Roadmap to Energy
In the Water and Wastewater Industry

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Executive Summary

Energy Use and Savings in Water

Municipal water supply and wastewater treatment (W&WW) systems are among the most energy-intensive facilities owned and operated by local governments, accounting for about 35% of energy used by municipalities. Water and wastewater treatment and distribution in the United States is estimated to consume 50,000 GWh, representing 1.4 percent of the total national electricity consumption, and cost over $4 billion annually. However, according to EPA's ENERGY STAR® program, 10 percent savings can readily be achieved in this area.

Roadmap Goals and Objectives

With the support and encouragement of an advisory committee of twelve interested agencies and organizations, ACEEE conducted a roadmap workshop on energy in the water and wastewater industry in July 2004. Forty-nine stakeholders representing the energy efficiency and water and wastewater communities came together to discuss avenues for increasing energy efficiency and strengthening the bottom line in the water and wastewater sectors, while maintaining or improving operational performance. The objectives of the workshop were:

- To bring all stakeholders to a neutral forum to map out their goals and to see where commonalities exist between the communities.
- To provide opportunities for activities, actions, or areas for common exploration.
- To establish "on-the-ground" linkages between the water and wastewater (W&WW) and the energy efficiency communities.
- To take a holistic (systems) look at energy use in the W&WW sectors, covering technologies, operations, optimization, and conservation.
- To produce an action plan and list of recommendations outlining energy efficiency opportunities within the sectors and steps needed to realize them.
- To identify possible organizational structures for implementing the action plan and also possible lead organizations.

In preparation for the meeting, ACEEE conducted a limited survey of stakeholders to identify the issues that would form the basis of discussions at the national roadmap meeting. Systems optimization was the highest ranked opportunity, with energy audits, energy management plans, shifting of energy-intensive operations to off-peak times, demand management, and plant automation also mentioned. Lack of information was identified as a key barrier. With respect to research and development, technology and education/information were identified as the primary areas of needed focus. Respondents also commented that the dissemination of results must be widespread to overcome informational barriers. Respondents also emphasized the importance of benchmarking to allow assessment of progress. Finally, the respondents identified security concerns and regulatory uncertainty as the major external drivers for energy use in W&WW.

Summary of Findings

The participants met initially as one group before splitting into two subgroups. One subgroup focused on implementation and the other on the research and development (R&D) aspects of the discussion. The two subgroups then reconvened to compare findings and assess common aspects of their discussions.

In the initial discussions, the combined groups quickly agreed to two common goals for their participation in the workshop:

- Change the mindset throughout the purchase chain in the W&WW industry from buying cheap to buying "right"
- Change the energy intensity of the W&WW industry by transforming the market to support energy-efficient best practices

The participants identified key audiences that would need to be influenced to achieve these goals:

- Plant and system managers
- Purchasing managers in the W&WW systems
- Plant and system operators
- Design engineers
- Equipment vendors and service providers
- Contractors involved with new facility construction, and renovation and expansion of existing faculties
- Regulators, including:
    - state water quality agencies
    - EPA
    - state public service commissions
    - state revolving fund (SRF) administrators
- City managers/local governance bodies (e.g., water boards or country commissions)
- State legislatures
- Consumers (commercial, residential, and industrial)

R&D Subgroup Discussions

The R&D subgroup agreed that the primary goal of the R&D effort is to support the implementation of energy-efficient practices by addressing the key technology and data needs, and demonstration of the existing technology that is already available in the market place. While the discussions were wide-ranging, three broad areas of agreement emerged in this subgroup:

- Need for ongoing coordination
- Need to balance short-term needs with longer-term, strategic explorations
- Need to identify specific research topics for future research

The R&D subgroup identified possible new research topics. Some of the ideas that emerged are:

- Rethinking the hydraulic model of W&WW treatment plants and systems
- Producing energy from wastewater treatment
- Considering small versus large systems
- Development of best-practice guidelines for smaller W&WW facilities
- Analysis of the "cost" of various contaminant control technologies—use common metrics to compare
- Verification and certification of technologies

The R&D subgroup came up with six priority action items:

- A National Research Council (NRC) study should be commissioned on the future of urban water management systems. The study should focus on energy efficiency and sustainability of urban W&WW systems and should involve all affected stakeholder groups.
- A workshop should be organized to identify and recommend specific water-energy materials that should be incorporated into environmental curricula.
- A water-energy R&D coordinating group should be established, involving the key funding entities.
- A list of research idea descriptions should be developed to use in future research requests for proposals (RFP's).
- A funding pool should be created to support high risk research and demonstration projects.
- A newsletter/e-letter should be established to publicize W&WW R&D RFP's and research results.

Implementation Subgroup Discussions

Participants in the implementation subgroup represented a more diverse set of communities than were present in the R&D subgroup, many with individual key needs and perspectives lacking the singular focus of the R&D community. As a result, the range of discussion was much broader in scope and the group converged to key action items more slowly than did the R&D subgroup. The subgroup identified nine key topic areas that needed to be addressed to make progress:

- Education and outreach
- Energy management
- Benchmarking (data needs)
- Codes and standards (performance)
- Regulator actions
- Systems approach
- Asset management
- Institutional structures (culture and behavior)
- Incentives/financing

While the subgroup did not have sufficient time to identify and prioritize specific action items, they did identify some "quick hits" that represent near-term action opportunities. Among the actionable suggestions are:

- Provide energy auditing guidelines to facilities
- Develop environmental engineering training curriculum that incorporates energy
- Develop a national marketing strategy including outreach to major conferences and events
- Create an inventory of existing case studies of energy in W&WW
- Ensure that water/wastewater energy considerations are incorporated into the green buildings/LEED/ENERGY STAR initiatives
- Link availability of state revolving loan fund financing to International Standards Organization (ISO) certification of energy efficiency

Crosscutting Issues Identified by the Subgroups

Two issues came up in both the R&D and implementation subgroups:

- Need for better information and data on water and wastewater operations and technologies in the United States. This includes benchmarking as well as broader data collection efforts on energy use by region, water source, treatment technology, and facility size.
- Need for incorporation of energy into educational programs.

These two crosscutting issues are clearly priorities.

Key Opportunities for Action

Four key areas were identified by the workshop advisory committee following the workshop for further action to advance energy efficiency in the water and wastewater industry:

- Energy efficiency should be included in educational curriculum at the university engineering, tech school, operator training, and continuing education levels.
- Standard data collection protocols need to be established so that comparable performance data can be collected, meaningful databases assembled, "best practice" guidelines identified.
- Energy efficiency metrics should be incorporated into requirements for NPDES permits and eligibility for state revolving loan funds for water and wastewater infrastructure.
- A means of coordination and information exchange needs to be established to identify and collect information across activities.

Recommended Next Steps

ACEEE recommends that a group of interested stakeholders should continue to work together after this report is released. This group would provide coordination, play a clearinghouse role, and—most importantly—identify key opportunities for action that are not being met by

established programs. It is suggested that a "working group" or "steering committee" for water and wastewater energy efficiency could meet this need. Many such groups have been established in the past when diverse stakeholders have needed to develop goals and oversee the implementation of a set of key strategies.

This steering committee on water/wastewater energy efficiency would be made up of interested parties who would contribute toward a modest administrative fund and provide in-kind support that would:

- Collect information on existing water and wastewater energy activities, making them available on a website
- Provide coordination among activities by organizing conference calls and meetings of key stakeholders
- Spot gaps, identify redundant efforts, and ensure that progress is being made on key action items

This entity would, by design, be created for a limited duration as directed by the supporting stakeholders. Participants in the roadmap workshop should be offered the opportunity to participate in this ongoing effort.

Introduction

Water and wastewater utilities are under increasing pressure to provide safe, reliable services at level or decreasing costs. Increasing energy prices and price volatility have made energy more of a cost concern for plant operators and local governments. Concurrently, policymakers, researchers, program implementers, and other stakeholders have identified the water and wastewater sectors as having a high potential for energy savings and consequently cost savings. In addition, reductions in purchased energy reduce utility exposure to future price volatility. This synergy has spurred the creation of a network of forward-thinking water and wastewater utilities and energy efficiency stakeholders to work together in identifying cost-effective energy efficiency opportunities and activities.

Beginning in late 2003, ACEEE began a project to bring together the energy efficiency and water and wastewater communities to define avenues for increasing energy efficiency and strengthening the bottom line in the water and wastewater sectors, while maintaining or improving operational performance. The goal was to organize a roadmap workshop to build on previous work and discussion, and to incorporate operational and program activities.

More specifically, the objectives of the workshop were:

- To bring all stakeholders to a neutral forum to map out their goals and to see where commonalities exist between the communities.
- To provide opportunities for activities, actions, or areas for common exploration.
- To establish "on-the-ground" linkages between the water and wastewater (W&WW) and the energy efficiency communities.
- To take a holistic (systems) look at energy use in the W&WW sectors, covering technologies, operations, optimization, and conservation.
- To produce an action plan and list of recommendations outlining energy efficiency opportunities within the sectors and steps needed to realize them.
- To identify possible organizational structures for implementing the action plan and also possible lead organizations.

In preparation for the meeting, ACEEE assembled an advisory committee of experts from the water, wastewater, and energy efficiency communities to identify a diverse group of stakeholders that would reflect the broad interests of all stakeholder groups in these areas. The members of this advisory committee were:

Janet Joseph, NYSERDA	Bill Haman, IEC
John Flowers, EPA	Mark Hanson, ASERTTI
Roy Ramani, WERF	Aimee McKane, LBNL
Linda Reekie, AwwaRF	Ted Jones, Consortium for Energy Efficiency (CEE)
Shahid Chaudry, CEC	Vestal Tutterow, ASE
Keith Carns, EPRI	Catarina Hatcher, EPA
Kevin James, ASE	Kathleen O'Connor, NYSERDA
Neal Elliott, ACEEE	Rolf Butters, U.S. Department of Energy (DOE)

This advisory committee defined the scope of the effort, developed a mission for the project, and established a set of goals. The members also assisted ACEEE staff with identifying key issues related to energy in the water and wastewater industries. These issues formed the basis for the design of a survey instrument that was used to collect impressions of key issues from a wider group of stakeholders identified by the advisory committee. Based on this research, ACEEE staff and the advisory committee developed an agenda that addressed key topics.

The advisory committee chose a wide variety of potentially interested stakeholders representing water and wastewater utilities, nonprofit organizations, professional associations, electric utilities, consultants, government agencies, and academia. The list of stakeholder participants is in Appendix C.

Sixty-two (62) survey packages identifying key issues in water and wastewater industry were sent electronically to the identified stakeholders. Follow-up surveys were sent a week later, and finally, an e-mail and fax of the survey package completed the effort. Recipients provided their comments on the identified key issues and in many cases added a few more based on their experience.

This consolidated list of key issues identified by the advisory committee and the stakeholders formed the basis of discussion at a national venue, organized and facilitated by ACEEE in Washington, D.C. in the summer of 2004. Based on discussion in the workshop, the participants developed consensus and prioritized identified issues. This report reflects the outcome of these efforts. ACEEE anticipates that the opportunities and recommended actions will serve as a roadmap for future activities to bring more thoughtful approaches to energy use in the water and wastewater sectors.

Scope of Discussion

In the beginning, the advisory committee identified four broad potential areas of exploration:

- Municipal water and wastewater systems
- Agricultural use of water, principally for irrigation
- Industrial use of water and effluent treatment
- Regional water resources and transportation

However, due to the diverse scope of these issues (see below), it was decided to narrow the focus to issues that have a broad, national importance.

- Agricultural water uses vary significantly by region, with many of the regional issues related to water resource competition. Most major agricultural regions already are working on irrigation energy issues.
- Industrial water and wastewater issues are significantly different from those facing municipal water and wastewater systems. Large industrial consumers are already further along the path than most municipal systems.
- Regional resource and transport issues (e.g., California) are so regionally specific that they are best dealt with at the regional rather than national level.

The above areas were excluded from further consideration under the scope of this study. Other justifications to limit the focus of the discussion to municipal water and wastewater systems[1] were as follows:

- Municipal systems are ubiquitous.
- In spite of regional variations in technologies and size, these systems face most of the same challenges.
- These systems represent a significant share of municipal energy consumption (estimates place the water and wastewater share of a municipal energy bill at 40–60%).
- National and regional associations exist that can facilitate coordination among facilities and other stakeholders.

The exclusion of agricultural, industrial, and regional resource and transportation issues from discussion should not be inferred to mean that no potential for energy efficiency exists in these areas. Rather, this was a strategic decision made to make the process more manageable and productive.

Technology Transfer & Implementation in Water & Wastewater Sectors

The advisory committee identified the current separation between the water and wastewater sectors as an important issue, as well as the coordination between research and development and implementation.

Water and wastewater systems have been described as a single system separated by a customer. Unfortunately, the customer might as well be an ocean, because many water and wastewater systems serving the same customers have little if any contact with each other. As the advisory committee discovered, the same situation is frequently true of the water and wastewater R&D sector as well. Further, there is some feeling that the R&D sector is not always responsive to the needs of the system operators. While many opportunities clearly exist for mutual benefits from coordination between the R&D and implementation sectors working in the same area (water supply or wastewater), better linkages need to be built between the water and wastewater communities. Thus, in order to breed further connections, the decision was made to keep together the implementation sector of the water and wastewater communities and similarly the R&D sector.

Further, the advisory committee felt that linkages between the outcome of R&D efforts and implementation in water and wastewater were particularly critical in view of the regulatory and market challenges facing systems. The increasing role of new and emerging treatment technologies will be critical in addressing the compliance challenges that will face system operators as regulations become more stringent (e.g., reduced discharge level) and resource challenges become greater (e.g., brackish water). The sense, however, was that R&D had already initiated the development of strategies for technology transfer, and as a result was perhaps further along in being responsive to the needs of implementers. Thus it was decided to provide separate subgroups for these two communities so they could advance at their own pace.

[1] These systems were defined as any water or wastewater system, either publicly or privately operated, that serves diverse groups of consumers within a given geographic area.

Participants

The advisory committee attempted to invite a diverse group of stakeholders that represented the necessary range of interests. From an initial list of 72 stakeholders, ultimately 49 participated in the roundtable. Table 1 presents the distribution of the invitees. In some cases, an invitee might represent more than one category (e.g., a consultant might also be involved in R&D). A list of all the workshop attendees with their affiliations appears in Appendix C.

Table 1. Distribution of Workshop Invitees

Water Utilities	Wastewater Utilities	Electric Utilities	Water R&D	Wastewater R&D	Consultant/ Vendor	NGO	Government/ Regulator
8	5	3	11	12	14	10	11

Workshop Format and Agenda

The format for the workshop was a facilitated discussion, with Aimee McKane of LBNL and Neal Elliott of ACEEE facilitating. Based on past experience, the advisory committee was concerned about a potential lack of interchange between the water and wastewater interests, and between R&D and implementation. As a result it was decided to meet initially as a group to discuss issues broadly, and then form two separate subgroups to address R&D and implementation issues, keeping the water and wastewater communities together. Each subgroup would discuss key needs and specific activity goals, and identify strategies to achieve these goals. The workshop agenda can be found in Appendix A.

Background on Energy in Water and Wastewater Industries

Water and wastewater treatment facilities are ubiquitous throughout the country, providing clean drinking water for municipalities and process water for industrial facilities, and treating municipal and industrial wastewater to preserve the quality of waterways and aquifers. In these systems, water is taken from a river, lake, or aquifer and processed to meet drinking water standards set by the federal government under the Safe Drinking Water Act and implemented by state regulatory agencies. This processed clear water is pumped through extensive distribution systems to customers. A separate system collects the wastewater, returning it to facilities where it is treated to meet allowable discharge standards set under the Clean Water Act. The principal concerns of these systems are compliance (with drinking water or discharge standards), capacity (the ability to meet customer needs), and costs.

Most systems are owned and operated by local governments (e.g., municipalities, counties, or regional authorities), though some systems are investor owned. Frequently, the water and wastewater systems are operated separately from each other. Local governments own about 60% of water systems while about 85% of wastewater systems are government owned. Many of the smaller privately owned water systems are in rural areas where the wastewater is handled through septic systems. Funding for public water and wastewater systems is primarily obtained through user fees, although some jurisdictions supplement their receipts with funds from general revenues. The cost of constructing water infrastructure is high. Public funding has been critical to the financing of the public plants, and is financed either through the Clean Water and Drinking

Water State Revolving Loan Funds (SRFs) administered by EPA and the states or through the use of municipal bonds.

Energy Use and Savings in Water

Municipal water and wastewater treatment facilities are among the most energy-intensive entities owned and operated by local governments, accounting for about 35% of energy used by municipalities (EFAB 2001). Water and wastewater treatment and distribution in the United States is estimated to consume 50,000 GWh representing 1.4 percent of the total national electricity consumption, and cost over $4 billion annually. However, according to EPA's ENERGY STAR program, 10 percent savings can readily be achieved in this area (EPA 2005).

A number of different techniques are used to process water and wastewater depending upon location and size. For example, daily electricity consumption for a million gallon per day (mgd) wastewater plant will vary from 1,811 kWh for a tricking filter plant to almost 3,000 kWh for an advanced plant with de-nitrification (WEF 1997). Motors consume the vast majority of the electricity used in municipal water systems, with most used for pumping (46%) and aeration (40%) (Xenergy 1998). An increasing number of technologies and practices that enable water users to improve their end-use efficiency can reduce water and wastewater energy requirements even further, while addressing environmental and economic development concerns (ASE 2002). New water treatment techniques are emerging that offer potential for enhanced performance with reduced energy requirements, including expanded use of digester systems that may be able to meet a substantial portion of onsite electricity generation while reducing solid loads (WEF 1997).

Market Players and Energy Activities

The water and wastewater industry is represented by three associations: American Water Works Association[2] (AWWA) that focuses on drinking water systems; Water Environment Federation[3] (WEF) that focuses on wastewater issues; and Water Reuse Association (WRA)[4] that focuses on water recycling and reuse. These associations act in trade and professional capacities, as well as undertaking research through their research foundations—Awwa Research Foundation (AwwaRF), Water Environment Research Foundation (WERF), and Water Reuse Foundation (WRF), respectively. In addition, there are two separate organizations that represent the largest systems: the Association of Metropolitan Water Agencies (AMWA)[5] and Association of

[2] The American Water Works Association (www.awwa.org) is an international nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply. Founded in 1881, AWWA is the largest organization of water supply professionals in the world. Its more than 50,000 members represent the full spectrum of the drinking water community: treatment plant operators and managers, scientists, environmentalists, manufacturers, academicians, regulators, and others who hold genuine interest in water supply and public health. Membership includes more than 4,000 utilities that supply water to roughly 180 million people in North America.

[3] Water Environment Federation (www.wef.org, formally the Federation of Sewage and Industrial Wastes Associations) was founded in 1928 and is a not-for-profit technical and educational organization with members from varied disciplines who work toward the WEF vision of preservation and enhancement of the global water environment. The WEF network includes more than 100,000 water quality professionals from 79 member associations in 32 countries.

[4] http://www.watereuse.org/

[5] http://www.amwa.net/

Metropolitan Sewage Agencies (AMSA, recently renamed the National Association of Clean Water Agencies [NACWA]).[6]

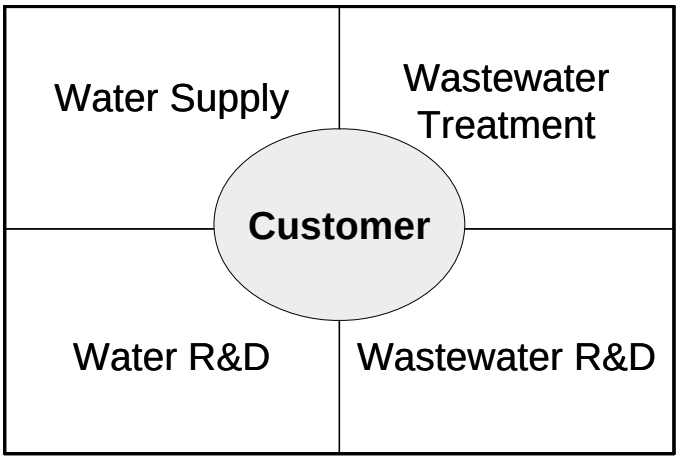
AwwaRF recently completed a research report (AwwaRF 2003) that looked at these issues for water treatment, while WEF published a book on energy in wastewater in 1997 (WEF 1997). The Environmental Financial Advisory Board to the administrator of the U.S. Environmental Protection Agency has recommended that the state revolving fund programs begin to offer loans for energy efficiency and co-generation technologies (EFAB 2001). In response, the EPA's ENERGY STAR® program is now looking at opportunities for a municipal water and wastewater initiative. The Alliance to Save Energy has completed a report, *Watergy*, on domestic and international opportunities for energy conservation in water systems (ASE 2002) and continues to pursue work in this area.[7] A number of electric utilities and market transformation organizations are offering energy efficiency programs, and the Consortium for Energy Efficiency has formed a committee to explore coordination among these efforts.[8] At the same time, the public power community has begun to look at voluntary initiatives they can participate in to reduce energy use and greenhouse gas emissions, with municipal water systems high on the list (Duncan 2002).

As briefly described above, a combination of factors suggests that water and wastewater system energy efficiency represents a national market transformation opportunity. The potential energy savings are substantial, key regional and national groups have demonstrated interest, technical resources (training, tools, etc.) are readily available, and new energy-saving technologies are entering the market. These factors represent a unique opportunity to form a coalition to support a national market transformation initiative. All that is needed is a focus that can provide coordination among all these groups.

Structure of the Water and Wastewater Market As It Relates to Energy

The water and wastewater industry can perhaps be viewed as two interrelated though independent industries linked by customers. This water/wastewater dichotomy creates challenges for viewing water systems in a holistic fashion. Similarly, R&D operates within a narrow set of paradigms that are driven by perceived needs. As a result, the R&D and implementation

Figure 1. Water/Wastewater Market Community Perspectives



[6] http://www.amsa-cleanwater.org/
[7] See http://Watergy.org for more information.
[8] See http://cee1.org/ind/mot-sys/wW&WW.php3 for more information on CEE's activities.

segments of the water and wastewater communities can be viewed as four separate sub-communities that in many cases have relatively limited or narrow interactions (see **Error! Reference source not found.**). The interconnection of these sub-communities is the customer, and actions on the customer side such as water conservation may have profound impacts on all these sub-communities. One of the goals of this roadmap effort was to begin bridging the gaps between these communities and establishing linkages.

For the water and wastewater communities, energy use is not a primary concern. In fact, operators of water and wastewater systems are more concerned about:

- ***Compliance*** with drinking water safety and environmental regulations
- ***Reliability*** of operation to avoid fines and interruption of service
- ***Capacity*** to meet growing demand and or changing treatment requirements
- ***Costs*** of construction or expansion of facilities and operation of the overall system

While reliable and cost-effective energy supply is an element in all these priorities, it is not by itself a focus. On the other hand, with the need to supply more water of a higher quality and treat wastewater to higher standards to meet future needs, energy use by water and wastewater utilities is likely to increase.

Water versus Wastewater

Issues such as water conservation or water recycling not only reduce water demand on the supply system, but also reduce the volume that is discharged to the wastewater system for treatment. From both an energy and holistic perspective, these steps reduce the energy associated with treatment in both systems as well as the cost of these systems. While on an intellectual level, the interactions between these industries and their customers is acknowledged, in many practical situations these are not fully recognized. An example from an energy efficiency perspective is a high-efficiency clothes washer. This technology reduces demand for water, which includes both the water associated with water treatment and distribution, and the energy associated with heating the water. The reduction in water demand also reduces the volume of wastewater, which reduces energy required to collect and treat this stream. From both water and wastewater perspectives, the benefits of reduced demand translate into reduced capacity requirements and operating costs.

R&D versus Implementation Focus

The level of coordination between the water and wastewater R&D sub-communities has not been as great as it could have been. In addition, the R&D community has been less responsive on more holistic issues than has the operational and implementation community. Significant progress has been made, however, due to the coordination between AwwaRF and WERF as a result of their work with CEC and NYSERDA on identification of research topics. This began with a roadmap workshop held in Sacramento, California, in February 2003.

Market Drivers

Recent years have seen a renewed interest in the relationship between energy and water and wastewater systems. This interest stems from a number of factors, including:

- New drinking water quality and water discharge regulations
- Aging water and wastewater infrastructure
- Need for new capacity to meet local growth
- Regional water supply shortages resulting from regional drought conditions and/or competition for water resources among different users and communities
- Local government budget crises resulting from increases in cost of government services where costs are not being met by increases in revenues
- Increasing energy prices that are increasing energy costs
- Global climate change commitments being made by states and local governments

As a result, opportunities exist for the energy efficiency and water/wastewater communities to work together to meet common goals (e.g., reducing costs through water conservation and energy efficiency). Among these opportunities from coordination are:

- Coordination to avoid potentially redundant activities
- Increased awareness of broad water/energy relationship
- Opportunities for synergies among efforts
- Leveraging of funds.

Stakeholder Survey Results

In preparation for the meeting, ACEEE conducted a limited survey of stakeholders to identify the issues that would form the basis of discussions at the national roadmap meeting. The survey questions were designed to be thought-provoking for stakeholders and spur creative thinking regarding major opportunities and challenges for energy efficiency in the water and wastewater sectors. The results identified commonalities and gaps in understanding within the water and wastewater communities regarding the benefits and costs of energy efficiency. The survey results, however, did not definitively identify all the opportunities and barriers to promoting energy efficiency in the water and wastewater sectors, but provide a wide range of ideas and opinions from a broad cross-section of interested stakeholders.

Summary of Results

Of the 62 stakeholders contacted, 20 surveys were returned. Table 2 provides a profile of those who responded to the survey. A qualitative summary of the survey results follows.

Table 2. Profile of Survey Respondents

Respondent ID	Community Represented		Category[9]			
	Water	Wastewater	Elec. Utility	Water Utility	R&D	Consultants/ Vendors
3	X					X
5	X	X		X		
6						X
9		X		X		
17						X
22	X	X		X		
24	X	X		X		
25	X	X	X		X	
26		X			X	
33	X	X				X
34	X	X				X
37	X	X		X		
38	X			X		
39	X	X				X
46		X			X	
47	X	X			X	
48					X	
52	X				X	
63		X	X			
64	X	X		X		

Water

Systems optimization[10] ranked highest among opportunities for energy efficiency in the water sector. Respondents reported that specific opportunities include the incorporation of energy audits, energy management plans, shifting of energy-intensive operations to off-peak times, demand management, and plant automation. Other opportunities identified by respondents include benchmarking and water efficiency/conservation.

Extensive technical and informational challenges as well as potential regulatory barriers were listed as reasons the opportunities had not been realized. Technically, respondents listed plant "overdesign" as the primary barrier. The tendency to over-design for infrequent and extreme events in this sector is large since the outcome of these events may have far-reaching and dire human health implications. Respondents commented that this barrier is intertwined with local government and regulatory policies as well as the past experience of the operator.

[9] As characterized by the advisory committee.

[10] For the purposes of the study, we assumed general definitions for the term "systems optimization." This definition includes sensors and monitors.

Lack of information was also identified as a barrier. Informational barriers included the lack of operator knowledge of energy cost and energy use. Respondents emphasized education and informational campaigns to educate and encourage proactive managers and plant operators as approaches to overcoming these barriers. Specific educational suggestions included training the operators about rate and tariff structures charged by electric utilities and the importance of benchmarking to saving money in the plant. Plant managers perceive energy audits and benchmarking as financially risky, in part because they are not fully informed of the associated benefits. Respondents noted that creating pro-active managers could uncover complex regulatory barriers related to the rate design and tariff structure of electric utilities. That challenge and opportunity, however, will only materialize if water utility managers are educated as to how energy is used and paid for within their facilities.

Wastewater

In the wastewater sector, as with the water sector, respondents ranked optimization of processes within facilities as the largest opportunity for energy efficiency due to its potential for low-cost solutions and incorporating demand-management solutions. Related to optimization, respondents ranked motors and motor systems as the second largest opportunity for savings. Spanning all ranks and cited most often as a large opportunity for savings was the incorporation of energy audits into management practices. Process modifications (primarily aeration) and distributed generation using biogas were also listed as large opportunities for savings in this sector.

Notably one respondent pointed out that the largest energy savings opportunity is related to changes in urban land use planning and the impacts on development. Decisions made by local authorities on future development define future water demand and the required capacity of wastewater systems. Local ordinances and codes can be an effective vehicle for encouraging water efficiency (reducing overall water and wastewater demand) or limiting allowable discharge concentrations into municipal sewers (particularly from industrial facilities), thus encouraging pretreatment of the waste stream at the source with the lowest overall cost.

Respondents also listed institutional, informational, market, and regulatory barriers to energy efficiency opportunities. Institutional barriers were most often cited and included a lack of managerial knowledge and understanding of energy efficiency opportunities. The most explicit comments regarded the lack of energy management plans at the facility level.

A notable institutional barrier raised in relation to every energy efficiency improvement was that plant managers view energy efficiency as a tool to achieve regulatory compliance, not as a cost, capacity, or energy savings opportunity. Survey respondents indicated that plant-level use of cost-effective energy efficiency is primarily to ensure that the plant is in environmental permit compliance. Plant operators do not use energy efficiency as a stand-alone cost savings or productivity enhancing tool. The reason for this is that the primary mission of water utilities is to provide a safe reliable supply of water to customers. Procedures or processes, such as energy efficiency, that are not viewed as advancing that mission are rarely considered.

Informational barriers reported included a lack of education regarding opportunities for plant managers, as well as a lack of awareness of case studies, and benchmarking and cost-effectiveness studies. Market barriers listed included the lack of financing capital and a general

lack of incentives for energy-efficient upgrades. Reported regulatory barriers related to electricity rates and tariffs as well as procurement policies. Some respondents pointed directly to the lack of regulation of utility "exit fees" as a negative incentive for promoting energy efficiency technologies and practices, though these fees appear to be declining in use. Other respondents indicated that the procurement policies of most municipalities strictly limit the choices of the plant managers, limiting their ability to install energy-efficient technologies.

Overarching Opportunities

Prior to this survey, the predominant energy efficiency stakeholder approach to program design has been to target both the water and wastewater sectors as a single market. This approach allows for the streamlining of resources and is particularly effective when technology types at the end-use of processes are the same. For example, if motors are a major energy end-use for both sectors, then a motor efficiency program targeting both sectors would streamline program resources and have a significant impact. Further, because this roadmap effort focuses on municipalities, which often have combined water and wastewater responsibilities, the deployment of programs would be simplified.

To the extent that water and wastewater facilities are optimizing the same end-use energy technology systems, the results of this survey support the combined water and wastewater sector approach of energy efficiency programs. From the opportunities listed by both the water and wastewater communities, we can conclude that optimization will often refer to motor efficiency gains and "right-sizing" of facilities, based on realistic growth and consumption estimates.

Government procurement practices are another area where programs can be deployed to the water and wastewater sectors for maximum impact. As a result, a large number of the stakeholders in the sector will have to go through government procurement agencies for supplies and services. Increasing knowledge and flexibility pertaining to energy-efficient products and services at the procurement office would have a broad impact on both the water and wastewater sectors.

The previous two examples are representative of the opportunities available to both the water and wastewater sectors in terms of energy efficiency. There are also sector-specific opportunities, such as biogas in the wastewater sector, that should be acknowledged and approached separately by energy efficiency programs.

Research, Market, and Policy Opportunities

The last section of the survey covered the similarities in both the water and wastewater sectors and asked the respondents to identify broader, longer-range opportunities for and barriers to energy efficiency through research, market and regulatory changes, and federal and state policies.

The first of these three questions focused on research needs to overcome the barriers to energy efficiency in the water and wastewater arenas. The responses can be divided into two primary categories: technology and education/information. In the technology category, respondents identified primary research focus areas as research into the use of waste heat, showcases of technology applications, and technology demonstrations. Respondents also commented that the

dissemination of results must be widespread to overcome informational barriers. Finally, respondents emphasized the importance of a benchmarking procedure that would allow the case studies and information to be interpreted uniformly among facilities.

The second question, which asked respondents to identify upcoming market or regulatory changes that would have an impact on energy efficiency promotion in the water and wastewater sectors, also earned a wide range of comments. The most common response was in reference to growing security concerns at these facilities. To the extent possible, energy efficiency must be framed as security enhancing to be a priority in the future. Other market and regulatory changes that may have an impact on the sectors are the Sewer Long Term Control Plans (requirements that systems reduce discharges of pollutants), Clean Air Act amendments (pending in Congress), and general regulatory uncertainty.

Finally, respondents were invited to suggest what state and federal policy actions, if implemented, could promote energy efficiency in the sector. Respondents had many ideas for a governmental role. The most common role identified for government was to provide financial incentives to municipalities for the design and implementation of capital-intensive projects, renewable energy systems, water conservation, and energy efficiency. A variety of permit streamlining and rate change suggestions were also suggested including removal of unnecessary permits, and governmental intervention to remove exit fees for distributed energy. Finally, one respondent suggested the incorporation of energy needs for water and wastewater facilities into the national energy plan.

Workshop Discussions

Topics of Discussion

Based on the results of the survey discussed above, ACEEE and the advisory committee chose the four key topics of interest to a broad range of stakeholders to be the focus of discussion at the roadmap meeting:

1) *Process-Oriented Energy Saving and Productivity Gain Opportunities*. Many stakeholders reported process optimization to be the largest opportunity for energy savings.
2) *Relations with Electric Utilities*. Communication between the electric utility and the water utility (in general one of its largest customers) is lacking, as is an understanding of rates and tariffs.
3) *Informational, Technical, and Market Barriers*. This topic covers the lack of communication, understanding, and transfer of information to appropriate stakeholders within management and the facility, as well as appropriate steps needed to overcome these difficulties. The survey respondents made multiple references to such barriers, including research and demonstration needs as well as the dissemination of the information collected from those projects.
4) *Institutional Barriers*. Attitudes and management techniques within a facility sometimes create many barriers to energy efficiency. Respondents indicated that a change in the way management views energy costs and their connection to productivity and cost savings must be clarified for progress to be made. The issues related to trade offs between

environmental and water quality compliance and efficiency reported in the survey are an example of the failure of the energy efficiency program developers and implementers to communicate adequately beyond the compliance benefits of energy efficiency.

Group Findings

As noted earlier, the participants met initially as a one group before splitting into two subgroups. One subgroup focused on implementation and the other on the R&D aspects of the discussion. At the end, the two subgroups reconvened together to compare findings and assess common aspects of their discussions. The notes collected during the workshop are transcribed in Appendix D.

In the initial discussions, the participants quickly agreed to two common goals for their participation in the workshop:

- Change the mindset throughout the purchase chain in the W&WW industry from buying cheap to buying "right"
- Change the energy intensity of the W&WW industry by transforming the market to support energy-efficient best practices

The assembled group moved quickly to a discussion of the audiences that would need to be influenced to achieve these goals. The key target audiences were agreed to be:

- Plant and system operators
- Plant and system managers
- Purchasing managers in the W&WW systems
- Design engineers
- Equipment vendors and service providers
- Contractors involved with new facility construction, and renovation and expansion of existing faculties
- City managers/local governance bodies (e.g., water boards or country commissions)
- State legislatures
- Regulators
    - state water quality
    - EPA
    - state public service commissions
    - state revolving fund administrators
- Consumers (commercial, residential, and industrial)

It was agreed that the primary goal of the R&D efforts was to support the implementation of energy-efficient practices by addressing the key technology and data needs, and demonstration of the existing technology that is already available in the market place. On the other hand, participants of the implementation subgroup represented a more diverse set of communities, many with individual key needs and perspectives, lacking the singular focus of the R&D community. As a result, the range of discussion was much broader in scope and the subgroup converged on key action items more slowly than did the R&D community. In many ways, the

R&D subgroup was more focused than the implementation subgroup, in part because most of the participants in this subgroup were from national research organizations (e.g., AwwaRF and WERF). As a result, the R&D subgroup was able to move quickly to begin identifying key research topics. In addition, both subgroups came up with a set of key action items. These activities were intended to make progress toward addressing the key opportunities identified in the previous discussions. Individual participants agreed to take responsibility for moving these action items forward and are identified in Appendix D.

R&D Subgroup

As mentioned previously, the dialog among the R&D community had been ongoing. While the discussions were wide-ranging, three broad area of discussion emerged:

- Need for ongoing coordination
- Need to balance short-term needs with longer-term, strategic explorations
- Need to identify specific research topics for future research

Coordination

The participants acknowledged that activities among various parts of the water and wastewater R&D community have not been very well coordinated. It was also noted that while communications between the water and wastewater R&D funding entities (e.g., AwwaRF and WERF) are improving, the efforts on coordination need to continue. With increased interest and funding coming from non-water groups, such as state and federal energy agencies, the need for coordination among R&D funding entities is even greater to avoid redundancy and duplication in their activities, while maintaining the diversity in perspective that comes from having organizations with different interests and regional focuses.

Coordination among R&D funding entities is also needed to help expand the pool of research funding available to address research needs. Among the most pressing needs are to create ways to support high-risk research and demonstration projects. There is a current lack of resources to take new research innovations and move them to demonstration to verify their performance in the field. Furthermore, there is a need to certify the performance of new technologies to increase the confidence among plant designers and operators so they are willing to deploy them.

While coordination in funding between government funding entities (e.g., EPA, California Energy Commission, and NYSERDA) and participant funded entities (e.g., AwwaRF and WERF) is needed, there was also the sense that ways should be explored to involve the venture capital community in these research activities. The involvement of private venture parties in R&D could expand the pool of funding while facilitating commercialization opportunities. However, the involvement of private funding entities with pubic entities may create some challenges in addressing thorny issues like ownership of intellectual property.

Short-term vs. Long-term R&D Needs

One of the challenges the subgroup identified was the need to balance between addressing shorter-term, reactive needs and pursuing longer-term, more strategic research areas. In the short

term, R&D is focused on reacting to market events such as changes in regulations or pressure on infrastructure resulting from economic growth. A key issue identified is the need for better data and metrics about water and wastewater systems operations. Current available information on water and wastewater practices across the country is not adequate, so a database of information on current systems and practices, reflecting the regional diversity, is needed.

It is also important to integrate energy into academic programs that support the water and wastewater industry. Currently, most environmental engineering programs do not include more than a cursory discussion of energy in their curriculums. Possible strategies could include working with the Accreditation Board for Engineering Technology (ABET) to get energy included in its curriculum guidelines, and working with professional engineering organizations at the state and national level to include energy in the fundamentals of engineering (EIT) and professional engineering (PE) tests and continuing education requirements.

For the long term, the subgroup was of the opinion that current models and paradigms for plant design and operation needed to be revisited by the R&D community. The main areas for reconsideration of current practices include:

- The hydraulic model for both plant and system design
- The dominance of aerobic processes in sewage treatment over anaerobic processes
- The dominance of centralized versus dispersed treatment models

More broadly, a rethinking of how water and wastewater systems fit into the overall economy is perhaps warranted. Interest is already increasing in generating energy from wastewater streams through anaerobic digestion. A potential exists to integrate wastewater with solid waste streams, either high organic content industrial wastes or municipal garbage to increase the energy output from the facilities, making the treatment plants net-energy exporters. In addition, these integrated waste management facilities could be used to extract salable products from the waste streams.

In the bigger picture, the subgroup suggested that sustainability may be considered the goal of water systems, rather than just energy efficiency. In this context, using wastewater and renewable energy to operate water and wastewater systems rather than relying upon non-renewable energy sources and products, such as chemicals, may be preferable. For example, using energy-intensive technologies such as ultraviolet and ozone disinfection, powered by a renewable energy source rather than purchased chemicals, might be the preferred path. In the revised scheme of operation, energy use in the system might increase over current normal consumption even after the energy efficiency practices are implemented, but externally procured energy (both fuels and chemicals) would decrease perhaps even to zero.

Ultimately this balance requires steps to address short-term infrastructures needs while maintaining the flexibility in the system to allow for future innovations.

Specific Suggested Research Topics

Because of the previous discussions by many of the participants in the R&D subgroup, attempts were made to identify possible new research topics. Some of the ideas that emerged during the subgroup discussions are as follows:

- Produce energy from wastewater treatment—considering small versus large systems
- Assess use of renewable energy in water/wastewater systems
- Evaluate energy efficiency potential in HVAC systems at W&WW facilities
- Demonstrate hot water reuse in commercial buildings, institutions, and industrial facilities
- Compare energy use in alternative wastewater treatment of liquids and solids, considering tradeoffs between
  - energy and land
  - water quality and land use regulations
- Consider micro-algae oxygenation in place of conventional aeration
- Use "Super Bugs" in wastewater treatment processes
- Develop best-practice guidelines for smaller W&WW facilities
- Study on the state and local level conservation opportunities, coupled with review of local regulations and barriers
- Analyze the "cost" of various contaminant control technologies—use common metrics to compare
- Explore dual water systems (e.g., potable and non-potable supplies)
- Evaluate biogas cleanup techniques
- Rethink the hydraulic model of W&WW treatment plants and systems
- Explore the role of online monitoring
- Develop strategies to address Class A sludge
- Verify and certify technologies
- Develop database linking urban planning and energy regulation with water quality and land use
- Integrate social science research into technology adoption assessment in R&D projects

R&D Action Items

The R&D subgroup came up with six priority action items:

- A National Research Council study should be commissioned on the future of urban water management. The study should focus on the energy efficiency and sustainability of urban water and wastewater systems and should involve all affected stakeholder groups.
- A workshop should be organized to identify and recommend specific water-energy materials that should be incorporated into environmental curricula.
- A water-energy R&D coordinating group should be established, involving the following groups:
  - ASERTTI (including CEC, NYSERDA)
  - WERF

  - AwwaRF
  - EPA
  - DOE/national labs
  - EPRI
  - Other organizations including AMSA, AMWA, WEF AWWA, USDA, NSF, HI, and WRF
- Develop research idea descriptions to use in future research RFP's
- Create a pool to fund high-risk research and demonstration projects (to be considered by the R&D coordinating group mentioned above)
- Establish a newsletter/e-letter to publicize W&WW R&D RFP's and research results

Implementation Subgroup

As noted earlier, the implementation subgroup was more diverse and had fewer previous opportunities for discussion than had the R&D subgroup. As a result, the subgroup started with a brainstorming exercise to identify key issues, identifying nine key topic areas

- Education and outreach
- Energy management
- Benchmarking (data needs)
- Codes and standards (performance)
- Regulator actions
- Systems approach
- Asset management
- Institutional structures (culture and behavior)
- Incentives/financing

The full list of ideas under each of these topics is available in Appendix D. Key points for each topic are summarized below.

Education and Outreach

Education and awareness prompted a wide-ranging discussion, focusing on a diverse group of audiences ranging from the plant to the public. Among the themes that emerged from the subgroup discussions were identifying the key audiences and developing targeted strategies to influence them. Among the specific ideas were insuring that energy is included in curricula for engineering and operator training, and developing support tools. A significant interest was expressed for making the "business case" for energy efficiency including: providing specific guidance for best practices for plant designers; equating energy savings with maintenance savings; applying lifecycle analysis to investment decisions; and focusing on "buying right," not buying lowest cost. Interest was also expressed in facilitating international exchanges with Europe and developing countries.

A somewhat different communications issue emerged about how well W&WW operators and managers understand electric utilities and their rate structures. It was felt that fostering better

understanding and communications between W&WW faculties and their utilities could prove mutually beneficial and contribute to better energy management.

Benchmarking (Data Needs)

Somewhat analogous to the data needs identified by the R&D subgroup, there was interest in better understanding the W&WW sector. In the implementation subgroup there was particular emphasis on benchmarking various plant or system performance metrics to identify best practices. These included performance metrics along with cost and management practices.

Codes and Standards (Performance)

Following somewhat along the same themes as the benchmarking discussion, there was a discussion of various approaches to codifying water/energy performance into guidelines such as building codes and other design guidance documents.

Systems Approach (System Boundaries)

With respect to design, there was a discussion of how system boundaries should be treated. There were concerns that boundaries were frequently defined too narrowly and that by looking at the system more broadly, greater efficiency could be achieved. For example, industrial pre-treatment of effluence could more cost effectively allow a treatment plant to meet discharge standards than could installation of additional treatment technologies at the facility. Similarly, designing an integrated control system for pumping and aeration of an entire plant could reduce energy requirements more than controlling each stage of treatment individually. The goal is to encourage a broad, systematic approach to the design of water and wastewater treatment systems.

Energy Management (Distributed Generation and Load Management)

This discussion focused on managing energy use at the plant to take advantage of existing electric rates and "opportunity fuels" such as digester or landfill gas. Issues discussed were the role of distributed generation and electric load response programs in reducing energy (principally electric) costs at facilities.

Institutional Structures and Asset Management

The subgroups expressed concerns about how energy is perceived within W&WW organizations and whether systems are managed and operated with sensitivity to energy impacts. Among the issues identified was the need for making links between leaks and infiltration and inflow (I&I), and the energy costs. Within the operational structures, energy needs to be identified as an operating metric for management and operations staff, and costs savings that result from changes need to be rewarded. The importance of an individual champion also needs to be recognized.

This discussion also raised several issues about how energy is communicated within W&WW organizations and to management. These observations led to suggestions that overall management systems should be considered broadly, with energy incorporated into the management plan as a control element.

Regulator Actions

The discussion identified roles for state and federal regulators as well in creating an environment in which energy efficiency is both recognized and rewarded. It is important for these regulators to make the energy efficiency capacity link and incorporate this linkage into their activities. Including energy audit information in the drinking water needs and clean watershed surveys would elevate the importance of energy efficiency among these audiences.

Incentives/Financing

The sense of the subgroup was that the current financing and incentive structure does not recognize the importance of energy and reward investment in energy efficiency. These structures need to be revisited to insure that all parties—operator, managers, consultants, engineers—are rewarded for taking actions that advance energy efficiency. Financing structures that consider the cost savings that result from investments in energy efficiency need to be implemented. Of almost equal importance is encouraging that provisions be made to protect these parties from retribution from implementing innovations that carry with them some degree of risk.

Implementation Action Items

While the subgroup did not have sufficient time to identify and prioritize specific action items, the members did identify some "quick hits" that represent near-term action opportunities. Among the actionable suggestions are:

- Develop a decision-making diagram (PRIORITY)—Who cares about increased energy efficiency?
    - What are the project development processes and drivers?
    - Where are the barriers?
    - How can the proposed activities address them?
- Provide energy auditing guidelines to facilities
    - Review EPRI guidelines
    - Expand to include sub-metering
- Develop a manual for plant operators on energy and link to PEA Operator Training, and include in the certification processes of the National Environmental Training Center for Small Communities (NETCSE) and the Drinking Water Academy
- Develop environmental engineering training curriculum that incorporates energy
- Create an inventory of existing case studies of energy in W&WW
- Incorporate energy efficiency best practices and asset management into ISO certification standards development
- Insure that water/wastewater energy considerations are incorporated into the green buildings/LEED/ENERGY STAR initiatives
- Link availability of state revolving loan fund financing to ISO certification of energy efficiency
- Develop a national marketing strategy including outreach to major conferences and events:

- Organize a technical session at the WEF Conference to highlight case studies and best practices
- City Managers Association
- AWWA:
  - ACE Annual Conference and Exposition
  - DSS—operators
- Large state events (e.g., CA, NY)

Crosscutting Issues Identified by the Two Subgroups

Two issues came up in both the R&D and implementation subgroups:

- Need for better information and data on water and wastewater operations and technologies in the U.S. This includes benchmarking as well as broader data collection efforts on energy use by region, water source, treatment technology, and facility size.
- Need for incorporation of energy into educational programs.

These two crosscutting issues are clearly priorities.

Conclusions and Recommendations

While interest in the relationship between energy use and municipal water and wastewater system operation is increasing, it is also clear that additional coordination is needed for significant progress to be made. Among the key themes that have emerged from the process that ACEEE facilitated are:

- Our understanding of how energy is used and managed in water and wastewater systems is at this point limited. Significant new data collection and analysis efforts are required to understand the regional and technology variations that exist in energy use in the municipal water and wastewater sectors.
- Energy use and associated costs in water and wastewater operations are not fully appreciated among most of the key stakeholder groups. A major education and awareness effort is needed if significant progress is to be made on changing energy use and management practices.
- A tension exists between meeting the short-term goals of energy and cost reduction and moving water and wastewater treatment practices onto a more sustainable path. While responding to current regulatory, capacity, and cost pressures is essential, the community needs to begin a deliberate process to reevaluate and reconsider current system models and practice paradigms.

It is equally clear that none of the stakeholder groups is capable of advancing the discussion of energy use in water and wastewater operations alone. What appear to be needed are mechanisms for coordination among the stakeholder groups. These mechanisms must encourage interaction between what are currently unrelated interests, but also must respect the unique interests and strengths of each group. One of these mechanisms has already begun to emerge through cooperation among AwwaRF, WERF, CEC, and NYSERDA on identifying research priorities

(and in some cases co-funding research). These efforts could effectively be expanded into a national R&D coordinating activity that would promote board exchange among the groups on research activities and better insure that a comprehensive portfolio of research topics is addressed while avoiding redundancy and duplication.

The route to a similar mechanism for the implementation sector is less clear, in part because of the more diverse nature of the various stakeholder interests. The discussions begun in Washington in July of 2004 need to be continued. Through continued discussions and cooperation it is hoped that an appropriate coordination structure will emerge at the state, regional, and national levels.

Energy will play an increasingly important role in water and wastewater operations as prices rise and demands increase as a result of external pressures. Managing energy effectively will insure that the goals of maintaining clean, safe, and available water are achieved while keeping the financial and environmental costs of energy use to a minimum.

Key Opportunities for Action

Since the roadmap meeting attendees did not have sufficient time to identify key action items, several members of the steering committee met by conference call recently to identify key areas for further action to advance energy efficiency in the water and wastewater industry:

- Energy efficiency should be included in educational curriculum at the university engineering, tech school, operator training, and continuing education levels.
- Standard data collection protocols need to be established so that comparable performance data can be collected, meaningful databases assembled, “best practice” guidelines identified.
- Energy efficiency metrics should be incorporated into requirements for NPDES permits and eligibility for state revolving loan funds for water and wastewater infrastructure.
- A means of coordination and information exchange needs to be established to identify and collect information across activities.

Recommended Next Steps

ACEEE recommends that a continuing group of interested stakeholders needs to continue to work together. This group would provide coordination, play a clearing house role, and—most importantly—identify key opportunities for action that are not being met by established programs. It is suggested that a “working group” or “steering committee” for water and wastewater energy efficiency could meet this need. Many such groups have been established in the past when diverse stakeholders have needed to develop goals and oversee the implementation of a set of key strategies.

This steering committee on water/wastewater energy efficiency would be made up of interested parties who would contribute toward a modest administrative fund and provide in-kind support that would:

- Collect information on existing water and wastewater energy activities, making them available on a website
- Provide coordination among activities by organizing conference calls and meetings of key stakeholders
- Spot gaps, identify redundant efforts, and ensure that progress is being made on key action items.

This entity would, by design, be created for a limited duration as directed by the supporting stakeholders.

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Appendix A—Agenda

Day 1 (Thursday July 29):

1:00 pm *Welcome and Introductions*—facilitator
The facilitator will provide an overview of the workshop and allow participants to briefly identify themselves and say one thing about why they are attending the workshop.

1:15 pm *Overview of Water/Energy Linkages*—Keith Carnes, EPRI
An expert will provide a brief overview of the water and wastewater markets, and discuss how energy is used within these industries.

1:45 pm *Summary of Participant Survey Results*—Elizabeth Brown, ACEEE
Liz will discuss the survey and summarize the issues that were identified as key to addressing energy use in water and wastewater.

2:00 pm *Goals and Outcomes for the Roundtable*—facilitator
The facilitator will lay out the rules for the discussions and will lead the group in a process to reach a shared set of goals and outcomes for the workshop. The emphasis will be on identifying tangible outcomes that participants will use to guide their discussion through the remainder of the workshop.

2:30 pm *Identification of Key Stakeholder Needs*—facilitator-led discussion
Participants will identify the key needs that exist to better manage and use energy in water and wastewater facilities serving municipalities and communities across the country. Needs could include anything from additional information, addition money for facilities, new technology, better communications, etc.

3:00 pm Break

3:15 pm *Discussion of Key Needs*—facilitator-led discussion
Participants will discuss the needs that were identified by the group and assign them to one or both of two breakout sessions: R&D issues and implementation issues.

3:30 pm *Breakout Sessions: Continued Discussion of Key Needs*–facilitator-led discussion
Breakout groups will discuss the key issues assigned to their groups and rank the issues in terms of importance to the group.

5:15 pm *Regroup and Review of Discussions*—breakout session reporters
A reporter selected from each breakout session will summarize the outcomes of the group's discussions, identifying the priority needs identified.

5:45 pm *Review for the Next Day*—facilitator
The facilitator will review plans for the second day and agreed-upon goals and objectives.

6:00 pm *Adjourn for the Day*

evening *Optional No-Host Dinner*

Day 2 (Friday July 30):

8:00 am *Continental Breakfast*

8:30 am *Review Day 1 Results/Discuss Goals and Objectives for Day 2*—facilitator
The facilitator will lead the group in a review of the breakout results exploring possible crossover areas between R&D and implementation. The group as a whole will review the breakout groups' rankings and build a consensus set of priority issues.

9:30 am Break

9:45 am *Breakout Groups: Develop Specific Activity Goals*–facilitator-led discussion
The breakout groups will identify specific strategies and actions required to address the priority issues assigned to the group. These strategies should be as specific as possible.

noon *Working Lunch*

1:00 pm *Identification of Strategies to Achieve Key Goals*—facilitator
Reporters chosen by each breakout group will present the strategies identified by each group to address their priority issues. The group will discuss these strategies and agree to key, overall strategies that can be best used to implement the identified actions.

2:00 pm *Next Steps: Identification of Action Items and Activity Leaders*—facilitator
The group will identify action items needed to implement the activities and strategies identified by the group. The action items need to specific, with clear outcomes and metrics to identify progress. Particular individuals will be identified to lead the implementation of the actions and participant teams will be formed. Others who have not attended and should be involved in the teams will also be identified.

2:50 pm *What to Expect Next*—ACEEE
ACEEE will discuss what will happen next: roadmap drafting, follow-up meeting, networking

3:00 pm *Adjourn*

Appendix B—Stakeholder Survey

	Water/Wastewater Industry Energy Roadmap Project: Stakeholder Survey March 2004

Identification Information

Name	
Title	
Company	
Phone	
Fax	
E-mail	

Are you interested in attending the roadmapping session in Washington, D.C. in the late spring or summer of 2004? Yes_____ or No _____

Survey Questions

1) Rank the following opportunities for energy savings and/or productivity enhancements through energy efficiency in the **water** industry from 1–5 (1 being the largest opportunity).

___Benchmarking
___Energy Audits
___Incorporating Energy Considerations into Procurement Strategies
___Motor Systems
___Operations and Energy Use Optimization
___Power Generation from Biogas
___Process Modifications (please specify) _____
___Water Efficiency/Conservation
___Other (please specify) _____

2) What aspect(s) of your highest ranks makes it the largest opportunity for potential savings?

3) Of your highest rank, please list the barriers that need to be overcome for the opportunity to be recognized.

4) Rank the following opportunities for energy savings and/or energy efficiency productivity enhancements in the **wastewater** industry from 1–5 (1 being the largest opportunity).

___Benchmarking
___Energy Audits
___Incorporating Energy Considerations into Procurement Strategies
___Motor Systems
___Operations and Energy Use Optimization
___Power Generation from Biogas
___Process Modifications (please specify) _____
___Water Efficiency/Conservation
___Other (please specify) _____

5) What aspect(s) of your highest rank makes it the largest opportunity for potential savings?

6) Of your highest rank, please list the barriers that need to be overcome for the opportunity to be recognized.

7) In the interest of overcoming barriers, what research needs to be completed, what information needs to be available, and what specific questions need to be answered in order to assist the industry with increasing energy efficiency?

8) In the next five years, is there any specific market or regulatory changes that you identify as impacting energy efficiency in the water and wastewater industries? If so, what are those changes and how will they impact the industry?

9) What federal and/or state policy changes can you envision that could encourage energy efficiency in your highest identified rank in the water and wastewater sectors?

10) What do you view as the next steps for increasing energy efficiency/productivity in the water and wastewater industries?

Appendix C—Participants List

Stefan Abelin
ITT Flygt Corporation

Bill Adams
Flowserve Corp

Cliff Arnett
Columbus Water Works, Georgia

Steve Bolles
Process Energy Services, LLC

Dave Burnett
Texas A&M University–Petroleum Engineering

Rolf Butters
DOE

Joseph Cantwell
SAIC

Keith Carns
EPRI/Global Community Environmental Center

Shahid Chaudhry
California Energy Commission

Katie Coughlin
LBNL

Diane Creel
Ecovation

Glen Daigger
CH2M Hill

Anthony Daniel
Water Administration, Temple, Texas

Andrea Denny
EPA

Patsy Dugger
PG&E

Neal Elliott
ACEEE

Stephen Fok
Pacific Gas and Electric Company

Don Gray (Gabb)
East Bay Municipal Utility District

Bailey Green
LBNL

Bill Haman
Iowa Energy Center

Caterina Hatcher
EPA

Danny Heredia
Fluid Conservation Systems

Mark Hopkins
Alliance to Save Energy

Gunnar Hovstadius
Consultant

Ted Jones
CEE

Ralph Jones
The Cadmus Group, Inc.

Janet Joseph
NYSERDA

Robert Kripowicz
ASERTTI

Lory Larson
Southern California Edison

Ken Lykens
Denver Water Authority

Omar Maghaddum
City of Los Angeles, Bureau of Sanitation

Aimee McKane
LBNL

Margaret McMorrow
Alliance to Save Energy

Timothy McProuty
EPA

Hugh Monteith
Hydromantis, Inc.

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City of Los Angeles, Hyperion Treatment Plant

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EPA–Drinking Water State Revolving Fund Team

Stephanie Tanner
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Alliance to Save Energy

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Appendix D—Meeting Notes

Goals

- Change the mindset throughout the purchase chain from buying cheap to buying "right"
- Change the energy intensity of the W&WW industry by transforming the market to support energy efficient best practices

Audiences

- Operators
- Design engineers
- City manager/local governance
- State legislatures
- Purchasing managers
- Regulators: state water quality, EPA, state public service commissions, state revolving fund administrators
- Vendors
- Contractors
- Consumers (commercial, residential, and industrial)
- Plant managers

Implementation Sub-Group

Brain Storming

Education and Outreach

- Energy education for W&WW treatment plant operators
- Energy education of engineering students
- Awareness opportunities—energy savings = maintenance savings
- Lifecycle cost decision making
- Best practice case studies packaged at a single source with communications tools
- Publicize water conservation opportunities
- Use language of management in case studies
- Outreach to decision makers—make "business case"
- Tiered marketing approach to "buying right"
  - Purchasing managers
  - Operators
  - Vendors
  - Engineers
  - Contractors
- Cultural exchange—Europe, developing countries
- Energy guidance to designers of existing and new facilities
- Better communications between W&WW and electric utilities

Energy Management

- Distributed generation
- Load management/peak shifting
- Producing energy from waste (self-generation)
- Electric rate structure for renewables
- Provide a way for wastewater plants to sell excess power

Benchmarking (data)

- Benchmarking implementation
- Benchmarking organizations
- Establish waster/energy cost and use data
    - Public and private
    - Cost/price transparency
    - Geographic data on constraints
    - Regulatory information
    - Incentives
    - Renewable
    - Net metering
    - Venture capital available

Codes and Standards (performance)

- Build energy efficiency into codes
- Make codes performance-based
- Allow for sizing equipment for current needs rather than for 20-year system life
- Voluntary standards and guidelines
- Regulatory standards—codes + performance guidelines

EPA/State Administrators

- Add energy audit info to drinking water—needs survey
- Clean watershed survey—EPA/WERF/EPRI/AwwaRF coordination
- Energy efficiency ⇔ capacity link

Systems Approach (boundaries)

- Take a broad, overall W&WW system perspective in sizing and designing systems
- Focus on systemic approach to energy on W&WW
- Optimize pump and aeration system control, monitoring, optimization
- Industrial pretreatment for wastewater

Asset Management

- Tighten up on leaks/infiltration on distribution and collection

- How to make energy significant within system
- Optimize pump and aeration systems—control monitoring and optimization
- Productivity enhancement: energy ⇔ capacity link
- Is energy efficiency or asset management the key driver in decision making
- Lifecycle cost (LLC) evaluation of decisions on capital costs → energy savings and maintenance
- Change culture to better adopt energy efficiency measures

Institutional Structure (Culture/Behavior)

- Need energy manager/champion who is accountable
- Change budgeting process to pay for upgrades and maintenance
- Outreach to decision makers—use financial terms to make business case
- Need to address "nothing happens" problem of energy efficiency implementation
- Fundamental change in institutional and management structure
- Separate W&WW facility budget from municipal/county budget
- Change culture—consulting firms and middle management need reward for energy efficiency

Incentives/Financing

- Inadequate incentives to consultants for energy efficiency
- Need incentives for:
  - Managers
  - Engineers
  - Operators

  with insurance to address the risk of innovation
- Incentives for best practices—grants, loans, SRC credits
- Address risk/reward barrier for adoption of new technology → recognition and regulatory flexibility
- Better financing solutions
- Look at venture capitalists as a resource to reduce risk of projects
- Need rewards for consulting firms and middle management

Quick Hits

- Define the audiences
- Determine what drives their decisions
- Target the message
- Develop manual for plant operators (Ralph Jones, Ken Kerri, and Cal State Sacramento)—link to PEA Operator Training Centers and include in certification process:
  - National Environmental Training Center for Small Communities (NETCSE)
  - Drinking Water Academy
- Develop engineering training curriculum that incorporates energy efficiency

- Incorporate energy efficiency into engineering guidelines with industry participation and get buy-in from regulators → recognize regional differences (George Tchobanoglous and John Novak)
- WEF Conference—technical sessions to highlight case studies and best practices—½ day (suggest Jim Wheeler)
- Different outreach techniques for small plants
- Inventory of existing case studies (ASE, DOE, HI)
- Develop national marketing strategy including outreach to major conferences and events:
  - AWWA:
    - ACE Annual Conference and Exposition (Margaret McMorrow)
    - DSS—operators
  - City Managers Association (Katy Hatcher)
  - WEF
  - Large state events (CA, NY)
- Provide energy auditing guidelines to facilities
  - Review EPRI guidelines (Shahid Chaudhry)
  - Expand to include sub-metering (Janet Joseph)
- Need to incorporate energy efficiency best practices and asset management into ISO certification standards development (Katy Hatcher and Cliff Arnett)
- Incorporate water/wastewater energy considerations into the green buildings/ LEED/ENERGY STAR initiatives (Katy Hatcher, Stephanie Tanner, and Anthony Radspieler)
- Voluntary guidelines for energy management to be developed: new facility and retrofit engineering, operation (Jim Wheeler)
- Professional certification that includes energy efficiency (defer to future)
- AwwaRF BP Study—water, wastewater benchmarking study already underway—macro-level
- Build awareness with plant managers, maintenance, and operating staff on availability and benefits of measurement instrument (attempt to factor into bonuses)
- Clearinghouse: look at existing datasets (include European data)—are there ways to integrate them? How to access?
- Make sure that training on asset management by WERF, AwwaRF, AMSA, and AMWA includes energy efficiency
- Develop a decision-making diagram (PRIORITY)—Who cares about increased energy efficiency? (Katy Hatcher and Bill Adams)
    - What are the project development processes and drivers?
    - What are the barriers?
    - How can the proposed activities address them?
  - Tie into existing asset management models
  - Involve participants from throughout the decision model
  - Be transparent—what are the actions designed to address?
  - Target the decision points
- Encourage every plant to have an energy manager or access to one
- Link availability of SRF financing to ISO certification
  - Discuss with the:

        - State EPA SRF workgroup (Peter Shanahan)
        - Analysis of public versus private capital and bonds (Ralph Jones)
    - Prepare case studies of performance contracting (Vestal Tutterow, Rob Taylor, and Katy Hatcher)
- Explore possibility of utility rate renegotiation (Stephen Fok and Joe Visalli)
- Impact of energy efficiency on fuel price vulnerability and asset management for financing options
- Bonus for operators to reward effective monitoring (future)
- National trust—could offer risk insurance, performance guarantee (future)

R&D Sub-Group

Key R&D Needs

- Institutionalize the W&WW energy connection
- Make the economic linkage between energy price and water price
- Address increasing energy intensity of W&WW treatment with new technologies to meet increasingly stringent water quality standards
- Shift from aerobic to anaerobic treatment of wastewater
- Develop way to address Class A sludge in an energy-efficient way
- Link long-term and near-term R&D with future regulations—develop technologies to respond to and evaluate cost/benefits of proposed future regulations
- Identify links to water security
- Lack of interagency coordination
- Proprietary issues are barrier to new technologies—public money discourages selecting proprietary technologies
- Loss of EPRI funding reduces funding flexibility
- Role of private industry to be early adopter—learn from past experience and figure out how to transfer experience
- Metrics—external savings from water conservation—have way to recognize savings
- Identify barriers to energy efficiency and renewable energy in W&WW
- Speaker series on energy/water linkages for leading universities
- Need to rethink the hydraulic model of W&WW plant

<u>Long Term versus Short Term:</u>

Long term:

- rethink models and paradigms:
    - aerobic versus anaerobic
    - distributed versus centralized
    - wastewater as a net energy producer
    - link to future regulations
    - role of renewable energy in W&WW
    - industrial pretreatment/reuse
    - source separation
    - extraction of products from wastewater

        - integrated treatment of solid waste and wastewater
    - scenario planning—consider alternate futures/rethink vision for industry
    - NRC study of institutional structure and implementation
    - Water "Industry of the Future" effort modeled upon DOE OIT roadmaps
    - Move W&WW toward greater sustainability—more renewable energy => greater sustainability: replace non-renewable inputs (e.g., chemicals) with renewable energy

Short term:

- develop database of current information and practices
- role of W&WW in climate change
- academic framework for energy water—link to ABET, EIT/PE, and continuing education credits
- need to figure out how to address current infrastructure needs without foreclosing future options
- develop appropriate metrics reflecting energy/water/sustainability

Need R&D Coordination

- Need coordination between participant-funded research groups and government agencies
- Eliminate duplication but understand regional and perspective differences—address boundary issues
- Need way to identify new areas of research
- Need way to support high risk research and demonstration
- Need way identify long-term research and development needs
- Develop cooperative role on R&D among venture capital groups, participant-funded research entities and government agencies
- Need way to verify and certify performance of technologies

R&D Actions

- Commission National Research Council Study on the future of urban water management—focus on energy efficiency and sustainability involving all interested parties (Glen Daigger)
- Workshop on incorporating energy in environmental curricula ASEEP with NSF funding (George Tchobanoglous)
- Establish a W&WW R&D coordinating group—ACEEE convene:
    - ASERTTI (including CEC, NYSERDA)
    - WERF
    - AwwaRF
    - EPA
    - DOE/national labs
    - EPRI
    - Others (AMSA, AMWA, WEF AWWA, USDA, NSF, HI,WRF)

- Develop research idea descriptions to use in future RFP's (Omar Maghaddum and Shahid Chaudhry)
- Create a pool to fund high-risk research and demonstration projects (to be considered by R&D coordinating groups mentioned above)
- Establish a newsletter/e-letter to publicize W&WW R&D RFP's and research results

Specific Water/Wastewater Research Topics

- Producing energy from wastewater treatment—considering small versus large systems (Hugh Monteith and Roy Ramani)
- Assess use of renewable energy in water/wastewater systems (Don Gray)
- Energy efficiency potential in HVAC systems at W&WW treatment plant (Linda Reekie)
- Demonstrate hot water reuse
- Comparison study on energy use in alternative wastewater treatment of liquids and solids, considering tradeoffs between (Bailey Green and Roy Ramani):
  - energy and land
  - water quality and land use regulations
- Micro-algae oxygenation (Bailey Green and Roy Ramani)
- "Super Bugs"
- Develop best-practice guidelines for smaller W&WW facilities
- Explore anaerobic treatments for smaller plant footprint (existing WERF project—Diane Creel and Bailey Green)
- Benchmark organizations (transfer to implementation—e.g., *Qualserve*)
- State and local studies of conservation opportunities coupled with review of local regulations and barriers (Linda Reekie)
- Analysis of "cost" of various contaminant control—use metric to compare (CEC/ AwwaRF
- Exploration of dual water systems (Linda Reekie)
- Biogas cleanup
- Rethinking hydraulic model of W&WWTP
- Role of online monitoring (Dave Burnett and Roy Ramani)
- Strategies to address Class A sludge—included energy in WERF RFP
- Verification and certification of technologies—(EPA-TVP)
- Develop database linking urban planning and energy regulation with water quality and land use
- Integrate social science research into technology adoption assessment in R&D projects

Water/Wastewater System of the Future

- Producing energy at wastewater treatment plants
- Using renewable energy
- Decentralizing the systems
- Exploring industrial pretreatment
- Integration of wastewater treatment plants with other waste treatment facilities (e.g., solid waste, storm water, and industrial wastes) and combining with product recovery

- Exploring expanded water reuse
- Exploring heat extraction from wastewater
- Exploring aerobic versus anaerobic treatment