NEMA Strategic Initiative

Increasing Energy Efficiency in Urban Water Supply Systems

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Preface

The National Electrical Manufacturers Association (NEMA) is the association of electrical equipment and medical imaging manufacturers, founded in 1926 and 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 provides a forum for the development of technical standards that are in the best interests of the industry and users, advocacy of industry policies on legislative and regulatory matters, and collection, analysis, and dissemination of industry data. NEMA supports these actions through strategic initiatives that advance knowledge and understanding to identify strategies and actions that advance their memberships' goals.

To support NEMA's strategic initiative related to the relationship of electricity and water in urban water systems, NEMA selected GEI Consultants and its partners, the Alliance for Water Efficiency and M.Cubed, to assist in analysis of issues. This initiative seeks to:

- Quantify the 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 NEMA member products.
- Reevaluate the viability of applying energy savings performance contract practices to finance modernization upgrades. This report presents the results of the project team's analysis and conclusions.

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. To accomplish this, the study team analyzed 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 practices, other financing mechanisms, and government grants to finance modernization 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 exist to apply best management strategies to improve energy performance of these systems. The survey was distributed to more than 3,000 agency representatives nationwide but for a variety of reasons had limited response. These respondents, however, 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 Energy Savings Performance Contracts 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, and the development of plans with measureable 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 (U.S.) to supply reliability, quality, and 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."[1] 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 with the cost of energy a significant portion of a utility's operational budget, investing in more energy efficient technology can help to lower ongoing costs.

As part of its strategic initiative to advance energy efficiency in urban water supply systems, the National Electrical Manufacturers Association (NEMA), supported by GEI Consultants, Inc. (GEI), 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.

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

- Evaluate the viability of applying energy savings performance contract (ESPC)[2] practices to finance modernization upgrades.

The study team conducted three primary tasks as part of this project: 1) 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., 2) 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 3) an analysis of the use of 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. We also interviewed a number of 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 applied the following methodology to identify and compile relevant resources:

- 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.
- Revisited terms and revise periodically, refine, and update as needed.

[2] Energy Savings Performance Contracts are a financing mechanism used by Energy Service Companies (ESCO) to make energy efficiency upgrades to facilities on behalf of the owner which are then paid for using money resulting from the energy savings. For more information see: http://energy.gov/eere/slsc/energy-savings-performance-contracting.

- Critically reviewed/analyzed materials to determine relevance to the defined goal and objective:
  - Focus of the documents
  - Scope of the study or analyses
  - Findings/Results
- Compiled the results in an Excel spreadsheet

Literature collected had to be 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 can be easily accessed by the public and is not confidential. These constraints ensure that research that is obscure, too narrowly focused or overly technical, or purely in the conceptual phases of research are not included in this effort.

The scope of the investigation was primarily focused on research conducted within the U.S. This criterion ensures that the research collected captures the issues that are relevant to the country's urban water supply systems. When appropriate, the study team determined that information contained within a non-U.S. resource provide information applicable to U.S. systems and thus was included it in the compiled literature. In addition, several relevant reports and documents included address energy efficiency in both water and wastewater systems because these systems use similar equipment such as pumps, motors, and meters. The study team also included guidebooks and compilations that summarize case studies and information on best practices. Finally, the database was catalogued by paper title; author(s); sponsoring or authoring organization; date of publication; primary subjects discussed; the area of study relevance; a summary of results or key points; and links to the internet source of the document.

Several informative sites were identified as part of this task and include:

- Alliance for Water Efficiency (http://www.allianceforwaterefficiency.org)
- Alliance to Save Energy (http://www.ase.org)
- American Council for an Energy-Efficient Economy (ACEEE) (http://aceee.org/topics/water-and-wastewater)
- ASCE (http://www.asce.org/)
- AWWA (http://www.awwa.org)
- Consortium for Energy Efficiency (http://www.cee1.org)
- Electric Power Research Institute (EPRI) (http://my.epri.com/portal/server.pt)
- New York State Energy Research and Develop Authority (NYSERDA) (http://www.nyserda.org)
- U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy (http://energy.gov/eere/office-energy-efficiency-renewable-energy)
- U.S. Environmental Protection Agency (EPA) (http://www3.epa.gov/)

- Water Research Foundation (WRF) (http://www.waterrf.org/Pages/Index3.aspx)

1.1.2 Urban Water Supplier Survey

The project team sought to compile a comprehensive list of qualified prospective respondents for the survey. Specifically, the team looked to target 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, contact information was requested for the right individuals to respond to the survey. The project team also conducted research to compile a list of all the 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 made calls to each utility to request an appropriate contact to complete the survey, assembling a list of 92 individuals. To this growing list of potential respondents, the project team added approximately 2,800 utility managers and consultants working on utility distribution systems and water loss control.[3] 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 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.

1.1.2.1 Survey Design

The project team put careful thought into designing a survey that would be user-friendly and easy to complete within a short timeframe, despite the complexity of the data requested. After evaluating available options, the team selected Survey Monkey® as the platform in which to build the survey. Survey Monkey® allowed the team easy assembly and revisions,

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

and presented the survey in an attractive and inviting format that does not intimidate the respondent. Survey Monkey® also allows for various analytical methods to process results and present insights.

The survey was also deliberately designed into three distinct sections (General Agency, Water, and Energy) to guide the respondent, with three to five questions per page. Once assembled, the survey was reviewed in preview mode by the full project team and amended several times to enhance the user experience and to ensure that responses would enable the analysis needed.

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 can 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 among the urban water supply sector is specifically needed to determine beneficial investments and potential funding mechanisms for these improvements.

The approach used by the study team included the following steps:

1. Extract known information regarding electrical usage of urban water suppliers collected during the review of available literature, interviews with NEMA Working Group Members[4], and the Survey of Urban Water Suppliers.

2. Using available rate information and water usage data, the study team computed the average water cost for the largest 50 cities.

3. From data developed in steps 1 and 2, determined 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. Considering information obtained through water supplier survey responses and other case studies, determined the cost effectiveness and energy savings potential.

1.1.4 Evaluating the Viability of Energy Service Companies in the Water Utility Sector

Energy service companies (ESCOs) are an existing market mechanism to deliver increased energy savings within various market segments, most popularly used in the building

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

management sector. ESCOs can be a fruitful means of promoting adoption of advanced electricity technologies among water utilities. This study sought information regarding and assessed the viability of ESCOs, and to the extent possible, other financing mechanisms and government grants to finance modernization upgrades. Although some NEMA member companies offer ESCO type services to water utilities, little information is available on specific outcomes associated with the application of these mechanisms to urban water supply systems.[5] Rather, the study team looked to how these contract practices have performed in other markets to gauge the potential opportunities for expansions in this market. In addition, the team assessed the unique organizational structures of water utilities that may have impeded the ESCO market in this sector. From this information, input from NEMA Working Group Members, and Water Utility Survey results, the study team assessed the viability of ESCOs to achieve modernization upgrades in urban water supply systems, and provided recommendations on possible actions NEMA may want to consider to capitalize on this opportunity.

[5] We are aware of several firms, including NEMA members Itron and Siemens, providing energy service performance contracts to water suppliers; however, the ESCO industry generally serves the building management sector, as discussed below. The National Association of Energy Service Companies (NAESCO) has over three dozen members.

2. Urban Water Supply Systems

In 2010, the water use in the United States was estimated at approximately 355 billion gallons of water a 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.

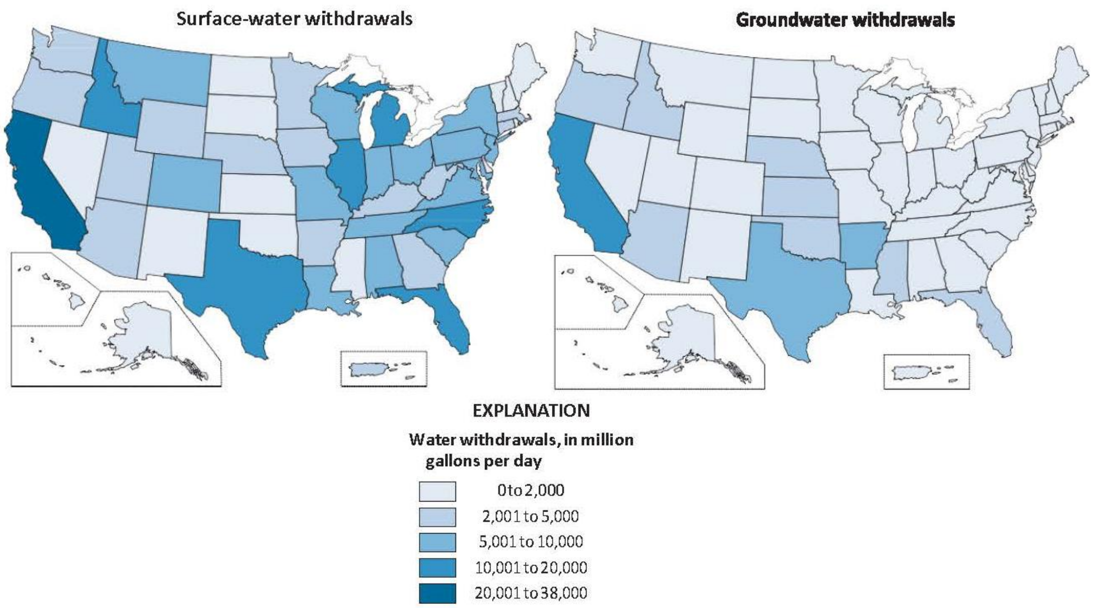


Figure 1 Water Withdrawals to Meet US Demand. Source- USGS 2014.

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 U.S. EPA reported that 93 percent of U.S. residents are served by community water systems (CWS), the remaining seven percent are 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 U.S. EPA conservatively estimates that over the next 20 years more than $380 billion will need to be invested in US water systems.[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., http://dx.doi.org/10.3133/cir1405.
[7] U.S. EPA (2015) *National Water Program Best Practices and End of Year Performance Report,* Fiscal Year 2014, published June 2015.
[8] U.S. EPA (2013) *Drinking Water Infrastructure Needs Survey and Assessment –Fifth Report*.

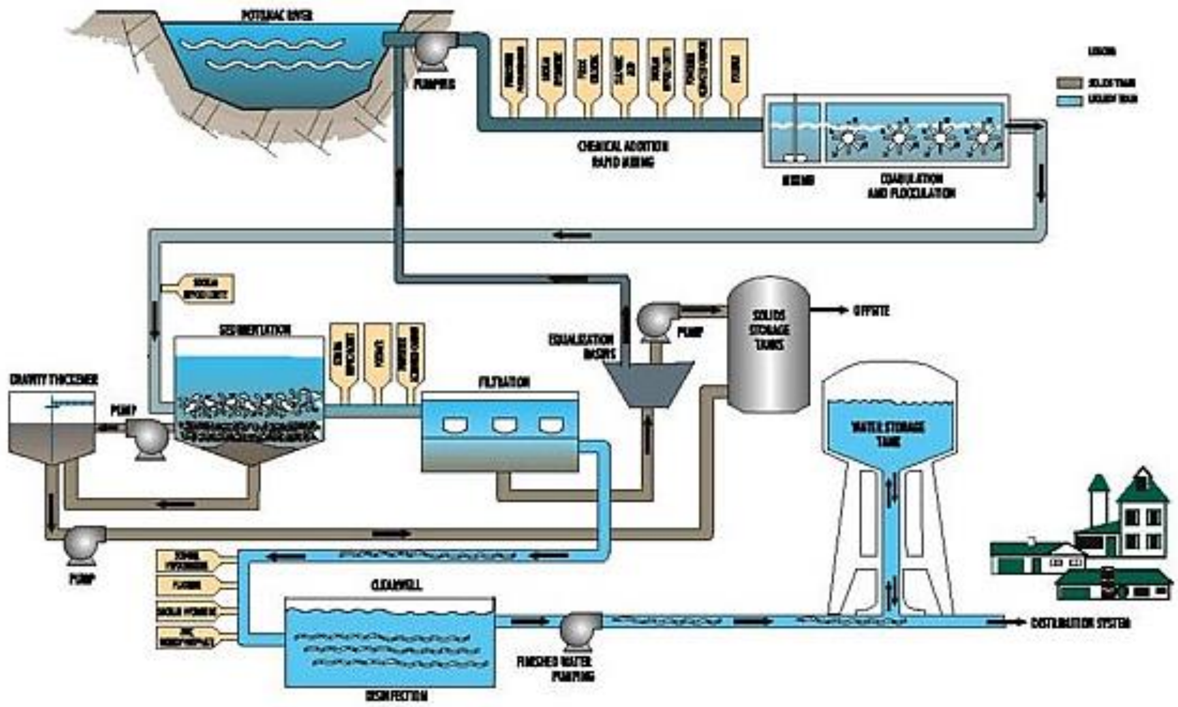
Table 1 Size Categories of Community Water Systems[9]

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%**

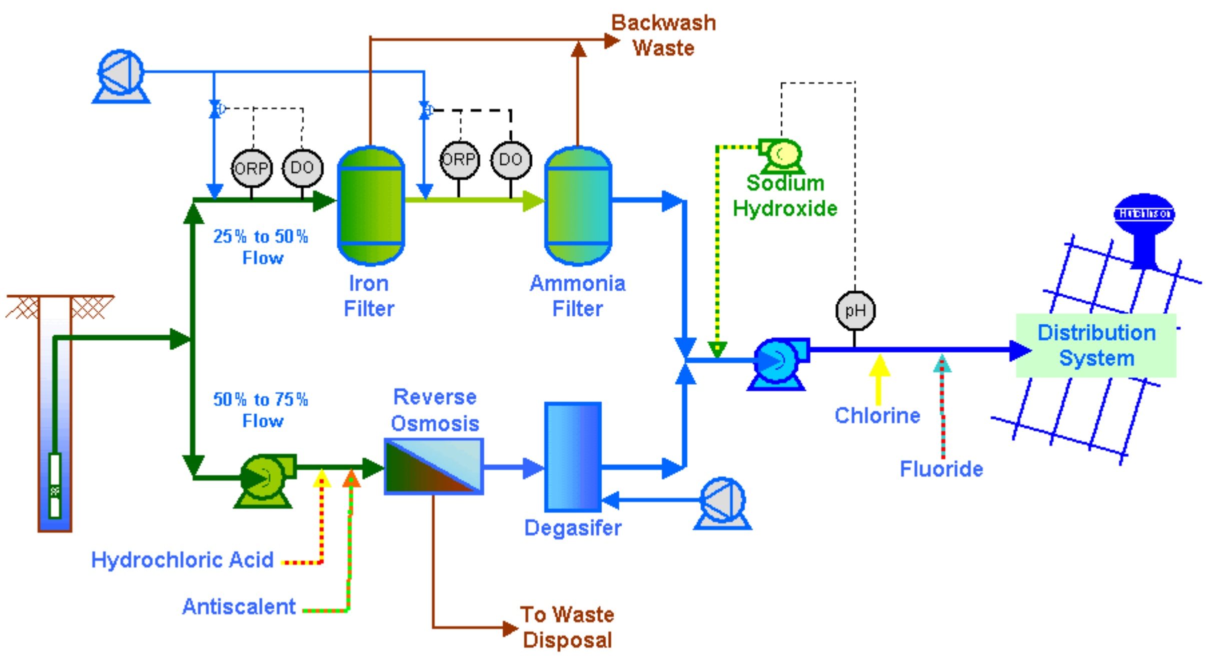
The infrastructure needed to develop, collect, treat, and deliver our water supplies includes reservoirs, pipes, storage tanks, treatment plants, pumping facilities, meters, sensors, electrical controls, buildings, and a variety of devices. Water systems vary in terms of design, size, treatment approach, 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 just 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 (Goal 1a) 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 (Goal 1d). 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 http://www.leesburgva.gov/government/departments/utilities-water-sewer/about-us/water-supply/water-supply-operations#WaterSystem
[11] http://www.health.state.mn.us/divs/eh/water/com/waterline/waterline_spring2007.pdf



Kenneth B. Rollins Water Treatment Plant



Hutchinson Water Plant

Figure 2 Example Urban Water Supply System

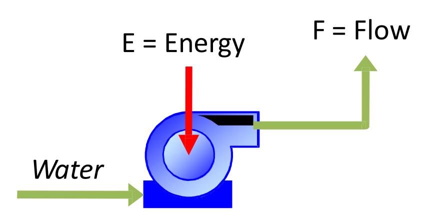
Despite the lack of details, it is important to recognize that urban water supply systems are not the same. Each system is designed and operated to meet the requirements of its community and geography. It is also important to note that the primary responsibility of water suppliers is to produce and deliver 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. In addition, buildings used by these water suppliers for administration services and system operation have similar energy consuming equipment as other 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. According to its study, EPRI estimated that between 55 - 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 where demand was approximately 28.3 billion kWh/yr. Thus, these utilities represent clear opportunities for energy efficiency improvement and investment.

2.1 Energy Intensity of Water Systems

Illustrative Energy Intensity Calculation for a Pump

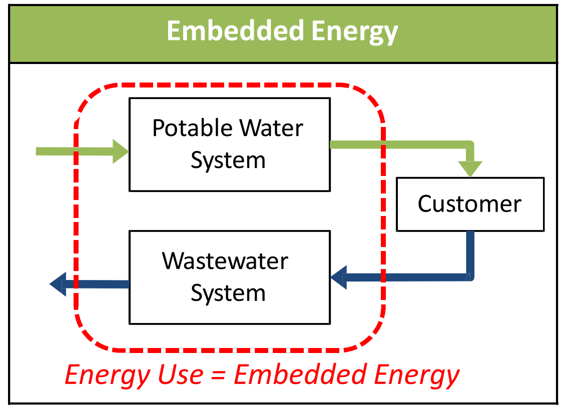


$$EI = \frac{E}{F}$$

Energy intensity is the term used to describe the amount of energy used to move or treat water. In the context of urban water supply systems, energy intensity is used to compare 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

[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.

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 used to provide water to end users and the amount of energy that is used to collect and transport wastewater for treatment prior to safe discharge of the effluent. Embedded energy captures the entire energy picture both upstream and downstream of an end use customer. This concept is useful in quantifying energy savings as a result of water savings (water saved x 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.

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 (m3) or in the case of our Canadian neighbors, liters (L). Regardless of the metric chosen, all metrics can easily be converted to the others.

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 MGD or AF, but by gallons or cubic feet per second (cfs).[14] When considering the performance of a given piece of equipment in a system such as a pump or motor, these metrics do not necessarily apply. Consider the parameters used to measure the performance of a pump as described by HIS Engineering 360 (http://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 ration of useful power versus required power).[15]

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

[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] http://www.globalspec.com/pfdetail/pumps/flow

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 MG per day (MGD) or AF per year (AFY). All energy consuming devices used in 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 much this energy intensity can vary depending on water source, geography, system design and end use (see Figure 3). 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]

[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

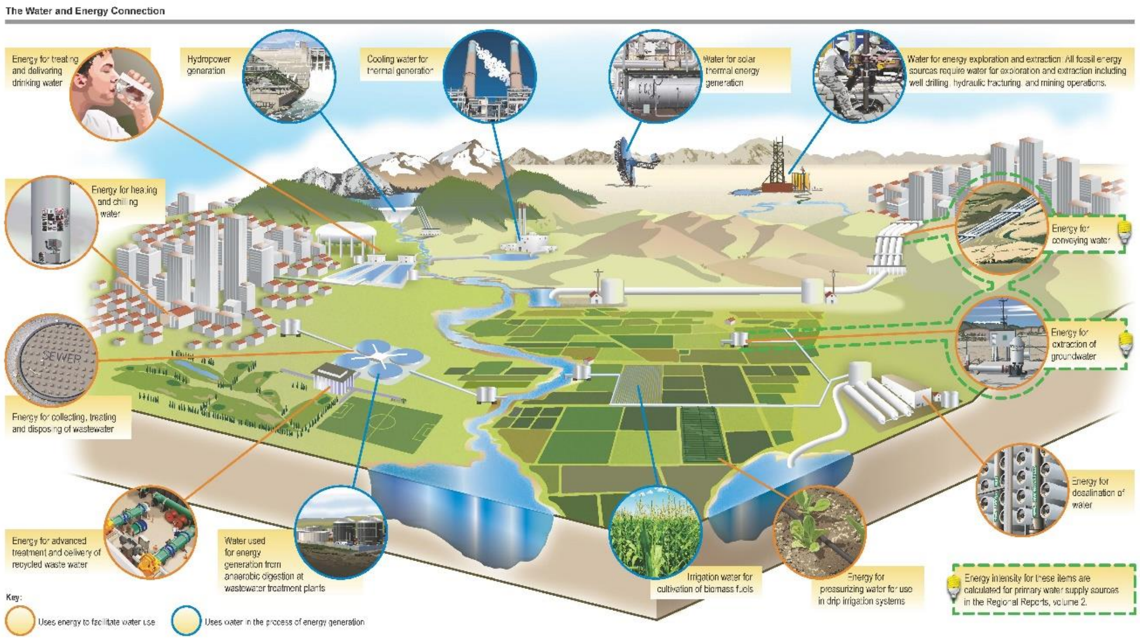

Figure 3 DWR Water and Energy Connection[19]

DWR is seeking voluntary reporting of energy intensities associated with water systems in Urban Water Management Plans required to be produced by urban water suppliers (California Water Code §§10631.2(a)). To aid those that are also reporting their greenhouse gas emissions, the Climate Registry (TCR) has developed a reporting protocol for measuring emission associated with energy embedded in water supplies. The metric being promoted by both the DWR and TCR is to report water deliveries by water purveyor (both public and private) is in AF or AFY.[20] As for the electricity-related metric used, both the DWR and TCR are recommending kilowatt-hour (kWhr). This works well for evaluating the demand per unit water delivered or produced, whether at the AF or MG level. It is also easily converted to megawatt-hour (MWhr)[21] when discussing total demand over a period of time for an entire system. For the purposes of this study, the team favors the use of kWh/MG, but also reports some information in terms of AF.

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[19] http://www.water.ca.gov/climatechange/WaterEnergyStatewide.cfm

[20] DWR (2015) Appendix O - Voluntary Reporting of Energy Intensity, Draft Urban Water Management Plan Guidance, July 27, 2015 http://www.water.ca.gov/calendar/materials/appendix_o_voluntary_reporting_of_energy_intensity_19545.pdf

[21] MWh = 1,000 kWh

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 these utilities. The U.S. EPA has identified and is implementing its best practices to improve water systems throughout the country. They define a best practice "as a process or methodology that consistently produces superior or innovative results." These best practices include:

- Using the Performance Based Training (PBT) approach, U.S. 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, U.S. 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 documents have been prepared and published that seek to assist the water sector to better manage their energy use and control associated costs. U.S. EPA[22] uses a Plan-Do-Check-Act 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 your energy targets.
5. Establishing energy management programs (i.e., action plans to meet your goals).
6. Monitoring and measuring the performance of your established target(s).
7. Documenting and communicating success.
8. Reviewing your progress periodically and making adjustments as necessary.

U.S. EPA has created a guidebook, supported by various tools it recommends using, including Portfolio Manager, EPA Performance Track and Cash Flow Opportunity Calculator, all of which are publicly available on its website. Water purveyors can also find tools through the U.S. EPA's ENERGY STAR program which are likewise designed to help them 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

[22] 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.

information about over a dozen policies and programs that States are using to meet their energy, environmental, and economic objectives.[23]

The New York State Energy Research and Development Authority (NYSERDA) has focused a great deal of support on improvements for water and wastewater systems because this sector reportedly consumes more than 3 billion kilowatts of electricity per year. [24] Priority areas of action for NYSERDA include:

- 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. [25] 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.[26]

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.[27] 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.

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

[24] http://www.nyserda.ny.gov/Communities-and-Governments/Communities/Municipal-Water-and-Wastewater

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

[26] 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.

[27] 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

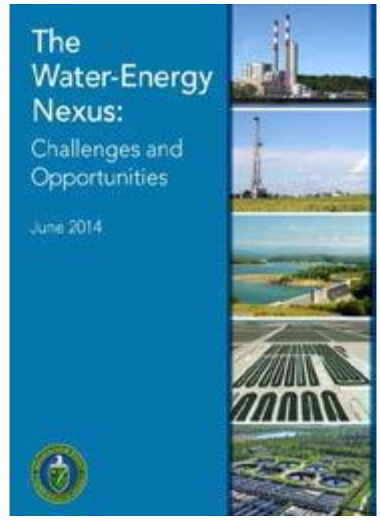
Energy Efficiency and Demand Response	Emerging Technologies and Processes	Energy Recovery and Generation
• Strategic Energy Management • Data Monitoring and Process Control • Water Conservation • High-Efficiency Pumps and Motors • Adjustable Speed Drives • Pipeline Optimization • Advanced Aeration • 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

In its fact sheet, the Center for Sustainable Systems[28] summarized solutions and sustainable alternative practices identified from several sources. These practices include:

- Major components that offer significant energy efficiency improvement opportunities include pumping systems, pumps, variable speed drives, motors, and power converters.
- Periodic rehabilitation, repair, and replacement of water distribution infrastructure would help improve water quality and avoid leaks.
- Achieve on-site energy and chemical usage efficiency to minimize the life cycle environmental impacts related to the production and distribution of energy and chemicals used in the treatment and distribution process.
- Reduce chemical usage for treatment & sludge disposal by efficient process design, recycling of sludge, and recovery and reuse of chemicals.
- On-site energy generation from renewable sources such as solar and wind.
- Effective watershed management plans to protect source water are often more cost-effective and environmentally sound than treating contaminated water. For example, New York City chose to invest between $1-1.5 billion in a watershed protection project to improve the water quality in the Catskill/Delaware watershed rather than construct a new filtration plant at a capital cost of $6-8 billion.
- Less than 4 percent of U.S. freshwater comes from brackish or saltwater, though this segment is growing. Desalination technology, such as reverse osmosis membrane filtering, unlocks large resources, but more research is needed to lower costs, energy use, and environmental impacts.

[28] 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

Other viable strategies can include using process waste heat, excess system pressure or biowaste products to generate onsite electricity. This opportunity may be particularly attractive for combined water/wastewater utilities. Another option emerging with the decentralization of electricity grid management is to use the ability to store and release water and to manage pump load levels and timing to provide energy storage to the grid. This service will become more valuable as the amount of residential and on-site renewable power which requires smoothing of power output increases on the local network. Many of the reports produced by U.S. DOE have contributed to the development of their strategic pillars regarding the Water-Energy Climate Nexus[29]:



- Optimize the freshwater efficiency of energy production, electricity generation, and end use systems
- Optimize the energy efficiency of water management, treatment, distribution, and end use systems
- Enhance the reliability and resilience of energy and water systems
- Increase safe and productive use of nontraditional water sources
- Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts
- Exploit productive synergies among water and energy systems

According to the 2014 report, the decision-making landscape is characterized by market drivers and institutional factors:

Market Drivers
- Water prices and development costs
- Fuel prices and operational costs
- Financial Incentives & funding mechanisms

Institutional Factors
- Water rights and quality
- Regulatory requirements and mandates
- Increasing demands
- System conditions (including age)

To address these and many other issues examined in this report, U.S. DOE recommended several steps; some are noted here that should be of interest to NEMA because of their ability to participate in these activities and have an influence on their success.

- Pursue R&D priorities in technology and modeling.
- Develop in-depth roadmaps and/or technical specifications.

[29] U.S. DOE. 2014 – The Water-Energy Nexus: Challenges and Opportunities, June 2014. Downloaded from http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf. See also Bauer, Diane. 2014. "Water-Energy Nexus: Challenges and Opportunities" Water-Energy Tech Team, Office of Energy Policy and Systems Analysis, U.S. Department of Energy, September 5, 2014.

- Develop systems analyses that bridge between policy and technology opportunity.
- Incorporate regionality into identification of needs and delivery of tools and resources.
- Pursue productive collaborative relationships across the federal government, states, local entities, tribes, the private sector, etc.

2.3 Available Funding

After labor, energy is the highest operating cost for water and wastewater service providers.[30] The study team primarily investigated current estimates for investment needs and available funding for water supply, but also found information regarding wastewater infrastructure that we chose to include. Most of this information was collected from reports and technical papers developed by the EPA and ASCE and compiled into a database. The team also included information on the major funding programs that exist to support projects that would address these needs. Funding opportunities were compiled based on information available from state, federal, and local government websites and press releases as of the end of 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: http://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 is needed over the next 20 years to bring America's drinking water and wastewater systems simply to address current issues with these systems. In July 2014, the Obama Administration launched "Build American Investment Initiative" to find new ways to increase investment in American's infrastructure, including water supply systems.[31] Through this initiative, the administration intends to facilitate partnerships between federal, state, local agencies and the private sector. In addition, the Water Infrastructure and Resiliency Finance Center[32] was launched at the

[30] 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.

[31] "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

[32] http://www.epa.gov/waterfinancecenter

U.S. EPA. Using federal grants to attract private capital, this center is promoting public private partnerships to support more effective investments in water systems and water quality improvements. Ensuring that these investments do not simply build what existed before, decision makers and investors need to understand technology 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 (both energy and water) are seeking permanent fixes to our infrastructure funding problem. Recent efforts have focused on innovative public-private partnerships, and creating new opportunities for investors interested in building resiliency and adapting to climate change (Green Bonds). For example, Southern California Edison (SCE) in collaboration with the AWWA is offering at least $1 million in 2016 to water utilities in its service territory to defray the cost of leak detection, leak repair, and other water system improvement projects.[33] This program goes beyond traditional utility programs that tended to focus incentives on the purchase of specific equipment or changing customer behavior. To encourage participation and obtain needed information, SCE is hosting a series of technical workshops with AWWA California Nevada Section to design the funding program. Depending on the results of funded projects, SCE may be able to make more funding available in the future.

As mentioned earlier, NYSERDA has collaborated with several utilities to implement projects to advance energy efficiency best practices at water and wastewater facilities. The DWR implements a Water-Energy Grant Program to provide funds to implement water efficiency programs or projects that reduce greenhouse gas emissions, and reduce water and energy use.[34] For 2016, this program has approximately $19 million to fund:

- Commercial Water Efficiency or Institutional Water Efficiency Programs.
- Projects that reduce greenhouse gas, reduce water and reduce energy use.
- Only projects with water conservation measures that also save energy.

The funding for this program is appropriated from the Greenhouse Gas Reduction Fund to the DWR to establish a grant program. AWWA is also exploring opportunities to leverage U.S. EPA's Clean Power Plan Rule to obtain infrastructure enhancement funding through their Energy Initiative.[35] For more discussion of available funding mechanisms, see Section 5 of this report.

[33] CA-NV Section AWWA - SCE Funding for Water Utility Improvements Webinar, February 24, 2016.
[34] http://www.water.ca.gov/waterenergygrant/index.cfm
[35] Carpenter, Adam (2016) EPA's Clean Power Plan Rule: A Catalyst for AWWA's Energy Initiative, and what it means for the water sector, Presentation by Adam T. Carpenter, CA-NV Section AWWA, February 24, 2016.

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 Advance Survey Preparation

Prior to preparing the survey questions, the project team sought input from the NEMA Working Group through targeted interviews. These interviews assisted the project team to understand information and resources the manufactures have regarding the known level of technology market penetration, customer adoption issues, level of interaction between the manufacturers and the ultimate user of their products, what studies they have already conducted, and what known barriers they are working to overcome in the water sector.

In addition, the project team also conducted outreach with AWWA representatives promoting new programs, including: credentialing programs; training and educations; outreach and communications; improving website and engaging more members to identify needed services; and programs of its members. Members of the team participated in an annual conference to identify partnering opportunities, level of interest in energy efficiency, and mechanisms available to facilitate increased interactions between NEMA members and end use customers.

3.1.1 Input for Survey Development

3.1.1.1 NEMA Working Group

- NEMA and the Hydraulic Institute have worked 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 to the water sector because even if the operator knows the manufacturer or pump is an efficient product, the process of purchase decisions must still go to bid, be subject to cost comparisons, and be evaluated against other factors.

- Customers do not always obtain 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, communication and outreach, technology demonstrations, public private collaboratives, and utility networking activities provide opportunities to overcome the challenge with the current mind set 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 (OEM). Rarely do the component manufacturers ever interact directly with an end use customer. In addition, these 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. In addition, 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 (budgets, staff biases, project modifications) can overwhelm efficiency goals.

- User friendly, on-line tools need to be made available to allow operators and others to explore various technologies and their application.

- Training operators and other staff can build 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 advocate going beyond current marketing methods (trade shows, magazine ads, vendor catalogues) to create a water forum that connects manufacturers with end users or supporting studies and research that demonstrates technologies and advances.

Others have held their own user events to address customer needs and experiences in order to help them to achieve their production, financial, conservation, etc. goals.

- Three NEMA members interviewed are providing ESCO services to water sector clients with success.
- Known barriers include cost of advanced energy efficient equipment, meters and control systems, procurement processes.
- 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.

Although some of the companies interviewed had performed studies or had done market research, the study team was unable to obtain copies of associated reports for consideration in this project as those reports were deemed proprietary.

AWWA Representatives

Early in this study, the study team engaged AWWA leadership directly about their efforts to advance energy management and efficiency within the water sector, interest they may have in engaging equipment manufacturers more fully, and the role that these manufacturers can play in addressing challenges being faced by operators and decision-makers. During the course of this study, the team continued to monitor and engage AWWA on their efforts and to the extent possible, include that information in this report.

Those contacted stated that the water suppliers have little interaction directly with product manufacturers, confirming what NEMA representatives had stated. Rather, the water industry tends to rely on consultants and distributors or vendors for product information. Exceptions to this may be very large system operators such as the Metropolitan Water District of Southern California, a large wholesaler serving 17 million residents in southern California. With few exceptions, AWWA representatives have little direct interaction with manufactures of products used in water systems and are not aware of any with NEMA representatives.[36]

According to the AWWA immediate Past-President, John Donahue, and CA-NV Section Executive Director, Tim Worley, greater involvement by NEMA would be welcomed.[37] Information on performance and possible applications of different technologies within water systems is welcomed directly from manufacturers and would be especially beneficial when it is put in the context of current issues being faced by water utilities and is brand neutral. This

[36] Adam Carpenter, March 2016.
[37] John Donahue and Tom Worley, November 2015.

involvement will in turn provide direct feedback to manufacturers on challenges and issues faced by this industry that they may be able to address. Areas where NEMA members can contribute their knowledge and expertise are:

- Participation in their Technical and Educational Program (i.e. development of training materials and guidebooks.
- Contributions of articles and technical papers to their publications.
- Presenting results of demonstrations and research at conferences and through webinars.
- Involvement in their standards programs.

3.2 Urban Water Supplier Survey Instrument

In early January 2016, a survey was sent to more than 3,000 utility contacts throughout the U.S. and 19 utility contacts in Canada. Responses were requested back by January 15 and several electronic reminders were sent. The survey request was also forwarded to representatives of AWWA seeking their assistance in promoting participation.

After January 15, when it was clear that survey responses were not coming in as expected, follow-up emails and personal calls were made to attempt to increase the response rate. The study team also conducted a raffle for those that participated in an effort to incentive responses. General feedback from survey participants indicated that the energy data being sought in the survey was largely not available to them, and thus the survey represented much more of a research project for the respondents than is usual for a survey of this type. High response rates to surveys generally occur when the surveys are short and simple, asking for opinions or readily available information. This was not the case here. The information being requested could only be obtained by the respondent seeking out multiple staff members in different departments of the utility. We knew that this effort would certainly not be exerted during the Thanksgiving to Christmas holiday season (and thus waited to issue the survey until after the holidays).

When we still did not receive the response that was hoped for, additional follow-up calls were made to urge participants to fill out the survey. In addition to the general contact follow-up made to all 235 utilities, specific emails and calls were made to the following utilities in an attempt to get them to respond and to discuss with them any concerns that they had. These utilities were singled out because of their size, geographic location, relationship to AWE, and perceived importance to the survey:

Completed After Targeted Outreach:

San Francisco Public Utilities Commission (CA)
Tampa Bay Water (FL)
City of Phoenix (AZ)

City of Bozeman (MT)
Cobb County Water System (GA)
City of Plano (TX)
City of Elgin (IL)
Valencia Water Company (CA)
City of Bremerton (WA)
City of Sacramento (CA)

Not Completed After Targeted Outreach:

San Antonio Water System (TX)
Denver Water (CO)
Albuquerque (NM)
DC Water (DC)
Massachusetts Water Resources Authority (MA)
Town of Acton (MA)

In all, we received responses or partial responses from 65 utilities spread all across the United States and Canada (see the map showing their locations in Figure 4). 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 was able to work with utilities across the country to obtain 49 responses that were complete or nearly complete. In eight cases, the respondent refused to give us their utility name, although they did fill out parts of the survey. The summary of responses below tallies the number of number of responses to each question.

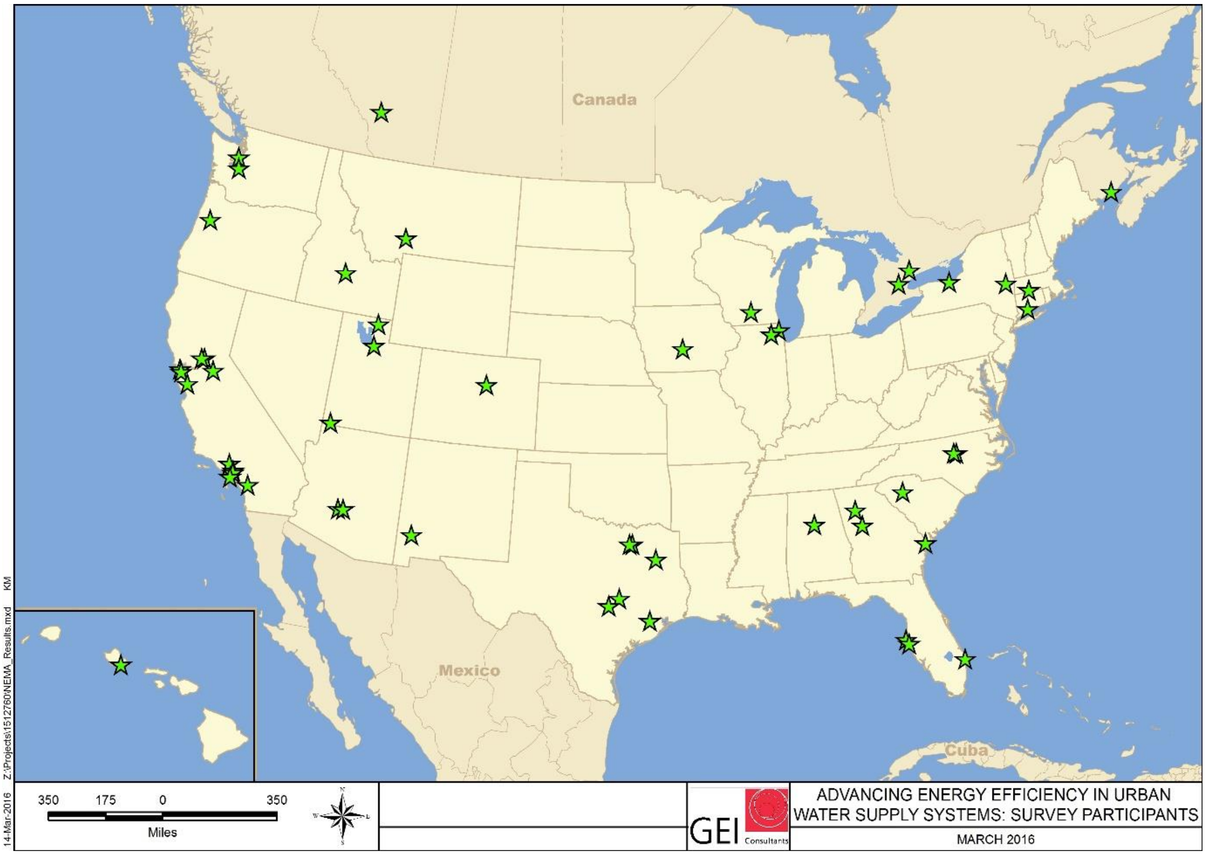


Figure 4 Distribution of Survey Respondents

3.2.1 Respondents' Informal Feedback

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

1. <u>The information requested was detailed and not readily available in one place</u>. Anytime that a utility employee has to cross departments for information, the chances of obtaining complete data dwindles appreciably. Utilities receive dozens of requests for surveys every year from a wide variety of sources, and thus only the easiest to fill out surveys get good responses rates. Those surveys that require significant research across utility departments are often not responded to.

2. <u>Many respondents did not have easy access to the requested information and were not able to obtain it within the time frame provided</u>. Many utilities are not regularly paying attention to disaggregated energy data in their utility and are not compiling or otherwise using energy information in any meaningful way for analysis, particularly in small utilities with limited resources. Even where this data is collected, it is not generally known throughout the utility where that information might be.

3. <u>Many utilities are reluctant to release specific information for public viewing or for attribution</u>. This is generally an issue, not just for the eight utilities who refused to

give us their name. Utilities are very sensitive about the amount of system information that they release to unidentified sources. Although the Alliance for Water Efficiency has a high degree of trust with its member utilities, there were still numerous questions about the intent of the project and whether their utility's information would show up in public documents or on product sales call sheets. Generally speaking, utilities are more comfortable in supplying data if they are assured that their data are anonymized. While we promised this openly right from the start, there was still skepticism.

4. The survey was too long and not all the questions could be answered easily in the time provided. We received a number of comments that the survey asked for too much information that required unbudgeted research time. To encourage a greater response rate, we urged respondents to fill out as much of the survey as they could, rather than not filling out the survey at all. Thus, a number of the energy questions were answered by less than half of the respondents since it was too difficult for them to expeditiously get the answers (see point #1 above).

3.2.2 Utility Survey Responses

Q1. Name of Utility. 65 utilities responded to this question. 8 utilities refused to give their name and entered dummy values in this field.

Q2. Total Number of Service Connections. 65 utilities responded to this question. Size ranges varied, from a low of 623 connections to a high of 870,000 connections. The majority of the responses were from small to medium sized systems.

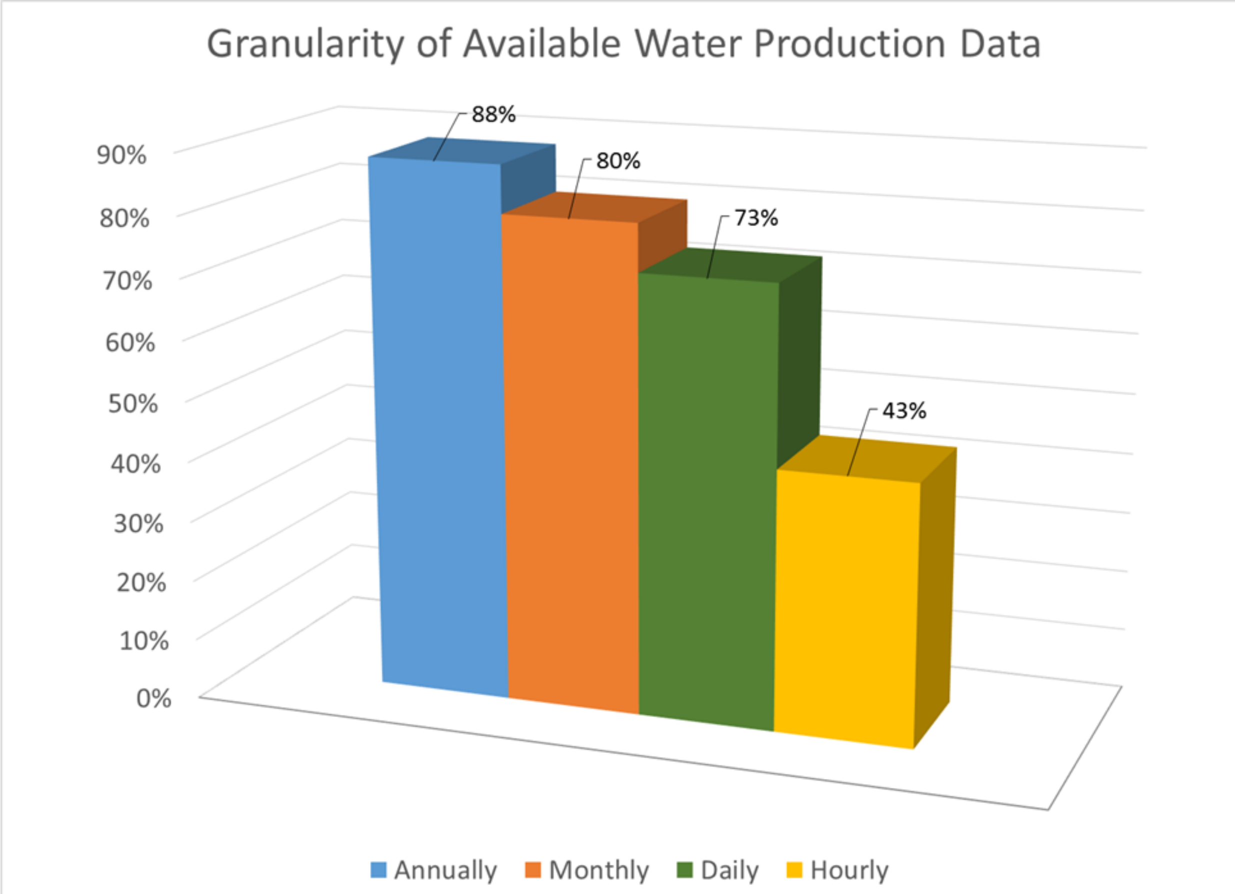
Q3. Population Served. 65 utilities responded to this question. Size ranges varied, from a low of 1,336 to a high of 40 million. The majority of the responses were from small to medium sized systems.

Q4. Unit of Measurement. 65 utilities responded to this question. 72 percent of the systems use MGD; the rest largely use AFY or a combination of both. The Canadian utilities used Cubic Meters or Megaliters.

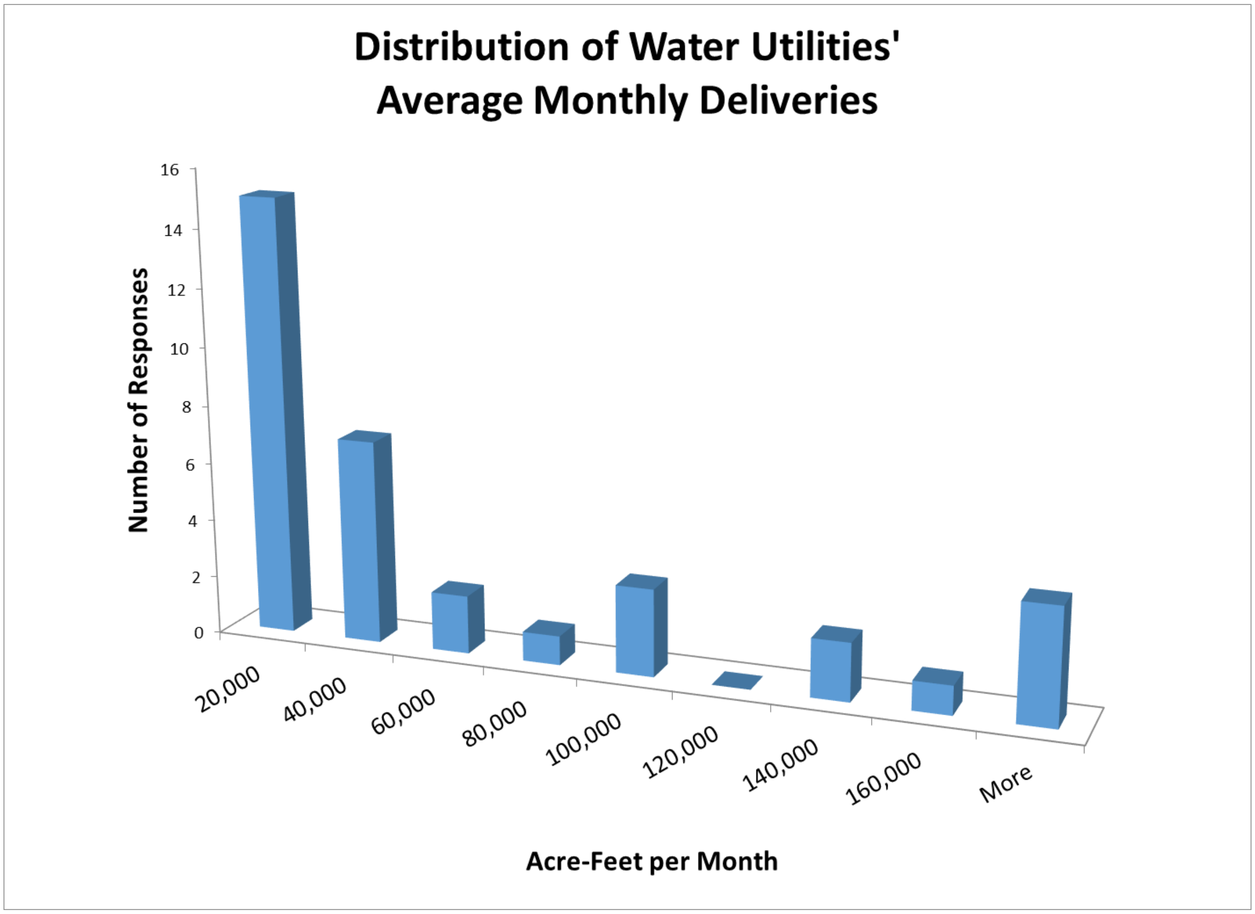
Q5. Total Current Daily Capacity. 56 utilities responded to this question. Capacity ranged from small systems (less than 1 MGD) to very large systems of 800 MGD or higher.

Q6. Type of Water System. 62 utilities responded to this question. 84 percent of the respondents served municipal customers; only 3 percent served agricultural customers. 11 percent served both.

Q7. Water Production Data. 51 utilities responded to this question. 88 percent of the respondents reported being able to readily supply annual metered water production data, 80 percent could provide it on a seasonal basis, 73 percent could provide monthly metered data. Interestingly 43 percent of respondents have hourly metered data available.



Q8. Total Annual Average Water Production Volume by Supply Source. 35 utilities responded to this question. Most respondents have smaller utility systems, with 43 percent delivering less than 20,000 acre-feet per year; however, the distribution is bi-modal, with four of the responding utilities producing more than 160,000 acre-feet per year, with the largest at 430,000 acre-feet.

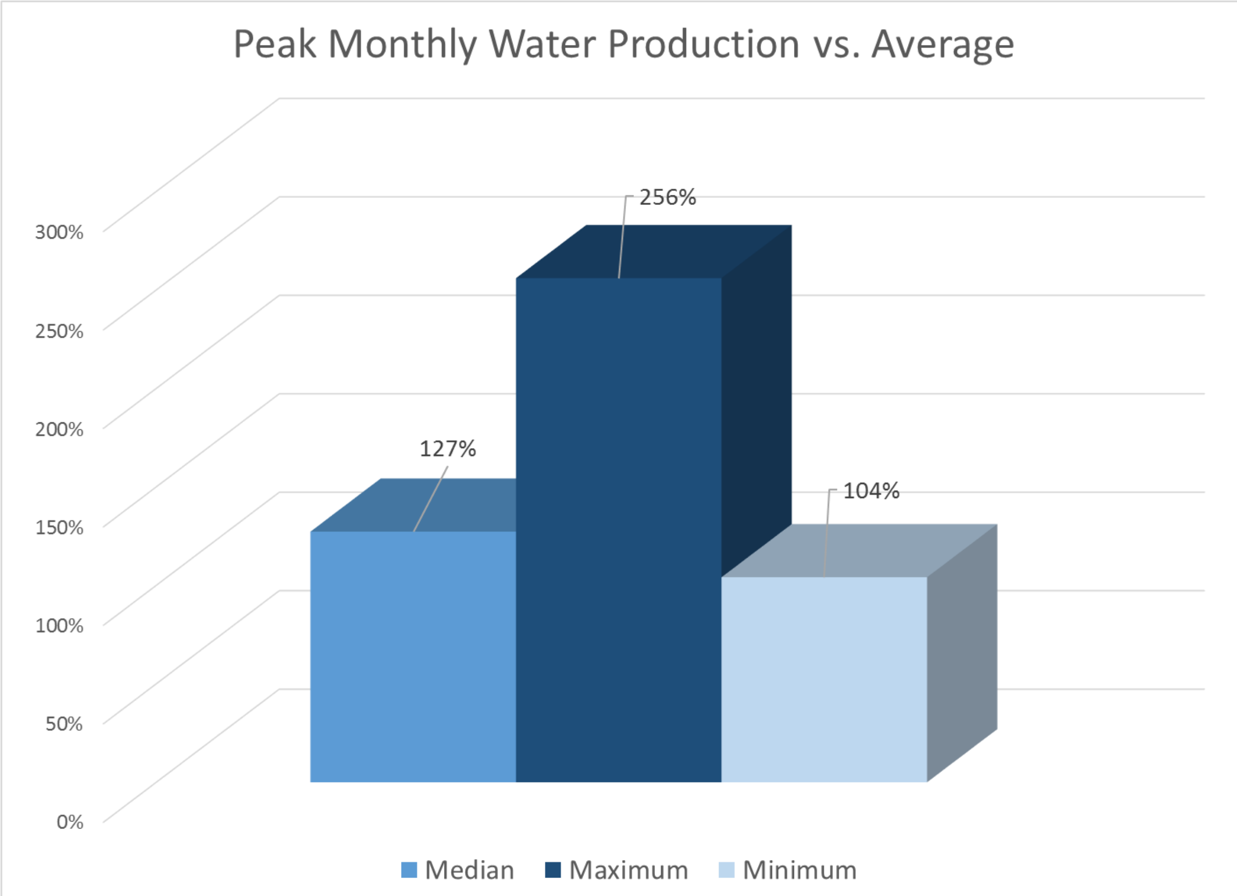


Q8. Water Supply by Source

Source	Median	Maximum	Number >0	% of Respondents
Surface Water	9,007	2,146,191	25	71%
Groundwater	1,461	806,502	20	57%
Brackish Water Desalination	0	1,500	1	3%
Ocean Desalination	0	1,232	1	3%
Recycled Water	0	126,240	11	31%
Purchased Wholesale Raw Water	0	340,523	3	9%
Purchased Wholesale Treated Water	0	86,998	10	29%
Other	0	304	1	3%
Total	26,500	3,293,215	35	100%

Many utilities rely on multiple water sources. Most responding utilities rely on direct surface water production, with 71 percent relying on that source; 38 percent purchase water, either raw or treated, from a wholesale provider. Purchased treated water is the least energy-intensive source as most of the pumping and processing is done by another party. Fifty-seven percent use groundwater sources that require pumping before water treatment. Desalination is energy intensive in water production, but only one utility each are using these sources; however, 31 percent are relying on energy-intensive recycled water sources.

Q9. Highest monthly production for each of your supply sources in the past year? 33 utilities responded to this question.



The median peak monthly production is 27 percent above the annual average among respondents. This indicates that the typical utility must maintain significant excess capacity; the system capacity factor akin to that typically reported by electric utilities is 79 percent. Note in some cases, the peak monthly production can be more than double the annual average rate.

Q10. Does your utility maintain its own plants? 41 utilities responded to this question. Nearly 83 percent of the respondents maintain their own water treatment plants.

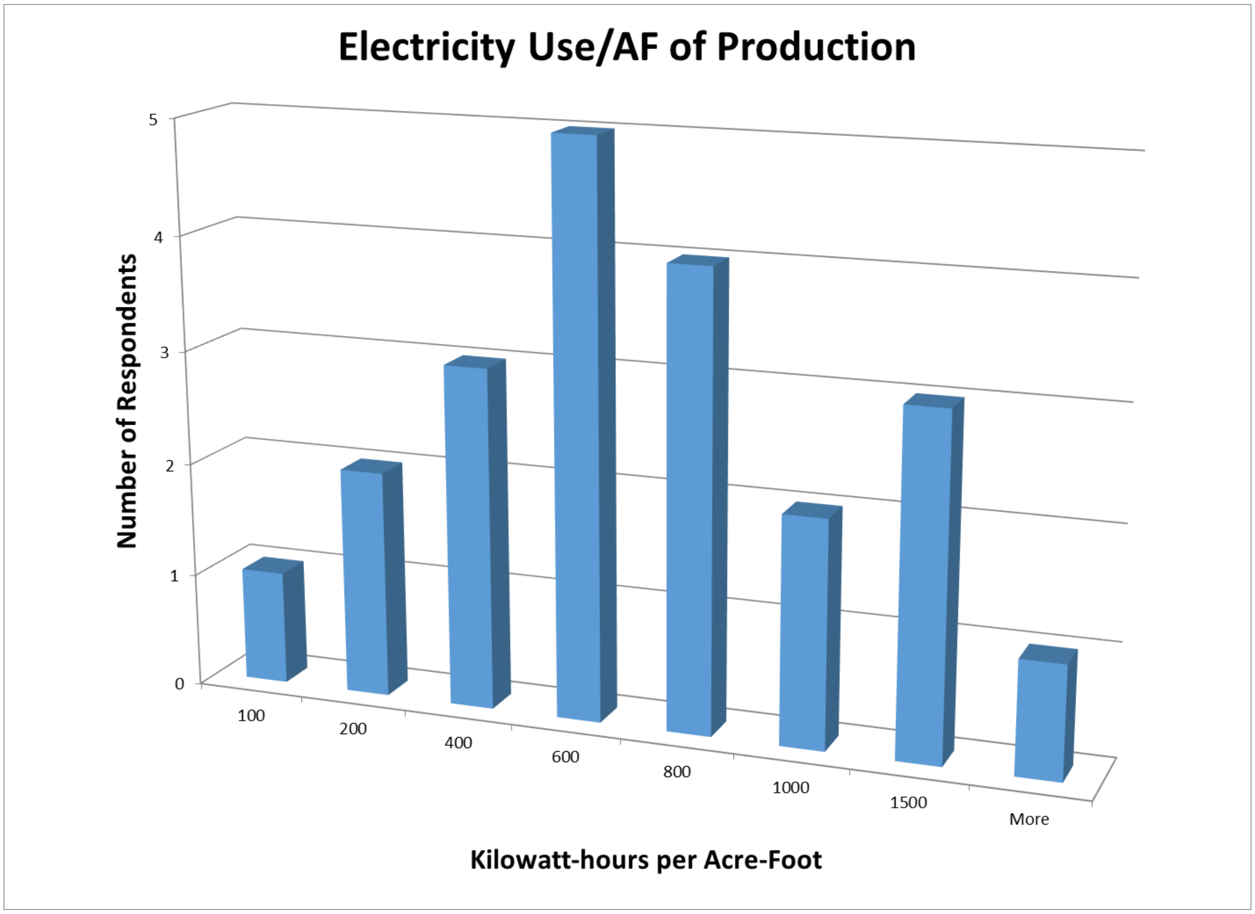
Q11. Total Reservoir and Water Tank Storage. 41 utilities responded to this question with their varying storage capacities. Responses were variable, ranging from a low of 1 million gallons to a high of 500 trillion acre-feet.

Q12. Total Reservoir Storage Capacity Used for Seasonal Carryover or Conveyance from an Outside Source (such as upstream or bulk storage). 41 utilities answered this question, again with widely varying responses. 58 percent of the answers were zero value or otherwise of no numerical response.

Q13. Age of the Bulk and Source Water Meters on Average across the System. 40 utilities answered this question. 30 percent of the meters are less than 10 years old; 25 percent of the meters are between 10 and 20 years old; 12.5 percent of the meters are between 20 and 30 years old, and 2.5 percent are greater than 30 years old. 10 percent of the respondents indicated that they did not know the age of their meters. Another 10 percent responded that the meter age stretched across all age groups or that they were not metered at all.

Q14. Age of the Wells, Pumps, Aerators, Boosters, Controls, etc. on Average across the System. 40 utilities answered this question. 7.5 percent of the equipment is less than 10 years old; 37.5 percent is between t ad 20 years old; 27.5 percent is between 20 and 30 years old, ad 17.5 percent is great than 30 years old. 7.5 percent of the respondents indicated that they did not know the age of this equipment. One respondent said it varied across all of those time periods.

Q15. How does your utility get its energy? 21 utilities answered this question. Electricity is the dominant energy source for water utilities; however 48 percent used other fuel sources. Four utilities get more than 10 percent of their energy from sources such as natural gas for water pumps. Ten percent buy electricity from another water provider rather than an electric utility.

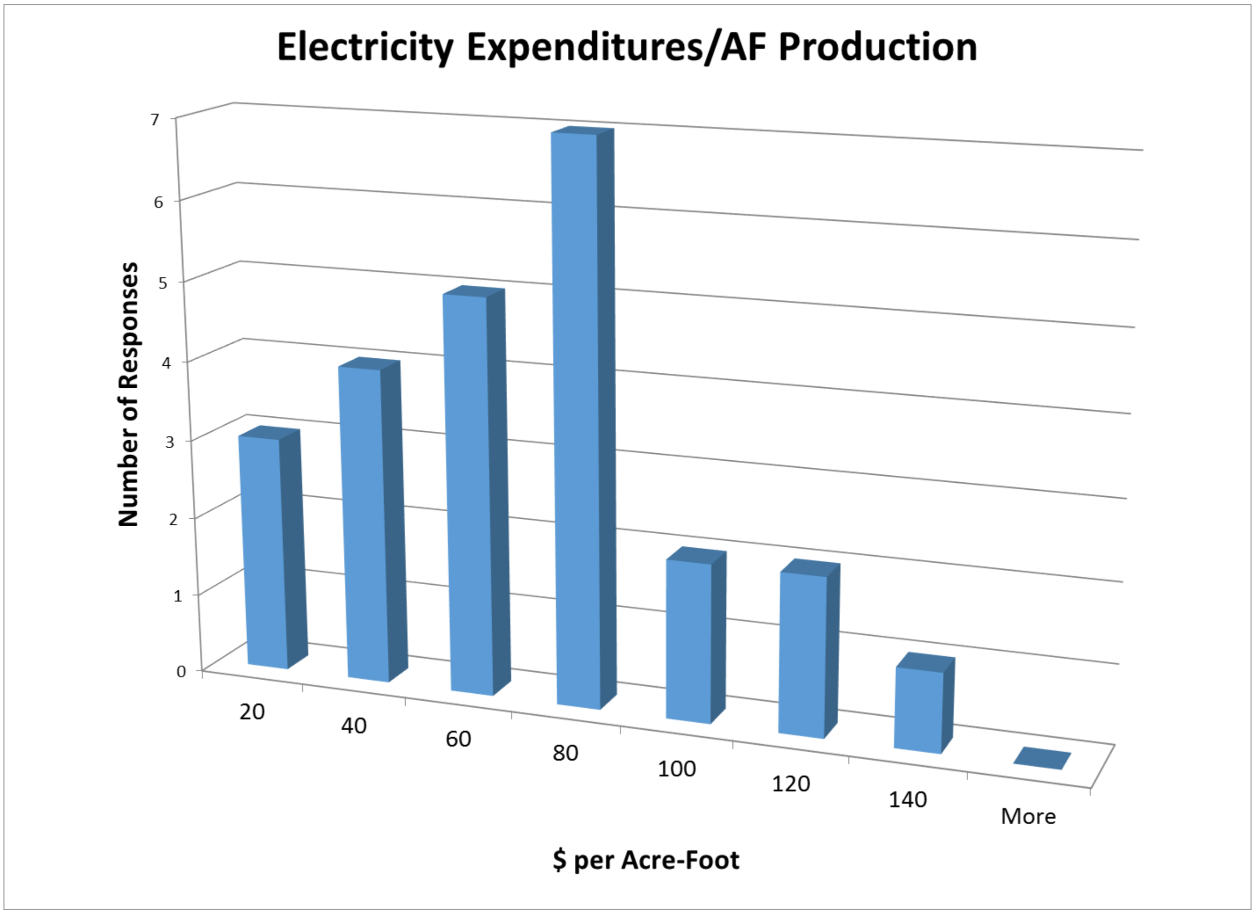


The median electricity use per acre-foot is 564 kWh or 1,731 kWh per MG. This is consistent with the estimates for typical water-supply systems derived from the EPRI/WRF study. Usage ranges from less than 100 kWh per AF or 300 kWh per MG on a gravity-fed system to one system exceeding 1,500 kWh per AF or 4,600 kWh per MG.

Q16. Highest Monthly Use for Each Energy Option. 33 utilities responded to this question. Electricity was the highest selected energy option (nearly 79 percent of the respondents). 30 percent of the respondents reported natural gas, 27 percent diesel, and 21 percent biofuels. 42 percent did not know this information.

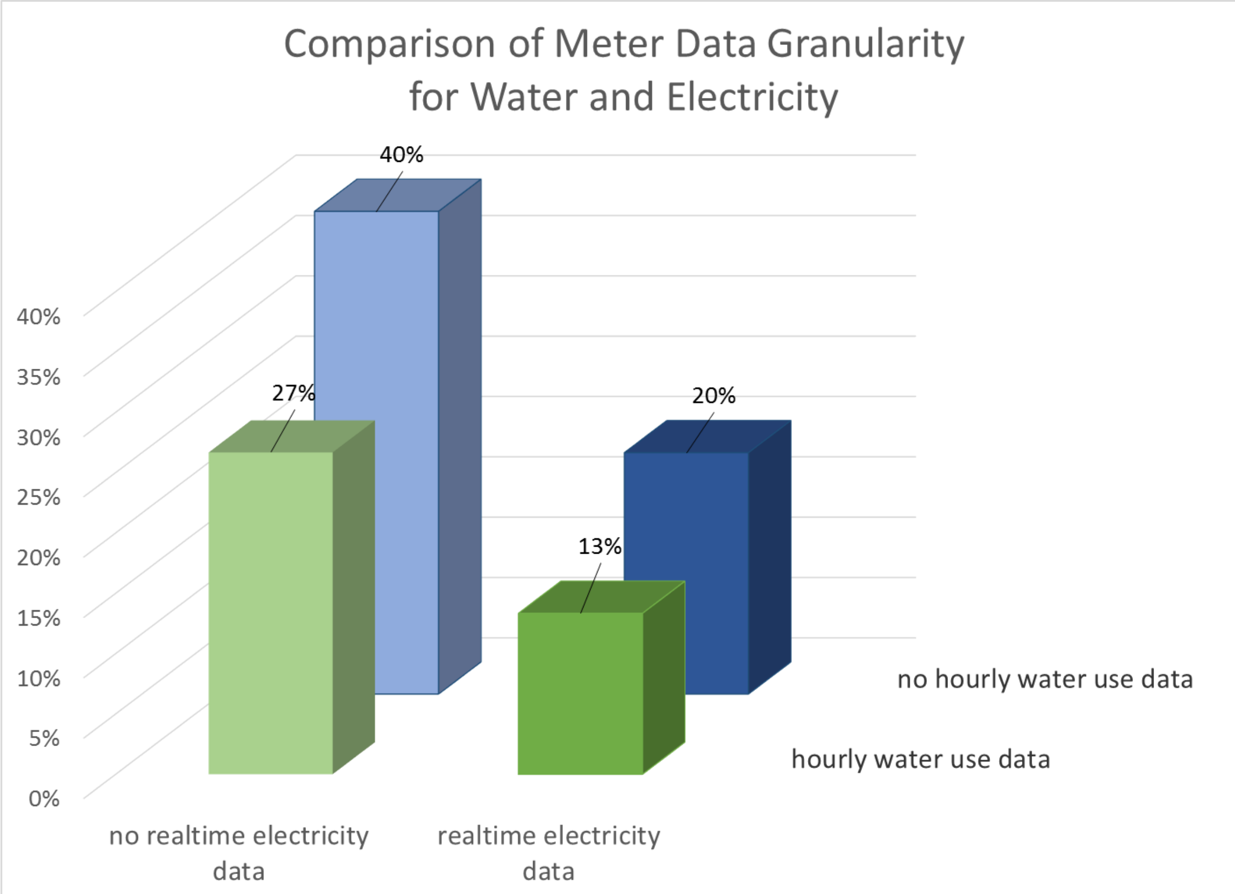
Q17. Who is the serving electric utility? Rather surprisingly, only 27 utilities responded to this question, with two of the answers being false values rather than utility names.

Q18. What is your total annual expenditure for electricity to provide drinking water to your customers? 33 utilities responded to this question, with responses ranging from a low of $108,600 to a high of $21 million. 8 answers were false values or "I don't know."



The average energy cost per water unit produced follows a similar pattern to the energy use. The median costs is $57 per acre-foot or $174 per MG. Again these values are consistent with the estimates from the EPRI/WRF study based on state average electricity rates from the Energy Information Administration.

Q19. Are you able to see your electric accounts usage in real time? 32 utilities responded to this question. Nearly 47 percent said no. 34 percent said yes, and 18 percent didn't know.



The majority of water utilities still do not have real-time electric meters installed. Only 13 percent have both electric advanced meter infrastructure (AMI) and hourly water production data; however, another 27 percent have hourly water data only, and 20 percent have AMI, but no hourly water data, indicating 47 percent of the utilities could be candidates for adding metering technology.

Q20. If not real time, how do you get your electric consumption data presented? 25 utilities answered this question, with the preponderance of the responses showing monthly data (84 percent). 8 percent didn't know.

Q21. How do you manage your electric accounts? 33 utilities responded to this question. 54 percent manage the accounts individually, and 30 percent simply on an aggregate basis. 15 percent didn't know.

Q22. Has your water utility participated in any energy efficiency and demand response programs within the past 15 years? 31 utilities responded to this question. 71 percent said yes, 22.5 percent no, and 6 percent didn't know.

Q23. If yes, did the programs incentivize action? 21 utilities responded to this question. The most common action was replacing inefficient pumps or motors (76 percent of the respondents). Other high actions were: adding variable speed drives to existing pumps (71 percent); site audits (66 percent); and installing energy efficient lighting, HVAC or other building improvements (66 percent).

Q24. Inventory or Assessment of Equipment for Pumping and Processing, with specific years and energy pump ratings for various pump and motor sizes? 31 utilities responded to this question. Nearly 55 percent of the respondents said yes, 32 percent said no, and nearly 13 percent didn't know.

Q25. Willing to Share this inventory for the purposes of the study? 29 utilities answered this question. 35 percent said no. 24 percent said yes. 41 percent did not know if they could.

Q26. What is the minimum payback period for your utility that would enable retrofit of your utility's pumps and other electrical equipment? 24 utilities answered this question. 45 percent of the respondents indicated 4 years or more; 41 percent indicated 2-4 years. Thus 86 percent of the respondents require a payback period of two or more years. Only 12.5 percent of the respondents require a 6 month or less payback period.

Q27. Do you have sole authority to be able to retrofit your utility's pumps and other electrical equipment if the payback period meets your requirements? 28 utilities responded to this question. Reflecting that most water utilities are municipally-owned and answerable to elected officials, 78 percent said no and only 21 percent said yes.

Q28. Who has the decision-making authority? 24 utilities answered this question. 33 percent of the respondents indicated that these matters are decided by their board. Only 12 percent indicated that either the Distribution System Manager or the Direction of Operations has that authority, 54 percent chose "other" and wrote detailed comments. This is an important finding, addressed in the section below.

Q29. Interested in learning more? 28 utilities responded to this question. 57 percent said yes, 43 percent said no. Within the "yes" responses, high interest was expressed in VFDs and high efficiency motors and pumps. Interest was also expressed for in-line Hydro, and analytical data packages.

Q30. Contact Information. Twenty-six utilities responded with their contact information (name and email). Twenty-three utilities provided a phone number.

3.2.3 Approval Barrier to Utility Procurement of Energy Efficient Equipment

Question 28 of the survey asked utilities who within their utility 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 in the utility had that authority. That is an important finding, but not a particularly surprising one.

According to the U.S. EPA, there are approximately 155,000 public water supply systems in the U.S. with 15 or more service connections.[38] The drinking water industry is thus highly fragmented and largely supplied through publicly-managed entities on either a municipal or regional basis. This is unlike the energy industry, which is served primarily by larger investor-owned companies in the electric and natural gas sectors and often have state oversight agencies.

The governance model of municipal and regional water suppliers is that of an elected Board of Directors overseeing the employees of the utility. In some cases, the water board directors are appointed by the local mayor or city council; 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 voters they serve; in the case of water utilities the voters and the utility 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. And large purchases for approval on the agenda do 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 don't 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 even 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:

[38] http://www.epa.gov/dwreginfo/information-about-public-water-systems

1. Operating fund revenues are declining across the country because of reduced water consumption, thus resulting in reduced water sales and a loss in revenue to the utility system. To compensate for this revenue loss, rates must be raised, to the consternation of the rate-paying public. Attempts are then made to reduce operating expenses to possibly reduce the magnitude of the rate increase, or perhaps eliminate it altogether.

2. Most publicly-elected water board officials are reluctant to approve continual increases in consumer rates for fear of voter reprisal. As a result, needed revenue for investments in the system are often not approved. The Black & Veatch *2015 Strategic Directions: U.S. Water Industry* report documents that 64 percent of the utilities in the United States are not able to recover in their customer rates the full cost of service and utility financial obligations.[39] This means that for these utilities, major expenses to improve the system get deferred year after year in an attempt to reduce the magnitude of the needed rate increase.

3. With a limited operating budget, projects compete for board member approval. We received comments from survey respondents that suggested that energy-efficient pumps would likely not be attractive enough for board member approval, even if clear long-term financial benefit could be proven. And while general managers may wish to reduce their energy consumption and thus their operating bill by purchasing this equipment, they too have to prioritize what their critical needs are for the system as to what they take to the board for approval. Water quality needs will trump everything else, as compliance with the Safe Drinking Water Act must legally be a first priority.

4. The availability of federal, state, or regional financial incentives can change this picture dramatically. Incentive funding is usually short term, and under the "use it or lose it" view, this funding can often tip the scales favorably because the board will always want to take advantage of free money being offered to the utility. A good example of this is grant funding for smart meters. Replacing existing outdated meters with smart meters is often an investment considered too costly on its own; the availability of grant funding to offset the cost usually propels the decision forward into a time frame that can take advantage of the available incentive funds. The utility is thus seen as proactive and saving its ratepayers money (a good political position for publicly-elected board members).

5. The business case for positive energy efficiency benefits is much hard to make for a water utility considering other priorities. The board member does not perceive it as the same because 100 percent of the funds for the energy efficiency improvement will have to come from the utility. And if the payback period is four years or longer, it goes beyond the elected term of the board member and thus none of the benefit will be visible to offset the high purchase cost out of the operating budget. Even though replacing the inefficient equipment may be a staff recommendation and a priority for utility system managers, it may not be a shared priority with the board.

[39] http://bv.com/reports/2015/water/financial-resilience

6. Purchasing energy efficient equipment through an operating budget poses challenges not faced with debt-financed investments. This equipment acquisition should be debt-financed, and that is much easier to do in a large utility than in a smaller one that may not have immediate access to municipal bonds or other investment funding. Regardless of utility size, the benefits of long term debt financing are clear. Capitalizing the purchase expense removes from the balance sheet the liability of the large up-front purchase cost. Spreading the cost over the benefit period of the investment would greatly improve the accounting balance sheet for the utility, and thus the chances for board member approval.

7. Asset Management is not well funded in many small to medium sized utilities. A good asset management inventory would identify the need to replace old meters and inefficient energy-using equipment, but many small to medium-sized utilities are not able to fund a comprehensive asset management program, largely because the needed revenue for it may not be forthcoming in the unapproved rate increases.

4. Market Potential for Electricity Efficiency in Urban Water Systems

4.1 Market Potential Estimates for Energy Savings Measures

4.1.1 Potential Energy Savings in Typical Water Utility Operations

The study conducted jointly by EPRI and WRF to assess electricity use for different water treatment and delivery systems provides a useful baseline for identifying the geographical markets and facility types that may be most amenable to adopting new equipment.[40] The EPRI/WRF report identified the separate processes within five example systems, listed in the table below. The table also lists projected energy use and intensity.

Table 3 Summary of Water Treatment Facility Examples

Treatment Plant Description	Total Daily Electricity (kWh/day)	Electric Energy Intensity (kWh/MG)
Example 1: 18 MGD conventional treatment plant treating surface water	25,605	1,420
Example 2: 80 MGD lime soda softening plant treating surface water	140,389	1,760
Example 3: 8 MGD ultrafiltration plant treating surface water using UV disinfection	20,067	2,510
Example 4: 14 MGD groundwater plant using aeration	30,970	2,210
Example 5: 4 MGD desalination plant treating ocean	54,247	13,600

Based on these values and the descriptions in the EPRI/WRF report, the energy use by process is identified in the table below.[41] The graphical scales in each cell compare the relative size of energy use within each system train. Most notable is that finished water pumping is by far the largest energy use in four of the five systems, with the only exception being reverse osmosis for ocean-water desalination. For plants with ultrafiltration, contaminant removal is the next largest use; for groundwater-sourced plants, the groundwater pumping is nearly as large as the finished water delivery.

[40] EPRI and WRF, *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries*, 3002001433, Final Report, November 2013.
[41] The totals in this table could not be fully reconciled with the results in the EPRI/WRF in the two examples for the lime-soda treatment facility and the ocean-water desalination plant.

Table 4 Energy Use by Process, Source: EPRI/WRF

	Examples:	1	2	3	4	5
	MGD	18	80	8	14	4
BY UNIT PROCESS		*Conventional*	*Lime Soda*	*Ultrafiltration*	*Groundwater*	*Desalination*
source water pumping	Raw surface water pumping	2,610	12,905	1,160		464
source water pumping	raw groundwater pumping				12,935	
clarification	rapid mixing	558	2,464	256		
clarification	flocculation	162	720			
clarification	sedimentation	158	701			
clarification	chemical feed systems	65	65	65	65	0
clarification	microfiltration (in lieu of sedimentation)					
clarification	ultrafiltration (contaminant removal)			6,400		
clarification	reverse osmosis (brackish water)					
clarification	reverse osmosis (ocearn water)					38,400
clarification	dissolved air flotation			1,432		
clarification	air stripping					
clarification	repumping within treatment plant		3,120			
filtration and solids handling	backwash water pumps	225	1,038	99		36
filtration and solids handling	residuals pumping	72	320	32		13
filtration and solids handling	thickened solids pumping	100	496		50	
disinfection, pumping and nonprocess loads	onsite chlorine generation for disinfection					
disinfection, pumping and nonprocess loads	ozone disinfection					
disinfection, pumping and nonprocess loads	UV disinfection			499	875	
disinfection, pumping and nonprocess loads	finished water pumping	19,456	86,819	8,754	15,248	3,428
disinfection, pumping and nonprocess loads	nonprocess loads (buildings, HVAC, lighting, computers, etc)	3,300	14,400	1,740	2,700	720
kWh/MGD		**1,484**	**1,538**	**2,555**	**2,277**	**10,765**
Total:		**26,706**	**123,048**	**20,437**	**31,873**	**43,061**

Using these five examples, electricity bill savings were estimated by state for average commercial and industrial utility rates.[42] Potential energy savings were calculated from the EPRI/WRF report based on improving from a “wire-to-water” efficiency of all pumping systems of approximately 65 percent to 75 percent for four of the examples, and from 55 percent to 75 percent for the lime-soda example system. The annual electricity bill savings were calculated assuming full operation 365 days per year.

The two tables below show the study team’s estimated energy bill savings per MGD by state and for the U.S. average. The states with the largest savings are shaded in red, and least savings in blue. The lime-soda and groundwater systems appear to have the greatest potential in financial savings from improves pump efficiency, and desalination the least.[43] The annual savings per MGD for the lower 48 states range across states from $5,000 to $27,000 on commercial rates and $3,000 to $23,000 on industrial rates. Annual savings per acre-foot for those on commercial rates range from $6 to $16 across system types, and $5 to $24 across states; savings on industrial rates range from $4 to $11 across types and $3 to $21 across states.

[42] U.S. Energy Information Administration, Form EIA-826, Monthly Electric Sales and Revenue Report with State Distributions Report, Table 5.6.B. Average Price of Electricity to Ultimate Customers by End-Use Sector, by State, Year-to-Date (Cents per Kilowatt-hour).

[43] Note however that reverse osmosis is highly energy intensive, but given that most plants are likely using the newest technology, the additional savings potential is minimal.

Estimated Electricity Bill Savings by Example Water Treatment Facility for Pump Efficiency Improvements						
Per MGD for Commercial Rates						
Example		1	2	3	4	5
		Conventional	Lime Soda	Ultrafiltration	Groundwater	Desalination
State	MGD	**18**	**80**	**8**	**14**	**4**
Connecticut		$13,647	$27,258	$13,731	$22,054	$10,640
Maine		$11,213	$22,396	$11,281	$18,119	$8,743
Massachusetts		$13,494	$26,953	$13,578	$21,806	$10,523
New Hampshire		$12,807	$25,581	$12,886	$20,696	$9,985
Rhode Island		$13,647	$27,258	$13,731	$22,054	$10,640
Vermont		$12,256	$24,480	$12,331	$19,806	$9,555
New Jersey		$11,187	$22,345	$11,256	$18,079	$8,723
New York		$13,129	$26,225	$13,210	$21,217	$10,238
Pennsylvania		$8,151	$16,280	$8,201	$13,171	$6,355
Illinois		$7,574	$15,128	$7,621	$12,240	$5,905
Indiana		$8,117	$16,213	$8,168	$13,117	$6,328
Michigan		$9,016	$18,008	$9,071	$14,570	$7,030
Ohio		$8,448	$16,873	$8,500	$13,651	$6,588
Wisconsin		$9,423	$18,822	$9,481	$15,228	$7,348
Iowa		$7,879	$15,738	$7,928	$12,733	$6,143
Kansas		$8,507	$16,992	$8,560	$13,747	$6,633
Minnesota		$8,151	$16,280	$8,201	$13,171	$6,355
Missouri		$7,752	$15,484	$7,800	$12,527	$6,045
Nebraska		$7,651	$15,281	$7,698	$12,363	$5,965
North Dakota		$7,506	$14,993	$7,553	$12,130	$5,853
South Dakota		$7,583	$15,145	$7,629	$12,254	$5,913
Delaware		$8,677	$17,331	$8,730	$14,021	$6,765
District of Columbia		$10,187	$20,346	$10,249	$16,461	$7,943
Florida		$8,219	$16,416	$8,269	$13,281	$6,408
Georgia		$8,388	$16,755	$8,440	$13,556	$6,540
Maryland		$9,440	$18,856	$9,499	$15,255	$7,360
North Carolina		$7,404	$14,790	$7,450	$11,966	$5,773
South Carolina		$8,626	$17,229	$8,679	$13,939	$6,725
Virginia		$7,023	$14,027	$7,066	$11,349	$5,475
West Virginia		$7,209	$14,400	$7,254	$11,650	$5,620
Alabama		$9,330	$18,635	$9,388	$15,077	$7,275
Kentucky		$7,863	$15,704	$7,911	$12,706	$6,130
Mississippi		$9,067	$18,110	$9,123	$14,652	$7,070
Tennessee		$8,634	$17,246	$8,688	$13,953	$6,733
Arkansas		$7,031	$14,044	$7,075	$11,362	$5,483
Louisiana		$7,311	$14,603	$7,356	$11,815	$5,700
Oklahoma		$6,472	$12,926	$6,511	$10,458	$5,045
Texas		$6,667	$13,316	$6,708	$10,773	$5,198
Arizona		$9,016	$18,008	$9,071	$14,570	$7,030
Colorado		$8,372	$16,721	$8,423	$13,528	$6,528
Idaho		$6,709	$13,400	$6,750	$10,841	$5,230
Montana		$8,711	$17,399	$8,764	$14,076	$6,793
Nevada		$7,931	$15,840	$7,979	$12,815	$6,183
New Mexico		$9,008	$17,992	$9,063	$14,556	$7,023
Utah		$7,515	$15,010	$7,561	$12,144	$5,860
Wyoming		$7,736	$15,450	$7,783	$12,500	$6,030
California		$13,528	$27,021	$13,611	$21,861	$10,548
Oregon		$7,472	$14,925	$7,519	$12,075	$5,825
Washington		$6,845	$13,672	$6,886	$11,061	$5,338
Alaska		$15,157	$30,274	$15,250	$24,493	$11,818
Hawaii		$23,342	$46,622	$23,485	$37,719	$18,200
U.S. Average		**$9,050**	**$18,076**	**$9,106**	**$14,624**	**$7,055**
U.S. Avg per MG		***$25***	***$50***	***$25***	***$40***	***$19***
U.S. Avg per AF		***$8***	***$16***	***$8***	***$13***	***$6***

Estimated Electricity Bill Savings by Example Water Treatment Facility for Pump Efficiency Improvements						
Per MGDG for Industrial Rates						
Example		1	2	3	4	5
		Conventional	Lime Soda	Ultrafiltration	Groundwater	Desalination
State	MGD	**18**	**80**	**8**	**14**	**4**
Connecticut		$11,077	$22,125	$11,145	$17,900	$8,638
Maine		$7,803	$15,586	$7,851	$12,610	$6,085
Massachusetts		$11,340	$22,650	$11,410	$18,325	$8,843
New Hampshire		$10,780	$21,532	$10,846	$17,421	$8,405
Rhode Island		$11,891	$23,752	$11,965	$19,216	$9,273
Vermont		$8,601	$17,178	$8,654	$13,898	$6,705
New Jersey		$9,483	$18,940	$9,541	$15,324	$7,393
New York		$5,488	$10,961	$5,521	$8,868	$4,278
Pennsylvania		$6,183	$12,350	$6,221	$9,992	$4,820
Illinois		$5,403	$10,792	$5,436	$8,731	$4,213
Indiana		$5,674	$11,334	$5,709	$9,169	$4,425
Michigan		$6,141	$12,265	$6,179	$9,924	$4,788
Ohio		$5,836	$11,656	$5,871	$9,430	$4,550
Wisconsin		$6,667	$13,316	$6,708	$10,773	$5,198
Iowa		$5,225	$10,436	$5,258	$8,443	$4,073
Kansas		$6,293	$12,570	$6,333	$10,170	$4,908
Minnesota		$6,073	$12,130	$6,110	$9,814	$4,735
Missouri		$5,394	$10,775	$5,428	$8,717	$4,205
Nebraska		$6,565	$13,112	$6,605	$10,609	$5,118
North Dakota		$7,099	$14,180	$7,143	$11,472	$5,535
South Dakota		$6,217	$12,418	$6,255	$10,046	$4,848
Delaware		$7,082	$14,146	$7,126	$11,445	$5,523
District of Columbia		$7,430	$14,840	$7,476	$12,006	$5,793
Florida		$7,108	$14,197	$7,151	$11,486	$5,543
Georgia		$5,013	$10,012	$5,044	$8,101	$3,908
Maryland		$7,464	$14,908	$7,510	$12,061	$5,820
North Carolina		$5,488	$10,961	$5,521	$8,868	$4,278
South Carolina		$5,132	$10,249	$5,163	$8,292	$4,000
Virginia		$5,954	$11,893	$5,991	$9,621	$4,643
West Virginia		$5,174	$10,334	$5,206	$8,361	$4,035
Alabama		$5,301	$10,588	$5,334	$8,566	$4,133
Kentucky		$4,597	$9,182	$4,625	$7,429	$3,585
Mississippi		$5,717	$11,418	$5,751	$9,238	$4,458
Tennessee		$5,411	$10,809	$5,445	$8,744	$4,220
Arkansas		$5,267	$10,521	$5,300	$8,511	$4,108
Louisiana		$4,597	$9,182	$4,625	$7,429	$3,585
Oklahoma		$4,554	$9,097	$4,583	$7,360	$3,550
Texas		$4,775	$9,538	$4,805	$7,716	$3,723
Arizona		$5,479	$10,944	$5,513	$8,854	$4,273
Colorado		$6,039	$12,062	$6,076	$9,759	$4,708
Idaho		$5,759	$11,503	$5,795	$9,306	$4,490
Montana		$4,504	$8,996	$4,531	$7,278	$3,513
Nevada		$6,090	$12,164	$6,128	$9,841	$4,748
New Mexico		$5,411	$10,809	$5,445	$8,744	$4,220
Utah		$5,386	$10,758	$5,419	$8,704	$4,200
Wyoming		$5,734	$11,452	$5,769	$9,266	$4,470
California		$10,458	$20,888	$10,523	$16,900	$8,155
Oregon		$5,157	$10,300	$5,189	$8,334	$4,020
Washington		$3,757	$7,505	$3,780	$6,072	$2,930
Alaska		$12,638	$25,242	$12,715	$20,422	$9,853
Hawaii		$20,059	$40,066	$20,183	$32,415	$15,640
U.S. Average		**$5,920**	**$11,825**	**$5,956**	**$9,567**	**$4,615**
U.S. Avg per MG		***$16***	***$32***	***$16***	***$26***	***$13***
U.S. Avg per AF		***$5***	***$11***	***$5***	***$9***	***$4***

4.1.2 Net Present Value of Energy Efficiency Savings

To assess the investment payback, the financial benefits can be expressed in the discounted present value of lifecycle energy savings. This can be compared to the cost of the energy saving measure or strategy to determine the internal rate of return and payback period. Based on survey, more than half of water utility managers are looking for a payback in four years or less.

Assuming a 30-year average expected life, a discount rate of 5 percent based on typical municipal utility bond rates and an electric utility rate escalation of 1 percent, the two tables below summarize the expected present value savings over the book life of the example system. Those can range from $80,000 to $312,000 per MGD based on the type of plant and the state. Across states, the savings can range from 37 percent below the U.S. average to about double the average for the most expensive rates in the lower 48 states.

Table 5 Net Present Values of Energy Efficiency Savings

Net Present Value of Savings - Commercial Rates						
Example		*1*	*2*	*3*	*4*	*5*
Type		*Conventional*	*Lime Soda*	*Ultrafiltration*	*Groundwater*	*Desalination*
MGD		**18**	**80**	**8**	**14**	**4**
U.S. Average		$156,493	$312,573	$157,466	$252,884	$121,995
U.S. Average per MG		*$429*	*$856*	*$431*	*$693*	*$334*
U.S. Average per AF		*$140*	*$279*	*$141*	*$226*	*$109*

Net Present Value of Savings - Industrial Rates						
Example		*1*	*2*	*3*	*4*	*5*
Type		*Conventional*	*Lime Soda*	*Ultrafiltration*	*Groundwater*	*Desalination*
MGD		**18**	**80**	**8**	**14**	**4**
U.S. Average		$102,369	$204,476	$102,996	$165,435	$79,803
U.S. Average per MG		*$280*	*$560*	*$282*	*$453*	*$219*
U.S. Average per AF		*$91*	*$183*	*$92*	*$148*	*$71*

4.1.3 Savings as a Proportion of Overall Costs and Ratepayer Bills

To assess the market potential for these measures, one must consider the potential for cost savings as a proportion of total costs. Water utility managers will focus on those elements that have the largest potential impact on their bottom lines. Water utilities are among the most capital-intensive industries, even more so than electric utilities. In these cases, savings on operational costs may not be as important as investment cost savings, particularly on the costs of financing such as interest rates.

To put these savings in perspective for the total costs of the water utilities, the table below shows the estimated percentage savings on residential water bills for each system on commercial electricity rates. Typical water bills for the 50 largest cities were drawn from

Black & Veatch's 2013 Water Rates Survey,[44] and residential domestic water use by state was calculated from U.S. Geological Survey's 2010 water use database.[45] Again, the greatest potential savings as proportion of total costs are shown in red. Of course, not all of these technologies are used in those individual cities (e.g., Oklahoma City will not have an ocean desalination plant). The median bill savings across the U.S. for cost savings ranges from 0.5 percent to 1.1 percent depending on the system technology. Savings can be as little as 0.2 percent and up to 3.8 percent. For conventional and ultrafiltration systems, the maximum is about 1.9 percent. Assuming that the savings on the conventional treatment system is typical for water utilities across the U.S., the total potential electricity bill savings are $217 million annually. The net present value of those savings would be $3.75 billion.

[44] Black & Veatch, "50 Largest Cities Water/Wastewater Rate Survey," http://www.saws.org/who_we_are/community/RAC/docs/2014/50-largest-cities-brochure-water-wastewater-rate-survey.pdf, 2013.

[45] USGS (2010), op. cit.

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

Energy service performance contracts (ESPCs) with energy service companies (ESCOs) have been used for two decades to promote energy savings strategies and measures, mostly in the commercial and public sector building sectors.[46] Water efficiency service companies (WESCOs) have been a much smaller sector serving water utilities. These companies bring together technical know-how, institutional knowledge about available funding and incentives, and risk-sharing to deliver customers operational savings (see also Appendix D for a general discussion). The latter two factors could be key to making this mechanism a useful means of increasing adoption of advanced electricity technologies in the water utility sector.

5.1 Institutional Understanding of the Target Market

First, we begin with an understanding of the structure and incentives of water utilities. As discussed earlier, the vast majority of water utilities are municipally-owned, either as divisions of cities and counties or as special districts. These organizations are driven by a concern for public welfare and political support. They are not profit-driven, and cost reductions are of concern to the extent that those reductions translate to changes in rates. Often these utilities have large, long-lived capital investments in various facilities and relatively small operational costs, even compared to electric and natural gas utilities; however, energy costs are usually a large portion of those operational costs. These utilities are almost always outside of state economic regulation and external incentives, the rationale being that local governments can best look out for the interests of their ratepayers. On the other hand, they face greater state and federal health and environmental regulations. Those latter agencies usually are not concerned about the economic consequences, and penalties for non-compliance can be large. For this reason, a focus on low-cost service may become secondary.

Because these are municipal entities, the governing boards tend to be conservative and risk-averse. Board members, particularly when compose of city or county elected officials, are less likely to be well-informed about water management issues, much less on technology advancements. Generally, these utilities' staff are much smaller than for investor-owned energy utilities, but in line with municipal electric utilities. Most of the technical staff are civil or mechanical engineers, with few electrical engineers who might be familiar with new technologies.

[46] Appendix D contains a review of the characteristics and performance of the general energy services company sector.

As public agencies, the procurement process for these water utilities can require more effort. As one observer pointed out, it is difficult to market to the water sector because even if the operator knows the manufacturer or pump is a good product, you still have to go to bid, do cost comparisons, etc. and in the end the decision is often made based on other factors.

The most important things to OEMs are first the lowest price, and then reliability and lowest energy usage. It is a complex process of dealing with vendors – this really needs to change if taking a systems approach.

As for the much smaller sector of investor-owned utilities, these companies are typically much smaller and often characterized by widely-separated service areas. The investor-owned company is often effectively a collection of many smaller companies (sometimes called "districts"). Staff is usually "lean and mean", focused on delivering water with the existing infrastructure however inefficient it may be; these utilities do not often have substantial technical expertise, particularly in electrical issues. While these utilities are regulated by state public utilities or public service commissions, such regulation is often overshadowed by electricity and natural gas. Either the regulatory staff is able to impose draconian requirements that ignore the capital requirements and revenue variability of the industry, or the companies are able to pass along all of their costs with little oversight. Unfortunately, either situation can mute incentives for cost savings, because either regulators take all of the savings for ratepayers without regard to long-term consequences, or managers see little pressure to change current practices.

These structures and incentives indicate a different set of objectives than for private and regulated investor-owned companies. Demonstrating the benefits of energy cost savings is more indirect. As indicated in the accompanying survey, payback periods likely have to be within the elected officials' terms of office. IOU water companies may view energy savings as a potential risk to their revenue stream in certain states. For public utilities, focusing on how ratepayers may benefit with little or no risk may be the most persuasive approach.

While each utility may be full of engineers, they typically will not be as familiar with electrical technology and the benefits of upgrading existing equipment. Providing credible outside expertise may be an important element in gaining staff support. One manufacturing representative said procurement mechanisms tend to be a challenge; it is important to get both utility staff and vendors to feel comfortable with the new technologies and methods for procuring them.

5.2 Considerations in Designing Successful Energy Service Performance Programs

The American Council for an Energy Efficient Economy (ACEEE) and the Alliance for Water Efficiency (AWE) promoted a contest to find the most effective water-energy programs. Among the most relevant findings is that the most effective programs gained savings in both energy and water, that they were partnerships and collaboratives across multiple organizations, and that they were part of broader long term initiatives that integrated resources. Another important feature particularly important to using ESCOs is that the programs acted as “one-stop shops” to get all relevant information. The challenges included gaining commitments and trust from partners, but conveying clear information about the benefits was key. Once the program started, maintaining sustained support also was a challenge. Finally, quantifying the amount of energy actually saved, including that outside of the water utility itself, was a problem.

ESCOs can facilitate many of these functions by providing a full range of support services. Recognizing and integrating the savings across both energy and water is critical given the mission of the water utilities. This is akin to the standard ESCO project focused on commercial and public buildings. In that case, energy savings must be delivered while maintaining comfort and improving building functionality. ESCOs will need to be able to track and access incentives for both energy and water savings, and to supply that information from a central place. As a corollary, ESCOs will need to be able to assist in negotiating the necessary collaborative efforts across multiple parties.

The introduction of water management adds a level of complexity that does not exist in a typical ESCO project. Energy savings usually can be measured as a separable indicator from other building functions—it is usually not an integral part of the building’s service delivery. That is not the case with water utilities. How energy is used to move or process water can have an effect on the total water usage, and conversely, water efficiency gains can have a direct impact on energy use. Improved water efficiency can actually lead to increased energy use. For example, pressurizing drip irrigation systems improves water efficiency but can increase energy use if the previous system was primarily gravity fed. This can create complications in computing incentive targets in energy services performance contacts. A water utility may implement a water saving measure that reduces overall costs but shifts some costs to the energy bill. Ensuring that the contract covers overall cost savings to some degree can address this problem.

A further complication is integrating more advanced technologies into an existing system. As one of the study participants said, retrofitted water-utility facilities are frequently not tooled and calibrated properly to best integrate new equipment, and as result will not provide lab-tested efficiency performance. The challenge is educating product consumers to focus on overall energy savings rather than just simple efficiency measures. Another manufacturer representative who works with ESCOs said facilities need to be retro-commissioned; software is needed to improve data management and support performance tracking. One manufacturer that has successfully implemented an ESCO in the water utility sector evaluates the integrated delivery system. The company considers the full train, including motor drive and pump and getting that train synchronized and tuned together. Still, end users too often are only looking at the efficiency of individual components within a system rather than the entire system.

Another factor adding complexity is that improved water efficiency can lead to reduced energy use upstream and outside of the water utility's system boundaries. For example, an interregional water conveyance system is typically managed by a water wholesale agency. A retail utility may not fully realize the full financial savings from the upstream energy reductions because the wholesale utility may not pass them through. This external energy source is one example of where "hidden energy" is embedded in delivered water. Providing the appropriate incentives for the retail utility to fully realize energy savings may require the intervention of the serving electricity utility, the regulatory commission or the state energy office. An ESCO which is probably more familiar with these organizations and available programs may be well positioned to assist a water utility looking for external incentive programs targeting these savings.

Water utilities also face financing issues for smaller-scale projects and will want to rely on the ESCO to mitigate annual cost increases. As one observer put it, "all public financing decisions begin with maximizing the use of other people's money." The availability of federal, state, or regional financial incentives as well as energy utility incentives can influence a water suppliers' decision to participate. ESCOs should come prepared with a financing package that relies on outside grants and incentives to the extent possible (see bullet #4 in Section 3.2.2 of this report).

Finally, risk sharing is an important consideration given the nature of the municipal utilities. As discussed above, a utility may be making trade-offs in water and energy savings, but it will want to push as much risk onto an ESCO as possible. An ESCO will want to assess how to develop a modified version of the standard guaranteed savings contract that accounts for potential trade-offs. Integrating the combined energy and water cost savings, while an unusual aspect of ESPCs, is key to this objective. Developing metrics for savings contributions from different strategies and measures will be important to formulating these contracts.

5.3 Financing Methods

Energy saving performance projects can be financed in a variety of ways. These projects are typically financed by a third-party financial institution. For water utilities, these financing options can move debt off its books while providing the advantages of spreading costs over a longer period. That can mitigate the potential for short-term rate increases from upfront equipment purchases. Water suppliers are funded predominately through the rates they charge their customers for the water the agency delivers to them. Other types of funding can include taxes, local bonds, tap or connection fees, and special district fees.[47] Often ESCOs can help the customer understand their financing options and arrange alternative financing.

[47] Helena Alegre and Sérgio T. Coelho, "Infrastructure Asset Management of Urban Water Systems," in *Water Supply System Analysis - Selected Topics*, LNEC – National Civil Engineering Laboratory, Lisbon, Portugal,

Although not common for public-sector customers such as water utilities, some large institutional customers that have sufficient capital on-hand may consider self-financing an energy efficiency project. Self-financing allows customers to save on interest costs and keep the entire energy savings as return on their investment. This may be a good option for entities that can draw on an endowment, capital budget, funds for deferred maintenance, or reserve accounts for efficiency investments. One option though is to use enterprise fund reserves from other municipal entities to finance these measures. Such funds currently earn extremely low returns, and making these type of low-risk investments could be a useful revenue generator for a municipality; however, since third-party financing is more typical, this section focuses on some of the most common third-party financing vehicles.

For all of these financing options, the borrower's payment obligation is not dependent on energy savings of the ESCO project. While the ESCO is obligated to make up any shortfalls in energy savings to the customer, the energy savings guarantee is independent of the borrower's agreement with its lender.

- **Tax-exempt lease-purchase agreement**—Lease-purchase agreements have historically been the most popular financing arrangement. Under a lease-purchase agreement the lessee purchases the energy saving equipment provided under an ESCO contract through scheduled installments. At the end of the agreement, ownership of the equipment is transferred to the lessee. The major advantage of the lease-purchase agreement is that they are often treated as off-balance sheet transaction, depending on specific contract language. Rather than being treated as a long-term debt obligation, which may require special approval for public agencies in particular, lease-purchase agreements can be treated as a series of renewable, short-term lease payments. This moves the debt obligation off the book and improves the agency's position for debt rating. Public institutions and in some cases nonprofit institutions can also benefit from lower interest rates because of the tax deduction that lessors receive on interest payments from those institutions.[48]
- **Capital lease**—A capital lease is an arrangement where ownership of the equipment remains with the lessor and the customer makes payments for use of the equipment. Under capital leases, there is often an option to purchase the equipment at a price below market value at the end of the lease period. The customer classifies the lease payments as capital expenses and recognizes the asset on its balance sheet. As in the case of lease-purchase agreements, government institutions can benefit from tax-exempt interest rates.[49]

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http://www.intechopen.com/books/water-supply-system-analysis-selected-topics/infrastructure-asset-management-of-urban-water-systems, 2012.

[48] Clinton Climate Initiative. 2009. *Energy Performance Contracting Financing Options*. http://www2.presidentsclimatecommitment.org/documents/ccitoolkit/Energy_Performance_Contracting_Financing_Options.pdf

[49] Ibid.

- **Operating lease**—Operating leases are similar to capital leases, except that there is no purchase option at the end of the term. These lease arrangements can be considered "off-balance sheet" since ownership of the equipment remains with the lessor indefinitely and can be a good option for institutions at or near their debt capacity. Operating leases are often more costly than capital leases and lease-purchase agreements because the customer does not benefit from tax-exempt interest rates (since ownership of the equipment remains with the lessor and not the tax-exempt entity). In addition, operating leases are often more complex, resulting in higher transaction costs.[50]
- **Leasing pools**—Leasing pools can be a financing option for large projects when no single investor is able to finance the entire project. Leasing pools use aggregated financing to reduce costs and access a larger pool of investors. After a leasing agreement is reached between a customer and a lessor, the lessor sells shares of the financing, called certificates of participation (COP) to other investors. The proceeds are forwarded to the customer to cover upfront costs of efficiency investments. A government agency providing a leasing pool builds a collection of funds by selling COPs for energy or utility type projects. The pool of funds can then be used to finance lease tax exempt lease agreements for the state or local agencies. Interest rates on COPs are usually higher than for general obligation bonds but leasing pools can be more cost-effective than securing individual financing from multiple investors.
- **Government bonds**—Bonds are a long-term debt obligation typically treated as on-balance sheet. As with the other financing options, government institutions can benefit from lower interest rates due to their tax-exempt status. Bonds are issued by local and state governments and may require approval from a legislative body or local voters. Often projects are financed in a bundle through a single bond issuance. It is not uncommon for enterprise agencies, such as water utilities, to issue bonds on a fairly regular annual basis.
- **Green bonds**--These bonds raise capital exclusively for projects or activities with specific climate or environmental sustainability objectives (e.g., renewable energy, waste management and energy efficiency). Moody's estimates that this financing segment may exceed $100 billion globally.[51] Performance for these bonds are evaluated on a multi-dimensional basis focused on sustainability metrics. Water and energy efficiency projects will have an easier task of qualifying for this type of financing.
- **Revolving loan pools**—Some states offer revolving loan pools for energy improvement projects. Principal and interest repayments on these loans go to reseed the fund, allowing the state to continue to support clean energy projects. According to the National Association of State Energy Officials (NASEO), all but a handful of

[50] Ibid.
[51] Moody's Investor Services, "Announcement: Moody's: Green bonds to blossom as global markets embrace more eco-friendly investments," https://www.moodys.com/research/Moodys-Green-bonds-to-blossom-as-global-markets-embrace-more--PR_326218, May 27, 2015.

states and territories had revolving loan funds in place.[52] "As of July 2013, NASEO has tracked 79 programs operating in 44 states and territories, representing a total of $2 billion in available financing."[53]

- **Tax equity financing**—Where an on-site energy project is an attractive option to combine with other energy efficiency measures, this mechanism can reduce the need for conventional financing. Many renewable energy projects rely to some degree on the tax equity market for financing. To the extent that energy savings projects can similarly use tax credits, this instrument may be attractive; however, tax equity can be a more expensive form of financing than other sources of capital. The tax equity market is not very transparent, nor is it highly liquid. In addition, each project is unique, with unique developers and investors. Participants in the tax equity market also face significant challenges of understanding and evaluating the array of energy technologies, project structures, and contract and market risks.[54] This uniqueness increases the transaction costs of using tax equity for financing. Investors are generally earning yields from 7 percent to 9 percent.[55]
  For renewable power projects, the choice of tax equity financing varies with the type of tax credit that is applicable and most beneficial to a project.[56] For projects using the investment tax credit, most common for solar for example, a sale/leaseback is most common. The tax equity investor leases the project for less than 80 percent of the project life, and provides more than 20 percent of the equity contribution (plus non-recourse debt).

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[52] NASEO, "State Energy Financing Programs," http://www.naseo.org/state-energy-financing-programs, retrieved February 2016.

[53] NASEO, "State Energy Revolving Loan Funds," https://www.naseo.org/Data/Sites/1/documents/selfs/state_energy_rlf_report.pdf, July 2013.

[54] One estimate puts the number of active players in the tax equity market at about 20 to 22 entities. See "State of the Tax Equity Market." Chadbourne & Parke, LLP, Transcript from Infocast Wind Finance and Investment Summit, San Diego, CA, February, 2012. Project Finance Newswire, May 2012.

[55] See Chabourne & Parke, LLP, May 2012 Project Finance Newswire. Also, Mendelsohn, M. and J. Harper. Section 1603 Treasury Grant Expiration: Industry Insight on Financing and Market Implications. National Renewable Energy Laboratory. June 2012, p. 19.

[56] "Investment in Alternative Energy After the End of Cash Grants," 19 September 2011, www.mondaq.com/unitedstates/x/145170/IRS+HRMC/Investment+In+Alternative+Energy+After+The+End+Of+Cash+Grants, retrieved January 18, 2013.

6. Conclusions and Recommendations

This study provides valuable information and data in support of NEMA's strategic initiative to advance energy efficiency in urban water supply systems consistent with the goals specified. GEI's study team was able to collect a significant body of literature regarding the current extent to which energy efficient technologies are deployed in our nation's water systems and the possible barriers limiting further adoption of these technologies. In addition, a summary of recommended best practices to advance system and energy performance is highlighted. Responses to the water agency survey came from a regionally diverse set of water agencies and provided meaningful insights to level of interest in energy efficiency, institutional and financial challenges to advancing efficiency in these systems and possible steps that can be taken to overcome them. Using information and data gathered during both the literature review and the survey, the study team was also able to determine a conservative estimate for energy efficiency savings potential in urban water systems. Lastly, we found that funding exists to implement many of energy efficiency projects, albeit insufficient to meet the entire investment need, and that the use of ESCOs and ESPCs are a viable business model to secure these funds and implement projects.

As some NEMA members already know, ESPCs have been and are being used by some water agencies to assist in reducing energy demands. Traditionally manufacturers have tended to develop relationships with vendors and distributors but in the future building stronger relationships directly with water agency representatives through activities such as training, webinars, system assessments may be more effective tools to advance their knowledge, understanding and acceptance of new technologies. In these interactions, NEMA must take a brand neutral or agnostic approach to ensure it is seen as a credible and trusted resource to which water utilities can turn for unbiased information and technical expertise.

Actions NEMA can take to advance energy efficiency of urban water systems which have been identified in this study are summarized below.

- Recognizing that some water utilities lack the analytic capacity or staff resources to perform certain energy-related evaluations, NEMA can develop programs and tools to facilitate site audits; perform pump evaluations, conduct testing and system optimization assessments; and educate and train agency and facility staff.
- To facilitate the development of these tools and resources, NEMA can establish a water sector focused group made up of facility managers and operators that can assist in the targeting of efforts to 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 understanding of the many opportunities the water sector has to improve the energy efficiency of their processes; stay current on information about issues and challenges being faced by water utilities; and access the paths to more direct agency interactions for project development.

- Recognizing that funding opportunities can vary from state-to-state and over time, facilitate the identification and organization of innovative funding approaches into various, more holistic portfolios for agencies that leverage ESCOs, public and private dollars, and energy utility incentives. These portfolios can be updated regularly and highlight what components of overall projects can be financed with what funding sources, how these sources can be aligned and share to meet “match share” requirement or fill funding gaps.

- As an organization, continue to directly fund, independently or in collaboration with other water research organizations, the demonstration of technologies, best practices and other types of energy savings strategies, disseminating the results at water conferences, industry publications and webinars.

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Appendix B

NEMA Member Products Potential Used in Urban Water Systems

Many products manufactured by NEMA members may have uses at water supply facilities.[57]

Building Systems

Building Wire And Cable
Dry Battery
Electric Resistance Heating
Electrical Submeter
Fire, Life Safety, Security and Emergency Communication Section
High Performance Wire And Cable
Low Voltage Distribution Equipment

Commercial Products

AFCI
Cable Ties
Cable Tray
Conduit Fittings
Enclosures
Flexible Metal Conduit
Fuse
Ground Fault Personnel Protection
Hazardous Location Boxes and Fittings
Low Voltage Surge Protective Devices
Outlet And Switch Box
Pin and Sleeve Plug, Receptacle, and Connector
Polymer Raceway Products
Steel Conduit And Electrical Metallic Tubing
Wiring Device

Connected Systems

Distribution Automation
Electric Vehicle Supply Equipment/System
Electrical Measuring Equipment
Energy Storage Systems
Power Electronics
Transportation Management Systems And Associated Control Devices

Industrial Products & Systems

Flexible Cords
Industrial Automation Control Products & Systems
Insulating Materials
Motor and Generator
Power And Control Cable

[57] http://www.nema.org/Products/pages/default.aspx

Lighting Systems

Ballast & Driver
Emergency Lighting
Light Source
Lighting Controls
Luminaire

Security Imaging and Communications

Utility Products

Capacitor
Electrical Connector
High Voltage Insulator
Surge Arrester
Switchgear
Transformers

Appendix C

Survey Participants

The following entities participated in the project survey:

- San Francisco Public Utilities Commission, CA
- City of Saint Petersburg Water Resources Department, FL
- Tampa Bay Water, FL
- City of Bozeman, MT
- City of Phoenix Water Services Department, AZ
- City of Sacramento, CA
- Des Moines Water Works, IA
- The Birmingham Water Works Board, AL
- Austin Water, TX
- Carmichael Water District, CA
- Marin Municipal Water District, CA
- Madison Water Utility, WI
- Valencia Water Company, CA
- Salt Lake City Department of Public Utilities, UT
- Sun Valley Water & Sewer District, ID
- Town of Bethlehem, NY
- City of St. George Water Services Department, UT
- South Central Connecticut Regional Water Authority, CT
- City of Highland Park, IL
- City of Corvallis, OR
- Williamson Water Utilities, NY
- City of Bremerton, WA
- Calaveras County Water District, CA
- Cobb County Water System, GA
- City of Plano, TX
- City of Elgin, IL
- City of Savannah, GA
- Town of Cary - Cary/Apex Water Treatment Facility, NC
- City of Thorndale, TX
- Utah State University, UT
- South Florida Water Management District, FL
- Hawaii Commission on Water Resource Management, HI
- Raleigh Public Utilities, NC

- Elsinore Valley Municipal Water District, CA
- Spanaway Water Company, WA
- Glendale Water & Power, CA
- Western Area Power Administration
- Town of Silver City, NM
- South Carolina Rural Water Association, SC
- City of Griffin Public Works and Utilities, GA
- Springfield Water and Wastewater Department, IL
- City of Avondale, AZ
- Crystal Systems, TX
- City of Torrance Water Division, CA
- City of Sugar Land, TX
- Canadian Respondents
    - City of Guelph
    - York Region
    - City of Calgary, Water Resources
    - City of Saint John New Brunswick

Appendix D

Background on Energy Saving Performance Contracts

This report is intended to address the question of whether energy savings performance contracts might be a desirable means of attracting greater investment in energy-efficient electrical equipment by water utilities. This analysis is based on a review of how the broader market is performing and what contracting instruments and terms are used for these types of projects. The report begins by reviewing the structure of these contracts, focusing on specific terms and risk shared among the parties. The report goes through types of contractual arrangements, then the financing mechanisms available. It concludes by comparing a set of model contracts for one type, the guaranteed-savings contract. We then summarize the existing energy service companies' (ESCO) markets for energy savings performance projects, and the success of those projects in forecasting and delivering savings.

Recently, regulators have pushed back on ESCO contracts terms as being too exorbitant.[58] How this might affect the municipal ESCO market is too early to determine.

D.1 Types of Contractual Agreements

Several types of contracts are used by ESCOs and their customers. The most common forms are guaranteed-savings and shared savings contracts, both of which are based on the performance of the project in delivering energy savings. Nonperformance-based contracts are also in use in the U.S. where compensation to the ESCO is not tied to project performance but is rather agreed upon ahead of time or "stipulated" along with the project scope. While this memo focuses on performance-based contracting as a method of reducing risk to customers and facilitating large-scale investments in energy efficiency, below is a description of the distinguishing characteristics of each contract type.

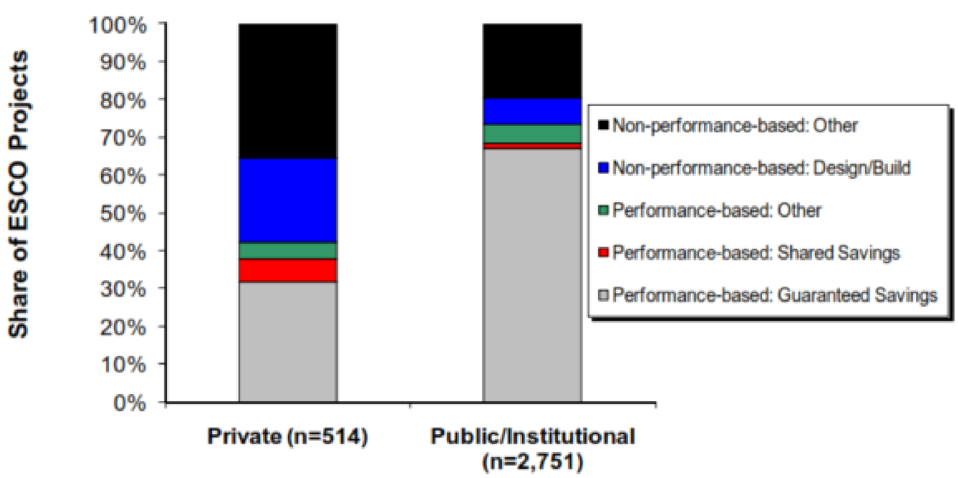
- **Guaranteed-savings**—Guaranteed-savings contracts are the most common type of ESCO performance contract in the United States. Typically under a guaranteed-savings agreement, the customer provides project financing either through its own resources, a capital lease, or other form, discussed in more detail below.
- **Shared savings**—Under this type of agreement, the ESCO typically secures project financing in addition to implementing project development. The ESCO is liable for repayment of upfront equipment purchases regardless of whether the project achieves energy savings. In this way, the ESCO takes on the performance and financing risk of the project. Because the ESCO takes on more risk under a shared savings agreement, such agreements are not common.

[58] http://www.utilitydive.com/news/ny-gov-cuomo-zero-tolerance-for-electric-service-companies-jacking-up-p/414511/

- **No-guaranteed-savings**—These contracts are non-performance-based; they are essentially upfront purchase agreements.
- **Pay from savings**—This contract type is a variation of the guaranteed-savings contract; however, unlike a guaranteed-savings contract, project financing is typically provided by the ESCO rather than the customer.
- **Chauffage**—This becomes a building management or service provision arrangement akin to types of full-service vendor agreements. The customer is entirely shielded from energy costs to the extent that the ESCO vendor passes through those costs. Chauffage contracts are common in Europe, but not in the United States.

Guaranteed-savings contracts are the most commonly used in the US, with shared savings contracts and other agreements also making up a portion of the market. Figure D-1 shows the breakdown of contract types for the private and public sector. In the 2014 Larsen sample of ESCO contracts, guaranteed-savings arrangements made up 84 percent of performance-based contracts in the public and institutional market sector.[59] This is the market segment representing most water utilities. Customers appear to prefer guaranteed-savings contracts because of the certainty of savings and avoidance of project risk. ESCOs prefer guaranteed-savings contracts because it relieves them of the financial risk; however, shared savings arrangements may be preferred when the customer would be unable to finance the project itself.

Figure D-1 ESCO Contract Types



Evidence from the NAESCO database analysis suggests that projects that used performance contracting had higher average costs ($2.3 million) than those using nonperformance-based contracts ($1.6 million). Larsen suggests that performance-based contracts are typically used for larger projects. Large projects may be required to compensate for upfront and administrative costs of a performance contract.

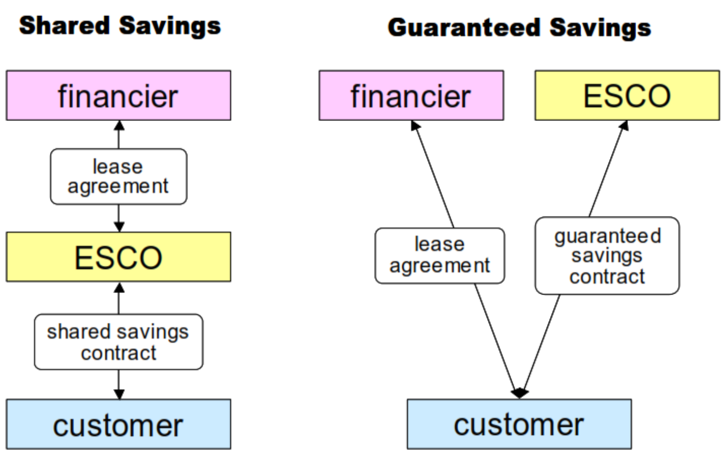
[59] PH Larsen, et al., "U.S. Energy Service Company Industry: Market Size and Project Performance from 1990 to 2008." Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, 2014.

Another factor may be that public/institutional customers have better access to low-cost financing. Private customers are less likely to find a significant improvement over financing rates offered by ESCOs, while public customers are more likely to see differences of several hundred basis points in the interest rates. The project cost savings can be substantial in those cases.

D.2 Comparison of Financing Arrangements

Under both guaranteed and shared savings contract models, the ESCO assumes the project performance risk, however the models differ in who assumes the debt obligation of the project and the credit risk.[60] In shared savings contracts, the ESCO takes on project-level financial risk, often from a third-party lender, assuming credit liability for the project. Under a guaranteed-savings contract, the customer takes a loan from a third-party financial entity, while the ESCO guarantees annual financial savings sufficient to cover the annual debt obligation. Figure D-2 illustrates this difference in these contractual relationships.

Figure D-2 ESCO Contractual Relationships



Source: Larsen, et al. 2014.

D.3 Comparing Model Guaranteed-Savings Contract Forms

For this review, we compared nine model ESCO contracts from state and federal energy agencies and industry organizations.[61] The contracts were broadly similar across a number of elements. All of the model contracts reflect a guaranteed energy savings arrangement between the ESCO and the customer; however, the level of detail contained in the contract for the guarantee and

[60] ICF, *Introduction to Energy Performance Contracting*, Prepared for U.S. Environmental Protection Agency ENERGY STAR Buildings, http://www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf, October 2007.

[61] Model contracts were collected online from the U.S. Department of Energy, the Energy Services Coalition (an industry group that promotes energy savings performance contracting), the Building Owners and Managers Association (BOMA), the California Energy Coalition, as well as state energy offices in the states of Louisiana, Massachusetts, Montana, Virginia, and Wyoming.

incentive structures and the monitoring and verification of project savings varies somewhat across contracts.

D.3.1 Project Specifications and Performance Periods

Contracts outline the various phases of an ESCO contract and how important dates in the project workflow are to be determined. During the energy audit phase the ESCO carries out a thorough audit of the customer's current buildings, equipment and energy use, and develops a detailed proposal of the energy conservation measures that would be included in the project. The savings guarantee period begins upon completion of project construction and signing of a certificate of acceptance.

The performance period generally ranges between 10 and a maximum of 20 to 25 years in the model contracts collected. According to the Goldman study of the ESCO market, states vary in the maximum contract term they allow, with 34 states allowing maximum contract terms of 10 years or more in 2002.[62] The histogram in Figure D-3 shows the number of states that allow various maximum contract terms. The maximum contract term in a state affects the energy saving strategy an ESCO can take. Large energy saving investments with a long payback period may be appropriate in some but not all states.

The contract also specifies how baseline energy consumption and energy savings are to be calculated and how measurement, verification and review are to be carried out. Baseline energy use is typically calculated based on 36 months of billing data and should be adjusted for changes in operation, occupancy or any other factors that impact energy consumption. Details of the calculations are not generally included in the model contracts but should be included in any actual contract.

[62] Charles A. Goldman et al. 2002. *Market trends in the US ESCO industry: Results from the NAESCO database project*. Lawrence Berkeley National Laboratory. Unfortunately, we were unable to find any subsequent analysis on this particular topic.

Figure D-3 ESCO Contract Terms

Source: Goldman 2002

D.3.2 Savings Guarantees

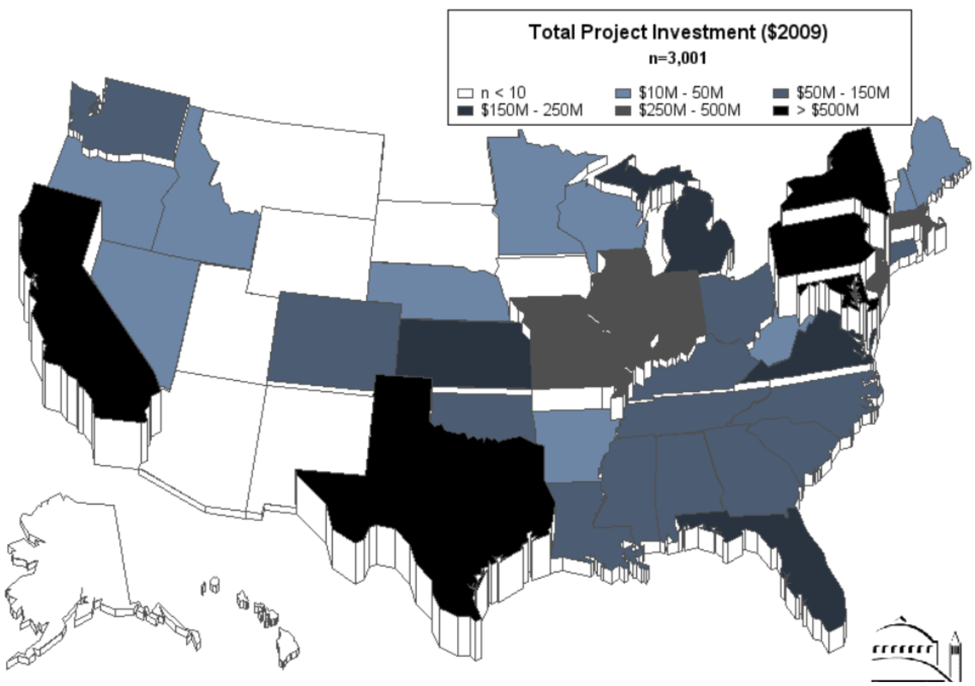
Definition of the savings guarantee and accompanying incentives are the area with the most variation across the model contracts. All of the contracts outlined the energy savings guarantee; however, some treated annual savings shortfalls and extra savings differently. Five of the contracts state that any savings deficiency is to be paid by the contractor. Several offer more flexible terms—Massachusetts allows the contractor 45 days to modify the project or pay the owner for the shortfall; the U.S. DOE contract allows the agency to adjust the payment schedule to correct for overpayments; two of the contracts do not mention the issue at all. Similarly on extra savings: extra savings goes entirely to the customer in three of the contracts. In two of the contracts, extra savings can count toward a guarantee shortfall in past years, but not future years. In one contract structured by the California Energy Commission, extra savings go to the company up to a specified amount, beyond which 10 percent goes to the ESCO, and 90 percent goes to an escrow fund that can be reinvested in additional energy saving measures at the discretion of the customer. At the conclusion of the contract the unused balance in the fund goes to the customer.

There are also multiple approaches to handling interim energy savings from the start of construction to the beginning of the guarantee period. In two of the contracts the savings go entirely to the customer; in one of the contracts the savings can be split between the customer and the ESCO on a percentage basis to be negotiated by the parties under the contract; in two other contracts the savings can either be credited to the ESCO's first year energy savings guarantee or remain with the customer; and in one contract the savings count toward the ESCO's savings guarantee in the first year automatically.

D.4 Surveying the Existing ESCO Market and Metrics

ESCOs are active in nearly every state, activity concentrated in population centers and states that have active and well-funded energy efficiency programs.[63] The National Conference of State Legislatures[64] and the Oak Ridge National Laboratory[65] have compiled the state statutes enabling ESPCs. From 1990 to 2008, the five states of New York, California, Texas, Pennsylvania and Maryland account for more than one-third of total market activity in the sample. New Jersey and Massachusetts, states that have had well-developed efficiency programs also show substantial ESCO market activity. Figure D-4 shows project activity from the NAESCO database by state through 2008 along with ranking in terms of REEP budgets. States such as Missouri, Kansas and Indiana, although not centers of population or economic activity, have energy offices that have championed performance contracting in institutional sector markets.

Figure D-4 Project Activity by State



***Source:* Larsen, P.H. et al. 2014.**

[63] This strand of literature is based on a database compiled by the National Association of Energy Service Companies (NAESCO). NAESCO requests that its member ESCOs submit information on up to 50 energy efficiency projects completed in the previous 42 months as part of its voluntary accreditation process. Although this database is the best available source of empirical data on performance contracting, it is not perfect. The data may not necessarily be representative of all ESCO contracts, since the process includes some self-selection of projects. Large ESCOs that had more than 50 projects over the time period selected their own subset of projects to submit. In addition some project entries are missing data fields, which limits the sample for some analyses. See Larsen et al, (2014), and Goldman et al (2002).

[64] http://www.ncsl.org/research/energy/state-energy-savings-performance-contracting.aspx

[65] http://web.ornl.gov/info/esco/legislation/newesco.shtml

Table D-1 lists the top 10 states by ESCO activity (in terms of project costs), as well as overall economic activity, population, and REEP funding.

Table D-1 Top 10 States by ESCO Activity

State	ESCO Project Investment (database)		ESCO Project Investment (2002 database report)		Economic Activity (2008 GSP)[14]		Population (2009)[15]		Ratepayer Funded EE Program (REEP) Budgets (2009)[16]	
	Rank	($M)	Rank	($M)	Rank	($B)	Rank	(Million People)	Rank	($M 2009)
New York	1	773	1	328	3	1144	3	19.5	2	378.3
Pennsylvania	2	615	10	75	6	553	6	12.6	10	96.9
California	3	536	3	230	1	1847	1	37.0	1	998.3
Maryland	4	451	N/A[17]	175	15	269	19	5.7	21	38
Texas	5	447	4	199	2	1224	2	24.8	9	98.7
Missouri	6	348	N/A	97	22	229	18	6.0	27	22.7
Illinois	7	348	7	109	5	634	5	12.9	11	89.9
New Jersey	8	271	2	267	7	475	11	8.7	6	132.3
Massachusetts	9	227	5	136	13	352	15	6.6	3	183.8
Indiana	10	210	6	120	18	246	16	6.4	35	13.6

Source: Larsen, 2014.

[14] BEA (2009b)
[15] U.S. Census Bureau (2009)
[16] Molina et al. (2010)
[17] Goldman et al. (2002) reported only rankings for the top-ten states in terms of total project investment. We calculated the project investment for Maryland, Missouri, Michigan, Kansas, Virginia, and Washington, DC for all projects prior to 2002 but could not replicate rankings by state.

Institutional sector projects have made up the bulk of ESCO projects over the time period. Of the over 2,000 projects that included market segment information from 1990 to 2008, 85 percent were for institutional customers.[66] Of the 1,489 projects that included facility type, only five are categorized as wastewater treatment plant projects; no water treatment plants were included indicating how rare these types of projects are in that sector.

A number of papers from Lawrence Berkeley National Laboratory explore the U.S. ESCO market and ESCO project performance; however, much of this empirical work covers the period before the 2008 financial recession, while the literature on performance since that time is sparse.

[66] Larsen, et al. 2014.

Of note is that market growth by 2008 had fallen below projections,[67] and continued to perform below expectations through 2011.[68] LBNL estimated the remaining market potential as of 2013 was $71 to $133 billion, of which state and local agencies represented $10 to $16 billion. For most ESCO in the survey, less than 10 percent of their projects relied on federal investment tax credits, indicating that these type of projects have been relying largely on internally generated positive returns on investment rather than external funding sources.

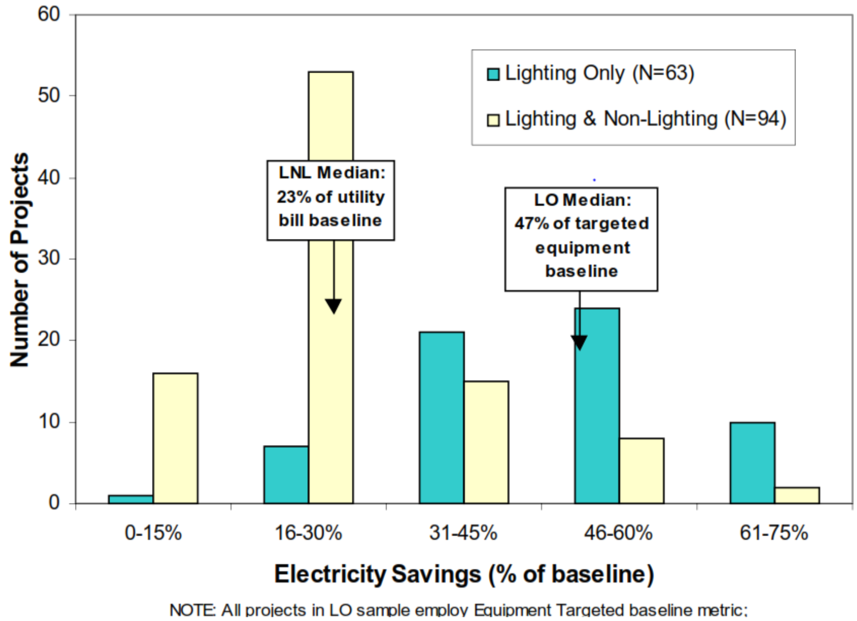
D.5 Summary of the Current Energy Savings Performance Market

ESCO contracts generally achieve a large amount of their target energy savings from reduced electricity usage, with a focus on buildings and related structures. According to one study that covers the period from 1990 to 2000, median energy savings were 15 thousand Btus (kBtu) per square foot (sf).[69] Reductions in electricity consumption made up the bulk of these savings, accounting for 80 percent of the total energy savings. Savings vary by specific market segment. Median energy savings range from 13-15 kBtu/sf for university/college, federal government and private sector projects to 18-19 kBtu/sf for state/local government and health/hospital projects.[70]

Figure D-5 shows the number of projects that achieved varying levels of electricity savings. For Lighting-Only projects covered in the 1990-2000 sample, the median electricity savings was 47 percent of the baseline use of the targeted equipment. For projects that employ both lighting and non-lighting measures as part of their approach, median savings were 23 percent of the total electricity baseline.

[67] Andrew Satchell, et al, *A Survey of the U.S. ESCO Industry: Market Growth and Development from 2008 to 2011*, Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, http://www.naesco.org/data/industryreports/ESCO%20study.pdf, June 2010.
[68] Elizabeth Stuart et al, "Current Size and Remaining Market Potential of U.S. ESCO Industry," Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, https://emp.lbl.gov/sites/all/files/lbnl-6300e-ppt.pdf, September 2013.
[69] Goldman et al 2002.
[70] Ibid.

Figure D-5 Electricity Savings



Source: Goldman et al. 2005.

D.5.1 Accuracy of Predictions and Savings Guarantee

Goldman et al (2002) examined the accuracy of ESCO savings estimates for the subset of projects in their sample that report both predicted and actual energy savings. [71] See Figure D-6 for a breakdown of accuracy. Of the 1,420 projects in the 1990-2000 sample, only 26 percent provided both actual and predicted savings. For these 369 projects, ESCOs were able to realize savings within 15 percent of predicted amounts in approximately 60 percent of cases; 37 percent were able to predict within 5 percent of actual savings.

[71] Ibid.

Figure D-6 Accuracy of ESCP Saving Predictions

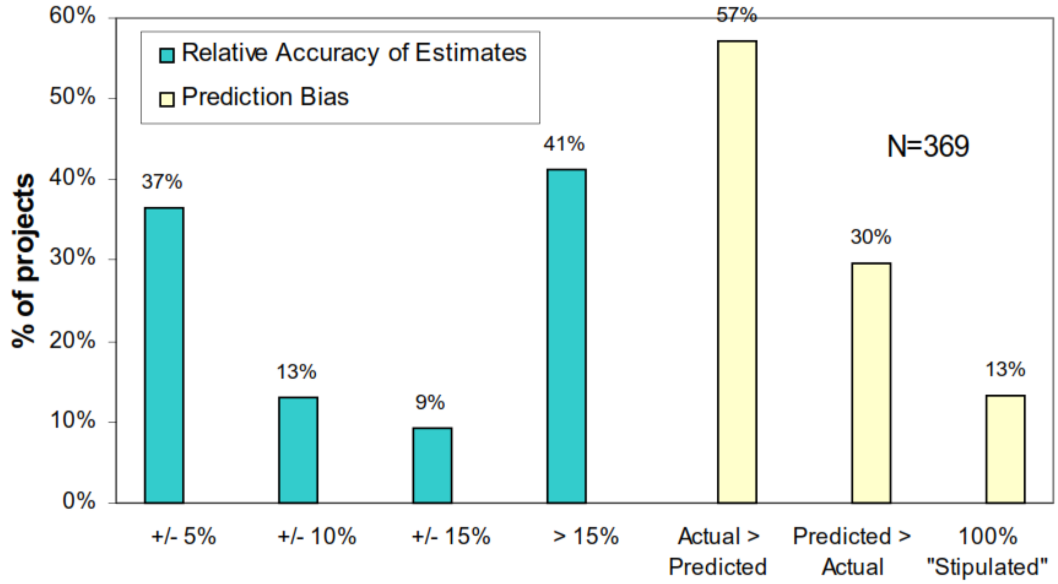


Figure 6 also shows the breakdown of predicted versus actual savings. From 1990 to 2000, 13 percent of projects stipulated savings for all installed measures (stipulated savings means assuming a savings amount based on assumed energy consumption rates and average usage data, without requiring measurement and verification of that amount). Out of the remaining projects that undergo a measurement and verification process to determine energy savings (a total of 314 projects), 57 percent had actual energy savings that exceeded predicted savings. For the entire period from 1990 to 2008, 85 percent of the subset of projects for public and institutional customers had savings that met or exceeded the guarantee.[72]

The majority of ESCO contracts are guaranteed-savings contracts. Some of the papers examine the relationship between the amount of savings predicted by the ESCO and the amount guaranteed by the ESCO. Only 15 companies provided information on both predicted and guaranteed-savings; however, for this small sample size, seven guaranteed 100 percent of predicted savings, six guaranteed an amount between 50 percent and 100 percent of predicted savings, and two guaranteed less than 50 percent of predicted savings.[73]

D.5.2 Other Indicators of Effectiveness

Goldman et al calculate three different measures of project effectiveness or economic value from the customer's perspective—project net benefits, a benefit/cost ratio, and simple payback time. These calculations do not include financial incentives from ratepayer-funded energy efficiency programs (REEP). These are incentives provided by local utilities that are often passed on in full or in part to customers to reduce the cost of the project. Approximately 30 percent of projects in

[72] Larsen et al. 2014.
[73] Goldman, C.A., et al. 2002.

the database reported receiving REEP incentives. For the period from 1990 to 2008, project net benefits totaled $3.94 billion over the entire sample of 2,484 projects, for an average per project of $1.6 million.[74] These calculations use a discount rate of 7 percent for institutional sector projects and 10 percent for private sector projects.[75]

The majority of ESCO projects have a benefit-cost ratio greater than one, indicating that they are produce positive benefits and meet a specified financial hurdle. Table D- summarizes net benefits and benefit-cost ratios for the different market segments. For individual market segments, the benefit-cost ratio ranges from 1.1 for K-12 schools to 2.6 for health/hospitals and private entities.

Table D-2 Net Benefits and Benefit-Cost Ratios Summary

Market Segment	Count	Total Net Benefits (million US$)	Median Project Benefit-cost Ratio
Federal Government	319	$2,111.9	1.7
State/local Government	367	$442.3	1.5
Health/Hospitals	186	$330.5	2.6
Public Housing	68	$68.8	1.4
K-12 Schools *	910	$28.4	1.1
Universities/colleges	281	$442.9	1.4
Private	353	$512.9	2.6
Total	***2,484***	***$3,937.8***	

Source: Larsen et al. 2014.

Simple payback time for energy efficiency investments among projects in the database is slightly longer for institutional sector projects than for private sector projects. From 1990 to 2000, the median payback time for the institutional sector is about seven years, with 44 percent of project having a payback time of six years or less. The median payback time for the private sector was about three years, with 83 percent having a payback time of six years or less.[76] For the entire period from 1990 to 2008, Table D-3 summarizes median payback time and benefit-cost ratio for different market segments and time periods.

[74] Larsen et al. 2014.
[75] These rates are consistent with guidance provided by the federal Office of Management and Budget.
[76] Goldman et al. 2002.

Table D-3 Median Payback Time and Benefit-cost Ratio Summary

Market segment	Installation Year	Simple Payback Time (years)	Benefit-cost Ratio
K-12 Schools	1990-1997	8.2 (n=125)	1.5 (n=121)
K-12 Schools	1998-2004	9.6 (n=540)	1.1 (n=536)
K-12 Schools	2005-2008	13.1 (n=263)	0.9 (n=263)
Other Public	1990-1997	3.9 (n=225)	3.0 (n=220)
Other Public	1998-2004	7.0 (n=724)	1.6 (n=708)
Other Public	2005-2008	9.0 (n=353)	1.2 (n=339)
Private	1990-1997	1.9 (n=138)	4.3 (n=138)
Private	1998-2004	3.7 (n=197)	2.2 (n=185)
Private	2005-2008	3.2 (n=33)	2.7 (n=31)

Source: Larsen et al. 2014.

D.6 Types of ESCO Contracts

- **Guaranteed-savings**—The ESCO guarantees a specific amount of energy savings. Using pre-defined assumptions about serving utility tariff rates the ESCO sets the guarantee so that the energy savings created by a project will cover the cost of project financing for the life of the project, typically 10 to 20 years. If savings are less than the guaranteed amount, the ESCO agrees to pay the shortfall amount, thereby mitigating the financial risk for the customer. Savings in excess of the guaranteed amount are retained by the customer. After the guaranteed-savings period, the building owner retains the full value of the energy savings and assumes ownership of the equipment. Guaranteed-savings contracts are the most common type of ESCO performance contract in the United States. Typically under a guaranteed-savings agreement, the customer provides project financing either through its own resources, a capital lease, or other form, discussed in more detail below.

- **Shared savings**—In a shared savings agreement project savings are divided at an agreed upon percentage between the customer and the ESCO. The ESCO only receives payment from the customer if there are positive energy savings during a given period. Under this type of agreement, the ESCO typically secures project financing in addition to implementing project development. The ESCO is liable for repayment of upfront equipment purchases regardless of whether the project achieves energy savings. In this way, the ESCO takes on the performance and financing risk of the project. In general, the

ESCO receives a higher proportion of project savings in early years to cover project financing, often ramping down over the course of the project. Because the ESCO takes on more risk under a shared savings agreement, such agreements are not common.

- **No-guaranteed-savings**—In a no-guaranteed-savings contract the ESCO provides the energy audit, design and construction of an energy savings project, but does not guarantee the energy savings. The customer assumes full responsibility for both the performance risk and the financial risk of the project. The customer provides project financing, though financing can be linked to projected savings from the project. These contracts are non-performance-based; they are essentially upfront purchase agreements.

- **Pay from savings**—This contract type is a variation of the guaranteed-savings contract, in which the payment schedule is tied to the level of savings. With higher levels of savings project costs can be repaid more quickly; however, unlike a guaranteed-savings contract, project financing is typically provided by the ESCO rather than the customer.

- **Chauffage**—In a chauffage contract, the performance contractor assumes operation of the building or facility, making energy savings upgrades and also taking over payment of utility bills. This becomes a building management or service provision arrangement akin to types of full-service vendor agreements. The customer is entirely shielded from energy costs to the extent that the ESCO vendor passes through those costs. Chauffage contracts are common in Europe, but not in the United States.

Appendix E

Acronyms and Abbreviations

ACWA	Association of California Water Agencies
AF	Acre Foot
AFY	Acre Foot per Year
AIEE	American Institute of Electrical Engineers
APPA	American Public Power Association
AWE	Alliance for Water Efficiency
AWWA	American Water Works Association
bgs	Below ground surface
CEC	California Energy Commission
cfs	Cubic feet per second
CPUC	California Public Utilities Commission
CUWCC	California Urban Water Conservation Council
CWA	Clean Water Act
DDW	California State Water Board Division of Drinking Water
DWR	California Department of Water Resources
EC	Electrical conductivity
EPRI	Electric Power Research Institute
ESCO	Energy Service Companies
ESPC	Energy Savings Performance Contracts
GEI	GEI Consultants, Inc.
gpm	Gallons per minute
GWh	gigawatt-hours
HI	Hydraulic Institute
hp	horsepower
HVAC	Heating, Ventilating, and Air Conditioning
IEEE	Institute of Electrical and Electronics Engineers, Inc.
kW	kilowatt

kWh	kilowatt-hour
MCL	Maximum contaminant level
mg/l	Milligrams per liter
Mgal	Million gallons
Mgal/day	Million gallons per day
MW	megawatt
MWh	megawatt-hour
NAESCO	National Association of Energy Service Companies
NASEO	National Association of State Energy Officials
NEMA	National Electric Manufacturers Association
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and maintenance
RFP	Request for Proposal
SWRCB	State Water Resources Control Board
TAF	Total acre feet
USBR	U.S. Bureau of Reclamation
US DOC	U. S. Department of Commerce
US DOE	U. S. Department of Energy
US EPA	United States Environmental Protection Agency
WERF	Water Environment Research Foundation
WRF	Water Research Foundation

Appendix F

Glossary of Terms

NOTE: This Glossary of Terms includes terms used in the definitions of terms and references used within this report for the convenience of the reader.

Acre-foot
A volume of water that covers one acre to a depth of one foot, or 43,560 cubic feet (1,233.5 cubic meters) or 325,851 gallons.

Advanced Metering Infrastructure (AMI)
Refers to a system that measures, collects, and analyzes energy usage while interacting with advanced devices such as water meters through various communication media, either on demand or on predefined schedules. This infrastructure includes hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software, and supplier and network distribution systems.

Aeration
The process of adding air to water. Air can be added to water by either passing air through water or passing water through air through mechanical processes.

Air Blower
A device used to ventilate [portions of a system such as] manholes and lift stations.

Air Lift Pump
A special type of pump consisting of a vertical riser pipe submerged in the wastewater or sludge to be pumped. Compressed air is injected into a tail piece at the bottom of the pipe. Fine air bubbles mix with the wastewater or sludge to form a mixture lighter than the surrounding water, which causes the mixture to rise in the discharge pipe to the outlet.

Air Padding
Pumping dry air (dew point –40°F (–40°C)) into a container to assist with the withdrawal of a liquid or to force a liquefied gas such as chlorine or sulfur dioxide out of a container.

Alternating Current (AC)
An electric current that reverses its direction (positive/negative values) at regular intervals.

Altitude Valve

A valve that automatically shuts off the flow into an elevated tank when the water level in the tank reaches a predetermined level. The valve automatically opens when the pressure in the distribution system drops below the pressure in the tank.

Analyzer
A device that conducts a periodic or continuous measurement of turbidity or some factor such as chlorine or fluoride concentration. Analyzers operate by any of several methods including photocells, conductivity, or complex instrumentation.

Aquifer
A natural, underground layer of porous, water-bearing materials (sand, gravel) usually capable of yielding a large amount or supply of water.

Asset Management
The process of maintaining the functionality and value of a utility's assets through repair, rehabilitation, and replacement. Examples of utility assets include buildings, tools, equipment, pipes, and machinery used to operate a water or wastewater system. The primary goal of asset management is to provide safe, reliable, and cost-effective service to a community over the useful life of a utility's assets.

Audit, Water
A thorough examination of the accuracy of water agency records or accounts (volumes of water) and system control equipment. Water managers can use audits to determine their water distribution system efficiency. The overall goal is to identify and verify water and revenue losses in a water system.

Average Demand
The total demand for water during a period of time divided by the number of days in that time period [such as a day to obtain the average daily demand].

Back Pressure
A pressure that can cause water to backflow into the water supply when a user's water system is at a higher pressure than the public water system.

Backflow
A reverse flow condition, created by a difference in water pressures, that causes water to flow back into the distribution pipes of a potable water supply from any source or sources other than an intended source.

Benchmarking
A process an agency uses to gather and compare information about the productivity and performance of other similar agencies with its own information. The purpose of benchmarking is

to identify best practices, set improvement targets, and measure progress. The benchmark is a standard or point of reference used to judge or measure quality or value.

Best Available Technology (BAT)
BAT is based on the very best (state-of-the-art) control and treatment measures that have been developed, or are capable of being developed, and that are economically achievable within the appropriate industrial category.

Best Practicable Technology (BPT)
A level of technology represented by the average of the best existing performance levels within the industrial category.

Capital Improvement Plan (CIP)
A detailed plan that identifies requirements for the repair, replacement, and rehabilitation of facility infrastructure over an extended period, often 20 years or more. A utility usually updates or prepares this plan annually. For water systems, the plan is often a part of a master plan that combines water demand projections with supply alternatives and facility requirements. For wastewater systems, the plan consists of programs and projects to upgrade and rehabilitate wastewater collection and treatment systems and increase their capacity to allow for future growth.

Commissioning
The procedures used by a utility agency to inspect, test, train staff, start up, operate, and ultimately accept a new facility.

Conduit
Any artificial or natural duct, either open or closed, for carrying fluids from one point to another. An electrical conduit carries electricity.

Consumptive Use
That part of water withdrawn that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment. Also referred to as water consumed.

Control System
An instrumentation system that senses and controls its own operation on a close, continuous basis in what is called proportional (or modulating) control.

Controller
A device that controls the starting, stopping, or operation of a device or piece of equipment.

Conveyance Loss
Water that is lost in transit from a pipe, canal, or ditch by leakage or evaporation. Generally, the water is not available for further use; however, leakage from an irrigation ditch, for example, may percolate to a ground-water source and be available for further use.

Cubic Feet per Second (cfs)
A rate of the flow, in streams and rivers, for example. It is equal to a volume of water one foot high and one foot wide flowing a distance of one foot in one second. One "cfs" is equal to 7.48 gallons of water flowing each second. As an example, if your car's gas tank is 2 feet by 1 foot by 1 foot (2 cubic feet), then gas flowing at a rate of 1 cubic foot/second would fill the tank in two seconds.

Current
A movement or flow of electricity. Electric current is measured by the number of coulombs per second flowing past a certain point in a conductor. A coulomb is equal to about 6.25 x 1018 electrons (6,250,000,000,000,000,000 electrons). A flow of one coulomb per second is called one ampere, the unit of the rate of flow of current.

Cycle
A complete alternation of voltage or current in an alternating current (AC) circuit.

Debt Service
The amount of money required annually to pay the (1) interest on outstanding debts or (2) funds due on a maturing bonded debt or the redemption of bonds.

Desalinization
The removal of dissolved salts (such as sodium chloride, NaCl) from water by natural means (leaching) or by specific water treatment processes.

Direct Current (DC)
Electric current flowing in one direction only and essentially free from pulsation.

Distributed Control System
A computer control system having multiple microprocessors to distribute the functions performing process control, thereby distributing the risk from component failure. The distributed components (input/output devices, control devices, and operator interface devices) are all connected by communications links and permit the transmission of control, measurement, and operating information to and from many locations.

Domestic Water Use
Water used for household purposes, such as drinking; food preparation; bathing; washing clothes, dishes, and dogs; flushing toilets; and watering lawns and gardens. About 85 percent of

domestic water is delivered to homes by a public-supply facility, such as a county water department. About 15 percent of the nation's population supply their own water, mainly from wells.

Drawdown

1. The drop in the water table or level of water in the ground when water is being pumped from a well.
2. The amount of water used from a tank or reservoir.
3. The drop in the water level of a tank or reservoir.

Electric Current
The flow of electric charges.

Electricity
Physical conditions associated with the presence and flow of electric charges.

Energy Savings Performance Contracts
ESPCs are a financing mechanism used by Energy Service Companies (ESCO) to make energy efficiency upgrades to facilities on behalf of the owner which are then paid for using money resulting from the energy savings. For more information see: http://energy.gov/eere/slsc/energy-savings-performance-contracting.

Enterprise Fund Reserves
Enterprise fund reserves typically serve two purposes: 1) funding unanticipated or emergency repairs to utility infrastructure (e.g., water main breaks, pump failures, etc.) and 2) making up for revenue shortfalls due to variations in utility usage (e.g., lower water usage during drought conditions) that provides a financial buffer avoiding the need to continually adjust rates to account for usage variations. The minimum level of reserves relative to investments and operations costs is often defined in the debt covenants with the lender.

Equity
The value of an investment in a facility.

Evaporation
The process by which water or other liquid becomes a gas (such as water vapor or ammonia vapor).

Feasible
Capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social and technological factors (California Water Code Section 8307).

Feedback

The circulating action between a sensor measuring a process variable and the controller that controls or adjusts the process variable.

Fixed Costs
Costs (rent, insurance, interest) that a utility must cover or pay even if there is no demand for water or no water to sell to customers.

Flow
The continuous movement of a liquid from one place to another.

Freshwater
Water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids; generally, more than 500 mg/L of dissolved solids is undesirable for drinking and many industrial uses.

Fuse
A protective device having a strip or wire of fusible metal that, when placed in a circuit, will melt and break the electric circuit if heated too much. High temperatures will develop in the fuse when a current flows through the fuse in excess of that which the circuit will carry safely.

Gauge
A device for checking or measuring a particular dimension of something, using specific standardized units. For example, a gauge might measure the elevation of a water surface, the velocity of flowing water, the pressure of water, the amount or intensity of precipitation, or the depth of snowfall. Gauges also are used to determine the location or position of equipment during installation and after operation.

Gravity Flow
Water or wastewater flowing from a higher elevation to a lower elevation due to the force of gravity. The water does not flow due to energy provided by a pump. Wherever possible, wastewater collection systems are designed to use the force of gravity to carry waste liquids and solids.

Greywater
Wastewater from clothes washing machines, showers, bathtubs, hand washing, lavatories and sinks.

Ground
An expression representing an electrical connection to earth or a large conductor that is at the earth's potential or neutral voltage.

Groundwater

Subsurface water in the saturation zone from which wells and springs are fed. In a strict sense the term applies only to water below the water table.

Groundwater Depth
The distance of the groundwater table below the surface at any selected location.

Groundwater Recharge
The natural or intentional infiltration of surface water into the zone (ground) of saturation.

Groundwater Table
The average depth or elevation of the groundwater over a selected area.

Head
The vertical distance, height, or energy of water above a reference point. A head of water may be measured in either height (feet or meters) or pressure (pounds per square inch or kilograms per square centimeter).

Head Loss
The head, pressure, or energy (they are the same) lost by water flowing in a pipe or channel as a result of turbulence caused by the velocity of the flowing water and the roughness of the pipe, channel walls, or restrictions caused by fittings. Water flowing in a pipe loses head, pressure, or energy as a result of friction. Also called FRICTION LOSS.

Headworks
The facilities where wastewater enters a wastewater treatment plant. The headworks may consist of bar racks or bar screens, comminutors, a wet well, and pumps.

Hectare
A metric unit equal to 2.471 acres or a 10,000 square meters

Hertz (Hz)
The number of complete electromagnetic cycles or waves in one second of an electric or electronic circuit. Also called the frequency of the current.

Hydraulic Gradient
The slope of the hydraulic grade line. This is the slope of the water surface in an open channel, the slope of the water surface of the groundwater table, or the slope of the water pressure for pipes under pressure.

Influent
Water or other liquid—raw (untreated) or partially treated—flowing INTO a reservoir, basin, treatment process, or treatment plant.

Injection Well
A well-constructed for the purpose of injecting water (including treated wastewater) directly into the ground. Water is generally forced (pumped) into the well for dispersal or storage into a designated aquifer.

Input Horsepower
The total power used in operating a pump and motor.

$$\text{Input Horsepower, HP} = \frac{(\text{Brake Horsepower, HP})(100\%)}{\text{Motor Efficiency, \%}}$$

Interceptor
A septic tank or other holding tank that serves as a temporary wastewater storage reservoir for a septic tank effluent pump (STEP) system.

Irrigation
The controlled application of water for agricultural purposes through manmade systems to supply water requirements not satisfied by rainfall.

Kinetic Energy
Energy possessed by a moving body of matter, such as water, as a result of its motion.

Life-Cycle Costing
An economic analysis procedure that considers the total costs associated with a sewer during its economic life, including development, construction, and operation and maintenance (includes chemical and energy costs). All costs are converted to a present worth or present cost in dollars.

Lift Station
In water systems, a series of pumps and valves that lifts water (or wastewater) to a higher elevation. Lift stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a pump station.

Mechanical Aeration
The use of machinery to mix air and water so that oxygen can be absorbed into the water. Some examples are paddle wheels, mixers, or rotating brushes to agitate the surface of an aeration tank; pumps to create fountains; and pumps to discharge water down a series of steps forming falls or cascades.

Metered
Measured through a meter, as a quantity of water or flow might be measured.

Million Gallons
A unit of measurement used in wastewater treatment plant design and collection system capacities or performances. One million gallons of water is approximately equivalent to these units of measurement:

- 13,690 Cubic Feet
- 3.07 Acre-Feet
- 8,340,000 Pounds of Weight
- 4,170 Tons of Weight
- 3,785 Cubic Meters

Motor Efficiency
The ratio of energy delivered by a motor to the energy supplied to it during a fixed period or cycle. Motor efficiency ratings will vary depending on motor manufacturer and usually will be near 90.0 percent.

Nameplate
A durable, metal plate found on equipment that lists critical installation and operating conditions for the equipment.

Operating Pressure Differential
The operating pressure range for a hydropneumatic system. For example, when the pressure drops below 40 psi in a system designed to operate between 40 psi and 60 psi, the pump will come on and stay on until the pressure builds up to 60 psi. When the pressure reaches 60 psi the pump will shut off. The operating pressure differential in this example is 20 psi.

Operation and Maintenance
Efforts that must be expended to keep facilities in good working order and condition so they continue to perform as designed; poorly maintained facilities tend to be more vulnerable to failure.

Outfall

1. The point, location, or structure where wastewater or drainage discharges from a sewer, drain, or other conduit.
2. The conduit leading to the final discharge point or area. Also see OUTFALL SEWER.

Overall Pump Efficiency
The combined efficiency of a pump and motor together. Also called the wire-to-water efficiency.

Overdraft
The pumping of water from a groundwater basin or aquifer in excess of the supply flowing into the basin. This pumping results in a depletion or mining of the groundwater in the basin.

Peak Demand

The maximum momentary load placed on a water treatment plant, pumping station, or distribution system. This demand is usually the maximum average load in one hour or less, but may be specified as the instantaneous load or the load during some other short time period.

Potable Water
Water of a quality suitable for drinking.

Raw Water

1. Water in its natural state, prior to any treatment.
2. Water entering the first treatment process of a water treatment plant.

Reclaimed Wastewater
Treated wastewater that can be used for beneficial purposes, such as irrigation and industrial processes that do not require potable water.

Recycled Water
Water that is used more than one time before it passes back into the natural hydrologic system.

Representative Sample
A subset (sample) of a population that reflects the entire population, such as portion of material, water, or wastestream that is as nearly identical in content and consistency as possible to that in the larger body being sampled.

Reservoir
A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.

Reuse
The use of water or wastewater after it has been discharged and then withdrawn by another user. Also see RECYCLE.

Reverse Osmosis (RO)
The application of pressure to a concentrated solution, which causes the passage of a liquid from the concentrated solution to a weaker solution across a semipermeable membrane. The membrane allows the passage of the water (solvent) but not the dissolved solids (solutes). In the reverse osmosis process, two liquids are produced: (1) the reject (containing high concentrations of dissolved solids), and (2) the permeate (containing low concentrations). The clean water (permeate) is not always considered to be demineralized. Also see OSMOSIS.

SCADA System
Supervisory Control and Data Acquisition system. A computer-monitored alarm, response, control, and data acquisition system used to monitor and adjust treatment processes and facilities.

Sensor
A device that measures (senses) a physical condition or variable of interest. Floats and thermocouples are examples of sensors. Also called a primary element.

Surface Water
Water that is on the Earth's surface, such as in a stream, river, lake, or reservoir.

Telemetering Equipment
Equipment that translates physical measurements into electrical impulses that are transmitted to dials or recorders.

Telemetry
The electrical link between a field transmitter and the receiver. Telephone lines are commonly used to serve as the electrical line.

Temperature Sensor
A device that opens and closes a switch in response to changes in the temperature. This device might be a metal contact, or a thermocouple that generates a minute electric current proportional to the difference in heat, or a variable resistor whose value changes in response to changes in temperature. Also called a heat sensor.

Tertiary Treatment
Any process of water renovation that upgrades treated wastewater to meet specific reuse requirements. May include general cleanup of water or removal of specific parts of wastes insufficiently removed by conventional treatment processes. Typical processes include chemical treatment and pressure filtration. Also called advanced waste treatment.

Ultraviolet (UV)
Pertaining to a band of electromagnetic radiation just beyond the visible light spectrum. Ultraviolet radiation is used to disinfect water and wastewater. When ultraviolet radiation is absorbed by the cells of microorganisms, it damages the genetic material in such a way that the organisms are no longer able to grow or reproduce, thus ultimately killing them.

Upstream
The direction against the flow of water; or, toward or in the higher part of a sewer or collection system.

Urban Area
A location characterized by high human population and human-built features; these areas can be cities or towns.

Urban Water Supply System
A water system designed and operated to supply the domestic supply needs of a city or town. This water is withdrawn from a source, treated to appropriate standards and then provided for domestic, commercial, thermoelectric power, industrial, and public water users.

Variable Costs
Costs that a utility must cover or pay that are directly associated with the actual production and delivery of service. These costs vary or fluctuate.

Variable Frequency Drive
A control system that allows the frequency of the current applied to a motor to be varied. The motor is connected to a low-frequency source while standing still; the frequency is then increased gradually until the motor and pump (or other driven machine) are operating at the desired speed.

Vault
A small, box-like structure that contains valves used to regulate flows.

Voltage
The electrical pressure available to cause a flow of current (amperage) when an electric circuit is closed. Also called electromotive force (EMF).

Wastewater
A community's used water and water-carried solids (including used water from industrial processes) that flow to a treatment plant. Stormwater, surface water, and groundwater infiltration also may be included in the wastewater that enters a wastewater treatment plant. The term sewage usually refers to household wastes, but this word is being replaced by the term wastewater.

Wastewater Facilities
The pipes, conduits, structures, equipment, and processes required to collect, convey, and treat domestic and industrial wastes, and discharge or reuse of the effluent and sludge.

Water Cycle
The process of evaporation of water into the air and its return to earth by precipitation (rain or snow). This process also includes transpiration from plants, groundwater movement, and runoff into rivers, streams, and the ocean. Also called the hydrologic cycle.

Water Supplier
An agency, utility or person that supplies water (usually potable water) to a customer.

Watt
A unit of power equal to one joule per second. The power of a current of one ampere flowing across a potential difference of one volt.

Well (water)
An artificial excavation put down by any method for the purposes of withdrawing water from the underground aquifers. A bored, drilled, or driven shaft, or a dug hole whose depth is greater than the largest surface dimension the purpose of which is to reach underground water supplies or to store or bury fluids below ground.

Wire-to-Water Efficiency
The combined efficiency of a pump and motor together. Also called the overall efficiency.

Yield (also called Safe Yield)
The quantity of water (expressed as a rate of flow—GPM, GPH, GPD, cu m/day, ML/day, or total quantity per year) that can be collected for a given use from surface or groundwater sources. The yield may vary with the use proposed, with the plan of development, and also with economic considerations.