EPA's Clean Energy-Environment Tech Forum

Clean Energy Opportunities in Water & Wastewater Treatment Facilities

Background and Resources

January 15, 2009

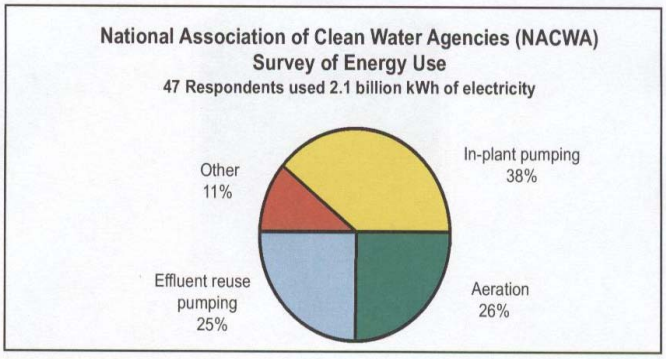
Many water treatment systems are owned by municipal governments. Because these facilities are typically their largest energy consumers, accounting for 30 to 40% of the total energy consumed,[1] local governments are keen to explore clean energy options. Water and wastewater treatment facilities require significant energy to power pumps, aeration systems, and other operations. Energy efficiency and clean energy, such as renewable generation and biogas, can reduce energy use, energy costs, and greenhouse gas emissions. In some cases, energy efficiency coupled with a change in process technology can result in even more benefits including increased treatment efficiency, potential for increased treatment capacity, and better capability to meet effluent standards.

This background document gives an overview of the nexus between water and energy, particularly opportunities for energy efficiency improvements, alternative energy applications and financing arrangements in water and wastewater facilities. It also details current state and local efforts to implement these innovative clean energy programs.

I. Overview of Water and Wastewater Industries and Energy Use

Water supply is typically provided by municipal water utilities, although a small number of users are supplied by private water utilities or privately-owned wells. Water supply and wastewater systems are regulated by state and federal governments. **At the state level, regulation of drinking water quality and wastewater discharges is entrusted to state health and environmental departments** and sometimes Public Utility Commissions; while at the federal level, these are regulated by the EPA.

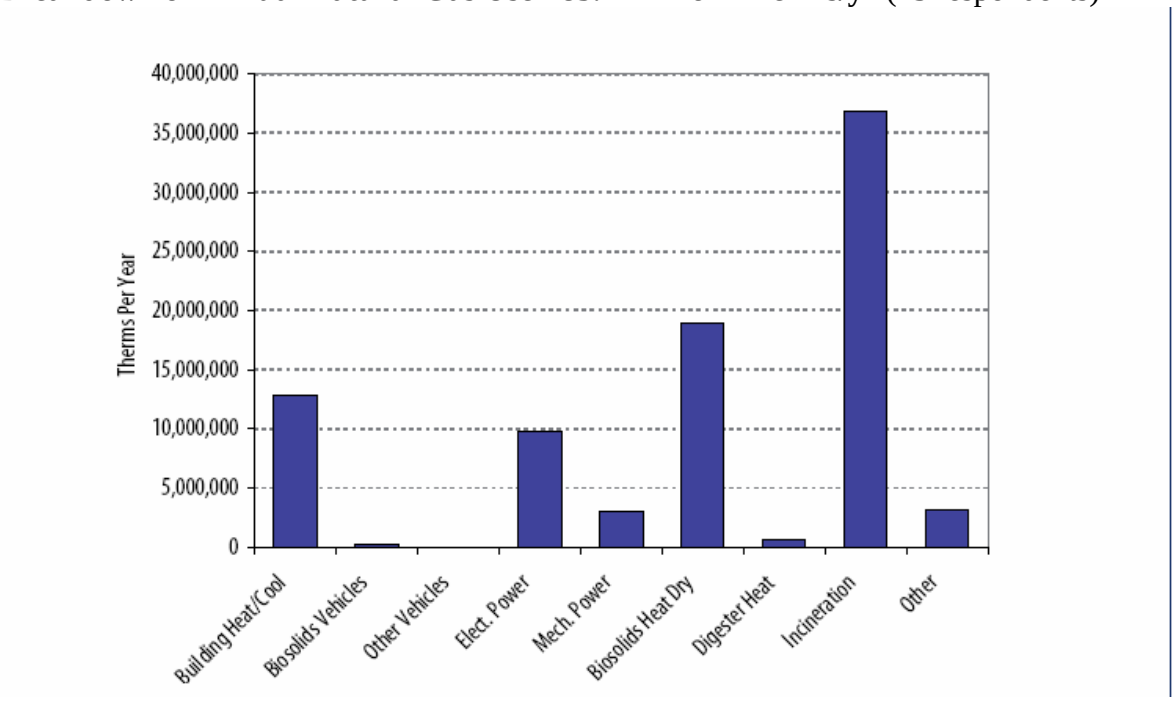
Drinking water and wastewater services account for an estimated 3% of national energy consumption, equivalent to between 56 and 75 billion kilowatt hours (kWh). With operating and maintenance costs looking as if they will increase due to aging infrastructure, population shifts, and increased need for treatment, operating deficits will continue to soar.[2]



The national average energy consumption for wastewater treatment facilities is 1,200 kWh per million gallons (MG) of wastewater generated (1 MG of wastewater is generated by 10,000 people per day). Energy use data collected from 47 wastewater facilities reveals that electricity is used primarily for pumping and aeration operations, while natural gas is used primarily for incineration and heating/drying biosolids.

[1] EPA, CPPD, Mar 2008. "Water and Energy: Leveraging Voluntary Programs to Save Both Water and Energy," viii.
[2] Ibid. 3-4.

Breakdown of Annual Natural Gas Use - 85.2 Million Therms/yr (45 respondents)



Source: http://www.cee1.org/cee/mtg/6-06_ppt/jones.pdf, slides 12 and 13

The national average energy consumption in drinking water treatment plants is 1,500 kWh per million gallons of water. (1 MG of water is used by 5,000 people per day.) As indicated by the graph below of Wisconsin water utilities, groundwater pumping stations tend to require greater energy use than surface water operations.

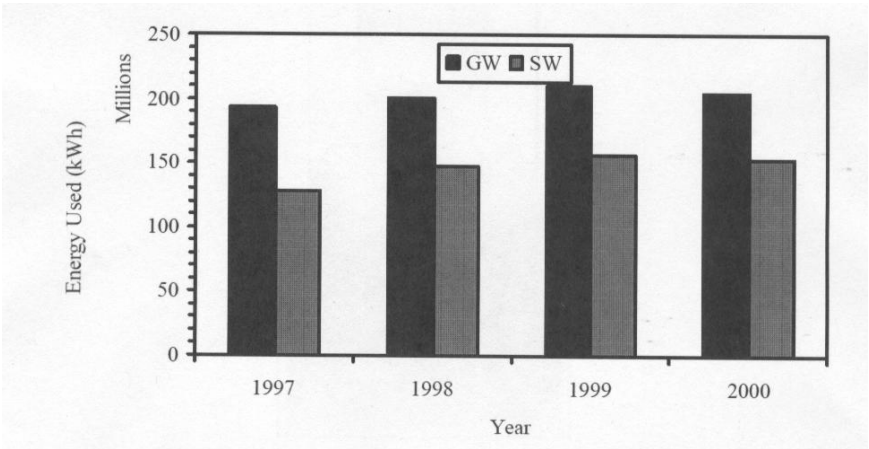


Figure 3.6. Energy use comparison between groundwater and surface water utilities.

Source: "Energy Use at Wisconsin's Drinking Water Facilities," (July 2003) Energy Center of Wisconsin. http://www.ecw.org/prod/222-1.pdf

Based on an average mix of energy sources, **total water and wastewater energy use adds approximately 45 million tons of greenhouse gases annually to the atmosphere**.[3] Methane (CH4) and nitrous oxide (N2O) are also emitted from wastewater treatment facilities and are particularly harmful because these gases have a higher global warming potential.

Energy efficiency improvements at water and wastewater treatment facilities can have high rates of return, and can significantly reduce costs at a facility since energy costs typically constitute 25-30% of the operations and maintenance costs at water & wastewater facilities.[4] What is more, loads are expected to increase by 20% in the next 15 years due to population growth, tightening regulation, growth of the power sector, and in the case of drinking water facilities in certain regions, increased groundwater pumping costs.[5] The nexus between water and energy is important because when you save energy, you tend to save water, and vice versa. Besides efficiency improvements for the pumping and aeration operations, **there is significant opportunity for clean energy generation on-site in the form of methane capture and utilization, as well as solar and wind energy.**[6]

II. Benchmarking Energy Use at Water and Wastewater Treatment Facilities

The first step in identifying opportunities for energy savings is to **establish current energy consumption patterns through a comprehensive energy audit**. An audit will establish the energy demands of each part of the water or wastewater treatment process, determine the most energy intensive equipment and processes, and provide information on energy use per throughput of water or effluent. This baseline assessment will also provide information to evaluate the benefits of any equipment or process changes to improve efficiency of the operation.

EPA has developed a number of tools for system-wide assessment of water utilities to assess energy performance and identify opportunities for reducing energy and water use and the associated GHG emissions.[7] The tools include:

- **Portfolio Manager**: EPA's Portfolio Manager, accessible on-line, helps to track and assess energy and water consumption within buildings and other facilities, such as water treatment plants and distribution systems and wastewater treatment plants. This interactive information management tool helps managers measure energy use intensity, benchmark energy performance, set reduction targets, track success over time, and calculate greenhouse gas emissions. http://www.energystar.gov/benchmark

    - **ENERGY STAR's Performance Rating**: Within Portfolio Manager, an ENERGY STAR Performance Rating is provided for wastewater treatment plants. The energy performance of a wastewater treatment plant is compared to similar plants

[3] EPA, 2008. http://www.epa.gov/waterinfrastructure/bettermanagement_energy.html
[4] EPA, GETF, Jan. 2008, p. 4. *Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities*. http://www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf
[5] EPA, March 2008. "Water and Energy: Leveraging Voluntary Programs to Save Both Water and Energy," vii.
[6] For a great resource on renewable options at water and wastewater facilities, and several US examples, visit http://epa.gov/region09/waterinfrastructure/technology.html#renew
[7] In a recent MOU between EPA's Office and Air and Radiation and the Office Water, the two divisions agreed to work closely together "to significantly improve energy use efficiency, expand onsite methane to energy production, and reduce and offset GHG emissions."

nationwide and a rating from 1 to 100 is provided. Data from a national survey conducted by the Water Research Foundation (formerly AwwaRF) of wastewater treatment plants is used as the basis of comparison. On the ENERGY STAR site, there is a document describing the method used to calculate an ENERGY STAR rating for wastewater treatment plants.
http://www.energystar.gov/index.cfm?c=evaluate_performance.pt_neprs_learn

- **Environmental Management System**: EMS is a set of protocols, competencies, and practices established at a utility to achieve overall environmental performance goals. Benefits from establishing such a system include cost savings through the reduction of waste, more efficient use of natural resources (electricity, water, gas and fuels), avoiding fines and penalties from not meeting environmental legislation, and reduction in insurance costs by demonstrating better risk management. EPA is currently working with Region 1 to use the EMS approach at water and wastewater facilities and has developed a step-by-step workbook entitled "Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities."
http://www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf

- **Combined Heat and Power (CHP) Partnership**: The CHP Partnership is a voluntary program seeking to reduce the environmental impact of power generation by promoting the use of CHP. The Partnership works closely with energy users, the CHP industry, state and local governments, and other clean energy stakeholders to facilitate the development of new projects and to promote their environmental and economic benefits. The Partnership has identified municipal wastewater treatment facilities as a strategic market and has completed an economic and technical potential study which is available at:
http://www.epa.gov/chp/markets/wastewater.html

III. Identifying Cost-Effective Opportunities for Energy Efficiency

The next step is to identify the cost-effective opportunities to reduce energy use and GHG emissions. Based on audits of over 200 facilities, EPRI's Water and Wastewater program identified these potential savings:

Water Facilities

10-15 % cost savings through load shifting
5-15 % energy savings through variable frequency drive (VFD) and high efficiency motors
10-20 % energy savings through process optimization and SCADA systems (Supervisory Control and Data Acquisition, generally referring to an industrial computer system monitoring and controlling a process)

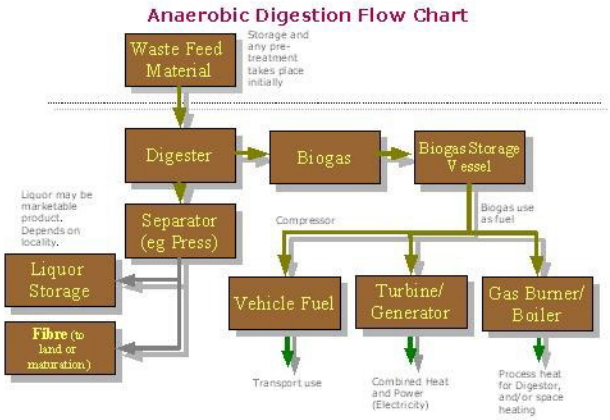
Wastewater Facilities

10-20 % energy savings through process optimization (e.g. lower Dissolved Oxygen levels)
10-20 % energy savings thru equipment modifications

IV. On-Site Energy Generation / Auxiliary and Supplemental Power Sources (ASPS)

Investment in ASPS or energy recovery equipment enables facility operators to produce clean energy on-site and reduce GHG emissions. **The CHP Partnership of the EPA conducted an analysis of the technical and economic opportunities for and benefits of CHP at wastewater** treatment facilities and found significant potential exists for (1) generating electricity and thermal energy, and (2) reducing greenhouse gas emissions at facilities that currently have anaerobic digesters.

More than 500 large wastewater treatment facilities (WWTF) around the country use anaerobic digesters to process their waste and produce biogas. If all of these facilities used their biogas to fuel CHP, they would generate an additional 340 megawatts (MW) of clean electricity each year.[8] This increase in CHP use would eliminate approximately 2.3 million metric tons of carbon dioxide annually. In general, a WWTF with a total influent flow rate of 4.5 Million Gallons per Day (MGD) can produce approximately 100 kilowatts (kW) of electricity to offset purchased electricity or sell to the grid.[9]



Besides CHP, there are also opportunities for solar and wind technologies to power water and wastewater facilities. **At the Santa Clara Valley Water District, an array of solar PV panels spread over three roofs generates approximately 20% of the water district headquarters campus's energy demands and saves approximately $240,000 in annual energy costs.** During FY 04-05 the solar panel arrays also provided emissions reductions of approximately 893,500 pounds of carbon dioxide, 20 pounds of nitrogen oxides, and 200 pounds of sulfur oxides. [10]

V. Paying for Clean Energy Projects

Financing for water utility capital projects is typically provided through revenues from user fees, debt and grants. Most debt contracted by utilities is commercial debt, usually in the form of tax-

[8] EPA. http://www.epa.gov/chp/markets/wastewater.html
[9] Ibid.
[10] Santa Clara Valley Water District, June 2007. *From Watts to Water: Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution*, p. 33.
http://www.valleywater.org/conservation/media/Documents/WUE%20Water%20Energy%20Report.pdf

free municipal bonds. In the past, substantial federal grants and other subsidies have been provided for capital projects, in particular to upgrade or expand wastewater treatment facilities in order to comply with the Clean Water Act. **However, the share of federal funding declined starting in the early 1980s.**

For about a decade different versions of a **Water Infrastructure Financing Act** have been submitted to Congress, but have not been approved. The **Clean Water State Revolving Fund** (SRF) has not been reauthorized since 1994, which has led to significant cuts in federal funding. The SRF aims at reducing water pollution by financing not only sanitary sewers, storm water drainage and wastewater treatment systems, but also nonpoint source pollution control such as erosion control and wetland protection and restoration.

The **Drinking Water State Revolving Funds** (DWSRF) was created in 1997 using the Clean Water State Revolving Fund as a model. It specifically targets drinking water supply infrastructure as opposed to wastewater infrastructure. Both publicly and privately owned community water systems and non-profit non-community water systems are eligible for funding under the DWSRF program. Eligible projects include installation and replacement of failing treatment facilities, eligible storage facilities and transmission and distribution systems. Projects to consolidate water supplies may also be eligible. [11]

VI. Relating Water and Wastewater Energy Use to Clean Energy Goals

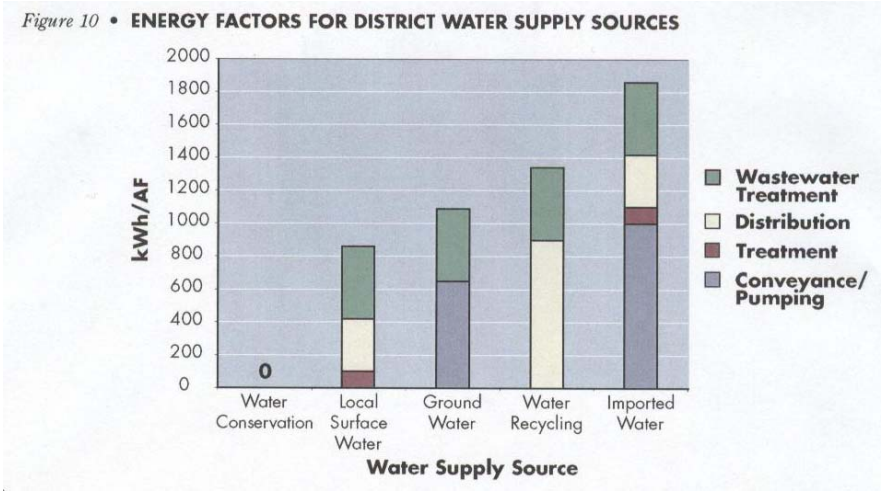
The Pacific Institute has developed a helpful quantitative tool, called the **Water-to-Air Model** to help water districts save energy, water, and money**,** as well as prevent air pollution and greenhouse gases. The model takes a whole-systems approach for quantifying water-related energy use and in doing so gives water supply planners an overview of the energy intensity of different water supply options, and allows them to compare water supply scenarios.[12]

In addition to the Water-to-Air Model, **Santa Clara Valley has quantified energy intensity embedded in water services, producing the unit 'kilowatt-hour per acre-foot' (kWh/AF) to describe the energy used to pump, treat, transport, and distribute water to the public**.[13] This is a helpful metric to determine the most efficient source for water.

[11] EPA. http://www.epa.gov/safewater/dwsrf/frequentquestions.html

[12] Pacific Institute, Oct. 2004. http://www.pacinst.org/reports/energy_and_water/water_to_air_manual.pdf and Santa Clara Valley Water District, June 2007. *From Watts to Water: Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution*, p. 12. http://www.valleywater.org/conservation/media/Documents/WUE%20Water%20Energy%20Report.pdf

[13] Santa Clara Valley Water District, June 2007. *From Watts to Water: Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution*, p. 16. http://www.valleywater.org/conservation/media/Documents/WUE%20Water%20Energy%20Report.pdf



Source: Santa Clara Valley Water District, June 2007. *From Watts to Water: Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution.*

VII. State Efforts to Promote Energy Efficiency

Wisconsin

Focus on Energy works with eligible Wisconsin residents and businesses to install cost effective energy efficiency and renewable energy projects. Its primary members include the Public Service Commission of Wisconsin, the Wisconsin Energy Conservation Corporation's Residential, Business and Renewable Energy Programs, and the Energy Center of Wisconsin. **Its water and wastewater division offers resources and experts at no cost to eligible Program Partners**, which then conduct energy surveys to identify energy-saving opportunities, develop an energy management plan, recommend energy-saving equipment options, model new technologies, and locate contractors and evaluate their proposals.[14]

California

The Santa Clara Valley Water District recently started a **pilot program that forms a unique partnership between the district and PG&E, an investor-owned utility, to help low-income customers save money, water and energy.** Under the program, low-income households receive free high-efficiency toilets (HETs), which are at least 20 percent more efficient than the current standard, and free installation.[15] This is the newest in a line of research and evaluative efforts to conserve water, which in the State of California constitutes the biggest use of electricity (pumping and treating water). Thus, California's urgent need to save water promotes energy savings, which, in turn, reduce greenhouse gas emissions. The state of California's efforts include extensive research and development, including over $5.5 million in the water utility sector between 1998 and 2004 through the Public Interest Energy Research (PIER) program.[16]

New York

NYSERDA encourages **New York's municipal water, wastewater, and solid waste facilities to adopt innovative technologies** that are more energy efficient and economical by working

[14] Wisconsin Focus on Energy. http://www.focusonenergy.com/Business/Industrial-Business/Wastewater.aspx
[15] SCVWD News, Dec. 9, 2008. http://www.valleywater.org/News_and_events/News_releases/2008_news_releases/December_9,_2008.shtm
[16] Public Interest Energy Research, Dec. 2004. http://www.energy.ca.gov/research/iaw/iaw_activities.html#history

closely with the consulting engineering firms, helping municipalities address regulation to decrease nutrients in wastewater, developing innovative ways to disinfect water, and optimizing performance to improve efficiency and increase wastewater treatment capacity.
NYSERDA offers programs including **energy studies, capital incentives for the installation of energy-efficient equipment and processes, and development and demonstration programs for innovative technologies.** In July 2007, NYSERDA developed and implemented the Focus on Municipal Water and Wastewater Facility Energy Efficiency program, which will provide water and wastewater operators and elected officials with the knowledge and resources necessary to successfully identify and implement energy efficiency improvement projects. Materials including "Best Practices Fact Sheets," a "Best Practices Handbook," and "Energy Checklists" for identification of simple opportunities for energy reduction measures are currently under development.[17] Benchmarking, assessments, and sub-metering are all being implemented within the program.

Massachusetts

The "**Energy Management Pilot for Wastewater and Drinking Water Plants**" brings together state and federal agencies and electric and gas utilities to conduct facility energy audits, assess each plant for its renewable and clean energy possibilities, and offer support for the implementation of these energy-related projects. **The audits cover electric, natural gas, and fuel oil usage.** As part of the program, each facility receives an EPA "ENERGY STAR Benchmarking" energy performance score. This provides an initial screening of the plants, as well as an on-going tracking measure to compare their energy performance against similar plants nationwide. [18]

Massachusetts is deploying a variety of other tactics for achieving greater energy efficiency at water and wastewater facilities, which are described in *Resources for Water and Wastewater Utilities Interested in Energy Efficiency and Renewable Energy*, published by the Northeast CHP Application Center.[19]

[17] NYSERDA, Focus on Water and Wastewater. http://www.nyserda.org/programs/Environment/muniwaterwwt.asp
[18] http://www.mass.gov/dep/public/publications/0108ener.htm
[19] Northeast CHP Application Center. http://www.northeastchp.org/nac/ and http://www.mass.gov/Eoeea/docs/eea/step/mawater_wastewater_energy_resources.doc

January, 2009 CEETF Webinar/Call Resources on Water & Energy

Documents by year	
Water and Energy: Leveraging Voluntary Programs to Save Both Water and Energy (ICF for EPA Climate Protection Partnership Division, 2008)	http://www.energystar.gov/ia/partners/publications/pubdocs/Final%20Report%20Mar%202008.pdf
Wastewater Management Fact Sheet: Energy Conservation (U.S. EPA, undated)	http://www.epa.gov/owm/mtb/energycon_fasht_final.pdf
An Economic Framework for Evaluating the Benefits and Costs of Biosolids Management Options (Water Environment Research Foundation, Oct. 2008)	http://www.werf.org/AM/CustomSource/Downloads/uGetExecutiveSummary.cfm?FILE=ES-04-CTS-2.pdf&ContentFileID=7867
Guidebook for Water Use Efficiency in New Development (AWWA Water Conservation Workshop, Feb. 2008)	http://www.awwa.org/files/Resources/Waterwiser/references/PDFs/sustainable2008_mon3-5.pdf
Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities (U.S. EPA, Jan. 2008)	http://www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf
From Watts to Water: Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution (Santa Clara Valley Water District, June 2007)	http://www.valleywater.org/conservation/media/Documents/WUE%20Water%20Energy%20Report.pdf
Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities (U.S. EPA CHP, April 2007)	http://www.epa.gov/chp/documents/wwtf_opportunities.pdf
Water and Wastewater Energy Best Practice Guidebook (SAIC for WI Focus on Energy, 2006)	http://www.focusonenergy.com/Business/Industrial-Business/Guidebooks/default.aspx
Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water (U.S. DOE, Dec. 2006)	http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf

Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies (U.S. EPA, Jan. 2006)	**http://www.epa.gov/dced/pdf/growing_water_use_efficiency.pdf**
Roadmap to Energy in the Water & Wastewater Industry American Council for An Energy Efficient Economy (ACEEE, 2005)	**http://www.aceee.org/pubs/ie054.htm**
Guidelines for Water Reuse (U.S. EPA, Sept. 2004)	**http://www.epa.gov/ORD/NRMRL/pubs/625r04108/625r04108.pdf**
Bringing Energy Efficiency to the Water & Wastewater Industry: How Do We Get There? (EPRI & Global Partners, LLC, July 2004)	**http://www.aceee.org/industry/carns.pdf**
Water and Wastewater Industry Energy Efficiency: A Research Roadmap (AwwaRF, 2004)	**http://www.energy.ca.gov/2004publications/CEC-500-2004-901/CEC-500-2004-901.PDF**
Energy Use in Wisconsin's Drinking Water Facilities (Energy Center of Wisconsin, July 2003)	**http://www.ecw.org/prod/222-1.pdf**
Cases in Water Conservation: How efficiency programs help water utilities save water and avoid costs (U.S. EPA, July 2002)	**http://www.epa.gov/owm/water-efficiency/docs/utilityconservation_508.pdf**
Water Conservation Plan Guidelines (U.S. EPA, Aug. 1998)	**http://www.epa.gov/watersense/pubs/guide.htm**
Websites (Alphabetical by Organization)	
American Water Works Association (WaterWiser website)	**http://www.awwa.org/Resources/Waterwiser.cfm?navItemNumber=1561**
Process Energy – Water/Wastewater Efficiency (California Energy Commission)	**http://www.energy.ca.gov/process/water/index.html**
National Municipal Water and Wastewater Facility Initiative (Consortium for Energy Efficiency)	**http://www.cee1.org/ind/mot-sys/ww/ww.php3**

Federal Water Efficiency Best Management Practices (DOE, EERE, Federal Energy Management Program)	**http://www1.eere.energy.gov/femp/water/water_bmp.html**
ENERGY STAR: Focusing on Energy Efficiency for the Drinking Water and Wastewater Industries (ENERGY STAR)	**http://www.aceee.org/conf/mt06/i4-hatcher.pdf**
ENERGY STAR for Wastewater Plants and Drinking Water Systems (Website)	**http://www.energystar.gov/index.cfm?c=government.wastewater_drinking_water**
Focus on Water and Wastewater (NYSERDA)	**http://www.nyserda.org/Programs/Environment/muniwaterwwt.asp**
Water Environment Research Foundation	**http://www.werf.org/AM/Template.cfm?Section=Home&Template=/Custom/home.cfm**
Water Research Foundation (formerly Awwa RF)	**http://www.waterresearchfoundation.org/index.aspx**
A Roadmap to Sustainable Energy Management: Every Journey Begins with a First Step (WERF 2008 Web Seminar Series, June 2008)	**http://www.werf.org/am/template.cfm?section=Search_Research_and_Knowledge_Areas&template=/cm/ContentDisplay.cfm&ContentID=8699**