Literature Review

This literature review is part of the National Electrical Manufacturers Association's (NEMA) Increasing Energy Efficiency in Urban Water Supply Systems Initiative. NEMA selected GEI Consultants Inc. and its partners to support their strategic initiative on the energy-water nexus. NEMA's initiative encompasses the following goals:

1) Collect data to quantify the effectiveness and efficiency of equipment in facilities representative of the U.S. urban water supply's delivery and treatment systems
2) Analyze the market potential to improve effectiveness of water supply, delivery, and treatment systems using NEMA member products (including HVAC and lighting)
3) Evaluate the viability of energy savings performance contract practices, other financing mechanisms, and government grants to finance modernization upgrades

As a fundemental component of first goal listed above (goal 1), GEI applied the following method to review readily available literature, gather pertinent facts, and compile this information contained within this document. Using goal 1 to set the scope of literature considered, the project team

1) identified key search terms and applied them to standard search internet engines;
2) considered documents that were in English, readily available on the internet at no cost;
3) revisited terms and periodically refined and updated terms;
4) critically reviewed and analyzed materials to determine relevance to the defined goal (i.e., determined the focus of the documents, scope of the study or analysis, and findings or results); and
5) compiled the results in this Excel spreadsheet.

The results of this literature review supported the analyses conducted as part of goals 2 and 3, discussed fully in the project report, *Advancing Energy Efficiency in Urban Water Supply Systems,* dated February 2016.

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GEI Consultants

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
Eric Meliton	Frost & Sullivan	Aug. 29, 2012	Water related infrastructure spending	Market drivers, technology trends, investments	This presentation discusses water and wastewater infrastructure challenges, market conditions and drivers, various case studies and recommendations to address challenges. Thes recommendations included: - Modify bond structures to encourage greater investments - Build stronger vendor relationships with users to develop collaborative solutions - Achieve full cost pricing of water and wastewater - Improve planning for investment in retrofits, replacements and expansions	http://www.slideshare.net/FrostandSullivan/2012-us-municipal-water-wastewater-infrastructure-spending-14165238
	ASCE	Mar. 2013	Infrastructure, water, wastewater, pipes	National (US)	• The grade for drinking water improved slightly to a D. Much of our drinking water infrastructure is nearing the end of its useful life. • There are an estimated 240,000 water main breaks per year in the US. • Assuming every pipe would need to be replaced, the cost over the coming decades could reach more than $1 trillion, according to the American Water Works Association (AWWA). The quality of drinking water in the United States remains universally high, however. • Though pipes/mains are frequently over 100 years old and in need of replacement, outbreaks of disease attributable to drinking water are rare.	http://ascelibrary.org/doi/pdf/10.1061/9780784478837
Pacific Northwest National Laboratory	U.S. Department of Energy	Sept. 27, 2011	ESCO, energy efficiency, risk management	National	This guide describes the benefits offered by ESCOs and the things to consider when selecting and contracting with your provider. Key benefits to working with ESCOs include improved building performance, options for project financing and risk management, and access to expertise, new equipment and training with little to no upfront cost. Discusses key considerations in risk management including operational issues, financial issues, and performance issues.	http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20939.pdf
Walter Short, Daniel J Packey, and Thomas Holt	National Renewable Energy Laboratory	3/1/1995	Economic evaluations; performance analysis	National	A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies provides guidance on economic evaluation approaches, metrics, and levels of detail required, while offering a consistent basis on which analysts can perform analyses using standard assumptions and bases. It not only provides information on the primary economic measures used in economic analyses and the fundamentals of finance but also provides guidance focused on the special considerations required in the economic evaluation of energy efficiency and renewable energy systems.	www.nrel.gov/docs/legosti/old/5173.pdf

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Rachel Young	ACEEE, National Association of Water Companies (NAWC)	Jun. 2015	Energy for Water, Energy Intensity, Water Management	National	As part of the Commercial Building Initiative, a survey conducted for NAWC's member companies related to their energy use and water processing. Findings: • The water companies surveyed have energy intensity (avg. 2,300 kWh/MG) similar to those seen in previous ACEEE research. • The distance water travels in the system, the water source, and the size of the water utility all impact the energy intensity of the water system. • 9 out of 11 participating utilities have instituted leak-detection efforts in the past three years and 5 out of 11 offer water conservation programs of some sort to their customers. 3 partner with an energy utility, including 1 water utility with a joint program for end-use customers.	http://aceee.org/sites/default/files/water-company-energy-use.pdf
Lorraine White, Kathleen Ave, Rob Swartz, Amy Talbot	SMUD	Apr. 2015	AB 32, Water-Energy Nexus, Greenhouse Gas, Conservation, Efficiency, Renewable Energy	Local (Sacramento)	A project that examined the water systems in the Sacramento Region to assess opportunities to reduce greenhouse gas emissions for the Sacramento Municipal Utility District. Readily available data and agency information was analyzed to determine energy intensities, load profiles and other baseline energy data for water systems in the Sacramento Region. • The energy intensity of the region's water supply is approximately 281 kWh/ML (1,062 kWh/MG) and for individual agencies range from 82 - 628 kWh/ML (312 - 2,379 kWh/MG), notably higher than previously calculated. Groundwater or sources that require water treatment tend to have higher energy intensities, mostly the result of well pumping-related energy demand or treatment technologies used. Peak water demand occurs during the summer, coinciding with peak energy demands in the region. To meet summer peak demand, pumping and diversions increase significantly, driving the energy intensity of the region's water systems higher during this time period. There are numerous opportunities to increase water and energy efficiency in the region lower associated GHGs.	Available upon request of authors.
Pacific Northwest National Laboratory, PECI	U.S. Department of Energy	Sept. 2011	Performance Improvements for Large Existing Office Buildings	National	A typical office building can cut energy use by up to 25% by implementing no and low cost measures and over 45% (including 25% EBCx savings) by pursuing deeper retrofit measures presented in this guide. The impact of such projects will be felt in the form of reduced operating costs, improved occupant comfort, and other related benefits.	http://apps1.eere.energy.gov/tribalenergy/pdfs/doe_eere_aerg_office_buildings.pdf

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Donald Gilligan	National Association of Energy Service Companies (NAESCO)	Sept. 9, 2014	ESCO, energy efficiency	National	This presentation discussed the following key points regarding ESCOs: 1. ESCO Market Drivers are the Federal Government programs and MUSH Market; 2. Cumulative results include $50 B in guaranteed and verified savings and $30 B of public facility improvements; and 3. significant economic potential existing for ESCOs and is estimated in the several tens of billions What ESCOs need from the States: • estimates of the value of GHG reductions • streamlined, transparent state rulemaking that separate ratepayer and utility stockholder interests • national or regional standards on key issues	http://annualmeeting2014.naseo.org/Data/Sites/4/media/presentations/Gilligan-Don.pdf
Hung-Wen Lin, GEL Tianzhen Hong	ACEEE (American Council for an Energy Efficiency Economy	2012	Space Heating in Small and Large Size Office Buildings	National	• The most influencing parameters are space heating temperature setpoint and setback strategies, air infiltration, VAV terminal box damper minimum position settings for the large office, window type, window-wall-ratio, and internal loads. The relative impacts of these parameters vary with building type and climate. Good operation practice can save more heating energy than higher design efficiency level of an office building. • The simulated space heating energy use varies greatly and depends upon building types, configurations, and climates, especially a few key influencing building design and operation parameters. High efficient designs and better operation of buildings can both reduce space heating energy use, but the latter plays a more important role. Improving building operations through commissioning and retrofits is an effective way to save space heating energy use for existing buildings. Using energy efficient appliances, installing energy management system, educating and training occupants are also excellent methods to save energy.	http://aceee.org/files/proceedings/2012/data/papers/0193-000068.pdf

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Vanessa Leiby	Water Research Foundation	2011	Water treatment, water distribution, energy savings, ozonation optimization, demand management system (DMS), variable frequency drives (VFDs), computerized air handling system	Regional (Michigan)	AAWTS is in the early stages of realizing how to conserve energy and lower energy costs. As it continues to implement energy savings strategies, it will continue to develop metrics to document the savings achieved. Currently, AAWTS is focusing attention on attainable goals to lessen the cost for purchasing power. • Operating ozonation disinfection system under the depressed water pH conditions has reduced ozone generation energy costs. • Demand Management System allowed AAWTS to switch to off-peak hour pumping which allowed AAWTS to buy power at a lower rate by avoiding on-peak surcharges. • Capital investment for VFDs and multiple pumps and motors can be larger than single speed motors, payback time on the investment can be about 5 years, significantly less than the useful life of the pump and motor. • AAWTS installed a computer system to control the operation of the heating, ventilation, and air conditioning system.	http://www.waterrf.org/resources/Lists/PublicCaseStudiesList/Attachments/12/Case_Study_Ann_Arbor.pdf
Oak Ridge National Laboratory	U.S. Department of Energy	Feb. 29, 2012	Climate Change, Infrastructure, Vulnerability, Water, Wastewater, Efficiemcy, Adaptation	National	This technical report summarizes existing knowledge regarding infrastructure vulnerability to climate change and methods to address risks. Its assessment findings include recognition that cross sectoral management of resources and systems has not received much attention, but must in the future in order to address impacts of disruption to these systems. A key finding is that to reduce future risk, actions must go beyond common practice and may require transformative change.	http://www.esd.ornl.gov/eess/Infrastructure.pdf
Cynthia Lane	AWWA	Sept. 2009	Energy for Water, Drinking Water Supply, Water Conservation, Water Management, Green Building, Smart Growth	National	Water and wastewater utilities spend about $4 billion a year to pump, treat, deliver, collect, treat and clean water. For drinking water utilities, electricity consumption by pumping systems constitutes 90% of total energy use. Energy consumption by water and wastewater utilities will increase 20% in the next 15 years. Study looked at annual O&M expenses, cost comparisons, and detailed energy usage of 10 drinking water utilities. • Energy optimization opportunities include: water-related energy conservation and production (ENERGY STAR, WaterSense), water conservation and management, water conveyance leak detection and remediation, industrial water conservation reuse/recycling, Green Building design and Smart Growth.	http://www.gwpc.org/sites/default/files/event-sessions/Lane_Cynthia.pdf

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Dr. Yukio Akashi, Peter Morante	Rensselaer Polytechnic Institute	2003	Dimming Sensors	Regional (Wisconsin)	• Offices designed to low lighting power densities will not financially support a dimming system responsive to daylight levels. A less costly strategy would be to utilize an automatic on/off control scheme for the row of lighting fixtures along the windows. • Window tinting still allows some glare in the absence of internal shading - especially true with east- and west-facing glass in the early morning and late afternoons. Manually operated shades or blinds must be provided so building occupants can control for any glare issues. • Controlling the quality of daylight is difficult with large expanses of east- and/or west-facing windows. Building orientations should allow for north- and south-facing glass while minimizing east- and west-facing glass. • To ensure blinds are reopened, management must be diligent in reminding employees to open the blinds to take full advantage of the daylighting scheme.	http://www.lrc.rpi.edu/programs/daylighting/pdf/TomoTherapyCaseStudy.pdf
Joseph Technology Corporation, Inc.	NYSERDA - New York State Energy Research and Development Authority	Sept. 2013	Fisonic Pumping Devices and Fisonic Heat Generating Devices	Regional (NY)	The Fisonic Devices (FDs) are supersonic, condensing heat pumps with a patented internal geometry which causes steam and water to mix and accelerate, converting a minute fraction of fluid's thermal energy to physical trust (pump head) with the outlet pressure higher than the pressure of the working medium at the inlet of the FD. The FD heats the recirculated building water by direct contact with steam and transports the water through-out the building-thus eliminating the tube and shell heat exchanger and the electrically driven pump. The use of the FD allows reducing the terminal temperature difference between steam and water, the required steam consumption, the amount of cold potable water and temperature and flow rate of liquid discharged to the sewer. The tests demonstrated that: (1) The FPD reliably operates as a direct contact heat exchanger;(2) The FPD has the capability to create discharge pressure higher than the pressure of the working (steam) and injected (cold water) streams, thus operating as a pump; (3) The discharge pressure is increasing with the higher water temperature rise in the FPD; (4) The FPD reliably operates as an indirect contact heater in a domestic hot water (DHW) system resulting in reduction of steam consumption by 14.7% in comparison with the conventional DHW system.	http://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Other-Technical-Reports

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Ethan A. Rogers	ACEEE	2015	Extended Motor Products, Pumps, Efficiency	National	• The task of developing a performance metric for extended products has proven to be more complex and challenging than for driven products. As a result, the fan and pump working groups are considering developing a device efficiency metric first, before taking on a wire-to-air or wire-to-water metric that would capture the performance of an extended product. Since the goal of the initiative is to develop models for efficiency programs, initial program proposals may be built around the simpler metric and an assumed extended product. • The initiative is on track based on the respective comparative metrics. The participating efficiency programs have indicated a desire to pilot one or more of the program models before the end of 2015. If successful, within the next few years several efficiency programs around the country will deploy new prescriptive rebate programs with deemed savings for common industrial and commercial fan, pump, and compressor products. These programs will accelerate the adoption rate of more efficient integrated products and bring about savings in the quadrillions of BTUs over the next ten years.	http://aceee.org/files/proceedings/2014/data/papers/3-401.pdf
	U.S. EPA	2004	Public Water Systems, Water Treatment, Flocculation, Sedimentation, Filtration, Ion Exchange, Absorption, Disinfection	National	This publication described public drinking water systems and the treatment levels required: • All public water systems must have at least 15 service connections or serve at least 25 people per day for 60 days of the year. • Drinking water standards apply to water systems differently based on their type and size. • Shows water treatment process, types of treatment, monitoring, and distribution to customers. • Types of treatment include: flocculation/sedimentation, filtration, ion exchange, adsorption, disinfection	http://nepis.epa.gov/Exe/ZyNET.exe/20001R7X.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1995+Thru+1999&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C95thru99%5CTxt%5C00000015%5C20001R7X.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

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Amul Sathe, Laurie Park, Lorraine White	California Sustainability Alliance, a Navigant Consulting Program	Oct. 2012	Water Infrastructure, Energy Management Practices, Efficiency, Demand Response, Energy Intensity, Clean Power	Local (EMWD)	Using EMWD as a case study, this report summarizes best practice strategies that are meant to guide internal water-agency policies and decision making towards more sustainable and energy efficient operation. This report also includes illustrative measures that can be implemented to achieve each best practice strategy. The illustrative measures listed are those that would most broadly apply to any water agency.	http://sustainca.org/programs/water_energy/overview
	U.S. Department of Energy	2001	Lighting Strategies and Planning	National	Argues that if energy effective relighting were accomplished in Federal office buildings, the benefit would extend above and beyond the energy savings. • Relighting (2x4 parabolic fixtures, 2 T8 lamps, 12-cell semi-specular louver, electronic ballasts, standard ballast factor) is a good open plan choice. Payback is less than 5 years, the fixtures are new, glare is reduced, and the power density is very low. • For private offices the clear winner is Relighting (4' semi-indirect pendant mounted fixture, 3 T8 lamps, high ballast factor), which has a lower payback than the retrofit solutions at 2.5 years. Low payback is achieved via reduction from two fixtures to one. • In some cases project constraints make it impossible to obtain new fixtures and retrofit becomes the only option. For the best retrofits, make an effort to reduce glare with the use of white reflectors or by using lenses that are thicker or designed to reduce lamp image. Also consider adding dimming ballasts and controls in the perimeter zones to take advantage of the daylight.	http://www1.eere.energy.gov/femp/pdfs/economics_eel.pdf
Carla Cherchi, Mohammad Badruzzaman, Joan Oppenheimer, Christopher M. Bros, Joseph G. Jacangelo	WRF, California Energy Commission	June 31, 2014	Energy and Water quality management system, water utilities, energy efficiency, water quality, demand forecasting	National	Holistic management of water and energy resources is critical for water utilities facing increasing energy prices, water supply shortage and stringent regulatory requirements. • Approximately twenty water utilities have implemented an Energy and Water Quality Management Systems (EWQMS) by interfacing commercial or in-house software optimization programs with existing control systems. For utilities with an installed EWQMS, operating cost savings of 8-15% have been reported due to higher use of cheaper tariff periods and better operating efficiencies, resulting in the reduction in energy consumption of ~6-9%. The review provides the current state-of-knowledge on EWQMS typical structural features and operational strategies and benefits and drawbacks are analyzed. • The review also highlights the challenges encountered during installation and implementation of EWQMS and identifies the knowledge gaps that should motivate new research efforts.	http://www.sciencedirect.com/science/article/pii/S0301479715000675

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	U.S. Department of Energy	Mar. 2015	Pump Efficiency, Test Procedure	National	DOE proposes to establish a new test procedure for pumps, specifically for measuring the hydraulic power, shaft power, and electric input power of pumps, inclusive of electric motors and any continuous or non-continuous controls. The proposed test procedure would be used to determine the constant load pump energy index (PEICL) for pumps sold without continuous or non-continuous controls or the variable load pump energy index (PEIVL) for pumps sold with continuous or non-continuous controls. The proposal reflects certain recommendations made by a stakeholder Working Group for pumps established under the Appliance Standards Rulemaking Federal Advisory Committee.	http://energy.gov/sites/prod/files/2015/03/f20/commercial_industrial_pumps_tp_nopr.pdf
Detlef Westphalen, Scott Koszalinski	U.S. Department of Energy	Apr. 2001	Central Cooling, Packaged Cooling, Room AC Units, District Heating, Boilers (Oil and Gas), Furnaces (Oil, Gas, and Electric), Packaged HVAC Unit Furnaces (Gas and Electric), Packaged Heat Pumps, Unit Heaters, Packaged Terminal Heat Pumps, Individual Space Heaters	National	The objectives of this study were to provide: • an accurate estimate of energy used by primary HVAC equipment in the US commercial building sector. • a physical understanding of the factors which contribute to energy use by the equipment. • a baseline estimate of current national energy use which can be used for calculation of the national energy savings impact of various options for reducing energy usage. 1995 estimate used. Findings: • About half of the cooling energy and most heating is associated with Packaged AC (mostly rooftop). The efficiencies of this equipment type are lower on average than those of other equipment types, particularly water-cooled chiller systems. • other cooling equipment types representing high energy use are centrifugal (efficient) and reciprocating chillers (less efficient). The heating equipment types representing high energy use other than packaged units are furnaces, boilers, and unit heaters. • By building type: the most energy use is in the Office, Mercantile & Service, and Public Building categories. • The South region represents the largest geographical energy use, in part because of large floorspace, but also because of high energy use for cooling.	http://apps1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/hvac_volume1_final_report.pdf

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Detlef Westphalen, Scott Koszalinski	U.S. Department of Energy	Oct. 1999	Central Cooling, Packaged Cooling, Room AC Units, District Heating, Boilers (Oil and Gas), Furnaces (Oil, Gas, and Electric), Packaged HVAC Unit Furnaces (Gas and Electric), Packaged Heat Pumps, Unit Heaters, Packaged Terminal Heat Pumps, Individual Space Heaters	National	Focuses on parasitic energy use, the energy required to distribute heating and cooling within a building, energy rejected to the environment as heat discharged by cooling systems, and energy to move air for ventilation purposes. Findings: • The parasitic equipment (pumps and fans) used in commercial building HVAC systems for thermal distribution and ventilation represent a considerable amount of total HVAC energy use. • The major users of this parasitic energy are fans associated with the air handling units and exhaust fans. While some of the supply fans, especially large VAV units, are fairly efficient at design load and are controlled to vary flow efficiently, many small-size fans have low or modest efficiencies, especially when installed in tightly packaged air conditioning systems. • Energy use of fans is significantly affected by system design practice, installation procedures, whether the system is properly commissioned, and whether the system receives proper maintenance. While the national impact of some of these factors cannot readily be determined, it is clear that A&E firms, installers, and users have a significant impact on system energy use.	http://apps1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/hvac_volume3_final_report.pdf
Kurt W. Roth, Detlef Westphalen, John Dieckmann, Sephir D. Hamilton, William Goetzler	U.S. Department of Energy	Oct. 1999	Central Cooling, Packaged Cooling, Room AC Units, District Heating, Boilers, Furnaces, Packaged HVAC Unit Furnaces, Packaged Heat Pumps, Unit Heaters, Packaged Terminal Heat Pumps, Individual Space Heaters	National	The report addresses opportunities for energy savings in commercial building HVAC systems, specifically technology options and their technical energy savings potential, current and future economic suitability, and the barriers preventing widespread deployment of each technology in commercial building HVAC systems. Findings: • Many – but not all – of the 15 options had attractive and/or reasonable simple payback periods • the separate treatment of ventilation and internal loads has received continued attention, driven by increased concerns about indoor air quality (IAQ). Fix Common HVAC Problems, Improved Delivery of Conditioning Where Needed, and Improved Part-Load Performance have always played an important part of HVAC system energy conservation work. • Beyond economics, the largest single market barrier impeding several of the 15 technology options is that they are unproven in the market.	http://www.lrc.rpi.edu/programs/daylighting/pdf/TomoTherapyCaseStudy.pdf

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Vanessa Leiby, Michael Burke	Water Research Foundation	2011	Energy Efficiency Practices, Conservation Practices, Funding Mechanisms and Partnerships	National	The report identified a multitude of energy efficiency best practices currently in use at drinking water systems in North America: • Energy efficiency improvements can help utilities deal with changing water quality standards, variations and changes in source water quality, changes in distribution systems, and can save a utility a significant amount of money. • All utilities, regardless of size, complexity, and management structure can undertake energy conserving measures to reduce energy use. In many cases, such improvements may not require expensive or extensive capital investments—simply optimizing a utility's current equipment and operations practices can lead to significant reductions in energy consumption.	http://edepot.wur.nl/175852
M. J. Brandt, R. A. Middleton, S. Wang	Global Water Research Coalition, WRF	Mar. 2011	Demand Management, Pumping, Treatment, Sludge, Generation, Drinking and Waste water	National	Research study to identify best practices in the energy efficient design and operation of water industry assets. There are promising developments and future opportunities to help deliver incremental improvements in energy efficiency through optimization of existing assets and operations, and more substantial improvements in energy efficiency from the adoption of novel (but proven at full scale) technologies. • There is direct correlation between energy demand and the location, availability, and quality of natural resources and treatment and disposal of sewage and sludge disposal. The key energy demand areas are pumping from distant or deep water sources; distributing potable water over wide areas, asset condition, and pipe leakage; treatment of sewage by aeration; and pumping raw and treated effluents. A customer's utility bill may be further impacted by where he is living: the real costs of services in areas of high population concentration with severe resource and disposal constraints will be increasingly higher.	http://www.ongov.net/mwb/carerfp/documents/(Q)%20WRF_Energy%20Efficiency%20Best%20Practices_4270.pdf
Joseph C. Cantwell, P.E. William R. King Robert T. Lorand, P.E. Science Applications International Corporation Robert C. Ganley, P.E. Nathyn M. Knipe, P.E. David I. Page O'Brien & Gere	Water Environment Research Foundation, NYSERDA	2010	Value engineering, wastewater treatment facility, national standard, energy efficiency.	General (US)	The study discusses the barriers to implementing value engineering analyses that focus on wastewater process energy reduction opportunities (e.g., cost of implementing value engineering analysis, lack of a requirement to perform analysis, or no specific focus in value engineering on identifying energy reduction alternatives). Additionally, no national WWTF design guideline exists that could serve as a platform on which to incorporate value engineering with respect to wastewater process energy reduction. The study suggests a national design guideline as a pathway to implementing value engineering with a focus on energy reduction.	www.nyserda.ny.gov

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Office of Energy Efficiency of Natural Resources Canada	Canadian Industry Program for Energy Conservation	2002	Energy Efficiency Measures	Canada	• The guide is meant to inform a variety of industries about energy efficiency technologies and strategies that are applicable both to their businesses and other industries. The report reflects changes in programs offered by utility companies at all levels of government and covers many aspects of industrial energy management. Contains evaluation worksheets for each energy topic at the end of each section for step by step of facilities and processes. • The report presents a holistic approach to energy efficiency considerations and management. It also fosters a more adaptive and pragmatic approach to include energy efficient measures that would likely be overlooked with a one-size-fits-all type strategy that often is used in energy efficiency assessments.	http://www.nrcan.gc.ca/sites/oee.nrcan.gc.ca/files/pdf/publications/infosource/pub/cipec/Managementguide_E.pdf
Steve Carlson and Adam Walburger, CDH Energy Corp.	AWWA Research Foundation, California Energy Commission, NYSERDA	2007	Efficient and Customer-Responsive Organization	National	The project developed metrics for comparison of energy use among wastewater treatment plants and water utilities; these comparisons were normalized, so that factors such as specific plant configurations or loading were removed. Water utilities are often characterized by water source: ground, surface, or purchased but little information exists regarding the distribution systems. The wastewater treatment plant model relates energy consumption to: average influent flow, influent BOD, effluent BOD, ratio of average influent flow to design influent flow, use of trickle infiltration, and nutrient removal. Other parameters that correlated to energy use are: on-site electricity generation, sludge incineration/land application, and pure oxygen, however these were not included in the model. The water utility model related energy consumption to: total flow, total pumping horsepower, distribution main length and elevation change, raw pumping horsepower and amount of purchased flow. Developing the metrics is a first step toward energy management by giving a relative assessment of performance. Scoring the different metrics can serve as an initial screening tool when designing plants and utility systems.	www.nyserda.ny.gov

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Kevin E. McCarthy	OLR Research Report	Feb. 8, 2011	Energy efficiency, performance contracting, energy savings, ESCO	Regional (Connecticut)	Three Connecticut municipalities contracted with an ESCO for a variety of energy efficiency improvements. The savings were verified by an independent third party and reported - the actual total annual savings for all four phases of the program have been approximately $926,000, compared to a guaranteed savings of approximately $565,000 per year. The report estimated that the efficiency measures reduced electricity consumption by approximately 3.5 million kilowatt-hours per year and natural gas consumption by approximately 184,000 therms per year (a therm is about 100 cubic feet of natural gas). The report also estimated that the program's electric efficiency measures reduced annual emissions of carbon dioxide, sulfur dioxide, and nitrogen oxides by about 6.6 million pounds, 5,200 pounds, and 6,500 pounds, respectively. The reductions for the gas efficiency measures are about 2.2. million pounds, 12 pounds, and 2,800 pounds (natural gas is a low sulfur fuel, so reducing its consumption has little effect on sulfur dioxide.	https://www.cga.ct.gov/2011/rpt/2011-R-0067.htm
Gema San Bruno	European Small Hydropower Association	2010	Small Hydropower, Energy Recovery	Global	• The multipurpose schemes equipped with small hydropower plants are limited. • The limited number of operating sites is mainly due to the lack of information on the possibility to recover energy. • Another obstacle would be the lack of simple administrative procedures adapted to small hydropower. • Due to the remaining potential in Europe, based on energy recovery in existing infrastructures, small hydropower has still a role to play among renewable energies.	http://www.esha.be/fileadmin/esha_files/documents/SHAPES/Multipurpose%20schemes%20brochure%20SHAPES.pdf
A.K. Plappally, J.H. Lienhard V	MIT	Sept. 19, 2011	Energy for Water, Energy Intensity, Pumping, Heating	National	This report surveys the available literature on energy intensity for water use in the municipal and agricultural sectors and separates the process into several stages. • Water extraction and pumping from ground and surface sources is considered. The energy intensity of treatment required for different types of water source is found to vary widely between the extremes of relatively fresh surface waters, which use energy mainly in pumping, and sea water, which requires desalination. • Energy usage for different methods of irrigation including pressurized as well as surface irrigation is studied. The energy intensity of residential end use is very high relative to other parts of the water supply cycle. • Processes such as heating water, washing clothes and dishes, and cooking are briefly studied within the water end-use stage. Hot water usage is responsible for making end use the most energy intensive stage of the water cycle. • Energy consumption in the agricultural sector is generally of lower energy intensity than for the municipal treatment or end use.	http://www.sciencedirect.com/science/article/pii/S1364032112003541

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
Claudia Copeland	Congressional Research Service	Jan. 2014	Energy for Water, Drinking Water Supply	National and Regional	This report provides background on energy for facilities that treat and deliver water to end users and also dispose of and discharge wastewater. Energy use for water and its intensity is a function of many variables. Estimates of water-related energy use range from 4-13% of the nation's electricity generation, but regional differences can be significant. • Energy consumption by public drinking water and wastewater utilities can represent 30-40% of a municipality's energy bill. At drinking water plants, the largest energy use (about 80%) is to operate motors for pumping. • Energy is the second highest budget item for these utilities, after labor costs. Opportunities for efficiency exist in several categories, such as upgrading to more efficient equipment, improving energy management, and generating energy on-site to offset purchased electricity. However, barriers to improved energy efficiency by water and wastewater utilities exist, including capital costs and reluctance by utility officials to change practices or implement new technologies.	https://www.fas.org/sgp/crs/misc/R43200.pdf
U.S. EPA	U.S. EPA	Jan. 2008	Systems approach to management; Plan-Do-Check processes; case studies; conservation; cost studies	National	The purpose of this Energy Management Guidebook is to demonstrate to utility managers that it makes sound business and environmental sense to utilize a management system approach to optimize energy conservation efforts. Specifically, this Guidebook will present a management system approach for energy conservation, based on the successful Plan-Do-Check-Act process that enables utilities to establish and prioritize energy conservation targets (Plan), implement specific practices to meet these targets (Do), monitor and measure energy performance improvements and cost savings (Check), and periodically review progress and make adjustments to energy programs (Act). The Guidebook will also provide real life examples of water and wastewater utilities who have already realized significant benefits through use of an energy management program and provide a step-by-step process to show how to achieve the same benefits for your utility.	https://owpubauthor.epa.gov/.../Final-Energy-Management-Guidebook.pdf

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EnerNoc	Electric Power Research Institute	Nov. 2003	Electricity demand; efficiency approaches; technology improvements	National	The use of electricity for water and wastewater treatment is increasing due to demands for expanded service capacity and new regulations for upgraded treatment. Options available to control the electricity costs include technological changes, improved management, and participation in electric utility sponsored energy management programs. Appropriate options for a specific system will vary depending on the system characteristics, availability of electric utility programs to assist the water and wastewater utilities, and adequate funding and management skills to implement changes. This study estimated that U.S. public drinking water systems use roughly 39.2 billion kWh per year, which corresponds to about 1% of total electricity use in the U.S. and a 39% increase from 1996 estimates. Municipal wastewater treatment systems in the U.S. use approximately 30.2 billion kWh per year, or about 0.8% of total electricity use in the U.S. and represents a 74% increase from 1996 estimates. Based on the macroscale analysis in the potential study, the team approximates that the realistic achievable potential for the water and wastewater industry by 2030 is approximately 8% of baseline.	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002001433
Juan Pablo Carvallo, Peter H. Larsen, Charles A. Goldman	Lawrence Berkeley National Laboratory	Dec. 17, 2014	Demand-side energy efficiency, electricity savings, energy efficiency, ESCO	National	• Introduces a method to estimate the total amount of electricity saved by projects implemented by the U.S. ESCO industry using a database of projects and biennial industry survey. Two metrics: incremental electricity savings and savings from ESCO projects that are active in a given year. • Overall, it is estimated that in 2012 active U.S. ESCO industry projects generated about 34 TWh of electricity savings—15 TWh of these electricity savings were for MUSH market customers who did not rely on utility customer-funded energy efficiency programs. This analysis shows that almost two-thirds of 2012 electricity savings in municipal, local and state government facilities, universities/colleges, K-12 schools, and healthcare facilities (i.e., the so-called "MUSH" market) were not supported by a utility customer-funded energy efficiency program.	https://emp.lbl.gov/sites/all/files/estimating_customer_electricity_savings_25nov2014_final.pdf
Robert Pitt	University of Alabama, Department of Civil and Environmental Engineering	2003	Ancient and historical water/wastewater infrastructure	Global	Wastewater issues have not changed for millennia. The need for reliable (and later centralized) conveyance of waste and treatment, and infrastructure ranging from Ancient Greece to 19th century Britain and the U.S. are explored in this PowerPoint presentation.	http://rpitt.eng.ua.edu/Class/Computerapplications/Module1/M1%20Historical%20Aspects%20of%20Urban%20Water%20Systems.pdf

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	U.S. Department of Energy	Mar. 2002 (revised)	Energy efficiency, water efficiency, load shifting, retrofit isolation	Global	• Provides an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects. Energy conservation measures covered include fuel saving measures, water efficiency measures, load shifting and energy reductions through installation or retrofit of equipment, and/or modification of operating procedures. • Defines basic terminology useful in the M&V field and general procedures to achieve reliable and cost-effective determination of savings. Such definitions then can be customized for each project, with the help of other resources. • Verification of savings is then done relative to the M&V Plan for the project. This volume is written for general application in measuring and verifying the performance of projects improving energy or water efficiency in buildings and industrial plants.	http://www.nrel.gov/docs/fy02osti/31505.pdf
Simon Bunn	Efficiency Valuation Organization, Derceto	Jun. 2014	Energy for Water, Water Management	National	In all Energy Performance Contracts (EPC) contracts there is always some element of risk. It is not always possible to remove all risk, or place all this risk solely onto the Energy Services Company (ESCO). When the water utility and the ESCO devise a mutually agreed process, then fairness prevails. While it is true that the ESCO has more experience with these issues and may want to use that expertise to word contracts in a way that fully protects their investment, the benefits of an ESCO funded project should be enough to allow a smart water utility, fore-armed with a little knowledge, to proceed with acceptable risk.	http://www.derceto.com/News/The-Bunn-Report/pod-files/TheBunnReport/TheBunnreport130314_IPMVP.pdf
	Johnson Foundation	Sep. 2014	Sustainability, Multi-benefits	National	Without significant changes, existing water systems will soon no longer be able to provide the services that citizens have come to expect. Recent water crises have illustrated the economic and social consequences of inaction. Since 2008, more than 600 experts from many different sectors have participated in Charting New Waters, collaborating to identify innovators, potential solutions to a remarkable range of water resource challenges. The recommendations fall under the following five key ideas: 1. Optimize the use of available water supplies 2. Transition to next-generation wastewater systems 3. Integrate the management of water, energy and food production 4. Institutionalize the value of water 5. Create integrated utilities	http://www.johnsonfdn.org/aboutus/capstone

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Stearns & Wheler, LLC	NYSERDA - New York State Energy Research and Development Authority	Oct. 2006	Wastewater Processes, Energy Consumption/Efficiency	Regional (NY)	Energy evaluations of 11 wastewater treatment plants located in New York State with plant flow rates ranging from 0.5 to 80 MGD were completed to identify and recommend specific process modifications and equipment replacements to save plant energy costs. Power metering was installed at each plant to accurately determine the energy consumption and savings of the evaluated processes. The following processes were evaluated as potential energy saving measures: pumping systems, aeration systems, biological treatment systems, polymer injection chemical feed systems, filtration systems, sludge handling systems (i.e., thickening, digestion, dewatering, disposal, etc.), and disinfection systems. Other energy saving measures evaluated included process elimination of processes or conversions, addition of variable frequency drives (VFDs), updated lighting systems, improved heating and ventilation systems, use of alternative fuels, and energy monitoring systems. In implementing the recommended energy saving alternatives for the participating plants, the total annual energy cost savings that can be achieved is $650,000. Some of the recommended alternatives will also provide operational costs savings totaling of $260,000.	http://www.nyserda.ny.gov/Communities-and-Governments/Communities/Municipal-Water-and-Wastewater/MWWT-Tools-and-Materials
Mohammad Badruzzaman, Carla Cherchi, Joan Oppenheimer, Christopher M. Bros, Joseph G. Jacangelo, Simon Bunn, Matthew Gordon, Vessie Pencheva, Christophe Jay, and Iyad Darcazallie	WRF, California Energy Commission	Mar. 2015	Energy and Water Quality Management System, Energy Efficiency, Water Quality, Demand Forecasting	National	Holistic management of water and energy resources is critical for water utilities facing increasing energy prices, water supply shortage and stringent regulatory requirements. • Approximately twenty water utilities have implemented an Energy and Water Quality Management Systems (EWQMS) by interfacing commercial or in-house software optimization programs with existing control systems. For utilities with an installed EWQMS, operating cost savings of 8-15% have been reported due to higher use of cheaper tariff periods and better operating efficiencies, resulting in the reduction in energy consumption of ~6-9%. The review provides the current state-of-knowledge on EWQMS typical structural features and operational strategies and benefits and drawbacks are analyzed. • The review also highlights the challenges encountered during installation and implementation of EWQMS and identifies the knowledge gaps that should motivate new research efforts.	http://www.waterrf.org/ExecutiveSummaryLibrary/4271_ProjectSummary.pdf

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RS Environmental Solution, Inc.	NYSERDA - New York State Energy Research and Development Authority	n/a	Peak-load Reduction, Energy Management	Regional (NY)	A consultant conducted a technical assessment at Monroe County Water Authority (MWCA) and identified the following ways to improve curtailment capacity: • Install real-time meters at each pump location to determine energy usage and verify actual reduction during an energy curtailment. • Integrate meters with the management system to analyze water reserves and ensure a proper water supply is available even during a curtailment.	http://www.nyserda.ny.gov/About/Publications/Case-Studies-and-Features/MWWT-Case-Studies
Global Energy Partners, LLC	Electric Power Research Institute	2009	Energy efficiency, technologies, water reuse	National	Electricity consumption associated with sourcing, treating, and transporting water is expected to increase significantly in the future as a result of a growing population and an increasing need for alternative water supplies. There is also a concern that climate change may necessitate an increase in irrigation in some areas of the United States. There is a critical need for technologies that can reduce the electricity consumption associated with water supply. Technologies that offer the best opportunities for these savings include high-efficiency pump/motor systems, variable frequency drives, pipeline optimization, advanced supervisory control and data acquisition (SCADA) systems, and automatic meter reading/acoustic leak detection integration. Energy-efficient desalination technologies will become increasingly important in the future as marginal quality water supplies account for a growing share of total water supply. It is recommended that electric utilities pursue activities in six primary technology areas: advanced SCADA systems, advanced reverse osmosis for desalination, membrane distillation, capacitive deionization, advanced ozonation, and photocatalytic oxidation.	http://www.xzero.se/doc/EPRI%20Report%20on%20MD.pdf
William Stowe, Doug Oscarson, Rod Elsworth	AWWA	Dec. 2015	Pump Efficiency, Energy Efficiency	Regional (Iowa)	To improve its operations and financial performance, Des Moines Water Works has made energy efficiency a cornerstone of its operating strategy. Most of the utility's energy management gains have been realized by optimizing its pumping systems.	http://dx.doi.org/10.5991/OPF.2015.41.0075
Afreen Siddiqi, Olivier L. de Weck	Massachusetts Institute of Technology; Masdar Institute of Science and Technology	Dec. 2013	Urban Water Systems, Planned Buildings, Treatment, Distribution, Wastewater Disposal	National	The dominant use of energy in new urban developments (case study in Masdar City, UAE) is attributed to water heating requirements, and the total energy use for obtaining hot water is estimated to range from approximately 20 to 50 million kWh annually. It is found that the residential sector in the city can have the greatest impact in affecting energy requirements associated with water use. For every unit reduction of indoor residential water use, it is estimated that up to 225 MWh may be saved annually.	http://www.researchgate.net/publication/270125753_Quantifying_End-Use_Energy_Intensity_of_the_Urban_Water_Cycle

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Schneider Electric	Schneider Electric	2012	Energy efficient plant design, electrical	National	Recommended electrical network architectures proven for multiple sizes of WWTP are presented in this marketing collateral for a WWTP contractor. • A new generation of transformers and motors made with high performance iron sheets and increased cross section copper windings can improve overall efficiency by up to 5%. • Low-pressure, high-intensity lamps are the more energy efficient technology. • Without a variable speed drive (VSD) pump, power requirements are virtually the same regardless of the liquid flow rate. However, if the valve or throttle is left fully open and the driving motor is adjusted to control the liquid flow rate, the power requirement can be slashed by 50% at an 80% nominal flow rate, • Using a medium-voltage power supply for high-power (> 100kW) motors reduces the line currents, thereby diminishing the Joule losses in transformers, cables, and motors. A low-voltage power supply may be cost-prohibitive for large equipment or when several sets of cables are needed. Two configurations are possible for medium-voltage variable speed drives: • A variable speed drive operating directly at a medium-voltage; or • The use of step-down/step-up transformers, so that the power circuits are operating at a low voltage (400V or 690V).	http://www.schneider-electric.com/solutions/in/en/med/25882144/application/pdf/1567_waterhandbook.pdf
Jeffrey Can Ess, Tricia Juse	Johnson Controls, Inc.	2010	ESCO, energy efficiency, water efficiency, green building, smart irrigation, metering	National	• Smart water management can help make the most of water on each step in its journey, from its source, to users, and back to the environment. In the face of demand, communities and water utilities find that - just as with energy - water efficiency is the best and cheapest route to greater capacity. On average, applying water-efficient design and products lead to 15% less water use, about 10% less energy use, and about 12% lower operating costs. • Private and public entities alike can receive grants or low interest loans under state-sponsored efficiency initiatives. They can also take advantage of performance contracting, a proven way to fund water and energy efficiency projects with the project’s guaranteed savings.	http://www.johnsoncontrols.in/content/dam/WWW/jci/be/energy_efficiency/water_solutions/SavingsMultiplied.pdf

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Robyn M. Moore	Victoria University of Wellington	Dec. 2011	Urban Water management, sustainable communities, theory of constraints, casual loop diagrams	New Zealand	• The combined framework provided a source of deep insights into the challenges, dilemmas, potential solutions and side effects facing resource managers and other stakeholders in an urban water system under pressure from population growth and climatic/topographical conditions. It is possible that the combined theoretical framework can be applied to other resource management cases. • The use of the Stakeholder Typology to complement TOC provided a tactical element not routinely evident in systems studies, valuing the experiential and historical perspectives of those who might otherwise be treated as being outside the system, their perspectives marginalized or ignored. Solutions that were sought and tested using TOC and CLDs have been put into practice and are driving actions and dialogue that to date, appear to be delivering positive change for the community and other stakeholders.	http://j.co.nz/robyn/Robyn_Moore_%20Shaping_More_Sustainable_Communities.pdf
	SIEMENS	Oct. 12, 2009	ESCO	Regional (North America)	Announcement of Siemens extending ESCO contract model to waste water treatment plants to obtain energy and operational cost-savings. Siemens identified numerous measures, opportunities and solutions such as biolsolids reductions, biogas production and use, high efficient technology applications and SCADA system improvments.	http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2009/industry/i200910022.htm&content[]=I&content[]=IIA&content[]=IS&content[]=DF&content[]=PD
Malcolm Pirne, Inc.	NYSERDA - New York State Energy Research and Development Authority	Nov. 2008	Electric Energy Use by Municipal Water and Wastewater Sector; Biogas Recovery; Biogas Generation Potential; Electric Production Potential; Energy Conservation Measures	Regional (NY)	Energy evaluations of 11 wastewater treatment plants located in New York State with plant flow rates ranging from 0.5 to 80 MGD were completed to identify and recommend specific process modifications and equipment replacements to save plant energy costs. Processes evaluated included pumping systems, aeration systems, biological treatment systems, polymer injection chemical feed systems, filtration systems, sludge handling systems (i.e., thickening, digestion, dewatering, disposal, etc.), and disinfection systems. Other energy saving measures evaluated included addition of variable frequency drives (VFDs), updated lighting systems, improved HVAC systems, use of alternative fuels, and energy monitoring systems. In implementing the recommended energy saving alternatives for the participating plants, the total annual energy cost savings that can be achieved is $650,000. Some of the recommended alternatives will also provide operational costs savings totaling of $260,000.	www.nyserda.ny.gov

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Glen T. Daigger	The Bridge: Linking Engineering and Society, Spring 2011 Urban Sustainability	Spring 2011	Urban water supply	National	A new approach is needed for supplying and managing water and resource infrastructure to achieve urban sustainability. Urban water and resource management should involve the following steps: collecting water in sufficient quantities to meet needs throughout the urban area; treating collected water to achieve the quality required for specific purposes; distributing water to end users; collecting used water; treating used water for reuse, including for environmental enhancement; managing residuals from treatment processes; and extracting useful materials, such as heat, energy, organic matter, and nutrients, from the used water stream. Urban water and resource management systems are evolving in a clear and unified direction: (1) from the use of remote water supplies to the use of local water supplies, such as rainwater and reclaimed used water; (2) from optimizing the cost of infrastructure to optimizing water use, energy production, and nutrient extraction; (3) from independent, single-purpose components to integrated, multi-purpose systems; and (4) from centralized systems to hybrid systems that incorporate centralized and decentralized components.	http://www.nae.edu/Publications/Bridge/43180/43201.aspx
Jerry Yang and Akiko Yamazaki	Water in the West, Stanford University	Feb. 2016	Financing	National	The objective of this paper was to identify and explore innovative funding and governance mechanisms that can be used to support the integration of new distributed water infrastructure, practices, and technologies. The authors believe that the water sector can learn many lessons from distributed project implementation in the electricity sector. Through this investigation, they determined that the water sector should utilize tools that promote cost sharing with end users, look beyond traditional water-specific funding resources, develop diverse financing portfolios, and encourage collaboration among all stakeholders. Many of these financing tools and governance structures could be used not only for distributed solutions, but by the water sector as a whole to help revamp our nation’s urban water systems. Examples of pathway mechanisms are loans and grants, rebates, tax credits, and on-bill initiatives. Finally, innovative governance such as project or financial aggregation, alternative investment structures, end to end service companies, and net metering can enable project development. In addition to utilizing and following this framework, the report also discusses lessons that the water sector can learn from existing practices in the electricity sector. Most importantly, regulations in the water sector must change to include, and more importantly encourage, the integration of distributed solutions.	http://waterinthewest.stanford.edu/sites/default/files/Woods%20Funding%20Water%20Projects%20Whitepaper%20v07_0.pdf

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
Craig Aubuchon, Adam Carpenter	AWWA	Oct. 2015	Clean Power Plan, climate change, energy-water nexus, energy efficiency, incentives, infrastructure costs, sustainability	National	The Clean Power Plan presents new incentives and opportunities to implement energy efficiency programs. This paper discusses the plan and ways in which water utilities can participate. In addition, benefits of participation and the opportunities for new collaboratives are also discussed.	http://www3.epa.gov/statelocalclimate/resources/action-guide.html
Water-Energy Technology Team	U.S. Department of Energy	Jul. 2014	Water for Energy, Energy for Water, Optimization, Reliability, Efficiency, Energy Management, Infrastructure	National	The water-energy nexus is integral to two policy priorities for DOE: climate change and energy security. there has been inadequate attention to the opportunities to share related R&D and modeling activities across programs. To address this gap, DOE initiated a department-wide Water-Energy Tech Team (WETT) in the fall of 2012.WETT's preliminary analysis has led to six guiding strategic pillars: - 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 This report provides an analytical basis to provide direction for next steps related to these pillars.	http://energy.gov/downloads/water-energy-nexus-challenges-and-opportunities
Water Research Foundation, Global Water Research Coalition, NYSERDA	Water Research Foundation, Global Water Research Coalition, NYSERDA	2013	Energy efficiency, GHG, climate change, costs	Global	The water industry is focusing efforts on optimizing water usage with minimal energy inputs. Continue research efforts into the fundamental biological and chemical equations and process models that describe the release of process and conveyance related GHGs in the wastewater component of the urban water cycle, both anthropogenic and biogenic. • Create a technical compendium of GHG emission methodologies that also provides guidance on the handling of calculation methodologies in remaining areas of uncertainty. • Incorporate the full urban water cycle into a single GHG emission methodology, including all scopes of GHG emissions. At present most methodologies include only a given subset of GHG producing assets involved in the full urban water cycle. • Incorporate full GHG emissions benchmarks into a combined energy and GHG benchmarking tool. At present most energy benchmarking tools include only GHGs that originate from the consumption of energy, and do not include other sources of GHGs.	http://www.waterrf.org/Pages/Projects.aspx?PID=4224

LITERATURE REVIEW

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
	University of Michigan	Oct. 2014	Water Supply, renewable energy, pumps, desalination	National	Supply Side Solutions and Sustainable Alternatives: • Major components that offer significant energy efficiency improvement opportunities include pumping systems, pumps, and motors. • Periodic rehabilitation, repair, and replacement of water distribution infrastructure would help improve water quality and avoid leaks. • Achieve on-site energy usage efficiency to minimize the life cycle environmental impacts related to production and distribution of energy and chemicals used in the treatment and distribution process. • On-site energy generation from renewable sources • Effective watershed management plans to protect source water are often more cost-effective and sustainable than treating contaminated water. • Less than 4% 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.	http://css.snre.umich.edu/css_doc/CSS05-17.pdf
National Action Plan for Energy Efficiency	U.S. EPA	Nov. 2008	Cost-effectiveness of Energy Efficiency Programs	National	The paper reviews the issues and approaches involved in considering and adopting cost-effectiveness tests for energy efficiency, including discussing each perspective represented by the five standard cost-effectiveness tests and clarifying key terms. Key Points: • There is no single best test for evaluating the cost-effectiveness of energy efficiency. • Each of the cost-effectiveness tests provides different information about the impacts of energy efficiency programs from distinct vantage points in the energy system. Together, multiple tests provide a comprehensive approach. • Jurisdictions seeking to increase efficiency implementation may choose to emphasize the PACT, which compares energy efficiency as a utility investment on a par with other resources. • The most common primary measurement of energy efficiency cost-effectiveness is the TRC - total resource costs, followed closely by the SCT - societal cost test. Choices to consider in developing costs/benefits of energy efficiency include: 1. where in the process to apply the cost-effectiveness tests; 2. which benefits to include; 3. net present values and discount rates; 4. net-to-gross ratio; 5. non-energy benefits; 6. GHG emissions; and 7. renewable portfolio standards	http://www.epa.gov/cleanenergy/documents/suca/cost-effectiveness.pdf

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
	DWR	Jul. 2015	Energy Intensity, Urban Water Supply, Reporting, Electricity Generation	National	Energy intensity reporting has many benefits for water utilities and their customers including: • Identify energy saving opportunities as energy consumption is often a large portion of the cost of delivering water. • Calculate energy savings and Greenhouse Gas Emissions reductions associated with water conservation programs. • Potential opportunities to receive energy efficiency funding for water conservation programs. • Informing climate change mitigation strategies • Benchmarking of energy use at each water acquisition and delivery step and the ability to compare energy use among similar agencies.	http://www.water.ca.gov/calendar/materials/appendix_o_voluntary_reporting_of_energy_intensity_19545.pdf
Water Research Foundation	WRF, NYSERDA, AWWA	Jan. 2016	Integrated Resource Planning	National	Describes the Objectives of IRP: • Offer insights on who, what, why, and how water and electric utilities engage in integrated resource planning • Help water and electric utilities understand commonalities and differences in their respective planning needs and goals • Present and evaluate a range of examples of interdisciplinary, integrated resource planning efforts between water and electric utilities • Identify barriers, means to overcome barriers, opportunities, and critical elements of success for interdisciplinary, integrated planning • Provide recommendations and be an impetus for water and electric utilities to continue to explore integrated resource planning Findings: • Overall, there is a lack of joint initiated planning projects • Significant benefit and effort present encouraging joint planning • Cost effectiveness is highly regarded in both sectors, especially in privately owned utilities (energy sector dominant) • Water security is a strong driver for integrated planning and many jurisdictions are looking a joint sponsored initiatives for end use efficiency • Integrated planning practices is considered a vehicle for encouraging joint planning efforts, but not a requirement • Still considered time consuming/difficult to bring multiple partners together	http://www.rem.sfu.ca/water/wp-content/uploads/2014/11/0-4469-workshop-presentation-waterrf.pdf

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Steve Conrad, Steven Kenway, Maria Brusher, Linda Reekie, Valerie Roundy	WRF, NYSERDA, AWWA	Oct. 2014	Integrated Resource Planning	International (US, Canada, Australia)	32 people representing water and electric utilities, water/energy sector professionals, federal and state regulators, and academic institutions took part in a simulated planning tournament to identify opportunities and barriers to water and electric utility integrated planning. Findings: • water is more closely linked with environmental values and public sense of rights than electricity • public awareness of water-energy link was not present and the sectors lacked awareness of the overall benefit of integrated planning benefits for joint utility planning included technical opportunities, watershed management, hydroelectric generation, water demand management, cost savings, broader consumer awareness of water/energy linkages, better capacity to respond to future events, and greater opportunity for developing innovative options and sustainable solutions	http://www.rem.sfu.ca/water/wp-content/uploads/2015/05/4469-tournament-summary-report-final-may-2015.pdf
Malcolm Pirnie, Inc.	New York State Energy Research and Development Authority (NYSERDA)	March 2010, revised Sept. 2010	Water and Wastewater System Operations; Energy Management, Efficiency, Renewable Energy, Demand Response	Regional (NY), National	This handbook provides the necessary guidnace for developing an effective energy management program within water and wastewater systems by defining required steps and explaining how to implement the recommended best practices. For water supply systems these practices include: W 1 – Integrate System Demand and Power Demand W 2 – Computer-Assisted Design and Operation W 3 – System Leak Detection and Repair W 4 – Manage Well Production and Draw-down W 5 – Sequence Well Operation W 6 – Optimize Storage Capacity W 7 – Promote Water Conservation W 8 – Sprinkling Reduction Program W 9 – Manage High Volume Users	http://search.its.ny.gov/search?as_sitesearch=www.nyserda.ny.gov&btnG=Search&client=default_frontend&output=xml_no_dtd&proxystylesheet=default_frontend&ulang=en&sort=date%3AD%3AL%3Ad1&entqr=3&entqrm=0&wc=200&wc_mc=1&oe=UTF-8&ie=UTF-8&ud=1&site=default_collection&q=water best practices

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
Daniel J. Van Abs	New Jersey Future	May 2014 (Revised June 23, 2014)	Water supply, municipalities, green infrastructure, utility management, urban water systems	Regional (New Jersey)	• CSO municipalities have old and aging water supply and sewer systems that will require extensive work and major expenditures if they are to remain viable. The longer we delay, the worse the problems will become at an accelerating rate. • CSO municipalities as a group are fiscally constrained, which have often forced a process where only the worst known issues are addressed. • Some CSO municipalities are experiencing positive economic trends that could play a major role in funding infrastructure improvement, but also exacerbating the deterioration of those same infrastructure systems through development disturbances and greater demands on fragile pipes. • the feasibility of successful CSO control will depend heavily on the selected controls, fiscal capacity of the CSO municipalities and relevant funding sources, and political will. • Innovations in CSO controls provide opportunities to the municipalities, but will require each municipality to become familiar with the opportunities/limitations of each approach. This will be difficult for small systems and municipalities, so cooperative approaches will be vital. • CSO municipalities will face major costs for the control of CSO discharges at the same time they must improve their existing infrastructure.	https://www.google.com/search?q=Water+Infrastructure+in+New+Jersey%27s+CSO+Cities&oq=Water+Infrastructure+in+New+Jersey%27s+CSO+Cities&aqs=chrome..69i57.606j0j4&sourceid=chrome&es_sm=122&ie=UTF-8
California Urban Water Conservation Council	California Urban Water Conservation Council	2015	Funding, grants, partnerships	Regional (CA)	Federal and state agencies have a long history of cost sharing with local water agencies for a wide variety of public benefit projects. Considerations when acquiring funding for projects include: Planning ahead, clearly identifying the need, necessary quantity of funding, identifying matching sources, selecting and preparing grant writers, composing applications, receiving and applying funds. Many partnership opportunities exist, especially when matching funds from the applicant are available. of additional resources to guide funding proposals. Not all resources that may be used for drought-related or drought-necessitated agency actions will be identified as drought-specific funding.	http://cuwcc.org/Portals/0/Document%20Library/Resources/Drought%20Resources/Tool%20Kit/Tool%209%20Water%20Resources%20Funding.pdf
Daniel Loucks, Eelco Van Beek	UNESCO	2005	Wastewater treatment modeling, analyses, hydrologic analyses	Global	This wastewater treatment textbook gives a broad overview and detailed case study examples related to wastewater theory, modeling and analysis methods, and also hydrologic cycle modeling.	https://ecommons.cornell.edu/handle/1813/2804

Author	Organization	Date	Subject	Area of Study	Summary/Key Points	Link
Daniel Loucks, Eelco Van Beek	UNESCO	2005	Water systems modeling, inputs and understanding	National	Urban water systems must include not only the reservoirs, groundwater wells and aqueducts that are the sources of water supplies needed to meet the varied demands in an urban area, but also the water treatment plants, the water distribution systems that transport that water, together with the pressures required, to where the demands are located. Once used, the now wastewater needs to be collected and transported to where it can be treated and discharged back into the environment. Underlying all of this hydraulic infrastructure and plumbing is the urban stormwater drainage system. Modelling the water and wastewater flows, pressure heads and quality in urban water conveyance, treatment, distribution and collection systems is a challenging exercise, not only because of its hydraulic complexity but also because of the stochastic inputs to and demands on the system. This chapter has attempted to provide an overview of some of the basic considerations used by modelers who develop computer-based optimization and simulation models for design and/or operation of parts of such systems. These same considerations should be in the minds of those who use the results of these models to make decisions.	http://unesdoc.unesco.org/images/0014/001434/143430e.pdf
Barry llner, Robert Lung, Lisa Tryson	Water Environment Federation, Alliance to Save Energy, Danfoss	2012	Barriers, incentives and solutions for efficiency	General	The meeting focused on the need for coordination among stakeholders in the water and energy sector to increase energy generation and efficiency at wastewater treatment facilities. Economics & Payback: 1. Incentivize energy efficiency and energy generation 2. Provide cost data on improving energy efficiency and generation program. 3. Provide easily accessible information on funding options. 4. Quantify nonfinancial benefits, energy-related costs & payback. Policy & Permitting: 1. Provide guidance foractions 2. Encourage policy and integrated planning 3. Offer grants, tax credits, state revolving funds, public private partnerships, or other option 4. Work to harmonize ESCO legislation in all 50 States Partnerships, Public Outreach & Communications: 1. Cultivate partnerships 2. Provide education and training 3. Create a messaging and information campaign 4. Develop a recognition program Technology Performance: 1. Increase the practice of energy benchmarking and the adoption of energy efficient technologies. 2. Use processes that maximize the effective use of carbon 3. Streamline the approval process for new technology. 4. Develop reference installations for new technologies to speed adoption 5. Create integrated data set for prioritization and benchmarking	www.wef.org/EnergyWaterMeetingSummary.aspx

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Eliza Jane Whitman	Global Water Research Coalition, WRF	5/2005	Water Treatment, Lighting, Pump Efficiency	Regional	• IEUA's energy intensity ranges from 400-3,200 kW/AF • IEUA adopted a policy of energy self-sufficiency, received "Flex Your Power" award for energy reduction programs, and re-evaluated water supply options in light of energy requirements Energy/Water Strategies: • incorporate efficient best practices into all aspects of facilities and system design operations • reduce dependence on high energy intensity water supplies • shift all possible peak loads to partial and off-peak periods • maximize digester gas production and use • develop other local energy resources	http://aceee.org/files/pdf/conferences/eer/2005/05eer_ewhitman.pdf
Lorraine White, Jennifer Lau, Kenny Croyle	GEI Consultants, Inc.	Jun. 2013	Water for Energy Research; Energy for Water Research	National	This paper, prepared by GEI Consultants, Inc. on behalf of and in collaboration with AWE and ACEEE, provides the results of an assessment into the status of research on the relationship or "nexus" between the water and energy sectors. Publicly available research papers and studies that met certain criteria were collected and catalogued into a database. These included investigations that addressed the water sector's impacts on energy resources and the energy sector's impact on water resources, including development, operations, and end-uses. The compiled research was then assessed to determine the topics investigated, the key results, and possible gaps. Finally, gaps or areas where additional research may be needed to advance understanding about ways to enhance multi-sector resource management and overall resource efficiencies were identified. A summary of the major findings from the collected research is provided and is compared to the major policy objectives and issues as identified in the AWE/ACEEE publication, Addressing the Water-Energy Nexus: A Blueprint for Action and Policy Agenda (Blueprint). From this comparison, final recommendations were developed that address additional research needs.	http://www.allianceforwaterefficiency.org/1Column.aspx?id=8254&terms=Water+Energy+Nexus
M.Arora, L. Aye, H. Malano, T. Ngo	Melbourne School of Engineering; University of Melbourne	Jun. 2013	Urban Water Systems, Energy Use, Greenhouse Gases	International (Melbourne, Australia)	This paper presents a conceptual accounting framework to quantify the life cycle energy use and GHG emissions of alternative urban water supply strategies. Findings: • At a local scale, the use of rainwater capture entails the highest use of energy while the use of conventional water resources consume the lowest amount of energy. The higher energy intensity of distributed systems are generally due to the processes involved, technological advances, inappropriate scale of operation and poor maintenance of these systems. • Total energy requirement and the GHG emissions for replacing the rain water and storm water with desalinated water presents the worst case.	http://ewra.net/wuj/pdf/WUJ_2013_06_02.pdf

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Judith A. Barry	Alliance to Save Energy	Feb. 2007	Energy for Water, Water Efficiency, Cost Effectiveness	National	• WATERGY principles have been applied in numerous cities around the world, demonstrating that water efficiency measures repay themselves quickly and yield many rewards: immediate improvements in water service, increased water delivery, reduced water and energy consumption, and more revenue for system upgrades and new customer connections. • The most promising areas for intervention within water supply systems are: improving the pumping system, managing leaks, automating system operations, regular monitoring (preferably with rigorous metering of end use). • These improvements often pay for themselves in months, most do so within a year, and almost all recover their costs within three years.	http://www.gwp.org/Global/ToolBox/References/WATERGY.%20Water%20Efficiency%20in%20Municipal%20Water%20Supply%20and%20Wastewater%20Treatment%20(The%20Alliance%20to%20Save%20Energy,%202007).pdf
Rachel Young	ACEEE	Nov. 2014	Energy for Water, Energy Intensity, Heating	National	This paper draws from existing data and methods for calculating savings. It develops national estimates of energy savings associated with water savings including energy used in water conveyance, water heating, and water and sewage treatment. It also estimates energy savings associated with end-use water savings, including reducing the use of hot water for buildings, treated potable water, untreated water for landscaping and agriculture, and treated and untreated water for industry. • Heating water is the most energy-intensive water-related activity. • Lack of end-use information, empirical data, and examples in literature for energy embedded in water throughout the entire water system.	http://aceee.org/sites/default/files/watts-in-drops.pdf
Siemens Corp.	Siemens Corp.	Oct. 25, 2011	ESCO	National	In the face of reduced budgets, aging infrastructure, and volatile energy prices, today's organizations must find cre- ative ways to reduce energy and operating costs without impacting capital budgets. By partnering with an energy services company (ESCO) for a performance contract, organizations are in a unique position to satisfy these business goals while achieving sustainability objectives. Selecting the right ESCO is critical to the success of a performance contracting project. The right ESCO will formulate, design, and implement customized solutions that help today's organizations achieve business and sustainability goals—reduced operating and energy expenses, realization of sustainability objectives, and improved building infrastructure—while delivering the added value of new, energy-efficient, and environmentally-responsible equipment.	http://w3.usa.siemens.com/buildingtechnologies/us/en/energy-efficiency/performance-contracting/Documents/PCWhitepaper.pdf