Water and Energy Nexus Research Database

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For more information about this database, please refer to "Water-Energy Research: Recommendations for Future Opportunities", May 2013, at ttp://www.allianceforwaterefficiency.org/.

Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Electrical Power Consumption for Municipal Wastewater Treatment	Robert Smith	EPA	7/1/1973	http://nepis.epa.gov/Exe/ZyNET.exe/9100TG7H.TXT?ZyActionD=ZyDocument&Client=EPA&Index=Prior+to+1976&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%5C70thru75%5CTxt%5C00000014%5C9100TG7H.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	E-W	Electrical power consumption; conventional, advanced processes, municipal wastewater; unit process basis; power consumption, individual processes, plant utilities; comparison, electrical power	• Electrical power consumed in municipal wastewater treatment is about 1% of the average residential consumption of electrical power when the distribution of treatment schemes given in the 1968 Inventory of Municipal Waste Facilities is used as a basis. If all communities were served by activated sludge plants, the electrical power used will be about twice this amount. This is equivalent to about 15 watts per household. • Thus, for complete secondary treatment, the power consumed is about equivalent to 24 hour operation of one desk lamp per household. • The power consumed by tertiary treatment depends on the processes used, but for the Lake Tahoe system of tertiary treatment, the power consumed is about 40-50% greater than the power consumed in conventional activated sludge treatment.
Energy Consumption of Advanced Wastewater Treatment at Ely, Minnesota	Donald J. Hernandez	EPA	1/1/1978	http://nepis.epa.gov/Exe/ZyNET.exe/20007OWW.PDF?ZyActionP=PDF&Client=EPA&Index=1976%20Thru%201980&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C76THRU80%5CTXT%5C00000000%5C20007OWW.txt&Query=&SearchMethod=1&FuzzyDegree=0&User=ANONYMOUS&Password=anonymous&QField=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&Docs=	E-W	Energy use, advanced wastewater treatment plant, Ely, Minnesota; plant operation; support services; indirect use	• The energy utilized by support services at Ely far surpasses energy utilization in the treatment process. Fuel is the largest single energy use. Regardless of the daily flow or level of treatment used (phosphorus removal) this energy use would not be reduced. An estimate of 205 t1J (57 kHh) per day for primary-secondary plant support services. This is very close to the probable use at the Ely primary-secondary plant. • After fuel the next largest use of energy is indirect use for the production of resources used. This use also far exceeds the energy used in the treatment process. Regardless of where a plant of this type is located, this utilization will remain relatively high. It can readily be seen that the greatest energy use is in the production of lime and electricity. • Of the total 62.37 GJ used per day at Ely, 27.68 GJ are attributable to heating the plant, 12.46 GJ are used in producing the lime, and 12.96 GJ are used in producing the electricity used at the plant. These three items constitute 85% of the plant energy use. • Energy use is a direct measurement of cost, in both dollars and natural resources. A complete and thorough evaluation should be carried out when an advanced wastewater treatment facility is considered, and no such facility should be built unless the study indicates a true need with minimum adverse effects. • Summary of daily energy utilization for AWT plant operation: Plant operation (5.36 GJ, 8.6%), Support services (31.03 GJ, 49.7%), Indirect (26.05 GJ, 41.7%), Total (62.44 GJ, 100%)

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Energy Conservation in Municipal Wastewater Treatment	George M. Wesner, Gordon L. Culp, Thomas S. Lineck, Daniel J. Hinrichs	EPA	3/1/1978	http://nepis.epa.gov/Exe/ZyNET.exe/00000IU3.PDF?ZyActionP=PDF&Client=EPA&Index=1976%20Thru%201980&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C76THRU80%5CTXT%5C00000000%5C00000IU3.txt&Query=&SearchMethod=1&FuzzyDegree=0&User=ANONYMOUS&Password=anonymous&QField=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&Docs=	E-W	Primary energy use, secondary energy use; primary energy conservation; municipal wastewater treatment construction; alternatives for energy reduction potential; consumables used in wastewater treatment	• For 1977, 142,870 Billion Btu/yr (Secondary: 141,800 Billion Btu/yr, Tertiary: 1,070 Billion Btu/yr) of energy use is expected, which represents 0.17 percent of the total national energy use in 1977; for 1990, 256,910 Billion Btu/yr of energy use (Secondary: 216,510 Billion Btu/yr, Tertiary: 40,400 Billion Btu/yr) is expected which represents 0.23 percent of the total national use in 1990. • Primary energy requirements are presented graphically in Figures 3-2 through 3-118 for the municipal wastewater treatment process listed in Table 3-1. • Secondary Energy Estimates – Activated Carbon (Fuel: 102 M Btu/ton, Elec: 4.9 kwh/lb); Alum (Fuel: 2 M Btu/ton, Elec: 0.1 kwh/lb); Ammonium Hydroxide (Fuel: 41 M Btu/ton; Elec: 2 kwh/lb); Carbon Dioxide (Fuel: 2 M Btu/ton, Elec: 0.1 kwh/lb); Chlorine (Fuel: 42 M Btu/ton, Elec: 2 kwh/lb); Ferric Chloride (Fuel: 10 M Btu/ton, Elec: 0.5 kwh/lb); Lime (Calcium Oxide) (Fuel: 5.5 M Btu/ton, Elec: 0.3 kwh/lb); Methanol (Fuel: 36 M Btu/ton, Elec: 1.7 kwh/lb); Oxygen (Fuel: 5.3 M Btu/ton, Elec: 0.25 kwh/lb); Polymer (Fuel: 3 M Btu/ton, Elec: 0.1 kwh/lb); Salt (Sodium Chloride) – Evaporated (Fuel: 4 M Btu/ton, Elec: 0.2 kwh/lb); Salt (Sodium Chloride) – Rock & Solar (Fuel: 0.5 M Btu/ton, Elec: 0.024 kwh/lb); Sodium Hydroxide (Fuel: 37 M Btu/ton, Elec: 1.8 kwh/lb); Sulfur Dioxide (Fuel: 0.5 M Btu/ton, Elec: 0.024 kwh/lb); Sulfuric Acid (Fuel: 1.5 M Btu/ton, Elec: <0.1 kwh/lb) • Heat requirements are presented for: Building heating/air conditioning; Anaerobic digestion; Heat conditioning of sludge to improve dewatering; Wet oxidation of sludge; Lime recovery by recalcination; Granular and powdered carbon regeneration; Ion exchange regenerant renewal • Anaerobic Digester Gas production, method for use, including electrical power generation, and cost estimates are presented. • Various incineration systems are briefly described and waste heat recovery is discussed. Incineration of sludge and combinations of sludge and solid waste are evaluated. Cost estimates are given for multiple hearth furnaces. Energy requirements for air pollution control devices are not included in the curves. • Several commercially available pyrolysis systems are briefly described and the potential for energy recovery and reuse is discussed. Treatment of sludge and solid waste combined is evaluated. • Energy requirements and the potential for waste heat recovery are discussed. • Systems to utilize the heat in wastewater and air are described and cost estimates presented. • Solar energy systems are briefly described and an example for space heating is presented. • Energy conservation procedures that could be used in existing wastewater treatment facilities are discussed. • Anaerobic digester gas utilization and use of waste heat from incinerators is not feasible in small plants. Engines and other necessary equipment are unavailable for small capacity plants. The smallest commercial multiple hearth furnace has a hearth area of 85 sq ft. Heat recovery from sewage through the use of heat pumps is possible for small plants.
Total Energy Consumption for Municipal Wastewater Treatment	Robert Smith	EPA	8/1/1978	http://nepis.epa.gov/Exe/ZyNET.exe/9100SR0P.PDF?ZyActionP=PDF&Client=EPA&Index=1976%20Thru%201980&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C76THRU80%5CTXT%5C00000018%5C9100SR0P.txt&Query=&SearchMethod=1&FuzzyDegree=0&User=ANONYMOUS&Password=anonymous&QField=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&Docs=	E-W	Energy consumed for+G10 collection and treatment of municipal wastewater; heat energy, electrical energy; energy used for construction of treatment plant; sewerage system; total energy consumed; plant operation; high efficiency aeration devices; good maintenance practices; conservation of energy; recovery of energy from sludge	• Heat energy is equated to electrical energy by a conversion factor of 10,500 Btu/kwh. • Total energy consumption ranges from 2300-3700 kwh/mg. • Energy used for construction of the treatment plant and the sewerage system represents 35-55% of the total energy consumed. The remainder used for plant operation is predominately (65-75%) electrical energy. • The use of high efficiency aeration devices combined with good maintenance practices appears to offer the best opportunity for conservation of energy within the plant. • Recovery of energy from the sludge produced at the plant can be accomplished by anaerobically digesting the sludge and using the digester gas as fuel for internal combustion engines. • In large plants, when the sludge is sufficiently dewatered, it is also possible to recover energy by incinerating the dewatered sludge with production of steam in a waste heat boiler. The steam can then be used within the plant or expanded through a steam turbine to produce mechanical or electrical energy.
Technology Assessment of Solar Thermal Energy Applications in Wastewater Treatment	Roy F. Weston, Inc. Designers-Consultants	EPA	2/1/1982		E-W	Technology assessment; cost-effective systems; energy-effective systems; publicy owned treatment works (POTW's); resource recovery and recycles practices	• Three major areas were identified for which solar thermal energy usage has potential applicability in POTW's. These areas include space and domestic water heating, anaerobic digester heating, and sludge drying. Based on energy usage as a function of facility size, a 3,785 m3/d (1 mgd) facility could potentially save about 31 percent of its total energy-usage by converting these three processes from conventional energy to solar thermal energy. Similarly, a 378,500 m3/d (100 mgd) facility would save approximately 10 percent of its total energy requirement. • Based on the analysis, solar-aided anaerobic digester heating proved uneconomical at all locations within the United States. • A sensitivity analysis was performed to determine which variable had the greatest effect on the cost analysis. Variables considered included collector system price per unit area, annual operations and maintenance cost, fuel escalation cost factor, and percent solids in digester feed. The analysis indicated that the collector system cost was the most sensitive item, and that system costs would have to be reduced to between \$162 and \$323/m2 (\$15 to \$30/ft2) in order to make the systems economically viable. Currently, the system costs are in the range of \$538/m2 (\$50/ft2).

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Monitoring Integrated Energy Systems at a Wastewater Treatment Plant in Maine	David R. Fuller, Douglas A. Wilke, Patric L. Thomas, Anthony J. Lisa	EPA	9/1/1984		E-W	Performance monitoring; municipal wastewater treatment plant in Wilton, Maine; active solar; passive solar; effluent heat recovery; digester gas generation; air-to-air heat recovery; electricity generation; digester gas; solar pyranometers; hydronic BTU computers; electrical and gas meters; weather station; temperature transmitters	The analysis of the monitoring data and the engineering evaluation of the energy systems at the Wilton, Maine, wastewater treatment plant have led to the following conclusions: 1. Heat recovery from wastewater treatment plant effluent through the use of a water-to-water heat pump is cost effective under relatively severe temperature conditions. Operational problems can be minimized by properly designing the effluent sump from which the heat pump draws to provide sufficient capacity at minimum plant effluent flows. 2. Heat recovery from ventilation air is cost effective. 3. Heat recovery from the generator cooling loop may be cost effective if increased use of the generator is warranted. 4. Passive solar heating is not cost effective as analyzed for the Wilton plant, but it can be made cost effective with design modifications. Passive solar heating of treatment plant structures can be cost effective in occupied areas such as the office and laboratory if good energy conservation principles are followed in the design of such areas. Passive solar heating is less cost effective when applied to process areas exposed to water surfaces. Combined with task heating (if necessary) and proper energy conservation design, passive solar heating and lighting can be cost effective in process areas. 5. When solar system instantaneous efficiencies are applied to clear-day insolation levels and the mean expected percent of sunshine, the result may be an overly optimistic evaluation of the actual long-term performance. These losses are related to the system threshold insolation intensity and the random weather patterns. Thus accurate estimate of long-term efficiencies would require computer simulation using site-specific, averaged, hourly weather data and system performance criteria. Moreover, since the threshold intensity level is predominantly affected by the difference in the average collector fluid and ambient temperatures, the long-term efficiency may be significantly reduced in northern climates. 6. Collecting solar thermal energy to produce supplemental heat for anaerobic sludge digesters is probably not cost effective under currently accepted economic projections, regardless of the size or location of the facility. 7. Instrumentation and controls should be simplified as much as possible. The theoretical advantages of integrated energy systems can be offset by complicated, trouble-prone instrumentation.
Alternative Energy Sources for Wastewater Treatment Plants		EPA	11/1/1988		E-W	Technology assessment, alternative energy sources, wastewater treatment plants; heat pumps; active solar systems for heating and cooling; photovoltaic systems; geothermal; direct-use systems; wind power systems; low-head hydro systems; passive solar systems; power generation systems; fuel cells; active solar systems for power generation	Based on this assessment the following alternative energy technologies appear to be potentially cost effective: 1. Heat pumps which use influent or effluent wastewater as their heat source, for supplying process or building heat. 2. Geothermal direct-use systems for large energy loads when geothermal source is adequate. 3. Wind power systems for large electrical loads when annual wind flux is adequate. 4. Passive solar systems where they can be cost-effectively integrated into the overall architectural design of a facility. 5. Low-head hydro systems may be appropriate for smaller plants which have an available head greater than three meters.
Impact of energy cost and water resource availability on agriculture and groundwater quality in California		Resource and Energy Economics	3/1/1994	http://www.sciencedirect.com/science/article/pii/0928765594900132	E-W	Simultaneous effects, water scarcity, energy price increases; farm-level decisions; water-related technology substitution; cropping patterns; groundwater quantity; groundwater quality; farm income; dynamic model; long-run private profits; water level and quality in aquifer; management; regional scale; Kern County, California	(For fee research paper) The simulation results suggest that over time, given the changes in water availability and energy prices: • The proportion of groundwater in irrigation water will increase • Cropping patterns will consist of higher shares of salt-tolerant crops • More energy and water saving pumping and irrigation equipment will replace existing technologies • Agricultural net income will drop significantly • The level of groundwater in the aquifer will drop, and its quality will degrade • In extreme scenarios, agriculture may cease in locations depending heavily on groundwater.
Energy Audit Manual for Water/Wastewater Facilities		EPRI	7/1/1994		E-W	water, wastewater systems; energy/demand relationships; walkthrough and detailed process audits; electrical energy efficiency	• Types of audits: lighting; HVAC; pumping; walkthrough process audits; detailed process audits • How to conduct walkthrough and process audits: (1) Conduct kick-off meeting; (2) Create the team; (3) Collect plant data; (4) Explain electric utility bills and schedules; (5) Conduct field investigation; (6) Create equipment inventory and distribution of demand and energy; (7) Develop ECMs (Energy Conservation Measures) and implementation strategies; (8) Follow-up • Description of potential ECMs for process areas of wastewater and water facilities • Challenges: product quality is mandated, energy is not; changes may require more operator attention, labor costs, training

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Case Studies in Residual Use and Energy Conservation at Wastewater Treatment Plant	Diane Stewart	EPA	6/1/1995	http://www.nrel.gov/docs/legosti/old/7974.pdf	E-W	Wastewater treatment plants; effluent; heating and cooling; pollution prevention	• Energy recovery from biogas is universally cost effective and has gained widespread acceptance. The technology exists to allow full use of biogas, and the extra costs of incorporating this energy source into a system are small. The payback period for installation of biogas energy recovery at plants having anaerobic digesters is short, typically less than six years. Recovery and use of biogas accomplish energy conservation and pollution prevention goals, and also cost savings making this an obvious choice for application in all treatment plants that employ anaerobic digestion for stabilization of wastewater biosolids. • Other energy conservation and municipal pollution prevention activities can be integrated with use of biogas, as demonstrated by the Sunnyvale WPCP (Water Pollution Control Plant), including collection and use of landfill gas recovery of waste heat,water reclamation, and municipal water conservation. • Converting biosolids to fuel achieves substantial benefit from the wastes before carbon dioxide is ultimately released. The experiences of these facilities show that actions which enhance process efficiency, such as advanced primary treatment, can simultaneously result in increased energy recovery. • There is no evidence that energy conservation efforts have in any way adversely affected receiving water quality. The energy conservation potential of effluent heating and cooling has been explored to date by only a few facilities. • Water reclamation projects should be designed not only to reclaim water as a valuable resource, but also to take advantage of any opportunities to substitute effluent heating and/or cooling for nonrenewable energy sources.
Water and Wastewater Industries: Characteristics and Energy Management Opportunities		EPRI	1/9/1996	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=CR-106941	E-W	Electricity for water and wastewater treatment; new regulations; increased service; upgraded treatment; control costs; technological changes; improved management; utility sponsored energy management programs; tool; challenges	(For fee research paper: key findings/recommendations not available)
Dawn of the Replacement Era – Reinvesting in Drinking Water Infrastructure	John Cromwell, Elisa Speranza, Haydn Reynolds	American Water Works Association	5/1/2001	http://www.win-water.org/reports/infrastructure.pdf	E-W	Water utilities; rate structure; long-term viability; streamline programs; federal government assistance	• On average, the replacement cost value of water mains is about $6,300 per household in today's dollars in the relatively large utilities studied. If water treatment plants, pumps, etc., are included, the replacement cost value rises to just under $10,000 per household, on average. • Demographic shifts are a significant factor in the economics of reinvestment. In some older cities, the per-capita replacement value of mains is more than three times higher than the average in this sample due to population declines since 1950. • By 2030, the average utility in the sample will have to spend about three and a half times as much on pipe replacement due to wear-out as it spends today. Even so, the average utility will also spend three times as much on repairs in that year as it spends today, as the pipes get older and more prone to breakage. • Overall, in the 20 utilities studied, infrastructure repair and replacement requires additional revenue totaling about $6 billion above current spending over the next 30 years. This ranges from about $550 per household to almost $2,300 per household over the period. These household impact figures do not include compliance with new regulations or the cost of infrastructure replacement and compliance for wastewater. Recommendations: 1. Utilities should develop a comprehensive local strategy that assesses the condition of the drinking water system infrastructure; strengthens research and development; works with the public to increase awareness of the challenge ahead, assess local rate structures, and adjust rates where necessary; and builds managerial capacity. 2. States should commit to respect the universal eligibility of all water systems for federal assistance; streamline their programs for delivery of assistance and allow alternative procurement procedures that save money; make their financing mechanisms more attractive by committing to grants and very low or negative interest loans; and use federal funds in a timely fashion or face the reprogramming of those funds to other states. 3. The federal role should significantly increased federal funding for projects to repair, replace, or rehabilitate drinking water infrastructure; increase in federally supported research on infrastructure management, repair and replacement technologies, and increase the availability and use of private capital.

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Construction and Operating Costs of Groundwater Pumps for Irrigation in the Riverine Plain	D.W. Robinson	CSIRO Land and Water	1/1/2002	http://www.clw.csiro.au/publications/technical2002/tr20-02.pdf	E-W	Installation; capital and operating costs of groundwater pumping systems; irrigation and salinity control	• Two types of groundwater pumping systems used for the purpose of irrigation - bores and spearpoint. Bores are used to pump groundwater from aquifers to supplement surface water supplies whereas spearpoint systems pump groundwater from shallow watertables and are mainly used for salinity and waterlogging control but can also supplement irrigation supply depending on the quality of the groundwater. • The capital cost of purchasing and installing a spearpoint system to pump a shallow watertable can vary from approximately $18,000 to $70,000. The high range can be attributed to the variability of spearpoint design, pumping capacity, depth of wellpoints, engine type, proximity to electric power and water discharge area and the cost of a geo-technical investigation. • The capital cost of purchasing and installing a shallow bore is variable with a range similar to spearpoint systems. A deep bore will range from approximately $90,000 to $320,000. The capital cost of purchasing and installing a bore will vary depending on pumping capacity, bore depth, system design, materials used, engine type, proximity to electric power and water discharge area • Before installing a groundwater pumping system it is advisable that a financial feasibility study is undertaken to assess whether a groundwater pump is a viable and worthy investment over a time frame equivalent to the effective life of the investment. The analysis should include a comparison of the different pumping system designs and alternative power sources available to determine which pumping design is the most cost efficient over its effective life.
The effects of longwall coal mining on overlying aquifers	Colin J. Booth	Department of Geology and Environmental Geosciences, Northern Illinois University	1/1/2002	http://sp.lyellcollection.org/content/198/1/17.abstract	E-W	Hydrogeological effects of longwall mines; fractured strata; fractured aquitards; permeabilities; secondary drawdown; water levels; Pennsylvanian coal; confined aquifers; transmissive aquifers; decline; recovery; enhanced well yields; water quality; oxidation and mobilization of in situ sulfides; subsidence; bedrock-drift continuity; conceptual model; local hydrogeological variations	(For fee research paper: key findings/recommendations not available)
Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities	Kathy Benschine; Myron Jones; Stephen Fok; Erik Dyrr; Carol Harty; Steven Giampaoli; Jayne Ng; Jeff Romberger; Patsy Dugger; Ben Wildman	PG&E	2/28/2002		E-W	Wastewater treatment plant; electricity usage; secondary wastewater treatment process; ultraviolet (UV) disinfection; sustainable energy efficiency improvements; benchmark; quantifying amount of energy used based on actual operating data	• The energy used for UV disinfection ranged from 117 to 557 kWh per million gallons treated when meeting disinfection limits of 200 MPN of Fecal Coliform /100 ml of wastewater. • When complying with an NPDES (National Pollutant Discharge Elimination System) effluent permit requiring a very high level of disinfection, 2.2 MPN of Total Coliform/100 ml of wastewater, energy use of 1,001 kWh per million gallons treated was required, even though the plant had an effluent TSS concentration of 1 mg/l and uses an automated control system to adjust the energy used for disinfection based on flow and UV transmittance. • The UV disinfection process required 14% and 23% of the total electrical energy used by the two plants for this benchmarking study. • It is inappropriate or statistically insignificant to draw a definitive conclusion regarding the comparative energy efficiency of low vs. medium pressure UV systems from the limited treatment plant data obtained for this study. However, it appears that low pressure systems are more energy efficient than the medium pressure systems. • On a global energy basis, it appears that UV disinfection can be competitive with chlorine/hypochlorite disinfection and dechlorination.
Water & Sustainability: U.S. Electricity Consumption for Water Supply & Treatment - The Next Half Century	B. Appelbaum	EPRI	3/1/2002	http://www.rivernetwork.org/sites/default/files/Water%20and%20Sustainability%20(Volume%204)-%20EPRI.pdf	E-W	Unit electricity requirements; fresh water supply; wastewater treatment; public water agencies; public wastewater treatment facilities; private wastewater treatment facilities; self-supply of water; domestic; commercial; industrial; mining; irrigation; livestock; thermal power generation; aggregate electricity requirements; impact on future projections	• For the first time, unit energy (electric) requirements have been estimated for all end-use sectors and for thermal power generation, with respect to water supply and treatment. • Generally, electricity demand associated with water supply and treatment for various end-use sectors will likely track Bureau of Census population growth projections of 50% by the year 2050. The only exceptions are irrigation pumping and industrial (excluding mining) uses, both of which will triple over that period. Thermal power generation electricity requirements associated with water use will remain relatively flat. • Some 4% of the nation's electricity use goes towards moving (80%) and treating water/wastewater. Approximately 80% of municipal water processing and distribution costs are for electricity. Electricity availability, while critical for water supply and wastewater processing, is not a major impediment to economic development. However, water is a key constraint on such development and will strongly affect the overall demand for electricity from human activities that depend on water availability. • Groundwater supply of water from public sources requires about 30% more electricity on a unit basis than supply from surface water. The difference is due primarily to a higher requirement for raw water pumping for groundwater systems. • Given EPRI's Electricity Technology Roadmap projections of some 7000 GW of additional electric generation needs by the year 2050, it is imperative that any critical resource availability on which this projection rests be evaluated and addressed. This Water & Sustainability effort did find that electricity availability is not a constraint on water supply and treatment capabilities; rather, it is electricity supply and demand that depend on water availability.

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Energy Use at Wisconsin's Drinking Water Utilities	Todd Elliott Benjamin Zeier Irene Xagoraraki and Gregory W. Harrington	University of Wisconsin	7/5/2002	http://www.ecw.org/prod/222-1.pdf	E-W	Energy efficiency; drinking water agencies; energy savings	• Overall, most energy and money can be saved by reducing energy use in Class AB because Class AB utilities used the most energy, treated the most water, and served the largest number of consumers. Even though Class AB utilities are using the least amount of energy per 1000 gallons of water pumped, this class has the most potential for energy savings. • Utilities at or below the 10th percentile and at or above the 90th percentile for energy use, energy expenditure, and water loss should be evaluated further to determine what in these specific utilities is placing them in the aforementioned percentiles. This analysis should help utilities in the high percentiles lower their energy use and costs while still providing a quality product to the residents of Wisconsin.
Long-term optimal aeration strategies for small-size alternating activated sludge treatment plants	B. Chachuata; N. Rocheb; M.A. Latifia	Laboratoire des Sciences du G´enie Chimique	12/1/2002	http://www.researchgate.net/publication/223904135_Long-term_optimal_aeration_strategies_for_small-size_alternating_activated_sludge_treatment_plants	E-W	Wastewater treatment; Alternating activated sludge process; Nutrient removal; Energy consumption; Dynamic optimization; Short and long time horizons	• Optimization over short time horizons discussed, and a simplification of the optimization problem was investigated to reduce the computational times. It is demonstrated that aeration rates of 31%, i.e., 7 h 30 min of aeration time a day, are enough to ensure constraints fulfillment over 24 h. However, too short aeration periods lead to a sharp decrease in autotrophic biomass which eventually results in a washout of autotrophic bacteria (nitrifying bacteria) as the optimal aeration strategy is applied repeatedly.
Desalination and Water Purification Technology Roadmap	William Blomquist, Shannon Cunniff, Peter Fox, David Furukawa, Marie Garcia, Michael Gritzuk, Lisa Henthorne, Anita Highsmith, Thomas Hinkebein, Kevin Price, Gary Wolff	USBR, Sandia	1/1/2003	http://www.usbr.gov/research/AWT/s_t_publications/Desal%20Roadmap.pdf	E-W	Desalination; water purification; water supply challenges; U.S.; 2020; research and development; technical solutions	• Create new technology. A comprehensive framework must be developed so that research projects are selected based on their ability to meet (or contribute to meeting) the metrics of the roadmap. • Characterize the resource. Mapping and characterizing saline aquifers is an important part of the process to improve water availability for the nation. It is essential to know the size, delineation, and quality of our national water resources. Another part of this same program is characterizing reservoirs that might receive concentrate produced by desalination technologies. • Address implementation issues. Greater attention should be paid to issues found in areas where the need for desalination is acute. • Commercialize and implement. Educating the public regarding the safety of desalinated water and the benefits that it provides will be important to smoothing the path for deployment. Working with the industry to develop incentives for early adoption of new technologies will speed their introduction to the marketplace. Developing independent testing facilities and creating comprehensive cost modeling software tools will also serve to mitigate barriers to commercialization. • Collaborate at the global scale. The United States should continue and expand its interactions with nations around the world where water supply issues may threaten regional stability.
Municipal Wastewater Treatment Plant Energy Baseline Study	M/J Industrial Solutions	PG&E	6/1/2003		E-W	Wastewater treatment energy consumption; primary treatment; secondary treatment; energy efficiency; UV disinfection; wastewater treatment baseline; treatment plant operation; discharge regulation	• Secondary treatment is the largest energy consumer (30 to 60% of total plant usage), followed by pumping and sludge processing. • Although suspended growth, activated sludge is the most common wastewater treatment process, it is not the most energy efficient. Aerated lagoons, trickling filters and rotating biological contactors are significantly more efficient. • In general, low pressure UV systems are substantially more efficient than medium pressure systems. • Energy efficiency opportunities in wastewater treatment include the use of fine bubble diffusers, dissolved oxygen control of aeration, high efficiency blowers, variable frequency drives on pumps and blowers, premium efficiency motors, and the reduction of the head against which pumps and blowers operate. • This lack of standardization and site-specific regulatory requirements make it impractical to establish a definitive wastewater treatment baseline in terms of a system configuration or a universal performance metric for wastewater treatment facilities. • It is recommended that PG&E should participate early in the design phase of new plants or major retrofits with support from consultants to analyze the design for base energy consumption. Options for energy efficiency improvements and applicable incentives can than be identified and presented for review by the plant management.
Energy Saving Opportunities for Wastewater Facilities: A Review	Todd Elliot	ECW	6/30/2003	http://www.ecw.org/ecwresults/221-1.pdf	E-W	Wastewater treatment; utilities	Identifies costs with wastewater treatment, provides alternatives to saving energy in treatment process.
Energy Use at Wisconsin's Drinking Water Facilities	Tood Elliott, Benjamine Zeier, Irene Xagoraki, Gregory W. Harrington	Energy Center of Wisconsin	7/1/2003	http://www.ecw.org/ecwresults/222-1.pdf	E-W	Wisconsin Focus on Energy; drinking water utilities; energy reduction program; statewide energy saving; energy consumption	• The state's largest utilities, those serving more than 4000 customers and listed in Class AB by the Wisconsin Public Service Commission (WPSC), consumed about 75% of the statewide energy used for water production. • Overall, the most energy and money can be saved by reducing energy use in Class AB because Class AB utilities used the most energy, treated the most water, and served the largest number of consumers. Even though Class AB utilities are using the least amount of energy per 1000 gallons of water pumped, this class has the most potential for energy savings. • Utilities at or below the 10th percentile for energy use, energy expenditure, and water loss should be evaluated further to determine what in these specific utilities is placing them in the aforementioned percentiles.

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Water Desalination Findings and Recommendations	Charles F. Keene	DWR, Water Desalination Task Force	10/1/2003	http://www.water.ca.gov/pubs/surfacewater/water_desalination_findings_and_recommendations/findings-recommendations.pdf	E-W	Desalination technology; opportunities; impediments; seawater; brackish water desalination; state role; legislative action; statutory changes	• One of the primary findings is that economically and environmentally acceptable desalination should be considered as part of a balanced water portfolio to help meet California's existing and future water supply and environmental needs. • Other findings provided in report • The overarching recommendation considered critical to the advancement of desalination is that desalination projects should be evaluated on a case-by-case basis. Because each facility is essentially unique, given local water supply and reliability needs, site-specific environmental conditions, project objectives, and proposed technology, case-by-case analyses are essential. • Other recommendations provided in report
Waste Not, Want Not: The Potential for Urban Water Conservation in California	Peter H. Gleick, Dana Haasz, Christine Henges-Jeck, Veena Srinivasan, Gary Wolff, Katherine Kao Cushing, Amardip Mann	Pacific Institute	11/18/2003	http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf	E-W	Water use; urban conservation; water use efficiency; California's water; agricultural water use; economics of water savings; water need and water quality; recycled water; indoor residential conservation; outdoor residential conservation; commercial, institutional, and industrial (CII) conservation; cost effectiveness	• Indoor residential use could be reduced by approximately 890,000 AF/yr (~ 40%) by replacing remaining inefficient toilets, washing machines, showerheads, and dishwashers, and by reducing the level of leaks. • Cost-effective reductions of at least 32.5% (a savings of 470,000 AF/yr) can be made with improved management practices and available irrigation technology; larger improvements can be made through long-term changes in plant selection and garden design. • The range of potential savings for traditional heavy industries is between 710,000 AF/yr and 1.3 MAF/yr over current use. Best estimate of practical savings in the CII sector is about 975,000 AF, or 39% of total current annual water use. • California is using water unsustainably. Improved efficiency and increased conservation are the cheapest, easiest, and least destructive ways to meet California's future water needs. Existing technologies for improving urban conservation and water-use efficiency have enormous untapped potential. There are barriers to capturing all conservation potential, but these barriers can be overcome. • Existing technologies are available to greatly reduce urban water use without reducing the goods and services we desire. New technologies are constantly evolving. • The power of proper pricing of water is underestimated. Economic innovation and financing mechanisms lead to cost-effective water conservation. • Appliance standards are powerful conservation tools that also help educate consumers. • Data and information are keys to successful conservation. Meter and measure all water uses. Appliance labeling is a powerful educational tool. Standardize water-use terms. Educate decision-makers about conservation opportunities. Give agencies and industries an opportunity to share success stories. Reconcile data reported from individual water agencies, industry associations, and various other agencies. • Be aware of the water implications of non-water policies. Promote reclaimed and recycled water as a secure source for water supply.
Experimental Determination of Energy Content of Unknown Organics in Municipal Wastewater Streams	Ioannis Shizas; David M. Bagley, M.ASCE	Natural Sciences and Engineering Research Council of Canada; Center for Research in Earth and Space Technology	1/1/2004		E-W	Organic matter; energy measurement; municipal wastes; wastewater management	• The energy content measurements indicate that for the fullscale treatment facility examined, the potential energy available in the raw wastewater exceeds the electricity requirements of the treatment process by a factor of 9.3. • The energy content of raw municipal wastewater and wastewater treatment sludges can be precisely determined using bomb calorimetry in conjunction with an appropriate combustion aid. • Energy content analysis indicates that the potential energy in raw wastewater exceeds the energy requirements of the treatment facility and with appropriate energy recovery technology, municipal wastewater treatment plants may become net producers of renewable energy.
Water and Wastewater Industry Energy Efficiency: A Research Roadmap	Edward Means, III	AWWA	1/1/2004	http://www.energy.ca.gov/2004publications/CEC-500-2004-901/CEC-500-2004-901.PDF	E-W	Energy efficiency; water/wastewater agencies;	A list of research projects by priority is listed in appendix A.
Energy Down the Drain -- The Hidden Costs of California's Water Supply	Ronnie Cohen; Barry Nelson; Gary Wolff	NRDC	8/1/2004	http://www.nrdc.org/water/conservation/edrain/edrain.pdf	E-W	Cost of energy use in western water systems; connections between water and energy; San Diego County; energy and urban water; Westlands Water District; energy and agricultural water; Columbia River Basin; energy and hydropower	• Water conservation lowers energy use and energy bills. • Water recycling is a highly energy efficient water source. • Retiring agricultural land may increase energy use if the water is transferred to other agricultural or urban uses. • Retiring agricultural land can save energy if the water is dedicated to the environment. • Diverting water above dams costs power and money. • Urban conservation is important. Water reuse is far less energy intensive than any physical source of water other than local surface water. • Energy use varies widely in Ag settings - not possible to generalize. Decision makers should better integrate energy issues into water policy decision making. • Water conservation should be given higher priority by policy planners in both water and energy sectors. Federal level planning: perform energy intensity analysis, produce a power balance, change energy use reporting requirements, include energy in NEPA (National Environmental Policy Act) evaluation. State level: revise the urban water management planning act, include energy intensity, integrate energy costs into economic analysis of water management alternatives, coordinate among resource management agencies. Local/Regional: modify the MOU, investigate energy implications of dry-year strategies, include energy in integrated resource planning, reduce energy and environmental impacts of desalination. Please see document for further recommendations about water conservation, land fallowing and water transfers, and areas of research.

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Pacific Institute Water to Air Models	Gary Wolff, Ph.D.; Sanjay Gaur; Maggie Winslow, Ph.D.	Pacific Institute	10/1/2004	http://www.pacinst.org/resources/water_to_air_models/index.htm	E-W	Quantify energy impacts, air quality impacts; water decision-making; energy intensive options; conservation; use-efficiency; urban model; agricultural model; water/energy/air quality nexus; energy use, energy intensity, air emissions	Spreadsheet models and user manual
Evaluating the costs of desalination and water transport	Yuan Zhou; Richard S. J. Tol	Water Resources Research	1/1/2005	http://www.fnu.zmaw.de/fileadmin/fnu-files/models-data/wrrdesalt.pdf	E-W	Desalination technology; water transport; development of desalination and its costs over time	• The unit costs of desalinated water for five main processes are evaluated, followed by regressions to analyze the main influencing factors to the costs. • The unit costs for all processes have fallen considerably over the years. This study suggests that a cost of $1/m^3 for seawater desalination and $0.6/m^3 for brackish water would be feasible today. The costs will continue to decline in the future as technology progresses. • Transport costs range from a few cents per cubic meter to over a dollar. • A 100 m vertical lift is about as costly as a 100 km horizontal transport ($0.05–0.06/m^3). • Transport makes desalinated water prohibitively expensive in highlands and continental interiors but not elsewhere.
Optimal aeration control of industrial alternating activated sludge plants	B. Chachuata,1, N. Rocheb,∗, M.A. Latifia	Laboratoire en Proc´ed´es Propres et Environnement	1/5/2005	http://www.researchgate.net/publication/223498177_Optimal_aeration_control_of_industrial_alternating_activated_sludge_plants	E-W	Wastewater treatment; alternating activated sludge process; dynamic modeling; aeration control; optimization	• Optimal aeration strategies can be calculated for an industrial alternating activated sludge treatment plant in order to improve its efficiency and reliability • ASM1 (Activated Sludge Model 1) model is used to describe the transient behavior of the plant, with a set of parameters being estimated from input/output experimental data in order to optimize a realistic system. • Two different optimization problems are considered. The first one addresses the minimization of the nitrogen concentration in the treated effluent; the second one consists in determining the aeration strategy that minimizes the energy consumption of the treatment plant (in terms of aeration time) while satisfying specified effluent standards. Either problems are formulated over a long time optimization horizon in order to guarantee that the improvements can be maintained in the long term. These problems are then solved by applying a systematic optimization procedure based on a gradient-based method.
California's Water Energy Relationship: Improving the Efficiency of California's Water and Energy Systems		CEC, Ca	3/28/2006	http://www.energy.ca.gov/process/water/2006-03-28_symposium/WHITE_CEC.PDF	BOTH	Water energy relationship; California; assesment of major energy trends and issues	• Examine cost, infrastructure, regulatory expenses, resource quality • Coordinate Utilities' Programs • Address regulatory issues such as system constraints and self-generation impediments • Better data/information is necessary
Desalination, With a Grain of Salt: A California Perspective	Heather Cooley, Peter H. Gleick, and Gary Wolff	Pacific Institute	6/1/2006	http://www.pacinst.org/reports/desalination/desalination_report.pdf	E-W	Comprehensive overview; history, benefits, and risks of ocean desalination; barriers; development in California	• The cost of desalination has fallen in recent years, but it remains an expensive water-supply option. • Desalination costs are influenced by many factors, making comparisons difficult and estimates uncertain; assumptions that desalination costs will continue to fall may be false. • More energy is required to produce water from desalination than from any other water-supply or demand-management option in California. The future cost of desalinated water will be more sensitive to changes in energy prices than will other sources of water. • Public subsidies for desalination plants are inappropriate unless explicit public benefits are guaranteed. • More research is needed to fill gaps in our understanding, but the technological state of desalination is sufficiently mature and commercial to require the private sector to bear most additional research costs. • Desalination plants offer both system-reliability and water-quality advantages, but other options may provide these advantages at lower cost. Cost-effective conservation and efficiency improvements are still possible. • Desalination can produce high-quality water but may also introduce biological or chemical contaminants into our water supply. • Desalination can produce water that is corrosive and damaging to water distribution systems. • Desalination produces highly concentrated salt brines that may also contain other chemical pollutants. Safe disposal of this effluent is a challenge. • Impingement and entrainment of marine organisms are among the most significant environmental threats associated with seawater desalination. • Subsurface and beach intake wells may mitigate some of the environmental impacts of open ocean intakes. The advantages and disadvantages of subsurface and beach intake wells are site-specific. • Desalination may reduce the need to take additional water from the environment and, in some cases, offers the opportunity to return water to the environment. • Desalination offers both advantages and disadvantages in the face of climatic extremes and human-induced climate changes. Desalination facilities may help reduce the dependence of local water agencies on climate-sensitive sources of supply. • Extensive development of desalination can lead to greater dependence on fossil fuels, an increase in greenhouse gas emissions, and a worsening of climate change.

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Emerging Technologies for Biosolids Management		EPA	9/1/2006	http://water.epa.gov/scitech/wastetech/upload/2007_04_24_mtb_epa-biosolids.pdf	E-W	Emerging biosolids management technologies; embryonic; innovative; established; state of development; cost; research needs	• Information on emerging biosolids management technology: objective, description, state of development, available cost information, associated contact names, related data sources. • This document further evaluates with respect to various criteria • Does not rank or recommend any one technology over another. • Research needs identified for each technology to help guide development of innovative and embryonic technologies and improve established ones.
Energy Baseline Study For Municipal Wastewater Treatment Plants	BASE Energy, Inc.	Pacific Gas & Electric Company New Construction Energy Efficiency Program	9/1/2006	http://www.rivernetwork.org/resource-library/municipal-wastewater-treatment-plant-energy-baseline-study	E-W	Wastewater treatment; Optimization; energy savings, energy efficiency	Developed a summary of evergy saving measures presented in a table format. This is viewable in the document
Energy Demands on Water Resources: Report to Congress	John A. Merson	Sandia	12/1/2006	http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf	W-E	Energy and water; supply energy; water quality; energy generation; water shortages; impacts on energy infrastructure; water management challenges; impact of future power generation on water supplies; opportunities to secure America's energy and water future; addressing critical energy-water challenges	• Expansion of cooperation with the Federal agencies could improve the country's ability to address issues related to the development, utilization and management of the critical resources of water and energy • Difficulty in predicting the future electrical generation supply and water demand - there are a lot of variables. • It is possible that major changes in electric generation, transmission and distribution approaches will need to be supported in different regions of the country to address water availability and value issues.
Refining Estimates of Water Related Energy Use in California	Richard Sapudar, Pramod Kulkarni, Nancy Jenkins, Martha Krebs, B.B. Blevins	CEC/Navigant Consultants	12/1/2006	http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF	E-W	Estimating the energy used on water for transport, filtration, heating, etc.; energy efficiency	• Indoor water is much higher energy than outdoor • Agriculture and Urban end use is approximately 50% of water related energy Other energy is consumed by operators • Supply and conveyance have both the highest water related energy and the highest variability. • Water energy magnitude is not the sole determination of energy saving potential. • Recommendations: Prioritize R&D. Drill down sub segments of the water use cycle to effectively target areas for R&D. Target supply and conveyance. Address data gaps. Use a phased approach.
Water & Wastewater Industry Energy Best Practice Guidebook	Science Applications International Corporation (SAIC)	Focus on Energy	12/1/2006	http://watercenter.montana.edu/training/savingwater/mod2/downloads/pdf/SAIC_Energy_Best_Practice_Guidebook.pdf	E-W	Water; wastewater; best practices; guidebook; implementation; energy savings; energy efficiency	Step 1) Establish a Baseline Energy Use Step 2) Estimate Energy Use for Major Systems Step 3) Identify Best Practice Opportunities Step 4) Quantify Savings and Project Costs of Best Practice Opportunities Step 5) Prioritize Projects Step 6) Project Management
Water-energy futures for Melbourne: the effect of water strategies, water use and urban form	Kenway, Turner, Cook, Baynes	CSIRO	1/1/2007	http://www.csiro.au/resources/~/media/CSIROau/Flagships/Water%20for%20a%20Healthy%20Country%20Flagship/WaterEnergyFuturesMelbourneFactsheet_WfHC_PDF%20Standard.pdf	E-W	Urban water; energy; Australia; Melbourne; utility; residential; urban system; urban metabolism; future scenarios; urban form; virtual water	• Simultaneous spatial/temporal modeling of water, energy, urban form, water strategies, residential water management options. • By 2045 a compact urban form over a sprawling Melbourne could reduce growth in residential water consumption by approx 100 GL/yr, primarily through reduced outdoor water use. • Compared to "business as usual", water demand management strategies could directly save 45 GL/yr of water. • Using solar hot water systems (HWS) could indirectly offset additional 10 GL/yr due to reduced water demand for electricity generation. • Using increased solar hot water systems, (80% on new dwellings, 20% of existing) could save 0.14 PJ/yr in water system. Could save around 30 PJ/yr through reduced residential energy use. • Compared to conventional water supply services, desalination increases energy consumption for water services by approximately 3 PJ/yr which leads to tripling of current energy use for water service provision. This increase marginal in context of anticipated growth in Melbourne's residential/total urban energy use (approx 200, 2000 PJ/yr respectively).
Proposed Water-Energy Conservation Activities at PG&E	Gerry Hamilton	PG&E	1/17/2007		E-W	Water-energy activities; water-embedded energy research; energy savings; pilot program; water utilities; data on water and energy used/saved for distribution and fresh- and waste-water treatment; measured water savings; water conserving high energy efficiency measures; Low Income Energy Efficiency Program	• Water-Embedded Energy research: CPUC Workshop, Comments and Replies on water-embedded issues, exploring opportunities and issues; Pilot Program examining water conservation, ways to use less energy intensive water, improve water distribution and treatment systems • Critical issues: Can Electric IOUs and Water agencies effectively partner? Can the water-embedded energy savings be measured? • Pilot proposal: Partner with EBMUD, Sonoma County Water District, Santa Clara Valley Water District; Seek a variety of commercial, institutional, and industrial sites with Significant water savings potential, Supply configuration able to measure changes in water usage (both inflows and outflows), Sites could include Schools, Food Processing, Food Service, Laundries, Manufacturing, Health Services, and Low Income Institutions or other suitable facilities; Obtain extensive data on water and energy used/saved for distribution and fresh- and waste-water treatment; Work with water agencies and the CPUC to develop satisfactory methods for measuring saved water-embedded energy • Low Income Energy Efficiency Program Opportunities: Low Flow Showerheads, Faucet Aerators, Leaky Water Heater Repair/Replacement

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Supply and Demand Side Water-Energy Efficiency Opportunities Final Report		GBs on behalf of PG&E - 2007	2/1/2007	ftp://ftp.cpuc.ca.gov/PUC/energy/electric/energy+efficiency/pgewaterenergyfinalreport21607.pdf	E-W	Embedded energy; delivery; wastewater treatment; multiple water uses within PG&E's service territory; energy use estimates; supply and conveyance; water treatment; water distribution; wastewater collection; wastewater treatment; wastewater discharge; recycled water distribution; uses of treated wastewater and recycled water; desalination and marginal water supplies; agriculture water use; urban water use; estimates of demand side water savings; water availability	• Calculated embodied energy estimate. • The energy savings potential from various programs being implemented.
Overview of Energy-Water Interdependancies and the Emerging Energy Demands on Water Resources	Ron Pate, Mike Hightower, Chris Cameron, Wayne Einfeld	Sandia	3/1/2007	http://www.circleofblue.org/waternews/wp-content/uploads/2010/09/SANDIA-research-needs2007-1349C_revised.pdf	BOTH	Interdependencies of energy and water; emerging energy demands on water resources; Energy-Water Report to Congress; major challenges; research directions; Energy-Water Roadmap process	Trends in energy use, water availability, and water demand suggest that the U.S. is at a critical crossroads in the development, utilization, and management of the critical resources of water and energy. Increasing population will increase demand for water for direct use, as well as water for energy and agriculture. Withdrawals for domestic water supply are growing at about the same rate as the population. If new power plants continue to be built with evaporative cooling, consumption of water for electrical energy production could more than double by 2030, and consumption by the electric sector alone could equal 1995's domestic water consumption by the entire country. Consumption of water for extraction and production of transportation fuels from domestic sources also could grow substantially. Meanwhile, climate concerns and declines in groundwater levels suggest that less freshwater, not more, may be available in the future. A more proactive approach to energy and water development and management should be considered. Although new technologies can reduce water use, these technologies cost more and will not be deployed overnight. Given the above constraints, it may not be possible in many areas of the country to meet the country's growing energy and water needs by following the current U.S. path of largely managing water and energy separately while making small improvements in freshwater supply and small changes in energy and water-use efficiency.
In Hot Water: Water Management Strategies to weather the effects of Global Warming	Barry Nelson, Monty Schmitt, Ronnie Cohen, Noushin Ketabi, Robert C. Wilinson	NRDC	7/1/2007	http://www.nrdc.org/globalwarming/hotwater/hotwater.pdf	E-W	Water management; climate change; overview of major scientific findings on climate change; affects to western water supply and management; water and energy connection; strategies, prevention and outreach	• Climate change will affect water management. Immediate and sustained action can reduce future impacts. Water managers are taking action on climate issues. • Recommendations: Provide vulnerability analysis - local analyses, regional impact, state and fed evaluations. • Guiding principles: strengthen institutional capacity, maximize flexibility, increase resilience, implement 'no regrets' strategies, address multiple stresses, invest in interagency relationships, incorporate climate change into ongoing project design, expand dialogue in the scientific community. Restore and protect aquatic ecosystems. Implement water management tools that are effective in the context of climate change - with conservation as the first tool. Incorporate climate and energy issues in water planning. Collaborate with energy utilities. Integrate regional water management. There are other and more detailed recommendations in the document as well
Anammox brings WWTP closer to energy autarky due to increased biogas production and reduced aeration energy for N-removal	Hansruedi Siegrist, David Salzgeber, Jack Eugster, Adriano Joss	Proceedings of the 11th World Congress on Anaerobic Digestion	9/1/2007	http://www.ncbi.nlm.nih.gov/pubmed/18309216	E-W	Nitritation, anammox, anaerobic digestion, primary clarifier, biogas production	• Sludge liquid treatment with the single stage nitritation/anammox process has been shown as a stable process allowing reducing denitrification capacity in biological main treatment by about 25% without reducing overall nitrogen removal (70-80%). This allows increasing HRT of the primary settler, introducing a partial pre-precipitation and therefore to increase primary sludge and biogas production by about 25%. As a consequence overall electrical consumption is reduced by more than 50% bringing the municipal nutrient removal plant a step closer to energy autarky.
Energy self-sufficiency as a feasible concept for wastewater treatment systems	B. Wett; K. Buchauer; C. Fimml	Asian Water	9/1/2007	http://www.araconsult.at/download/literature/let07_wett_energy_selfsufficiency3.pdf	E-W	Wastewater treatment systems; anaerobic digestion provides onsite renewable energy source; medium and large scale plants; energy efficiency; biological nitrogen removal (BNR); anaerobic sludge stabilization; energy consumption; potential savings	• Wastewater treatment facilities will increasingly claim their role as resources recovery plants instead of nutrient removal systems – recovery not only in terms of water and nutrients but also of energy. • The presented experiences from Central Europe point towards large energy saving potentials of typically 30- 50%, which are just gradually being exploited nowadays. • What is feasible to reach in large-scale municipal WWTPs is underlined by the case study Strass, which already reached a positive energy balance without any relevant cosubstrates.
Energy Benchmark for Wastewater Treatment Processes - a comparison between Sweden and Austria	Malin Jonasson	Lund University	9/10/2007	http://www.iea.lth.se/publications/MS-Theses/Full%20document/5247_full_document.pdf	E-W	Benchmark; wastewater treatment plant; biogas; electrical and thermal energy	• Benchmarking encourages competition between WWTPs and repeated energy benchmarks have decreased energy consumption by the will of improvements. • Wastewater characteristics also play a main role in the energy consumption. • Swedish plants have a higher influent wastewater flow. • Austria has less diluted wastewater with higher concentration of influent organic matter, which provides better conditions for energy efficiency in the wastewater treatment processes. • The results from the energy benchmark study shows that Swedish WWTPs uses approximately 45 % more electricity compared to Austrian WWTPs. Hence, potential for energy savings in Swedish WWTPs is high.

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Climate Change & Greenhouse Gas Emissions	Roy Martinez	AWWARF	11/6/2007		E-W	Hydrologic impacts of climate change; impacts to drinking water utilities; climate change research	• Research to Support Adaptation Strategies: Incorporating Climate Change Information in Water Utility Planning: A Collaborative, Decision Analytic Approach" (Project #3132); "Dynamic Decision Support System (D2S2) for Water Supply Planning in the Lower East Coast of Florida" (Project #4074); "Evaluating Effects of Climate Change on Planning Criteria & Design Standards" (Project #4154) • Research to Support Reduction of GHGs: "Greenhouse Gas Emission Inventory Guidance, Specialty Protocol Development, and Management Strategies for Water Utilities" (Project #4156) • EPA Climate Leaders Program: A voluntary EPA partnership with U.S. companies to develop long-term, comprehensive climate change strategies • Leak Management: Automated Meter Reading – Best Practices for Selection, Acquisition and Implementation #4000; Synthesis Document on Pipe Location and Leakage Management #4144; Evaluating Water Loss and Planning Loss Reduction Strategies #2811; Leakage Management Technologies #2928; Continuous System Leak Monitoring – From Start To Repair #3183 • Conservation: Water Efficiency Programs for Integrated Water Management #2935; Integrated Urban Water Management Approaches #4008; Water Conservation: Customer Behavior and Effective Communication #4012; Changes in Water Use Patterns #4031; Socioeconomic Impacts of Water Conservation #497; Residential, Commercial, and Institutional End Uses of Water #241 • Energy Focus – completed: Energy and Water Quality Management System (1997); A Total Energy and Water Quality Management System (1999); Implementing a Prototype Energy and Water Quality Management System (2003, publication #90948F); Optimizing Operations at JEA's Water System (2005, publication #91079) • Energy Projects – Ongoing: Assessing Risks and Benefits of Drinking Water Utility Energy Management Practices #3058; Development of a Utility Energy Index to Assist in Benchmarking of Energy Management for Water and Waste Water Utilities #3009; Evaluation of the Dynamic Energy Consumption of Advanced Water and Wastewater Treatment Technologies #3056; Water Consumption Forecasting to Improve Energy Efficiency of Pumping Operations #3066; Decision Support Systems for Sustainable Energy Management #4090
Implications of Climate Change for Urban Water Utilities	John E. Cromwell, Joel B. Smith, and Robert S. Raucher, PhD	Association of Metropolitan Water Agencies	12/1/2007	http://www.amwa.net/galleries/climate-change/AMWA_Climate_Change_Paper_12.13.07.pdf	E-W	Climate change; water agencies; metropolitan; GHG reductions	The relevant responses to climate change are already being adopted by many water utilities. These include: 1) vulnerability analysis to identify near-term priorities for adaptation of capital and operating plans; 2) IRP to provide a comprehensive framework within which to further study the change processes and devise a broad array of adaptive measures that can sustain water supplies despite ongoing environmental changes; and 3) GHG reductions to help mitigate the global warming process.
Energy use in the provision and consumption of water	Kenway, Priestley, Cook, Inman, Gregory	CSIRO and WSAA	1/1/2008	http://csiro.au/~/Media/CSIROau/Flagships/Water%20for%20a%20Healthy%20Country%20Flagship/WaterEnergyReportAustraliaNewZealand_WfHC_Publication%20Standard.pdf	E-W	Urban water; energy; Australia; New Zealand; utility; residential; urban system; urban metabolism; future scenarios	• Total energy use by water utilities in major Australian cities 2006/07 was 7.1 petajoules (PJ) and met the needs of 12.5 million people. • Average of 590 megajoules per person per year [MJ/(cap*a)]). This figure is approximately 0.2% of total urban energy use and less than 15% of the energy used for residential water heating – modeled as at least 46 PJ for 2006/07. • Imported electricity, represented 76% of energy used by water utilities. F • or the scenarios analysed, the amount of energy required to deliver water services in 2030 ranges from 7 to 36 PJ/a representing growth of 0 to 29 PJ from 2006/07 levels.
Benchmarking of Large Municipal Wastewater Treatment Plants Greater Than 100,000 PE in Austria	Stefan Lindtner, Heidemarie Schaar, Helmut Kroiss	WEFTEC	1/1/2008		E-W	Benchmarking, best practice, wastewater treatment, performance indicators, cost efficiency optimization, full scale results	• The Austrian benchmarking system was developed during a six-year period starting in 1999. Since 2004 it has been operated via an internet platform and more than hundred wastewater treatment plants have been investigated. • The objectives of the Austrian benchmarking system are the development of performance indicators and the identification of best performance and cost reduction potentials. • Real costs are linked to four defined main processes and two support processes. For each process the operating costs are attributed to six cost elements. • The paper shows the benchmarking results of six Austrian plants with a design capacity > 100,000 PE representing approximately 30 % of the Austrian municipal wastewater treatment plant capacity. • The total yearly costs of the benchmark are 23.2 €/PE110. • For large waste water treatment plants continuous benchmarking represents a powerful management tool. • Comparison with the benchmarks and information exchange amongst the treatment plant managers makes it possible to increase cost-efficiency relation. However, benchmarking is not only a tool to enhance cost-efficiency, but offers the opportunity to prove excellent performance of treatment plant operation.

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Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities	Jim Horne	US EPA & Global Environment and Technology Foundation	1/1/2008	http://www.epa.gov/owm/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf	E-W	Guidebook; energy management; wastewater and water utilities; Plan-Do-Check-Act management system; energy efficiency; renewable opportunities	The steps outlined in the Guidebook are replicable and based on a Plan-Do-Check-Act process that will assist you in: 1. Benchmarking and tracking monthly and annual energy use; 2. Identifying and prioritizing energy operations and issues that can increase efficiency; 3. Identifying energy efficiency objectives and targets; 4. Defining the performance indicator(s) to use to measure progress towards your energy targets; 5. Establishing energy management programs (i.e., action plans to meet your goals); 6. Monitoring and measuring the performance of your established target(s); 7. Documenting and communicating success; and 8. Reviewing your progress periodically and making adjustments as necessary.
Framework of a Sustainable Energy Master Plan for the Bergen County Utilities Authority Little Ferry WPCF	Luis M. Tavares, PE, CEM, CBCP, CGBP, LEED; Richard M. Cestone, PE, CHMM; Robert M. Gerard, CHMM	WEFTEC	1/1/2008		BOTH	Bergen County Utilities Authority (BCUA); Sustainable Energy Master Plan (SEMP); energy; environment; biogas; digester gas	• Based on a the energy data collected from 12 consecutive months of billing in 2006, the BCUA Water Pollution Control Facilities (WPCF) operation used seven (7) sources of energy: electricity, natural gas, digester gas (biogas), fuel heating oil, kerosene, gasoline and diesel. • The WPCF consumes approximately 29 mKw-hrs of electricity per year and more than 144,508 gJ (1,370,000 therms) of natural gas per year. Electricity is the largest operating cost for the facilities at almost $2.75 million with natural gas second at almost $1.5 million annually. • The WPCF produced 11.09 mill m^3 (391.7 mill ft^3) in 2006 of biogas from its digester process. • Estimated cost avoidance from using biogas instead of purchasing natural gas and/or fuel oil was $685,000.00. • The estimated total gas required for the new cogeneration system is 11.3 million cubic meters (400.2 mill ft^3). • The cogeneration unit will require an additional 0.6 mill m^3 (21.1 mill ft^3) of natural gas in order to operate all year round at full loading. • The estimated electric generation for the cogeneration unit system should account for approximately 85 percent of the electricity energy usage at the WPCF. The remaining 10 to15 percent electricity energy usage and demand side management could be supplemented by renewable energy resources such as Solar PV and Wind Power (PMK has completed a wind and solar energy study). • PMK has recommended to the BCUA to investigate innovative technologies such as; thermal hydrolysis, mechanical abrasion and fluid Sonics in order to improve digester performance and increase biogas production.
Desalination: A National Perspective		Committee on Advancing Desalination Technology, National Research Council	1/1/2008	http://www.nap.edu/catalog.php?record_id=12184#description	E-W	Desalination; technologies; cost; implementation challenges; long-term goals; action; research; estimates funding necessary; roles for governmental and nongovernmental entities	(For fee research paper) • Two overarching long-term goals for further research in desalination: (1) Understand environmental impacts of desalination, develop approaches to minimize these impacts relative to other water supply alternatives, and (2) Develop approaches to lower financial costs of desalination so that it is an attractive option relative to other alternatives in locations where traditional sources of water are inadequate. • Understanding potential environmental impacts of desalination in both inland and coastal communities and developing approaches to mitigate these impacts relative to other alternatives are essential to the future of desalination in the United States. • The environmental impacts of both source water intakes and concentrate discharge remain poorly understood. • The uncertainty about potential site-specific impacts and their mitigation are large barriers to the application of coastal desalination in the United States (stakeholder disagreements, lengthy/costly planning and permitting process) • Uncertainties remain about the sustainability of brackish groundwater resources and the environmental impacts from concentrate discharge to surface waters. • Without rigorous scientific research to identify specific potential environmental impacts (or a lack of impacts), planners cannot assess the feasibility of desalination at a site or determine what additional mitigation steps are needed.
City of Thousand Oaks Uses Innovative Power Purchase Agreements for Renewable Energy at its Hill Canyon Wastewater Treatment Plant	Chuck Rogers; Mark D.Wakins,	City of Thousand Oaks	1/1/2008	http://www.ingentaconnect.com/content/wef/wefproc/2008/00002008/00000011/art00003	E-W	Power Purchase Agreements	(For fee research paper: key findings/recommendations not available) • Both solar and cogeneration opportunities were identified and acted upon. Neither cost the City a cent in capital costs because of innovative power purchase agreements where both systems were owned and operated by private parties. • Initially, the City saved 30,000 in energy costs the first year and is anticipating savings of 100,000 the second year. • This model of generating onsite renewable energy without capital outlay has been widely copied by other water and wastewater agencies throughout California and could easily be adapted elsewhere.

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Water and Energy: Leveraging Voluntary Programs to Save Both Water and Energy		EPA	3/1/2008	http://water.epa.gov/scitech/wastetech/upload/Final-Report-Mar-2008.pdf	E-W	Co-benefits of energy and water efficiency programs; current and future opportunities; ENERGY STAR; WaterSense; water use in the United States; water savings	Given the inter-related nature of water and energy resources, increased attention is warranted for improving the efficiency of both resources simultaneously. Energy- and water-efficiency initiatives and the ENERGY STAR and WaterSense programs in particular, provide an opportunity for implementing some promising strategies. Both the ENERGY STAR and WaterSense programs have existing program infrastructures and methods for reaching decision makers involved in both water and energy. Some of Energy STAR's program tools and concepts, such as Portfolio Manager and Home Performance, can be extended to encompass water efficiency opportunities. Likewise, the water savings realized through WaterSense's product labeling efforts and its new home initiatives have inherent energy savings that can be emphasized along with the water savings. Cooperative efforts between ENERGY STAR and WaterSense and all the various institutions involved in energy and water efficiency should be explored as a cost effective option for 7-32 achieving resource efficiency. These entities should work together to promote and create a resource efficiency ethic across the nation.
Independence Energy Report (Final)	Kennedy/Jenks Consultants	ACWA	3/7/2008	http://www.kennedyjenks.com/pdf/EIP_Report_KennedyJenks.pdf	E-W	Domestic wastewater treatment plants; energy independent; optimizing plant energy efficiency; renewable resource; energy independence; digester gas; energy efficiency measures; operational impacts; environmental impacts	•Report weighs the costs and benefits of various renewable energy options at many of the major wastewater treatment plants in Oregon. •Individual suggestions based on the specific needs of each plant •Overall recommendations on how feasible/cost effective it would be to make Oregon's Wastewater plants energy independent, and how to go about that
State-of-the-Science Energy and Resource Recovery from Sludge	Hugh D. Monteith	WERF	3/24/2008	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO3R07	E-W	Resource recovery; energy strategies; recovered products	(For fee research paper) • With large number of technologies available, technically feasible to recover energy/building materials from sludge. It is well established that resource like phosphorus (P) can be recovered w/efficiency of 60-70%, possibly higher. Although full-scale P recovery is technically feasible option, operating practices in early stages because most of the technologies still in development. • To be attractive, technologies for energy/resource recovery must be affordable/cost- effective, but currently not always the case. Some projects failed because of high capital/O&M costs (i.e. phosphorus recovery, building material production processes) • Social acceptance of technology depends on inputs/outputs. • Chemical use may be required in certain processes, but may not be best option in terms of health protection, life cycle impacts (energy use/emissions during production/transportation). • Technologies w/high potential for pollutant emissions, either upstream or onsite, will have less public acceptance. • Technologies involving several process units generally viewed as less desirable complex processes, which require material/energy for production, greater land consumption, higher capital/O&M costs. • Cursory TBL assessment could not evaluate all technologies in depth, should therefore be used as general guide rather than as definitive review. • Four market drivers: (1) sustainability/environmental concerns (i.e. threat of soil pollution, global warming, resource depletion); (2) rising energy costs, the need of more electricity/heat to operate plants; (3) requirements for high quality of resources for industrial applications (i.e. calcium phosphate for phosphate industry); (4) regulation as factor stimulating development of new technologies • Sweden/Japan are probably most advanced countries. Many other countries, including Netherlands, U.S, U.K, Germany, New Zealand, China, Malaysia, have been implementing energy/resource recovery from sludge for many years.
Economic Efficiency of Water Use and Allocation in California - A Scoping Level Analysis DRAFT	Roger Mann, Ph.D.; RMecon	For Delta Vision Process	6/1/2008	http://deltavision.ca.gov/BlueRibbonTaskForce/June2008/Economic_Efficiency.pdf	E-W	Economic efficiency and water allocation; water pricing; water use programs; water transfer; water supply and conveyance development; water rights enforcement.	• Some surface water use maybe economically inefficient b/c water cannot be transferred. • Groundwater use laws lead to inefficient use and unsustainable overdraft in some groundwater basins. • Potential for expanded volumetric pricing for ag water is limited by the accuracy of existing measurement. • May be inefficiencies in fed, state and private water pricing because the price charged for energy required to pump and convey the water is less than market rates. • For water supplies the main purpose of water pricing is cost recovery and not economic efficiency. • For water use efficiency analysis from the California perspective - water should be valued based on op costs of energy, not necessarily the price paid for water. • More information is needed regarding the reasons why urban users do not adopt conservation tech that appear to be efficient. • For water rights - legislation is needed to establish an ability to conduct voluntary water transfers from land irrigated under riparian rights. • All state grants for water use efficiency or supply development should require a finding of economic efficiency from the state perspective. • There are more - please see document.

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Reducing Electricity Used for Water Production: Questions State Commission Should Ask Regulated Utilities	David Denig-Chakroff	NRRI	6/30/2008		E-W	Regulated utilities; public utlity commission; water utility; water used for pumping; regulation	Utilities should conduct comprehensive energy audits; regulatory commissions can induce action by establishing standards, evaluating energy adjustment clauses, promoting energy saving projects, increasing economies of scale, and requiring energy audits.
More With Less: Agricultural Water Conservation and Efficiency in California	Heather Cooley, Juliet Christian-Smith, Peter H. Gleick	Pacific Institute	9/1/2008	http://www.pacinst.org/reports/more_with_less_delta/more_with_less.pdf	E-W	Agricultural water-use efficiency; cost-effective technologies and management practices; implementing feasible policy; agricultural sector in California; reducing pressures on the Delta; reducing water use; quantity of water in storage; reduce risk of drought; reliability of available water; water conservation; water efficiency; improvements	Our analysis concludes that: • All four agricultural efficiency scenarios show substantial potential water savings, ranging from 0.6 to 3.4 million acre-feet. -These savings can be achieved without adversely affecting the economic productivity of the agricultural sector. -Improvements in efficiency are just as effective as, and can be far less expensive than, new, centralized water storage and infrastructure, even if such new infrastructure could be sited, funded, approved, and built. -These efficiency improvements can reduce the size and cost of any infrastructure that may subsequently have to be built. Recommendations: • Actions are needed to both ensure a sustainable agricultural sector and to reduce the water required for it. • Water conservation and efficiency improvements can reduce water use and improve water quality while maintaining or increasing crop yield. Smart policies can reduce this barrier. • Agricultural commodity-support programs should be refocused on the potential to save water. • Eliminate Federal and State programs that encourage inefficient use. • More aggressive efforts are needed to apply the constitutionally mandated concepts of reasonable and beneficial use in ways that encourage improvements in water-use efficiency. • Many proven technologies and practices can improve water-use efficiency. Strengthen and expand efforts to promote the use of these technologies and practices. • Efforts should be implemented immediately to improve our understanding of actual water use in the agricultural sector. • Education and technical assistance programs are important to encourage the widespread adoption of these technologies. Existing programs should be expanded and new ones implemented.
California's Water: An LAO Primer	Catherine B. Freeman; Mark C. Newton	LAO	10/1/2008	http://www.lao.ca.gov/2008/rsrc/water_primer/water_primer_102208.pdf	E-W	California's water governance; water supply, source and delivery; demand and use of water; financing water projects; cost drivers for water and legislative concerns	Primer document - therefore no key findings more just explanations about CA water supply.
Energy implications of bottled water	Peter H. Gleick; Heather S. Cooley	Pacific Institute	11/18/2008	http://iopscience.iop.org/1748-9326/4/1/014009/pdf/erl9_1_014009.pdf	E-W	Bottled water; energy	• For water transported short distances, the energy requirements of bottled water are dominated by the energy to produce the plastic bottles. • Long-distance transport can lead to energy costs comparable to, or even larger than, the energy to produce the bottle. • Far less energy is needed for processing and treating the water, and cooling bottles for retail sale. • Transportation costs are highly variable, ranging from 1.4 MJ for water produced within 200 km of the consumer market to 5.8 MJ for water produced in France and sold in Los Angeles. • Combining all of the energy inputs totals, producing bottled water requires between 5.6 and 10.2MJ/l—as much as 2000 times the energy cost of producing tap water. • Given an annual consumption of 33 billion liters of bottled water in the US, the annual consumption of bottled water in the US in 2007 required an energy input equivalent to between 32 and 54 million barrels of oil or a third of a percent of total US primary energy consumption. Roughly three times this amount was required to satisfy global bottled water demand.
Water Resources Research Center Annual Technical Report FY 2009		USGS	1/1/2009	http://water.usgs.gov/wrri/AnnualReports/2009/FY2009_HI_Annual_Report.pdf	BOTH	Several technical reports from Water Resources Research Centers describing E-W/W-E research projects occuring at the Water Resources Research Center University of Hawai'i at Manoa	Several technical reports from Water Resources Research Centers describing E-W/W-E research projects occuring at the Water Resources Research Center University of Hawai'i at Manoa
Embodied Energy in the Water Cycle	Michael Wilson, P.E.	WEFTEC	1/1/2009		E-W	Embodied energy, wastewater, product, reclamation, water cycle, carbon footprint, value chain, sustainable principles, greenhouse gases	• The value of reclaimed water includes the embodied energy that is reclaimed from the water cycle. • When embodied energy in reclaimed water is accounted for over a 50 year life cycle term, at 12 cents per kilowatt-hour and not including interest it has a value between $8.5 to $14.8 million dollars per million gallons. • The capital cost and operating cost for the reclaimed water infrastructure is a minimal cost when compared with the overwhelming operational energy recovery savings. • If you want to truly be sustainable wastewater reclamation is the cornerstone that provides the greatest environmental benefit. • Water conservation, while an important component of a sustainable water resources management plan does not provide the same value chain impact in terms of reducing the carbon footprint and does not reclaim the energy already embodied in the water product.

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Energy Savings Through Pump Refurbishment and Coating	Paul Maier; Christian King	NYSERDA	1/1/2009	http://www.ingentaconnect.com/content/wef/wefproc/2009/00002009/00000008/art00050	E-W	Pump; refurbishment; energy savings; coating; flow rate; hydraulic pressure; pump efficiency	• Correlations explored between efficiency gains and pump size, pump specific speed, rpm, and pump horsepower to determine if pump coating and refurbishment is more effective on certain types of pump applications. • qualitatively assess the original roughness of each pump surface prior to sandblasting so that a correlation between initial roughness and efficiency gain can be explored. • Roughness documented with photographs and measurements of tubercule/corrosion height will be made. • The effect of efficiency improvement on the operating point of the pump examined, with a look at how increasing corrosion and roughness may effect the operating point, as well as efficiency, over time. • The cost/benefit of pump coating examined with reference to coating material costs vs. electric bill savings. • Helpful graphs developed to assist decision makers in calculating energy savings based on pump run time, horsepower and efficiency improvements. • A sample energy savings calculation presented.
EPA's role in promoting Water Efficiency	Mary Ann Dickinson	AWE	3/31/2009	http://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=1000&context=water_pubs	E-W	WaterSense funding; setting requirements for water efficiency project funding w/ state revolving fund programs; comprehensive water efficiency research programs re: appropriate standards, specs and measures for future savings.	Research needs: • Indoor plumbing produce and appliance performance testing and savings measurement • Outdoor water use management and improved landscape irrigation efficiency, integrative research on selected topics (i.e water and energy connection on a national basis, state & reg models, ...) • Opportunities for innovation in green building. Recommendations: • Create a roadmap for labeling in the non-residential sector. • Develop outreach and implementation through new business sectors. • Certify plumbers to get more traction for watersense labeling. Enact parallel activities in other sectors (ie medical equipment, hospitality). • Rep watersense on all national green building guidelines. • Develop product research and labeling. • Recognize gray water as a legitimate source of "new" water. • Research gray water applications and long-term effects of gray water diversion. • Set national definitions of water quality as they relate to gray water treatment and reuse. • Structure a national water efficiency research program.
Energy and air emission effects of water supply	Stokes JR, Horvath A.	UC Berkeley	4/15/2009	http://www.ncbi.nlm.nih.gov/pubmed/19475934	E-W	Life-cycle air emission effects; supply water; hybrid life-cycle assessment; recycled water; desalination; importation; energy footprint; air emission footprint; brackish groundwater; seawater desalination; energy; CO2 emissions; water demand of California; electricity; alternative electricity mixes; renewable sources; solar thermal energy; greenhouse gas emissions; environmental footprint; decision support tool (WEST); water policy; energy consumption; material use effects	(For fee research paper: key findings/recommendations not available)
Sustiainable Water Systems: Step One - Redefining the Nation's Infrastructure Challenge	R. Bolger, D. Monsma, R. Nelson	The Aspen Institute	5/1/2009	http://www.aspeninstitute.org/sites/default/files/content/docs/pubs/water_infra_final.pdf	E-W	Water infastructure, water utility, sustainable	Recommendations: 1. Redefine "water infrastructure" as one that integrates built infrastructure components w/protection/restoration of supporting natural watershed infrastructure, the use of emerging small-scale water technologies/water management solutions. 2. Watershed-oriented entities should manage redefined water infrastructure according to Sustainable Path. 3. Fed, state, local officials should adopt watershed-oriented policies, regulations that incorporate Sustainable Path into funding decisions. Resource management entities/water utilities should adopt Sustainable Path in operations/administration. 4. Water utilities must lead in building partnerships that use integrated water resource planning/management as principal tool for preserving/restoring water resources while meeting human/ecosystem needs for water in context of changing climate. 5. Fed, state, local govt's, other entities should find ways to remove/modify institutional barriers/practices that impede/prevent sustainable water resource management according to Sustainable Path, should actively address all sources of pollution, degradation, depletion on a watershed basis. 6. Utility/system managers, regulators/governing boards should ensure that price of water services fairly charges ratepayers/customers total cost of meeting service/sustainable water infrastructure requirements, subject to concerns about affordability. Funding for water utilities should rely on cost-based rates/charges, water revenues should not be diverted to unrelated purposes. 7. Water utilities should employ variety of practices, including: transparency in governance/ops; public outreach/consultation; integrated water management; asset management; workforce management; conservation/efficiency (water/energy); advanced procurement/project delivery methods; adaptation to/mitigation of climate change; R&D; technological/managerial innovation.

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Increasing California's Water Efficiency in Commercial, Industrial and Instituional sector	Ronnie Cohen, Kristina Ortez, Crossley Pinkstaff	NRDC	5/1/2009	http://www.nrdc.org/water/cacii/files/cii.pdf	E-W	Tech for increase CII water efficiency, alternative sources of water, case studies of sucessful water agency programs.	• Increasing CII water efficiency is cost effective and delivers a range of shared benefits such as lowering the cost of business, extending limited water supplies, saving energy, reducing global warming, restoring fisheries, improving water quality etc. • Establish efficiency standards for water-using products. • Set performance-based water savings targets that provide water agencies w/ flexibility. • Prioritize water conservation above increasing supply. • Adopt a public goods charge on water sales to provide dedicated funding source for water efficiency programs. • Encourage partnerships with energy utilities and wastewater agencies. • Streamline the process for recycled water use. • Encourage volumetric pricing for sewer services. • Decouple water agencies sales from revenue. • Improve water reuse data collection and management.
The Carbon Footprint of Water	Bevan Griffiths-Sattenspiel and Wendy Wilson	The River Network	5/1/2009	http://www.rivernetwork.org/resource-library/carbon-footprint-water	E-W	Integrated planning; energy efficiency; wastewater; emissions reduction	Explore ways to integrate water and energy policies at the federal, state and local levels to ensure the sustainable management of both resources. • Develop a standard methodology for water utilities to quantify the energy intensity of their water supplies and benchmark their energy usage. • Create national guidelines for reporting water use across end-use sectors. • Introduce a national requirement for all water and wastewater service providers to regularly report on annual energy consumption and the energy intensities of their respective water supplies. • Allow public access to energy intensity values so that consumers are aware of the energy and carbon implications of their water use. • Conduct research on the energy embedded during end-uses of water, particularly commercial and industrial uses. A better understanding of the energy required for different end-uses would allow water conservation programs to target the most energy-intensive uses of water and optimize carbon emissions reductions. • Launch pilot water conservation, efficiency, reuse and Low Impact Development programs that measure the energy savings achieved and can serve as case studies.
Program on Technology Innovation: Electric Efficiency Through Water Supply Technologies—A Roadmap	C. Arzbaecher, K. Carns, R. Ehrhard, G. Hamilton, P. Hurtado, J. Murphy	EPRI	6/1/2009	http://www.scarab.se/pdf/EPRI%20Report%20on%20MD.pdf	E-W	Electricity use in public water supply; energy intensity of public water supply; alternative water sources; electricity use in agriculture irrigation; water technologies with electric efficiency potential - pumping systems and controls (high-efficiency pump/motor systems, variable frequency drives, pipeline optimization); water use efficiency (Acoustic leak detection integration, urban irriggation efficiency, high efficiency agriculture irrigation hardware); advanced treatment	• Technologies that offer the best opportunities for electric energy savings include high-efficiency pump/motor systems, variable frequency drives, pipeline optimization, advanced supervisory control and data acquisition (SCADA) systems, automatic meter reading/acoustic leak detection integration. • High-efficiency pump/motor systems can save 10%–30% of the baseline pumping energy consumed by public water utilities and by agriculture irrigators, which could be as much as 14,900 million kWh per year in energy savings. • Other technologies can provide additive energy savings proportional to the subsequent baseline. The aggregate level energy savings potential for all of the technologies discussed here could reach 30%–50% of baseline. • Several emerging desalination technologies offer opportunities for electric energy savings. These savings can be achieved only if electric utilities and water suppliers fully engage in advancing the use of energy-efficient water technologies. In addition, the value of these technologies extends beyond energy savings by enabling enhanced water resource management, including water conservation, water reuse, and innovative water reclamation. Recommended next steps are based upon one of four different types of projects. The four project types include: • Convening diverse audience for inter-industry idea generation/planning • Technology Demonstrations for commercially available, proven technology that has yet to achieve significant market penetration (i.e. "pilots")Technology Assessments for emerging technology that has yet to be adequately field tested for industry applications • Technology Development for promising technologies that still require basic science research • Recommended for future support by EPRI: Advanced SCADA; Advanced Reverse Osmosis (RO); Capacitive Deionization; Advanced Ozonation; Membrane Distillation; Photocatalytic Oxidation
Price Impact on the Demand for Water and Energy in California Residences	Larry Dale, K. Sydny Fujita, Felipe Vasquez Lavin, Mithra Moezzi, Michael Hanemann, Loren Litzenhiser	California Climate Change	8/1/2009	http://www.energy.ca.gov/2009publications/CEC-500-2009-032/CEC-500-2009-032-F.PDF	E-W	Investigated the impacts that water and energy demand have on their prices	Inconclusive; more research needed

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Best Practices for Sustainable Wastewater Treatment: Initial Case Study Incorporating European Experience and Evaluation Tool Concept	George V. Crawford	WERF	8/17/2009	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07a	E-W	Energy reduction; wastewater treatment; nitrogen removal	(For fee research paper: details and recommendations not available) • Tool to analyze wastewater treatment processes for energy efficiency and recovery: Carbon Heat Energy Assessment Plant Evaluation Tool (CHEApet) provides an estimation of overall energy, heat and carbon relationships based on wastewater treatment plant data. Also calculates carbon footprints using different approaches. Highlights areas where the largest potential gains in sustainability are possible and allows users to optimize plant operations by running successive 'what-if' scenarios to achieve efficiency goals. The lessons learned that contributed to the success of optimization efforts at Strass include: • A highly educated, well-paid work force that was motivated, trained, and experienced • A high level of automation which allowed for a smaller, specialized operations team • The use of advanced process analysis tools • The tolerance for process risk and in-depth understanding of processes deployed, including the use of novel treatment processes • The ability to quantify gains
Combined Heat and Power Case Study: Gloversville-Johnstown Joint Wastewater Treatment Facility		ASERTTI	9/1/2009	http://www.asertti.org/programs/wastewater/NY/Gloversville-Johnstown_Case_Study.pdf	BOTH	Aeration system efficiency; site improvements; energy efficiency; generators; cost benefit analysis; energy independence; energy efficiency measures; operational impacts; environmental impacts; renewable energy; digester gas	•To gain the greatest impact from CHP technologies, it is imperative that older treatment facilities review original design assumptions from days of less expensive energy: •GJJWTF (Gloversville-Johnstown Joint Wastewater Treatment Facility) has made significant modifications to other process subsystems to reduce the amount of electricity needed to run the facility; •All process subsystems need to be analyzed to determine how to produce the greatest amount of biogas from digesters. GJJWTF has substantially improved operation of both aeration and digester processes to control BOD loadings and produce more biogas for feed to CHP engine generators; •GJJWTF has relied heavily on support organizations (NYSERDA) for assistance in analyzing and acquiring funds to improve plant operations. Doing so helps deploy the latest, most efficient process technology and leverage CHP technologies to reduce facility electricity costs (and reduce emissions from fossil-fueled utility electricity generation that is offset).
Cities of Gloversville-Johnstown Joint Wastewater Treatment Facility Biogas-Fired Engine Electricity Generation and Heat Recovery	David Terry	ASERTTI	9/1/2009	http://www.asertti.org/programs/wastewater/NY/Gloversville-Johnstown_Fact_Sheet.pdf	E-W	Biogas; wastewater; siloxanes; sustainable energy	• Ten percent of the biogas from the digesters was routinely flared in 2007, but by midyear 2008 50 percent of the valuable digester byproduct fuel was flared even with the two existing engine-generators running at full capacity. • The new strategy uses a design and has allocated funds to replace the two existing 150kW engine generators and purchase two new 350-kW units to handle the peak electric load of 700 kW. • Waste heat recovery components from the engines will continue to recover engine heat for supply to the digesters.
Cities of Gloversville-Johnstown Joint Wastewater Treatment Facility Biogas-Fired Engine Electricity Generation and Heat Recovery		ASERTTI	9/2/2009	http://www.asertti.org/programs/wastewater/NY/Gloversville-Johnstown_Fact_Sheet.pdf	E-W	Aeration system efficiency; site improvements; energy efficiency; generators; cost benefit analysis; energy independence; energy efficiency measures; operational impacts; environmental impacts; renewable energy; digester gas	•Fact sheet only see " Achieving Zero Net Energy Utilization at Municipal WWTPs: The Gloversville-Johnstown Joint WWTP Experience" for more details on findings
Assessing the impacts of changes in treatment technology on energy and greenhouse gas balances for organic waste and wastewater treatment using historical data	Jens Aage Hansen; Tjalfe G. Poulsen	ISWA	9/18/2009	http://wmr.sagepub.com/cgi/content/abstract/27/9/861	E-W	Solid waste; treatment technologies, greenhouse gases; organic waste; wastewater; historical data; energy content utilization	•The total energy potential in the four organic waste fractions from Aalborg in terms of upper fuel value plus the energy represented by nutrients contained in waste materials is 1.6 × 1015 J year–1. This is equivalent to 0.2% of the total annual Danish energy consumption including transport. •The population responsible for waste and wastewater production in Aalborg is about 4% of the Danish population. •By 1990 the energy balance is positive and net energy production is equivalent to about 40% of the total energy content in the organic wastes. •By 2020 it is expected that total net energy production will be equivalent to about 68% of the total energy content in the waste materials. The improvement compared to 2005 is mainly due to the implementation of condensation of water vapour in the flue gas from incineration and biogas production from the food waste.
Arizona Water Infrastructure Finance Authority (WIFA) ARRA Green Project Reserve Case Study	EPA	EPA	12/1/2009	http://water.epa.gov/aboutow/eparecovery/upload/2010_01_26_eparecovery_ARRA_AZ_Case-Study_FINAL_low-res_10-28-09.pdf	E-W	Drinking water; wastewater; infastructure; rehabilitation; conservation; energy audits	The 2009 American Recovery and Reinvestment Act Green Project Reserve funding played a key role in advancing WIFA's efforts to encourage sustainable and green project initiatives within drinking water and wastewater systems across the entire state of Arizona, including: • Waived local match for green TA projects which received an award of up to $35,000 • Free of charge energy audits for drinking water systems • To date, seven facilities have requested free energy audits

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Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Massachusetts Energy Management Pilot Program for Drinking Water and Wastewater Case Study		MassDEP, EPA	12/1/2009	http://water.epa.gov/aboutow/eparecovery/upload/2010_01_26_eparecovery_ARRA_Mass_EnergyCasyStudy_low-res_10-28-09.pdf	E-W	Energy efficiency; GHG emissions; clean energy; drinking water; wastewater	• In total, over $5.0 million of annual energy savings are anticipated to be achieved through energy efficiency ($2.8M) and on-site clean energy power generation ($2.6M). • Over 29 million kilowatt hours are estimated to be saved annually through project implementation (equivalent to powering 3,450 average sized homes) and 22,000 tons of carbon dioxide emission reductions will result annually from these green infrastructure investments.
Sustainable Water Resources Management, Volume 1: Executive Summary	Bob Goldstein	EPRI	1/1/2010	http://www.ndwrcdp.org/documents/DEC6SG06/Executive%20Summary.pdf	E-W	Sustainable water resources management study; green building sustainability; watershed sustainability; green building rating system; case studies; literature review	Objectives: • To summarize the elements of the Sustainable Water Resources Management Study • To analyze the relationship among community water resource management, green building, and watershed sustainability and evaluate the role of green building rating systems in that relationship Results: • Outcomes for a project are better when driven by local water priority issues rather than by a green building rating system based on universal criteria. • More sustainable approaches to water management at the local level can be achieved when the plan includes stakeholders involved with all facets of water—supply, use, treatment, stormwater management. Oftentimes, the best approaches are contradictory to one or more existing regulations, codes, rules, or rating systems that do not take into account new technologies and practices and limitations on water availability.
Sustainable Water Resources Management, Volume 2: Green Building Case Studies	L. Dufresne, V. Kiechel	EPRI	1/1/2010	http://ndwrcdp.werf.org/documents/DEC6SG06b/Green%20Building%20Case%20Studies.pdf	E-W	Sustainable water management practice; green building rating system; strengths and limitations; water sustainability, community level; energy management	• Universal standards do not necessarily provide the greatest benefit for specific local/regional situations. Rating systems and regulators should consider the value of making ratings and regulations responsive to local factors. • Very few aspects of current green building rating systems attempt to measure downstream or wider watershed impacts. Much of the focus is on water conservation and efficiency, with efficiency related to building plumbing fixtures—whether internal (toilets, sinks) or external (irrigation systems). There are rewards for site strategies that take into account permeability, infiltration, reuse, and evapotranspiration rates; but in general these factors are weighted equally with efficiency measures, even though they may be of greater benefit to the watershed and the environment as a whole. • Consideration of single issues without regard for synergistic impacts is problematic. There is a need for inter- or multi-disciplinary judgments. • Green building rating systems should consider incentivizing establishment of management frameworks to insure continuity between design and operations. Project teams should not end their involvement at the design and construction phases, but extend their involvement to operations. The electric sector needs to understand the perspective of the building sector and work to create and test new collaborative green building technologies and practices to achieve energy/water sustainability on the community and regional levels.
Sustainable Water Resources Management, Volume 3: Case Studies on New Water Paradigm	Trevor Clements, Vic D'Amato, Kimberly Brewer, Scott Struck	EPRI	1/1/2010	http://www.decentralizedwater.org/documents/DEC6SG06a/Case%20Studies%20on%20New%20Water%20Paradigm.pdf	E-W	Water sustainability; water sector infrastructure; water supply; wastewater treatment; new water management paradigm; low impact growth	• Based on input received at the retreat and follow-up research, the research team defined the new paradigm as a composite of five integrated components: 1) sustainability goals, 2) sustainability operating principles, 3) integrated technological architecture, 4) institutional capacity, and 5) adaptive management. • Core principles defined for the new paradigm: valuing all water as a resource, moving toward a performance-based regulatory framework, aspiring toward better outcomes, and recognizing true costs while maximizing the value of action. • Framework for supporting a new sustainable water infrastructure paradigm: integrated planning structure that connects current institutional silos; a technical toolbox to use in the context of performance-based requirements at the watershed and community scale; regulatory flexibility to encourage innovation and affect better outcomes; research and demonstration to build knowledge and capacity; new partnerships and funding mechanisms; variety of means for engaging the community stakeholders to broaden support and affect better outcomes.
Water & Wastewater Energy Management Best Practitices Manual	NYSERDA	NYSERDA	1/1/2010	http://www.nyserda.ny.gov/en/Page-Sections/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/~/media/Files/EERP/Commercial/Sector/Municipalities/best-practice-handbook.ashx	E-W	Innovation/technological imporvement; objective analysis of practices; legislation	various recommendations on how to upgrade technology and more efficiently use energy at a wastewater treatment plant

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Safe Drinking Water Act (SDWA): Selected Regulatory and Legislative Issues	Mary Tiemann	Congressional Research Service	1/13/2010	http://infousa.state.gov/economy/technology/docs/CEABD595d01.pdf	E-W	Safe Drinking Water Act Issues: Regulating drinking water contaminants (contaminant candidate list, regulatory determinations, unregulated contaminant monitoring, standard-setting, recent and pending rules); pharmaceuticals in drinking water; drinking water infrastructure needs and funding; small systems issues (exemptions, small system variances and affordability, affordability criteria review, small system legislation); underground injection control program	• Recent issues have involved infrastructure funding needs, regulatory compliance issues, and concerns caused by detections of unregulated contaminants in drinking water, such as perchlorate and pharmaceuticals and personal care products (PPCPs). • Another issue involves the adequacy of existing regulations (such as trichloroethylene (TCE)) and EPA's pace in reviewing and potentially revising older standards. • A long-standing and overarching SDWA issue concerns the cumulative cost and complexity of drinking water standards and the ability of water systems, especially small systems, to comply with standards. • Water infrastructure financing legislation has been offered repeatedly in recent Congresses to authorize higher funding levels for the Drinking Water State Revolving Fund (DWSRF) program, and also to provide grants and other compliance assistance to small communities. • A newer SDWA issue concerns proposals and research regarding the underground injection of carbon dioxide (CO_2) for long-term storage as a means of reducing greenhouse gas emissions.
Sustainable Treatment: Best Practices from the Strass in Zillertal Wastewater Treatment Plant	Lauren Fillmore; George V. Crawford	WERF	1/1/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07b	E-W	Operations; energy consumption; analysis tools; automation	• Highly educated, well-paid workforce Operations staff members were experienced tradesmen (electricians, plumbers) and/or university graduates with degrees in chemistry, biology, or chemical engineering • Each operator was responsible for overseeing maintenance in his area of expertise throughout the plant. • The plant superintendent was a licensed, Ph.D. engineer. • The operations personnel focused on operating the plant, while also overseeing the small team of maintenance personnel, but outsourced some non-core activities. This opened the door for dynamic management of the treatment process and additional savings. • High level of automation • A cadre of highly qualified plant operators fostered the successful use of automation, which allowed for a smaller, more specialized operations team. • Use of advanced process analysis tools Because it was possible to have running mass balances on the plant in terms of nitrogen and carbon, as well as an energy consumption breakdown, operations staff was able to identify the hot spots for process optimization quickly and gauge the return on the effort and investment.
Energy Efficiency in Value Engineering: Barriers and Pathways	Joseph C. Cantwell	WERF	3/16/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO6R07a	E-W	Wastewater; energy efficiency; technology alternatives; value engineering; barriers; life cycle cost analysis; ghg; sustainability;performance	(For fee research paper) Key Recommendations: • Scalable system design which can operate incrementally at flows below maximum design • Life-cycle cost analysis (LCCA) for each alternative, present net present value of any energy savings. Best Practices: • Implementation of energy efficiency measures using performance-based contract w/program implementation contractor. • Maintenance of lists of qualified engineering consultants/project implementation contractors. • Support variety of marketing/outreach activities. • Personalized project facilitation services throughout project to ensure that it moved to completion. • Program assistance to smaller wastewater systems which have fewer financial/staff resources. • Provided access to independent funding sources/financial incentives such as cost-share grants to develop energy efficiency projects. • Presentation of non-energy benefits of energy efficiency projects (e.g., reduced green house gas emissions/improved sustainability) to municipal decision makers. • Responded to participants' needs as program grew by refining program services.
Overview of State Energy Reduction Programs and Guidelines for the Wastewater Sector	Joseph C. Cantwell,	WERF	3/16/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO6R07b	E-W	Energy efficiency; water/wastewater agencies	(For fee research paper: key findings/recommendations not available) • This report evaluates successful state programs which promote energy efficiency in the wastewater sector. • The study highlights three states (California, New York, and Wisconsin) that have effective energy reduction programs for the wastewater sector with a long-term history of performance. • It looks at the feasibility of establishing a national design standard for wastewater treatment plants that incorporates energy efficiency and the report provides suggested language for incorporating energy efficiency into design guidelines or standards. • The report includes results from a technical working session of selected municipal wastewater agencies that focused on the issue of incorporating energy guidelines into their respective standards.
Energy Efficient Alternatives for the Fortuna Wastewater Treatment Facility	Jennifer Fuller	The Community Clean Water Institute Fortuna Water Quality Project	3/23/2010	http://ccwi.org/programs/Fuller-EnergyEff.pdf	E-W	Wastewater treatment; operating costs; energy efficiency; energy usage reduction	• Costs associated with energy consumption will continue to be a large portion of the City of Fortuna's wastewater treatment facility operational budget. • With rising energy prices, increased population growth energy conservation will become essential to the success of a small treatment facility. • Conserving energy is not only cost effective but is also reduces green house gases.

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Ontario's Water-Energy Nexus - Will We Find Ourselves in Hot Water… or Tap into Opportunity?	Carol Maas	POLIS	4/1/2010	http://poliswaterproject.org/sites/default/files/nexus-report_final.pdf	E-W	Water-energy nexus; energy used to pump, treat, and heat water, generate steam, water treatment; wastewater treatment; greenhouse gas emissions; residential; commercial	• Energy embedded in water for pumping, treating and heating water and generating steam consumes 40% of Ontario's natural gas and 12% of electricity. • Providing water services uses more natural gas than any single economic sector in Ontario; more than natural gas used by each of industrial, transportation, residential and commercial sectors. • Eighty percent of all energy used for water services generated by fossil fuels, • Fossil fuel consequences: Substantial costs to for energy to pump/treat water; Release of greenhouse gases (further need to find and treat more water); Rising water/energy costs; Significant environmental, social and economic impacts of developing new energy sources to provide more water.
Energy Recovery from Wastewater Treatment Plants in the United States: A Case Study of the Energy-Water Nexus	Ashlynn S. Stillwell; David C. Hoppock; Michael E. Webber	University of Texas, Austin	4/5/2010	http://www.mdpi.com/2071-1050/2/4/945	BOTH	Wastewater; energy; biogas; biosolids incineration; energy recovery; policy	• Implementing anaerobic digestion with biogas utilization in varying degrees nationwide can reduce electricity consumption for wastewater treatment by 2.6 to 27%. • Through incorporation of anaerobic digestion with biogas utilization and biosolids incineration with electricity generation, wastewater utilities can reduce electricity consumption by 4.7 to 83% in the state of Texas. • These wide ranges in electricity percent savings for the wastewater sector are due to the difference in wastewater flows analyzed in each individual scenario of our analysis.
Technology Roadmap for Sustainable Wastewater Treatment Plants in a Carbon-Constrained World	George V. Crawford	WERF	5/17/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07d	E-W	Wastewater; carbon neutral; sustainable energy practices	(For fee research paper: key findings/recommendations not available) • The Roadmap describes the current status of wastewater technologies, projects future treatment quality requirements, identifies research needs, and summarizes ongoing activities to meet perceived future objectives including reducing the carbon footprint while achieving lower nutrient levels.
News: The Dutch Roadmap for the WWTP of 2030	STOWA	STOWA	6/1/2010	http://www.stowa.nl/Upload/publicaties/stowa%20rapport%202010-24%20engels.pdf	E-W	Wastewater; drinking water; water sector; energy efficiency; roadmap; resource management	• The roadmap cannot be set given the current situation. It must be an activley changing plan that accomadates for new phenomena as they occur. • This plan will adapt to new situations and keep on route for the final destination.
Energy Efficiency in Wastewater Treatment in North America: A Compendium of Best Practices and Case Studies of Novel Approaches	Julian Sandino	WERF	6/11/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07e	E-W	Energy conservation; case studies; wastewater; emerging technologies	(For fee research paper: key findings/recommendations not available) • This report compiles North American best practices for energy-efficient operation of wastewater assets as part the Global Water Research Coalition's project, Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies, which looks at these best practices worldwide. It provides a comprehensive bibliographic resource of best efficiency practices, documents case studies of novel energy conservation and recovery techniques, and identifies implementation risks, obstacles, and management strategies. • It is intended to serve as a starting point for wastewater treatment facilities that want to implement energy conservation/recovery approaches and/or technologies, by providing details of successful implementation, including methodologies, techniques, strategies, and expected result
Sustainable Energy Optimization Tool - Carbon Heat Energy Assessment Plant Evaluation Tool (CHEApet)	George V. Crawford	WERF	6/15/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07c	E-W	Energy efficiency; water/wastewater agencies; model	(For fee research paper: key findings/recommendations not available) A web-based plant-wide energy model that considers all forms of energy (calorific, electric, thermal, and recovered biogas from cogeneration) as well as Greenhouse Gas emission predictions is part of the Optimization Challenge.
Co-Digestion of Organic Waste Products with Wastewater Solids	David L. Parry	WERF	6/18/2010	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO5R07a	W-E	Co-digestion; anaerobic digester; biogas	(For fee research paper: key findings/recommendations not available) • This report includes additional knowledge on co-digestion of organic waste that the research team developed and evaluates the benefits for increase biogas production. This interim report is a summary of the work conducted under the first of three phases of this project. The final report is not published by WERF at this time, but will be published as OWSO5R07 when the pilot-scale and field scale activities are finished.

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Achieving Zero-Net Energy at Drinking Water and Wastewater Facilities	Christopher Pompi	EPA	7/1/2010	http://www.mass.gov/dep/water/priorities/zeronet.pdf	BOTH	Zero net energy; wastewater; drinking water; renewable energy emission reductions	• A zero-net energy facility is one that has greatly decreased its dependence on outside energy supplies moving toward a goal of total energy independence. • Facilities striving to reach ZNE should first reduce the plant's total energy needs through investment in renewable technologies, reduced energy consumption equipment, and operational efficiencies using a variety of approaches, including those described in EPA's Energy Management Guidebook for Wastewater and Water Utilities, available at www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf. • Once the total operational energy needs have been mitigated, alternative or "green" power sources can be used for on-site energy production. Through the use of low-cost, locally available, nonpolluting, renewable energy sources—such as solar cells, methane-powered microturbines, and wind turbines—a utility can generate enough renewable energy on site to equal or even exceed its annual energy use. • Three facilities in Massachusetts have done to reach zero- or close to zero-net energy through a combination of state and 2009 American Reinvestment and Recovery Act (ARRA) funding. These facilities also participated in a pilot program managed by the Massachusetts Department of Environmental Protection to help utilities across the Commonwealth identify ways to improve their overall energy efficiency.
Increasing Energy Efficiency through ARRA Funding: New York State Wastewater Initiatives		EPA, New York State Environmental Facilities Corperation	8/1/2010	http://water.epa.gov/infrastructure/sustain/upload/10504-11-NYState-case-study_v4_highres_1.pdf	BOTH	Energy effcient; wastewater treatment; utilities; innovation	Energy-saving measures used in many ARRA-financed projects include: • Improved aeration processes • Solar power generation • Reed bed sludge treatment • Gravity belt sludge thickeners • Premium efficiency motors and variable frequency drives • Low pressure/high output lamp technology for ultraviolet disinfection • Efficient insulation and lighting that exceeds building codes • Combined heat and power, including alternative fuel use and anaerobic digestion
Embedded Energy in Water Studies Study 2: Water Agency and Function Component Study and Embedded EnergyWater Load Profiles	GEI	CPUC	8/31/2010	ftp://ftp.cpuc.ca.gov/gopher-data/energy%20efficiency/Water%20Studies%202/Study%202%20-%20FINAL.pdf	E-W	Collection, analysis, compilation of detailed water/energy data; California; energy impacts on water; framework for computing embedded energy	• Electricity use by the water sector is higher than the CEC's conservative 2005 estimate of 5 percent of statewide electricity requirements. • Water sector electricity use is at least 7.7 percent of statewide electricity requirements, and could be higher. • Amount of energy deemed embedded in water is likely understated. Recommendations: • Collect more water-energy data, and with more granularity; • Develop and adopt a methodology for computing the energy embedded in a unit of water; • Quantify water losses throughout the water use cycle
Embedded Energy in Water Studies Study 1: Statewide and Regional Water-Energy Relationship	GEI	CPUC	8/31/2010	ftp://ftp.cpuc.ca.gov/gopher-data/energy%20efficiency/Water%20Studies%201/Study%201%20-%20FINAL.pdf	E-W	Detailed water and energy data; large or wholesale water agencies; estimation of the total amount of energy used in the Supply and Conveyance segment of the water use cycle; development of a predictive model for estimating the range of energy impacts under a variety of scenarios of water supply portfolios and water demand for five types of hydrology years	• Groundwater energy accounts for a significant portion of the additional energy in the Supply and Conveyance segment. • The primary driver of electricity use by the Supply and Conveyance segment of the water use cycle is water demand in relation to the types and location of water resources used to meet that demand. • The amount of energy previously attributed to the Supply and Conveyance segment of the water use cycle is likely understated. Recommendations: • Collect more water-energy data, and with more granularity; • Develop and adopt a methodology for computing the energy embedded in a unit of water; • Quantify water losses throughout the water use cycle
Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities	Laura Dufresne; Stephen Couture; David Reardon; Kenneth Henderson; James Wheeler; Phil Zahreddine	EPA	9/1/2010	http://water.epa.gov/scitech/wastetech/upload/Evaluation-of-Energy-Conservation-Measures-for-Wastewater-Treatment-Facilities.pdf	E-W	Energy conservation measures (ECMs); publicly owned treatment works (POTWs); cost/benefit; energy efficient equipment replacement; operational modifications; process control enhancements; energy efficiency; cost savings; payback period; innovative; emerging; wastewater treatment plant; detailed facility assessments; energy savings	• Innovative ECMs (Energy conservation measures): Integrated air flow control, Automated SRT/DO Control, High-speed gearless (Turbo) blowers, Single-stage centrifugal blowers with inlet guide vanes and variable diffuser vanes, Hyperbolic mixers, Pulsed Large Bubble Mixing, Vertical linear motion mixer, Upgrading multiple hearth furnaces to incorporate waste heat recovery/combustion air pre-heating • Emerging ECMs: Intermittent Aeration, Dual Impeller Aerator (mechanical mixing), Respirometry for aeration control, Critical oxygen point control, Off-gas monitoring and control, Online monitoring and control of nitrification using nicotinamide adenine dinucleotide, Bioprocess Intelligent Optimization System, Ultra-fine bubble diffusers, New diffuser cleaning technology, Low-pressure high-output lamps for UV disinfection, Automated channel routing for UV disinfection, Membrane air scour alternatives, Solar drying

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Evaluating the energy and carbon footprint of water conveyance system and future water supply options for Las Vegas, Nevada	Eleeja Shrestha	University of Nevada, Las Vegas	10/1/2010	http://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=1678&context=thesesdissertations	E-W	Water conveyance; Energy; Carbon footprint; Arid region; Las Vegas, NV; Lake Mead; desalination; scenario; model	• The model simulations show that currently (2009) significant amount of energy is required (0.85 million MWh/y) to satisfy the water needs of the Las Vegas Valley and it will increase substantially (nearly 58%) by the year 2035 based on assumptions. • When a conservation scenario is assumed in which per capita demand gradually lowers to 753 lpcd (199 gpcd) by 2035, the rise in energy requirements is approximately 32% as compared to the present energy requirements. • Considerable amount of energy is required to pump water from Lake Mead to water treatment plants. It comprised nearly 35% of the total energy requirements. These energy requirements tend to rise as the Lake level declines. However, the major portion of total energy (65%) is consumed to move treated water in the distribution system. • Even a small change in population growth rate, can vary the future energy requirements and associated emissions by substantial amount. Variation in population growth rate by 0.5% can change the energy and CO2 emissions by around 12.8% as compared to the status quo. So, the future emissions can vary if there is different growth in population compared to what is currently forecasted by CBER. • The change in the lake levels considered in this study resulted in the change in energy requirements and CO2 release by 3.3% when compared with the total CO2 emissions. • Conserving water from 908 lpcd (240 gpcd) to 753 lpcd (199 gpcd) results in a significant reduction in the energy consumption and associated CO2 emissions. The energy and CO2 emissions in the year 2035 decreased 16.5% as compared to the status quo scenario. Increasing the reuse rate of treated wastewater effluent lowered the energy requirements and associated CO2 emissions of moving water in Las Vegas Valley by considerable amount. At present the reuse rate is nearly 30 MCM (22 mgd) and is expected to reach 77 MCM (56 mgd) by 2020 which will result in nearly 3.6% energy saving as compared with no change in reuse rate. However, if 20% of the treated wastewater is reused the energy use can lower by 9%, sufficient enough to light approximately 11,000 US homes on average for a year based on an average annual electricity consumption of 11,040 kWh for a US residential home in 2008 (USEIA, 2010). • A combination of multiple scenarios in which water demand is reduced to 753 lpcd (199 gpcd) by 2035, wastewater reuse is increased to 77 MCM by 2020 and renewable energy sources is increased to 50%, resulted in the decrease of energy requirements by nearly 0.28 million MWh/y (20.7%) and CO2 emissions by 0.39 million metric tons/y (46%) by 2035 when compared with the status quo.
Embedded Energy in Water Pilot Programs Impact Evaluation	Steven Grover; John Boroski; Jenny Yaillen; Ted Helvoigt; Geo Lee; Heather Carver	Econorthwest - for CPUC	10/9/2010	http://www.cpuc.ca.gov/NR/rdonlyres/51BF9A0B-42C9-4104-9E71-A993E84FEBC8/0/EmbeddedEnergyinWaterPilotEMVReport_Final.pdf	E-W	Water savings & embedded energy methodology, IOU program evaluations	• Leak loss offers greatest E savings potential • Detention facility projects generate high e-savings • Recycled water retrofit projects can offer large potable water savings, but need more research, other programs do not appear to be cost effective even when embedded energy is included, but need more research. • Systematically inform all of the agencies from which embedded energy data will be required. • Conduct further research about recycled water particularly IOU embedded energy for tertiary treatment and retail costs to consumers. • Evaluate larger samples if possible. • Incorporate changes in end-user energy consumption into cost-effectiveness calculations.
Quantifying the links between water and energy in cities.	4. Kenway, S. J., P. Lant, and A. Priestley	The University of Queensland	1/1/2011	JournalofWaterandClimateChange2(4):247-259.	E-W	Urban water; energy; greenhouse gas emissions; direct; indirect; Urban Heat Island; water supply	• Water-related energy in cities accounted for 13% of the total electricity and 18% of the natural gas used in Australia in 2006-2007. Collectively, this represented 9% of the primary energy use or 8% of total national GHG emissions.
Achieving Zero Net Energy Utilization at Municipal WWTPs: The Gloversville-Johnstown Joint WWTP Experience	Robert E. Ostapczuk, P.E., BCEE; Paul C. Bassette; Chamindra Dassanayake; James E. Smith, Jr.; George Bevington	Malcolm Pirnie, the Water Division of ARCADIS	1/1/2011	http://scholar.qsensei.com/content/1t6vm9	E-W	Domestic wastewater treatment plants; energy independent; optimizing plant energy efficiency; renewable resource; energy independence; energy efficiency measures; operational impacts; environmental impacts; renewable energy	•Not all WWTP's will be able to achieve net zero energy, however, small to medium WWTPs will be able to utilize GJJWWTP as a model for energy independence. •Combining energy conservation and electrical generation, allows WWTPs to break from the business as usual mode and focus on resource recovery. WWTPs looking to codigest will need to evaluate high strength feedstocks within local proximity to the WWTP. •Prior to focusing on energy generation, WWTPs should reduce energy consumption where possible without risking treatment or flexibility. •Developing an energy management team or committee will allow a WWTP to bridge competing interests within operations, management, and maintenance.
Embedded Energy in Water Studies Study 3: End-use Water Demand Profiles		CPUC	1/1/2011	ftp://ftp.cpuc.ca.gov/gopher-data/energy%20efficiency/Water%20Studies%203/End%20Use%20Water%20Demand%20Profiles%20Study%203%20FINAL.PDF	E-W	California end-user water demand profiles; water-efficiency; energy efficiency; quantify the percent of total daily water demands that occurred during the peak daily electric demand period	• Four patterns of use observed: morning and evening, night-time, daytime, and continuous. • Residential end-users tended to demand water during morning and evening periods. • Irrigation tended to occur during night-time hours. • While many commercial and public building facilities were daytime users, those in the industrial category were the most likely to be continuous users. • While all of the water demand profile categories showed some use during peak energy demand hours, none could be singled out has having a key relationship with peak energy demand. • Many water demand profile categories may not be a good target for peak reduction programs. • Energy efficiency and demand response programs might successfully target those uses that exhibit the strongest link to the peak energy period (e.g., toilets and showers in the residential sector, car washes and agricultural irrigators).

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State of the Science on Biogas: Treatment, Co-Generation, and Utilization in High Temperature Fuel Cells and as a Vehicle Fuel	Lauren Fillmore	WERF	1/1/2011	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO10C10a	BOTH	Biogas; wastewater; siloxanes; sustainable energy; fuel cells, co-generation, fuel, vehicle	(For fee research paper: key findings/recommendations not available) • The significant volume of biogas produced from the anaerobic digestion of wastewater solids is a valuable resource for energy recovery and makes this a leading investment option for plants interested in sustainable wastewater treatment operations. • This document consists of these four affiliate reports: D1a: State of the Art on Biogas Treatment D1b: State of the Art on Co-Generation Using Sewage Biogas D1c: State of the Art on High Temperature Fuel Cells Using Sewage Biogas D1d: State of the Art on Biogas Utilization as a Vehicle Fuel
The Future of Research on Climate Change Impacts of Water, A Workshop Focusing on Adaptation Strategies and Information Needs		Water Research Foundation	1/1/2011	http://www.waterrf.org/PublicReportLibrary/4340.pdf	BOTH	Research needs; decision support tools; climate change adaptation strategies for water supply, wastewater, stormwater management; outreach effort by federal agencies; National Oceanographic and Atmospheric Administration; University Corporatopm for Atmospheric Research; US EPA; NASA	The principal topics of this workgroup's discussion focused around three key themes: 1. problems faced with understanding energy availability, pricing and incentives; 2. challenges of getting good, up-to-date data on the energy implications/use of different equipment or processes; and 3. the need to plan for energy and water needs jointly across sectors. Recommendations: • Project 1: Update the 1996 EPRI energy intensity of water and wastewater processes and equipment. • Project 2: Opportunities for integrating multi-sector basin-wide planning across all water users. • Project 3: How to communicate to stakeholders the need to invest in the future reliability of energy and water supply in the face of climate change. • Project 4: Develop and appropriately scaled planning tool for integrated water energy demand forecasting. • Project 5: Water quantity and quality requirements of energy generation, extraction, and mitigation technologies (differented water footprinting for energy). • Project 6: Opportunities and barriers for energy generation within water and wastewater systems/utilities. • Project 7: Case studies for how the water energy nexus is addressed by integrated water energy utilities.
EBMUD's Journey to Becoming a Net Electricity Producer	Alicia R. Chakrabarti, John M. Hake, Donald M.D. Gray, Vincent P. De Lange, and Edward H. McCormick	East Bay Municipal Utility District	1/1/2011	http://www.ingentaconnect.com/content/wef/wefproc/2011/00002011/00000006/art00045?crawler=true	BOTH	Net electricity producer; net energy producer; energy efficiency; renewable energy production; publicly-owned treatment works	(For fee research paper: key findings/recommendations not available) • The East Bay Municipal Utility District (EBMUD) Main Wastewater Treatment Plant (MWWTP) has been producing renewable energy on site since 1985 and has more than doubled the amount of energy produced since 2002, from over 2 megawatts (MW) to over 4 MW. • Becoming a net electricity producer is a result of both reducing on-site demand and increasing on-site generation. • More significantly, high-strength organic waste co-digestion has increased biogas production and electricity generation. In order to utilize the additional biogas and reduce flaring, the on-site power generation facility is being expanded to increase the electrical production capacity from 6.5 MW to 11 MW. • Major challenge: Maintaining energy efficiency while meeting nutrient limits during non-energy crisis periods • Analysis Boundaries: Net electricity producer or energy independent; Energy in, electricity out and beyond
Co-digestion of Organic Waste Products with Wastewater Solids, Ongoing	David L. Parry	WERF	1/19/2011	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO5R07	E-W	Anaerobic digester; energy recovery	(For fee research paper: key findings/recommendations not available)
Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies - Global Report	Malcolm Brandt	WERF	2/26/2011	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO9C09	E-W	Best energy practices; wastewater	(For fee research paper: key findings/recommendations not available) • Best practices for energy management in the wastewater and water industry worldwide. • Detailed examination of current best practices and technologies and identifies promising new developments. • Supplements the WERF report OWSO4R07e: Energy Efficiency in Wastewater Treatment in North America.

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Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Big Relief for Taxpayers Facing Mounting Municipal Infrastructure Costs: New Revenue Streams and GHG Reduction Through Bold, Integrated Water and Energy Recovery	Wm. Patrick Lucey	Metro Vancouver and the North Shore Communities	3/29/2011		BOTH	IRM, IRR, integrated resource management, integrated resource recovery, Proper Functioning Condition (PFC), valuation, GHG, municipal infrastructure asset management, taxpayer, engineered ecology, natural capital, ecosystem services, climate change	• Six Integrated Resource Recovery (IRR) scenarios were evaluated and compared with a modified traditional waste management option. All six IRR scenarios produce higher net financial benefits compared with wastewater treatment alone. • Four IRR scenarios that combine centralized treatment with an energy centre for processing solid waste are financially superior and may be profitable. • Three IRR scenarios appear capable of returning a dividend to the taxpayer. • The results do not support undertaking resource recovery at the wastewater treatment plant alone. • Combining an optimized IRR approach with long-term financing may be able to reduce taxpayer costs to an average as low as $10 per door per year for approximately the first six years of the project, during which time the maximum funding required is in the order of $180 per door. This is in contrast with the $1300-$1400 per door annual projected cost of wastewater treatment alone. • IRR will reduce greenhouse gas emissions by 20% for the North Shore and will improve ecological values in some streams and wetlands through reducing water withdrawals and stream augmentation with reclaimed water. Although IRR will create disruption through constructing up to 50 km of district energy systems and will require a high degree of source separation, on balance, it will result in significant reductions to the taxpayer. • The combination of recovering heat and electricity close to a major industrial centre and creation of a utility corridor to distribute those resources to the community improves the business case for the taxpayer.
Addressing the Energy-Water Nexus: A Blueprint for Action and Policy Agenda		Alliance for Water Efficiency	5/1/2011	http://aceee.org/files/pdf/white-paper/Water-Energy%20Blueprint.pdf	E-W	Water-energy nexus; joint efforts; policy agenda; federal, state, local, watershed levels; policy/codes, research, programs; energy; electricity generation; water; treated water; wastewater	Recommendations: • Incorporate cost-effective energy and water efficiency measures into building codes, equipment standards, and tax credits • Survey existing programs that clearly address the energy-water nexus to identify examples of best practice programs. Prepare a report for local and state policymakers and water utilities that identifies lessons learned from energy experiences, addresses rate-related barriers to efficiency program implementation, and helps to clarify utility disincentives for encouraging efficiency • Develop a baseline of total energy use by water and wastewater utilities and water use by electric utilities, which would include raw water transmission and treatment; treated water distribution; and wastewater collection, treatment, and disposal energies, not just energy use at the plant level • Establish ongoing water and energy workgroups to increase cooperation among energy and water agencies, utilities, and communities, to share best practices and recognize the nexus as the first step toward working together
Greenhouse-gas emissions from energy use in the water sector	Sabrina G.S.A. Rothausen, Declan Conway	Nature Climate Change	6/26/2011	http://www.nature.com/nclimate/journal/v1/n4/pdf/nclimate1147.pdf	E-W	Water management; challenges; stricter water-quality standards; increasing demand for water; climate change; reduce emissions of greenhouse gases; abstraction, conveyance and treatment of fresh water and wastewater; energy demand;	(For fee research paper: key findings/recommendations not available)
Site Demonstration of the Life Cycle Assessment Manager for Energy Recovery (LCAMER) Tool	George V. Crawford	WERF	6/28/2011	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07f	W-E	Anaerobic digester, energy recovery	(For fee research paper: key findings/recommendations not available) • WERF developed the LCAMER spreadsheet-based tool in 2006 to help utilities compare life cycle costs for energy recovery systems. This project focused on demonstrating the applicability, effectiveness, and areas of improvement for the LCAMER tool by evaluating proposed anaerobic digestion and biogas-to-energy improvements for two wastewater utilities.
Case Studies in Utilizing a Decision Support System for Sustainable Energy Management	Steve Conrad	Water Research Foundation	7/14/2011		BOTH	Energy management Decision Support System (DSS); water utilities; sustainable energy management decisions; financial, environmental, social issues associated with energy management options; supply, operational, demand side of energy management; cost of energy; carbon footprint; future regulatory requirements; greenhouse gas emissions	• Three Big Drivers: Energy Supply/Demand concerns, Cost Control, Emissions management • Electric Rates = Projected Steady Increase: Average Over 10¢ per KWH by 2025 • Drivers Result in Numerous Decisions: 1. Control of energy performance and costs; 2. Carbon and GHG management; 3. New service area and/or treatment level and replacement of existing infrastructure; 4. Encouraging reduction in customer water use and its effect on the energy use of the utility; 5. Best options for energy recovery and generation • Four Utilities Piloted Use of the DSS Tool: Tarrant Regional Water District (TRWD), JEA, Sunnyvale, CA, Sydney Water • TRWD Will Analyze Transmission Line Design Options Using the Tool: $1.6B "integrated pipeline" project includes base design with options for improved energy efficiencies and generation; Tool will be used in design proposals to evaluate best options; Options for pumping and transmission system include considerations for emission reductions, green energy generation, and optimized operation to reduce energy costs. • JEA used the tool to compare various biosolids options. Tool results showed meeting their goal to reduce energy use. • Sunnyvale's baseline showed significant increase in energy use. Selected options for motor replacement and increased biogas production met their goals. • Sydney Water set very aggressive goals. The tool results showed that most goals could be met.

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Domestic Wastewater Treatment as a Net Energy Producer – Can This be Achieved?	Perry L. McCarty; Jaeho Bae; and Jeonghwan Kim	Stanford	7/14/2011	http://pubs.acs.org/doi/abs/10.1021/es2014264	BOTH	Process optimization; wastewater treatment; energy savings; operating strategy; retrofit; reduce external energy	• Energy can be obtained from wastewater's organic as well as from its thermal content. • Using wastewater's nitrogen and P nutrients for plant fertilization, rather than wasting them, helps offset the high energy cost of producing synthetic fertilizers. • Microbial fuel cells offer potential for direct biological conversion of wastewater's organic materials into electricity, although significant improvements are needed for this process to be competitive with anaerobic biological conversion of wastewater organics into biogas, a renewable fuel used in electricity generation. • Newer membrane processes coupled with complete anaerobic treatment of wastewater offer the potential for wastewater treatment to become a net generator of energy, rather than the large energy consumer that it is today.
Energy Production and Efficiency Research - Roadmap to Net-Zero Energy		Water Environment Research Foundation	8/1/2011	http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDEQFjAA&url=http%3A%2F%2Fwww.werf.org%2Fc%2F2011Challenges%2FEnergy_Optimization_.aspx&ei=WU21UObYDefJigLPj4DQDA&usg=AFQjCNHvdAm5-Ju2MJT1k7REx-L1r6xL5A&cad=rja	BOTH	Energy content of Domestic WW; current Energy requirements of WW Treatment; energy-neutral wastewater treatment; energy proudction opportunities; roadmap	Research will promote energy management within the wastewater sector and promote the wastewater sector as green energy industry
Desalination: Technologies, Use, and Congressional Issues		Congressional Research Service	8/15/2011	http://pennyhill.com/index.php?option=com_jmsfileseller&view=document&doc_id=1310&Itemid=0&order_id=R40477	E-W	Desalination; Congress; federal investment; research and development; prioritize; construction; operation; federal government; municipal water investment	(For fee research paper: key findings/recommendations not available)
Decision Support System for Sustainable Energy Management	Steve Conrad	WERF	11/26/2011	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO7C07	E-W	Non-renewable energy; greenhouse gases; wastewater	(For fee research paper: key findings/recommendations not available) • The Water RF and WERF collaborated in this project to provide better decisions on reducing non-renewable energy use and greenhouse gas (GHG) emissions in the water and wastewater service sector. • A software tool is included that guides a utility through the process of developing a portfolio of options to meet their goals for reductions in energy use, GHG emissions, energy cost and increasing the percentage of renewable energy. The tool is a Microsoft Excel workbook that includes guidance on the use of the tool.
Energy Self-Assessment Tools and Energy Audits for Water and Wastewater Utilities	James Horne; Jason Turgeon; Eric Byous	EPA	12/1/2011	http://water.epa.gov/infrastructure/sustain/upload/EnrgMgmtWebcst_Dec2011.pdf	E-W	Energy use and water utilities; energy reduction; maximize energy efficiency; self-assessment tools; benchmarking; energy use assessment tool; energy audits; demand and supply; renewable energy	• EPA Energy self-assessment tools: ENERGY STAR Portfolio Manager; EPA Office of Groundwater and Drinking Water Energy Use Assessment Tool; EPA Energy Management Planning Self-Assessment worksheet • Non-EPA Energy self-assessment tools: NYSERDA Water and Wastewater Focus Program; CEE Water and Wastewater Self-Audit Checklists; WERF Carbon Heat Energy Analysis Plant Evaluation Tool (CHEApet); Mass Energy Insight • Audit tools: Maine DEP Sample Audit RFP Language; EPRI Energy Audit Manual for Water/WW Facilities • Lessons Learned – Audit Process: Target proper level of audit; Discuss your payback period thresholds with auditor; Request an initial simple draft report with brief summary of recommendations; Discuss draft report with contractor to determine where further detail is required; Leads to an effective final report…expensive contractor time not wasted on unwanted info • Potential savings of $650K/yr and 4 megawatt hours/yr with a 5.7 year payback through addition of a cogeneration facility • Potential for no capital cost to implement this renewable energy project if a Power Purchase Agreement used (prelude to a webinar later in this series) • Next Steps: Conduct a Self-Assessment (including benchmarking) of your utility's energy use; Conduct a Level II or III energy audit at your facility; Begin implementing an energy management program to implement audit recommendations
Demonstration of the Carbon Heat Energy Assessment and Plant Evaluation Tool (CHEApet)	George V. Crawford	WERF	12/6/2011	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO4R07g	E-W	Operating energy, energy efficiency; wastewater; carbon footprint	(For fee research paper: key findings/recommendations not available) • The Carbon Heat Energy Assessment Plant Evaluation Tool (CHEApet) uses predictive models to quantify plant operating energy requirements and predict the carbon footprint from wastewater treatment plants. • This report presents demonstration studies applying CHEApet at three different sized wastewater facilities who were interested in documenting and improving their energy efficiency. The demonstration studies include data on the CHEApet model setup for the existing plant, simulated energy information compared to real energy demand data measured at each facility, estimated carbon footprint, and examples of how efficiency scenarios can be used to evaluate plant upgrades and improvements.
The Water-Energy Nexus and Urban Metabolism. Connections in Cities.	Kenway, S.J.	The University of Queensland	1/1/2012	http://www.urbanwateralliance.org.au/publications/UWSRA-tr100.pdf	E-W	Urban water; energy; greenhouse gas emissions; Australia; residential; utility; mass balance; urban metabolism	• Water-related energy in cities is equivalent to one-third of the total energy use of all Australian industry (excluding transport); it is equal to approximately half the energy usage of the Australian residential sector; and it is over four times the direct energy use of Australian agriculture (excluding embodied energy use). • Water-related energy accounted for 59% of household energy use (excluding transport), and 35% of the GHG emissions of a single household studied in detail.

Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Environmental Management Systems (EMSs): A Key to Financial Viability, Environmental Excellence - and Worthy of Regulatory Incentives	Dan Roberts	Palm Bay, FL, Utilities Department	1/1/2012	http://www.peercenter.net/ewebeditpro/items/O73F24974.pdf	E-W	Environmental Management System (EMS); ISO 14001:2004; regulatory incentives; effective utility management; significant environmental aspects and impacts; performance measures; operational cost savings; bond ratings; sustainability; and optimization.	• EPA and other agencies representing the water and wastewater sectors can conclude from the previously described evidence of benefits that EMSs have a role to play in the design of regulatory and permitting programs. • The EPA and water and wastewater associations have laid the ground work and should continue to work collaboratively to provide legislative and regulatory models, MOAs, templates and tools to incentivize the implementation of EMSs.
Seawater Desalination Costs White Paper		WateReuse Association	1/1/2012	http://www.watereuse.org/sites/default/files/u8/WateReuse_Desal_Cost_White_Paper.pdf	E-W	Desalination technology; cost drivers; components; present costs; comparison with other supply alternatives; challenges; perceptions; recent advances	• Membrane desalination has experienced an overall downward trend in overall costs, and technological advances will continue to bring costs down even further. • When investigating the costs associated with desalination compared to other supplies, comparable cost estimating practices will tend to level the playing field when all of the costs associated with delivering water are considered. • As with any infrastructure project, it is important to recognize that the various components supporting the overall desalination treatment facility can vary significantly and are based on site location. • For membrane desalination, decreasing technological costs, the drought-proof nature of the process, and producing superior water quality are among a number of significant reasons why this application is the water treatment technology of choice in the United States and around the world.
A primer on energy efficiency for municipal water and wastewater utilities	Feng Liu, Alain Ouedraogo, Seema Manghee, Alexander Danlenko	The World Bank	2/1/2012	http://water.worldbank.org/sites/water.worldbank.org/files/publication/ESMAP-EECI-WWU.pdf	E-W	Energy use; efficiency; network-based water supply and wastewater treatment in urban areas; supply side of municipal water cycle; extraction; treatment; distribution of water; collection and treatment of wastewater	• Electricity costs are usually between 5 to 30 percent of total operating costs among WWUs. • Improving EE is at the core of measures to reduce operational cost at WWUs. Since energy represents the largest controllable operational expenditure of most WWUs, and many EE measures have a payback period of less than five years, investing in EE supports quicker and greater expansion of clean water access for the poor by making the system cheaper to operate. • Based on the review of existing literature, most of the commonly applied technical measures to address EE issues at WWUs generate 10 to 30 percent energy savings per measure and have 1- to 5-year payback periods. • Adopting efficiency measures, such as those described in this primer, could see global energy saving potential of the sector at its current level of operation in the range of 34 to 168 terawatt hours (TWh) per year. The upper bound is roughly the annual generation of 23 large thermal power plants, or more than the annual electricity production of Indonesia in 2008. • The main challenges to scaling up EE in municipal water and wastewater services stem from sector governance issues, knowledge gaps, and financing hurdles.
Water-Energy Nexus Survey Summary Report		Illinois Section American Water Works Association	3/1/2012	http://allianceforwaterefficiency.org/uploadedFiles/News/NewsArticles/NewsArticleResources/ISAWWA-Water-Utility-Survey-Report-2012.pdf	E-W	Energy intensity, energy cost, Illinois. water supply; water-energy nexus; water supply and energy consumption; withdrawal, conveyance, treatment, distribution	• On average, energy cost % of utility's total annual operating expenses generally consistent regardless of size. • Small utilities tend to use more/pay more for energy/unit of water when compared to larger sized. • Surface water utilities tend to dedicate higher percentage of annual operation budget to energy cost, tend to have higher water production cost/unit of water than groundwater and Lake Michigan utilities respectively. • Survey respondents reported 22,501 million gallons of water loss in 2010, equating to loss of $2 million in energy costs. • On average, large utilities tend to have higher % of water loss, have highest associated energy costs of water loss. Recommendations: • Consistent and comparable data collection methodology needed across Illinois/nationally to gather/track water/energy data at utility level, establish benchmarks. • Greater collaboration needed btwn energy/water utilities and within municipal departments in terms of data sharing, tracking, auditing. • More integrated research needed on water/energy operations at utility level. • More education/outreach to utilities, public officials, general public needed on W-E nexus and how can improve efficiency at utility level. • Energy data could be provided to customers via utility's annual water quality report (consumer confidence report). • More detailed breakdowns of energy use data throughout each step of water supply process needed.

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2009-2011 Indiana Energy Management Pilot	EPA	EPA and IDEM (Indiana Department of Environmental Management)	4/1/2012		BOTH	Pilot project; drinking water; wastewater; energy costs; energy usage; sustainability; energy management; guidebook; carbon dioxide; utilities; energy efficiency	•The Pilot was a practical opportunity to track water utilities " progress over multiple years as they managed energy. The following three outcomes highlight how the Pilot utilities improved. •As the Pilot concluded, Pilot utilities were asked to complete a self-assessment by scoring themselves from 1 (low) to 15 (high) in the following 10 areas: audit, benchmarking/tracking energy use, energy policy, energy goals, energy management action plans (or EIP), training & awareness, standard operating procedures (SOPs)/operational controls, measurement (of energy management progress), adoption of PDCA management system, and renewable sources of energy. 5 The chart in Figure 4 depicts average scores of the five Pilot utilities that responded. Benchmarking and tracking energy use are the greatest strengths. The nine remaining topics are evenly ranked at around 10, suggesting comfort with accomplishments coupled with awareness of room for improvement. •Pilot utilities reported energy, flow and energy-related costs continuously beginning with a baseline or "pre-pilot" period of 2008, except for the Mishawaka wastewater treatment plant (WWTP) which upgraded in 2008 and used 2009 as a baseline. •Electrical energy intensity improved for eight of the utilities. All ten Pilot utilities reduced natural gas consumption and nine reduced electrical consumption.
Energy Management System Short Guides: A Supplement to the EPA Energy Management Guidebook for Drinking Water and Wastewater Utilities (2008)		EPA	4/1/2012	http://www.epa.gov/r5water/energymanagement/pdf/IN_Pilot_WW_Manual-April_2012.pdf	BOTH	Electricity requirements; fresh water supply; wastewater treatment; public water agencies; public wastewater treatment facilities; self-supply of water; domestic; commercial; industrial; aggregate electricity requirements; operations	• The following steps can be used to enforce an energy efficiency plan: • Annually (or insert your preferred frequency), confirm the date and time for a management review meeting. Identify who will attend. •Work with the Energy Team to determine the topics for the management review, such as (1) progress in achieving objectives and targets; (2) quantitative and qualitative benefits; (3) suitability and effectiveness of the energy management system; (4) continued appropriateness of the Energy Policy; (5) focus areas for the next round of energy objectives and targets; (6) lessons learned in developing and implementing the energy management system. •Develop an agenda for the management review meeting and distribute it as appropriate. •Lead the management review meeting. •Document and record the issues discussed, what decisions were reached, and any follow up action items and responsibilities These meeting minutes will include, a list of attendees, a summary of key issues discussed, and any action items arising from the meeting. Any action items will be tracked to closure using the Monitoring and Measuring System Procedure. A copy of the meeting minutes will be distributed to attendees and any individuals assigned action items. A copy of the meeting minutes will be retained on file. •Develop plans to communicate the results of the management review meeting and the quantitative and qualitative benefits of the energy management system.
Green Energy Life Cycle Assessment Tool (GELCAT) and User Manual	Robert T. Lorand	WERF	4/20/2012	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO6R07c	E-W	Renewable energy technologies; wastewater	(For fee research paper: key findings/recommendations not available) • The Green Energy Life Cycle Assessment Tool (GELCAT) is a Microsoft Excel®-based screening tool that can be used to determine the economic viability and energy and environmental benefits/costs of selected renewable energy technologies at wastewater treatment facilities. In its current version, three renewable electric technologies are represented: photovoltaic systems, wind turbine generators, and hydro-turbine generators. The user's manual provides information on how to use the GELCAT software.
Sustainable Food Waste Evaluation	David L. Parry	WERF	4/27/2012	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO5R07e	E-W	Sustainability goals; public agency; utilities	(For fee research paper: key findings/recommendations not available) • To fully capture resources and achieve broader sustainability goals, planners and utility managers need to take a holistic look across conventional public agency boundaries and explore ways to connect and integrate systems and existing infrastructure. • The most common practice, such as the landfill disposal of residential food waste, may not be the best practice from either economic or environmental perspectives.
Innovative Energy Conservation Measures at Wastewater Treatment Facilities	James Horne	US EPA	5/17/2012	http://water.epa.gov/infrastructure/sustain/upload/EPA-Energy-Management-Webinar-Slides-May-17.pdf	E-W	Anaerobic digester; methane; GHGs; carbon emissions; VFDs	• By metering-in the High strength wastes into our Anaerobic Digesters we have increased our methane gas production by more than 200 percent. • Optimizing biogas production has resulted in a reduction in the purchase of energy from outside sources. (electric and natural gas). • By burning methane gas in the micro -turbines we have significantly reduced our green house gas emissions (Methane and Carbon Dioxide) • The installation of energy efficient motors and VFDs (Variable Frequency Drives) has reduced our energy consumption by 5,600 MWH through 2011 and reduced our green house gas emissions by 8,400,000 pounds, equivalent to planting 4,200 trees.

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Aqueous Sludge Gasification Technologies		EPA	6/1/2012	http://nepis.epa.gov/Adobe/PDF/P100EM1Q.pdf	E-W	Sludge gasification technologies; impacts; stages of development; critical ocmponents; development status; potential benefits and drawbacks; environmental and economic impacts	• Gasification offers a potentially viable option compared to conventional methods for sludge disposal. Gasification is capable of providing a clean and manageable process with the possibility of net energy gains. The variability and lack of information on commercial scale systems however, makes it difficult to ensure a complete analysis and concrete conclusions on sludge gasification's viability. • Unlike incineration, there is potential for sludge gasification to deliver negative GHG emissions. This is accomplished through energy production from biogenic sources and avoiding GHGs which would have been created in a different process. The emergence of systems designed to process the sludge throughput of individual plants will also help to reduce GHGs through the avoidance of burning fossil fuels during transportation. • A review of available literature and discussions with industry experts has revealed that pulp and paper mill sludge may not be a suitable candidate for gasification with current technology. The high moisture and mineral content in sludges result in low energy values, ultimately making full scale operation uneconomical, at least until sludge waste disposal becomes more problematic and costly. Recommendations: • It is critical to investigate a system's ability to adhere to Clean Air Act standards along with any other applicable federal and state regulations. The design, economics and performance of a system will be influenced by waste stream restrictions. Approach this issue by taking full account of all elements entering and exiting the system (i.e., if there is mercury in the feedstock, there will be mercury in a waste stream). • When considering performance, it is important to verify energy consumption of the entire process, including mechanical pretreatment, drying, gasifier energy demand and gross output. Keep in mind that if digested sludge is being used, there will be a loss of potential energy from removal and release of carbon in the form of CH4 or CO2 created during digestion. • Capital costs, operating costs and maintenance costs should all be thoroughly investigated. Many of the chemicals in the sewage sludge may corrode a system, leading to unforeseen high maintenance costs.
Barriers to Biogas Use for Renewable Energy	John L. Willis	WERF	6/5/2012	http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO11C10	E-W	Wastewater, anaerobic digester, biogas, energy recovery	(For fee research paper: key findings/recommendations not available) • Not all wastewater treatment plants with anaerobic digestion beneficially use their biogas beyond process heating. Knowing this, there must be actual or perceived barriers to broader use of biogas to produce combined heat and power (CHP). • This study documented these barriers so that actions can be taken to reduce or remove the barriers that promote energy recovery using proven technology – anaerobic digestion with combined heat and power generation. • Includes case studies and biogas factsheet and other materials.
Workshop: Water and Watts: potential to save energy and water in the Muni, Industrial and Commercial Sectors		Atlantic Council - ideas, influence and impact	6/19/2012	http://www.acus.org/event/water-and-watts-potential-save-energy-and-water-municipal-industrial-and-commercial-sectors	E-W		Not Available
Evaluating the energy consumed for water use in the United States	Kelly T. Sanders; Michael E. Webber	Environmental Research Letters	8/22/2012	http://iopscience.iop.org/1748-9326/7/3/034034	E-W	Energy; water; energy water nexus; residential; commercial; industrial	• Energy embedded in the US water system represents 12.3 ± 0.346 quads (12.6%) of national primary energy consumption in 2010 • We estimate that 5.4 quads of this primary energy (611 billion kWh delivered) were used to generate electricity for pumping, treating, heating, cooling and pressurizing water in the US, • Future analyses will assess the opportunities for carbon and energy reductions by water-conservation efforts, efficiency improvements, and new technologies. • Future work will aim to identify a general framework for characterizing the energy and carbon intensities of water systems based on regional variability in geography, climate and policy frameworks.
Model-Based Aeration Systems Design - Case Study Nansemond WWTP	Leiv Rieger; Charles B. Bott; William J. Balzer; Richard M. Jones	EnviroSim Associates Ltd.	9/1/2012	http://www.researchgate.net/publication/229429203_MODEL-BASED_AERATION_SYSTEMS_DESIGN_-_CASE_STUDY_NANSEMOND_WWTP	E-W	Aeration control; ammonia-based control; feedforward control; methanol savings; energy reduction	• Significant savings potential w/ ammonia- and/or DO-based aeration control strategies. • Feed-forward ammonia control was only active at low temperature (12 °C), did not significantly lower effluent ammonia peaks. • Feed-forward not selected for full-scale implementation - could not justify additional investment/O&M costs against improved effluent quality or reduced risk. • Article presents annual savings for plant
DRAFT: Guidebook to Assist Agricultural Water Suppliers to Prepare a 2012 Agricultural Water Management Plan	Kamyar Guivetchi; Manucher Alemi; Spencer Kenner; Kent Frame; Fethi Benjemaa; Nirmala Benin; Martin Berbach; Sabrina Cook; Andria Avila	DWR & Natural Resource Agency	9/10/2012	http://www.water.ca.gov/wateruseefficiency/sb7/docs/DRAFT-AgWaterManagemntPlanGuidebook.pdf	E-W	Ag plans w/ lack of energy considerations	The ag plans do not include energy which is notable.

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Solar Energy for Water and Wastewater Utilities: Step-by-Step Project Implementation and Funding Approaches	James Horne; Eric Byous; Bryan Gates; Matt Pearson	US EPA	10/11/2012	http://water.epa.gov/infrastructure/sustain/upload/Solar-Energy-for-Water-and-Wastewater-Utilities-Step-by-Step-Project-Implementation.pdf	E-W	Cost analysis; PV solar; wastewater treatment	Results of a study designed to create a tool that uses a management system approach for energy conservation, based on the successful Plan-Do-Check- Act process.
Implementing Renewable Energy at Water Utilities [Project #4424]	Bryan Lisk, Ely Greenberg, Frederick Bloetscher	Water Research Foundation	11/1/2012	http://www.waterrf.org/Pages/Projects.aspx?PID=4424	E-W	Renewable energy options for water utilities; opportunities, barriers, risks, costs, and benefits associated with renewable energy resources; case studies from the United States and one from Australia	• Solar photovoltaic technology was (and is) the most prevalent technology choice among water utilities as it is a mature technology that is easy to install and operate. However, it is not suited to every site. Other technologies that have been implemented include wind, micro-hydro, or geothermal. Tidal and wave energy harvesting is relatively young, though viable (and less common) option for water utilities. • Many funding and grant opportunities available to water utilities from government and private agencies to promote the use of renewable energy systems: i.e. power purchase agreements with third-party energy services companies, thereby allowing utilities to benefit from renewable energy with no upfront capital costs. • Recommendations: water utilities should explore reducing their energy costs and improving energy efficiency through energy audits, energy benchmarking, and demand management: -Review the available renewable energy generation technologies that are applicable to the water utilities' available energy resources; -Evaluate the capital investment and the potential returns to determine the economic feasibility; -Evaluate financing options; -Identify the barriers; -Identify the public impacts; -Evaluate how the energy generated will be used to provide the water utility with the highest level of benefit; -Determine the project delivery method that will meet the water utility's needs; -Evaluate the potential benefits of delivering a renewable energy project through a third-party energy product developer.
Report on Energy Management Roundtables in New Hampshire	Madeline Snow	Lowell Center for Sustainable Production University of Massachusetts Lowell	1/1/2013		E-W	Reduce energy use; emissions; climate impact; sustainable water infastructure; asset management; operating costs	1) Interactive sessions which promote peer-to-peer learning work well. 2) Optional field trips enhance learning and relationships. 3) Following the plan-do-check-act framework is a challenge when (a) the utilities vary greatly regarding energy audits 4) The more roundtable participants who have had audits, the better the discussions and learning. 5) Other EPA activities between roundtable meetings are important. 6) Inter-state participation is possible. The nexus of energy and more stringent permits can be discussed constructively even when there is contention around the issue.
On/Off Aeration Energy Savings	Ronald G. Schuyler, Rothberg, Tamburini & Winsor, Allen Coriell, Michael Carrano	City of Montrose			E-W	Activated sludge; aeration; wastewater treatment; energy savings; on/off diffused aeration	• The approach that the staff used in the ditches was to turn off the brush aerator nearest to the infuent in November, 1997. An anoxic section was produced all the way to the next brush. • The power usage represents more than just the brush aerators, and includes equipment such as clarifier collector mechanisms, lighting, etc. However, by controllng the system with an anoxic section, that portion of the plant overall saved 16% in power (kWhmonth) and 20% in power cost ($/Month). • An analysis of infuent flow showed a decrease in average flow however, the decrease resulted from the time of year and the actual months included in the calculation. • Twelve out of the 18 months where data was collected were from the low flow winter months. • If data were available for a complete two year basis, the flows would be very similar.
Cost effective energy usage at Himmerfjärdsverket sewage treatment plant in Sweden	Malin Tuvesson, Lars Gunnarsson, Mats Holmberg, Christian Rosen	WEFTEC			BOTH	Energy uses; energy balance; simulation tool; sewage treatment; energy production; electricity; heat; biogas; heat; simulation model	• Conclusion: Efficiency increase of pumping; Thickening of sludge to digester; No heat pump; No electricity from biogas; Mechanical energy from biogas engine; Vehicle fuel production • Actions: Modernize inlet pumps; New centrifuge for sludge thickening; Gas engine and a new blower; Contract to provide gas for vehicle fuel; Introduce deamonification • Results: Inlet pumping efficiency – decreased energy cost with 5%; Thickening – 25 % reduction in heating; Gas engine – Reduction in total electricity demand 10 %, Reduced costs for heating, Vehicle fuel – Income / Nm3 biogas produced; Deamonifiction – Reduced cost of N red. with 15% • Target: Energy efficiency and Biogas sale by 2011 to reduce costs equivalent to 2/3 of energy costs 2007
Lean Six Sigma and Environment Case Study: JEA	EPA	EPA		http://www.epa.gov/lean/environment/studies/jea.pdf	E-W	Utility; drinking water; wastewater; lean initiative; sigma six iniciative; Nitrogen discharge; fertalizer; truck management; sewer overflow reductions	•Achieved a utility-wide cumulative cost savings of $579 million from Lean and Six Sigma initiatives. •Avoided an impact of $95 million on the utility's 2010 budget from projects specifically focused on cost reduction. •Saved an average of $950 per customer and avoided rate increases of $20 per month directly related to process improvement efforts. •Reduced nitrogen discharge to the St. Johns River by 74 tons per year. •Increased the number of jobs per day that each water maintenance crew is able to complete from 4.36 to 6.23, which is a total of 479 additional jobs per year across the fleet of trucks. •Reduced SSOs from 43 per month in 2002 to 30 total from October 2009 through September 2010 (average of 2.5 per month over 12 months) using data-driven Lean Six Sigma methods.

Water and Energy Nexus Research Database

Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Water & Sustainability (Volume 1): Research Plan	B. Appelbaum, R. Myhre, P. Ricci, L. Ricci	EPRI	3/1/2002	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001006784&Mode=download	W-E	unavaillable	unavaillable
Water & Sustainability (Volume 2): An Assessment of Water Demand, Supply and Quality in the U.S. – The Next Half Century	Paolo Ricci, Luke Ricci	EPRI	3/1/2002	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001006785&Mode=download	W-E	unavaillable	unavaillable
Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century	R. Myhre	EPRI	3/1/2002	http://www.circleofblue.org/waternews/wp-content/uploads/2010/08/EPRI-Volume-3.pdf	W-E	Water management; sustainability; electricity generation; electricity demand; electric grid	• Trends in the power industry, such as the predominance of natural gas combined-cycle plants for new capacity, are decreasing both the quantity of water withdrawn and the quantity consumed (evaporated to the atmosphere) per MWh. • Total U.S. water consumption by the power generation sector over the next 20+ years may increase or decrease, depending on the rate of decrease in unit freshwater consumption (which in turn depends on the plant and cooling system mix employed) and on the rate of growth in MWh produced. • The “coal predominates” and “restrictive fish protection regulations” scenarios showed modest freshwater consumption increases for 2020 relative to 2000, whereas the “major shift to gas” scenario showed a substantial decrease
Spray-Cooling Enhancement of Air-Cooled Condensers	J. Maulbetsch, M. DiFilippo	EPRI	9/1/2003	http://www.energy.ca.gov/reports/2004-03-09_500-03-109.PDF	W-E	Low-pressure spray enhancement; efficiency/capacity penalties of dry cooling; decreased energy requirement; lower capital expenditures; reduced operation and maintenance (O&M) costs	As part of a previous study (Comparison of Alternate Cooling Technologies for California Power Plants, EPRI and CEC, #83362), researchers determined that heat rate and capacity penalties during the hottest hours of the year were the major drawback to the use of dry cooling at many locations in California. • Researchers showed that the allocation of cooling water in modest quantities (less than 10 to 15% of what would be required annually for the use of recirculating wet cooling) reduced the hot day penalties by 50% or more. • Of the several methods that have been proposed for “hot day” enhancement of dry cooling, researchers selected the use of sprays to cool the inlet air for development and testing based on its simplicity, low capital cost, and projected return on investment. • Spray system design criteria included low-pressure (< 300 psia) operation, moderate to high flow rates per nozzle (>0.1 to 0.4 gpm/nozzle), fine sprays (< 50 µ Sauter mean diameter), and low construction material cost. • Researchers evaluated fifteen nozzles and three demister designs in laboratory tests. • Researchers selected three nozzles and one demister for further testing at a full-scale cell of an air-cooled heat exchanger at an operating power plant (Crockett Cogeneration in Crockett, California).
Use of Degraded Water Sources as Cooling Water in Power Plants	M. DiFilippo, J. Maulbetsch	EPRI	10/1/2003	http://www.energy.ca.gov/reports/2004-02-23_500-03-110.PDF	W-E	Cooling water; freshwater conservation; degraded water sources	• Emerging treatment technologies and processes that make it possible to use degraded and reclaimed water identified • Identify processes not considered in the mainstream of treatment approaches. • Technologies focus primarily on environmental contaminants typically associated with degraded water - heavy metals, pesticides and organic compounds. • One technology involves de-ionization (salinity reduction). • Many of the technologies are in the early phases of research and development and some are commercial. • Contact information is provided for each technology.
Design Considerations for Hydropower Development In a Water Distribution System	David P. Chamberlain, Ed Stewart, Fei-Fan Yeh	San Diego County Water Authority	1/1/2004	http://www.hrcshp.org/cn/chshpdb/db/US/2.Design%20Considerations%20for%20Hydropower%20Development%20In%20a%20Water%20Distribution%20System(2004w).pdf	W-E	Hydraulic turbine, water distribution system; long pipeline reaches; fixed speed unit; optimized; operating envelope; turbine design speed; 4.3 MW Rancho Penasquitos Pressure Control/Hydroelectric Facility; licensing requirements for small inline hydroelectric facilities	• Development of small hydroelectric facilities on water distribution systems is a small but significant step to promoting renewable sources of pollution-free power. • A conduit hydroelectric facility is environmentally preferable to many other types of generation because it does not produce carbon dioxide, NOx, SOx, or other potentially harmful particulates that are major contributors to various pollution problems in an urban environment, and therefore, should be considered a genuine “green power” project. • Fast implementation, long project life, zero fuel cost, and freedom from price volatility of fossil fuels should make similar conduit hydroelectric facilities an economic project in a competitive open market.
Estimated Use of Water in the United States in 2000	USGS	USGS	1/1/2004	http://pubs.usgs.gov/circ/2004/circ1268/pdf/circular1268.pdf	W-E	Water usage; energy generation	statistical report, very little analysis

GEI Consultants

Alliance for Water Efficiency

ACEEE American Council for an Energy-Efficient Economy

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A Survey of Water Use and Sustainability in the U.S. with a Focus on Power Generation		EPRI	1/1/2004	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001005474&Mode=download	W-E	Water source sustainability; electric power generation; Electricity Technology Roadmap; freshwater availability; generation demand; impacts of water supply limitations; management approaches to limiting impacts	Information provided will be of particular value to power generation and delivery managers and planners, as well as government energy and water resource managers and regulators.
The Formation and Fate of Trihalomethanes in Power Plant Cooling Water Systems	M. DiFilippo	EPRI	5/1/2004	http://www.energy.ca.gov/reports/2004-05-26_500-04-035.PDF	W-E	Trihalomethane; THM formation; cooling water systems; THM predictive models	• THM compounds were formed during halogenation in the two cooling systems studied. • Site 1 involved fresh water (well water) using sodium hypochlorite for biological control. Site 2 involved a blend of fresh water (well water) and reclaimed municipal effluent using activated bromine for biological control. Data collected at this site, however, was based upon chlorinated samples since the bromine injection equipment was not operable. • Intermittent chlorination at Site 1 did not generate a significant amount of total THM compounds (TTHM), and all of it attenuated to nondetectable levels in the cooling water in several hours. • Continuous halogenation at Site 2 generated detectable levels of THM on a continuous basis. • However, approximately 80 percent of the THM escaped from the cooling tower in the airstream and the rest in blowdown. • At both sites, calculated airstream concentrations of TTHM were very low and far below the workplace health-threat level for chloroform (one of four THM compounds).
Comparison of Alternate Cooling Technologies for U.S. Power Plants: Economic, Environmental and other Tradeoffs	J. Maulbetsch	EPRI	8/1/2004	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001005358&Mode=download	W-E	Cost and effect of plant performance; dry cooling in place of recirculating wet cooling	• Water savings through dry cooling over recirculated wet cooling: 2,800 ac-ft/year (900 million gallons/year) • Water savings through dry cooling over 350 MW coal-fired plant: 6,400 ac-ft/year (2 billion gallons/year) • Capital cost of dry cooling: \$21-\$26 million for combined-cycle plant vs. \$5.7-\$6.5 million for wet cooling • Capital cost ranges from x4.5 at a hot, arid site to x3.5 at moderate site • Dry cooling imposes heat rate and lost-capacity penalty on a plant that can range up to 25% during the hottest hour of the year, exceed 8% for over 1,000 hours at hot, arid site • Base case operating and economic assumptions: “cost of water saved” = \$1,100-\$1,400/ac-ft or \$3.5-\$4.45/thousand gallons of water
Framework to Evaluate Water Demands and Availability for Electric Power Production Within Watersheds Across the U.S.: Development and Applications	Bob Goldstein; Mike Hightower	EPRI	1/1/2005	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001010116&Mode=download	W-E	Evaluate available water resources; sustain present and projected electrical power production; four case studies around the United States.	The framework consists of five steps: • Step 1: Select hydrologic units for analysis • Step 2: Gather needed information • Step 3: Perform historical long-term analysis • Step 4: Perform focused analysis on selected critical periods • Step 5: Perform alternatives analysis Since the framework is still under development, one of the primary purposes of this report is not only to explain what has been done, but also to provide opportunities for electrical power companies to comment on the framework and to suggest how it can be made more useful to them. The framework is designed to be implemented on the spatial scale of either small or large watersheds and to be applicable to different critical historical and future conditions.
Bringing Energy Efficiency to the Water and Wastewater Industry: How Do We Get There?	Keith Carns	EPRI Solutions, Inc.	1/1/2005	http://www.ingentaconnect.com/content/wef/wefproc/2005/00002005/00000007/art00012	E-W	Energy use; energy efficiency; energy management; electrotechnologies	SIX STEPS TO AN ENERGY-EFFICIENT SYSTEM 1. Establish a regular maintenance and performance testing program. 2. Conduct an energy audit of the system. 3. Implement recommendations of the audit. 4. Improve instrumentation and control systems. 5. Install new energy-efficient equipment. 6. Know your electric rates.
California's Water-Energy Relationship, Prepared in Support of the 2005 Integrated Energy Policy Report Proceeding	CEC Staff	CEC, Ca	11/1/2005	http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF	BOTH	Relationship between the water and energy sectors; increase efficiency	• Proactively manage water-related energy consumption • Increase understanding of the state’s water-energy relationship • Implement statewide integrated water and energy resource management • Increase water utilities’ energy self-sufficiency
Air-Cooled Condenser Design, Specification, and Operation Guidelines	Karl Wilber; J. Maulbetsch	EPRI	12/1/2005	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001007688	W-E	Air-cooled condenser (ACC); heat rejection in steam electric power plants; water conservation; environmental effects of once-through and evaporative cooling	• In contrast to once-through and evaporative cooling systems, use of the air-cooled condenser (ACC) for heat rejection in steam electric power plants has historically been very limited, especially in the United States. • However, greater industry focus on water conservation - combined with continued concern over the environmental effects of once-through and evaporative cooling - will almost certainly increase interest in ACC applications. • While operating experience and performance data are, to some extent, available from ACC suppliers, consultants, and owner/operators, there is no one repository of such information.

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Onondaga County Department of Water Environment Protection: Process Optimization Saves Energy at Metropolitan Syracuse Wastewater Treatment Plant	EERE	USDOE	12/1/2005	https://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/onondaga_county.pdf	W-E	Process optimization; wastewater treatment; energy savings; operating strategy; retrofit; impellers	• Changes in technologies and processes often represent significant opportunities for energy savings in wastewater treatment and other industrial plants. Realizing when such evolutions occur and remodeling motor and process systems in response to new parameters can save energy and improve productivity. • At the Onondaga County plant, an analysis that made use of the PSAT and MotorMaster+ tools helped plant engineers decide how to optimize the wastewater treatment process. Using VFDs (Variable Frequency Drives), more efficient pumps, and a new filtration system, plant aeration requirements were reduced from 21 large blowers down to 13. Projects and methodologies such as these can be applied at virtually all wastewater treatment and industrial facilities that require water for process needs.
Water and Wastewater Industry Energy Best Practices Guidbook	Focus on Energy	Focus on Energy	1/1/2006	http://watercenter.montana.edu/training/savingwater/mod2/downloads/pdf/SAIC_Energy_Best_Practice_Guidebook.pdf	W-E	Best practices; maximize electricity use; wastewater treatment plant	many different ways to increase energy conservation in wastewater treatment processes
Emerging Issues for Fossil Energy and Water	Melissa Chan, John Duda, Sarah Forbes, Traci Rodosta, Robert Vagnetti	US Department of Energy	6/1/2006	http://www.netl.doe.gov/technologies/oil-gas/publications/AP/IssuesforFEandWater.pdf	W-E	Water-energy; development of energy resources; relationship between water and coal extraction; fuel options; coal-to-liquids (CTL) production; oil shale development; actions to reduce carbon dioxide emissions; CO2 ambient concentrations; biological and geological carbon capture and storage; local and global impacts on water supply; water quality; carbon capture and sequestration; climate change; estimates of water use, consumption, and quality; technology implementation;	• Two issues in the placement of a CTL plant will be (1) availability of water and (2) the environmental concerns related to the discharge of water after use. • The withdrawal and consumption of water in regions where water is not abundant and where the plant would be competing with other users (e.g., thermoelectric power generation and agriculture) must be analyzed to further address potential shortages and environmental concerns. • Design optimization process focusing on four objectives: (1) minimizing water withdrawal and consumption, (2) maximizing conversion efficiency, (3) minimizing environmental impact, and (4) minimizing capital cost. • The discharge water from a CTL plant would be more similar to that of a thermoelectric plant or refinery—not brine but possibly contaminated with organics. However, the environmental risk could be mitigated by incorporating into the process design the need for activated carbon filters to remove any dissolved organics in the waste water before disposal. This cost could be included as an option for minimizing the environmental impact of a CTL plant in any of the three regions evaluated. • • With respect to in-situ techniques, improvements in groundwater characterization and monitoring are needed to ensure against potential groundwater contamination and longterm damage to subsurface aquifers. • Also, increased levels of CO2 in the atmosphere may increase plant growth, affecting the rate of water uptake and availability on landscape scales. Climate change mitigation strategies like carbon sequestration, although designed to decrease atmospheric CO2 levels, will also impact water resources. • Terrestrial/biologic carbon sequestration has the ancillary benefit of improving water quality but the potential of decreasing stream flows. • In the case of produced waters, geologic carbon storage has the potential to increase water availability in areas with limited resources.
Renewable Energy Storage Analysis for Irrigation and Residential Applications in Colorado's San Luis Valley, Research Progress Update Report	Greg Martin, John Levine, Richard Moutoux	University of Colorado at Boulder	8/30/2006	http://www.colorado.edu/engineering/energystorage/files/CDA_Attachments/SLV_EnergyStorage_Report_(CDA)_2006-08-30.pdf	W-E	Energy storage methods; pumped water; compressed fluid; batteries; preliminary estimate of system costs	• Given the strength of the sun in the San Luis Valley, a photovoltaic (PV) solar generating system is proposed. • Because of the intermittent nature of solar power, a method to store energy that provides continually available electricity is needed. There are promising options for on-site energy storage systems. • The estimated total system costs for several storage options are compiled in Table 12. • The dominant cost of each system is the photovoltaic solar system. This suggests that the next step is to investigate ways to reduce the cost of the PV array. -First, economies of scale need to be taken into account for the large solar system needed. -Next, the storage options might be redesigned in ways that minimize the instantaneous power requirement. • The very large water reservoir storage concept is an example of opportunities to do this. • Additional future work must include design of DC load systems for use with each of the storage options. • The concept of the compressed steam and water system must be developed further including thermodynamic analysis and refined component cost research.
Program on Technology Innovation: An Energy/Water Sustainability Research Program for the Electric Power Industry	J. Wolfe	EPRI	1/1/2007	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001015371&Mode=download	W-E	Water sustainabiliy, electric power industry; water, decision-making, individual power plants; water resource sustainability, hydroelectric power generators.	• Proposed program of research for the electric power industry to address the highest priority water resource challenges identified in the interviews with power generators. • Total cost of proposed research program is $37.5 million over a ten year period. • Estimates provide a basis for an overall comparison of costs and benefits of the program, constructed by extrapolating estimated plant-level savings to an industry-wide total. • Considerable uncertainty in the potential savings from each technology, once developed, and the market penetration of each technology. • The greatest potential gain is for new facilities, where a new technology can be integrated into the design of the plant, rather than replacing existing systems. The estimates of cost do not include additional water-conservation-related capital investment costs, beyond those that would be needed to implement existing technologies, because full-scale cost estimates simply do not exist for the emerging technologies discussed in this report.

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Program on Technology Innovation: Water Resources for Thermoelectric Power Generation	C. McGowin, M. DiFilippo, L. Weintraub	EPRI	1/1/2007	http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001014487&Mode=download	W-E	Assessment of produced water from oil and gas wells; produced water infrastructure availability and transportation analysis; produced water use - treatment - and disposal analysis; emerging water treatment technology testing; treated produced water compatibility assessment	(For fee research paper: key findings/recommendations not available)
Aquifer Underground Pumped Hydroelectric Energy Storage		University of Colorado	9/27/2007	http://www.colorado.edu/engineering/energystorage/files/EESAT2007/EESAT_AquiferUPHS_Paper.pdf	W-E	Underground pumped hydroelectric energy storage (UPHS); small to medium sized systems (less than 1 MW); agricultural operations; cost effective; energy storage solutions; environmental impacts; residential systems; distributed energy storage installations; on-grid; off-grid; small community scale	In this paper, a new concept for the underground pumped hydroelectric storage of energy is presented. • Studies indicate that this system is a promising candidate for use in small renewable energy plants, especially agricultural energy systems. • Estimations of efficiency and cost are provided for an example application sizing. • Future work will refine the technical analysis of the hydro and electric systems involved in the concept, economic analysis, and siting considerations.
Exploring linkages in water and energy demand in california residences draft	Larry Dale; K. Sydny Fujita; Felipe Vasquez Lavin; Mithra Moezzi; Michael Hanemann; Loren Litzenhiser	CEC	12/1/2008	http://www.energy.ca.gov/2009publications/CEC-500-2009-032/CEC-500-2009-032-F.PDF	BOTH	Price elasticity of demand; block rate pricing; natural gas; electricity; water; demand; California	• Analysis of the joint demand for natural gas and electricity and for water and electricity largely inconclusive. • The price elasticities of demand for natural gas and electricity in the joint model are below those found in the single-commodity analysis. • Since natural gas and electricity are substitute goods in the long run, high natural gas prices during the period of analysis may have contributed to a rise in electricity use that is unexplained by electricity prices. In that case, the estimate of the price elasticity of demand for electricity reported above may be too high. • Analysis of the joint demand for water and electricity highlights the data problems involved in this type of analysis.
How Greening California Cities Can Address Water Resources and Climate Challenges in the 21st Century	Noah Garrison, Robert C. Wilkinson, Richard Horner	NRDC	8/1/2009	http://www.nrdc.org/water/lid/files/lid_hi.pdf	E-W	Low impact development and the urban environment; California's water supply; water harvesting; water supply and energy in California	• Successful LID practices - maximize infiltration, provide retention areas, minimize the impervious footprint through reducing paved surfaces, directing runoff onto landscaping, capturing run off in rain barrels • Recommendations: implementing LID practices at new and redeveloped residential and commercial properties in parts of California can increase water supplies by billions of gallons each year
The Water Energy Nexus	Melissa Lamberton, David Newman, Susanna Eden, Joe Gelt	ARROYO - Water resources research center	1/1/2010	https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/Arroyo_2010_0.pdf	BOTH	Energy sources; water energy nexus; biofuel	Provides a background on the water-energy nexus and enery/water efficient solutions, especially as it applies and effects dry areas such as Arizona.
Protecting the Lifeline of the West		EDF, Western Resource Advocate	1/1/2010	http://www.westernresourceadvocates.org/water/lifeline.php	BOTH	Coal fired power plants; GHGs; electirical utilities; fresh water	The following measures are essential to the current and future prosperity of the West: 1. Adopting comprehensive, national climate and clean energy legislation. 2. Implementing energy-efficiency measures in homes, businesses, and the industrial sector. 3. Expanding the region's reliance on carbon- and water-efficient sources of energy 4. Accelerating efforts to improve urban water conservation. 5. Expanding use of recycled water. 6. Advancing new, emerging technologies that optimize reductions in carbon emissions and water use. 7. Working collaboratively to move away from the most polluting, water-intensive resources.
Future U.S. Water Consumption: The Role of Energy Production	Deborah Elcock	Journal of the American Water Resources Association	1/29/2010	http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2009.00413.x/abstract	W-E	Water consumption; water-energy policy; water-energy coefficients; energy production; fuel extraction; projections; biofuels; geographic information system; water resources management	• While Arizona's sunny climate is conducive to solar energy production, its arid landscape poses significant challenges to the deployment of solar energy systems. • Conventional concentrating solar power (CSP), the preferred technology for utility-scale solar energy production, consumes more water per megawatt-hour than most other types of thermal energy production. • A considerable amount of the power produced by CSP in Arizona could be exported to other states, effectively resulting in the exportation of the state's water to the rest of the country. • In order to protect Arizona's limited water supplies, state and federal policymakers should ensure that energy policy takes into account the amount of water needed to produce solar energy and does not contribute to existing water constraints.
Small Hydro and Low-Head Hydro Power Technologies and Prospects	Richard J. Campbell	Congressional Research Service	3/1/2010	http://nepinstitute.org/get/CRS_Reports/CRS_Energy/Renewable_Fuels/Small_hydro_and_Low-head_hydro_power.pdf	W-E	Small and low-head hydropower; further development of hydropower resources	• Run-of-river hydropower facilities can generate electricity by placing a small, mini-, or microturbine into a waterway, and do not necessarily require the construction of a large dam. • Some hydropower turbine technologies do not need dams to operate, if the flow of water is large enough to turn the turbine. Site conditions will therefore dictate the economics of developing projects. • Most of the technologies for high and medium head sites are fairly mature, but low head sites could benefit from innovation and optimization to develop technology that is suitable for the remaining low head resource. • Smaller hydropower applications and some of the newer hydropower technologies. Specfic results for technologies are available

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A Brief Overview of the Solar-Water Nexus		Office of Senator Jon Kyl	5/1/2010	http://www.circleofblue.org/waternews/wp-content/uploads/2010/08/solar-water1.pdf	W-E	Water supply; Arizona; federal and state energy policy; utility-scale conventional concentrating solar power (CSP); power export	CSP Policy Recommendations: • Water intensive conventional CSP is a poor choice for renewable energy production in the Southwest, particularly in Arizona where consumer demand for power does not exceed current capacity. Since conventional CSP continues to be the solar technology of choice for utility-scale solar, federal and state officials need to address its potential water use. Given the water constraints in the state, Arizona should consider: • Redefining the definition of renewable with respect to solar to factor in water consumption; • Eliminating the eligibility of CSP for the RPS unless the plant will be dry-cooled or will use an alternative water source such as treated effluent. The Arizona Corporation Commission and the State Legislature should consider: • Following California's lead and requiring all new CSP projects under its regulatory control to be dry-cooled unless they have degraded water readily available, such as city wastewater. • Developing criteria for permitting that include a cost-benefit and water budget impacts analysis of using Arizona water to produce energy that will be exported out of state. • Amending Arizona Revised Statute §40-360.06 to specifically require the Power Plant and Transmission Line Siting Committee to consider water resource and supply impacts in issuing a certificate of environmental compatibility. The Department of the Interior and the Department of Energy should: • Be more aggressive in protecting arid state water resources to ensure that multiple-use objectives can be sustained on public land. At a minimum, all Environmental Impact Statements for solar energy applications should require companies proposing to use wet-cooling technologies to analyze an alternative that conserves water, such as dry cooling. • Deny right-of-way applications for those projects that do not have a sustainable water supply or do not adequately protect water resources needed to sustain other multiple uses in the area.
Water-Energy Sustainability Perspectives and Policy Approaches		Watercat Consulting LLC	8/1/2010	http://www.watercatconsulting.com/022411_W-E_ReportNEWback.pdf	BOTH	Carbon footprint; enregy conservation; water footprint; cooling	This Summary Document: • Provides an overview of DOE-funded activities and initiatives leading up to the 2009 Water-Energy Symposium; • Summarizes Symposium presentations and participant survey responses on: energy perspectives on water; water perspectives on energy; integrated water+energy planning • Announces the 2010 Symposium: Water+Energy in a Changing Climate, Sept 25-29, 2010, in Pittsburgh, PA
Mapping the Energy-Water Policy Landscape - Final Report to the Union of Concerned Scientists	James M. McElfish, Jr.; Read Porter; Adam Schempp	Environmental Law Institute	8/1/2010		W-E	Regulatory laws and policies; connections between energy and fresh water; thermoelectric generating facilities; transportation fuels and related feedstocks	This publication by the Environmental Law Institute identifies the regulatory laws and policies currently affecting the connections between energy and fresh water within the United States. The review is limited to federal, state, and interstate legal regimes affecting thermoelectric generating facilities and transportation fuels and their related feedstocks; it does not address taxes or subsidies.
The connection between water and energy in cities - a review	Kenway, S. J., P. Lant, A. Priestley, and P. Daniels	The University of Queensland	1/1/2011	WaterScienceandTechnology63(9):1983-1990	E-W	Energy; water; cities; greenhouse gas emissions; urban metabolism; research; literature review; objectives	Major knowledge gaps: • Energy use associated with water in industrial and commercial operations as well as socio-political perspectives. • Lack of a unifying theoretical framework and consistent methodology for analysis. This is considered a prerequisite for quantitative trans-city comparisons.
Effects of Natural Gas Production on Water Quality in Garfield County, Western Colorado		University of Colorado at Boulder	1/1/2011	http://www.colorado.edu/honorsjournal/content/effects-natural-gas-production-water-quality-garfield-county-western-colorado	W-E	Natural gas production; wastewater impacts; surface water impacts; groundwater impacts	• No real case for natural gas activity impacting water quality in Garfield County • Mamm Creek Field on Divide Creek show evidence of contamination • Unlikely that hydrocarbons in domestic wells attributed to other sources than fracking • Need for improved operational practices/technology • Need for stronger regulatory power over fracking/drilling fluid use

Water and Energy Nexus Research Database

Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Energy and Water in the Great lakes	Vincent Tidwell and Barie Moreland	Great Lakes Commission	8/17/2011	http://www.glc.org/energy/glew/pdf/Energy-and-Water-in-the-Great-Lakes_Tidwell.pdf	W-E	Water used in power production	1. Water withdrawal/consumption metrics for thermoelectric power generation are significant in Great Lakes Watershed. The thermoelectric sector accounts for 76% of basin's withdrawals, 13% of consumption. Most water use directly from Great Lakes, 81% of all withdrawals from Great Lakes. 2. Thermoelectric water use characteristics could radically change over the next 25 years due to increasing demands, potential policies aimed at encouraging green energy development, reducing green-house gas emissions, regulating large water intake structures. 3. According to 5 scenarios, water withdrawals for thermoelectric power production in 2035 could grow by 2695 MGD (10%) for BAU scenario or decrease by 22,671 MGD (87%) for OLCP scenario. Alternatively, all cases result in growth in consumptive use ranging from 31 MGD (7.6%) for RPS to 97 MGD (24%) for the CCS scenario. Less dependence on direct lake diversions expected if restrictions on open-loop cooling are enacted (cost of lake-front property would encourage siting of new facilities away from the lake). 4. In comparison non-thermoelectric withdrawals projected to increase by 1811 MGD while consumption will grow by 335 MGD. Some of new growth in thermoelectric sector projected to occur in watersheds experiencing negligible non-thermoelectric growth. 5. Any increase in water use has potential to impact environmental quality of Great Lakes Watershed. Low flow indicator is calculated: ratio of streamflow to total withdrawals in driest/highest human water use month of year (August). Watersheds w/ratio <0.5 classified as vulnerable environmental quality. In 2007, twenty-four watersheds or 22% classified vulnerable, 19 of which had some thermoelectric withdrawal. Projected growth in thermoelectric sector expected to increase number of watersheds classified hydrologically vulnerable by 3, 3, 6 for NNOLC, RPS, BAU cases respectively. CCS/OLCP do not increase or reduce number. 6. Potential for new power plants to obtain water withdrawal permits pursuant to state programs required by Great Lakes/St. Lawrence River Basin Water Resources Compact (state mandated thresholds were used). Permitted facilities would range from 22 (NOLC) to 113 (CCS), tend to be clustered in New York, Wisconsin, Michigan. Fewer facilities subject to permitting due to consumptive water use are projected ranging from 1 (BAU) to 12 (316b), which largely match locations for withdrawal violations.
Policy and institutional dimensions of the water–energy nexus	Christopher A. Scott, Suzanne A. Pierce, Martin J. Pasqualetti, Alice L. Jones, Burrell E. Montz, Joseph H. Hoover	Energy Policy	10/1/2011	http://www.sciencedirect.com/science/article/pii/S0301421511006100	W-E	Water-energy nexus; institutional challenges; decision-making; water and energy development; coal development; environmental quality; social impacts; economic development; water-scarce; shale natural gas; national effort to assess energy-water scenarios; transportability of electricity; raw coal; raw gas; regionalized global-change adaptation; water availability; improved coordination between water and energy policy	• Three water–energy nexus cases in the United States are examined: 1. water and energy development in the water-scarce Southwest; 2. conflicts between coal development, environmental quality, and social impacts in the East; 3. tensions between environmental quality and economic development of shale natural gas in the Northeast and Central U.S. • We find that localized challenges are diminished when considered from broader perspectives, while regionally important challenges are not prioritized locally. • The transportability of electricity, and to some extent raw coal and gas, makes energy more suitable than water to regionalized global-change adaptation, because many of the impacts to water availability and quality remain localized. • We conclude by highlighting the need for improved coordination between water and energy policy.
Energy for Water - Water for Energy		Atlantic Council - ideas, influence and impact	10/1/2011	http://www.acus.org/files/publication_pdfs/403/111011_ACUS_EnergyWater.PDF	BOTH	concerns of workshop; electricty water sprial upward together, water demand, increasingly scarce water supplies, industry faces significant regulatory uncertainty, federal efforts lagging, state efforts developping, solving E-W nexus, competing agricultural sector needs	• Generation choices impact water use, climate change strategies likewise impact water usage, cooling tech equally alter U.S. water withdrawals and consumption. • There are tools and time enough to solve water-energy in the US: 1. lay ground rules among the competing sectors and regions. 2 fed govt must craft a national energy policy. 3 - state governments must improve their regional coordination. 4 - utility industry must develop ways to produce energy more efficiently. 5 - must be a resolution of the current regulation impasses that balances the economic and environmental costs. Solutions: • New fed govt, state govt actions • Good governance strategies • Effective regulations • Electric generation impact water demand • Changing cooling methods, • In plan water conservation tech • Water pricing policies • Innovative solutions and resources.
Fossil Fuels and Water Quality. The World's Water, Chapter 4	Peter H. Gleick, Lucy Allen, Michael J. Cohen, Heather Cooley, Juliet Christian-Smith, Matthew Heberger, Jason Morrison, Meena Palaniappan, and Peter Schulte	Pacific Institute	10/1/2011	http://www.worldwater.org/data.html	W-E	Water quality; producing fossil fuels; water-quality threat; energy policies and activities; fracking; natural gas formations	• Not including the very large volumes of produced water that are re-injected or discharged into the oceans, on the order of 15 to 18 billion m3 of freshwater resources are affected annually by fossil-fuel production. • Despite these impacts, information on global water-quality impacts of fossil-fuel production is scarce, old, incomplete, or nonexistent. • Several relatively new methods of fossil-fuel extraction, such as fracking, can cause widespread contamination of groundwater resources, affecting drinking water systems and both surface water and groundwater. • This chapter offers an initial assessment of the water-quality impacts of fossil-fuel production and use, but much more work needs to be done to better understand the scope and intensity of such impacts.

Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
Freshwater use by U.S. power plants: Electricity's thirst for a precious resource	Kristen Averyt, Jeremy Fisher, Annette Huber-Lee, Aurana Lewis, Jordan Macknick, Nadia Madden, John Rogers, Stacy Tellinghuisen	Energy and Water in a Warming World Initiative	11/1/2011	http://www.ucsusa.org/assets/documents/clean_energy/ew3/ew3-freshwater-use-by-us-power-plants.pdf	W-E	Power plant water use; water stress; effects of power plant cooling on water resources; quality of information; water-smart energy choices; water use characteristics; electricity generator; analytical approaches; fuels; power plant technologies; cooling systems; U.S. Energy Information Administration (EIA); withdrawal and consumption of freshwater	Findings on the water profile of power plants in 2008 show that: • Power plants are thirsty. • Where that water comes from is important. • East is not west: water intensity varies regionally. • Low-carbon electricity technologies are not necessarily low-water. Our findings on the impact of power plant cooling on water stress in 2008 show that: • Power plants across the country contribute to water-supply stress. • High-temperature water discharges are common. • The mix of power plants in the nation's fleet matters. Our analysis reveals a number of gaps and apparent inaccuracies in federal data reported for 2008. As a result, analyses based on that information would have overlooked regions facing water stress. We found: • Gaps add up. • Discrepancies are widespread. • Discrepancies stemmed from a range of causes. • Good analysis requires good information. Using the available data masks existing water stress. Analysis provides a strong initial basis for making water-smart energy choices. Here are some ways to do so: • Get it right the first time. Developing new resources for meeting electricity demand provides a critical opportunity for reducing water risks for both power plant operators and other users. Utilities and other power plant developers would be well advised to prioritize low-water or no-water cooling options, particularly in regions of current and projected high water stress. Some developers are already making such choices. • Retool existing plants. Owners and operators of existing power plants with substantial effects on the supply or quality of water in water-stressed regions could consider retrofitting to low-water cooling. • Set strong guidelines for power plant water use. Public officials can draw on good information on electricity's thirst to help owners of existing and proposed power plants avert energy-water collisions. Public utility commissions, which oversee the plans of utilities and specific plant proposals, can encourage or require investments that curb adverse effects on water supply or quality, particularly in areas of current or projected water stress. Legislators also have a stake in averting energy-water collisions.
Water for Energy: Future Water Needs for Electricity in the Intermountain West	Heather Cooley; Julian Fulton; Peter H. Gleick	Pacific Institute	11/1/2011	http://www.pacinst.org/reports/water_for_energy/water_for_energy.pdf	W-E	Water for energy production; water availability; resource conflicts; trends in energy use, water demand, and water availability; sustainable use; energy efficiency improvements; dry cooling systems; climate change	Conclusions • Water scarcity affects energy production. • Sustainable water and energy use requires integrated study and management. • Under a business-as-usual approach, water resource challenges are likely to intensify throughout the Intermountain West. • Electricity can be generated in the Intermountain West using less water, especially with the adoption of energy-efficiency improvements and dry cooling systems and greater reliance on renewables. • Extracting fuels for energy production has a water cost that must be evaluated. • Climate change will have major implications for water resources and electricity in the Intermountain West. • The production of electricity affects water quality and human and environmental health. Recommendations • Improve data, information, and education on impact of energy sector on water resources. • Accelerate efficiency improvements. • Promote renewable energy systems. • Establish cooling-technology requirements. • Promote switching to alternative water sources. • Expand research and development efforts.
Implications of Future Water Supply Sources for Energy Demands	Heather Cooley; Robert Wilkinson	WRRF	1/1/2012	http://www.pacinst.org/resources/wesim/report.pdf	E-W	Water-energy; energy, greenhouse gas implications; water provision and use; energy intensity of water sector	This report provides background information on the Water-Energy Simulator (WESim) model, including its basic forma and structure. A detailed user guide for WESim is included as a companion to this report.

GEI Consultants

Alliance for Water Efficiency

ACEEE American Council for an Energy-Efficient Economy

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The Energy-Water Nexus: Managing the Links between Energy and Water for a Sustainable Future	Karen Hussey; Jamie Pittock	Ecology and Society	1/1/2012	http://www.ecologyandsociety.org/vol17/iss1/art31/	BOTH	Security of supply; sustainability; economic efficiency; energy and water sectors; challenges; policy framework; trade-offs; desalination plants; inter-basin transfers; groundwater pumping; first-generation biofuels; hydropower plants; decentralized water supply solutions; rainwater tanks; modern irrigation techniques; Australia; Europe; United States; policy and management strategies and solutions; integration	The First Four Steps to Achieving Sustainable Energy and Water Security 1. Review the carrying capacity (environment and social dimensions included) of a given region/state in relation to water supply and energy production. 2. Undertake a review (ideally collaboratively with other jurisdictions and stakeholders) of all data needs, availability, gaps, and quality; other relevant jurisdictions' available data sets and data collection methodologies with a view to filling gaps; other relevant jurisdictions' institutional arrangements and regulatory frameworks related to the energy and water sectors; key stakeholders for future planning processes. 3. Undertake basic scenario analysis that integrates existing water and energy forecasting data for a given region/state with available data on energy and water footprinting. Having identified the dynamics of the energy–water mix of your region, link available projections of climate and other pressures/changes to ascertain the risks, vulnerabilities, and resilience of relevant social systems. 4. Review existing policies to identify where negative incentives or positive synergies may exist, what the key drivers are; and, where possible, quantify the potential economic impacts of removing negative incentives and adopting positive ones. 5. Promote the use of existing or emerging technologies that exploit the potential for more efficient, cost effective, sustainable, and local closed-loop solutions. Review the potential for certification and labeling of embodied water and energy use on all products, and engage with existing communities to do so. Consider valuation mechanisms (ecosystem services) that can be used as drivers for more sustainable use. Consider how to internalize externalities (environmental and social costs).
Burning Our Rivers: The Water Footprint of Electricity	Wendy Wilson, Travis Leipzig & Bevan Griffiths-Sattenspiel	The River Network	4/1/2012	http://www.rivernetwork.org/sites/default/files/BurningOurRivers_0.pdf	W-E	Energy generation; water use; water footprint; energy effciency; conservation	Key Findings: The authors conclude that approximately 42 gallons of freshwater was consumed, withdrawn and/or used to produce the average kilowatt hour of electricity in the U.S in 2009. Water is impacted by passing through turbines (straining out and damaging aquatic life), evaporating from cooling systems, warming in reservoirs (with impacts to aquatic life and water quality), or through chemical pollutants. The nation could potentially reduce the "water footprint of the electricity" by an order of magnitude. Barriers to change include inadequate water-use reporting, economic under-valuation of fresh water and lack of accounting for the costs of water pollution.
Fueling America and the Energy Water Nexus: How and Why it impacts the nexus and what next		Atlantic Council - ideas, influence and impact	5/1/2012	http://www.acus.org/files/EnergyEnvironment/062212_EEP_FuelingAmericaEnergyWaterNexus.pdf	BOTH	Drivers; issues for water and primary/transportation fuels	• Congressional action is needed more than ever but is unlikely, federal bureaucracy hinders progress, conflicts in Fed/State roles undermine development of water management policies, comprehensive - up to date energy and water nexus data is lacking, biofuel policies reduce fossil fuel usage but incur water costs, coal mining requires continued efforts to protect local water quality amid concerns whether regulations are effective, shale oil and gas revolution raises water quantity and quality issues, shifting regulatory and political agendas are leading to an uncertain regulatory outlook • Recommendations: Publish tech roadmap, create a presidentially appointed task force, improve coordination between agencies, new paradigm of cooperation, decentralize water management to watershed level, improve clean water act and the safe drinking water act, congress should direct full funding for USGS, apply appropriate pricing and rate design, integrate climate change impacts into water resource planning, focus as many resources as possible on water demand reductions, rethink water supply initiatives, improve hydro resources, recognize adverse tech developments, encourage stakeholders to pressure congress and the administration to move forward, find examples of good and bad policy
Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction	Heather Cooley; Kristina Donnelly	Pacific Institute	6/1/2012	http://www.pacinst.org/reports/fracking/full_report.pdf	W-E	Natural gas production; hydraulic fracturing; fracking; impacts of water resources; shale gas	• key water-related concerns: (1) water withdrawals; (2) groundwater contamination associated with well drilling and production; (3) wastewater management; (4) truck traffic and its impacts on water quality; (5) surface spills and leaks; and (6) stormwater management. • identified the overall water requirements of hydraulic fracturing and the quantity and quality of wastewater generated as key issues • Most significantly, a lack of credible and comprehensive data and information is a major impediment to identify or clearly assess the key water-related risks associated with hydraulic fracturing and to develop sound policies to minimize those risks • The dialog about hydraulic fracturing has been marked by confusion and obfuscation due to a lack of clarity about the terms used to characterize the process. Additional work is needed to clarify terms and definitions associated with hydraulic fracturing to support more fruitful and informed dialog and to develop appropriate energy, water, and environmental policy

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Hydropower : Federal and Nonfederal Investment	Kelsi Bracmort, Charles V. Stern, Adam Vann	Congressional Research Service	6/26/2012	http://www.fas.org/sgp/crs/misc/R42579.pdf	W-E	Federal government involvement, hydropower generation; regulation of nonfederal hydropower generation; current roles; processes; common concerns	• Conventional hydropower accounted for approximately 6% of total U.S. net electricity generation in 2010. Its advantages include its status as a continuous, or baseload, power source that releases minimal air pollutants during power generation relative to fossil fuels. Some of its disadvantages, depending on the type of hydropower plant, include high initial capital costs, ecosystem disruption, and reduced generation during low water years and seasons. • Congress faces several issues as it determines how hydropower fits into a changing energy and economic landscape: -increasing federal funding -utilizing alternative funding -privatizing federally owned dams -encouraging additional small-capacity generators -whether to significantly expand or encourage expansion of hydropower • Potential expansion of hydropower projects could take place by improving efficiency at existing projects or by building new projects, or both. • Another issue is the rate at which FERC issues licenses for nonfederal projects, which is slower than some find ideal.
Energy-Water Nexus Coordinated Federal Approach Needed to Better Manage Energy and Water Tradeoffs	USGAO	USGAO	9/1/2012	http://www.gao.gov/assets/650/648306.pdf	BOTH	Aquifer recharge rates; biofuel; water resources; congress; water use policies; technologies; hydrological processes; national policy	•Location greatly influences extent to which energy/ water affect one another. For example, impact of increased biofuel production on water resources will depend on where feedstock grown, whether or not irrigation required. It is important for Congress/fed agencies to consider effects national energy production/water use policies can have at local level. •Although technologies/ approaches exist to reduce the impact of energy development on water resources and reduce the energy needed to move, use, and treat water, widespread adoption inhibited by barriers such as economic feasibility and regulatory challenges. Congress/fed agencies need to be cognizant of barriers when deciding whether to promote adoption of these technologies/approaches. •Making effective policy choices will continue to be challenging w/o more comprehensive data/research. • Improved energy/water planning will require better coordination among fed agencies/other stakeholders. Improved planning will require fed agencies to work w/one another/other stakeholders, such as state/local agencies, academia, industry, environmental groups. •Uncertainties affecting energy/water resources cannot be ignored-they could significantly affect future supply/demand of both resources.
A Powerful Thirst - Managing the Electricity Sector's Water Needs and the Risk of Drought	Stacy Tellinghuisen	Western Resource Advocates	10/1/2012	http://www.westernresourceadvocates.org/media/pdf/powerfulthirstreport2012.pdf	W-E	Clean energy policies; water use reduction; drought on electricity production; mitigating the impact of future droughts	• In the Interior West, policies that have supported renewable energy, energy efficiency, and the retirement of older coal plants have contributed to a reduction in the energy sector's water demands. These water savings are valuable; they can help mitigate the risk of future water shortages. • Utilities should analyze and report current and future water use in resource plans. • Utilities should comprehensively value the water used for current and future energy generation. • Regulators and utilities should analyze and recognize the benefits of water-efficient electric energy resources, which provide a hedge against the potential impacts of drought on the electric system. • Utilities, regulators, and state or federal agencies developing long-range energy plans should act upon these analyses.
Water-related energy in households: a model designed to understand the current state and simulate possible measures.	Kenway, S. J., R. Scheidegger, T. A. Larsen, P. Lant. and H. P. Bader,	The University of Queensland and Eawag	1/1/2013	EnergyandBuildings.58:378-389	E-W	Urban water; energy; greenhouse gas emissions; costs; direct; indirect; technology; behaviour; Australia; model	• In order to understand energy use related to water in households a detailed mathematical flow analysis of materials, energy, CO2 emissions and costs (MMFA) for household water use was set up and tested for a specific family household in Brisbane, Australia. • The simulation results for the current state of this household were well within 20% of the monitored data. After calibration, a detailed scenario investigation determined the impact of (i) potential and (ii) realistic reduction values for all relevant (a) behavioural and (b) technical parameters, including a shift from gas to a solar hot-water system. • The reduction potentials for water use, greenhouse gas emissions, water-related energy con-sumption, water costs and water-related energy costs were 4–77%, 14–85%, 15–93%, 1–31% and 13–90% respectively. • The study showed that for this household, technical improvements alone, without changing to a solar hot-water system, result in less than a 15% change in terms of energy and greenhouse gas emissions. In contrast, combined behavioural and technical changes have a much higher reduction potential.
Managing water-related energy in future cities - a research and policy roadmap.	Kenway, S., J. McMahon, V. Elmer, S. Conrad, and J. Rosenblum.	The University of Queensland and Lawrence Berkeley National Laboratory	1/1/2013	JournalofWaterandClimateChange(inpress)	E-W	Energy; future cities; greenhouse gas emissions; urban metabolism; water; research; policy; priority; method	• International workshop established vision of future cities, including elements of success, research needs, barriers. • Survey estimate potential, effort, "potential-to-effort" ratio of suggested elements. • First suggested steps in roadmap include: development of educational programs, combined standards, guidelines, funding and planning for water and energy efficiency, improved understanding and management of factors motivating consumers, and improved methods to quantify and track targets of "water-related energy and related greenhouse gas emissions". • "Roadmap" could help streamline future effort and sequencing action. The authors note and reflect on the importance of representation at such a workshop, and an effort is made to understand sources of variability in viewpoints.

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Tackling the Nexus: Exemplary Programs that Save Both Energy and Water	Rachel Young and Eric Mackres	ACEEE, AWE	1/1/2013	http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=8340	E-W	Energy saving programs; water saving programs; efficiency; U.S.; Canada; Australia; multiple sectors	• first in-depth look at efficiency programs that save both water and energy and are being implemented across the country • provides a directory of programs and their design details, implementation, and performance, as well as being cost-effective and replicable in manner • key elements to successful programs • lessons learned
Water Demand for Energy to Double by 2035	Marianne Lavelle; Thomas K. Grose	National Geographic News	1/30/2013	http://news.nationalgeographic.com/news/energy/2013/01/130130-water-demand-for-energy-to-double-by-2035/	W-E	Water for energy production; coal-fired electricity; biofuel; natural gas; water scarcity; cooling technology; dry cooling; fracking	• If today's policies remain in place, the IEA calculates that water consumed for energy production would increase from 66 billion cubic meters (bcm) today to 135 bcm annually by 2035. • Coal-fired power plants = 51.9% of water used for energy; biofuel = 30.4% of water used for energy • Coal-power will drive water use in future; If today's trends hold steady on the number of coal plants coming on line and the cooling technologies being employed, water consumption for coal electricity would jump 84 percent, from 38 to 70 billion cubic meters annually by 2035 • Nuclear plants will not be a large consumer of water (fewer and fewer plants in operation) • Coal power could cut water consumption through use of "dry cooling" systems. Such plants cost three or four times more than wet cooling plants. Also, dry cooling plants generate less efficiently. • Wind and solar photovoltaic power have such minimal water needs they account for less than one percent of water consumption for energy now and in the future. Natural gas power plants use less water. While providing 23 percent of today's electricity, gas plants account for just 2 percent of today's energy water consumption, shares that essentially would hold steady through 2035 under current policies. • Low carbon does not equal low-water • 242 percent increase in water consumption for biofuel production by 2035, from 12 billion cubic meters to 41 bcm annually. • biofuels' contribution will edge up to just 5 percent of the world's (greatly increased) transportation demand by 2035, but fuel processed from plant material will by then be drinking 72 percent of the water in primary energy production • Water consumption for natural gas production would increase 86 percent to 2.85 billion cubic meters by 2035, when the world will produce 61 percent more natural gas than it does today • water consumption for oil production would slightly outpace oil production itself, growing 36 percent in a world producing 25 percent more oil than today • localized stresses to production of fossil fuels due to water scarcity and competition—in North Dakota, in Iraq, in the Canadian oil sands.
Colorado Water and Energy Research Center		University of Colorado, CWERC		http://www.outreach.colorado.edu/programs/details/id/392	W-E	Hydrologic impacts of natural gas development; groundwater/surface water monitoring program baseline protocols; information exchange btwn researchers and regulators; natural gas extraction; best practices recommendations; industry mitigation activities	This is a program website with descriptions of the research being done.
Energy Efficiency Best Practices for North American Drinking Water Utilities	Vanessa Leiby, Cadmus Group; Michael Burke, CH2M Hill	Water Research Foundation, NYSERDA	2011	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Drinking water; energy optimization; energy efficiency; energy audit	Recommendations: energy efficiency improvement can be done by utilities of all sizes and requires leadership commitment at the executive level and operator buy-in to be successful; Optimizing energy use is a way to save money, promote environmental stewardship, and improve sustainability; vital to allocate adequate resources for staff training and equipment maintenance; Partnerships with the energy providers; target improvements to pumps and motors since pumping accounts for up to 90 percent of the energy used at most water utilities; energy audits; monitoring; see document for detailed findings

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Electricity Generation from Anaerobic Wastewater Treatment in Microbial Fuel Cells	University of Connecticut; HydroQual Inc.; Fuss & O'Neill Engineers; Baikun Li	WERF, NYSERDA	5/23/2011	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Microbial fuel cell (MFC); wastewater; carbonaceous oxygen demand; hydraulic retention time; catalyst; pilot-scale	This project tested anaerobic microbial fuel cell (MFC) treatment of domestic wastewater and produced sustainable electricity at the pilot scale. The team developed a novel MFC system in a multiple anode/cathode granular activated carbon configuration (MAC-GACMFC); effectively integrating multiple MFCs into a single unit. The unique advantage of this novel configuration is increased power generation in a small footprint, which is beneficial when considering wastewater treatment plant applications. Four pilot-scale, 16-liter (L) MAC-GACMFCs were operated over a six-month period, with the primary focus on organic loading rate and hydraulic retention time (HRT). The MAC-GACMFCs achieved COD removal exceeding 80%, and effective power densities on the order of 300 mW/m3. • MAC-GACMFC is a promising microbial fuel cell configuration that integrates multiple fuel cells into a single unit. The system achieves excellent wastewater treatment efficiency and produces power when treating actual domestic wastewater. • By growing biofilms on GAC particles, MAC-GACMFCs improve power generation. • Operational parameters, COD and HRT, affect MFC performance. Sufficient time is needed for contact between biofilms and substrates. • Oxygen reduction at the cathode limits the power generation. Electrode numbers, instead of electrode areas, improve power generation. Therefore, MAC-GACMFC substantially increases power generation when compared with single-anode/cathode MFC. • MnO2 catalyst demonstrated good power generation and efficient wastewater treatment, and reveals great promise for replacing platinum. • MAC-GACMFC has the potential to be applied in wastewater treatment plants to achieve self-sustainable treatment processes, but improvements should be identified through future research to enhance power conversion efficiency and ensure stable operation.
Alternative Treatment and Energy Management Town of Windham Wastewater Treatment Plant	Town of Windham, NY	NYSERDA	9-Dec	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Membrane bioreactor (MBR); energy efficiency; enhanced nutrient removal; small footprint; Windham NY	Savings in electrical, chemical, and residuals disposal costs are achieved in the piloted system; Recommendations: piloted system be used in the retrofit of an underperforming WWTP in a critical watershed, retrofit would comply with guidelines of NYS Green Innovation Grant Program; see docment for detailed findings
Statewide Assessment of Energy Use by the Municipal Water and Wastewater Sector	Matthew Yonkin; Malcolm Pirnie, Inc.	NYSERDA	8-Nov	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Electric energy use; municipal water sector; wastewater sector; trends and impact on electric energy use; biogas recovery; biogas generation potential; electric production potential; energy conservation measures	NYSERDA contracted with Malcolm Pirnie, Inc. (Malcolm Pirnie) and its subconsultant, Strategic Power Management, LLC (SPM) to conduct an assessment of energy use by New York State's municipal water and wastewater treatment sector. Using information from publicly available datasets and supplemented with facility information obtained through mailed survey instruments, the overarching goal of the assessment was to evaluate the potential for energy efficiency and energy production improvements in the municipal water and wastewater sector of New York.
Energy Efficient Sludge Management Evaluation for Reduced Energy Consumption	Frank Miller	NYSERDA	8-Aug	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Filtration; dewatering; wastewater sludge; drinking water filtration sludge; sludge dewatering; spent diatomaceous earth dewatering; spent de dewatering	This trademarked technology achieved dewatering performance consistent with conventional dewatering technologies at a significant reduction in labor and energy. Consistent levels of dewatering were achieved on municipal wastewater treatment sludge in excess of 20% solids and in excess of 35% solids on municipal drinking water treatment sludge. See full document for specific benefits to this technology.
Anaerobic Digester Gas-to-Electricity for the Muncipal Wastewater Sector in New York State	Malcolm Pirnie, Inc.	NYSERDA	7-Nov	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Electrical production potential; biogas; New York; wastewater treatment plant	Surveys were sent to the 590 municipal WWTPs as part of a Statewide Energy Assessment (conducted under a separate contract). Roughly 20%, 145 of the 590 WWTPs, have anaerobic digestion facilities in place. As part of this Market Characterization, significant follow-up efforts were focused on these 145 WWTPs, as they represent approximately 75% of the overall wastewater treatment capacity within the State.
Energy Index Development for Benchmarking Water and Wastewater Utilities	Steven Carlson, Adam Walburger; CDH Energy Corp.	AWWARF, NYSERDA	7-Jun	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Comparison; energy utilities; water utilities; wastewater treatment plants; normalized data; plant configuerations	This project sought to develop metrics that allow comparison of energy use among wastewater treatment plants and among water utilities. These comparisons normalized away multiple factors such as specific plant configurations or loading that historically made such comparisons challenging.

Water and Energy Nexus Research Database

Paper Title	Author	Organization	Date	Link	E-W, W-E or Both	Key Words	Key Findings
NYSERDA Submetering Program Summary Report	Stearns & Wheler, LLC.	NYSERDA	6-Oct	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Submetering; New York; wastewater treatment plant	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 energy and process data collected resulted in calculated energy use per unit and assist in making process efficiency comparison between the various monitored plants. Each treatment plant has existing conditions making each application a unique project. Energy saving measures have been found at each of the evaluated plants. Process performance was evaluated and compared to plant flow rate calculations. Capital improvements were recommended with manageable calculated payback periods. Energy saving trends within specific treatment processes were reported.
Municipal Wastewater Treatment Plant Energy Evaluation Summary Report	Jerry Kleyman; Malcolm Pirnie, Inc.	NYSERDA	6-Mar	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	New York; energy conservation measures; submertering; wasewater treatment	A total of eight facilities across the state, varying in sizes from 3.5 MGD to 135 MGD, participated in this study. Submetering at each facility was conducted over a six-to-eight week period, along with a simultaneous process data collection effort for the processes being submetered. The submetering and process data were evaluated to develop an energy usage breakdown by different WWTP processes. Additionally, the data were evaluated to establish benchmarks for energy consumption per MGD of treated wastewater and pound of BOD destroyed.
Online Process Monitoring and Electric Submetering at Six Municipal Wastewater Treatment Plants	Linda Ferguson, Peter Keenan; CH2MHill, Inc.	NYSERDA	Jul-98	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Electrical submetering; energy conservation opportunities (ECOs); municipal wastewater treatment plant; New York State; size (flow rate); location; treatment technologies; sludge management practices	An investigation was made of New York State wastewater treatment plants (WWTPs) to determine if process audit and electrical submetering techniques are an effective method of identifying energy conservation opportunities (ECOs) at municipal wastewater treatment plants. The study at six municipal WWTPs included a range of facility sizes, locations, and treatment technologies. A combination of online process monitoring, offline sampling, electrical submetering, and specific performance efficiency testing techniques was used to obtain real-time process and electrical consumption data.
Wastewater Treatment and Sludge Management: Energy Reference Guide	David Smith, Karen Clark; Malcolm Pirnie, Inc.	NYSERDA	Oct-95	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Municipal wastewater treatment; energy efficiency; demand-side management; environment	This report summarizes the efforts of a multi-year evaluation undertaken by the New York State Energy Research and Development Authority in cooperation with the New York State Environmental Facilities Corporation and the New York State Department of Environmental Conservation. The focus was to evaluate 24 wastewater treatment plants (WWTPs) throughout New York State with respect to energy efficiency.
Energy Efficiency in Municipal Wastewater Treatment Plants: Technology Assessment	Lawrence Pakenas	NYSERDA	Sep-95	http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Final-Reports-for-Water-and-Wastewater-Technology-and-Demonstration-Projects.aspx	E-W	Fuel; biogas; anaerobic digestion; sewage sludge; natural gas; fuel oil; sludge management practices; plant heating; cooling.	This report presents the project overview, an introduction to energy conservation at WWTPs, treatment processes and potential energy conservation measures and summaries of the case studies conducted for the municipalities.
Survey of High-Recovery and Zero Liquid Discharge Technologies for Water Utilities	Michael Mickley	WateReuse Foundation	1/1/2008	http://www.swrcb.ca.gov/water_issues/programs/grants_loans/water_recycling/research/02_006a_01.pdf		High-recovery; zero liquid discharge; water utilities; performance analysis; cost analysis; volume minimizationregulatory issues	1. Cost reductions are necessary for applications of most high recovery and ZLD processing schemes. Research should be conducted to address reductions in capital costs and operating costs due to energy and chemical requirements. 2. Newer commercial technologies (Geo-Processors SAL-PROC, EET Corporation's HEEPM, New Logic's VSEP, and O'Brien & Gere's ARROW) be piloted and benchmarked against more traditional high-recovery and ZLD approaches. 3. Future analyses needs to consider the effects of water quality (salinity and composition) on each processing step to ensure good cost prjections. 4. Detailed water quality analyses needs to be done to determine if resulting brine or solids may be hazardous. 5. Knowledge needs to be developed that acknowledges the real cost and environmental consequences of large scale brine disposal for inland desalination plants.
Use of Degraded Water Sources as Cooling Water in Power Plants	Dr. Carl E. Adams, Jr.	ENVIRON	3/13/2013	http://www2.epa.gov/sites/production/files/documents/adams.pdf	W-E	Zero water discharge; hydrofracturing; freshwater supplement; disposal costs; chemical additives; management plan; treatment; disposal; reliability	• Presentation - no paper found • Synopsis of zero water discharge management for hydrofracturing including objectives/goals, development of industrial wastewater management program, WW treatment/disposal options, major technology categories, evaluation categories Recommended work • Confirmation of approach and realistic economics o Task 1. Bench-scale laboratory screening investigation o Task 2. Small-scale field confirmation o Task 3. Full-scale field performance

GEI Consultants

Alliance for Water Efficiency

ACEEE American Council for an Energy-Efficient Economy

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Integrated Approach to Water/Wastewater Treatment at Zero Liquid Discharge, Combined Cycle Power Plants	Dave Ciszewski	GE	2/1/2011	http://www.gewater.com/pdf/Technical%20Papers_Cust/Americas/English/TP1043EN.pdf	W-E	Zero liquid discharge; water treatment; wastewater treatment; power plants; integrated treatment; case studies	The integrated approach at TIE Guadalupe yielded the customer the following benefits: • Significant reduction in the sludge produced compared with the original design concept, reducing landfill disposal costs up to 25%. • A simplified process design with more operating flexibility for feed chemistry fluctuations and flow rates. • A single-source supplier dramatically reducing the overall schedule and providing single-point accountability and more efficient supplier management. • Common integrated control system for monitoring the entire water and wastewater treatment plant, which allowed for reduced operator requirements. The integrated system installed at the Ironwood power plant provided the following benefits: • Optimized recirculating cooling tower treatment program. • Elimination of the lime softener clarifier minimized addition of bulk chemical and reduced off-site sludge disposal requirements by up to 40%. • Simplified treatment system with fewer unit operations, yet flexible enough to accommodate chemistry variations in the make-up water. • Shorter contract schedule and more efficient supplier management by utilization of a single-source supplier for the entire plant water/wastewater treatment system. • Common, integrated control system interface for all the plant water and wastewater treatment functions allowing for streamlined operation and fewer operators.
Getting to Zero Discharge: How to Recycle That Last Bit of Really Bad Wastewater	Joe Bostjancic, Rodi Ludlum	GE	2/1/2011	http://www.gewater.com/pdf/Technical%20Papers_Cust/Americas/English/TP1041EN.pdf	W-E	Evaporation; crystallization; spray drying; recycle; reuse; case studies; wastewater	• Typically 95% of the wastewater feed will be converted to distillate (<10 ppm [mg/L] TDS) for reuse in the plant. • Case One: Montana Baseload Power, 1976 Evaporator/Solar Ponds - Distillate is used as boiler makeup, with the remaining concentrated brine sent to a series of solar evaporation ponds on site. Climate, terrain and the remote locations of the first zero discharge plants made solar ponds a sensible option. • Case Two: Florida Power, 1981 Evaporator/Spray dryer - Concentrated brine is sent to a spray dryer at the rate of about 2 to 4 gpm (0.01 to 0.02 m3/h) and reduced to solids for disposal at a landfill on site. Dry solids production averages about 20 tons per week. • Case Three: Virginia Power, 1991 Evaporator/Crystallizer - A small amount of the brine evaporates and crystals form. Most of the brine is recirculated back to the heater; a small stream is sent to a filter press for final dewatering to a 20% moisture content. Filter cake from the press is dis-charged at the rate of about 365 pounds per hour. • Case Four: Polish Coal Mine, 1992 RO/Evaporator/Crystallizer - Nearly three million gallons per day of mine drain-age is preconcentrated with reverse osmosis before is sent to two RCC Vapor Compression Evaporators at the rate of about 800 gpm (3 m3/h). Because of the high levels of sodium chloride in the mine drain-age, Polish engineers also chose to recover commercial grade sodium chloride from the con-centrated brine. This is sold at about US$100 per ton to help offset the cost of pollution control. • Case Five: Florida Cogeneration, 1993 RCC Calandria Cyrstallizer - Calandria Crystallizer: In the early 90's, researchers developed an inexpensive crystallizer to reduce wastewater to dry solids. The process, used at several Florida cogeneration plants, is suitable for low volume (~2 gpm [0.01 m3/h]) wastewaters. The design is an updated version of a 100-year-old crystallizer called a calandria.
Reducing Wastewater to Dryness: Zero Liquid Discharge Case Studies at New Power Plants	J. Bostjancic, R. Ludlum	GE	2/1/2011	http://www.ionics.com/pdf/Technical%20Papers_Cust/Americas/English/TP1046EN.pdf	W-E	Zero liquid discharge; wastewater; power plants; crystallizer; case studies; Florida; evaporators	• Case One: 920 MW Coal-Fired Baseload Power Plant – evaporation/crystallization. Designed to produce 26,000 lbs/day of solids. o Energy savings: The new evaporator was designed with extra-long heat transfer tubes (65 feet [20 m] vs. the normal 50 feet [15 m]). The longer tubes increased capital cost by US$150,000 but is designed to reduce the energy requirement to about 18 kWh per 264 gallon (1 m3) of feed. A typical energy requirement for a 600 gpm (140 m3/h) evaporator would be about 25 kWh per 264 gallon (1 m3) of feed. Figuring electrical costs at US$0.05 per kWh, long tubes should save the plant about US$425,000 per year in energy costs. • Case Two: 250 MW Coal-Fired Cogeneration Plant – uses wastewater from steam host, evaporator crystallizer, lined pond, wastewater treatment/reuse. Produces 83,000 lbs/day of solids for landfill. • Case Three: 150 MW Combined-Cycle Cogeneration Plant – Evaporator/crystallizer. Evaporator distillate is used for cooling tower makeup; waste brine is sent to the crystallizer. All crystallizer vapor is sent directly to the condenser. Slurry from the crystallizer is sent to a filter press for final dewatering. The filter press produces about 2,200 pounds (1,000 kg) of solids per day.
Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling		SWRCB, CalEPA	3/1/2008	http://www.energy.ca.gov/2008publications/SWRCB-1000-2008-001/SWRCB-1000-2008-001.PDF	W-E	Scoping document; thermal electric power plant; cooling; once through cooling; OTC; California; policy; Clean Water Act; biological impacts	• This scoping document is intended to provide the public with a preliminary proposal for a state policy (draft attached in Appendix A) and supporting documentation. This scoping document will describe the current status and biological impacts of power plants situated along the California coastline and within coastal estuaries. The purpose of the proposed project is to describe the rational and support for a statewide policy to implement section 316(b) of the Clean Water Act. • Statement of Goals: To adopt a statewide policy to implement Clean Water Act section 316(b) that controls the harmful effects of once through cooling water intake structures on marine and estuarine life.
The connection between water and energy in cities: a review	S. J. Kenway, P. A. Lant, A. Priestley and P. Daniels	IWA	1/1/2011	http://www.iwaponline.com/wst/06309/09/default.htm	E-W	Water energy nexus; review; urban metabolism; cities	The lack of application of a consistent theoretical framework and method is a major gap; however this is not to be unexpected given the infancy of the overall research effort. A consistent framework however would have a tremendous impact on our understanding of the linkages of relevance. A well developed theoretical framework may help to classify or group cities based on their relative performance. It could help differentiate urban performance, and help our understanding move from specific situations though to general principles. Such analysis would have numerous practical examples including helping to quantify what comprises a water-sensitive city.

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The Water-Energy Nexus and Urban Metabolism Identification, Quantification and Interpretation of the Connections in Cities	Steven John Kenway	The University of Queensland	4/30/2012	http://espace.library.uq.edu.au/view/UQ:278404	E-W	Water; energy; greenhouse gas emissions; urban metabolism; cities; performance indicator; research priorities	This paper has outlined a vision for cities seeking greater efficiency in water and energy. It is clear that there is significant action, research and policy development necessary to achieve this vision. Those areas having the highest priority included education programs – at multiple levels - and development of combined water and energy standards, guidelines and planning processes. A clear methodology for determining water-related energy is needed, as are targets. Improved understanding of what motivates people and their consumption of water and energy will be necessary. Many more exist. Further effort is required to translate the priority areas identified into structured research questions and projects. Collaboration across the water and energy sectors, research, industry, government, not-for-profit and private sectors is necessary. Formation of a research "consortium" or alliance across the various affected parties, organisations and research bodies could be a highly effective way of progressing. To achieve this, a research agenda with wide endorsement would be required. Such an effort could help unite the many component pieces of information and enable a collective picture to progressively emerge. Special effort should be given to include political representation.
Water Energy Roadmap 2006: Integrated Planning Group	AWWA, ASCE, ASME, DOE	Sandia Labs	1/1/2006	http://www.iwaponline.com/wst/06309/09/default.htm	E-W	Water for energy production; water availability; resource conflicts; trends in energy use, water demand, and water availability; sustainable use; energy efficiency improvements; dry cooling systems; climate change	Various findings in areas of integrated planning, policy development, long term water/energy planning, economic policy models, hydro power, and other intergrated planning.
Challenges at Energy-Water-Carbon Intersections	PMSEIC Expert Working Group	Australian Government	1/1/2010	http://www.chiefscientist.gov.au/wp-content/uploads/FINAL_EnergyWaterCarbon_for_WEB.pdf	E-W	water energy nexus, review, carbon footprint, emissions, climate change, interconnections	path to energy-water-carbon resilience for Australia: (1) consistent principles for the use of finite resources of water and carbon emissions; (2) improving the distribution and use of energy and water with smart networks; enhancing the energy-water-carbon sustainability of (3) landscapes and (4) the built environments in cities and towns; and (5) enhancing Australia's knowledge and learning capabilities to meet new demands for integrative knowledge. All of the recommendations span sectors and industries. Our focus is on developing the knowledge, systems and approaches needed to address challenges that demand long-term transformations, rather than advocating particular solutions in particular places. The recommendations cover a range of time scales, from short-term and focused to long-term and transformational. While the recommendations are designed as a complete set, implementation begins with short-term steps. This does not lessen the importance of long-term recommendations, but it does mean that not everything has to be done at once.
Water, Energy and Climate Change	James Griffiths , Eva Zabey , Anne-Léonore Boffi	World Buisness Council for Sustainable Development	3/1/2009	http://www.worldwewant2015.org/node/317835	W-E	Water; energy; climate change; ecosystem; innovation; technology; renewable energy	Water and energy are inextricably linked Global energy and water demand are increasing Both water use and energy use impact and depend on ecosystems Climate change will affect availability and use of both water and energy Technology, innovation, a sense of shared responsibility and political will are factors that bring real solutions as we strive to keep pace with increasing needs from a growing population
Greenhouse-gas emissions from energy use in the water sector	Sabrina G. S. A. Rothausen and Declan Conway	Nature Climate Change	6/26/2011	http://www.nature.com/nclimate/journal/v1/n4/abs/nclimate1147.html	E-W	Greenhouse gases; emissions; water energy nexus; climate change; carbon	Although results of assessments in the sector are becoming available, these are generally limited to the grey literature (less so for irrigation water use). Progress in the UK and the US, notably California, has been primarily in response to regulatory requirements to monitor and reduce GHG emissions in the water industry, and to growing concern about water and energy security. In countries with extensive groundwater-based irrigation such as India and China, concern about energy use and access has stimulated interest in the issue. What evidence there is shows that energy use in the water sector is considerable and growing. This growth is likely to continue, sometimes as an unintended policy outcome, with greater pressure to use and maintain quality of water resources. Despite some recent progress, we need to better understand and profile the role of the water sector as a GHG emitter. A coordinated view of the water sector, with clear sector boundaries, will promote more comprehensive assessments of energy use. Standardized methodologies will enable comparisons between assessments of different technologies and processes, and between regions or countries. The water sector faces great challenges during the coming decades. Greater focus on its energy requirements will be a crucial part of the policy response to these challenges.
Challenge Projects on Low Energy Treatment Schemes for Water Reuse - Phase I - Carollo Engineers, Inc.	Andrew T Salveson,	Carollo Engineers, Inc.	5/8/2013	http://www.werf.org/a/k/Search/ResearchProfile.aspx?ReportID=ENER2C12a	E-W	Water reuse; low energy treatment; emerging treatment systems	(For fee research paper: key findings/recommendations not available) Documents the process used by the research team to identify potential emerging technologies for low energy treatment. Using a combination of cited literature and internal knowledge, the project team sorted through emerging treatment systems and innovative treatment concepts which have great potential for low energy wastewater treatment and wastewater reclamation. This was a cooperative project co-funded by WERF and the WateReuse Research Foundation.

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Challenge Projects on Low Energy Treatment Schemes for Water Reuse: Phase 1 – Univ of Nevada, Reno	Eric Marchand,	Univ of Nevada, Reno	5/8/2013	http://www.werf.org/a/k/Search/ResearchProfile.aspx?ReportID=ENER2C12b	E-W	Multi barrier systems; wastewater; emerging technologies; membranes; models	(For fee research paper: key findings/recommendations not available) Investigates the use of a multi-barrier system to produce a potable effluent from a common wastewater influent, while remaining cost competitive with current wastewater treatment. The proposed design combines new and emerging membrane technologies with innovative methods of solids management to create a comprehensive treatment system. In order to maintain a low-energy profile, the design includes sustainability measures, such as methane harvesting and struvite capture. The project included a comprehensive literature review of the selected unit processes, the development of a computer model of the system, and an energy balance using model data. This was a cooperative project co-funded by WERF and the WateReuse Research Foundation.
Challenge Projects on Low Energy Treatment Schemes for Water Reuse: Phase 1 – Univ of Notre Dame	Robert Nerenberg	University of Notre Dame	5/8/2013	http://www.werf.org/a/k/Search/ResearchProfile.aspx?ReportID=ENER2C12c	E-W	Energy costs; energy savings; biofilm reactor; membrane biofilm reactor; activated sludge; wastewater	(For fee research paper: key findings/recommendations not available) Shows the potential energy and cost savings of a novel biofilm reactor technology based on membrane aerated biofilm reactors (MABR) in comparison to conventional activated sludge (CAS) for water and wastewater treatment. The report focuses on a comparison of energy consumptions for both processes and cost estimations based on reference membrane and electricity prices for retrofit configurations. This was a cooperative project co-funded by WERF and the WateReuse Research Foundation.
Challenge Projects on Low Energy Treatment Schemes for Water Reuse - Phase I - University of Michigan	Steven J. Skerlos	University of Michigan	5/8/2013	http://www.werf.org/a/k/Search/ResearchProfile.aspx?ReportID=ENER2C12d	E-W	Anaerobic membrane bioreactor; bioreactor; activated sludge; wastewater	(For fee research paper: key findings/recommendations not available) Evaluates anaerobic membrane bioreactor (AnMBR) technology as a low energy alternative of conventional activated sludge (CAS) wastewater treatment for reuse. Results from bench-scale operation (U4R08) indicate that anaerobic membrane bioreactors can achieve direct discharge limits and the report includes a life cycle evaluation which shows that AnMBR can serve as the core technology in water reuse schemes with a potential for economic and environmental benefits compared with conventional activated sludge processes. This was a cooperative project co-funded by WERF and the WateReuse Research Foundation.
Building a Climate-Ready Regulatory System	Jonathan Gledhill, Chad Seidel, Jeff Oxenford	Water Research Foundation	1/1/2012	http://op.bna.com/env.nsf/id/phey-8xzsth/$File/WRF.pdf	W-E	Drinking water; MCLs; climate change; solar credits; policy; green house gases	The next decade will bring several important MCLs that would give EPA an opportunity to carry out reforms. EPA plans several new national drinking water standards (aka "MCLs") that are opportunities for EPA to incorporate climate-ready regulatory principles into its program, e.g., to define the SDWA benefit-cost criteria to include all of the social costs that could occur if utilities lose their flexibility to adapt to climate change. When utilities hear "climate change regulations," they should think "higher electricity prices." For the next decade GHG emission regulations will almost exclusively affect water utilities through higher electricity prices. Numerous U.S. government agencies and other nonpartisan analyses estimate higher electricity costs as a result of policies to curb GHG emissions from the electric utility sector. When GHG emission regulation of electric utilities is coupled with other environmental regulations facing that sector, real electricity prices will rise during the decade by at least 10 percent over the levels set by the widely-fluctuating energy markets. The electricity market has exploded into a colorful bazaar created by policy officials. This new electricity market has solar credits, efficiency incentives, tax rebates for this renewable, subsidized loans for that renewable, billing fees, and many more offerings. Electricity prices will rise; wading into the new energy marketplace is the primary way to get some of this money back. Vendors in the bazaar – public utility commissions, electric companies, investors – are seeking energy efficiency and renewable energy generation capacity opportunities. Water utilities have these opportunities.
Optimization of Wastewater Lift Stations for Reduction of Energy Usage and Greenhouse Gas Emissions	David Wilcoxson and Travis Crane	MWH Americas Inc, Jacksonville Energy Authority	8/7/2012	http://isawwsymposium.com/wp-content/uploads/2012/07/WWAC2012_Wilcoxson-Crane_LiftStationEnergyEfficiency_paper.pdf	E-W	SCADA; programmable logic controller; human machine interface; lift stations; hydraulic modeling; energy; green house gases	The project set out to accomplish several goals; reduction in energy usage across the pilot study areas and a reduction of GHG emissions due to less use of trucks and a reduction in emissions from energy producers required to power the wastewater installations. Ultimately another goal is to provide guidance to other utility agencies thinking of reducing their own energy usage and reduction of GHG through publication of a guidebook. We achieved our goals, at least for the Julington Creek Plantation sites as the San Jose sites are still being tested at publishing date, but it did not come without proper planning and some setbacks which will take longer than the study period we had and will be an ongoing effort to provide the final payoffs.
Realizing the Potential of U.S. Unconventional Natural Gas	Lisa A. Hyland, Sarah O. Ladislaw, David L. Pumphrey, Frank A. Verrastro, Molly A. Walton	Center for Strategic & International Studies	4/1/2013	http://csis.org/files/publication/130409_Ladislaw_RealizingPotentialUnconGas_Web.pdf	W-E	Fossil fuel extraction; hydraulic fracturing; fracking; groundwater; drinking water; surface water; water-related risks; risk minimizing policies; drilling practices; contamination	Several relatively new methods of fossil fuel extraction, such as hydraulic fracturing (fracking), can cause negative impacts to groundwater resources, affecting drinking water systems and both surface water and groundwater. This problem is additionally aggravated by a lack of understanding and credible and comprehensive data, which according to the Pacific Institute, "is a major impediment to identify or clearly assess the key-water related risks… and to develop sound policies to minimize those risks".51 The problem is more complex than just the process of hydraulic fracturing, and involves good drilling practices. A recent Center for Strategic and International Studies report indicates that "faulty well construction improper casing or intersection with old abandoned well" is a more likely source of groundwater contamination.