-quality water services. JVWCD joins the growing number of water utilities embracing energy management as a best practice (MassDEP 2017, Sowby 2016, Jones et al. 2015, Mundt & Dodenhoff 2015, Horne et al. 2014, USEPA 2013). Since pursuing its energy management program, the district has found new meaning in its vision "to provide a sustainable water supply."

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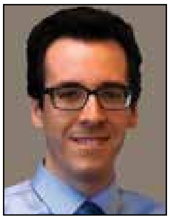

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