# An Update on the Implementation of ISO 50001 and the Superior Energy Performance Program at Water and Wastewater Facilities

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ABSTRACT

Energy can account for over 10% of a local government's annual operating budget. The water and wastewater treatment sector consumes a significant portion of this energy. Nationally, the energy consumed by water and wastewater utilities account for 35% of typical US municipal energy budgets. Superior Energy Performance (SEP) is a US DOE program that recognizes excellence in energy management and continual energy performance improvement. Built on a foundation of third party certification to the ISO 50001-energy management system standard, with the addition of energy performance improvement requirements, SEP provides organizations the focus and framework to achieve significant and lasting energy savings. An ISO 50001 energy management system elevates and integrates energy into management structure of an organization, as has happened for safety and quality and is now happening with asset management; connecting staff from the boardroom to the operations floor, bringing organizational change to the corporate culture.

Proven within the manufacturing component of the industrial sector, SEP leads to deeper, sustained savings with advanced tools and credible, third party verification by an ANSI-ANAB accredited entity. Over 28 industrial facilities are currently certified in the SEP program, finding value in the robust, data driven energy performance improvement result that the SEP program delivers. Analysis from the industrial sector shows a highly attractive return on investment, significant energy and energy cost savings, and many non-energy benefits.

The US DOE is bringing the benefits of SEP to the water and wastewater treatment sector through a pilot program involving seven water and wastewater treatment agencies. These agencies are participating in a co-learning cohort that is educating them on ISO 50001 and SEP while providing a forum for information and best practice sharing. In addition, by working with this sector, SEP will develop the relevant metrics and protocols for a sector with which it is less familiar. The expectation is that SEP can be configured to yield value in a more specific manner to this sector. The process of gaining previously unknown, sector-specific information can serve as a model for SEP program staff as they extend into different industrial/economic sectors. Presented are findings to date from the cohort members' experience and lessons learned that could be applied to other water and wastewater facilities looking to implement ISO 50001 and SEP.

## INTRODUCTION TO THE WATER AND WASTEWATER SECTOR

In the U.S., energy consumption in the water and wastewater treatment sector is between 75 and 100 billion kWh each year (approximately 3-4% of U.S. energy use, valued at approximately $4.7B), but represents 30–40% of total energy consumed by many U.S. municipalities [1]. As of 2010, there were more than 51,000 community water facilities that treat and deliver potable water, and approximately 15,000 wastewater treatment facilities, including 6,000 publicly owned treatment facilities in the U.S. alone. Together, these water and wastewater facilities serve approximately 298 million people in the U.S [2]. These facilities operate industrial-scale pumps, aeration fans, compressed air systems, motors, and

other equipment 24 hours a day, 7 days a week, making them some of the largest consumers of energy in a community.

Many wastewater treatment facilities focus on reducing energy costs by capturing the energy in wastewater by burning biogas from anaerobic digesters in a combined heat and power system. This allows wastewater facilities to produce some or all of their own electricity and space heating, turning them into "net zero" consumers of energy [1]. While this process may reduce utility bills, the underlying energy efficiency of the facility may not be improved upon. To this end many facilities improve energy efficiency of select equipment as it needs to be replaced on a project-by-project basis.

Water and wastewater treatment facilities recognize energy efficiency as an essential strategy to continue meeting their critical mission of delivering clean drinking water to the community and returning clean water to the environment [1]. However, compared with the manufacturing component of the industrial sector, the water and wastewater treatment sector has been underserved by many energy efficiency programs. As a result, it is anticipated that the energy savings potential in the water and wastewater treatment sector could be significant. According to the U.S. Environmental Protection Agency (U.S. EPA), a 10% reduction in energy consumption in the U.S. water and wastewater treatment sector is possible without any capital upgrades. Based on an average cost in the U.S. of $0.075/kWh, a 10% reduction in water and wastewater treatment agency energy consumption would yield aggregate energy cost savings of between $562 million and $1 billion/year.

Experience has shown that energy performance gains from various one-off energy efficiency projects do not deliver sustained energy performance improvements if they are not monitored and adjusted in a continuous manner [3]. A facility wide approach, commitment from top management, and focus on operational control[1] is needed to ensure continual energy performance improvement. The economic and environmental costs associated with water and wastewater facility energy consumption can be reduced by continually improving the facilities' energy performance. This paper details on-going efforts by the U.S. DOE to understand the potential impact of facility wide management of energy through a pilot program of multiple water and wastewater treatment facilities in the ISO 50001 based Superior Energy Performance (SEP) program.

## ISO 50001 – ENERGY MANAGEMENT SYSTEM STANDARD

The U.S. DOE provided a strong leadership role in the development of *ISO 50001 – Energy management systems* – Requirements with guidance for use, an international standard that provides a framework for the implementation of an energy management system (EnMS) for the purpose of continuously improving energy performance [4]. This leadership role was taken as the U.S. DOE recognized the need to move beyond the project-based approach to energy efficiency and to a data driven continual improvement model.

ISO 50001 provides guidance to industrial and commercial facilities for integrating energy efficiency into their daily management practices. ISO 50001 introduces a disciplined approach to energy, previously missing in most organizations that are analogous to the approaches that industry already applies to safety, product quality, environmental performance and asset management. For industrial facilities this includes fine-tuning production processes and improving the energy efficiency of industrial systems. The standard gives organizations management strategies that can be

[1] Establishing operational and maintenance controls helps to ensure that an organization's critical equipment, systems, processes and facilities are operated and maintained to achieve optimal output and efficient performance. In short, operational control is a combination of procedures and work instructions, physical controls, or the use of licensed or other qualified personnel that prevent backsliding of energy efficiency gains. Determining operational and maintenance controls involves identifying and planning activities to ensure that critical factors affecting energy performance are known, used, and communicated to responsible personnel.

used to reduce energy consumption, carbon intensity, and costs, and to improve environmental performance. Organizations implementing ISO 50001 conduct an energy review, develop an energy policy, establish objectives, targets and action plans related to its significant energy uses, and engage top management in decision making specifically regarding energy efficiency.

The ISO 50001 standard is flexible and can be adopted at various organizational levels, from a single building to several installations across an entire region. ISO 50001 can be implemented solely or be used in conjunction with other ISO management system standard such as ISO 14001 – Environmental Management, ISO 9001 – Quality Management, and ISO 55000 – Asset Management. ISO 50001 is complementary yet different from other ISO management system standards as it has a focused structure to manage energy performance with a data driven emphasis. Globally there have been more than 3,500 ISO 50001certifications encompassing over 11,000 sites.[2]

ISO 50001 – Energy Management Systems Standard codifies a methodology for facilitating continuous energy performance improvement in an organization by mandating energy performance planning, including developing a facility baseline, analyzing energy flows, and selecting appropriate tracking metrics for evaluating energy performance. The ISO 50001 standard was published in June 2011 and has been adopted by the U.S. and other many countries.

A core concept of ISO 50001 is an Energy Management System (EnMS). The EnMS is based on the concept of determining significant energy uses, developing actions plans to improve the performance of those uses, and supporting these ongoing improvements with work instructions, training, policies and procedures, monitoring and checking. It is a technology-agnostic approach that seeks to provide context for effective decision-making on energy performance improvements, while providing a platform for enhanced knowledge sharing on energy efficient practices. The application of advanced controls and monitoring devices may enhance the impact of ISO 50001 by providing decision makers more detailed data, but is not a requirement.

ISO 50001 calls for commitment of top-level management, thus making energy performance improvement a shared goal for the entire organization while moving beyond single projects to a more holistic organizational approach. It also reduces dependence upon an energy champion to ensure continuous energy performance improvement, by integrating energy management into daily decision process across the organization. This system integration helps ensure continual energy performance maintenance and/or improvement, even as trained personnel are transferred between assignments and individual energy improvement projects are completed.

ISO 50001 is data driven- making the best use of available data to improve overall energy performance without specifying improvement targets or how energy performance improvements are to be made.

This paper details a pilot program the U.S. Department of Energy has undertaken to implement ISO 50001 through the Superior Energy Performance program at seven water and wastewater municipalities. The approach to this pilot project and the anticipated results based upon experiences in the industrial sector are presented.

## BACKGROUND

Saving energy through energy efficiency improvements can cost less than generating, transmitting, and distributing energy from power plants, and provides multiple economic and environmental benefits. Energy savings can reduce operating costs for local governments, freeing up resources for additional investments in energy efficiency and other priorities [1]. Due to these factors and a growing interest in sustainability the water and wastewater treatment sector is showing stronger interest in improving energy efficiency in

[2] Analysis of ISO 50001 certifications based upon data from (DIN 2015)

their operations. Up until recently, implementation of energy efficiency improvements within the water and wastewater treatment sector has been uneven. Some agencies have done little to nothing to improve energy performance, while others have spent significant amounts if staff time and money to improve energy performance with a few wastewater treatment agencies achieving near net-zero energy consumption by generating and re-using biogas effectively.

Another driver of energy efficiency in this sector are higher energy costs, the result of installing energy intensive equipment required to meet more stringent water quality regulations [5]. Two such regulations, the Interim Enhanced Surface Water Treatment Rule and the Long-Term Enhanced Surface Water Treatment Rule, aim to reduce the presence of pathogens and address the treatment of saline water. Energy intensive advanced water treatment technologies used to meet these rules include ultra-violet (UV) disinfection, ozonation, micro-filtration/ultrafiltration and nano-filtration/reverse osmosis. Depending on the technology used and the design flow, these new water treatment technologies can increase energy costs of treating surface water between 10% and 830% for the largest water utilities (100 MGD or more).

Two important differences exist between the water and wastewater treatment sector and mainstream manufacturing that can inhibit energy management. One of these differences is that the water and wastewater treatment sector has some important regulatory parameters that can constrain their options to improve energy efficiency. Within the water and wastewater treatment sector reliability and quality of both treated water and wastewater cause important energy requirements for these agencies' processes. Because these agencies can be subjected to fines for water quality violations and exceeding permit limits in wastewater treatment agencies, the consequence is that they take precedence over measures to use energy efficiently [5]. In addition, new water quality regulations portend more energy intensive processes to comply with more stringent water quality standards. This is similar to the tension in manufacturing between production (output and product quality) and energy efficiency. Historically, energy efficiency has been subordinated to the need to meet desired output and quality levels. As has been seen with the manufacturers that have achieved SEP certification, improvements in energy management and productivity do not have to be mutually exclusive. This experience from mainstream manufacturing could inform how energy efficiency is adopted within the water and wastewater treatment sector.

Another important difference is that water and wastewater treatment agencies are more dependent on engineering and infrastructure consulting firms to maintain equipment and ensure compliance with water quality mandates [6, 7]. These engineering and infrastructure service providers offer a variety of services including facility and process design, leak detection and management, tunnel and pipeline rehabilitation, equipment optimization (with a focus on reliability) and maintenance services. In many cases, staffs of these engineering consulting firms are embedded within the water and wastewater treatment plants of the agencies they serve. As interest in sustainability and energy efficiency has grown, many of these engineering and infrastructure firms have begun consulting on energy efficiency and renewable energy resources to fully address their clients' needs. Some research indicates that there can be wide divergence in the methodologies used by the infrastructure and energy services community to facilitate energy efficiency in water and wastewater treatment agencies. In particular, some engineering and infrastructure consulting organizations that serve the water and wastewater treatment sector have proposed sound energy management approaches and energy efficiency implementation that is consistent with best practices within manufacturing and industrial-scale energy efficiency [8]. In some cases however, there is a tendency for some of these firms to assume that infrastructure expansion and replacement of energy-using equipment as a first step is part of a sound approach towards energy management [5].

## FEDERAL ENERGY EFICIENCY OFFERINGS FOR THE WATER AND WASTEWATER SECTOR

The U.S. federal government operates a number of programs to encourage improvement in energy performance at water and wastewater facilities. A few of these programs are highlighted before the current pilot project is detailed.

### U.S. Environmental Protection Agency And Energy Star

The U.S. EPA's Office of Water and Wastewater Treatment has a long history of supporting water and wastewater treatment facilities to improve water and energy efficiency. The U.S. EPA has produced technical literature to assist facilities as they strive for improved energy performance [1, 9-12]. In addition to project-by-project recommendation, the U.S. EPA recommends implementation of an energy management system based upon Edward Deming's Plan-Do-Check-Act cycle. This is the same PDCA cycle on which ISO 50001 is built. The U.S. EPA has developed tools that can help with the planning process of energy efficiency, including the Energy Use Assessment Tool [13]. Additionally, the U.S. EPA also offers Portfolio Manager, a facility energy-benchmarking tool that has been adapted for wastewater treatment facilities [14].

### Better Plants

The U.S. DOE's Better Buildings, Better Plants program is a private public partnership in which leading manufactures and industrial-scale energy-using organizations demonstrate their commitment to improving energy performance by signing a voluntary pledge to reduce their energy intensity by 25% over a ten year period. Better Plants Partners benefit from DOE technical support, national recognition and are able to implement cost-effective energy efficiency improvements that save energy and improve competitiveness. Collectively, these companies are showing that good energy management practices are good for business and good for the environment.

The Better Plants program consists of more than 180 industrial organizations (including 19 water/wastewater treatment agencies), representing about 2,600 facilities and 12% of the total U.S. manufacturing energy footprint. Five of the seven water and wastewater treatment facilities participating in the Superior Energy Performance program demonstration discussed in this paper are Better Plants Partners.

### Superior Energy Performance

Building on the foundation of ISO 50001, the U.S. DOE developed the Superior Energy Performance (SEP) program in collaboration with industry and other stakeholders. The SEP program requires participating industrial facilities to achieve ANAB third-party verification of its ISO 50001 EnMS and meet pre-established energy performance improvement targets, currently at least 5% over 3 years [15]. The SEP certification program provides facilities a transparent, globally accepted system for verifying improvements in energy performance and management practices.

As of March 2016, 36 facilities representing a diverse range of sectors, sizes, and locations are certified to SEP, with facility-wide energy performance improvements over a three-year achievement period ranging from 5% to more than 25% [16]. Many of these improvements are being achieved through refinements in operations requiring little capital investment, even in facilities that had previously undertaken energy efficiency projects. Further, by establishing an energy management system (EnMS), these companies are ensuring that their performance gains will be sustained. A pilot program in commercial buildings is now underway [17].

SEP provides a structured approach to help organize and focus facility staff energy management efforts, resulting in dramatic increases in energy savings percentages. SEP is credited with increasing average quarterly energy saving percentages an additional 11.1% above the business-as-usual (BAU) case of 3.2% during the second year after beginning SEP participation. Similarly, quarterly average energy cost savings of 12.0% were calculated for the second

year after the beginning of SEP participation, of which 10.0% is attributable to SEP [18].

A study of the costs and benefits of certifying to the SEP program demonstrated the cost-effectiveness of SEP. On average the cost incurred by facilities to develop, implement, and certify to ISO 50001 and SEP for the first time was found to be $77K when excluding internal labor costs and in total $180,000. Facilities with baseline source energy spend greater than $2M can expect a less than 1.5 year marginal payback for SEP participation [18].

## SEP™ WATER AND WASTEWATER SECTOR PILOT PROJECT

### Introduction to the Pilot Project

The U.S. DOE is partnering with a group of leading water and wastewater treatment agencies, including five Better Plants partners, to demonstrate the energy and efficiency benefits of implementing the Superior Energy Performance® (SEP™) program through the SEP Water and Wastewater Pilot Project.

The goal of this pilot project is to demonstrate that the applicability and results of SEP in the industrial sector will translate to the water and wastewater treatment sector. Given the process oriented operations and industrial-scale systems present in water and wastewater treatment facilities it is anticipated that similar energy performance improvement levels will be obtained as in SEP-certified manufacturing facilities. Additionally, the ISO 50001 should be particularly robust as many water and wastewater treatment facilities already possess strong commitments to energy efficiency at all levels of operations, including top management. As public purpose organizations, water and wastewater treatment facilities have a vested interest in reducing energy consumption and decreasing harmful impacts on the surrounding environment.

Through the pilot, facilities will integrate energy management into their business operations and culture through a systematic approach to managing energy. This approach enables continual improvement of energy performance in water and wastewater treatment facilities, reducing costs and lowering demand for energy.

Partners in this pilot project agree to implement SEP at one of their water or wastewater treatment facilities, provide resources to implement SEP, consider use of combined heat and power (CHP), and share data and provide feedback to the U.S. DOE. The U.S. DOE will offer software tools and provide no-cost energy management experts to train and assist the partners' energy teams with 3 multi-day training sessions over 12 months. Assistance through regional Technical Assistance Partnerships will help partners explore application of CHP.

Once SEP is implemented, a third party verification body will audit each partner's facility to verify that SEP requirements are met and will issue the SEP and ISO 50001 certificates. SEP-certified water/wastewater treatment partners will receive national recognition by the U.S. DOE for achieving the SEP certification. DOE will also develop case studies to document and share partners' successes and experiences.

Seven water/wastewater treatment agencies are currently engaged in this pilot project:

- California: Delta Diablo Sanitation District (also a Better Plants partner)
- California: Victor Valley Water Reclamation Authority (also a Better Plants Challenge partner)
- Delaware: Kent County Department of Public Works (also a Better Plants partner)
- Iowa: Des Moines Water Works (also a Better Plants partner)
- Virginia: Alexandria Renew Enterprises (also a Better Plants partner)
- North Carolina: Utilities, Inc.
- Texas: City of Laredo

## Pilot Project Approach

A Phase-based approach organized around the Plan-Do-Check-Act continual improvement framework of ISO 50001 was used to execute this project and implement the EnMS. In such an approach, the project begins with implementation planning and organization and ends with an internal assessment and the possibility of third-party certification. In between, there are three Phases of EnMS development and implementation:

- Phase 1 – Energy planning ("plan")
- Phase 2 – Implementation and operation ("do")
- Phase 3 – Checking and management review ("check" and "act")

Each phase is taught by subject matter experts from Georgia Tech. The phases are taught in three day long in-person sessions conducted six months apart from one another. Phase 1 training was conducted in December 2015 and hosted by the Kent County Department of Public Works in Dover, DE. In addition, the project instructors support and guide the partner implementation teams through the entire project with one on one monthly check in calls. Quarterly group learning calls are being implemented at the suggestion of previous manufacturing sector SEP pilot projects. These phone calls are designed to allow pilot project participants to ask their peers about challenges being faced and communicate together to share experiences.

ISO 50001 specifies "what" is to be done in the EnMS, but it is up to the implementing organization to determine "how" it will be done. Each training phase started with group training on the "what" of the ISO 50001 requirements; however, the team exercises in the group training addressed the "how." The results of a gap assessment and learning through the implementation process helped determining "how" the various processes of the EnMS would be implemented. A key construct of this approach was to "avoid reinventing the wheel" as much as possible. Relevant processes already in place were used or adapted for the purposes of the EnMS, especially the management system processes of the quality and environmental systems.

In addition to technical content experts, pilot project participants have access to U.S. DOE EnMS resources such as the eGuide and EnPI tool. eGuide is an online step-by-step tool that explains the components and how to implement an EnMS at a variety of levels including those for ISO 50001 and SEP. The DOE EnPI tool is a freely available Microsoft Excel Add-In that walks facilities through the process of conducting regression analysis to determine energy performance improvement that is conformant with the requirements of SEP.

## Value Of SEP To Water And Wastewater Facilities

As part of providing market definition around energy management, the energy management approach required by SEP (based on the ISO 50001 standard) will inform the development of internal energy management systems as it has for mainstream manufacturing. This energy management approach has been applied successfully in mainstream manufacturing. Results have shown that plants with energy management systems aligned on the ISO 50001 standard are more likely and capable of addressing energy consumption continuously and can make energy savings from implementation projects more persistent [19]. Because water and wastewater treatment plants and pumping stations possess systems that are similar to those found in manufacturing plants the potential to replicate this success is good.

Another area through which SEP could offer value is by promoting the philosophy embodied in the System Assessment Standards that that the U.S. DOE co-developed with the American Society for Mechanical Engineering (ASME) and encouraging water and wastewater treatment agencies to apply them. Two of these standards cover two types of systems found in water and wastewater treatment plants, pumping and compressed air systems. The ASME standards do not focus on how to perform energy assessments, but rather what should be part of an energy assessment. This can help water and wastewater agencies gain a better understanding of best practices with respect to energy assessments and can help these agencies

become a more educated customer for energy consulting services.

Given the potential for more energy intensive processes in the future and variability in energy consulting philosophies of established service providers that serve the water and wastewater treatment sector, one possible role for government programs such as SEP could be to provide technical assistance and market definition around energy efficiency. Based on its proven success with mainstream manufacturing, SEP can establish relevant metrics or key performance indicators for this sector. An internal DOE analysis applied the EnPI regression tool to five water/wastewater treatment agencies in the SEP cohort [20]. Initial results suggest that an intensity metric based on flow, e.g. energy/volume of water, shows a higher impact on energy consumption than does an energy metric based on BOD, even for wastewater treatment plants. While the results suggest that flow is a "good" metric, it should be noted that additional factors such as influent quality, influent composition, effluent permit limits and the types of treatment methods/technologies applied need to be integrated into future analysis. For example, some wastewater treatment plants treat greater amounts of food waste and fats, oils and greases (FOG). Some wastewater treatment plants have discharge limits that can be 2 to 3 times more stringent than the limits for other wastewater treatment plants. Also, different wastewater treatment plants use different technologies in secondary treatment such as rotating biological contactor, air activated sludge, air activated sludge with Nitrification and Denitrification, high purity oxygen activated sludge, oxygen produced by pressure swing adsorption, high purity oxygen activated sludge, oxygen produced by cryogenic process and Trickling Filters. These technologies will affect BOD values for wastewater treatment. Developing credible and robust metrics can be a key contribution by SEP.

## RESULTS TO DATE

The cohort of seven water and wastewater facilities started in the fall of 2015. Since the first SEP training each of the agencies in the cohort have formed their own energy team and have begun developing energy policies, energy baselines, and energy performance improvement adjustment models, identifying energy management system scope and boundaries, and securing top management commitment. All agencies have presented self-developed energy management system materials such as an energy policy and energy performance improvement model to instructors. Most of the cohort agencies have developed energy data collection protocols and all are starting to use the SEP regression tool (EnPI Tool) to generate a baseline of their respective facilities' energy consumption. The successful use of the regression tool is noteworthy because it shows that the agency staffs were able to identify meaningful key performance indicators that could yield valid model results. These results to date are exceptional and demonstrate the commitment of all participating agencies.

In addition to the goals of this project, the participating agencies have provided value to the U.S. DOE by reviewing draft materials for an updated version of the SEP M&V Protocol. Updates to the SEP M&V Protocol are focused on clarifying issues identified by certified SEP facilities, SEP Performance Verifiers, and other stakeholders. One critical topic being clarified was the use of biogas and other natural energy resources on-site. Participating water and wastewater treatment facilities have provided crucial insight and real world grounding to the updated Protocol.

## MOVING FORWARD

The water and wastewater treatment sector pilot cohort will meet in June and December 2016 to conduct their phase 2 and 3 trainings. Along with the monthly one on one calls and quarterly group webinars, the facilities implementing ISO 50001 will be provided technical assistance to achieve their energy performance improvement goals. The U.S. DOE and Lawrence Berkeley National Laboratory will study the impact of SEP at these facilities and help Georgia Tech tailor its trainings to better serve the water and wastewater sector in the future. U.S. DOE technical assistance tools such as the ENPI tool and eGuide will be evaluated to ensure they properly reflect the needs of the water and wastewater treatment sector based upon the results of this project.

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