Using Sector Specialists to Drive Increased Efficiency in the Water Industry

Layne McWilliams, BPA Energy Smart Industrial
Jennifer Eskil, Bonneville Power Administration
Dawn Lesley, BPA Energy Smart Industrial

ABSTRACT

Despite the growing recognition of the crucial water-energy nexus, and although electric utilities increasingly recognize conservation opportunities within the water sector, the industry presents challenges due to its economics, culture and regulatory oversight. Since 2010, Bonneville Power Administration's (BPA) Energy Smart Industrial (ESI) program has used experienced water-industry engineers (sector specialists) to lead conservation efforts with industry stakeholders. This approach has resulted in increased engagements, projects, and kilowatt-hour energy savings achieved in the region.

This paper discusses the value of the water/wastewater (W/WW) sector specialist, conservation strategies, and results achieved for systems of varying sizes. By acting as liaison between the electric utility and the water industry, the W/WW sector specialist provides a context for energy conservation to water system owners and operators, and helps utility staff capitalize on opportunities for their water system customers. ESI's sector specialist approach has been successful, with more than 100 engagements involving over 70 water systems.

What Qualifies a W/WW Sector Specialist?

A W/WW sector specialist is an industry professional with experience in design, construction and operations, who also has deep energy efficiency (EE) expertise. In general, the W/WW sector is friendly, cooperative and non-competitive, but is also somewhat insular and slow to change. To initiate meaningful conversations about change in this environment, the W/WW sector specialist must prove credibility by demonstrating an understanding of operators' daily tasks and priorities, the regulatory environment, and engineering consultants' budget realities. A W/WW sector specialist must be an effective communicator who can 'bridge the gap' between utility energy conservation staff and W/WW industry players, by:

- Explaining to W/WW operators, managers, consultants and regulators how conservation can drive efficiency without jeopardizing regulatory compliance,
- Educating W/WW industry stakeholders about EE from basic terminology to the complexities of statistical energy modeling, and
- Debunking myths about the negative consequences of EE.

The W/WW sector specialist must be effective at helping electric utility EE staff understand W/WW industry infrastructure:

- How processes may, or may not, be modified given the regulatory framework,
- How to estimate energy savings and costs for public infrastructure projects, and
- How to manage measurement and verification (M&V) protocols for both capital and O&M changes given seasonal variations and expected growth.

From a technical standpoint, the specialist views infrastructure design and operations through a lens that is different from anyone else involved in a project. The specialist brings ideas from past experience with other plants and systems and from his or her broad-based knowledge of current practices in the industry. For capital projects, this might mean information about new or modified processes and equipment. For behavioral programs, it's about sharing best practices from inside and outside the industry.

Finally, the W/WW sector specialist employs equal parts patience and tenacity. Successful projects can require multiple engagements over months, and often years, before EE is accomplished.

The ESI Program has included a W/WW-focused sector specialist to increase energy savings in the Pacific Northwest for five years. The program now employs two half-time specialists who split BPA's large service territory roughly into west and east regions. See Figure 1.

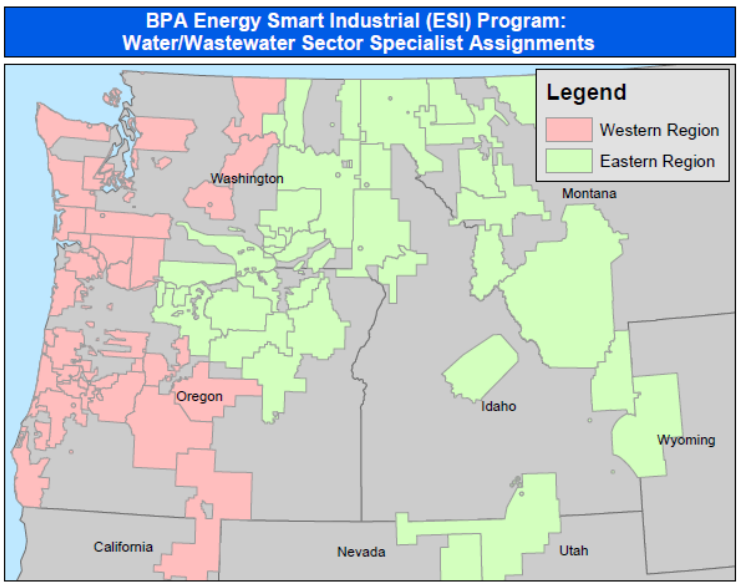


Figure 1. W/WW Sector Specialist Service Territory

Why is a W/WW Sector Specialist Necessary?

BPA and local utilities have lost opportunities in the W/WW sector. Each year, state and local agencies in BPA's service territory spend hundreds of millions of dollars on improvements to the W/WW infrastructure. For example, in 2010-11, Washington State funded $118 million in wastewater improvements through the Clean Water State Revolving Fund program (WA ECY). http://www.ecy.wa.gov/programs/wq/funding/Projects/ProjectsMain.html. In 2013, Washington's Drinking Water State Revolving Fund awarded nearly $185 million to 70 drinking water systems and projects (WA DOH 2013). http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/WaterSystemAssistance/DrinkingWaterStateRevolvingFundDWSRF/DWSRF2014Update. Generally, these projects have not included energy conservation programs and missed EE opportunities. Based on the ESI program's experience the main reasons for not considering EE during water system improvements are:

W/WW systems may be ubiquitous, but they are also specialized and complex. As shown in Table 1 below, there are hundreds of water systems in every state. Dozens of processes may be involved in wastewater and water treatment, as well as many different collection, conveyance, and distribution methods. In most wastewater systems, complex biological processes are essential to effective treatment. Although most plants have similar equipment, the W/WW sector specialist understands the particulars related to processes, regulatory constraints, and staff concerns, so that operators and management stay engaged and interested when EE measures are identified. Without a deep understanding of W/WW systems, the chances for identifying opportunities, having meaningful conversations, and completing successful projects is low.

Table 1. Public Water System Counts in BPA Region Source: EPA "Envirofacts" Safe Drinking Water Information System, http://www.epa.gov/enviro/facts/sdwis/search.html

State	Number of Community Water Systems (all sizes)	Systems Serving Over 500 People
Idaho	738	154
Montana	721	137
Oregon	880	264

The W/WW industry is ultra-conservative in capital expenses and O&M practices. Other concerns prevail for W/WW stakeholders. For example, engineering firms prioritize capacity, redundancy and reliability in their designs before considering capital costs and flexibility. Although attention to EE is increasing, it doesn't dominate the conversation. EE features are routinely removed from designs, saving up-front capital but sacrificing long-term energy cost. New O&M practices may be met with initial skepticism because operators are not inclined to change current practices unless they trust the person making the suggestion. A W/WW sector specialist helps maintain a focus on efficiency and has the credibility to combat the conservative nature of designers and operators.

The fund-design-bid-build cycle is lengthy. Due to complex funding and the use of public dollars, most public infrastructure development requires three to five years to move from a go-ahead to actual operation. Large projects, such as the Chambers Creek Wastewater Treatment Plant (WWTP) upgrade (figure 2) can take nearly a decade. Even small projects, such as lighting retrofits, can take a year or more to budget. Funding cycles, regulatory reviews, equipment lead times and the public contracting process all create delays. The W/WW sector specialist provides ESI program utilities and their end users with continuous support and technical expertise helping to drive project development forward from funding to fruition.

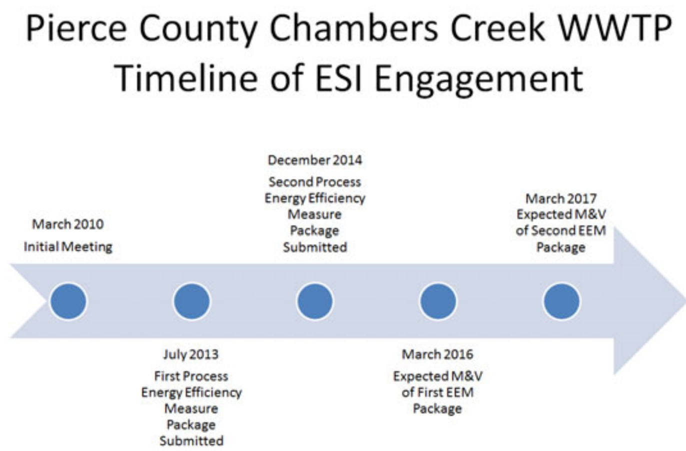


Figure 2. Sample timeline for a regional wastewater treatment plant upgrade.

Historically, the W/WW industry has not prioritized EE. Systems for the supply and distribution of drinking water, and the collection, treatment and discharge of wastewater were developed to protect public health and the environment. The operators of these facilities are highly trained, but they have not historically paid much attention to kilowatt-hours. In fact, most operators have never seen their plant's electric bill, nor have they been given a reason to care about how much electricity their facility uses.

How do Sector Specialists Engage the W/WW Industry?

Sector Specialists promote energy efficiency through their work with industrial end users, consultants, vendors and regulators in the W/WW industry.

End Users: This group includes plant operators, managers, public works directors for municipal systems, and system managers and operators for industrial treatment facilities. The W/WW sector specialist provides program outreach via conferences, tradeshows and operator short-schools; no-cost scoping audits at municipal and industrial facilities; workshops and training for Continuing Education Units (CEUs) for licensed operators and managers; technical assistance for longer-term O&M savings programs; and technical studies and analysis for capital projects.

Consulting Engineering Community: Consulting engineers are a key stakeholder, and almost all infrastructure improvements use design consultants. Consultants include local and national firms providing forecasting, design, and construction administration for infrastructure projects. The W/WW sector specialist provides outreach via conferences, tradeshows, and direct office visits; design review for EE opportunities; and invitations to engineering firms for program workshop and O&M cohort training participation.

Industry Vendors: Industry vendors include the 10-15 manufacturers' representatives that sell nearly all the equipment found in a water or wastewater system in a region. The W/WW sector specialist provides outreach via tradeshows and direct visits; assistance with incentive calculations for proposals; and development of "trade allies" who bring projects to the conservation program.

Regulatory Agencies: The regulatory agencies are the state departments of environmental quality, health, ecology or natural resources that regulate and monitor the design and operation of W/WW systems, and provide funding for upgrades and new construction. The W/WW sector specialist provides outreach via conferences, tradeshows, and direct office visits; design review for EE opportunities; invitations to participate in program workshops and O&M cohort trainings; classes for CEU credit for regulatory staff; and collaboration with agency technical staff for operator training programs.

What Makes a Sector Specialist Program Effective?

Rather than working only on specific projects, an effective W/WW sector specialist position should represent the conservation program to the industry. W/WW sector specialists are more valuable as they become known in the region.

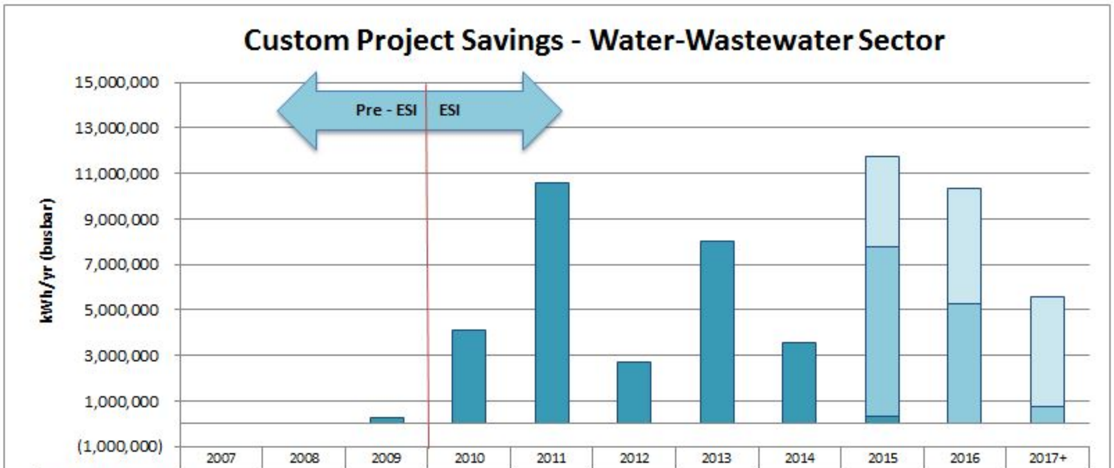
For most utility conservation programs, this approach to funding technical assistance is radically different from the traditional "one project, one report." Because of the focus on outreach and long-term engagement, the short-term cost effectiveness of using a W/WW sector specialist may be lower than the traditional approach when measured in cost per kWh saved. However, over time, the number of projects entering the program pipeline, the number of new customers exposed to the conservation program, and the awareness and momentum created within the operations community all improve the cost effectiveness. From a customer service perspective, sector specialists often work in rural and remote areas on small systems that would otherwise have little, if any, interaction with a conservation program

Working on behalf of a conservation program the specialist functions as an informational clearinghouse for the W/WW industry. Through regular participation and presentations at conferences, operator section meetings, and workshops, the specialist establishes a reputation as the "go to" person for energy incentive questions. A conservation program builds multiple touch points through a specialist's scoping audits, walk-throughs, and attendance at design and planning meetings. This increases the likelihood that project requests will be triggered at the right time, rather than too early or too late.

Summarizing ESI's W/WW Sector Specialist Success

ESI's increased focus on the W/WW sector has yielded significant gains in energy savings and created a robust pipeline of future projects. Figure 3 summarizes the impact. Energy savings achieved in the W/WW sector within the program grew from approximately 250,000 kWh in FY2009 to well over 29 million kWh of booked savings to date, representing 92 completed custom (new construction or retrofit) projects. Twenty-one W/WW custom projects with 3.5 million kWh in savings were completed in FY2014.

In addition to traditional capital projects summarized in Figure 3, seven W/WW facilities are currently participating in longer term behavioral-based energy management projects, with a combined 0.65 million kWh booked within the program to date for these facilities from operational improvements. One example is presented in the first case study below.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017+
Prospective Projects Est Savings (kWh/yr)	-	-	-	-			-	-	3,941,615	5,111,454	4,812,677
In-Progress Projects Est Savings (kWh/yr)	-	-	-	-	-	-	-	-	7,449,991	5,252,937	776,479
Completed Projects Savings (kWh/yr)	-	-	248,112	4,131,494	10,583,806	2,686,117	8,002,326	3,540,924	322,124	-	-
Total Savings	-	-	248,112	4,131,494	10,583,806	2,686,117	8,002,326	3,540,924	11,713,730	10,364,391	5,589,156

Figure 3. Custom Project Savings in the W/WW sector. More than 500 municipal W/WW facilities are located in the BPA service area. Completed projects: 92 to date (21 in FY2014). Current in-progress projects: 31. Current prospective projects: 40. Outreach to 168 facilities representing 74 utilities. ESI's two sector specialists have participated in over 800 W/WW-focused meetings, conferences, and site visits since the program began, including nearly 130 in FY2014 alone.

Three case studies are presented below. The case studies illustrate the value of the W/WW sector specialist in changing practices around managing energy, improving O&M, and tailoring programmatic approaches.

Case Study: W/WW Sector Specialist as Long-term Energy Management Partner

The City of Vancouver is the fourth largest provider of drinking water in the state of Washington, delivering 9.4 billion gallons to over 230,000 people in 2013. In June 2010, the City's Water Division enrolled in ESI's High Performance Energy Management (HPEM) program with the support of sponsoring utility, Clark Public Utilities.

HPEM brings the principles and practices of continuous improvement to industrial energy management similar to the safety, environmental, and quality initiatives that many facilities have successfully implemented for years. During the program's first year, City staff attended 12 HPEM workshops to learn and implement energy management projects and best practices.

As part of HPEM, program coaches, with assistance from sector specialists, developed an energy model that predicts energy use based on the magnitude of water production over a corresponding time period. The approach is a top-down, multi-variable regression model at the meter level, as described by the International Performance Measurement and Verification Protocol (IPMVP). Overall energy savings is tracked by ESI's Energy Performance Tracking (EPT) lead, using a cumulative sum of differences (CUSUM) methodology that quantifies the aggregate difference between predicted energy use and actual energy use for a defined time period.

Sector specialists on the HPEM team provided critical support in the program's first years. Midway through the first year, the City had attended the required workshops, formed an energy team, and set an energy goal, but they had yet to identify a single energy-related O&M measure that operators could investigate and implement.

Recognizing the need for specific, technical assistance to develop actionable ideas, the sector specialist led a half-day brainstorming session with the energy team and senior operations staff. During this focused, facilitated event, the energy team generated over a dozen opportunities for investigation. Some, such as identifying the most efficient pump in each lineup, could be done by staff immediately. Other ideas, such as reducing fan speeds on air-stripper towers, required initial analysis from an outside engineer. The biggest impact of the meeting, however, from the HPEM staff's opinion, was the sense amongst the Vancouver team that they really could reduce their energy footprint.

At the brainstorming meeting, one of the bigger opportunities identified involved the implementation of energy modeling within the City's existing hydraulic model. Almost all municipal water systems use hydraulic models. Typically, these software-based models are used during the design and planning phase to determine where new water sources, reservoirs, boosters and other infrastructure should be located to ensure that customers receive the required quality and quantity of water. Hydraulic models are capable of quantifying the amount of energy used by pumping stations at various production levels, but this capability is rarely used. In a co-funded effort, the City's consultant updated the model with the energy metrics for each pump and then provided instructions to the City staff on running scenarios and maintaining the model.

City staff spent several months of follow-on work calibrating and correcting the model. Once the model was calibrated, multiple pumping scenarios were run for typical production scenarios during winter, shoulder seasons, and peak summer. The model revealed that a 17 percent reduction in energy intensity was possible—without capital improvements! The impact of practical realities such as manpower, geographical location, water rights, and water quality issues have prevented the City from running continuously at the most efficient modeled scenario. However, the City moves toward the modeled scenario whenever possible and now has the tools and knowledge to actively and intentionally work to deliver water at the lowest cost possible.

The City recently completed year four of the five-year HPEM program, and between O&M improvements and capital projects (partial list in Table 2), City staff has reduced energy intensity by 13.3 percent. This reduction represents electrical savings across all pumping stations throughout Vancouver's water system.

Table 2: City of Vancouver ongoing energy efficiency measures

Activity/project description	Project type
Year 1	
Employee engagement event (Energy Scan)	O&M
Water station (WS) #4 pump variable frequency drives (VFDs)	Capital
Air stripper tower fan study	O&M
System hydraulic model – initiated model evaluation and inputs for energy	O&M

High-efficiency motor purchasing policy	O&M
Year 2	
WS #4 VFDs on booster #1, #2 and #3; WS #3, Well #3 motor upgrade	O&M/Capital
WS #1 sheave change on five stripper fans to reduce air flow	O&M
Lincoln Heights – dropped pressure in zone to slow pump down	O&M
WS #3, pumps #2 and #3 reduced pump impeller diameter to lower total head	O&M/Capital
System hydraulic model – completed model inputs for energy	O&M
Year 3	
Employee update and awareness event	Awareness
Modeling scenario test #1	O&M
Staging of stripping towers at station 1; WS #4 stripper fan adjustments	O&M
SCADA system energy metrics; flow meters at booster stations	Capital
Year 4	O&M
Modeling scenario testing (ongoing)	O&M
WS #4 stripper fan adjustments, Flow meter install continues	Capital
Replacement of damaged booster pump impellers	O&M

Energy performance is illustrated in a CUSUM graph, which is periodically shared with City of Vancouver employees, along with EE project plans and results. Figure 4 below shows the City's CUSUM graph showing savings through year four. Total site energy savings to date is 2,923,903 kWh. (Note: In the HPEM program, the CUSUM resets to zero at the start of each program year, creating the regular "sawtooth" spikes in the chart.)

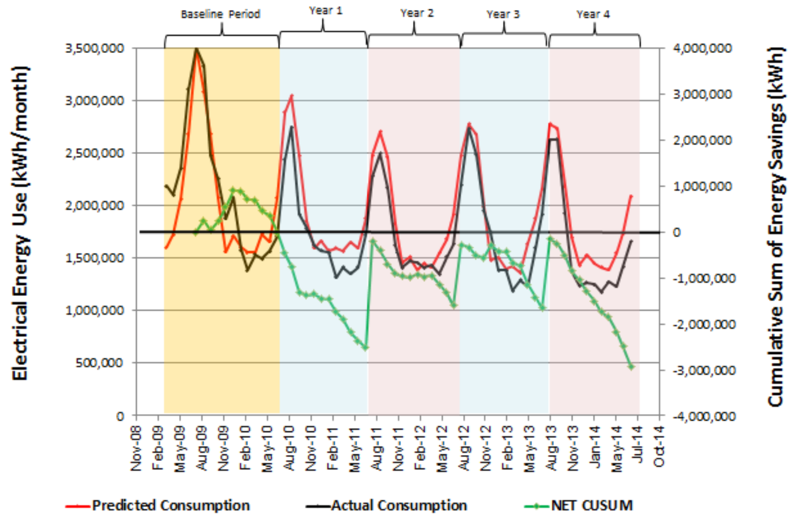


Figure 4: City of Vancouver energy tracking graph (baseline, years 1-4)

The City has also achieved impressive incremental savings throughout its four-year involvement in HPEM. See Figure 5 for additional detail.

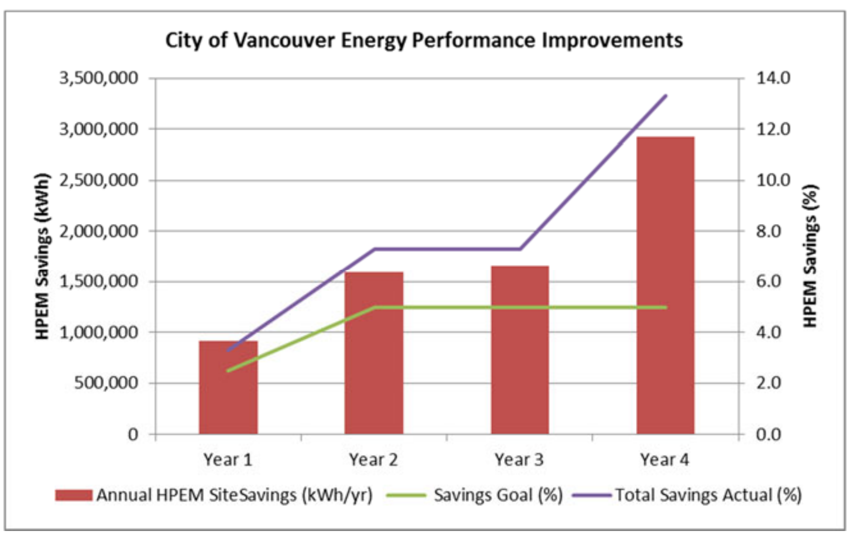


Figure 5. City of Vancouver energy performance improvements

Since the initial brainstorming session, the W/WW sector specialist has maintained an informal, ongoing relationship with the City's energy champion. Ideas are discussed along with referrals and assistance through email and phone calls. The W/WW sector specialist and the energy champion meet occasionally and informally during conferences as well as when the specialist is traveling in the area. This consistent support is critical and easily accomplished because, as stated above, the specialist is not funded by or attached to a specific project budget, but rather as a representative for the program across sectors.

Case Study: W/WW Sector Specialist as Technical Assistant

The City of Richland, Washington's municipal water system supplies water to approximately 49,000 customers with 22,700 connections. The City's water system functions within 12 pressure zones served by two major production facilities, the Water Treatment Plant (WTP) and the Well Field. The WTP treats water drawn directly from the Columbia River. The Well Field also uses Columbia River water that is then discharged to infiltration basins. Shallow well pumps pull water from below the infiltration basins. This water is disinfected using ultraviolet light before it enters the distribution network. Fifteen reservoirs and two clearwells provide water storage for the system. Based on plant operations and electrical bill data, in 2011 the City's system produced 5.2 billion gallons of water and used 8,274,564 kWh of energy at its pumping facilities, for an annual energy metric of 1,590 kWh/million gallons produced.

Prior to engagement with the ESI team, the City had received a BPA-funded optimization study from its local consulting firm. After compiling field-test efficiency data for the 46 pumps in the system, the study identified two energy efficiency measures to reduce system energy use: improved pump sequencing and the potential for pressure reduction. The study estimated roughly 800,000 kWh in annual savings based on the efficiency measures identified.

As a result of the study, the City was approached about participating in ESI's Track and Tune program. Sponsored in conjunction with local energy provider Richland Energy Services, Track and Tune offers participants incentives based on energy savings from retro-commissioning actions to optimize existing equipment and operations. Similar to HPEM, a top-down system model is used to track resulting savings.

In this case, the W/WW sector specialist was involved from the beginning of the engagement. First, the specialist helped the other program staff understand the water system components and the source of the optimization study's savings. This allowed the statistical modeling and data gathering to proceed without delay.

Second, the specialist lead a robust vetting discussion amongst the City's water leads, the consulting engineers, and the ESI Program staff. The discussion was aimed at thoroughly understanding and itemizing the operational, permitting, water quality, and regulatory constraints under which the City operates, and understanding how they would impact the City's efforts to save energy through sequencing and pressure optimization. Once operational constraints were fully understood, the ESI Program funded a consulting firm's re-evaluation of the savings potential. The savings estimate was reduced to just over 400,000 kWh annually. Thus, the W/WW sector specialist's work helped both the City and the electrical utility move forward with realistic expectations for energy savings.

During the course of the engagement, the W/WW sector specialist identified the City of Richland water system as a potential candidate for a pilot demand response (DR) demonstration also sponsored by BPA. The pilot program looks to explore the interaction between EE efforts and DR events. Through the relationships and system knowledge gained during the Track and Tune program, the W/WW sector specialist has played an integral role in the pilot. This includes designing curtailment strategies that respect the water system's capabilities as well as calculating expected reductions in demand during the curtailment period.

Case Study: Leak Detection and Repair Saves Water AND Energy

W/WW sector specialists work closely with municipalities and homeowner associations, often in rural areas, to identify and incentivize many types of efficiency projects. One somewhat novel project type involves water line and reservoir leaks. Nearly every water system leaks, but the lump-sum costs of locating and repairing underground leaks are high enough that system operators will simply "pump more" rather than make the repairs. Often, the operators do not have the resources to calculate what the lost water is costing them every month. Again, the sector specialist helps make the connection between water and energy.

Recognizing that a leak not only wastes water, but also wastes the energy used to pump and treat the water, the ESI Program considers detection and repair of underground water pipes to be a qualified EE measure. Any water system serving the public, including those owned by home-owners or neighborhood associations, is eligible. However, smaller and rural systems have taken the most advantage of the program due to the relatively high costs of locating and repairing underground leaks, which are roughly the same regardless of the size of the system.

The W/WW sector specialist starts by analyzing the energy and water production in the system. Monthly energy consumption, corrected for the meter reading date, is compared with monthly water production, and the system's average energy metric is determined in kilowatt-hours per million gallons (kWh/MG) pumped. (See Figure 7.) In the service region's northern climate, the energy metric from July to September is energy associated only with pumping. The other months include some heat load.

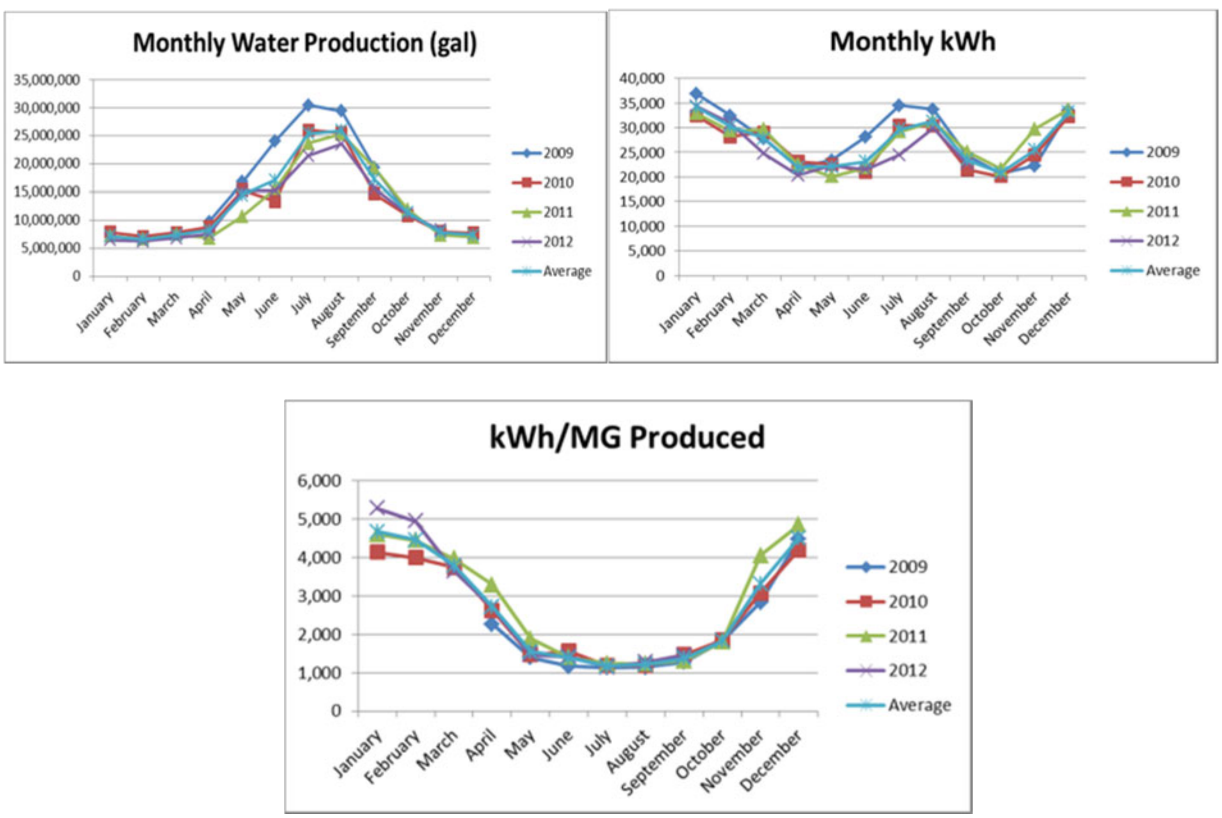


Figure 7: Combining monthly water and energy data creates a chart of kWh/MG Produced.

Once the pumping metric is identified, the total energy associated with water production and the total energy associated with system leaks can be determined. This forms the basis for the incentives that help pay for the leak detection and repair projects. Additionally, the energy calculations can show how much energy is being used for something other than pumping water. In the example below, roughly one-third of the total energy consumed was for winter heating (Table 3, line f), which was unexpected and helped focus some productive attention to an item that had been assumed to be a negligible component of the overall energy use.

Table 3: Example leak detection and repair project economics on a system with ~20% leak rate.

SUMMARY OF PROJECT ECONOMICS BASED ON 2009-2012 DATA			
ITEM	Amount	Unit	Description
a	156,005,667	gal	Annual Water Production (from report)
b	31,257,351	gal	Annual Unallocated Water (from report)
c	1,339	kWh/MG	Summertime Unit Pumping Energy (calculated)
d	323,127	kWh	Annual Overall Energy Consumption (from billing)
e	208,860	kWh	Annual Pumping Energy (= a x c)
f	114,267	kWh	Annual Heating Energy (= d - e)
g	41,847	kWh	Annual Energy Associated withUnallocated Water (= b x c)
h	$ 0.25		Incentive Rate per kWh
i	$ 10,462		Max Incentive (assumes 100% leak repair)
j	$ 0.045		Blended Energy Rate ($ / kWh)
k	$ 1,883		Annual Energy Cost Reduction from 100% Repairs

Conclusion

Deploying sector specialists experienced in the W/WW industry has proven to be an effective way for BPA's electrical utilities to achieve lasting EE improvements in both large and small water systems. The W/WW sector specialists are uniquely positioned to communicate the benefits of EE to *all* industry stakeholders, whether the specialist is involved in a specific project or not. This kind of proactive, agile communication ultimately helps the industry move forward toward a more sustainable future. W/WW specialists help electric utilities and their partners and stakeholders improve their relationships while achieving savings in an industry that is ubiquitous, growing, and cannot be outsourced or moved offshore. In the three years *prior* to sector specialist implementation, total W/WW savings were less than 250,000 kWh. In the past three full years, W/WW savings totaled 14.2 million kWh (Figure 3). As this paper indicates, the W/WW sector specialists are often a critical link between conservation programs and the water-system staff, because they spark support for behavior-based programs, set realistic expectations and provide technical assistance when starting a project. W/WW sector specialists are instrumental in proving to the water industry that saving water can result in saving energy too.