Appendix 4

Literature Review

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1 Introduction

This report surveys and reviews the existing literature on energy efficiency in the water industry. The objective is to establish the technical state of science in the field of energy efficiency to allow techniques, processes and engineering proposals to be assessed as proven, viable or experimental. A secondary objective is to review the coverage of the subject to identify any gaps that may need further research.

Energy saving is becoming an increasingly important feature in water/wastewater treatment process operation. In the past a few years considerable research effort has been made to explore any possible ways to efficiently save or re-use energy in the water industry. Among these efforts are high level guidelines & reports, treatment process audits, benchmarking exercises, and applications of novel technology.

2 Methodology

Literature from academic and commercial sources, government department publications, conferences and personal contacts is recorded and reviewed in chronological order under the three main sections of the Water Matrix: Clean Water, Wastewater and Sludge.

Some high level reports summarise the current status, overall policies and guidelines on energy efficiency across the whole water industry. This literature is reviewed before the above three main sections.

3 Results

3.1 Across the Water Industry

In the UK, DEFRA (Department for Environment Food and Rural Affairs) has in 2008 presented to Parliament Future Water – The Government's Water Strategy for England. DEFRA Reported that the UK water industry used almost 7,900 GWh of energy in its total operations during 2006/07. The energy is mostly consumed in abstracting, pumping, treating and heating water and treating and pumping wastewater.

Due to energy crisis and the fact that water industry is a big energy consumer, ways of saving energy and using renewable energy in water treatment process are encouraged by the government. Water UK has committed to a voluntary emissions reduction target: that the water companies will seek to ensure that at least 20% of all energy used by the UK water industry comes from renewable sources by 2020.

DEFRA is also currently consulting on how to improve the energy performance of domestic heating and hot water systems, to support delivery of our objectives for energy efficiency and sustainable consumption and production. Such performance improvements can also have positive impacts on water efficiency.

The Environment Agency is funding a two-year project, Climate Change & Global Warming Water Resources, which is looking into increasing energy efficiency and carbon reductions in the water industry. The project aims to:

- identify opportunities for improving energy efficiency in the water and wastewater sectors through different initiatives;
- identify barriers and potential solutions for improved energy efficiency in the sector, especially any created by regulation; and
- ensure that the Environment Agency's approach to sustainable water resource management and climate change objectives are aligned.

The Periodic Review 2009 of the UK or 'PR09' determines how much water companies can spend on maintaining their services as well as improving them. OFWAT (Office of Water service) in 2008 addressed the PR09 Treatment of Renewable Energy to all Regulatory Director of all water and wastewater companies. An outlined guidance is set out to help companies to correctly allocate costs and incomes. Their PR09 investment in renewable energy aims to ensure:

- promotion of processes or technologies with natural synergies with appointed business functions such that it does not make economic sense to separate the energy generation function from the core appointed business;
- cost beneficial incremental costs associated with renewable energy generation;
- main asset function remaining delivery of the appointed business function; and
- the appointed business benefits from any income streams associated with energy generation.

They also addressed that for schemes structured as renewable energy projects, there are larger payback periods and we should be prepared to take account of this.

Environment Agency has related energy consumption to greenhouse gas emission. They have published a science report which provides detailed evidence and presents a methodology for assessing the carbon costs and benefits of future water resource options. The conclusion is that carbon impacts can be minimised through increased efficiency, technology innovation, use of renewable energy and implementing alternative low energy consumption solutions.

The 2007/08 Annual Report of the Environmental Knowledge Transfer Network states that energy efficiency from water and wastewater treatment is in the top 3 of their Priority Technology Area Index. The estimated saving is greater than $400million per annual.

Environmental Consultant, Enviros introduced the concept of energy management in water industry, with an example of how such a programme can be implemented with an indication of the results achieved by the company. They concluded that a systematic approach, incorporating people and systems as well as technical issues, is necessary to sustain energy cost reductions in water and wastewater treatment plants.

The environment agency and energy saving trust of the UK has published a full technical report, named quantifying the energy and carbon effects of water saving, which concentrates on domestic usage. In the report, domestic energy saving associated with water saving has been investigated. Various recent studies and regulations make it increasingly important to ensure that water and energy efficiency are considered in tandem so that domestic water efficiency policies can complement energy efficiency policies as there is clearly the potential for them to conflict. Home appliances, such as showers, baths, taps and washing machines have been investigated, and the correlations between water and energy savings of these appliances are discussed.

In Australia, a number of water companies take part in the Australian Government’s Energy Efficiency Opportunities Program, which is designed to lead to:

- improved identification and uptake of cost-effective energy efficiency opportunities
- improved productivity and reduced greenhouse gas emissions
- greater scrutiny of energy use by large energy consumers.

The program requires around 210 companies using greater than 0.5 petajoules (0.5×10^{15} J = 0.14×10^{9} KWh) of energy a year to participate. Participating companies must assess their energy usage, identify opportunities and publish publically available reports on a regular basis. Public reports identifying energy saving opportunities are currently available from Sydney Water, Melbourne Water, South Australian Water Corporation, SunWater and Western Australia’s Water Corporation.

A Dec 2008 report by CSIRO (Commonwealth Scientific and Industrial Research Organisation) titled “Energy Use in the provision and consumption of urban water in Australia and New Zealand”, shows that water utilities in Australia consumed 590 MJ/person/annum. The report suggests that sourcing recycled or desalinated water close to the point of use may use less energy than pumping water from remote areas. The report also recommended that efforts to minimise GHG emissions should focus on minimising the use of imported electricity and using internal energy sources, such as biogas.

The report also found that residential hot water heating uses 6 times the energy used by water utilities and that reducing hot water consumption by 15% would completely offset the emissions by water utilities. It recommended that data from a large number of utilities be analysed to improve the understanding of energy used with different treatment processes.

In the US, the American Water Works Association (Awwa) and Awwa Research Foundation have published a report titled Best Practices For Energy Management. This research report on interactive CD-ROM shows utilities how they can reduce energy costs. The study documents best practices utilities can implement to save energy costs and includes case studies showing how the practices were developed and are used. The CD-ROM also provides a program for utilities to apply immediately to achieve savings.

There are two publications from Awwa named Variable-Frequency Drives (VFD) Streamline Emergency Applications (McVay R, Oct 2009), and Low-Cost Strategies Optimise Energy Use (Morgan D and Barron C, Dec 2009), where VFD controls of pumps are discussed, and best efficiency point (BEP) is introduced.

USEPA published a guide book, named Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities, to provide water and wastewater utility managers with a step-by-step method, based on a Plan-Do-Check-Act management system approach, to identify, implement, measure, and improve energy efficiency and renewable opportunities at their utilities. The system will assist people in:

- Benchmarking and tracking monthly and annual energy use;
- Identifying and prioritizing energy operations and issues that can increase efficiency;
- Identifying energy efficiency objectives and targets;
- Defining the performance indicator(s) to use to measure progress towards your energy targets;
- Establishing energy management programs (i.e., action plans to meet your goals);
- Monitoring and measuring the performance of your established target(s);
- Documenting and communicating success; and
- Reviewing your progress periodically and making adjustments as necessary.

A report named Energy Index Development for Benchmarking Water and Wastewater Utilities was published by the Awwa Research Foundation, California Energy Commission, and the New York State Energy Research and Development Authority. This project sought to develop metrics that allow comparison of energy use among wastewater treatment plants and among water utilities. The metrics developed in this project can provide the means to motivate energy management. Low scoring utilities can pursue investigations as to why they score low, which might lead to implementing improvements. High scoring utilities might be identified as a source to investigate for examples of best practices.

Water Environment Research Foundation (WERF) also published the “Water and Wastewater Energy Best Practice Guidebook” in Dec 2006. The objective of this Guidebook is to provide information and resources to assist water/wastewater management and staff in identifying and implementing opportunities to reduce energy use.

The information in this guidebook will help managers, administrators and/or operators to identify opportunities to significantly reduce energy requirements at their facilities without affecting production. It also provides the user with information on the value and need for proactive energy management with water and wastewater systems. Contents include:

- Benchmarking results from selected Wisconsin wastewater facilities
- Best practice approaches to on-going management of energy use
- Documentation of technical best practices for planning, designing and operating water/wastewater system treatment and for conveyance and distribution
- Best practice funding and financing opportunities
- References for further opportunities in water/wastewater system energy efficiency and power demand reduction

Alliance to Save Energy based in Washington DC appeal to utility companies on taking advantage of untapped energy and water efficiency opportunities in municipal water systems. They stated many worthwhile energy efficiency actions can be completed for little or no cost, and installing metering and monitoring systems can save 10 percent of energy cost simply through behavioural changes and improved maintenance. They believe energy consumption in most water systems worldwide could be reduced by at least 25 percent through cost-effective efficiency actions.

EPRI Community Environmental Centre has produced an Energy Audit Manual for Water/Wastewater Facilities, where they have conducted pumping, walk-through, detailed process, lighting and HVAC audits, and provided ideas and tips to develop a successful energy conservation program.

3.2 Clean Water

United Utilities has recently summarised all their energy efficiency projects, in which pump and pumping system efficiency optimisation is top on the list. They are refurbishing 20 major pumping systems and including high efficiency internal coatings to save energy and enhance asset life. This will deliver approx 2.5million kWh per year energy savings.

At the same time, United Utilites have considered using Derceto (company name) Water Network Optimisation. An intial study states that energy consumption may be reduced by around 18% using this system.

United Utilities has also considered hydro electric generation. Phase 1 of their investigation has identified six viable hydro locations based on financial criteria; Phase 2 discovered another three viable hydro locations. The total hydro generation potential is estimated to be 2000 MWh/year.

ITT Goulds, an industrial pump manufacturer, has looked into the life cycle cost savings in water pumping systems. Pumping systems account for 50% of electricity consumption in the water industry. Energy saving opportunities are looked in the areas of reduced energy consumption at non-peak times, soft starting and stopping, and installation of VFDs or VSDs. They concluded, to focus on real energy savings winth the plant, it is vital tu understand the pumping system network. This includes knowing true sytem requirements at peak and non-peak loads, as well as increasing the efficiency of pump systems and their components.

The 273,000 m3/d immersed membrane system at Chestnut Avenue Water Works (CAWW) is a good example on how to save energy in clean water sector. The siphon-based permeation design is “simplicity of design”, and the key advantages are from many perspectives including: Simple controls; Easy piping routing and building design; Minimal equipment area; Less equipment maintenance; and Lower energy requirements. These advantages translate directly into a system with low capital and operating costs.

A Water UK Energy Forum was formed in 2002, aiming to provide a platform for energy issues within the water industry, share energy ideas and spread best practice. Two sub-groups were formed to pursue energy consumption benchmarking in water and waste water treatment processes.

South Staffordshire Water conducted the Potable Water Benchmarking Exercise. They formulated standardised approach for collecting asset data, and grouped sites according to asset type and treatment process. Through this process they:

- provided a standard efficiency for “best in class” – kWh/ML/m Lift;
- defined what should be done and what should be avoided in treatment processes; and
- provided KPIs to contractors for new sites and site refurbishments.

This resulted in a broad definition of energy efficient sites, and recommendations to improve inefficient sites. The 2nd stage of this process has now started with the aim to improve data quality, benchmark treatment processes, analyse results and produce guidance documents.

University of Wisconsin-Madison has assessed the variable frequency drives for increased energy efficiency at drinking water utilities supplied by groundwater. The case study suggests that a number of items must be considered before water utilities implement variable frequency drives. First, if valves are throttled to stop hard startups or to decrease the frequency of pump startups, a variable frequency drive may increase energy efficiency. Second, adding automatic controllers and operating a pump away from the optimal efficiency point can reverse the positive effects of a variable frequency drive. Third, simply comparing wells without considering all possible variables can lead to misleading results. Fourth, a new energy-efficient motor may achieve more energy efficiency at a lower cost than a variable frequency drive.

In 2007, using short-term water consumption forecasting to minimize cost of pumping operations has been discussed as one of the energy management strategies. The short term means forecasting consumption at 15-60mins resolution for the next one to seven days. The cost savings and effectiveness of optimization programs are dependent on and proportional to the accuracy of the forecast. The accuracy is highly dependent on the quality of historical data. Water utilities will save millions of dollars on energy costs and managing water supplies better through daily consumption forecasting. This exercise concentrates more on the cost of energy than the saving of energy.

Black & Veatch has conducted assessment of carbon footprint (CF) in water production process. Developing a CF is a good first step for utilities to identify ways to lower emissions of the highest contributing factors, which typically are energy consumption during operation. Utilities can evaluate how much energy use could be reduced, and adopt a plan or policy that focuses on achieving that goal. Efforts to improve the CF for capital improvement projects can potentially be linked to lower operational emissions. Because a portion of a utility’s CF is linked to energy use, performing a CF analysis may highlight opportunities for better, more energy-efficient operations.

3.3 Wastewater

Southern Water carried out a benchmarking exercise on wastewater, similar to the potable water benchmarking activity by South Staffordshire Water and over the same period. This study was conducted to counter a lack of existing benchmark information and reliable data, and to overcome the challenges of diverse systems. Methodologies used are definitive kWh per mg BOD removed; energy audits based on installed plant; and total site energy against flow to treatment. The results from the exercise produced as many questions as answers, providing poor correlations and too many variables. Therefore, in the next stage, they will seek updated information from various companies; and only look at energy against flow.

United Utilities has reported major savings on ASP (Activate Sludge Plant) optimisation and control. More than 35% electricity savings were made, equating to 600 MWh/year (equivalent to around £45k/year). Other saving potentials include:

- installation of Byzak "Retroflo" wastewater pump control module on a pumping station at the end of large diameter tank sewer, with prospective 12% of energy savings.
- Innovative BAFF control using Hach Lange instrumentation and revised BAFF control, where approx 0.5m kWh energy saving is expected.
- Hach Lange variable set point DO control for ASPs. Energy savings are yet to be investigated.

New York Energy Research and Development Authority evaluated the energy performance using submetering installed at 11 sewage treatment works to accurately determine the energy consumption and savings of the evaluated processes. This project identified opportunities totalling $910k per year to reduce plant energy costs while maintaining or increasing treatment capacity were.

NYSERDA, a public benefit corporation established by the New York State Legislature, offers a variety of programs aimed at developing and implementing projects to improve energy efficiency, reducing energy consumption and recover energy from various treatment processes. They identified the most energy intensive processes at a typical wastewater treatment facility are: treatment process (70%), influent pumping (16%), solids disposal (7%) and lighting/buildings (7%). They estimated that energy consumption at most facilities could be reduced by 10 to 20 percent with opportunities to reduce energy consumption at some facilities by up to 50 percent.

USEPA has published a wastewater management fact sheet – energy conservation, as they believe evaluating a facility for energy efficiencies and adopting an energy conservation plan often result in increased treatment efficiency, along with the potential for increased treatment capacity, an increased ability to meet effluent limitations, reduced O&M requirements, and reduced energy costs. It is concluded the key components of an effective energy management plan are:

- Creating a system to track energy usage and costs
- Performing energy audits of major operations
- Upgrading equipment, systems, and controls, including facility and collection system improvements to increase energy efficiency

- Developing a cost-effective electric supply purchasing strategy
- Optimizing load profiles by shifting operations where possible
- Developing in-house

Apart from water companies and authorities, engineering consultants and suppliers are considering innovative design, active energy management and efficient equipment selections to achieve energy savings.

With the objective to develop cost functions for investment and operation of energy saving technologies, the University of Minho formulated the cost functions of energy saving wastewater treatment systems, which calculated the relationship between energy costs and population served. They found the formulated cost functions follow a power law, and the cost decrease with the increase of the served population, which is important to allow the elaboration of budgeting operation costs.

Siemens installed an OMNIFLO Interchange SBR (Sequencing Batch Reactor) in the state of California, which requires minimal aeration, while greatly reducing the amount of sludge disposal. The result is promising with 90% of the power for solid treatment is saved, and less than 0.1 kg of biological solids wasted from the plant per kg of BOD treated.

In Italy, an energy saving project has been implemented on a conventional wastewater treatment plant, where several management actions, previously manually operated, are now supervised remotely and operated by automatic controllers. The remote control system enables close monitoring of energy consumption, and the result shows a considerable energy saving can be achieved by automatic control of the DO level.

Soil & Water in Finland analysed energy economy in aeration systems, where energy efficiency was modelled by power function in ratio of the design AOR load of the plant. It was found that the energy efficient aeration system is not dependent on load variations. It was widely noticed that the selection of efficient equipment is only the first step towards cost reductions. Human actions often run over the physical-chemical impacts.

KemWater in Sweden demonstrated that in comparison to conventional biological activated sludge treatment, chemical treatment plants are cheaper in terms of cost per unit of BOD removal and that they require less energy per unit as well. The evaluation of energy consumption is based on the major energy associated elements: chemicals, air and biogas.

3.4 Sludge

In the 2007 – 2008 annual report of Environmental Knowledge Transfer Network, energy from solid waste is the top on their Priority Technology Area Index, and sludge produced from water treatment process is part of it.

In the UK, most companies plan to make more use of onsite alternative energy, particularly sludge biodigestion, wind power and small hydro systems. Northumbrian Water and Southern Water have set themselves 20% targets for self-generated energy by 2015 and 2020 respectively. Anglian Water and Wessex Water expect to have met this level - or slightly more in Wessex's case - by 2010.

Thames Water has appealed to water utility companies to understand the drivers for anaerobic digestion. Anaerobic digestin offers the most environmentally sustainable and cost effective treatment for municipal biosolids. It has been suggested holistic approach should be applied when optimising wastewater treatment works. Understanding the process begins at the inlet works through to final effluent, transport and disposal. It is necessary that the evaluation of the various sludge treatment options must take the whole treatment process into account.

In Jordan, A 267,000m3/d wastewater treatment plant serving 2.2 million people in Greater Amman was inaugurated in 2008. The plant is almost autonomous in energy, which is a major asset for a facility of this scale. Hydraulic turbines installed upstream and downstream, combined with gas turbines powered by digestion biogas, produce 95% of the electricity required for treatment; and only the remaining 5% is obtained from the national grid.

The East Bay Municipal Utility District (EBMUD) of Oakland, US hahs developed migitation and adaptation strategies to deal with the chancing climate and its effects on water resources. EBMUD uses available capacity at its wastewater treatment plant to convert nonhazardous waste, such as food processing waste and wastewater sludge to methane, which is used to generate renewable energy. The renewable energy production has increased from 2 to 4.5 megawatts over 6 years. The facility generates enough energy to power 2500 homes at one time and supplies nearly all power required by the WWTW.

Strass WWTP in Austria is also a very good example of energy self-sufficiency for wastewater treatment system. Strass municipal WWTP provides a two stage biological treatment to treat loads varying from 90000 to 200000 PE weekly. The percentage of energy self-sufficiency was steadily improved starting from 49% in 1996 to 108% in 2005 by many individual measures. A big step forward in energy production was the installation of a new 8 cylinder CHP unit which provides power of 340kW in 2001. Strass has reached a positive energy balance without any relevant co-substrate. Wastewater treatment facilities will increasingly claim their role as energy recovery plants.

At Bingen sewage treatment works in Germany, semi-dried sludge is turned into the form of glittering black granules, charcoal. Proponents of the technology say it is so effective at storing carbon that it should be included in the next global climate agreement. A growing worldwide movement is now bringing together the soil scientists fascinated by the benefits of biochar, which was first discovered in Pre-Columbian Amazonia, and the engineers devising new ways of making the char.

They are being backed by activists who are concerned about climate change. Netherlands biogas generation knowledge has been transferred to a WWTP in Romania, and energy saving measures has been implemented. The implemented technical solution is based on a CHP cogeneration unit, from which 3million kWhenergy is produced, representing 58% of the total energy consumption at this WWTP.

At Hamburg's Köhlbrandhöft WWTP the demand for external energy supply is minimised by the state of art sludge treatment. The sludge is subjected to thickening, anaerobic digestion, dewatering, drying and incineration. The digester gas is used in a combined gas and steam turbine process. The sludge incineration also produces steam, which is also used in the steam turbine that follows the gas turbine. The turbines produce electricity, and partially expanded steam is used for the sludge drying process. Heat from the condensation of vapours from sludge drying is used to heat the anaerobic digesters. The overall process requires no external heat or fuel and produces 60% of the WWTP's electricity demand.

In Switzerland, solid organic wastes were co-digested together with sludge of a sewage treatment works. More than 1 cubic metre of waste was added to the digester every day. The pre-treatment and treatment costs for co-digestion on STWs were calculated to be in the range of 55 US$/ton treating half a ton per day and 39 US$/ton treating one ton, respectively. Economic studies about co-digestion on agricultural biogas plants showed that the codigestion is a must at the current energy prices, which are far too low for agricultural AD without an additional income by treating solid wastes for third parties.

A design model of sewage sludge incineration plants has been developed to examine the possibilities for energy recovery. It was evident that, without sludge drying, there was a high fuel (methane), but considerable amount of electric energy is obtainable. Sizes of boiler and whole exhaust gases treatment line are in this case quite large. On the contrary, fuel consumption can be lowered at 44% concentration by introducing sludge drying. In this case fuel is needed only in the afterburning chamber, as the combustion in the fluidized bed furnace is autothermal. Boiler and exhaust gas treatment line are considerably reduced in size when power production is not performed, thus allowing a simpler and smaller plant to be designed.

4 References

Australian Government Energy Efficiency Opportunities Program (2009): http://www.ret.gov.au/energy/efficiency/eeo/pages/default.aspx

Clarke A, Grant N and Thornton J (2009) Quantifying the energy and carbon effects of water saving, Full Technical Report, Final Report. Energy saving trust, EA.

McVay R (2009) Variable-Frequency Drives Streamline Emergency Applications. American Water Works Association. 10/2009.

Morgan D and Barron C (2009) Low-Cost Strategies Optimise Energy Use. American Water Works Association. 12/2009.

Paul Fountain (2009) Understanding drivers for anaerobic digestion. Thames Water.

Paul Gaskell (2009) Operations and Maintenance – Strategy and Control Energy Efficiency Projects – High Level Summary. United Utilities

Payne, Gregory A. and Dr. Gregory Harrington (2009) Assessment of Variable frequency Drives for Increased Energy Efficiency at Drinking Water Utilities Supplied by Groundwater. National Regulatory Research Institute. http://nrri.org/pubs/water/NRRI_var_freq_dr_assess_jan09-01.pdf

Saran Sohi, Elisa Lopez-Capel, Evelyn Krull and Roland Bol (2009), Biochar, climate change and soil: A review to guide future research, CSIRO Land and Water Science Report. 02/2009

Andy Howe (2008). Climate Change & Global Warming Water Resources. Enviroenment Agency Website.

DEFRA (2008) Future Water – The Government's Water Strategy for England

Environmental Data Services Report 390 (2008), p 13.

Environmental KTN (2008) Environmental Knowledge Transfer Network 2007 – 2008 Annual Report

European Water News (2008) 95% Energy Self-sufficient Wastewater Treatment Plant. http://www.european-waternews.com/news/id198-Energy_Selfsufficient_Wastewater_Treatment_Plant.html

Lampman, Gregory, Kathleen O'Connor, and Amy Santos (2008) NYSERDA and Startegic Energy Management at Municipal Wastewater Treatment Facilities. Clearwaters.

OFWAT (2008) PR09 Treatment of Renewable Energy - to all Regulatory Director of all water and wastewater companies.

S.J. Kenway, A. Priestley, S. Cook, S. Seo, M. Inman, A. Grogory and M. Hall, (2008) CSIRO, Energy Use in the provision and consumption of urban water in Australia and New Zealand. URL: http://www.clw.csiro.au/publications/waterforahealthycountry/2008/wfhc-urban-water-energy.pdf

Strutt, Justin, Sian Wilson, Hooly Shorney-Darby; Andrew Shaw, and Andrew Byers. (2008) Assessing the Carbon Footprint of Water Production. Journal AWWA. Vol. 100, No. 6. 80-91.

USEPA. (2008). Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities. USEPA Office of Wastewater Management, Washington, DC., 113 pp.
http://www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf

Wallis, Michael J, Michael R. Ambrose, and Clifford C. Chan. Climate Change: Charting a Water Course in an Uncertain Future. (2008) Journal AWWA. Vol. 100, No. 6. pp 70-79.

B.Wett, K.Buchauer and C. Fimml (2007) Energy self-sufficiency as a feasible concept for wastewater treatment systems. Asian Water, Techno Focus, September 2007.

Carlson, Steven W. and Adam Walburger (2007) Energy Index Development for Benchmarking Water and Wastewater Utilities. American Water Works Association Research Foundation, Denver, CO. 196 pp.

Jentgen, Larry, Harold Kidder, Robert Hill, and Steve Conrad (2007). Energy Management Strategies Use Short-term Water Consumption Forecasting to Minimize Cost of Pumping Operations. Journal AWWA. Vol. 99, No. 6. pp 86-94.

R Nogueira, I Ferreira, P. Janknecht, J.J. Rodriguez, P. Oliveria, and A.G. Brito (2007). Energy-saving Wastewater Treatment Systems: Formulation of Cost Functions. Water Science & Technology Vol 56 No 3 pp 85-92.

Robert Lax, Karen Sanchez and Vestal Tutterow (2007) Life Cycle Cost Savings in Water Treatment Pumping Systems. WaterWorld. http://pennwell.printthis.clickability.com/

Thomas W Devine (2007). Energy Performance through Submetreing Wastewater Treatment Plants. NYSERDA. USA.

David Riley (2006). Potable Water Benchmarking. CIWEM Energy Saving Conference, Nottingham, 2006.

Denys Clarke (2006). Wastewater Benchmarking. CIWEM Energy Saving Conference, Nottingham, 2006.

Focus on Energy, Science Applications International Corporation (2006), Water and Wastewater Energy Best Practice Guidebook. Water Environment Research Foundation . http://www.werf.org/AM/TemplateRedirect.cfm?template=/CM/ContentDisplay.cfm&ContentID=9896

OFWAT (2006) A Sustainable Water Industry – To PR09 and beyond

Peter Cohen (2006) Energy Efficiency in Water and Wastewater Treatment. CIWEM Energy Saving Conference, Nottingham, 2006.

USEPA. (2006). Wastewater Management Fact Sheet: Energy Conservation. USEPA Office of Water, Washington, DC, EPA 832-F-06-024. 7 pp.
http://www.epa.gov/owm/mtb/energycon_fasht_final.pdf

Case Study: Energy Saving Wastewater Treatment System (2005). Siemens Water Technologies. http://semiconductoronline.com/

Monica Melinte (2005) Energy Saving Measures at Wastewater Treatment Plant. ManagEnergy, Aquaserv Romania.

S. Marsili-Libelli, and G.M. Maietti (2005). Energy saving through remote control of a wastewater treatment plant. Acque SpA Italy.

Arnold Janson, Gerry O'Toole, LEE Mun Fong, Allan Toh (2004) The 273,000 m3/d Immersed Membrane System at Chestnut Avenue Water Works: Its Novel Design and First Year of Operation

M Heinonen, T Fred and H Kieru (2004). Energy Economy in Aeration Systems. Water Intelligence Online.

Energy Center of Wisconsin. (2003) Energy Use at Wisconsin's Drinking Water Facilities. Report #222-1. 108 pp. http://www.ecw.org/prod/222-1.pdf

John (Jack) Jacobs, Thomas A. Kerestes, W. F. (Rick) Riddle (2003). Best Practices For Energy Management. American Water Works Association and Awwa Research Foundation Edition: 2003 - CD-ROM

James, Kevin, Stephanie Campbell and Christopher Godlove. (2002) Watergy: Taking Advantage of Untapped Energy and Water Efficiency Opportunities in Municipal Water Systems. Washington D.C.: Alliance to Save Energy

R.D. Thierbach and H. Hanssen (2002) Utilisation of energy from digester gas and sludge incineration at Hamburg's Köhlbrandhöft WWTP. Water Science & Technology Vol 46 No 4-5 pp 397–403

W. Edelmann, H. Engeliand M. Gradenecker (2000) Co-digestion of organic solid waste and sludge from sewage treatment. Water Science and Technology Vol 41 No 3 pp 213–221

G. Mininni, R. Di Bartolo Zuccarello, V. Lotito, L. Spinosa and A. C. Di Pinto (1997) A design model of sewage sludge incineration plants with energy recovery. Water Science and Technology Vol 36 No 11 pp 211–218

Ingemar Karlsson (1996) Environmental and Energy Efficiency of Different Sewage Treatment Processes. Water Science and Technology Vol 34 No 3-4 pp203-211.

Reardon, David (1994) Energy Audit Manual for Water / Wastewater Facilities: A Guide for Electric Utilities to Understanding Specific Unit Processes and their Energy/Demand Relationship at Water and Wastewater Plants. CEC Report CR-104300, St. Louis, Missouri, EPRI Community Environmental Center.