NEMA Strategic Initiative

Increasing Energy Efficiency in Urban Water Systems

Summary Report

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Executive Summary

The National Electrical Manufacturers Association (NEMA) represents electrical equipment and medical imaging manufacturers and is headquartered in Rosslyn, Virginia. Nearly 400 Members strong, its companies manufacture a diverse set of products including power transmission and distribution equipment, lighting systems, factory automation and control systems, and medical diagnostic imaging systems. Total U.S. shipments for electro-industry products exceed $100 billion annually.

NEMA funded a Strategic Initiative related to the relationship of electricity and water in urban water systems. It sought to:

- quantify the effectiveness and electrical efficiency of equipment in facilities representative of the U.S. urban water supply's delivery and treatment systems
- analyze the market potential to improve performance by using NEMA Member products.
- reevaluate the viability of applying energy savings performance contract (ESPC) practices to finance modernization upgrades

This report presents the analysis and conclusions.

Notable Findings of the Study

- During interviews with NEMA Members, the study team learned that product manufacturers have little to no interaction with end users; products are bought on spec and installation quality/accuracy varies in the field.
- Likewise, specifier and end-user knowledge on new products, systems, software, and additional options (e.g., metering) is highly variable.
- Survey and analytical outreach revealed that end users want training and education, for reasons such as aging/new workforce and desire to gain knowledge about the full range of potential new solutions.
- The survey taught us that most utilities have convoluted design/permitting/ purchasing/installation practices and policies, making "selling modernization" to them difficult.
- While data about energy savings potential from modern equipment is very interesting, having more NEMA product–related energy savings data may not impact utility purchasing.
- Future NEMA/Member resource allocations should be optimized in training and education of utilities and their associations.

2015 Study's Summary[1] Conclusions/Recommendations

NEMA should:

- Develop programs and tools to assist agency and facility staff, because water agencies lack the analytic capacity and/or staff resources to perform certain energy-related evaluations.
- Establish a water sector-focus group of water-related associations, facility officials and managers/operators to assist in targeting the most important water-related topics and infrastructure needs.
- Get more involved and maintain a consistent presence in water-related associations, non-governmental organizations, and advocacy groups to increase awareness of NEMA member products, solutions, and services.
- Facilitate the identification and organization of innovative funding approaches into more holistic portfolios for agencies that leverage energy services companies (ESCOs), public and private dollars, and energy utility incentives.
- Continue to fund, independently or in collaboration with other water-related organizations, the demonstration of technologies, best practices, and other types of energy-savings strategies, disseminating the results at water conferences, industry publications, and webinars.

[1] Detailed conclusions and recommendations are in the full written report

Abstract

Urban water systems throughout the country rely on energy-consuming technologies to develop, transport, treat, and deliver billions of gallons of water to end users. Over the years, the energy efficiency and performance of these technologies has improved significantly, potentially reducing costs, improving reliability, and providing operational flexibility for system managers. Despite these potential benefits, the water sector has been slow to adopt these new and innovative devices. In response, the National Electrical Manufacturers Association (NEMA) selected GEI Consultants, Inc. (GEI) and its partners (the Alliance for Water Efficiency and M.Cubed) to assess and identify new strategies and approaches to support the advancement of energy efficiency in urban water supply systems. The study team accomplished this by analyzing available information regarding the application of energy-efficient technologies in water systems and the financing mechanisms used to fund these improvements. The team also engaged industry and water agency representatives through interviews and surveys to obtain more agency-specific information. Responses and available literature were analyzed to determine the extent of the current market penetration and the potential for further adoption. GEI's team also evaluated the viability of energy savings performance contract (ESPC) practices, government grants, and other financing mechanisms to finance modernization and system upgrades.

The literature review resulted in the compilation of a significant amount of information and data produced from numerous studies and projects over more than 20 years of efforts. The studies identified how systems operate, where energy is used most, and where opportunity exists to apply the best management strategies to improve the energy performance of these systems. The survey was distributed to more than 3,000 water agency representatives nationwide. These respondents represented a regionally diverse set of water agencies and provided meaningful insights into the level of interest in energy efficiency, institutional and financial challenges to advancing efficiency in these water systems, and possible steps that can be taken to overcome them. The study team determined that significant energy-efficiency savings potential exists within the urban water systems and that ESPCs are a viable business model to secure available funds to implement improvement projects.

Results from this study will inform future collaborations between NEMA members and water utilities as well as the development of plans with measurable outcomes that advance the energy efficiency of urban water supply systems.

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1. Introduction

Americans rely on extensive infrastructure systems to develop, treat, and deliver water supplies for their various needs. Operators of these water supply systems are facing an increasing number of challenges in the United States with respect to water supply system reliability, maintaining its quality, and containing costs, including:

- more stringent drinking water standards and treatment requirements
- rising energy demands associated with the development, treatment, and overall system operation associated with various water suppliers
- aging infrastructure that impacts operational reliability and flexibility
- non-technical barriers such as lack of funding to optimize energy use and achieve energy efficiency
- significant reductions in operating revenue from declining customer sales, which impact a water supplier's ability to be progressive

In its 2013 Report Card for American Infrastructure, the American Society of Civil Engineers (ASCE) assessed drinking water systems in our country at a "D" grade, stating that "(a)t the dawn of the 21st century, much of our drinking water infrastructure is nearing the end of its useful life."[2] Although the quality of drinking water in the U.S. remains high, the American Water Works Association (AWWA) estimates that $1 trillion in infrastructure investments is needed to ensure continued reliability and quality over the coming decades. Much of this investment is required to replace pipes and mains, but because the cost of energy is a significant portion of a utility's operational budget, investing in more energy-efficient technology can help lower ongoing expenses.

As part of its strategic initiative to advance energy efficiency in urban water supply systems, NEMA, supported by GEI Consultants, Inc., seeks to understand the current conditions and opportunities to facilitate this advancement. This initiative has three primary goals:

- Assess the current effectiveness and efficiency of equipment in facilities representative of the U.S. urban water supply's delivery and treatment systems.
- Analyze the market potential to improve performance by using more energy efficient products.
- Evaluate the viability of applying energy savings performance contract (ESPC)[3] practices to finance modernization upgrades.

[2] American Society of Civil Engineers (2013) "2013 Report Card for America's Infrastructure," ISBN (PDF): 978-0-7844-7883-7.

[3] Energy savings performance contracts are a financing mechanism used by energy service companies to make energy-efficiency upgrades to facilities on behalf of the owner which are then paid for using money resulting

The study team conducted three primary tasks as part of this project:

- an extensive investigation of available information and literature on the status of energy efficiency efforts and best practices by urban water suppliers in the U.S.,
- a survey of water supply utilities regarding their past efforts to improve the efficiency of their systems and level of current interest in increased energy efficiency opportunities, and
- an analysis of the use of energy services companies (ESCOs) to advance energy efficiency and ways in which this model is or can be used by water utilities.

Additionally, the study team compiled available information on current water infrastructure funding needs and programs available to water utilities to support system improvements; repairs; expansions; and retrofits, including those for improved energy efficiency. The team also interviewed several NEMA members to gain an understanding of the current level of engagement and information exchange between manufacturers of energy efficient equipment and the water utilities that use it. The results of this work are presented in this report.

1.1 Study Approach

1.1.1 Literature and Information Review

A literature review was conducted as part of this project to obtain a critical understanding of the current level of energy efficiency in the urban water supply systems and the extent to which emerging advanced efficiency technologies have been applied. The compiled literature provides an extensive bibliography of resources available to the study team to support NEMA's strategic initiative. Relevant literature included peer-reviewed publications, research reports, white papers, technical conference presentations, agency fact sheets, and case studies.

Using the defined strategic goals and objectives of the initiative, the research team employed a methodology to identify and compile relevant resources. The team:

- Identified key search terms related to urban water supply systems and designs, optimization and energy efficiency, water infrastructure financing, and energy service providers.
- Used standard internet search engines.
- Considered documents that were in English, readily available electronically via internet, and at no cost.
- Reconsidered terms and will periodically revise, refine, and update as needed.
- Critically reviewed/analyzed materials to determine relevance to the defined goal and objective:

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from the energy savings. For more information see: energy.gov/eere/slsc/energy-savings-performance-contracting.

  - Focus of the documents
  - Scope of the study or analyses
  - Findings/results
- Compiled the results in a spreadsheet

Reviewed literature was publicly available, supplemented by contributions from the NEMA Working Group and internal knowledge of the research team. In this case, "publicly available research" was interpreted to mean that the research is easily accessed by the public and is not confidential. These constraints ensure that research that is obscure, too narrowly focused, overly technical, or purely in the conceptual phases of research are not included.

1.1.2 Urban Water Supplier Survey

The project team accumulated a comprehensive list of qualified prospective respondents for the survey. Specifically, the team targeted urban water utility professionals who would be adequately informed about the system's energy-related costs and have an interest in increasing system efficiency. These individuals would likely be in upper management roles in the Operations department of the utility, but may also hold positions including the following, depending on the size of the system:

- General Manager
- Engineer
- Distribution System Manager
- Water Loss Control Supervisor
- Maintenance Supervisor
- Environmental Services Manager
- Water Conservation Manager

Starting with the list of the Alliance for Water Efficiency's 219 member water utilities, the team requested contact information for the right individuals to respond to the survey. The team also conducted research to compile a list of all medium to large systems throughout the U.S. to capture the major water suppliers from each state and to ensure geographic diversity. Where contact information was not available, the project team called each utility to request an appropriate contact to complete the survey. The result was a list of 92 individuals. To this growing list of potential respondents, the project team added approximately 2,800 managers and consultants working on utility distribution systems and water loss control.[4] These individuals manage plants and distribution infrastructure for urban water systems or consult for water systems, and are therefore very interested in energy-efficiency investments that can optimize operations and reduce costs. Finally, the project team worked with the AWWA California-Nevada Section to inform their membership of the survey and encourage

[4] Contact information for these individuals was obtained from a previously purchased list.

participation. Through this research, the project team assembled a potential respondent pool of more than 3,000 utility managers or consultants from throughout the U.S.

1.1.3 Assessing Energy-Efficiency Potential

The assessment of energy-efficiency potential is a quantitative analysis of the amount of energy savings that may exist, is cost effective, or could be realized by implementing energy-efficiency policies and programs in a state, sector, or region. Energy-efficiency potential studies may be an effective tool for building the policy case for energy efficiency, evaluating efficiency as an alternative to supply-side resources, and formulating detailed program design plans. For this study, determining the potential for advancing energy efficiency in the urban water supply sector is specifically needed to determine beneficial investments and potential funding mechanisms for these improvements.

The study team:

1. extracted known information about electrical usage of urban water suppliers collected during the review of available literature, interviews with NEMA Working Group Members[5], and the Survey of Urban Water Suppliers

2. used available rate information and water usage data to compute the average water cost for the largest 50 cities

3. used data developed in steps 1 and 2, to determine a reasonable average cost for overall water service and compared that to energy savings from the example systems to identify the most promising locations and measures

4. considered information obtained from water supplier survey responses and case studies determine the cost-effectiveness and energy savings potential

[5] The NEMA Working Group consisted of a subset of NEMA members that develop equipment used by the water sector.

2. Urban Water Supply Systems

In 2010, the water use in the U.S. was approximately 355 billion gallons of water per day. This demand is the lowest level since before 1970 and 13 percent below 2005 levels, based on analyses conducted by the U.S. Geological Service (USGS).[6] Sources of this supply are both surface and groundwater, including saline water resources.

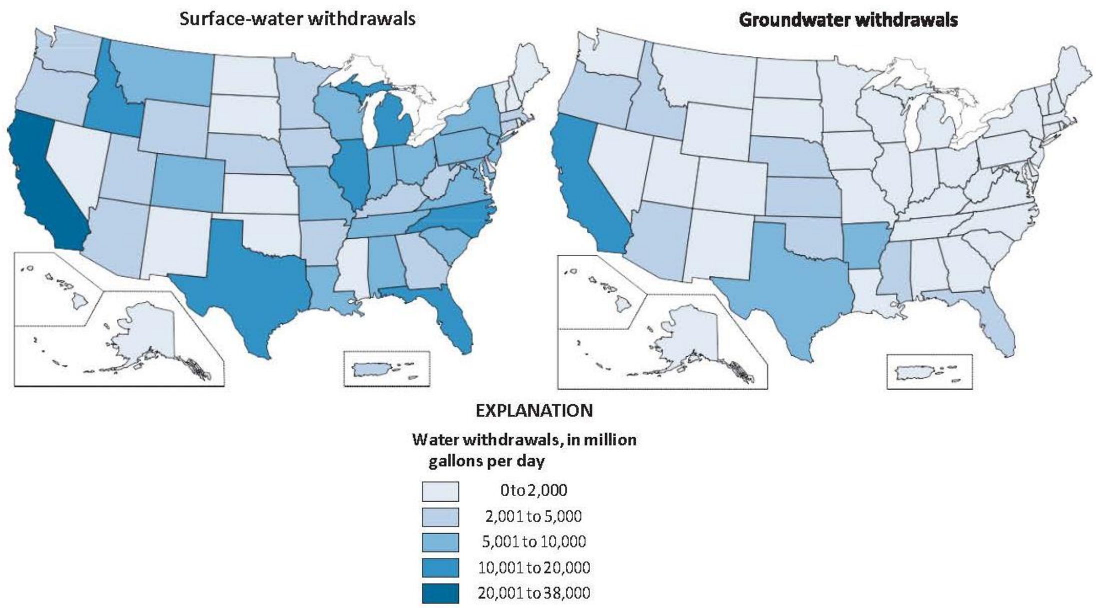


Figure 1 Water Withdrawals to Meet US Demand. Source: USGS 2014.

Twelve percent of this total use, or 42 billion gallons per day (47.1 million acre-feet per year [AFY]), is provided by water suppliers to nearly 300 million people. In 2014, the Environmental Protection Agency (EPA) reported that 93 percent of U.S. residents are served by community water systems (CWS); the remaining seven percent are served by small private systems. Of the more than 51,000 CWS that exist today, the large and very large systems provide drinking water to 82 percent of the country's population.[7] To ensure that this water meets standards for safe, clean drinking water, the EPA conservatively estimates that more than $380 billion will need to be invested in U.S. water systems over the next 20 years.[8] Others, such as AWWA, project this amount to be much higher.

[6] Maupin, M.A., et al. (2014) *Estimated Use of Water in the United States in 2010: U.S. Geological Survey, Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S.,* Circular 1405, 56 p., dx.doi.org/10.3133/cir1405.

[7] EPA (2015) *National Water Program Best Practices and End of Year Performance Report,* Fiscal Year 2014, published June 2015.

[8] EPA (2013) *Drinking Water Infrastructure Needs Survey and Assessment –Fifth Report*.

Table 1 Size Categories of Community Water Systems[9]

System Size (population served)	Number of CWSs	Population Served (millions)	% of CWSs	% of U.S. Population Served by CWSs
Very Small (25-500)	28,462	4.8	55%	2%
Small (501-3,300)	13,737	19.7	27%	7%
Medium (3,301-10,000)	4,936	28.7	10%	10%
Large (10,001-100,000)	3,802	108.8	7%	36%
Very Large (>100,000)	419	137.3	1%	46%
Total	**51,356**	**299.2**	**100%**	**100%**

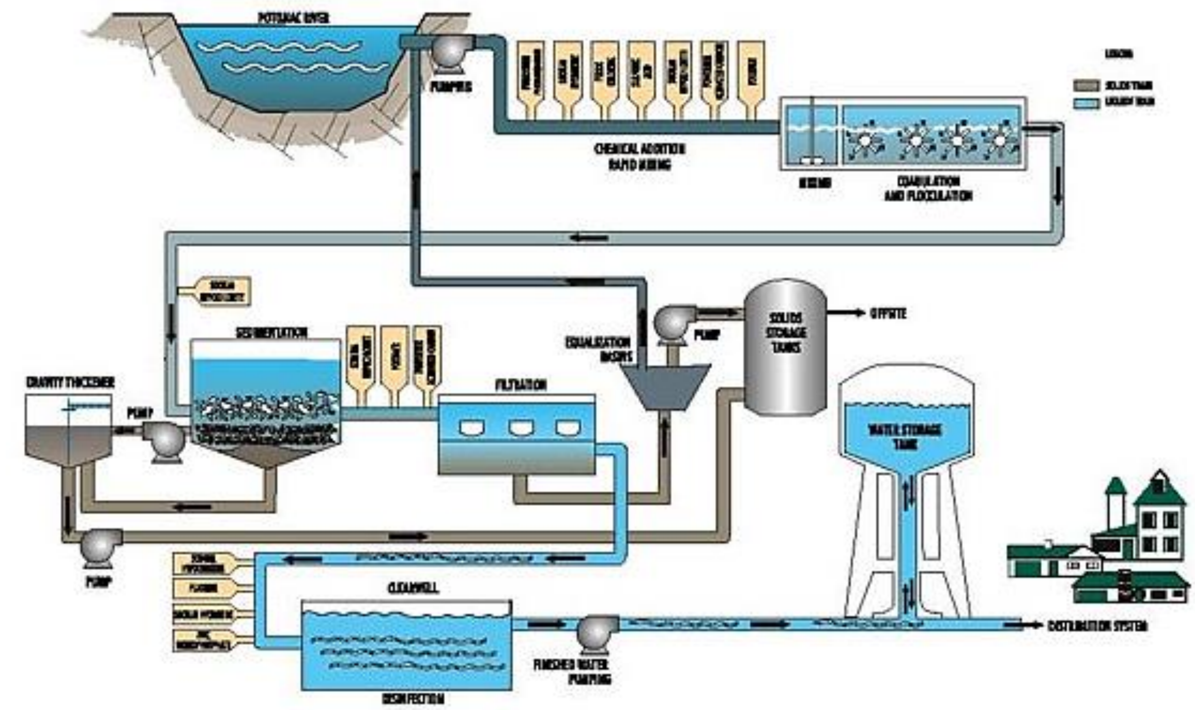
The infrastructure needed to develop, collect, treat, and deliver water supplies includes reservoirs, pipes, storage tanks, treatment plants, pumping facilities, meters, sensors, electrical controls, buildings, and a variety of devices. Water systems vary in design, size, treatment approach, and distribution for a variety of reasons. Two primary conditions dictate a water systems design: the quality and location of the source water, and the geographic conditions in which the system must operate. During the literature review, many diagrams and schematics depicting water supply systems were found. Figure 2 shows two examples: the Kenneth B. Rollins Water Treatment Plant in the City of Leesburg, Virginia[10] and the Hutchinson Water Plant in Minnesota.[11] These examples show major elements of the water-supply systems, but only on a general level.

This literature review revealed a significant data gap regarding specific information sought through this project: 1) urban water supply systems and subsystems sufficient to estimate electrical needs of components, and 2) energy consumption information, age, and efficiency of discrete components and details sufficient to estimate energy reduction potential. Even though case studies were identified, these did not provide adequate inventories of system components or analytical detail to estimate energy intensities of individual or groups of components within the subsystems, including controls (extraction and production, conveyance and delivery, and treatment).

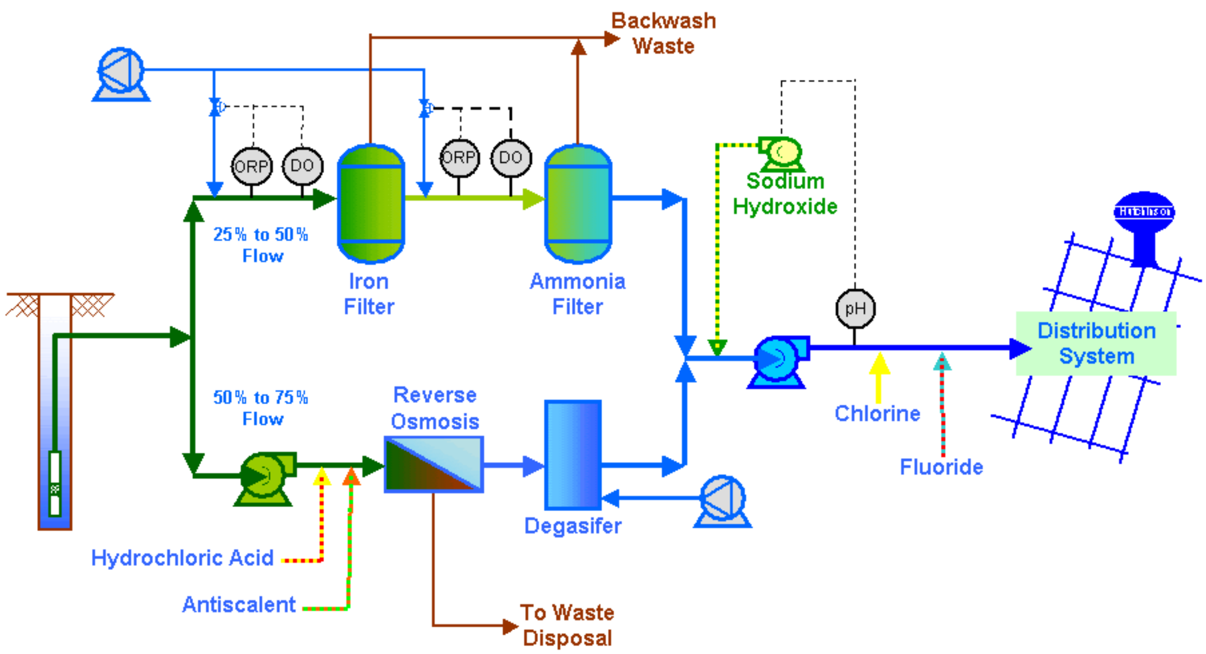
[9] Center for Sustainable Systems, University of Michigan (2015) "U.S. Water Supply and Distribution Factsheet." Pub. No. CSS05-17. October 2015. See http://css.snre.umich.edu/css_doc/CSS05-17.pdf

[10] See www.leesburgva.gov/government/departments/utilities-water-sewer/about-us/water-supply/water-supply-operations#WaterSystem

[11] www.health.state.mn.us/divs/eh/water/com/waterline/waterline_spring2007.pdf



Kenneth B. Rollins Water Treatment Plant



Hutchinson Water Plant

Figure 2 Examples of Urban Water Supply System

Despite the lack of details, it is important to recognize that urban water supply systems are not the same. Each system is designed and operated to meet the requirements of its community and geography. It is also important to note that the primary responsibility of water suppliers is to produce and deliver water; energy efficiency is subordinate to this priority. As a result, any effort to improve energy efficiency must not compromise water quality or reliability. Opportunities for enhancements and improvements are also based on local priorities, system conditions, available resources, and level of flexibility within a system.

What is the same among urban water systems is the types of equipment relied upon to move and treat water— pumps, motors, meters, controls, and other energy-consuming devices. Also, buildings used by these water suppliers for administration services and system operation have similar energy-consuming equipment commonly found in office and service buildings. It is the nature of this equipment that affords these suppliers the opportunities to collectively improve the energy efficiency of their systems, and what provides NEMA the opportunity to support such improvements. Using an approach that focused on these common elements, the Electric Power Research Institute (EPRI) developed a "typical" treatment system to estimate the distribution of energy use in these systems. In its study, EPRI estimated that between 55 and 90 percent of overall electricity use by water supply systems is associated with pumping.[12] The EPRI team then developed energy use intensity values (total kWh/day) for different water supply processes, using several assumptions about how these processes operated. In communities with significant elevation changes throughout their service area, or where water supplies are conveyed over long distances, the electricity used for pumping can be orders of magnitude higher than the average utility use.

In their 2013 study, EPRI and Water Research Foundation (WRF) estimated that U.S. public drinking water systems used roughly 39.2 billion kWh per year, which corresponds to about one percent of total electricity use in the country. Even when taking into account the emphasis on energy efficiency over the last several decades, this demand represents a 39 percent increase from 1996 when demand was approximately 28.3 billion kWh/yr. Thus, these utilities represent clear opportunities for energy-efficiency improvement and investment.

[12] EPRI/WRF (2013) *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries*, Final Report, prepared by EnerNOC, Inc. under contract to EPRI, November 2013.

2.1 Energy Intensity of Water Systems

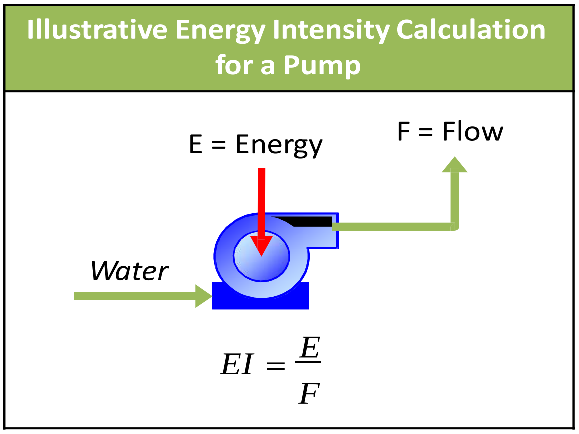


Figure 3 Energy Intensity Calculation

Energy intensity is the term used to describe the amount of energy needed to move or treat water. See figure 3. In the context of urban water supply systems, energy intensity compares the relative energy values of different types of water supply resources, such as surface water, groundwater, saline water, or reclaimed water. The energy intensity is associated with a particular facility and is similar to a measure of efficiency. Energy efficiency is improved when a given level of service is provided with reduced amounts of energy inputs—using less energy to produce a product reduces the intensity.[13] The energy intensities of individual facilities within a water agency can be aggregated to represent the energy intensity of water supply.

Energy embedded in water, on the other hand, is the amount of energy that is needed to provide water to end users and the amount of energy that is used to collect and transport wastewater for treatment before safe discharge of the effluent. Embedded energy (figure 4) captures the entire energy picture upstream and downstream of an end-use customer. This concept is useful in quantifying energy savings as a result of water savings (water saved × energy intensity = embedded energy saved) over an entire community's water supply system and wastewater system. For purposes of this study, the team focused primarily on the energy intensity of water supplies to determine potential energy savings. To the extent appropriate, information regarding wastewater system has been provided for illustrative purposes.

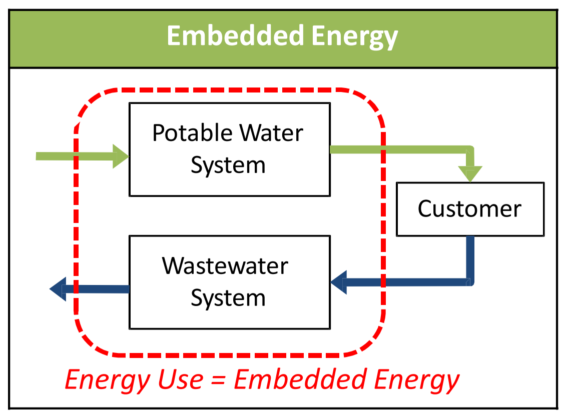


Figure 4 Embedded Energy Quantifies Energy Savings

Aggregating all the energy and water data from an entire water utility's operations allows calculation of average energy intensity of water delivered by that utility. Typically, the metrics used to express water data are based on the traditional conventions used by a given utility: acre-feet (AF), million gallons (MG), cubic meters, or liters (L). Regardless of the metric chosen, all metrics can easily be converted to the others.

[13] U.S. Department of Energy. http://www1.eere.energy.gov/analysis/eii_efficiency_intensity.html

Large metrics are quite appropriate when looking at combined water systems and large regional volumes; however, water utilities generally measure the flow through pumps, motors, and booster stations not by million gallons per day (MGD) or AF, but by gallons or cubic feet per second.[14] When considering the performance of a given piece of equipment in a system (e.g., a pump or motor), these metrics do not necessarily apply. Consider the parameters used to measure the performance of a pump as described by IHS Engineering 360 (www.globalspec.com/pfdetail/pumps/flow): flow rate (as defined as gallons per minute), pressure (usually pounds per square inch), head (distance from the top to bottom of the water column), power (horsepower), and efficiency (the ratio of useful power versus required power).[15]

When the electricity-related metric is added, the relationship is expressed as either kilowatt hours per million gallons (kWh/MG) or kilowatt-hours per acre-foot (kWh/AF).[16] Frequently, a duration metric is also included such as MGD or AFY. All energy-consuming devices used by a utility to provide services can be included: production, treatment, and delivery of water to the end user, as well as lighting, air conditioning, security systems, meters, and other controls. Most U.S. survey respondents reported using MGD as their primary metric, the remainder reported in AFY.

In its 2013 California Water Plan Update, the Department of Water Resources (DWR) showed how this energy intensity can vary depending on the water source, geography, system design, and end use. DWR assessed the intensity of each region in the state finding it ranged from near zero to as much as 2,000 kWh/AF.[17] Energy demands associated with water treatment varied considerably based on the treatment technologies used and the quality of the incoming water supplies, whereas demands associated with water delivery varied based on distance traveled and geography. Treatment alone can add energy demands between 50 and 650 kilowatt-hours per acre-foot (kWh/AF) of water over demands associated with delivery.[18]

2.2 Best Energy Management Practices for Water Systems

Managing the energy demands of water systems is one of the most controllable operating costs incurred by water utilities. The EPA defines a best practice as a process or methodology that consistently produces superior or innovative results. It has identified and is implementing its best practices to improve water systems throughout the country.

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[14] A cubic foot equals 7.48 gallons. A common monthly water billing metric is 100 cubic feet (CCF or HCF) which equals 748 gallons.
[15] www.globalspec.com/pfdetail/pumps/flow
[16] Since the focus of this study was electric products, metrics typical used in reference to natural gas products, such as BTUs, were not considered.
[17] DWR's water energy nexus pages: http://www.water.ca.gov/climatechange/RegionalEnergyIntensity_test.cfm
[18] http://www.water.ca.gov/climatechange/RegionalEnergyIntensity_test.cfm

- Using the performance -based training approach, the EPA is training water treatment plant operators to address programmatic drinking water resiliency rather than just technical water optimization.
- To improve the performance of their grant program, EPA's Region 3 is working with other regional offices through one-on-one assistance and training to share expertise on grants-related issues and processes.

Several published documents assist the water sector to better manage its energy use and control associated costs. The EPA uses a Plan-Do-Check-Act[19] approach that includes:

1. benchmarking and tracking monthly and annual energy use
2. identifying and prioritizing energy operations and issues that can increase efficiency
3. identifying energy efficiency objectives and targets
4. defining the performance indicator(s) to use to measure progress towards the energy targets
5. establishing energy management programs (i.e., action plans to meet goals)
6. monitoring and measuring the performance of established target(s)
7. documenting and communicating success
8. reviewing progress periodically and making adjustments as necessary

The EPA has created a guidebook that is supported by various recommended tools including Portfolio Manager, EPA Performance Track, and Cash Flow Opportunity Calculator, all of which are publicly available on the EPA website. Water purveyors can also find tools through the ENERGY STAR® program that are designed to help lower the costs associated with assessing beneficial investments for energy-efficiency improvements. These tools include guidelines for energy management, benchmarking resources, and resources to help measure and track progress. The *Energy and Environment Guide to Action: State Policies and Best Practices for Advancing Energy Efficiency, Renewable Energy, and Combined Heat and Power* (2015 Edition) provides in-depth information about over a dozen policies and programs that States are using to meet their energy, environmental, and economic objectives.[20]

The New York State Energy Research and Development Authority (NYSERDA) focused a great deal of support on improvements for water and wastewater systems because this sector reportedly consumes more than three billion kilowatts of electricity per year. [21] Priority areas of action for NYSERDA include:

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[19] U.S. EPA (2008) *Ensuring a sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities*. Publication EPA 832-R-08-002. January 2008.

[20] www3.epa.gov/statelocalclimate/documents/pdf/guide_action_full.pdf (downloaded February 9, 2016)
www3.epa.gov/statelocalclimate/documents/pdf/guide_action_chapter3.pdf
www3.epa.gov/statelocalclimate/documents/pdf/GTA_Chapter_4.2_508.pdf

[21] www.nyserda.ny.gov/Communities-and-Governments/Communities/Municipal-Water-and-Wastewater

- working closely with the consulting engineering firms to promote innovative and energy-efficient technologies in New York
- helping municipalities address regulatory pressures to decrease nutrients in wastewater
- developing innovative ways to disinfect water
- optimizing performance to improve efficiency and increase water- and wastewater-treatment capacity

NYSERDA has conducted several case studies and from these has developed a variety of tools and materials offered through its Municipal Water and Wastewater Program to assist operators and municipal officials with understanding energy efficiency. [22] In collaboration with WRF, NYSERDA prepared the *Efficiency Best Practices for North American Drinking Water Utilities*, which exhaustively discuss energy efficiency best practices in several areas critical to water systems and lists actions that can be taken in each of these areas.[23]

With pumping representing the largest percentage of energy demand for water systems, EPRI in collaboration with WRF examined cases that showed significant savings opportunities of as much as 30 percent.[24] As part of the EPRI/WRF study, several energy management opportunities were listed that the EPRI team determined to provide significant energy savings potential, including several for electro-technologies as seen in table 2.

[22] www.nyserda.ny.gov/Communities-and-Governments/Communities/Municipal-Water-and-Wastewater/MWWT-Tools-and-Materials

[23] Leiby, Vanessa and Michael Burke (2011) Energy Efficiency Best Practices for North American Drinking Water Utilities, Water Research Foundation and New York State Energy Research and Development Authority, ISBN 978-1-60573-159-9, 2011.

[24] WRF (2010) Energy Efficiency in the Water Industry: a Compendium of Best Practices and Case Studies. Web Report #4270. Prepared for the UK Water Industry Research Limited. 2010.

Table 2 Energy Management Opportunities

Energy Efficiency and Demand Response	Emerging Technologies and Processes	Energy Recovery and Generation
• Strategic Energy Management • Data Monitoring and Process Control • Water Conservation • High-Efficiency Pumps and Motors • Adjustable Speed Drives • Pipeline Optimization • Advanced Aeration • Demand Response	• Odor Control • Membrane Bioreactors • Deammonification Sidestream Process • Water Reuse • Residuals Processing • Microbial Fuel Cells • LED UV Lamps	• Cogeneration Using Digester Biogas • Use of Renewable Energy to Pump Water • Recovery of Excess Line Pressure to Produce Electricity

2.3 Available Funding

After labor, energy is the highest operating cost for water and wastewater service providers.[25] The study team primarily investigated current estimates for investment needs and available funding for water supply, but information regarding wastewater infrastructure is included. Most of this information was collected from reports and technical papers developed by the EPA and ASCE. The team also included information on the major funding programs that support projects that could address water infrastructure improvement needs. Funding opportunities were compiled based on information available from state, federal, and local government websites and press releases as of December 31, 2015. Additional information on available funding specifically available for water and wastewater utilities can also be found at EPA's Water Infrastructure and Resiliency Finance Center located at www.epa.gov/waterfinancecenter.

Commonly identified funding resources used by urban water utilities to finance infrastructure projects include:

- financial incentives: rebates, performance-based funds
- loan programs: revolving loans, energy performance contracts
- bonds: municipal, tax exempt, and green
- utility operating funds derived from rates revenues

Reviewing this information clearly shows the gap between investment needs and available funding resources. It is estimated that more than $600 billion dollars are needed over the next 20 years for utility professionals to address current issues with these systems and update

[25] WRF (2011) *Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies,* Published by WRF for Global Water Research Coalition, Web Report #4270. March 2011.

America's drinking water and wastewater systems. In July 2014, the Obama administration launched the Build American Investment Initiative to find new ways to increase investment in American's infrastructure, including water supply systems.[26] Through this initiative, the government intends to facilitate partnerships between federal, state, and local agencies, and the private sector. Also, the EPA launched the Water Infrastructure and Resiliency Finance Center.[27] Using federal grants to attract private capital, this center promotes public-private partnerships to support more effective investments in water systems and water quality improvements. To ensure that these investments do not simply build what existed before, decision makers and investors need to understand technological advances that can move our water infrastructure into the 21st century.

2.3.1 New Funding Opportunities

To bridge this gap, the federal government, private organizations, state agencies, and utilities (energy and water) seek permanent fixes to our infrastructure funding problem. Recent efforts have focused on innovative public-private partnerships, creating new opportunities for investors interested in building resiliency, and adapting to climate change (green bonds).

[26] "FACT SHEET: Increasing Investment in U.S. Roads, Ports and Drinking Water Systems through Innovative Financing", The White House Press Release dated January 16, 2015. Downloaded February 2016: https://www.whitehouse.gov/the-press-office/2015/01/16/fact-sheet-increasing-investment-us-roads-ports-and-drinking-water-syste

[27] www.epa.gov/waterfinancecenter

3. Urban Water System Efficiency Survey

The project team's approach to the development and implementation of the urban water supplier survey relied on input from NEMA members, AWWA leadership, and initial findings associated with the literature review. The survey sought direct input from water supplier representatives about the status of their systems, system operations and energy usage, history of energy efficiency efforts, and the level of interest in energy efficiency. Information derived from this survey was subsequently used in gauging the possible national energy savings that could be obtained by advancing the use of energy efficient equipment and controls.

3.1 Survey Preparation

3.1.1 Input for Survey Development

3.1.1.1 NEMA Working Group

- NEMA and the Hydraulic Institute work closely with regulators and manufacturers on efficiency standards related to a variety of equipment used by the water sector.

- Some NEMA members find it difficult to market products directly to the water sector. Even if the operator knows of products that will improve overall efficiency, the purchasing decision process requires the plans go to bid, be subject to cost comparisons, and be evaluated against other factors.

- Customers do not always realize expected savings of retrofitted systems because new devices are not properly integrated into the existing system through recommended retooling and calibration of the components together.

- Focus groups, communications and outreach efforts, technology demonstrations, public-private collaboratives, and utility networking activities provide opportunities to overcome the challenge with the current mindset regarding performance and offers an opportunity for educating consumers about how best to obtain efficient product performance.

- Some NEMA members interviewed are advocating a "systems" approach with their customers that captures the duty cycle, establishes a baseline for loss, and then implements ways to reduce losses. By considering the full train, including motor, drive, and pump, the system can be properly synced and tuned together, producing more efficiency than achieved by only looking at the efficiency of individual components within a system.

- The current market structure poses challenges to advancing system energy efficiency. For example, some NEMA members make parts for other manufacturers or original equipment manufacturers (OEMs). Rarely do the component manufacturers interact directly with an end-use customer. Also, OEMs— those that make equipment from component-parts manufacturers— tend to focus on lowest price, then reliability, and then lowest energy usage, in that priority order. Also, water utilities tend to work with consultants on system designs, modifications, and equipment decisions, rather than directly with manufacturers and OEMs.

- Procurement mechanisms can result in significant time between decisions to initiate a project with defined goals and the ultimate equipment purchasing decisions. If the value engineering is not supported and re-enforced throughout the entire process, which can take years, other factors (e.g., budgets, staff biases, and project modifications) may overwhelm efficiency goals.

- User-friendly, on-line tools need to be available so that operators and others may explore various technologies and their applications.

- Training operators and other staff can build a greater understanding of various technologies and their use. These tools need to be technology focused, put in the context of issues the operators are facing, and be brand agnostic.

- Some advocates recommend going beyond current marketing methods (e.g., trade shows, magazine ads, and vendor catalogs) to create a forum that connects manufacturers with end users. This approach would bring together studies that support alternative marketing methods with research that demonstrates the feasibility of technological advances. Others have held their own user events to address customer needs and experiences to help them to achieve their production, financial, conservation, etc. goals.

- Three NEMA members are providing ESCO services to water sector clients.

- Known barriers to increased modernization and improvements of water utilities include the cost of advanced energy efficient equipment, meters and control systems, and procurement processes.

- The level of interaction among those interviewed varies from those that have no direct contact with water utilities to those that have extensive and varied interactions such as one-on-one meetings, participating in planning efforts and demonstration projects, conducting research in collaboration with water utilities, and conducting technical training.

3.2 Urban Water Supplier Survey Instrument

In early January 2016, a survey was sent to more than 3,000 utility contacts in the U.S. and 19 in Canada. The survey request was also forwarded to representatives of AWWA seeking their assistance in promoting participation.

When it became apparent that survey responses were not returned as expected, follow-up emails and personal calls were made to increase the response rate. The study team also conducted a raffle for those that participated to incentive responses. High response rates to surveys occur when the surveys are short and simple, asking for opinions or readily available information. This was not the case here. The information requested could only be obtained by seeking out multiple staff members in different departments of the utility.

In all, the study team received responses or partial responses from 65 utilities across the U.S. and Canada (see figure 5). All sizes of systems responded, from small systems of less than 1,000 connections to large utility systems of half a million or more. Ultimately, the study team obtained 49 responses that were complete or nearly complete. Eight respondents refused to identify themselves by name, although they did fill out parts of the survey.

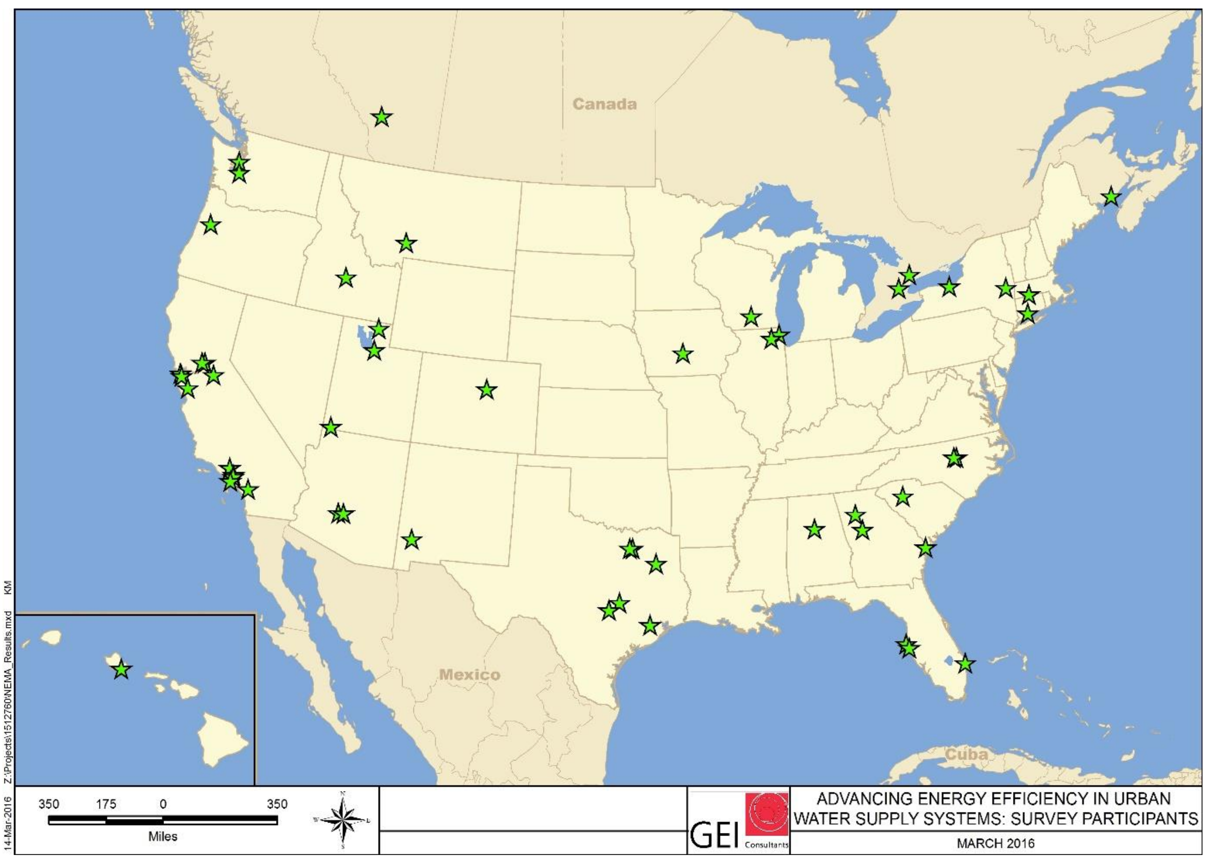

Figure 5 Distribution of Survey Respondents

3.2.1 Respondents' Informal Feedback

During the study team's conversations with utilities, it received some informal feedback from the respondents. This feedback fell into the following categories:

1. The information requested was detailed and not readily available in one place.
2. Many respondents did not have easy access to the requested information and were not able to obtain it within the time frame provided.
3. Many utilities are reluctant to release specific information for public viewing or attribution.
4. The survey was too long and not all the questions could be answered easily in the time provided.

3.2.2 *Approval Barrier to Utility Procurement of Energy-Efficient Equipment*

One question asked utilities who had the decision-making authority to purchase energy-efficient pumps and other equipment, provided that the payback period was satisfactory. Only 12 percent of the respondents indicated that the Distribution System Manager or Director of Operations had that authority. That is an important finding, but not a particularly surprising one.

According to the EPA, there are approximately 155,000 public water supply systems in the U.S. with 15 or more service connections.[28] The water industry is thus highly fragmented and largely supplied through publicly-managed entities on either a municipal or regional basis. This structure is unlike the energy industry, which is served primarily by larger investor-owned companies in the electric and natural gas sectors and often has state oversight agencies.

The governance model of municipal and regional water suppliers varies. In some cases, an elected board of directors oversees employees. In other cases, the water board directors are appointed by the local mayor or city council; and in other cases, the city council itself serves as the governing body for the utility.

The effect of this governance model is political. Elected officials are inherently responsive to the citizens they serve; in the case of water utilities, the voters and the system ratepayers are usually the same people. Thus, purchasing decisions of any magnitude are made in full public view with the opportunity for public involvement. Moreover, large purchases for approval on the agenda bring out the public.

A general manager of a utility typically has signature authority for a certain dollar amount. Budgeted line items within that signature authority are certainly within his or her jurisdiction and do not need to go again before the board. Often $25,000 is the ceiling beyond which separate purchase approval must be obtained from the board, and vendor bids are usually required before that purchase approval can finally be granted. For small utilities, the signature authority limit may be lower.

Consequently, large purchases over the signature authority show up on water board meeting agendas as a matter of law. Often these purchases become controversial to the ratepayers because of the size of the investment and the perceived lack of immediate benefit. Here are some of the reasons why energy-efficient pump purchases may drop to the bottom of a board priority list:

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[28] www.epa.gov/dwreginfo/information-about-public-water-systems

1. Operating fund revenues are declining across the country because of reduced water consumption.
2. Most publicly-elected water board officials are reluctant to approve continual increases in consumer rates for fear of voter reprisal.
3. With a limited operating budget, projects compete for board member approval.
4. The availability of federal, state, or regional financial incentives can change this picture dramatically.
5. The business case for positive energy efficiency benefits is much hard to make for a water utility considering other priorities.
6. Purchasing energy efficient equipment through an operating budget poses challenges not faced with debt-financed investments.
7. Asset Management is not well funded in many small to medium sized utilities.

4. Market Potential for Electricity Efficiency in Urban Water Systems

This section is available as a separate NEMA white paper.

5. Use of Performance Contracts for Advancing Efficiency in Water Infrastructure

This section is available as a separate NEMA white paper.

Appendix A

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