Turning Vision Into Reality

Leveraging Technology and Culture to Realize Energy Savings at a Large Public Utility

Ernest Jolly, CEM, CEA, Energy Manager, DC Water
Rich Atoulikian, Vice President, MWH Americas, Inc.

ABSTRACT

The operating pressures faced by today's utilities include an increased focus on fiscal responsibility and cost reductions, combined with a higher and ever-increasing level of environmental quality standards. This puts a brighter spotlight and greater pressure on improving operational efficiency and optimizing the performance and operation of their facilities, which not only saves energy but makes them more environmentally sustainable. An energy audit is a process typically used to evaluate a system for such efficiency and the associated energy savings. Energy audits also provide the factual basis needed to support the establishment of a culture that focuses on energy efficiency as a core part of its decision-making model.

When energy audits are performed for water and wastewater utilities, not only can electrical energy savings be achieved, but savings in other areas such as process chemical use or parasitic water losses may also realized. The energy audit and savings plan conducted for DC Water at their Blue Plains Advanced Wastewater Treatment Plant and associated water, wastewater, and stormwater pumping stations provides a case study on how these audits should be conducted for maximum effectiveness and identification of a path forward toward realizing energy savings and carbon footprint reductions. Specific focus areas include:

1. Evaluation of treatment process configuration and operation, followed by an analysis of modifications or capital additions that can be made to reduce energy consumption. This also includes an analysis of building envelopes, HVAC systems, lighting, general rotating equipment, and electrical distribution systems.

2. A review of current energy use, patterns of use, and opportunities to conserve, including development of an energy baseline and benchmarking.

3. Alternative energy evaluation covering the areas of biosolids, solar, wind, and small hydro, including both on-site production and procurement from third parties.

Development of an implementable, prioritized energy management plan is critical. This includes identifying "quick wins" or low- to no-cost measures that can be implemented in the short term with little initial capital investment, resulting in an almost immediate decrease in energy consumption. The process continues with the identification of opportunities that are more capital intensive (but still have reasonable payback periods) and are more time consuming to implement. In addition, a successful program must go beyond implementation of audit results and include monitoring and verification, as well as continuous improvement practices. When conducted properly, our experience demonstrates that the payback period on these audits is such that the cost of the audit alone can be recovered in less than two years by implementing certain recommendations. The actual payback period on the recommended opportunities is also very short.

Finally, the technical side of an energy management plan is only half of the equation. The other half is the *culture change* required at all levels in the organization to implement the results of the plan, both initially, and more importantly, in a sustainable fashion. Organizational change management starts with a compelling vision from the top of the organization, with an understanding of the significance and potential benefits of the change at all levels. Regular communication is essential, once the vision is set. A process for feedback from the organization and demonstrating that the organization is engaging input from its employees is also important.

This article examines the benefits of energy savings for one of the nation's largest water utilities at the forefront of sustainable practices, DC Water. Included will be a brief overview of why DC Water has chosen to implement an energy and carbon reduction program, how and what has been done, and how the data will be used to implement energy reduction programs in the future, from both technical and cultural perspectives.

INTRODUCTION

DC Water distributes drinking water and collects and treats wastewater for more than 500,000 residential, commercial, and governmental customers in the District of Columbia and neighboring communities. It operates the Blue Plains Advanced Wastewater Treatment Plant, which is the largest advanced wastewater treatment plant (WWTP) in the world. It is also responsible for a number of stormwater pumping stations across the District. Figure 1 shows the baseline electricity consumption by service area, based on fiscal year 2008 data. The three primary service areas in DC Water are wastewater treatment (Blue Plains), sewer pumping, and water pumping.

As of 2008, DC Water had already established the importance of environmental improvement as a critical success factor. The organization has created a policy statement for sustainable energy consumption:

> DCWASA is committed to efficient use of energy as an essential resource needed to provide reliable and cost effective water, sewer, and wastewater services to its customers. In the conduct of day to day operations and fulfillment of the capital improvement plan, energy efficiency and use of renewable energy generation and renewable energy credits to reduce DCWASA carbon footprint will be an integral part of the decision-making process.

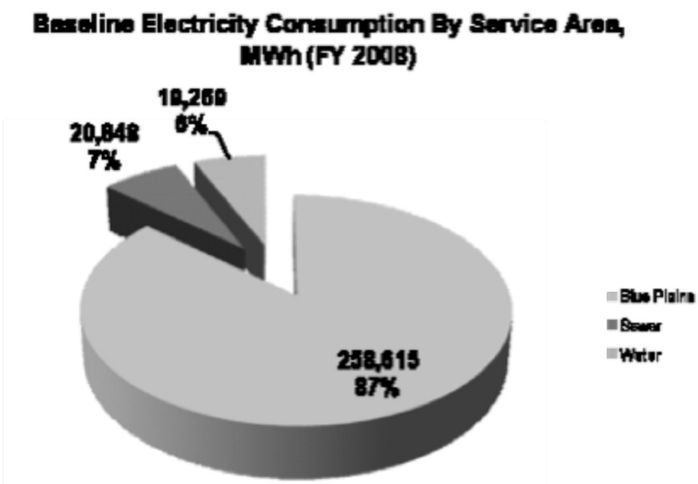


Figure 1. Baseline Electricity Consumption by Service Area, MWH (FY 2008)

At DC Water, greenhouse gases and energy consumption are substantially equal and related challenges to meeting sustainability goals in the face of rising demand for water and wastewater treatment and quality. As such, a joint task force and committee was launched to begin to address these issues, quantify the energy and carbon footprint baselines, and find ways to reduce consumption and emissions.

But DC Water leaders wanted to take the authority's sustainability practices and solutions to the next level. The first step was creating and filling the position of a full-time energy manager at DC Water. One of the first steps identified by the new energy manager was to conduct an independent evaluation of energy use to lay the groundwork for implementation of energy conservation measures. Additionally, quantifying the greenhouse gas reductions possible through energy use reductions enabled DC Water to understand ways to reduce these emissions. In this manner, DC Water is truly advancing its mission of being an environmental steward in the community.

In the fall of 2009, following a competitive selection process, MWH Global, Inc. (MWH) was selected to conduct an energy audit, including development of recommendations in an energy savings plan for DC Water's use in implementing energy savings and carbon footprint reduction measures. Notice to Proceed was given in December, 2009.

Performing the audit and development of the plan are the first steps in the journey of improving a utility's energy efficiency. (See Figure 2.) The next steps in the process, just as important in overall success, are implementation of recommendations, followed by monitoring and control to confirm that the proposed savings are being achieved. Finally, a continuous improvement step provides an agency such as DC Water with the ability to sustain the program moving forward. The final product will be an energy savings plan that incorporates conceptual designs for energy savings measures, as well as select renewable energy options.

With a 12-month duration, and completed in December 2010, the audit first established an energy baseline to better understand DC Water's use of energy and production of greenhouse gas (GHG) emissions across all its facilities. The results of the baseline were also used to provide a framework to identify the areas of greatest energy use, which may be the areas where the greatest potential savings can be found. In the development of the baseline, significant data were reviewed. These data were analyzed to enable opportunities for savings to be identified—first

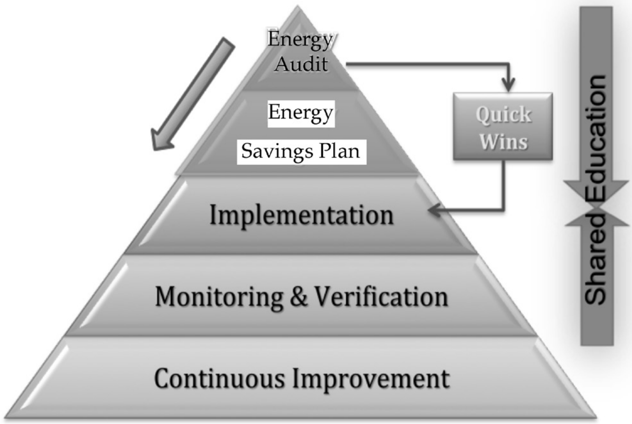


Figure 2. An Energy Program's Success Requires These Steps

through quick wins for near-term paybacks and then through more capital-intensive projects to further reduce greenhouse gas emissions in the long term. MWH's goal in performing these audits was to bring energy savings opportunities forward in a timely fashion, to afford DC Water the opportunity to begin realizing savings as soon as possible.

MAIN BODY

DC Water's Facilities

To begin, the MWH team worked with DC Water to review its key assets for supplying water via a number of pump stations of various sizes. To serve these water needs, DC Water operates more than 1,300 miles of pipes, five pumping stations, five reservoirs, four elevated water storage tanks, 36,000 valves, and 9,600 public hydrants. The water treatment function is provided by the US Army Corps of Engineers (USACE) through the Washington Aqueduct, which maintains and operates the Dalecarlia and McMillian Water Treatment Plants, with a combined average capacity of about 180 mgd. These plants provide reliable and safe potable water to the District of Columbia, Arlington County, and the City of Falls Church, Virginia. As part of this effort, DC Water has reached out to the USACE to identify mutually beneficial energy management strategies associated with the delivery of finished water from these plants into the distribution system.

DC Water also provides wholesale wastewater treatment services for a population of 1.6 million in Montgomery and Prince George's counties in Maryland, and Fairfax and Loudoun counties in Virginia. To collect wastewater, DC Water operates 1,800 miles of sanitary and combined sewers, 22 flow-metering stations, and nine off-site wastewater pumping stations. Wastewater is treated at the Blue Plains Wastewater Advanced Treatment Plant, with an average day flow of 370 mgd.

Energy Audit Approach

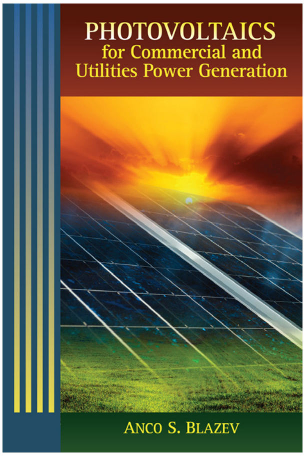
As part of this effort, the various components of the water and wastewater pumping, distribution, and collection systems were investigated with respect to identifying an energy baseline and energy and carbon savings opportunities, including pump stations, electrical power, HVAC, lighting, building systems, mechanical systems, water systems, and water use. In addition, the team evaluated options for renewable energy, and it is evaluating smart grid and smart meter options and other specialty systems.

The approach that MWH follows on energy audits starts with data collection interviews and site visits, followed by opportunity formulation, bringing forward quick win opportunities, data and project analysis, a project prioritization workshop to develop conceptual designs, and development of an overall energy savings plan that includes an implementation path forward. (See Figure 3.) It is important to note that the schedule for this project has been accelerated to 10 months, to better align with DC Water's fiscal year and to bring energy savings opportunities forward sooner. Each of the steps in the approach is discussed further in the following paragraphs.

A. Data Collection, Interviews, and Site Visits

The water and wastewater related components of DC Water are generally located in three departments—Water Pumping, Sewer Pumping, and Blue Plains. Data were collected and utilized to perform comparative determinations between various facilities to identify higher priority opportunities. In addition to extensive data collection and facility site visits, an important part of this process was the interviewing of DC Water staff at all levels. Over 35 individuals were interviewed, some more than once, across the various

PHOTOVOLTAICS FOR COMMERCIAL AND UTILITIES POWER GENERATION



Anco S. Blazev

Photovoltaic technologies for commercial, industrial, and utilities power generation are seen by most experts to be where the future of solar energy lies. The scope of this book encompasses the development and current state of the art of thermal and photovoltaic solar technologies, with emphasis on both existing and future applications of photovoltaic equipment in the commercial, industrial, and utility sectors. Special attention is given to the particulars of large- and very large-scale power generation plants in the U.S. as well as abroad. The photovoltaic aspects of solar technology are reviewed from both a theoretical and a practical applications perspective, looking closely at the design parameters, materials, structure, manufacturing, operation and applications, emphasizing current and future use as a major alternative energy source. The advantages and disadvantages of each specific technology are examined and projected into the future, in search of a niche for each of them. The result is an integrated approach to using solar energy, with the ultimate goal of providing the best alternatives to electric energy generation, and the need to meet the energy and environmental demands of the 21st century.

ISBN: 0-88173-652-X

8½ x 11, 408 pp., Illus.
Hardcover, $145

ORDER CODE: 0652

CONTENTS

BOOK ORDER FORM

① Complete quantity and amount due for each book you wish to order:

Quantity	Book Title	Order Code	Price	Amount Due
	Photovoltaics for Commercial and Utilities Power Generation	**0652**	**$145.00**	
			Applicable Discount	
			Georgia Residents add 6% Sales Tax	
			Shipping Fees	**10.00**
			TOTAL	

② Indicate shipping address: **CODE: Journal 2011**

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order) EMAIL ADDRESS

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

③ Select method of payment:

☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

Make check payable in U.S. funds to:
AEE ENERGY BOOKS

CARD NO.

Expiration date *Signature*

MEMBER DISCOUNTS
A 15% discount is allowed to AEE members.
☐ **AEE Member (Member No.__________________)**

④ Send your order to:
AEE BOOKS
P.O. Box 1026
Lilburn, GA 30048

INTERNET ORDERING
www.aeecenter.org

TO ORDER BY PHONE
Use your credit card and call:
(770) 925-9558

TO ORDER BY FAX
Complete and Fax to:
(770) 381-9865

INTERNATIONAL ORDERS
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.

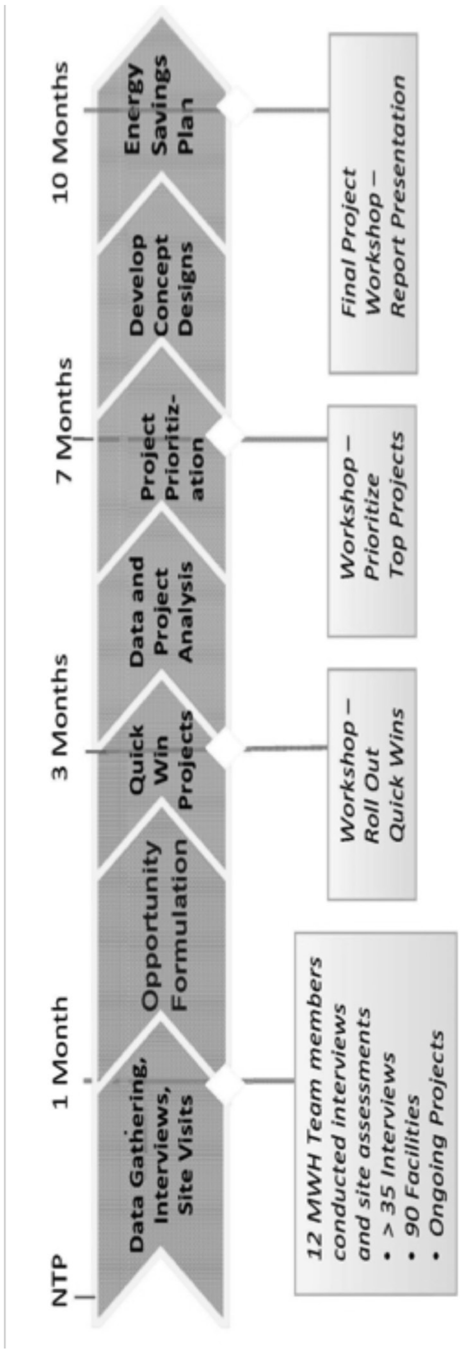


Figure 3. DC Water Energy Audit Project Approach

organizational departments; also included were the Facilities group, the Chief Financial Officer, Information Technology, and others.

The purpose of these interactions was to introduce the project and our team, describe the project and our approach, and to solicit ideas from each individual that could potentially reduce energy consumption. Multiple interactions across any organization are important in developing a common understanding and focus toward reducing energy consumption. To supplement the one-on-one and small group interactions, workshops were also held with key staff to use the *power of the group* to first establish, then prioritize, the concepts developed. In support of each of these workshops, an in-depth analysis was conducted of the data, resulting in recommendations for energy savings measures. These workshops helped focus the various components of DC Water on the overarching goals of this project. These interactions, both one-on-one and in small groups, were all part of the overall organizational *management for change* process.

At Blue Plains, a process model was used to evaluate different options for optimizing performance from an energy and carbon standpoint. An energy baseline was developed for Blue Plains, as shown in Figure 4. This baseline can be readily modified to incorporate ongoing improvements and then reflect the energy consumption breakdown between the various processes.

Being the progressive agency that it is, DC Water already had a number of projects underway to meet more stringent regulations, as well as to replace aging facilities. It is looking to the future, with a large project dedicated to incorporating renewable energy into its operations. One such project is incorporation of the Cambi® anaerobic digestion process into their process stream for sludge stabilization. This project is coupled with a new, combined heat and power system that will put DC Water on the cutting edge in this regard. Overall, the management at Blue Plains is very proactive with respect to energy management, and as a result, many of the concepts which the audit team had initially identified already had some traction in the organization.

B. Opportunity Formulation

This step consists of taking all of the data obtained from field visits, interviews, and other sources and utilizing the data as the ba-

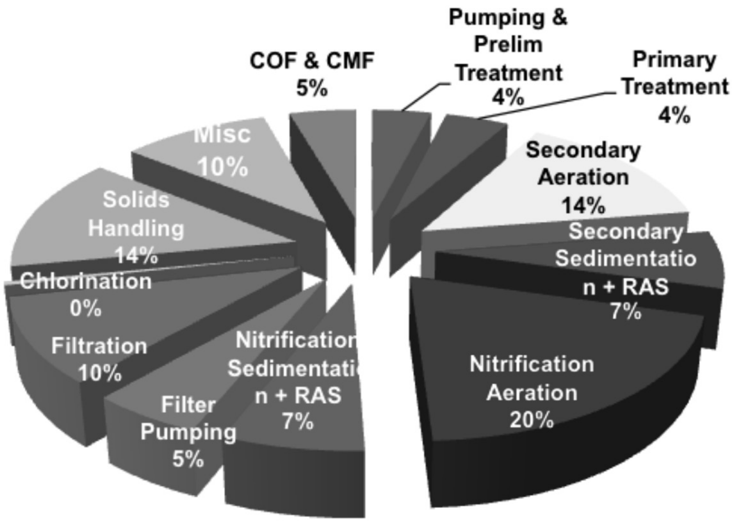


Figure 4. Estimated Energy Baseline—Blue Plains AWT

sis for developing specific recommendations. MWH has developed a proprietary tool, mAudit®, which enables easy gathering of field data on tablet computers, followed by automatic downloading of that information into a web based database from which the data can be utilized for developing and sorting potential opportunities.

C. Quick Wins

As noted above, a key aspect of this work was to identify and bring forward to DC Water quick wins with respect to energy savings. These are those items that can be readily implemented at little or no cost. Establishing them in a timely fashion enables DC Water to start saving money sooner rather than later. A Quick Wins Workshop was held within three months of Notice to Proceed to present the findings to the DC Water departmental leaders. (It would have been sooner, but two weeks were lost during the holiday season.)

MWH outlined more than 250 quick win projects that could be implemented immediately, to result in a total savings of $500,000 per year, with very short payback periods ranging from as short as a couple of weeks to 12-18 months. The list primarily includes upgrading to more efficient lighting, HVAC improvements, building envelop improvements, and resetting setpoints or installing automated controls.

In addition, in many cases utility rebate programs exist which can offset the capital costs associated with implementing energy efficiency projects. Identification is early in the audit process, to enable optimal use of such programs to fund some or all of the projects.

A highly prominent example of a quick win relates to lighting. DC Water uses more than 1 megawatt of power in lighting facilities, which is extremely high compared to the 1½ kilowatts we use in our homes. By converting to more efficient lighting and ballasts, and installing motion sensors that turn the lights on and off based on when the facilities are being occupied, energy consumption could be significantly decreased, resulting in several hundred thousand dollars in energy savings.

D. Data and Project Analyses

Once the quick wins have been brought forward to the client, the remaining opportunities go through an initial screening by looking at financial metrics such as initial capital cost, payback period, or return on investment (depending on client preference). In addition, many times ease of implementation is also an important consideration. The potential project opportunities that pass this test are then developed further, to better quantify these metrics before they are presented in the Project Prioritization Workshop.

As part of this effort, a further look at renewable energy was conducted, such as the use of wind turbines, solar power, or small hydro to recover excess energy from the hydraulic profile. Larger wind turbines were not practical at Blue Plains since it is in the flight path for Reagan National Airport. While these devices could be used at some of the other facilities, the amount of wind energy generation possible was not sufficient to provide a reasonable payback period. Solar energy is a viable alternative, and installation of solar panels at one DC Water facility (to start with) is one of the recommendations. Rebates and financial incentives make this alternative financially attractive, and the positive public perception associated with DC Water's use of renewable energy further strengthens the case for solar. Micro turbines in the flow stream at Blue Plains are a possibility and could be placed just downstream of the effluent filters, where the water quality is expected to be good. One of the challenges, however, is how to best combine the effluent pipes (over 80) into a smaller number that would make this option more attractive.

E. Project Prioritization Workshop

In this workshop, non-quick-win potentials that meet the appropriate financial and implementable criteria are presented to the group. Each potential opportunity is explained in sufficient detail to enable the group to then prioritize them. Many times, the prioritization process entails rating the projects based on different criteria and seeing how the ranking changes with the criteria (i.e., ease of implementation to determine what can be done most readily to demonstrate success, low capital cost if funds are limited, or payback period/return on investment—whatever metric is most important to the organization for prioritizing and implementing a project). The MWH tool mPlanner® was used to manage and prioritize the various projects in an interactive fashion during this workshop.

As part of this process, MWH identified more than 40 potential project opportunities totaling over $3M in annual savings through more capital-intensive projects. The top projects identified can save an annual $2M, with paybacks of 12-18 months. These projects generally fell into the following categories:

1. Capital projects, which require detailed design and construction contract development.
2. Procedural/programmatic activities, such as development of standard operating procedures in such cases as the use of high efficiency or premium motors, or modifying building thermostat setpoints.
3. Maintenance and related activities, such as installation of power monitoring to enable equipment operating in parallel to be compared—to see if any individual device may be operating out of standard performance and to identify the consumption of extra power (e.g., by a pump due to a clogged line or broken impeller).

It is also recommended that the *energy* perspective be brought to project reviews for ongoing projects being conducted by DC Water.

As shown in Figure 5, the greatest opportunity to impact a project from an energy standpoint is early in its project lifecycle, i.e. in the planning stage. The ability to impact a project is progressively less as a project moves from design through procurement, implementation, and closeout. Many times, capital cost, operational flexibility, reliability, or redundancy tend to be the drivers for how a project progresses from the study phase through design and construction. However, in the new world of energy management, a look at the impacts of energy on cost, operations, etc. is just as important. Since the greatest ability to impact a project is in the early phases, this is where the value associated with reviews from an energy perspective can be most impactful.

F. Conceptual Design of Long-term Potential Project Opportunities

The projects selected by DC Water from the Project Prioritization Workshop to move forward into conceptual design generally fall into one of the three categories noted above. Further, the capital projects can be delineated into process modifications, equipment substitutions, equipment optimization, and renewable energy. The energy savings percentage associated with each of these types is shown in Figure 6. These include measures such as:

1. *Motor replacement*. Standard motors can have a motor efficiency up to 10% lower than that of premium efficiency types. Typically, the delta in motor efficiency is the highest for motors with a relatively low capacity, and vice versa. In addition, premium type motors can have a significantly higher power factor. The combination of both can result in efficiency gains up to 30%, particularly if the existing motor has been rewound.
2. *Replacement of the air-cooled chiller condenser with a water-cooled type*. The more stable condenser temperature will result in a chiller efficiency gain. The preferred water source is the process water (final effluent) system, treated appropriately.
3. *Solar Photovoltaic Arrays*. With potential roof and land availability for just under 500 kW, DC Water has the potential to reduce its long-term energy bills and utilize a zero-carbon energy source.
4. *Raising the water levels on the suction side of certain pumps*. This

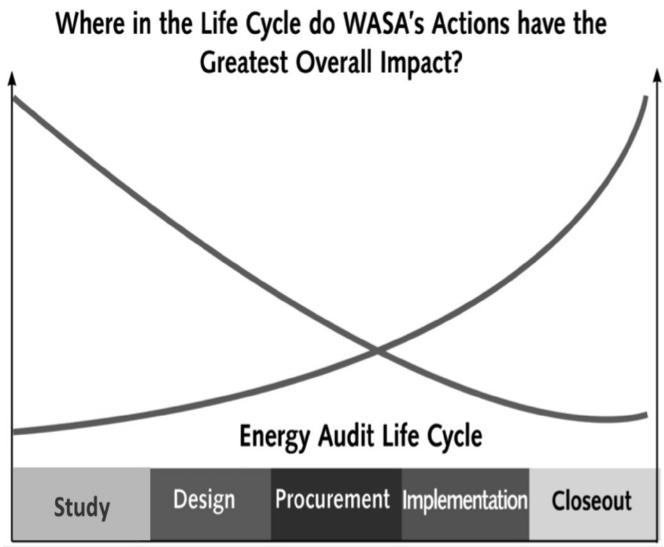


Figure 5. Where in the Life Cycle Do WASA's Actions Have the Greatest Overall Impact?

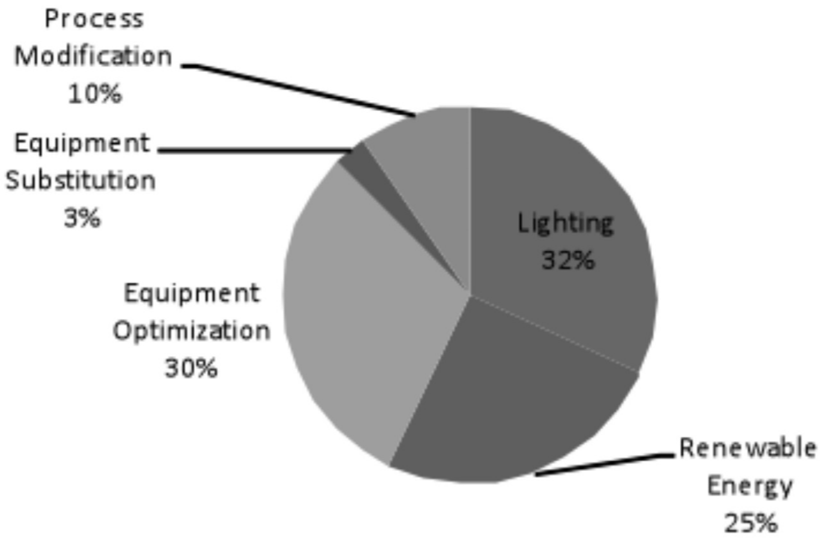


Figure 6. Cost Savings Identified (% Total $/year)

was also identified by DC Water as a potential project to be moved forward. Since horsepower consumption is proportional to pumping head, raising the suction level reduces horsepower. It is recognized that in some instances, operational strategies must be modified so as to mitigate potential adverse impacts (i.e., potential for greater deposition), but the benefits far outweigh infrequent changes to what had previously been standard operating procedures.

5. *Provision of an energy dashboard that would be incorporated into DC Water's overall control system.* This would reinforce the cultural change and raise the awareness of the importance of energy management in DC Water's day-to-day activities; it would show the respective organizational goals and real time progress toward those goals. The dashboard would show key performance indicators related to energy consumption and indicate trending. It would be available for viewing by all levels in the organization, from the front lines up to the General Manager.

G. Energy Savings Plan

DC Water is determining the changes it will ultimately make, and the findings from the energy savings plan will be an important consideration as DC Water develops its ultimate path forward. Through consistent process improvements, employee engagement and training, and equipment adjustments, DC Water will have significant opportunities to positively impact energy use and thus decrease energy costs. In addition, the projects identified would reduce DC Water's carbon footprint by nearly 10%, a significant reduction from a leading utility in our nation's capital.

SUMMARY AND CONCLUSIONS

In conclusion, realizing energy savings and carbon reductions starts with developing a baseline for the energy consumption of existing facilities, followed by opportunity identification and development of a plan for implementation. Additionally, achieving the desired results requires both implementing technical solutions and changing the culture of the organization.

The adoption of an energy savings mentality and embracing that culture start with the technical findings that can quantify the potential savings and showing discrete measures that can move them forward. However, as noted in the title of this article, the cultural change is just as important as implementation of the technical changes. Organizational change requires such a change, which starts with the message being clearly articulated at the top, as DC Water has done, and then is embraced throughout the organization, particularly on the front lines where daily decisions can impact energy consumption. This culture change must include continuous leadership advocacy; financial evaluation that, in addition to initial capital investment, accounts for total lifecycle cost of energy usage; and embracement by the operations, maintenance, and engineering staff. It also requires a passionate advocate for change—an individual that keeps the possibilities in front of the group and challenges them to improve. In the case of DC Water, this is the energy manager, with the full advocacy of the general manager.

References

There are a number of individuals who have contributed to the success of this project by sharing their knowledge and experience. This includes the following from DC Water: Len Benson, Olu Adebo, Dave McLaughlin, Walt Bailey, Charles Kiely, Cuthbert Braveboy, Hiram Tanner, John Mattingly, Chuck Sweeney, Muminu Badmus, Aklile Tesfaye, Salil Kharkar, Wayne Raither, Steve Caldwell, Duncan Mukira, Denise Edwards, Greg Bloomstein, Chris Peot, David Cross, Pade Zuokemefa, Lola Oyeyemi, George Armstrong, Roland Kamdem, and many others.

From MWH, we would also like to acknowledge Bert Wellens, George Simon, Robyn McGuckin, Bob Yurick, Don Smith, Ken Brischke, and Bruce Petrik for their commitment to the success of this effort. We would also like to thank our team members on this project, Shah and Associates Inc. and J-Dos Internationale, for their valued contributions.

MWH offers a full suite of tools for energy and resource optimization, including the mAudit® and mPlanner® tools described in this article. Our most recent addition is the mCO2™ carbon emissions calculation tool. The tool calculates and analyzes an organization's greenhouse gas emissions to help in the development of carbon reduction programs. For example, mCO2 collects all direct and indirect sources of greenhouse gas emissions produced by municipalities, industrial facilities, or other companies. It then automatically converts this data into actionable reports. MWH has used these carbon accounting principles for a growing number of utilities and other clients in the U.S.

ABOUT THE AUTHORS

Ernest L. Jolly, CEM, CEA, is the inaugural energy manager at DC Water (DCWASA) and is leading the development of the organization's Energy Management Strategic Plan. He received his B.S. in general engineering from the U.S. Naval Academy. Mr. Jolly developed expertise in power plant generation and energy efficiency, erosion and sediment control, and sustainable development over his career of service in the U.S. Navy and Naval Reserves, the electric utility industry, higher education, and the water and wastewater industry. He has combined his technical knowledge and training skills with his leadership expertise in organizational transformation to support the development of an energy efficient-focused culture.

Ernest L Jolly, CEA, CEM
Energy Manager
DC Water
500 Overlook Avenue, NW
Washington, DC 20032
Ernest.Jolly@dcwater.com
(202) 787-2370

Richard G. Atoulikian, PMP, PE, BCEE, is a vice president with MWH in Cleveland, Ohio. He has 34 years of experience in environmental engineering, focusing on water and wastewater treatment and pumping for municipal clients. Over his career, Mr. Atoulikian has embedded energy conservation and energy management into the projects which he has lead. Having received his BSCE and MSCE from Cleveland State University, he has managed projects across the country, using a variety of project delivery systems. He has also managed a number of energy audits/studies and understands both the technical and cultural issues associated with increasing an organization's energy awareness.

Richard. G. Atoulikian, PMP, PE, BCEE
MWH
1300 East 9th Street – Room 1100
Cleveland Ohio 44114
Richard.G.Atoulikian@mwhglobal.com
(216) 272 0297