Water and Electric Utility Integrated Planning

Project #4469

Water and Electric Utility Integrated Planning

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Water and Electric Utility Integrated Planning

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FOREWORD

The Water Research Foundation (WRF) is a nonprofit corporation dedicated to the development and implementation of scientifically sound research designed to help drinking water utilities respond to regulatory requirements and address high-priority concerns. WRF’s research agenda is developed through a process of consultation with WRF subscribers and other drinking water professionals. WRF’s Board of Directors and other professional volunteers help prioritize and select research projects for funding based upon current and future industry needs, applicability, and past work. WRF sponsors research projects through the Focus Area, Emerging Opportunities, and Tailored Collaboration programs, as well as various joint research efforts with organizations such as the U.S. Environmental Protection Agency and the U.S. Bureau of Reclamation.

This publication is a result of a research project fully funded or funded in part by WRF subscribers. WRF’s subscription program provides a cost-effective and collaborative method for funding research in the public interest. The research investment that underpins this report will intrinsically increase in value as the findings are applied in communities throughout the world. WRF research projects are managed closely from their inception to the final report by the staff and a large cadre of volunteers who willingly contribute their time and expertise. WRF provides planning, management, and technical oversight and awards contracts to other institutions such as water utilities, universities, and engineering firms to conduct the research.

A broad spectrum of water supply issues is addressed by WRF's research agenda, including resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide a reliable supply of safe and affordable drinking water to consumers. The true benefits of WRF’s research are realized when the results are implemented at the utility level. WRF's staff and Board of Directors are pleased to offer this publication as a contribution toward that end.

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Chair, Board of Directors
Water Research Foundation

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The list of acknowledgements for this research project is substantial and indicative of the multifaceted nature of water and electric utility integrated planning. The researchers would like to first thank the Water Research Foundation, the American Water Works Association (AWWA), and the New York State Energy Research and Development Authority for funding this project. Funding for this project was possible through AWWA's Water Industry Technical Action Fund. The researchers highly appreciate the guidance provided during the course of the project by Linda Reekie, WRF's Research Manager, and by the members of the Project Advisory Committee: Adam Carpenter, Delon Kwan, Mike Hotaling, Kathleen O'Connor, and Robert Goldstein. The members of the Project Advisory Committee not only provided valuable oversight but members of the committee also participated in utility interviews and attended the water and electric utility integrated planning tournament.

Second, the researchers would like to express their gratitude to the following utilities and organizations for their valuable participation provided on this project, the number of individuals from these organizations that assisted us in preparing our case studies and research findings was extensive and the researchers thank them all:

- American Water (NJ)
- City of Calgary (AB, Canada)
- City West Water (Australia)
- California Public Utilities Commission (CA)
- Ergon Energy (Australia)
- Green Mountain Power (VT)
- Jemena (Australia)
- Los Angeles Department of Water and Power (CA)
- Melbourne Water (Australia)
- Metro Vancouver (BC, Canada)
- Monroe County Water Authority (NY)
- New York City Department of Environmental Protection (NY)
- Newport News Waterworks (VA)
- Seqwater (Australia)
- Stanwell Corporation Limited (Australia)
- Tualatin Valley Water District (OR)
- US Environmental Protection Agency (DC)
- Yarra Valley Water (Australia)

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EXECUTIVE SUMMARY

OBJECTIVES

The objective of this study was to investigate integrated planning across water and electric utility systems, inclusive of water supply, water treatment, water distribution, wastewater collection and treatment, wastewater reuse distribution, water retail use, electric power generation, electric power transmission, and electric power wholesale and retail distribution and use. Through this project, the researchers aimed to 1) present and evaluate a range of activities that feature integrated planning efforts between water and electric utilities, 2) identify barriers, opportunities, and sector needs for integrated planning, 3) help water and electric utilities understand the similarities in their respective planning goals, and 4) provide recommendations for water and electric utilities to engage in water and electric utility integrated planning (WEUIP) activities.

APPROACH

To achieve the objectives of this project, the researchers first conducted a literature review to establish background information. They then conducted select utility interviews, focusing on how and where utilities currently engage in WEUIP. They researched commonalities between water and electric utilities, including similarities between applied planning frameworks in each utility sector. The researchers conducted additional interviews to prepare example case studies and then developed and conducted a water and electric utility integrated planning tournament (WEUIP Tournament) to assist sector participants' discussion of opportunities for future planning efforts.

The researchers then tested the themes and WEUIP benefits, needs, and initiatives (a program, activity, or other action aimed at promoting WEUIP) identified across literature, interviews, case studies, and the WEUIP Tournament, in a web-based survey open to the water and electric utility industry. The survey focused on confirming the project findings on the benefits of WEUIP and assessing the relative potential to effort of WEUIP initiatives.

Finally, the researchers prepared a final report to synthesize their research observations and outcomes, as well as provide a resource for water and electric utilities interested in pursuing water and electric utility integrated planning practices.

RESULTS

The researchers defined WEUIP as the process by which water and electric utilities jointly develop plans to maintain and/or improve the delivery of water and electric power services. The project findings suggest that water and electric utilities see benefit in WEUIP, and some are taking measures to actively develop integrated planning options. Yet, there are limited examples of true integrated planning efforts. In general, the findings suggest that cross-utility partnership and planning is not common. Integrated approaches that consider water and energy do exist; however, water and electric utilities are more often noted as separately investing in water and energy efficiency planning options. Other projects that would result in decreased electric power demand, such as heat recovery and biogas generation from wastewater distribution and treatment, are often pursued by water and wastewater utilities with limited electric utility participation. Likewise, end user efficiency of water and electricity services has been adopted, but not consistently jointly implemented.

The literature review and case studies highlight a number of WEUIP activities with varying degrees of water and utility interaction. Demand management is driving electric utilities to partner with water utilities to achieve non-network alternative solutions. In some cases, water utilities are being paid by electric utilities for load shedding. Moreover, watershed planning highlights close collaboration between water and electric utilities and other stakeholders. Across the project findings, the researchers noted 10 planning themes that highlight the potential of WEUIP:

1. Alternative Water Supply and Wastewater Services
2. Demand Management and Demand Response (including alternative pricing strategies)
3. End Use Efficiency
4. Infrastructure Resiliency and Operational Efficiency
5. Regional Planning
6. Regulation of the Water-Energy Nexus
7. Renewable Energy (including co-generation)
8. Collaboration and Research on Embedded Water and Energy
9. Watershed Planning
10. Public and Professional Education on the Water-Energy Nexus

This project identified similarities between water and electric utilities that provide significant opportunity to foster WEUIP. For instance, water and electric utilities both seek to use resources (water or energy) efficiently and minimize costs, are facing growing demand pressures with limited or fixed supplies, are impacted by climate uncertainties, and depend on water availability. A changing energy sector will also affect both water and electric service delivery. The researchers found that water availability was a significant driver for both water and electric utilities in that alternative water supply sources from wastewater recycling or stormwater capture and reuse are being used to diversify water supply sources and reduce demand for energy intensive water supplies. These alternative water services are also creating opportunities to promote water and energy efficiency.

An analysis of water and electric system connections identified several pathways that may also provide opportunities to foster WEUIP. For example, there are a number of interconnections between water and electric utility systems on end user (or retail) management, the use of water and wastewater resources to generate power, and the use of water resources for electric utility cooling services. These interconnections form common pathways by which water and electric utilities could pursue integrated planning activities.

Barriers to WEUIP identified at the WEUIP Tournament include the fragmentation of water vs. electric utility systems. There are currently many quite small water utilities vs. large electric utilities, and water utilities are often publically owned and operated; whereas, electric utilities are frequently privately owned and operated. Silos, lack of communication, funding mechanisms, lack of integrated approaches to data collection, storage and analysis, terminology, and the water and electric utility regulatory environment were also noted as significant barriers to WEUIP.

Survey responses from 105 water and electric sector professionals suggest several WEUIP themes. First, respondents generally indicated an acceptance of the benefits presented by WEUIP, selecting the most significant benefits that WEUIP provides as water and energy savings and enhanced communication among water and electric sector professionals. Second, survey responses highlighted the potential of many initiatives to promote WEUIP, noting high potential to low level of effort for initiatives 1) promoting education of the public and professionals on the energy embedded in water and the water embedded in energy, 2) joint water and electric utility programs on internal water and energy reduction, and 3) joint water and electric utility demand management programs.

The researchers also found that the most significant change needed to promote WEUIP was the creation of regulatory structures that provide incentives for investing in water and energy efficiencies. Utilities repeatedly commented on the lack of financial incentives to engage their utility counterpart. Other needs of note were identifying specific areas where there is overlap of water and electric utility jurisdiction and interest, developing consistent and comparable methods for measuring embedded water and energy, and allowing alternative cost accounting and cost effectiveness frameworks in regulatory rate setting and planning review. Both water and electric utilities noted that they needed new accounting methods and other means to account for non-financial benefits of WEUIP, and flexibility in rate setting to encourage broad operationalization of water-energy interactions.

RECOMMENDATIONS

Many elements of WEUIP are included in current utility practices, but progress will require identifying approaches that overcome significant institutional and regulatory barriers. Sector investment in the needs noted above would significantly improve the environment conducive for WEUIP. The researchers also recommend that water and electric sector professionals consider the potential of public and professional education on the energy embedded in water and the water embedded in energy.

The project findings suggest water and electric utilities would most likely undertake WEUIP projects when considering:

- watershed planning
- demand management or demand response programs
- joint water and electric end use efficiency programs
- alternative water supply & wastewater services
- renewable energy projects

The findings also suggest that water and electric utilities should first focus their conversation with their counterpart utility on the above areas and gradually broaden the conversation to other WEUIP initiatives. Utilities are especially encouraged to have conversations with their counterparts on designing and creating joint water and electric utility demand management programs and explore additional ways they can engage in joint water and electric utility operations planning.

Utilities may also encourage WEUIP activities by applying existing and future national standards that link water and energy management and developing land-use and planning codes that account for water and energy efficiency. Utilities are encouraged to utilize scenario planning, as it was demonstrated to be successful in leading diverse stakeholder groups through a WEUIP exercise. Overall, while energy generation projects ranked second to the opportunity presented by joint end user management, the generation of energy from wastewater treatment processes in excess of the energy needed onsite may provide sufficient incentive for WEUIP. Renewable energy investments from water and wastewater systems are also likely the next step for the water industry to take to reduce waste and improve total resource management at water utilities. Water utilities are encouraged to involve their counterpart electric and gas utilities in these plans.

The importance of having a direct communication channel between water and electric utilities was repeated throughout all interviews. Whether as a customer to supplier (water utility to electric utility or electric utility to water utility), or as a potential stakeholder in a new development, the existence of a permanent communication pathway between utilities corresponds to opportunities for future collaborations, and the researchers encourage water and electric utilities to establish these communication channels.

The application of the WEUIP Tournament suggests an avenue to encourage water and electric utility sector integrated planning. The WEUIP tournament fostered the sharing of knowledge (including terminology) and experiences, and may encourage utilities to collaborate more in the development of realistic water and electric integrated plans. The researchers recommend that water and electric utilities exploring joint collaborations consider hosting their own local WEUIP Tournaments to encourage conversation and exchange of knowledge between diverse sector representatives.

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CHAPTER 1
INTRODUCTION

PROJECT BACKGROUND

This project originates from the realization that water and electric utilities routinely plan separately, yet share the same water resource; one that is increasingly scarce. In scare conditions electric utilities may scale back plans to develop hydroelectric generation facilities or seek alternative sources of water to provide cooling services. Conversely, as energy sources are restricted due to clean air regulations or rising costs, water utilities may adjust plans to explore high-energy water sources, such as desalination or reuse. New water supplies require more energy, and many new energy supplies require more water. These interconnections are just two examples of the feedback cycle existing with regard to water and energy management and there are many more. This feedback creates a massive challenge for utility management, but it also creates the opportunity for innovative solutions, of which planning must be at the forefront.

Despite numerous management similarities between drinking water, wastewater, and electric utilities, many utilities manage, operate, and plan in separate silos. Today, the effort bridging related water-energy management issues is minor and at best uncoordinated. There is a lack of shared resources, knowledge and approaches. Most effort addresses sub-components of the problem, rather than the opportunities of interaction.

But how can water/electric utilities work together to manage scarce resources? Water and electric utilities often operate in silos, even in combined utilities, and many barriers do exist to such initiatives, yet already, many water service and electric/natural gas utilities provide combined services. For example, the Los Angeles Department of Water and Power is one of many joint water and electric utilities operating across the United States. Lessons can be learned from such organizations, as well as from innovative "water-only" or "electric only" utilities that have been proactive in integrated water-energy planning.

There are appreciable opportunities for integrated utility planning and this gives cause for further investigation. To address this need, the researchers undertook an investigation of water and electric utility integrated planning (WEUIP), identifying opportunities and barriers for advancing integrated planning and exploring the similarities and differences between water and electric utilities and their respective planning goals.

WHAT IS WATER AND ELECTRIC UTILITY INTEGRATED PLANNING?

To consider WEUIP, one must first address the question: what is utility planning? Utility planning is a process for the formulation and execution of one or more plans to maintain or improve levels of services. It is process of thinking about desired outcomes and assessing the options that will help achieve the outcome. In its simplest form, a typical utility planning process involves four steps:

1. Identifying the vision, goals, and objectives desired
2. Assessing the options for achieving goals and objectives and delivering the desired outcomes
3. Prioritizing and implementing the options selected
4. Evaluating and monitoring the outcomes of the plan

Planning and the activities involved in the planning process are initiated in response to a number of conditions and may involve few or many processes, tools, and organizations. Planning may occur in response to specific events such as changes in regulations that govern utility services or in preparation for future conditions such as climate change, drought, or population growth. Planning may also occur to achieve a new strategic vision such as reducing carbon emissions or achieving regional sustainability. Planning activities may occur across different groups within a utility or involve multiple organizations. Moreover, planning activities may be supported by decision support tools and/or specific planning frameworks, and planning options may require review by regulatory authorities or external stakeholders.

Applying the above planning steps to WEUIP would see water and electric utilities actively engaged in each step of the planning process. Water and electric utilities would participate in the identification of goals and objectives, jointly assess the options for achieving these goals, and have varying degrees of participation in the implementation and monitoring of the selected options. Thus as a vision of what WEUIP would embody, the researchers define it as the process by which water and electric utilities jointly develop plans to maintain and/or improve the delivery of water and electric power services.

PATHWAYS OF WATER AND ELECTRIC UTILITY COLLABORATION

To further ground their study of WEUIP, the researchers examined the interconnections between water utility and electric utility systems to determine where utilities could engage in WEUIP. The pathways shown in Figure 1.1 highlight these interconnections. Water and electric utilities may, for example, collaborate on end user (or retail) management, the use of water and wastewater resources to generate power, and the use of water resources for electric utility cooling services. These interconnections form common pathways by which water and electric utilities could pursue integrated planning activities. Activities and programs related to these pathways are discussed and highlighted throughout the report.

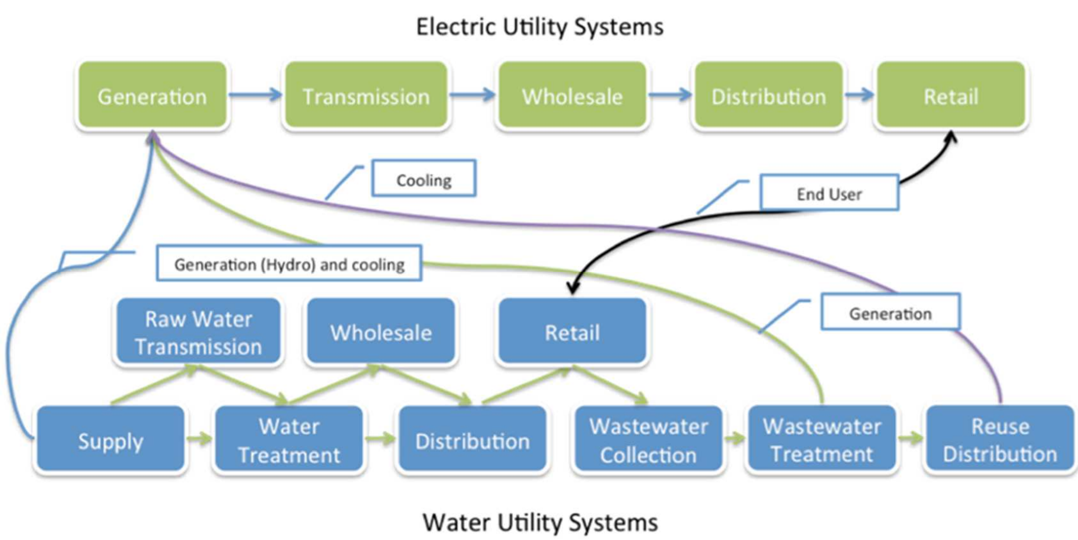

Figure 1.1 Water and electric utility integrated planning pathways and interconnections

REPORT OBJECTIVES

In this report, the researchers aim to explore the state of the above WEUIP vision and where water and electric utilities are engaging in or investigating WEUIP. This report summaries the outcomes of the investigation of WEUIP across the various aspects of water and electric utility systems inclusive of: water supply, treatment, and distribution, wastewater collection and treatment, wastewater reuse distribution, water retail use, electric power generation, electric power transmission, and electric power wholesale and retail distribution and use.

This report is intended for water and electric utilities interested in exploring WEUIP. It provides a summary of outcomes from a water and electric utility integrated planning tournament (WEUIP Tournament), selective case studies, and a web-based survey; along with a discussion of common WEUIP themes observed from these activities and literature. While this report stops short of providing utilities a descriptive direction for WEUIP, the following chapters should provide useful guidance and observation on where water and electric utilities could collaborate across a number of synergies and common pathways to pursue more integrated planning activities.

CHAPTER 2
RESEARCH APPROACH

This chapter briefly discusses the research approached used to collect, analyze, and document research findings. Subsequent chapters also contain a short highlight of the methods used to prepare the findings being presented, and a number of appendices are included to provide additional information on the various research components (Appendix A - Appendix G).

LITERATURE REVIEW

At the onset of this research, a literature review was conducted to build an overarching picture of the current state of knowledge and practices in WEUIP. An initial scan of literature, both published and gray, reflected an absence of specific literature on WEUIP. As such, the researchers expanded their review to include literature on the water-energy nexus to explore more general opportunities for planning across water and electric utility systems. Two significant reports assisted with identifying appropriate literature in this regard: The UK Water Industry Research report, *Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies* (Brandt et al. 2010), and the report *Water-Energy Nexus Research: Recommendations for Future Opportunities* (GEI Consultants et al. 2013). Other literature was gathered across three subject areas:

1. Specific discussion of integrated water and electric utility planning
2. The Water-Energy nexus background and opportunities for collaboration
3. Examples of planning frameworks and processes used by water and electric utilities

An annotated bibliography was prepared, summarizing the most relevant information from the literature on the water and energy nexus (see Appendix A). The annotated bibliography provides: 1) a brief summary of key findings and challenges, and 2) opportunities and suggested directions provided by the authors. Following the review, common themes were identified and noted for each piece of literature. There are 47 sources included in the annotated bibliography and the researchers recommend that readers utilize the bibliography as a resource to explore the challenges and opportunities of the broader water-energy nexus.

An accompanying annotated summary of planning frameworks and processes used in the utility sector was also prepared (see Appendix B) noting which planning frameworks and processes are used by water and/or electric utilities, and which ones include a comprehensive review of both electric and water resources. The annotated summary provides comment on how water and electric utilities have utilized the various planning frameworks and processes to address various components of water and electric systems areas (e.g., water allocations, demand planning, infrastructure development, supply management). The annotated summary provides a comprehensive review of planning approaches applicable to WEUIP and the researchers recommend readers review this summary to explore the multitude of tools available to support WEUIP activities.

Key Focus Lists

During the review of literature, the researchers prepared three key focus lists to help focus subsequent research tasks, synthesize existing knowledge, and aid in identifying main themes. These focus lists are included for reference in Appendix C, and the themes identified are discussed further in Chapter 6.

- Challenges and opportunities for integrated planning or collaboration within the water and energy sectors
- Tools, processes, and planning elements within integrated planning frameworks
- Similarities between water and electric utilities

UTILITY INTERVIEWS

Following the literature review, the researchers conducted semi-directed interviews with water and electric utilities using an interview questionnaire prepared from literature themes. Key goals guiding the interview questionnaire development were:

- Exploring utility planning activities, issues and challenges (including successful and unsuccessful experiences)
- Exploring current tools and methods used internally by water and electric utilities as well as those used during integrated planning activities
- Discussing integrated planning principles
- Identifying specific barriers affecting water and electric utility integrated planning
- Identifying possible case study topics and locations
- Exploring similarities between water and electric utilities

Examples of integrated planning activities were used in the questionnaire to stimulate discussion around particular issues for each interviewee's utility and elicit feedback on the utility's current activities. The questionnaire was designed to consider varying degrees of knowledge of water and electric utility integrated planning; as such, not all components of the questionnaire were reviewed with each interviewee. The questionnaire allowed for an open-ended discussion around those planning activities deemed most important by the utility. A copy of the interview protocol and questionnaire are included in this report as Appendix D.

The utilities that were interviewed for this stage of the research included: American Water (NJ), Green Mountain Power (VT), Los Angeles Department of Water and Power (CA), Monroe County Water Authority (NY), Newport News Waterworks (VA), New York City Department of Environmental Protection (NY), and Tualatin Valley Water District (OR).

CASE STUDY SELECTION AND PREPARATION

A set of case study selection criteria was prepared based on a synthesis of information gathered during the literature review, initial interviews, and webinar discussions. Utilities were selected for case studies based on where it appeared there was an opportunity to uncover WEUIP activities. The researchers considered the likelihood of being able to prepare a case study and the willingness of the utility to participate in case study development was paramount. Some of the participating utilities that attended the various project webinars expressed interest in showcasing their practice as a case study. Later, utilities that participated in the WEUIP Tournament provided the research team with another opportunity to develop case studies as well as conduct short in-person interviews, described below, that informed understanding of the nature of the utility's integrated practices.

The set of utilities considered for the WEUIP case studies ranged across North America and Australia and focused on multiple elements of WEUIP. Also, because of the relatively limited number of examples of full WEUIP, the researchers expanded their case study selection to include examples of integrated water-energy planning focusing on water and electric utility system interconnections. Case studies were prepared accordingly, and the final set of case studies prepared is shown in Table 3.1.

Case Study Interviews

The researchers conducted semi-structured interviews to support development of each case study. Prior to holding the telephone or in-person interview, an explanatory statement and consent form (Appendix E) was read to the individual being interviewed. The following interview points were used to guide the discussion and expand on previous knowledge of the organization.

- Describe the integrated water/energy practice in detail, including deployment of personnel and technologies, if any. Who are the major stakeholders and what is their role in planning and operations (e.g., political/council members, utility executives, mid-level management, operations and maintenance, community advocates, etc.)? How did the idea for the practice get started? What are the overarching governance structures, legislation and regulation that influence water and electric utility planning? What are the specific initiatives or drivers that have led to integrated planning (e.g., sustainability program, high energy costs, initiative to reduce fossil fuels, expansion of renewable energy)?
- What is the nature, if any, of collaborative efforts across water and electric organizations or community organizations that have been needed to put the practice into place?
- What is the planning process, and how did it work? What were the original goals for the practice? Were there specific planning tools and models used in the integrated planning practice (e.g., decision-support tools, data analysis, etc.)? Was there a cost-sharing mechanism used to establish a financial partnership?
- Are there identified risks or concerns with integrated water and energy planning specific to the context? What are the barriers the organization has had to overcome when engaging in integrated planning, and how have they been dealt with? (e.g., institutional arrangements, limited resources, mandated requirements, lack of working relationships between energy and water)
- What resources were required for the effort? How much time and resources were invested?
- What have the costs and benefits of integrated planning been?
- What outcomes (and unintended consequences) have come out of the planning effort?

Interviews lasted 30-60 minutes, and recordings and transcripts are being held confidential by the research team. Additional utilities and organizations that were interviewed to prepare the case studies, beyond those previously listed, include: California Public Utilities Commission (CA), Ergon Energy (Australia), City West Water (Australia), Yarra Valley Water (Australia), and Seqwater (Australia).

Documentation

Chapter 3 discusses the case studies conducted to explore the various applications of WEUIP. A summary of the case studies and overview of common themes is presented. The full case studies are included as a separate document, which may be found on the project #4469 webpage.

Data and information contained in the case studies was collected from public and previously published sources, guided by utility interviews, for most of the case studies. Partner utilities provided final review and validation of the case studies to ensure the information presented in the case studies depicts the practices accurately.

WATER AND ELECTRIC INTEGRATED PLANNING TOURNAMENT

Concurrent with preparation of the case studies, a WEUIP Tournament was held in order to explore WEUIP in a hypothetical planning session, to identify barriers to integrated planning as well as opportunities and strategies to promote WEUIP.

The WEUIP Tournament was conducted following a modified tournament format established by Agriculture and Agri-Food Canada for drought tournaments (Hill et al. 2014). Invitations to attend the Tournament were sent to a diverse group of water and electric utility sector parties in order to balance representation on each team. Those invited included state, federal, local, utility, industry, research and not-for profit sector representatives across the water and energy sectors. Expense reimbursement was offered to encourage travel to the Tournament and in total 32 individuals participated and five teams competed at the tournament.

Tournament Preparation

For the WEUIP Tournament, the research team prepared a fictitious city named Meadowlands. Details about Meadowlands and its people and environment are included with this report in Appendix G. Although Meadowlands was a fictitious city, it was based on real-world data, including water and energy consumption profiles averaged across similarly sized (1 million people) cities in North America. Meadowlands' geography was set inland, yet close to the coast, to allow for consideration of desalination options for future water supplies. Meadowlands' energy generation profile was mixed to include a combination of hydroelectric generation and coal/gas fired generation plants.

In developing the scenarios for the tournament, the research team considered observations gained in preparing the annotated bibliography and feedback from industry interviews. The research team identified scenarios affecting water supply and generation capacity that would likely encourage WEUIP. The first scenario focused on presenting a reduction in water supplies for the Meadowlands' region, affecting both drinking water and hydroelectric generation. In framing scenario 1, the research team wanted participants to consider the impact water supplies have on energy generation as well as trade-offs between investing in additional water supplies and investing in water conservation programs. Data for scenario 1 were prepared using hypothetical flow data and energy cost data from British Columbia, Canada, and adjusted proportionally to fit the population of Meadowlands.

Scenario 2 presented participants a federal requirement to reduce carbon emissions affecting the future of coal and gas-fired generation in the Meadowlands' region. The U.S. Environmental Protection Agency (EPA)'s proposed Clean Power Plan provided a model for framing the scenario. However, at the time of the tournament, the details of the final rule were unavailable. As such, the research team provided participants with a range of possible reduction requirements in generation supplies (from 10% to 25%) and allowed teams to decide the level for which they would develop a plan. Data for scenario 2 was prepared using average electricity generation data for the Alberta Canada, and, like scenario 1, adjusted proportionally to fit the population of Meadowlands.

Also prepared for the WEUIP Tournament was a list of planning options from which participants could develop an integrated plan, while ensuring they met the goals of the scenario. Plans were expected to reduce the environmental impacts and address the societal and economic impacts in the region. In developing the planning options, the research team considered options that allowed teams to introduce strategies for demand management, metering and monitoring, water and energy efficiency, water quality improvements, alternative water and energy sources, and alternative pricing structures. Realizing that the list of planning options was far from comprehensive, teams were also encouraged to develop their own management strategies or innovations during the tournament.

World Café

At the conclusion of the WEUIP Tournament process, participants were led through a discussion following the World Café method outlined by Dunn (2004). The tournament participants were self- arranged into 'café-style' tables of five or six people. A 'host' and 'scribe' were identified for each table. All tables worked on the following two questions:

1. What are the benefits, or desirable outcomes of integrated water and electric utility planning (what will be "lost" for utilities, cities, regions without integrated planning)?
2. What are key barriers to be overcome to enable integrated water and electric utility planning?

After a relatively short period of discussion, all people at the table, with the exception of the 'host', were required to move to other tables of their choice. The role of the host was to briefly explain the main points already made at the table and facilitate input from the newcomers on major points that they had heard at their previous table. After two or three rounds, presentations from each table were then made to the entire group on the most important points. These were recorded on flip charts and discussed among the entire group.

Documentation

Chapter 4 provides a summary of the WEUIP Tournament. It includes a synthesis of observations and outcomes from the tournament, including the World Café session. It also presents needs (actions or changes to the water and electric power sector that would help enable WEUIP activities) identified. The WEUIP Tournament is described further in WEUIP Tournament workbook included in this report as Appendix G and a complete listing of participating organizations, the agenda, scenarios, and planning options is available in the WEUIP Tournament summary report available on the #4469 project page of the Water Research Foundation website, under Project Papers.

SURVEY

Following the WEUIP Tournament the researchers prepared a web-based survey to: 1) provide a general ranking of opportunities, 2) prioritize perceived benefits, 3) ground acceptance of identified WEUIP initiatives (a program, activity, or other action aimed at promoting WEUIP) and needs, and 4) determine the relative potential to effort of these initiatives with the goal to influence progress toward water and electric utility integrated planning.

Thematic Analysis

To develop the survey, the researchers first conducted a thematic analysis of the case studies to identify recurring themes and similar elements found in each of the case studies. This was done by grouping practices into similar categories. Using an iterative approach, five major themes emerged. They were: efficiency and cost effective measures, efficient codes and standards, integrated operational planning, integrated land use planning and end use efficiency program partnerships. The research team compared these categories to similar themes in the annotated literature and the WEUIP tournament outcomes to case study findings. Themes emerging from the thematic analysis were utilized in developing the WEUIP initiatives for the survey and a listing of themes and resulting WEUIP initiatives are included in Appendix H.

Web-Based Survey Development

The project team custom-developed a web-based survey to host the survey questionnaire (see Appendix F). The questionnaire contained four sections:

1. A short introduction to water and electric utility integrated planning and the purpose of the survey
2. A section hosting questions about the respondent's organization, location, and industry sector to assist in data segmentation
3. A section for utilities only that included questions about the utility's systems to assist in segmenting responses (e.g., raw water transmission, etc.)
4. A section with questions derived from the thematic analysis (described below)

The opening screen of the survey is shown in Figure 2.1 and the website was extensively tested by the research team and pre-tested by students at Simon Fraser University.

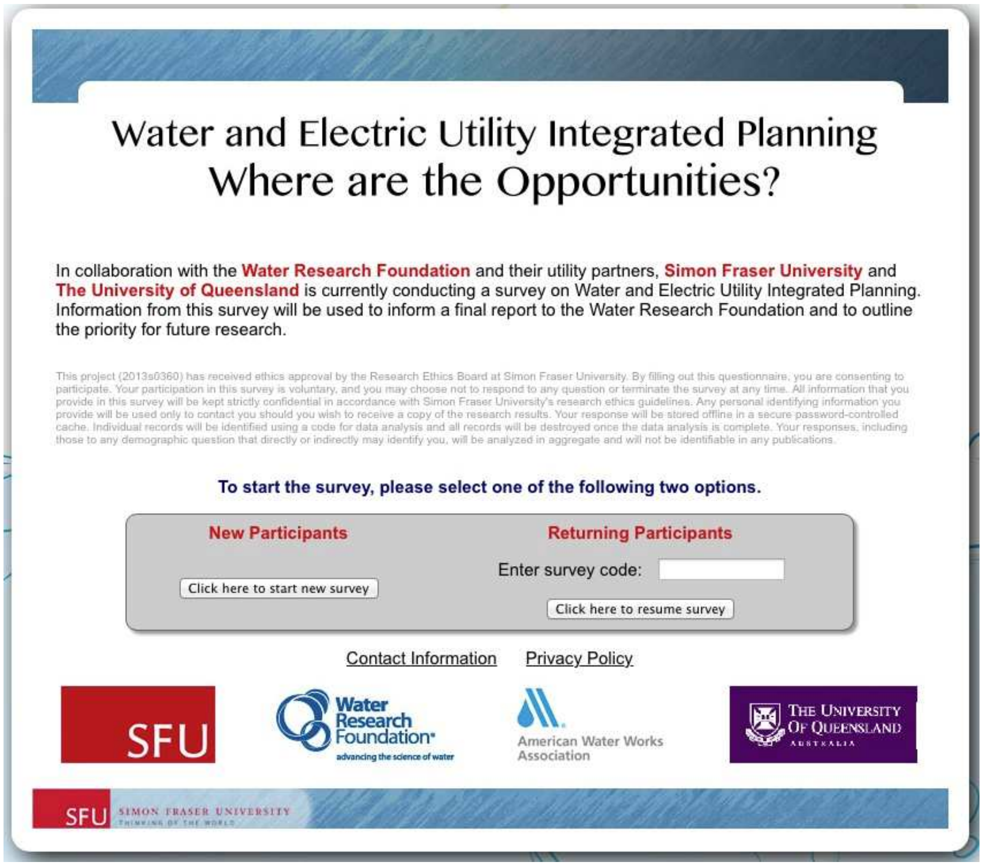

Figure 2.1 Web-based survey opening screen

Survey respondents were asked to rank their agreement with researched benefits of WEUIP, rank the potential and level of effort of WEUIP initiatives, and rank certain needs required to progress WEUIP as follows:

1. To what extent do you agree that the following are BENEFITS of water and electric utility integrated planning?
2. On a scale of 1 – 5, to what extent do you believe the following initiatives have POTENTIAL to support progress toward water and electric utility integrated planning and realize benefits? (Where 1 means no potential and 5 means significant potential)
3. Given the same initiatives as in Q7, on a scale of 1 - 5 how significant a LEVEL OF EFFORT do you think will be needed for the initiative to influence progress toward water and electric utility integrated planning? (Where 1 means little or no effort needed to have an effect and 5 means significant effort needed to have an effect.)
4. On a scale of 1 – 5, to what extent do you believe the following NEEDS are important to progress water and electric utility integrated planning? (Where 1 means not important and 5 means a very important.)

A listing of the benefits, WEUIP initiatives, and needs that formed the questions for the survey are provided in Appendix H.

Survey Sampling Approach

An invitation to complete the survey was distributed to professionals, utility staff, association groups, government representatives, and other water and electric utility sector stakeholders. Contacts were identified using the contact network of the project principal investigators, project researchers, and utility collaborators. Primary responses were solicited from this contact list using the modified Tailored Design Method (Dillman 2009) process below to ensure adequate response.

- An introduction email communicated the purpose, scope, management and outcome of the questionnaire with a link to the web survey.
- One week later, a follow up reminder email was sent
- Two weeks later, a final follow up reminder email was sent

Secondary responses were solicited from associations and at industry conferences. An invitation to the survey was included in a WRF and AWWA monthly newsletters. In addition, the research team distributed 100 survey cards (see Figure 2.2) at the 2015 AWWA Annual Conference and Exposition in Anaheim, CA.

Figure 2.2 Post tournament web-survey solicitation card

Data Analysis and Documentation

The researchers used a number of statistical methods to analyze the survey response data. IBM SPSS Statistics 19 was used to compile the descriptive elements of the survey, including sample frequencies and means. Chapter 5 presents highlights from this analysis and detailed survey results for all questions in the survey are included in Appendix I. One-way analysis of variance (ANOVA), Kruskal Wallis H, and Pearson Chi-Square tests were also performed in SPSS 19 to identify variances in data by utility sector, utility size, and organization type (e.g., utility, academic, non-governmental organization). Statistically significant differences at the 95% confidence level are discussed in Chapter 5 with details included in Appendix I.

DISCUSSION OF FINDINGS

Chapter 6 provides a discussion of findings across literature, interviews, case studies, the WEUIP Tournament, and survey. Key conclusions are summarized and emerging themes discussed. The chapter also includes a short discussion on the future directions of WEUIP. The chapter concludes by providing recommendations for utilities and the water and electric utility sector, and suggesting research directions.

CHAPTER 3
CASE STUDIES

INTRODUCTION AND OVERALL OBSERVATIONS

This chapter presents a discussion of the case studies prepared covering utility experiences with WEUIP. Ten in depth case studies are included as a separate document available through the project #4469 webpage, while two shorter, focused, case studies are provided in this chapter. Case studies were prepared using data collected during semi-structured interviews and from public and previously published information.

In preparing the case studies the researchers endeavored to identify examples of integration and collaboration across the full vision of WEUIP (see *What is Water and Electric Utility Integrated Planning* in Chapter 1); however, it was quickly apparent that examples of full WEUIP are not common. Integrated activities, like the collaboration between Metro Vancouver and BC Hydro in British Columbia Canada to evaluate and revise pump station pumping to reduce energy or the various demand response reduction programs between electric operators and water utilities (Monroe County NY and the New York Independent System Operators for example), do exist in isolated cases. Some large-scale planning projects, like the Catawba-Wateree River Basin planning project led by Duke Energy in North Carolina, also include water utilities as part of the many stakeholders in the project. Yet overall, water and electric utilities are more often observed as separately planning their services and operations, even when assessing options that include water and energy considerations. For example, co-generation plans that would result in decreased local electric power use or provide for new energy generation are being pursued by wastewater utilities with limited electric utility participation. Similarly, plans to promote end use efficiency of water and/or electricity are routinely being pursued by water and electric utilities, but not jointly developed or implemented.

The researchers did identify, however, a growing awareness and linkage between water and electric utility systems that have fostered a number of impromptu collaborations. For instance, the ongoing Supervisory Control and Data Acquisition (SCADA) work at Albuquerque Bernalillo County Water Utility Authority provides data to and helps Public Service of New Mexico balance energy production during peak demand days. Alternative water supply sources from wastewater recycling or stormwater capture and reuse are being used to diversify water supply sources and reduce demand for energy intensive water supplies (e.g., Yarra Valley Water and LA Department of Water and Power). In addition, water utilities routinely consult their regional electric utilities when planning new infrastructure to ensure electric power demand is balanced. Likewise, electric utilities often promote programs that encourage new consultation opportunities. For instance, Ergon Energy and the Government of Queensland are encouraging biogas renewable energy generation projects from landfill sites, rendering plants, and waste water treatment plants, promoting benefits to increase water efficiency or to derive revenues from renewable electricity production. The researchers considered all these types of collaborations when selecting case studies for this study including how these collaborations could facilitate opportunities for full WEUIP.

Listing of Case Studies

The case studies presented in this chapter focus on water and electric power utility systems. Across the utility system pathways shown in Figure 1.1, there are a number of specific programs that highlight where water and electric utilities currently are or could engage in WEUIP. For instance, water and electric utilities could collaborate on end user efficiency improvement programs, demand management programs, joint metering programs, and customer rebate and incentive programs. Energy demand management programs also provide a pathway for collaboration across water and wastewater utility systems. Figure 3.1 illustrates the range of activities where water and electric utilities collaborate across water and electric utility system components.

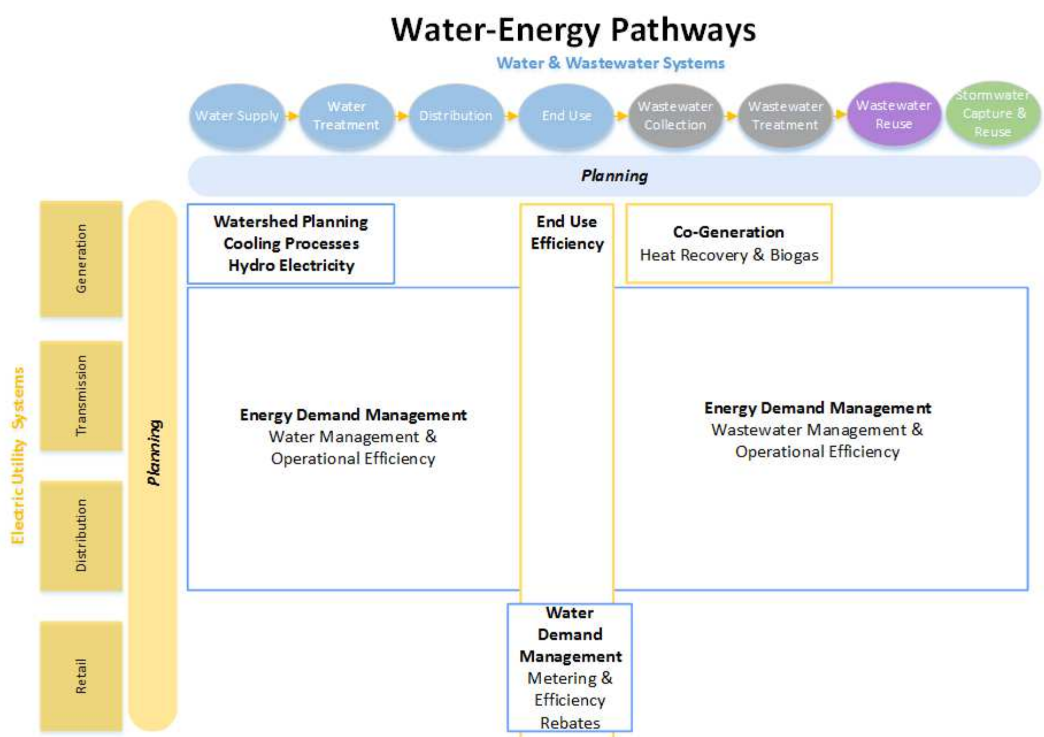

Figure 3.1 Areas of collaboration between water and electric utility system components

Table 3.1 lists the case studies prepared for this report. These case studies cover a range of planning activities including: watershed planning, co-generation, energy efficiencies within the water system, as well as water and energy efficiency management by end users. However, because of the relative shortage of full examples of WEUIP, the researchers explore the broader relationship of integrated water-energy planning throughout the case studies and in the subsequent discussion. As such, they also include case studies that present regional planning, alternative water services (water supply for new sources, and infrastructure and operational resiliency.

Table 3.1
Case studies completed examining water and electric utility integrated planning

Region		Organizations	Focus
USA	**California**	LA Department of Water and Power (Department of Public Works responsible for LA Sanitation, Bureau of Engineering; Bureau of Street Services)	End Use Efficiency, Alternative Water Supply & Wastewater Services, Renewable Energy, Watershed planning, Infrastructure Resiliency & Operational Efficiency
		California Public Utilities Commission	End Use Efficiency, Regulation of the Water-Energy Nexus
	New Mexico	Albuquerque Bernalillo County Water Utility Authority (mini study included in Chapter 3)	Demand Management and Demand Response
	New York	New York City Department of Environmental Protection (mini study included in Chapter 3)	Infrastructure Resiliency & Operational Efficiency
	North Carolina	Charlotte Water and Duke Energy	Watershed planning
Canada	**Ontario**	City of Toronto, Toronto Hydro, and EnWave Corporation	End Use Efficiency, Infrastructure Resiliency & Operational Efficiency
	British Columbia	Metro Vancouver, BC Hydro (electric utility), and the City of Vancouver	Alternative Water Supply & Wastewater Services, Infrastructure Resiliency & Operational Efficiency, Renewable Energy, Regional Planning
Australia	**Queensland**	Ergon Energy (Energex (electric utility), community of Townsville, Government of Queensland)	Demand Management and Demand Response, Renewable Energy
		South East Queensland Water (University of Queensland, Ergon Energy, Energex (electric utility), Department of Energy and Water Supply, Logan Water, Redland Water and Economic Department Queensland)	Collaboration and Research on Embedded Water & Energy
	Victoria	City West Water	End Use Efficiency
		Yarra Valley Water, Jemena (electric utility), APA Gas, Melbourne Water	Renewable Energy (bio-gas) & Alternative Water Supply & Wastewater Services
		Melbourne Region (Melbourne Water, City West Water, South East Water, Yarra Valley Water, Ergon Energy, Energex)	End Use Efficiency, Regional Planning, Renewable Energy

SUMMARY OF CASE STUDIES

To guide the discussion of case studies, the researchers identified nine themes by which utilities engage in various aspects of WEUIP (the additional 10th theme listed was identified from literature, the survey, and the WEUIP tournament discussed in Chapter 6), these are:

1. Alternative Water Supply & Wastewater Services
2. Demand Management and Demand Response
3. End Use Efficiency
4. Infrastructure Resiliency & Operational Efficiency
5. Regional Planning
6. Regulation of the Water-Energy Nexus
7. Renewable Energy
8. Collaboration and Research on Embedded Water & Energy
9. Watershed Planning
10. Public and Professional Education on the Water-Energy Nexus

For each of the case studies listed in Table 3.1, the researchers make note of the drivers; organizations; utility system process or processes involved; and the activities, tools, and approaches utilized. For each case study, they also provide a discussion of WEUIP activities across the categories listed above noting the outcomes, if known, from these WEUIP focused activities. For more detail on the case studies discussed in this chapter, refer to the case studies document available on the project #4469 webpage.

Los Angeles Department of Water and Power

The Los Angeles Department of Water and Power (LADWP) is a municipal utility responsible for supplying over 3.9 million residents of the City of Los Angeles with water and 1.4 million customers with electricity.

Drivers

The combination of changing climate conditions impacting water availability and energy demand along with a highly energy intensive water system is a major driver for California and LADWP to integrate water and energy planning and management. Traditional water supply sources for LADWP have been under pressure due to ongoing drought, environmental regulations and groundwater basin contamination. Decreased water supply increases the conflict between water for energy generation and water for direct consumption. In response, LADWP has committed to "accelerating investments in conservation, water recycling, stormwater capture, and local groundwater development and remediation" (LADWP 2016). Carbon emission reduction and energy efficiency is also important for LADWP and other California utilities. The 2006 Global Warming Solutions Act (California Global Warming Solutions Act of 2006) requires greenhouse gas pollution to be reduced to 1990 levels by 2020 and 33% of California's energy supply to be sourced from renewables. In 2015, the California Senate Bill 350 increased this target to 50% renewables by 2030 (LADWP 2015).

WEUIP Activities

Since 1916, LADWP has jointly managed water and electric services (LADWP 2014b). The joint management of services allows for several connecting points across water and electric utility systems. These include power generation cooling; hydroelectricity; energy used in water systems; energy generation in wastewater systems; end use efficiency and conservation; and use of recycled water, including stormwater capture for recharging of groundwater basins. LADWP undertakes a number of WEUIP activities that are documented through a series of integrated planning documents including the Urban Water Management Plan, Power Integrated Resource Plan, Mayor's Sustainable City pLAn, and City's One Water Plan. This case study highlights, if informally, activities along all the stages of WEUIP. The following sections describe these activities.

Alternative Water Supply & Wastewater Services. The Mayor's Sustainable City pLAn directs the Department of Water and Power to establish a multi-faceted approach to developing a *locally* sustainable water supply (City of Los Angeles 2014b). Targets for long-term outcomes have been set for: reducing purchases of imported water by 50% by 2025 and increasing sources of local water (including stormwater capture) by 50% by 2035; reducing per capita water use through conservation with a 22.5% reduction by 2025 and 25% reduction by 2035; and improving stormwater quality and reducing annual sewer spills. To achieve reduction of purchased imported potable water by 50% by 2025, and increase local water sources by 50% by 2035, the urban water management plan for 2015 includes expansion of recycled water supply and stormwater capture for reuse (rain gardens, cisterns and rain barrels) and recharge of groundwater (LADWP 2016).

LADWP also anticipates that the investment in diversified water supply sources will help reduce reliance on energy-intensive imported water supplies. Once-Through-Cooling (OTC) requirements also mandate LADWP to use closed cycle cooling for LADWP's coastal generating stations (LADWP 2014a), and LADWP has a series of repowering projects that will eliminate the use of water for cooling at coastal generating stations by 2029 (LADWP 2015). Even with increases in the local energy used to supply these new sources of water, e.g., treat recycled water or pump groundwater, these sources have lower energy intensities than imported water (LADWP 2016).

The One Water Plan process is another example of LADWP working to develop a locally sustainable water supply (City of Los Angeles 2015). The One Water Plan brought together diverse groups, including the Department of Public Works, the Department of Recreation and Parks, and the Bureau of Street Services, in partnership with LADWP for planning and implementation of investments in local water supplies.

End Use Efficiency. On-going drought in California has resulted in a number of end use efficiency requirements. First, in March of 2015, California emergency regulations were expanded to require all urban water suppliers to implement water shortage contingency plans in order to achieve 20% water-use reduction (State of California OAL 2015a). Then, in May 2015, these regulations were increased to require 25% water use reduction from June 2015 to February 2016 (State of California OAL 2015b).

End use efficiency at LADWP is focused on reducing water and energy use through a range of conservation tools. These tools include education influencing conservation behavior, promoting and implementing building and appliance efficient codes and standards, as well as seeking opportunities to reduce embedded energy in the water system. LADWP also utilizes a number of integrated power strategies in their Power Integrated Resource Plan that focus on increasing their renewable energy portfolio, end user energy efficiency, and demand management programs (LADWP 2015).

Infrastructure Resiliency & Operational Efficiency. LADWP uses hydroelectric facilities within their service area to regulate delivery of energy, balance system load electricity demand, and reduce the severity of issues associated with intermittent renewable energy sources (LADWP 2014a). To maintain flexibility in their system, LADWP is using pumped water storage. The Castaic Hydroelectric Plant is one facility that uses pumped water to maintain reservoir levels for hydroelectric generation. This plant is LADWP's largest source of hydroelectric generation capacity with a maximum generation capacity, if flow-through-water schedules are received, of 1,247 MW (megawatts) (LADWP 2014a).

Renewable Energy. Renewable energy generation, demand response programs in power and water, embedded energy in water system reduction strategies, and a diversification of water supply options are part of LA's effort to meet Greenhouse Gas Emission reduction targets (LADWP 2016, LADWP 2014a). Energy generation through biomass and waste counts for 5% of LA's overall power resources. The energy generated from the Bradley, Lopez Canyon, Toyon and Hyperion digester gas processes, for example, are used to supply energy in wastewater treatment (LADWP 2014a). These wastewater processes are managed by Los Angeles's Department of Public Works.

Watershed Planning. Joint watershed planning is routine at LADWP. The process for initiating the planning, design, construction and any rehabilitation of hydroelectric facilities falls under a process, where water and power division engineers and project managers discuss key decisions, establish delineation of funding sources for capital costs, as well as responsibility for ongoing operations and maintenance.

Outcomes

LADWP's WEUIP activities have resulted in a number of water and energy savings and the development of efficiency programs targeting active and passive water and energy savings. LADWP's cumulative annual water saving from hardware installations increased from 31,825 AF (acre-feet) prior to 1990/91 to 118,034 AF in 2014/15. Total Annual Savings (active and passive, combined) in 2015 reached 390,755 AF (LADWP 2016). In 2014/15 there were about 200 individual customer service accounts for recycled water use with an annual demand of 36,738 AF (LADWP 2016). Developed energy efficiency program elements include: mass market programs, commercial, industrial and institutional programs and a set of crosscutting programs.

California Public Utilities Commission

Regulating the water-energy nexus is a challenging task and within the mix of responsible parties lays the California Public Utilities Commission (CPUC). The CPUC has a defined role in water-energy nexus policy and regulation. Responsible for regulating electric, natural gas, and water companies, the CPUC "serves the public interest by protecting consumers and ensuring the provision of safe, reliable utility service and infrastructure at reasonable rates, with a commitment to environmental enhancement and a healthy California economy" (CPUC 2014).

Drivers

In 2000 to 2001, California experienced an energy crisis caused by "supply and demand imbalance characterized by electricity price instability and blackouts" (EIA 2014). This crisis brought to light many challenges with California's deregulated electricity market (Weare 2003, CEC 2003). More importantly, the result was that communities throughout California experienced blackouts and significant electric power price increases. This event kept public awareness for energy efficiency programming high on the political agenda and has been a driver for demand response programs to ensure adequate, reliable and reasonably priced electrical power and natural gas supply.

In 2005, the California Energy Commission (CEC) published a landmark analysis of the energy intensity of California's water supply and distribution systems (CEC 2005). This report initiated water-energy nexus policy discussions, with several studies being commissioned to better understand energy consumption within the water system.

Starting in 2013, challenges with water security and drought response became a strong driver for water and energy efficiency. Drought conditions were shown to impact the electric generation supply mix, as large hydroelectricity generation decreased 36% in 2012 and another 10% in 2013 (CEC 2015). Then in 2015, the Governor of California declared the California drought a State-of-Emergency and water restrictions and awareness of drought conditions has remained a driver for water and energy efficiency programs.

WEUIP Activities

The CPUC's water-energy management efforts aim to determine regulatory rules and efficiency programs that address the water-energy nexus and protect utility consumers. The major water-energy pathways promoted in CPUC decisions involve energy embedded in the water system and water and energy end use efficiency by consumers. While this CPUC case study is not an example of WEUIP, it is included in this report to explore the regulatory measures taken to promote water and energy programs for demand management and operational efficiency, as well as end use efficiency that can encourage WEUIP activities across California.

End Use Efficiency. CPUC's involvement in water and energy conservation regulation dates back to the creation of the Public Goods Charge (PGC) in 1996. The PGC established a consumption based charge on electricity to fund energy efficiency programs, renewable technologies investment and public interest research. The PGC has provided $1 billion for investment in energy efficiency programs (CEC 2003).

Regulation of the Water-Energy Nexus. CPUC's water-energy policy and regulatory actions focus on first establishing a standard method for quantifying energy intensity embedded in water systems, and second, determining cost effectiveness of energy efficiency programs as a foundation for fair and legal partnerships between energy investor-owned utilities and the largely publically owned water sector.

In 2007, authorized by Decision 07-12-050 (CPUC 2007), the CPUC set out to understand how it would regulate water-energy nexus issues by authorizing a set of water-energy pilot projects and three specific studies intended to a) validate claims that saving water can save energy, b) explore whether embedded energy savings associated with water use efficiency are measurable and verifiable and c) gather end use water demand profile data to develop an accurate hourly water use profile data set.

CPUC has also initiated procedures for rulemaking that will better define how to form partnerships between Investor Owned Utilities (IOUs), Publically Owned Utilities (POUs) and state agencies interested in water resource management and energy. In 2013, the petition (P. 13-05-003) was approved in rulemaking (R.13-12-011), ordering rulemaking into policies to promote a partnership framework between energy investor owned utilities and the water sector to promote water-energy nexus programs. Included in this order was direction to consider how cost effectiveness should be analyzed for water-energy nexus programs including how best to account for avoided water capacity and environmental costs and benefits that come with reduction of embedded energy water conservation. These types of programs for information and data collection, analytical tools and standards, and procedures and protocols will likely support a path forward for WEUIP.

Outcomes

Investment in energy efficiency portfolios by IOUs varied from 2010 to 2015, as does gross electricity saved. The greatest outcome was in 2010, with 2,640 GWh (Gigawatt hour) energy saved through energy efficiency programs (CPUC 2016). In 2014, total expenditures were highest, with $789 million invested in energy efficiency programs (CPUC 2016). Some of these process measures relate to water and wastewater operation optimization, such as Pacific Gas-Electric Company (PGE)'s program for California Wastewater Process Optimization that was estimated to save 7.04 GWh from 2010-2012 at a cost of $2.19 million USD (CPUC 2016).

Quantification of embedded energy through pilot projects and other research programs in order to establish a basis for a robust cost-effectiveness calculator continues. In 2006, IOUs were invited to participate in a one-year pilot program to invest in water-energy saving programs that a) conserved water, b) used less energy intensive water, and c) made delivery and treatment systems more efficient (CPUC 2006). The selected water-energy pilot projects were approved in 2007 under CPUC D.07-12-50 (CPUC 2007) as a research and development investment. In 2010-11, ECONorthwest evaluated the selected pilot programs. Evaluation focused on water efficiency through end use and measured energy efficiency by kWh/MG (kilowatt/hour)/(Million gallons) of water. The leak detection program showed the highest water and energy savings, along with savings from implementation of commercial customer audit measures.

Albuquerque Bernalillo County Water Utility Authority and EnerNoc

The Albuquerque Bernalillo County Water Utility Authority (WUA) uses electricity to pump water from an aquifer, treat river water, blend surface and ground water, and send this water to customers. WUA uses more than 120,000,000 kWh per year measured from 120 large electric meters and the majority of electric usage is from June to September.

Drivers

WUA has a long history of managing its energy through its SCADA technology, utilizing the Water Research Foundation's Energy Water Quality Management System (EWQMS) framework, off-peak pumping, and pump efficiency optimization. WUA recently determined that its water system flexibility provided an opportunity to negotiate options for energy pricing further through an energy demand response program.

WEUIP Activities

This case study focuses on the implementation stages of WEUIP with a focus on implementing demand management and demand response options.

Demand Management and Demand Response. In 2010, WUA signed a contract through a 3rd party company (EnerNoc) with Public Service of New Mexico (PNM) who is the electric provider for the state. PNM offers a Peak Saver program designed to help large commercial electric customers reduce the amount of energy they use during peak demand days, typically the hottest days of the year. Because WUA is one of the largest electric users in New Mexico, it was expected that WUA could benefit from demand response and shave power when PNM is in critical peak period. There is no cost to WUA whether they are asked to reduce usage or not.

After a detailed analysis and review of WUA's power consumption in the summer, both parties agreed that WUA could benefit from putting 15 large electric accounts into a contract of 3 megawatts (MW).

Outcomes

The first two-month contract (July and August) included three interruptions. For reducing their electricity usage as requested, WUA received $68,000 from PNM. WUA has now signed a contract for 6 MW of interruption over 4 months (June through September) and continues to operate under this agreement.

WUA's SCADA collects real time data from each electric meter every minute. By providing this real time data to EnerNoc, WUA is able to receive more incentive payments because EnerNoc does not have to put monitoring hardware at each site.

New York City Department of Environmental Protection

The New York City Department of Environmental Protection (NYCDEP) manages the water supply and wastewater treatment for the City of New York. Water is supplied from 19 surface water reservoirs located up to 125 miles from the City and is conveyed almost entirely by gravity. Over 90 percent of NYCDEP's energy use is associated with the treatment of wastewater.

Drivers

As part of NYCDEP's resiliency and reliability efforts, NYCDEP it is looking at mechanisms that may afford a greater independence from electric utility supplied power and improve the sustainability/resiliency of its current infrastructure.

WEUIP Activities

This case study focuses on the visioning and assessment of options stages of WEUIP, with a focus on implementing infrastructure resiliency and operational efficiency options. It highlights drivers that many water utilities consider regarding improving their infrastructure resiliency and a possible pathway for involving regional electric utilities in WEUIP.

Infrastructure Resiliency & Operational Efficiency. Cross-utility planning for NYCDEP on the electric side includes looking at geographic locations of electric distribution difficulties in power supply and/or quality (e.g., voltage). The NYCDEP has installed voltage meters at all of its WWTPs and they have been placed on the electric utilities critical infrastructure list. NYCDEP's regional electric utilities (e.g., Consolidated Edison Company of New York) provide notices to the individual facilities and central engineering in the event of planned voltage reductions or feeder outages. In addition, the NYCDEP and electric utility have a Memorandum of Understanding whereby the NYCDEP will voluntarily shed load by turning on emergency generators under very specific conditions to prevent electric distribution blackouts.

The NYCDEP also has a Water for the Future program as the result of historic level infrastructure repair that will interrupt 60 percent of the City's water supply (9 million consumers in total) as they attend to planned or unplanned infrastructure issues. This program is taking a broad-based approach to conserving water and providing alternate supplies during this multi-year interruption. As part of this, the NYCDEP approached neighboring electric utilities to discuss their water use in relation to steam generation. In addition, the NYCDEP implemented a wastewater treatment optimization program to reduce internal water use.

Outcomes

A new 12MW cogeneration facility is being designed at one of the 14 WWTPs that will supply all base power and emergency power needs using digester gas and natural gas. A feasibility study for cogeneration is underway at a second WWTP and control upgrades and engine modifications are taking place at two additional WWTPs to allow for increased use of existing cogeneration units. A 1.2 MW solar PV system is being installed at one of the WWTPs. NYCDEP is also continually seeking to maximize the production, capture, and beneficial use of anaerobic digester gas from the WWTPs, such as through on-site cogeneration or for export as renewable natural gas, and is poised to become a significant producer of clean, renewable biogas energy in New York.

The NYCDEP has adopted several alternative planning methods including the implementation of a green infrastructure (e.g., bio swales, green and blue roofs, enhanced tree pits, etc.) program in lieu of traditional grey infrastructure (e.g., tanks, tunnels, etc.) to control combined sewer overflows, and the implementation of distributed generation to provide a level of independence from electric utility supplied power.

NYCDEP completed a Project Delivery Standard Operating Procedure (SOP) to govern energy conservation and greenhouse gas (GHG) reduction design considerations during the project design lifecycle for all new construction or reconstruction projects. The SOP requires all projects to produce an energy profile report to baseline and project the energy use and GHG emissions. This report is updated throughout the lifecycle of the project. The SOP is accompanied by energy design guidelines that were developed for designers and engineers to evaluate more energy efficient alternatives for unit processes and equipment.

Charlotte Water and Duke Energy

Charlotte Water (formerly Charlotte-Mecklenburg Utility Department) is the largest water service utility in the Carolina's serving over 800,000 customers in the City of Charlotte, North Carolina and greater Mecklenburg County that includes the towns of Matthews, Mint Hill, Pineville, Huntersville, Davidson, and Cornelius. Charlotte Water provides drinking water and wastewater services for approximately 255,000 water service accounts and a key management concern for Charlotte Water is the management of water supply (Charlotte-Mecklenburg Utility Department 2013). Annual water withdrawals amount to approximately 102 million gallons per day (mgd) (Charlotte Water n.d.).

Drivers

The Catawba-Wateree River Basin provides water for recreation, power generation, commercial and industrial uses, and drinking water and wastewater assimilation. Duke Energy manages 13 hydroelectric stations and 11 reservoirs under a US Federal Energy Regulatory Commission (FERC) hydroelectric power license (Duke Energy 2015a). Water demand along the Catawba River Basin, and the way in which water is used, is changing dramatically and water demand projections are indicating that water use will likely double in the next 50 years (HDR Engineering 2006). At the same time, Duke Energy's license to operate the dams on the Catawba River was set to expire in 2008.

Charlotte Water and Duke Energy, like many other water and electric utilities, are struggling to match future water demand with projections of water supply. When water supplies serve multiple uses, such as power generation and drinking water, there is a need to collaboratively examine regional water supply planning, and identify strategies to improve the sustainability of water supplies to meet future demand pressures. This driver, and the opportunity presented by the need for Duke Energy to renew its operating license, prompted the integrated planning efforts described in this case study.

WEUIP Activities

This case study presents an example of WEUIP that summarizes a working collaborative with the Catawba-Wateree Water Management Group and Charlotte Water and Duke Energy to examine water use along the Catawba-Wateree river. It is an example of the visioning and assessing options stages of WEUIP.

Watershed planning. In 2006, Duke Energy started a multi-stakeholder project to examine water use along the Catawba-Wateree river and prepare a new license until 2058. HDR Engineering (2006) led the relicensing project on behalf of Duke Energy to evaluate future water demands in the Catawba-Wateree River Basin. HDR Engineering utilized a water simulation model developed for the Catawba-Wateree River Basin project to examine water use and demand across drinking water supply, power generation, industrial and manufacturing uses, and agriculture using historical hydrological data, drought management protocols, and hydroelectric generation operations. The conclusion of this work indicated that future water extractions will exceed the safe yield (a term used to describe the amount of water that can be diverted from a watershed or to measure the dependability of a water source) of the system, jeopardizing municipal water supplies and capacity to generate electric power (HDR Engineering 2006).

Outcomes

Working collaboratively with Catawba-Wateree Water Management Group, best practices for defining water supply safe yields in multi-use reservoir systems were established as part of Duke Energy's relicensing project. In the final report, HDR Engineering indicated that water withdrawals from the river basin would exceed the safe yield of the system by 2048. The implication of this finding was a requirement for closer coordination between water users of the River Basin. Mosteller and Knosby (2013) identified 12 enhancement strategies that would extend the safe-yield of multi-use reservoir systems. These strategies involve physical infrastructure changes, operational and management options, and developing demand-side interconnections and reducing water demands related to both water and electric utilities.

Mosteller and Knosby (2013) noted that understanding the operational logic, overall water use, and impact of climate change on a multi-use, multi-reservoir system can work to extend the yield of the water system. Extending this observation to this research suggests that water and electric utility integrated water planning should be a requirement on any multi-use reservoir system.

City of Toronto, Toronto Hydro, and EnWave Corporation

Toronto Water in the City of Toronto, Ontario Canada, provides drinking water, wastewater, and stormwater management services for the greater approximately 3.4 million residents and business in the greater Toronto region and portions of York (City of Toronto 2015).

Toronto Hydro provides electric power distribution services for the City of Toronto. It plans, maintains, and distributes electric power to approximately 730,000 residential, commercial, and industrial customers across Ontario (Toronto Hydro Corporation 2014).

The Enwave Energy Corporation (Enwave), a private corporation owned jointly by the City of Toronto and the Ontario Municipal Employees Retirement System, is a regional energy service provider with operations in Canada and the United States. Enwave operates thermal energy plants that provide hot water and/or chilled water to regional buildings.

Drivers

The drivers for integrated water-energy planning and management in the Toronto area included a desire by Toronto Water to minimize hydro costs, reduce energy usage, and utilize existing resources. Joint use of Lake Ontario to provide drinking water and thermoelectric cooling, as well as end use efficiencies, are pathways that led to integrated water-energy planning and management practices.

Electricity distribution in the City of Toronto is also currently transmission constrained. According to a presentation by Baxter at the City of Toronto (Baxter 2011), existing transformer stations are at capacity and there is little room within the system for redundancy. At the same time, the City of Toronto was exploring how to modify the existing downtown cooling system by harnessing energy from Lake Ontario.

WEUIP Activities

This case study presents an example of WEUIP between Toronto Water and Toronto Hydro, as well as a study of a public-private partnership, to improve end use efficiency and infrastructure resiliency & operational efficiency.

End Use Efficiency. In reviewing options for introducing lake water into its existing cooling network, the City of Toronto was concerned that this would lead to environmental issues as warmer, returned, water from the network was discharged to Lake Ontario. An alternative was to connect the cooling network with the drinking water system, however this would require the City to operate an energy utility. So instead the City formed a private-public partnership to create the Enwave energy corporation to capitalize on the opportunity to harness energy from Lake Ontario and use return water as drinking water.

In 2004, Enwave constructed the Deep Lake Water Cooling (DWC) system. DWC involves using naturally cold water as a heat sink in a heat exchange system, eliminating the need for conventional air conditioning. The cold water is drawn from near the bottom or below the thermocline of a nearby water body (at a temperature of only 4 degrees C (39.2 F)). Toronto's Deep Lake Water Cooling system began operation in July 2004 and helps keep downtown Toronto buildings cool year-round.

Infrastructure Resiliency & Operational Efficiency. In 2004, Toronto Water undertook a Transmission Operations Optimizer (TOO) study to examine how to improve the efficiency of pumping in its drinking water system. According to the City of Toronto (2007), key outcomes from the TOO study demonstrated that optimizing pumping in the water system can lead to:

- Minimizing hydro cost
- Reducing energy usage
- Ensuring service delivery levels are met, including pressures, reservoirs, and water quality
- Providing the ability to simulate "what-if" situations for use in: emergencies, training, and hydro rate negotiations

An opportunity for Toronto Water to invest in improving pump efficiency came when in 2010, the Minister of Energy and Infrastructure of Ontario directed the Ontario Energy Board to establish conservation and demand management targets for electricity distributors. Electric distribution licenses were subsequently amended to require distributors to achieve energy savings during peak demand periods. Toronto Hydro received approximately $50 million CAD from the Ontario Power Authority to deliver conservation and demand management programs (Toronto Hydro Corporation 2014). Toronto Water applied for the Toronto Hydro SaveOnEnergy program that provides financial incentives and technical assistance to help improve energy efficiency to replace outdated pumps with energy efficient versions.

Outcomes

The DWC system reduces energy demand (to cool the downtown core) by 90% and has additional benefits of reducing emissions of ozone-depleting substances and greenhouse gases. The DWC system has the capacity to eliminate harmful ozone-depleting refrigerants (CFCs and HCFCs) and remove 79,000 tons of carbon dioxide from the air. Modification of the existing downtown cooling system to harness energy from Lake Ontario reduces the need for cooling towers, saving 714 million liters of potable water (General Manager, Toronto Water 2013).

Toronto Hydro received $50 million CAD from the Ontario Power Authority to deliver conservation and demand management programs. As part of the Transmission Operations Optimizer program, Toronto Water conducted a detailed review and evaluation of pump flow, pressure and electricity use data to identify energy-saving opportunities in their operations. They identified an opportunity and funding from Toronto Hydro to replace six pumps at their F.J. Horgan Water Treatment plant, one pump at their Parkdale Pumping Station, and one pump at their William Johnston pumping station.

Metro Vancouver, BC Hydro, and the City of Vancouver

Metro Vancouver, and its affiliate, the Greater Vancouver Water District (GVWD), is a Canadian water utility serving the 2.4 plus million people in its 24 member municipalities in the greater Vancouver, British Columbia area. The City of Vancouver is one of the 24 municipalities that comprise the Metro Vancouver regional board. The City works collaboratively with the

GVWD to supply water to the city's 600,000 (Statistics Canada 2011) residents and numerous businesses. BC Hydro, a British Columbia crown corporation, is the main electric utility in British Columbia serving 1.8 million customers.

Drivers

As an organization, Metro Vancouver has committed to sustainability as an underlying business principle. It is the core vision for Metro Vancouver with the ultimate goal for Metro Vancouver to be the greenest region in the world by 2020 (Metro Vancouver 2010). The Sustainable Region Initiative (SRI) identifies the need for a series of management plans to address delivery of services according to the principles of sustainability (Metro Vancouver 2010).

WEUIP Activities

This case study describes a small set of water-energy planning and management practices in the Metro Vancouver region. The case study highlights how Metro Vancouver's regional sustainability initiative has led to energy efficiency collaborations as well as the development of a district energy utility operated by the City of Vancouver. It also highlights energy efficiency collaborations between the GVWD and BC Hydro. This case study is an example of the visioning, assessing options, and implementing options stages of WEUIP.

Alternative Water Supply & Wastewater Services. To help define and implement the SRI, Metro Vancouver's Drinking Water Management Plan (DWMP) was adopted in 2005 (Metro Vancouver 2011). The goals of the plan are to:

- Provide clean, safe drinking water;
- Ensure the sustainable use of water;
- Ensure the efficient supply of water; and
- Manage and protect the watersheds that provide the region's water as natural assets.

The region is moving toward managing water by encompassing the full water cycle. The DWMP includes actions to match water quality usage requirements by assessing alternative sources of water (rainwater, grey water, and wastewater) for non-potable use; eliminating once-through cooling water; requiring water efficient fixtures in new construction and renovations; implementing leak identification and repair programs; enforcing the Water Shortage Response Plan; developing residential water metering programs; establishing municipal rebate programs for water efficient fixtures and appliances; and assessing the merits of standardized industrial, commercial, and institutional water audits for the largest 25 percent of business users to initiate water conservation improvements (Metro Vancouver 2011).

Infrastructure Resiliency & Operational Efficiency. To help meet goals outlined in the SRI and reduce energy consumption at Metro Vancouver's water system, the GVWD partnered with the Power Smart Division of BC Hydro to take advantage of its Power Smart Partner Program. The Power Smart Partner Program provides eligible organizations the opportunity to gain access to a variety of tools and resources to become more energy efficient. GVWD partnered with BC Hydro to evaluate the energy savings during off-peak times at two pump stations – Central Park and Cape Horn. These pump stations were built in the mid 1970's using fixed speed motors when energy use was not a consideration in their original design.

GVWD constructed a custom GHG calculator and economic analysis tool to assess the feasibility of pump replacement and system configurations to reduce energy use. Following initial analysis, system engineers determined that energy reduction was possible through using demands downstream of the Central Park pump station to cycle the reservoir and eliminate all pumping, and to use the low motor speed at the Cape Horn pumping station during the off-peak times to save electrical energy.

Regional Planning. Following the 2010 Winter Olympics, the City of Vancouver set a goal to become the greenest city in the world by 2020 (City of Vancouver 2015a). Goals related to climate leadership, reduced GHG emissions, and water efficiency in the *Greenest City 2020 Action Plan* (GCAP) are described below (City of Vancouver 2014).

- Reduce community-based greenhouse gas emissions by 33% from 2007 levels by 2020
- Reduce energy use and greenhouse gas emissions in existing buildings by 20% over 2007 levels
- Require all buildings constructed from 2020 onwards to be carbon neutral in operations
- Reduce per capita water consumption by 33% from 2006 levels

Renewable Energy. Renewable energy is a fundamental strategy to reduce resources and energy (from fossil fuel sources) needed to operate the water treatment and distribution system, and to meet Metro Vancouver's Sustainability Framework Targets and Priorities, including:

- Energy: work toward 100% renewable energy in the region
- Greenhouse Gases: Be carbon neutral by 2012 excluding solid waste operations (achieved)
- Greenhouse Gases: Reduce regional greenhouse gases by 15% by 2015 and 33% by 2020
- Waste: Increase energy from liquid waste by 10% by 2012 (achieved)

The Southeast False Creek Neighborhood Energy Utility (FCNEU) is a district heating system that recovers heat from untreated wastewater and then pumps the heat energy to neighboring buildings to provide space heating and hot water services. The utility is owned and operated by the City of Vancouver and serves 395,000 m^2 (4,300,000 ft^2) of residential, commercial, and institutional space in Southeast False Creek community (Laszlo 2012).

Outcomes

Metro Vancouver has developed a number of operational efficiency tools including constructing a custom GHG calculator and economic analysis tool to assess the feasibility of pump replacement and system configurations to reduce energy use. Following initial analysis, system engineers determined that energy reduction was possible through using demands downstream of the Central Park pump station to cycle the reservoir, which eliminated all pumping, and to use the low motor speed at the Cape Horn pumping station during the off-peak times to save electrical energy.

The FCNEU district heating operations results in 60% reduction in GHG and supplies 70% of annual energy demand in area (City of Vancouver 2010). The City of Vancouver notes that sewage heat recovery outperforms most other geothermal systems due to both higher source heat and lower installation costs (City of Vancouver 2010).

Ergon Energy

Ergon Energy is an Australian energy distributor with a subsidiary retail corporation. Ergon owns and maintains a distribution network made up of substations, power transformers, power lines and power poles as well as 33 stand-alone power stations for delivery of electricity to over 720,000 customers throughout regional Queensland (Ergon Energy 2014b).

Drivers

Ergon Energy's strategic distribution challenge is to reduce the cost of delivery of energy across Ergon's network, while preserving its sustainability, establishing flexibility, and ensuring reliability. This is difficult to achieve given a low population density compounded by seasonal disruptive climatic events and increasing peak energy demand. Consequently, the distribution network is susceptible to damage from cyclones (hurricanes). High temperatures also contribute to greater peak demand during the non-winter months. Coupled with relatively long transmission distances to a small customer base, Ergon Energy is in a challenging position. In response, Ergon has pursued options in non-network alternative solutions including investment in demand management strategies that integrate water-energy management.

WEUIP Activities

This case study profiles the efforts by Ergon Energy to reduce cost of energy service delivery across Ergon's network, while improving system resiliency. This case study does not feature a collaboration between a water and electric utility, yet it provides context on the water to energy considerations of many electric utilities and where they may engage water utilities in WEUIP.

Demand Management and Demand Response. Ergon Energy has implemented several demand response initiatives including an "energy sense" demand management program targeting energy and water use efficiency in its retail customer base. Ergon Energy has also implemented the Empower Mackay program, a demand reduction incentive program to reduce infrastructure investment in the area of Mackay, Queensland.

Ergon's demand management programs, emphasizing non-network alternatives, focus primarily on energy efficiency during peak periods in order to defer capital investment. Non-network alternatives involve incentivizing customers (including water utilities and other large commercial, industrial and institutional customers) to reduce electricity load during peak periods and plan for standby generators when needed.

These electric utility driven programs provide an opportunity for water utilities to engage electric utilities to develop joint water and energy efficiency programs and promote WEUIP. Moreover, energy focused demand management has great potential to engage water utility planning and management that has not yet been fully realized through information sharing. Ergon Energy aims to gain access to water utility network connection plans and promote energy retailers to have Time of Use (TOU) plans. These TOU plans can promote increased water storage and ensure pumping outside of peak tariffs. Information sharing between water and electric utilities can ensure the criticality of pumping loads and storage capability during peak-demand events.

The “Energy Sense Communities” program in Townsville brings together several demand management projects. Under the purview and strategic advantage of Townsville’s Energy Sense Community’s multiple perspectives, multiple demand management projects have been successfully scoped, analyzed and approved. These include: sustainable residential development, residential business modeling, and hot water demand response enabling device installations for multi-unit complexes. The Smart Water Pilot program, a part of the Townsville Dry Tropics Water Smart program, is a program deploying smart metering to homes around the north-Queensland city providing water data to the city of Townsville.

Renewable Energy. Ergon Energy and the Government of Queensland are also encouraging renewable energy generation projects from biogas from landfill sites, rendering plants, and waste water treatments benefits like generating electricity promoting benefits to increase water efficiency or to derive revenues from renewable electricity production. In 2014, Ergon Energy worked to support customers able to produce biogas (e.g., Darling Downs Fresh Eggs, Tong Park and Bettaport) in order to achieve demand reductions (Ergon Energy 2014a).

Outcomes

Overall, since 2011, Ergon Energy’s demand management reductions and diversity of programs have increased, and peak demand reductions have more than doubled. The Townsville network demand management program has had varying results since 2011 (Ergon Energy 2014a). Investments in the MacKay demand reduction programs anticipate 4.31 Mega Volt Amp (MVA) demand reduction in November 2016 and 5.59 MVA demand reduction by Nov 2017 (Ergon Energy 2011).

South East Queensland Water

South East Queensland Water (Seqwater) is the Queensland Government statutory authority responsible for ensuring a safe, secure and cost effective bulk water supply for more than three million people across South East Queensland, Australia. The authority works in partnership with South East Queensland water service providers and the water businesses of local councils. Seqwater also provides irrigation water, flood mitigation services, catchment management and recreation opportunities.

Drivers

South East Queensland’s regional efforts to integrate water-energy planning is driven by projected increases in energy costs associated with urban water supply, pressure to improve the energy efficiency of the Queensland economy and contribute to national carbon emission reductions. Population growth, spreading cities and tightening water and wastewater regulatory standards are also contributing to growing energy demands in the water sector. The Queensland Government expressed a need for greater energy efficiency in the Queensland economy, demonstrated in the Queensland Department of Energy and Water Supply’s (DEWS) electricity strategy (DEWS 2012b).

The Australian Government is also committed to reducing Australia’s greenhouse gas emissions to 26–28 per cent below 2005 by 2030 (Commonwealth of Australia 2015). To achieve the 2030 target, Australia notes the contribution of carbon emissions by the water sector, both direct and indirect energy consumption, plays a key role in reaching this target.

WEUIP Activities

This case study describes Seqwater's initial involvement with WEUIP with a goal to identify and quantify the water-related energy use, GHG emissions, and associated costs in the water system. This is relatively unique in the case studies reviewed for this research project, in that the Seqwater approach strategically considered the entire system, from catchment to tap, and even beyond the immediate water system. It was anticipated that this approach would enable Seqwater and wider water system stakeholders to improve long-term water and energy efficiency and assist in prioritizing investments that achieve greatest efficiency at the lowest cost to the community. In partnership with the University of Queensland, Seqwater developed a system model framework to gather more information about potential energy reductions gained from specific investments. This approach focuses on the goal setting stage of WEUIP with potential to involve regional electric utilities in the application of the developed framework and later stages of WEUIP.

Collaboration and Research on Embedded Water & Energy. Seqwater, like many water utilities, routinely considers the direct energy impacts of their operations (Kenway et al. 2008). However, the indirect energy use influenced by water pricing and other policies are less obvious to water managers. Analysis of Seqwater's indirect energy use involved a systemic analysis and quantification with: 1) identification of energy questions relevant to water stakeholders, 2) definition of a system boundary, and 3) use of the boundary to quantify water-related energy throughout the system. Applying the resulting system boundary framework to water-related energy in South East Queensland (SEQ) identified that over 96% of identifiable water-related energy in SEQ is outside the influence of the bulk water supply authority (Kenway et al. 2014a).

Outcomes

The research identified that collectively, urban water influenced 3,185 GWh annually of electricity, plus 2,791 GWh (comparative thermal energy) of natural gas in 2011-12. This is equivalent to 13% of the total 22,000 GWH electricity supplied by Energex to Seqwater in that year (Energex 2013) plus 18% of the total natural gas consumption (15,000 GWh thermal) by Seqwater (AEMO 2014). Bulk water assets comprised 3.6% of the energy influence. Additionally, other urban water infrastructure (wastewater, retail water and rainwater tanks) comprised approximately 7% of overall water-related energy use.

The project has brought together entities including Seqwater, Energex, Ergon, Unity Water, Department of Energy and Water Supply, and to a lesser extent the Australian National University, Queensland Competition Authority, Logan Water, Redland Water, and Economic Development Queensland and involved a Californian Energy Commission water-energy expert. The participatory process across industries created an appetite for further collaborative research between Seqwater, Ergon Energy and Energex. A major outcome was a submission for a first-ever collaborative grant proposal seeking to identify mutually supportive, least-cost options.

City West Water

City West Water (CWW) provides water, sewage, commercial liquid waste, and recycled water services to approximately 390,000 customers (CWW 2015) in Melbourne Australia. Nearly 10% (37,210) of the customers are commercial, industrial and institutional as CWW's service area includes Melbourne's Central Business District as well as the city's major industrial hub (CWW 2015).

Drivers

Efficient use of water and energy is important to City West Water's delivery of services. Dominating the commercial, industrial and institutional customers (CII) water consumption are Melbourne's manufacturing sector, rental, hiring and real-estate (office buildings and shopping centers) and arts and recreation (open space) (CWW 2015). CWW's efficiency programs target these sectors, especially as the CII customer profile has grown 37 percent over the past 13 years (CWW 2014). CWW's concentration of industrial customers is also of particular interest because of the significant water and energy savings found in the manufacturing and industrial processes of CWW's major customers.

WEUIP Activities

This case study offers a snapshot of the Business Resource Efficiency Program (BREP) at CWW. The primary purpose of the BREP is to help businesses analyze and understand water, energy and commercial liquid waste generation patterns, and identify improvement opportunities. The BREP is administered by CWW and while not a full example of WEUIP, its focus on water and energy efficiency provides a model for how water and electric utilities could implement joint water and energy efficiency end user programs.

End Use Efficiency. CWW's BREP helps businesses to implement water and energy efficiency measures. Established in 2003, the initial objective of the program was to reduce contaminants in wastewater in order to allow for more recycled wastewater for agricultural use (A4WE 2014). Beginning in 2005, the program took on a stronger role in water efficiency, driven primarily by water security challenges brought on by the Millennium Drought (DSE 2007). The BREP has been a delivery partner for the Smarter Resources, Smarter Businesses, a program coordinated by Sustainability Victoria. Through the Smarter Resources, Smarter Businesses program, and partnership with the Australian Industry Group (AIG), CWW is receiving a small amount of external funding to deliver water, energy and waste audits to its customers.

Outcomes

The BREP program won an award for its program innovation and strategic outlook on GHG emissions and water efficiency by improving water and energy efficiency of steam systems. Working outside of CWW's own system boundaries to achieve reduced GHG emissions and water efficiency was supportive in achieving long-term water and energy efficiency for the Melbourne region.

Several different types of audits, efficiency training and device replacements have been included in the BREP including fire sprinklers, pre-rinse spray valves, cooling tower and steam system efficiency trainings, clean-in-place processes, and basic energy and water audits for small and medium sized businesses. A detailed case study outlines the major program achievements, savings identified and learning gained from the program implementation at CWW.

By 2012-13, non-residential water use within the CWW residential area dropped by 16.2 billion liters (4.3 billion gallons) from 2000-2001 levels (CWW 2014). This reduction is attributed to working closely with customers obligated to complete a Water Management Action Plans (action plans that help improve water efficiency) and sustained efforts to achieve 30% reduction in water consumption from 1990 levels (CWW 2011).

Yarra Valley Water

Yarra Valley Water (YVW) is a state-owned retail water corporation covering 4,000 km^2 (2,485 square miles) of the greater Melbourne Australia area (YVW 2012a). To service this area, YVW owns and maintains over 9,000 km (5,592 miles) of water and sewer mains.

Drivers

Limitations on water supply, changes in regional regulations, and changes in corporate vision have encouraged water utilities to explore alternative water supply and wastewater services. For example, the Millennium Drought (1997-2011) in Australia placed significant pressure on Melbourne's water security and encouraged YVW to explore alternative water solutions. During this period, the Natural Step program was used as a tool by YVW to gain buy-in within the organization and to move the sustainability objectives from philosophical to pragmatic and operational (Pamminger 2008, Pamminger and Crawford 2006).

Since the initial interest in pursuing alternative water supply options in 2005, Yarra Valley Water has worked closely with community, government, and project partners to plan for servicing Melbourne's Northern Growth area. In partnership with Melbourne Water, YVW published a preliminary integrated whole-of-water cycle management strategy in 2013. The integrated strategy outlines a community-cost framework describing the potential benefits of alternative water servicing options that includes reducing energy and promoting distributed energy generation.

WEUIP Activities

This case study highlights the success of YVW in implementing water and energy integrated management. First, there are a variety of customer awareness programs in place at YVW to promote end use efficiency in water and energy consumption. Currently this effort is focused on the water cycle (e.g., integrating water, wastewater and stormwater), however discussions with the local electricity and natural gas utilities (Jemena and APA Gas respectively) have been initiated. YVW also actively participates in research to better understand the potential for harvesting water and energy from water, wastewater, and drainage systems. Research has led to proof-of-design projects that use alternative water supply and treatment processes including district level wastewater and stormwater reuse. This case study presents WEUIP from the perspective of a water utility and while discussions have been initiated, engagement with the local electric utility is promising but still relatively minor. Most of the energy benefits from the renewable energy projects described here are directed to on-site energy savings, rather than interconnections to the grid. However, this case study illustrates a number of pathways where water utilities can open the conversation with their respective electric utility to engage in WEUIP.

Alternative Water Supply & Wastewater Services. In addition to traditional water and sewerage services, YVW is building a diverse portfolio of 'Next Generation' water services (e.g., services that produce zero greenhouse gas emissions, supply recycled water, or reduce excessive waste nutrients) as part of an integrated water management strategy to serve Melbourne's North (YVW 2012b).

The 'Next Generation' of water services includes alternative water supply and treatment projects that seek to maximize community benefits. Stormwater harvesting, regional recycled water systems and onsite rainwater and greywater systems have the added benefit of reducing potable water demand and urban runoff and nutrients discharged into the environment, combined with being less energy intensive than other water supply options (YVW 2013). The Kalkallo Stormwater Harvesting project, Doncaster Hill Service Centre and a waste-to-energy facility near the Aurora Sewage Treatment Plant are examples of next generation services offered by YVW.

Renewable Energy. The 2013-2018 YVW Water Plan outlined additional innovations in sewage treatment in order to convert waste to energy, which will have the outcome of lowering costs and producing green energy (YVW 2012a). A waste-to-energy facility next to the Aurora Sewage Treatment Plant powers the treatment facility by producing biogas from organic waste through the gate and sewage sludge from the treatment plant. Excess electricity will be exported to the grid, contributing to energy production in the area (YVW 2015). At the time of undertaking the case study, YVW had not had specific discussions with the energy utility in relation to the potential for this project. While YVW approached the electric sector there has been relatively minor response, possibly because most of the water-energy linkages for this project are to be via natural gas, which is the dominant form of energy for water heating in Melbourne. Discussions are ongoing and more dialogues are opening between YVW and their counterpart electric utilities.

Outcomes

YVW's involvement in WEUIP is focused on first testing the hypothesis that there is an inter-connection between water and electric utilities, and then determining what YVW's role is in promoting opportunities to leverage the inter-connection. The hypothesis is that there is a lot of energy in the existing water and sewer system, and theoretically there is more in it then is actually consumed. YVW's work in alternative supply sources and work on quantifying and preparing plans for co-generation will provide quantified linkages for future WEUIP activities.

Melbourne Region

Melbourne's water (Victoria, Australia) and wastewater system provides 399 billion liters (87.8 billion gallons) of potable water supply, 49.7 billion liters (13.1 billion gallons) of recycled water and 313,349 billion liters (82.3 billion gallons) of sewage treatment (Melbourne Water 2014). Melbourne's water service providers include four state-owned corporations, one bulk service provider (Melbourne Water) and three retail service providers (City West Water, South East Water, and Yarra Valley Water). Victoria's energy market has operated as a regulated private market beginning in 2008 (gas) and 2009 (electric). Energy companies are private and operate at either a regional, state or national scale, depending on the scope of the company. Their involvement with the National Electricity Market (NEM) and obligation to the National Energy Market Operator (NEMO) as a licensed business ties them to national regulations.

Drivers

The region has faced variable and uncertain climate conditions. Most notably were the 1997-2011 drought (The Big Dry or Millennium Drought) and the pressures on drainage services when the drought ended as heavy rain events caused urban flood damage. A comparison of 2007/08 and 2009/10 energy consumption data shows increases in energy consumption from water supply pumping and treatment caused by the drought circumstances (Cook et al. 2012). A reduced yield of water coming from natural catchments resulted in higher reliance on water being pumped from the Yarra River system, which also required higher treatment. In addition, the north-south pipeline was utilized in early 2010, which required more pumping (Cook et al. 2012). In response, the urban water system has begun to leverage centralized and decentralized technologies for supplying water and treating sewerage and stormwater (Ferguson et al. 2013).

To date there is limited interaction between private energy companies and state-owned water corporations in Australia to deliver on energy efficiency programs. Due to different structures of regulation and a lack of incentive to work together, there little incentive to help water corporations reduce their energy load. Integrated water-energy planning in Melbourne is driven by changes in water security and water demand. Alternative approaches to providing water services (i.e., rainwater harvesting, greywater systems) have the potential to reduce the energy intensity of water services, while also enhancing livability of the urban environment. Carbon reduction and energy efficiency policy directives are also incentives for integrated water and energy planning.

WEUIP Activities

The Melbourne Region case study is presented as a high-level descriptive case study, exploring how the region has approached integrated water and energy practices. It provides an overview of drivers for integrated planning such as climate changes and policies that influence demand and supply of water and energy. This case study highlights how water and energy interactions are viewed at a regional scale and how these interactions affect future WEUIP.

End Use Efficiency. A state-level incentive for energy efficiency measures was the Victorian Energy Efficiency Target (VEET) scheme established under the Victorian Energy Efficiency Target Act 2007 (ESC 2014a). From 2009-2014, the Essential Services Commission allowed for accredited businesses to offer discounts and rebates on energy saving products and appliances that were installed at homes, businesses or other non-residential premises. Products included in the VEET were: energy efficient water heating devices, space heating and cooling, space conditioning, low water use shower rose (rainhead), incandescent lighting replacement, refrigerator or freezer replacements, television replacements, clothes dryers, pool pumps, standby power controllers, in-home displays, motors, refrigerated display cabinets, refrigeration fans, commercial lighting upgrades, low flow trigger nozzles and pre-rinse spray valves. The potential savings offered was based on the amount of greenhouse gas reduction of the device. This initiative was intended to make energy efficiency improvements more affordable and help the state contribute to a reduction of greenhouse gases (ESC 2014b).

Regional Planning. Since the initial interest in pursuing alternative water supply options in 2005, Yarra Valley Water has worked closely with community, government, and project partners to plan for servicing Melbourne's Northern Growth area. In partnership with Melbourne Water, YVW published a preliminary integrated whole-of-water cycle management strategy in 2012 (YVW 2012b). The integrated strategy outlines a community-cost framework describing the potential benefits of alternative water servicing options. The process started by sharing a vision with members of the community, government and committed project partners. With the vision in mind, five potential service options were identified, covering traditional and integrated approaches to water, sewerage and drainage services. Option 1 involved household rainwater harvesting; option 2 focused on regional wastewater recycling; option 3 pursued regional wastewater recycling with drainage system disconnection; option 4 focused on regional wastewater recycling complemented by household rainwater harvesting; and option 5 relied on the traditional approach with 5 star homes update, which maintains rainwater tanks for toilet flushing and outdoor uses.

The Millennium Drought highlighted the region's vulnerability to variable climate conditions. This was the primary driver for embracing the water sensitive city agenda. The Living Victoria policy has resulted in better linkages between water management and urban planning.

Integrated Whole-of-Water Cycle management plans were included for the first time in the Plan Melbourne 2030 (Government of Victoria 2014).

Renewable Energy. Hydro and biomass energy production has become an important component of water and wastewater operations for Melbourne's water corporations. Melbourne Water's Eastern Treatment Plant and Western Treatment Plant both convert sewage to energy (Melbourne Water 2015). The Western Treatment Plant generates 71,500 megawatt hours of renewable electricity annually. This supplies nearly all of the treatment plant's electricity needs. In some cases, there is excess electricity exported to the electricity grid. The Western Treatment Plant is also able to use biogas for most of its electricity and heating and cooling needs (Melbourne Water 2015). Melbourne Water also has a mini hydro program with hydroelectric facilities on reservoirs throughout the water supply system. This contributes 51,000 megawatt hours of renewable energy supply to the region. All these small-scale projects are generating renewable energy within the urban water system. The generation of energy from wastewater treatment processes in excess of the energy needed onsite may provide sufficient incentive for wastewater utilities to engage their electric utility counterpart to engage in WEUIP provided financial opportunities are available.

Outcomes

Despite a disparate collection of stakeholder interest in water and energy planning, the region has been successful in reducing water consumption and investing in a diverse water supply portfolio, particularly in Melbourne's northern growth corridor. Additionally, Victoria has experienced a reduction in energy demand and introduced more renewable energy generation.

Over the course of the Millennium Drought, Melbourne's total water consumption fell by approximately 30% during the period 2000/01-2010/11 (500 GL (113 billion gallons) to 343 GL (77.8 billion gallons) per annum) (Government of Victoria 2013). Victoria's energy consumption from the grid represents a decline by 1.6% over the same period (AER 2014a).

The result of investment in alternative water supplies means that Melbourne has a diverse water supply portfolio including desalination, and recycled wastewater. Melbourne has increased the number of wastewater plants capable of producing Class A recycled water. The total effluent recycled to Class A level and supplied to customers in 2012/13 was 37,633 ML (8.6 billion gallons).

CHAPTER 4
WATER AND ELECTRIC UTILITY INTEGRATED PLANNING TOURNAMENT

INTRODUCTION

The WEUIP Tournament is a concept based on the Invitational Drought Tournament developed at the Science and Technology Branch of Agriculture and Agri-Food Canada (Hill et al. 2014). Using a simulation gaming concept, a tournament helps actors discuss opportunities for future planning efforts. The WEUIP Tournament provided an effective means for providing data for the larger study and provided a mechanism to support WEUIP in real world applications.

Tournament Background

The WEUIP Tournament was an event hosted by the Water Research Foundation and the American Water Works Association on October 16 and 17, 2014 in Denver Colorado. The primary goal of the WEUIP Tournament was to create a scenario where water and electric utilities would follow the process of WEUIP (see *What is Water and Electric Utility Integrated Planning* in Chapter 1) from goal setting to evaluation of options to the preparation and modification of an integrated water and electric utility plan. Other objectives of the WEUIP Tournament were:

- To develop a WEUIP Tournament framework and apply it to hypothetical but realistic WEUIP scenarios
- To encourage active conversations between water and electric utilities with specific attention to identifying the opportunities and barriers for WEUIP
- To create an enjoyable environment for sharing of ideas and challenges through gaming and to explore the constructs of WEUIP

Thirty-two people from the United States, Canada, and Australia and representing water and electric utilities, water and energy sector professionals, federal and state regulators, and academic institutions were in attendance (see Figure 4.1). Participants were invited from various disciplines to create a distributed but equal representation of water and electric utility viewpoints. Participants were grouped into five teams of five. A panel of five judges with one member of each team comprising 2 water utilities, 1 energy regulator, 1 industry representative, and 1 academic was selected to collectively rank team results. The research team provided technical and referee oversight of the process.

Figure 4.1 Team 5 (left) and Team 1 (right) deliberating options to include in their water and electric integrated plan

Process

The teams were guided through two integrated planning scenarios set in a fictitious city and region. The scenario included information about the city and its biophysical, political, and social environment (e.g., demographics, temperature, precipitation, water and energy demand projections). Teams were provided a technical memo and participated in two tournament rounds. Through discussion, teams worked together to develop an integrated water and electric utility plan consisting of several planning alternatives. Teams scored each other based on their integrated plan's abilities to meet the goals of the scenario, minimize economic impact and maximize system resiliency in both the short and long term. The team with the highest score at the end of the second scenario won the tournament. For an extended discussion of the tournament process see Appendix G.

As a closing component of the tournament, an open-ended process was used to elicit feedback from the participants on selected key questions of interest to the research team, focused on integrated planning by water and electric utilities. The adopted process was the World Café method used previously by the research team (Kenway et al. 2013b). Café tables were commenced based on the team groups assigned earlier in the tournament. The following questions were put to all tournament participants:

- What are key barriers to be overcome to enable integrated water and electric utility planning?
- What are the benefits, or desirable outcomes of integrated water and electric utility planning (what will be "lost" for utilities, cities, regions without integrated planning)?

For each table, a table "host" was identified and led a discussion of the question. Toward the end, the host facilitated agreement on major points where that was possible. After approximately 20 minutes, everyone except the host had to leave the table and go to another table at the café and the host continued to lead the discussion with new participants. The process was repeated and table guests again changed tables. Finally, the café was "closed", with each table host briefly presenting (2-3 minutes) the main points arrived at by the table.

SUMMARY OF KEY FINDINGS

The WEUIP Tournament was successful in encouraging conversation and exchange of knowledge between diverse sector representatives, and in addressing a challenge of terminology differences between water and electric utilities. Teams worked aggressively to a) develop integrated plans across both scenarios (including introducing new innovations) and b) come to consensus on the most opportunistic areas for integration. The following sections highlight results from the WEUIP Tournament. For a complete listing of findings, see the WEUIP Tournament summary report via the link provided at the end of this chapter. Information collected in this tournament was also subsequently tested in an industry sector survey. Results from this survey are discussed in Chapter 5.

Tournament Outcomes

Teams set goals focusing on achieving regional water and energy sustainability, improving system resiliency, minimizing risk and cost, and promoting innovation. They utilized these goals to select planning options for their integrated water and electric utility plan.

Round 1 - Securing Water Supply Futures

For round 1, teams considered a scenario that presented declining water supplies affecting drinking water, hydroelectric generation, and coal generation cooling. Teams were required to address the looming water conflict and prepare a strategy for sustainable management of water over the next 20 years. In this round all team plans selected to undertake leak identification and repair programs and pursue alternatives to potable water. Four of the five teams implemented a regional water and electric conservation program and funded municipal rebate programs for water and energy efficient fixtures and appliances. Three of the five teams implemented a watering restriction program and set wholesale water rates and water rate structures to reflect the full cost of regional water supplies. Two teams opted to expand wind generation facilities. One team opted to expand solar generation facilities. Another team opted to implement a combined real-time metering and customer reporting program and a joint watershed management program to improve water quality, and to develop a three-tiered water rate structure, and to investigate a series of innovation options for improving building codes and introducing a program for agricultural water leasing. Yet another team proposed a development offset charge.

Round 2 - Clean Energy Regulations (CO_2 Emission Limits)

For round 2, teams considered a scenario where the federal government was proposing to regulate carbon dioxide (CO2) emissions from coal-fired and gas-fired generation facilities reducing electric generation capacity from 10% to 25%. Teams were required to prepare for the pending regulation and prepare an integrated water and energy transformation plan for the next 10 years. Teams were given the option to start from their existing plans or develop a new plan. All teams opted to build from their earlier plans. One team did not modify their existing plan, feeling the options selected served to meet the goals of scenario 2. Two teams added a combined real-time metering and customer reporting program to their integrated plan. and one team set wholesale water rates and water rate structures to reflect the full cost of regional water supplies. This team also eliminated their proposal for development offset and instead proposed an innovation option for improving building codes to ready the region for solar power. Another team eliminated the choice to implement a joint watershed management to improve water quality from their previous plan. Yet another team opted to add a region-wide water and electric conservation program, complete a joint water use plan to manage hydropower at the Lake 1 (one of the region's water supply sources), and expand wind generation facilities.

Water and Electric Utility Integrated Planning Themes

Participants felt reducing waste and improving efficiency were the highest priorities, followed by reducing water use by residential customers. Following these priorities, the most frequently selected and discussed options focused on the following themes (these themes were later analyzed as part of the study's thematic analysis to form the 10 WEUIP areas of opportunities):

- End use efficiencies through joint water and electric utility conservation programs and rebate programs (reducing water and energy demands significantly, deferring new capital projects)
- Internal waste reduction and efficiency (through leak management, internal optimization)
- Investing in alternatives to potable water supply for irrigation, industrial uses, and electric power cooling (enhancing longer term sustainability with diversified energy supply, minimal new infrastructure, optimizing existing sources)
- Water and energy restrictions (role of regulations and policy)
- Alternative water pricing strategies
- Renewable power generation (co-generation, solar, wind)
- Cost effective solutions (provides the most "bang for buck")
- Opportunity to focus on non or low carbon generation with no increase in water demand
- Opportunity for education and public outreach and efficiency and conservation

Opposing Viewpoints and Challenges

Teams identified a number of opposing viewpoints and challenges that might hinder the preparation of water and electric utility integrated plans in real world applications, including:

- Regional perspectives vs. city perspectives
- Water use conflicts (e.g., conflicts between potable water for drinking water vs. water use in industry and agriculture)
- Cost overrides or cost limitations that prevent the consideration of fully integrated planning options
- Gaining community and customer acceptance and support of integrated options and associated costs
- Priority of water use for power generation vs. drinking water
- Communication and enforcement of integrated plan options
- Interpretation of and understanding of generation capacity to meet CO_2 regulations

World Café – Answering Key Questions

As a component of the tournament, an open-ended process was used to elicit feedback from the participants on selected key questions focused on the barriers to and benefits of WEUIP. The summary below is a discussion of the points made by each team.

Barriers to WEUIP

Question 1: What are key barriers to be overcome to enable integrated water and electric utility planning? A number of barriers were identified including current fragmentation of water systems vs. energy systems. There are currently many quite small water systems and utilities. This makes it difficult for the (generally larger) electric utilities to coordinate with them. There is also a difference in public vs. private goals, drivers, and management between water and electric utility systems. Water systems are often municipal systems whereas electric utilities are typically privately operated. The different operational jurisdictions, the degree of utility centralization/decentralization, and the lack of consistent spatial boundaries of operation (of water and electric utilities) were all seen as barriers to integration.

A barrier was also noted by the separate mechanisms for funding water and energy assets. Integrated funding, such as government funding mechanisms that encourage integrated water and energy solutions could break silos and foster collaboration. One water utility representative noted that revenue decoupling had helped enable stronger collaboration across water and energy. Decoupling had involved separating financial returns to utilities from volumetric sales (e.g., sales of kWh/ML). In contrast, "decoupled" utilities received increased payments for meeting conservation targets. It was noted however that "decoupling" was individually insufficient to incentivize joint planning efforts and is not common across the United States. Further, a lack of allocation/accounting methodology for receiving credit or recognition for implementing actions that results in external benefits (e.g., implementing water initiatives which have energy sector benefits such as reducing peak demand) was noted as a barrier.

Lack of integrated approaches to data collection, storage and analysis, both within and across each sector, was seen as a barrier. Integrated or improved coordination was viewed as essential to quantifying some of the impacts (e.g., of water or energy) and consequently would be of strong value in designing water-energy systems in ways that are mutually-beneficial (perhaps as opposed to problem-shifting). A key research need was identified – "quantify benefits of integrated water-energy planning." However, it was also noted that such quantifying benefits can be partially dependent on integrated water-energy data, i.e., being able to actually access mutually compatible water and energy data (of similar spatial, temporal pattern) such that impacts of water on energy, or vice versa, could be quantified.

Finally, the water and electric utility regulatory environment was noted as a significant barrier to WEUIP, as participants discussed how regulations encourage water and electric utilities to plan in isolation. State regulators, for instance, often require water utilities to present plans that focus on water quality; whereas, electric utilities present plans focused on rates and profits (for IOUs). Rate setting can be local or regional for water utilities whereas electric utilities set rates under state level public utility commissions (although this is not consistent across the US and Canada). Moreover, the deregulated electric utility market presents additional challenges to aligning WEUIP.

A listing of all barriers from the World Café session is available in the WEUIP Tournament summary report via the link provided at the end of this chapter.

Benefits of WEUIP

Question 2: What are the benefits, or desirable outcomes of integrated water and electric utility planning (what will be "lost" for utilities, cities, regions without integrated planning)? Tournament participants identified a number of benefits of WEUIP. These benefits included joint utility goal setting and joint evaluation of water and electric utility interconnections. Common strategies for metering and sharing infrastructure investment were noted as a significant cost-savings benefit. Better consumer awareness of the linkage in water and electric (energy) systems could be achieved through WEUIP through developing joint water and electric marketing and education campaigns, combined water and energy efficiency audits, and single rebate programs. Overall, participants felt that water and electric utilities should be aligned in their messages about water and energy resource conservation and management.

Improved system resiliency was noted as a benefit of WEUIP, along with opportunities for understanding and promoting mutual operational efficiency. Participants noted that WEUIP could facilitate a shift in utility rates to reflect the true cost of resources. A substantial opportunity was noted in jointly planning storage resources for drinking water or electricity generation.

Participants also discussed how better information about water and electric utility use and services could be made available to customers through WEUIP. Professional and customer awareness of the linkages between water and energy was noted as a key benefit of WEUIP. For instance, combined billing could provide opportunities to educate and promote water and electric efficiencies as well as educate customers and the quantity of water needed to supply their electricity and electricity to supply their water.

A full listing of all benefits from the World Café session is available in the WEUIP Tournament summary report via the link provided at the end of this chapter.

IDENTIFYING NEEDS TO PROMOTE WEUIP

In addition to identifying barriers to and benefits of WEUIP an active discussion of the strategies and needs of future WEUIP activities occurred throughout the Tournament. The following section discusses these needs and strategies.

Specific Needs to Realize WEUIP

Participants noted that to realize WEUIP, there is a need to address and modify aspects of the water and electric utility sector. For instance, participants identified the need to clarify and describe areas of overlap in jurisdiction and interest between regional water and electric utilities to further identify where and how water and electric utilities may engage in WEUIP. Participants also noted that it is necessary to consider the connection between wastewater – energy – heat, as there is a strong resource link between wastewater and energy generation in WEUIP, including recognizing wastewater as a source of renewable energy. There was significant discussion about the need to incentivize future relationships between water and electric utilities in order to promote WEUIP. Implementing broader regulations that focus on water-energy interconnections was one strategy discussed by participants for addressing this need.

Participants felt the benefits to the water utility sector were greater than benefits to the electric utility sector, however participants did not quantify the difference. As such, there is a need to share water/energy costs and benefits between water and electric utilities. Harvesting these benefits can be a challenge as costs and benefits are spread across a number of systems (or even households/sites). Individual benefits may also present small savings, but collectively they can be significant. The need to account for shared costs and benefits could be considered in rebates and demand management programs, for example.

Participants identified specific needs promoting multi-state and multi-regional approaches focusing on identifying a regional water-energy management goal. Participants felt there was a need to implement a joint water and electric utility coordinating body and process. The development of a joint water and electric utility urban planning and capacity development was also noted as needed for WEUIP.

MORE INFORMATION

A copy of the full WEUIP Tournament summary report, including a detailed agenda, tournament scenarios, and a detailed listing of findings, participants, and planning options is available on the #4469 project page of the Water Research Foundation website, under Project Papers.

CHAPTER 5
SURVEY RESULTS

INTRODUCTION

This chapter provides a summary of results from conducting and analyzing data from an industry survey on WEUIP. The researchers first provide an overview of survey responses, focusing on key benefits of and opinions on WEUIP. They then assess how survey respondents ranked and prioritized WEUIP initiatives. This chapter concludes with a description of differences in responses by utility size, water or electric utility sector focus, and organization type. More detailed survey results are provided in Appendix I.

SURVEY RESULTS

A total of 165 visits to the survey website occurred during the data collection period. Of the 165 visits, 112 respondents participated in the study for a 68% completion rate. Of those that did not complete the survey, 85% did not proceed past the introduction page to suggest self-selection was occurring. Protest and invalid responses were identified and eliminated by reviewing the length and pattern of responses, and the completeness of each survey section. A final sample size of 105 was used in the analysis of results. The sample size represents a random sampling of water and electric professionals. The survey was not, however, designed to represent a statistical representation of all water and wastewater utilities, and as such, population significance factors were not analyzed. The authors note that while survey results do not provide a representation of the overall water and electric utility population, the results below present an expert opinion on the benefits, opportunities, and needs of WEUIP.

Sector Representation

The majority of respondents (59.6%) represented water and electric utilities. Water treatment was the largest represented utility function (9.9% of respondents indicated their utility provided this service), followed by treated water distribution (9.1%), electric power generation (8.7%), and wastewater collection and treatment (8.3% each). More than half (51.0%) of the respondents indicated their utility provided services for populations more than 1 million while a small portion of respondents (8.2%) indicated their utility provided services for populations between 3,301 and 10,000. The survey did not collect responses on utilities serving populations less than 3,301.

The remainder of respondents (41.4%) represented non-utility organizations. These non-utility respondents indicated they worked primarily in the water/wastewater sector (75.0% of non-utility respondents), with research organizations representing the largest group of non-utility respondents.

Key Benefits of WEUIP

Survey respondents (utility and non-utility) generally indicated an acceptance of the opportunity presented by WEUIP. Overall, retail or end user management, was identified by nearly half (48.8%) of the respondents as the greatest area of opportunity for WEUIP and energy generation represented the second greatest area of opportunity by 37.5% of respondents. Respondents also indicated strong agreement with all the benefits (see Appendix H for a listing of benefits) included in the survey with respondents most strongly agreeing with the statement of the benefits that WEUIP "provides water and energy savings" (88.6% net agreement) and "enhances communication among water and electric sector professionals" (87.1% net agreement). Respondents' opinions were neutral toward the statement that WEUIP "increases utility accountability to the public" with only 47.8 % of respondents strongly agreeing or agreeing with this statement and other respondents (42.1%) showing neutral opinions. Few respondents expressed disagreement with the benefit statements included in the survey. Respondents noted minor disagreement with the benefit statements that WEUIP "incentivizes transition to renewable energy systems" (2.9% of respondents strongly disagreed), "enhances utility system resiliency and response to uncertainties" (4.3% of respondents strongly disagreed), and "increases utility financial stability" (1.4% of respondents strongly disagreed).

Potential of WEUIP Initiatives

Respondents were asked to rank WEUIP initiatives (see Appendix H for a listing of WEUIP initiatives) formed from the study's thematic analysis, on the potential (from 1 - low to 5 - high) they believed the initiatives would support progress toward WEUIP, and realize the benefits of WEUIP. Respondents indicated high potential for "joint water and electric utility operations planning" (mean 4.1 out of 5.0) and "joint water and electric utility demand management programs" (mean 4.0 out of 5.0). While respondents indicated that all initiatives had potential, the initiative "programs focused on expanding renewable energy generation (e.g., solar, wind, biogas, etc.)" ranked lowest with a mean potential of 3.5 out of 5.0. However, the researchers caution readers when interpreting these results, as the potential for all initiatives ranged from 3.5 to 4.1 suggesting relatively high importance of all initiatives.

Level of Effort of WEUIP Initiatives

Respondents were also asked to rank the WEUIP initiatives on the level of effort (from 1 - low to 5 - high) they believed would be needed for the initiatives to support progress toward WEUIP and realize the benefits of WEUIP. Respondents indicated that many initiatives would require effort, including significant effort for "joint water and electric utility regulations" (mean 4.2 out of 5.0) and "implementing a regional water and electric coordinating body and process" (mean 4.0 out of 5.0). The initiative that respondents felt would require the least level of effort was "professional education of the energy embedded in water, and the water embedded in energy" (mean 2.8 out of 5.0).

Mapping of Potential to Level of Effort of WEUIP Initiatives

A mapping of potential to level of effort of the ranked WEUIP initiatives is shown in Figure 5.1. Values greater than 1.0 suggest high potential to low effort for the initiatives "[public and] professional education of the energy embedded in water, and the water embedded in energy," "joint water and electric utility programs on internal water & energy reduction (e.g., leak management, transmission loss reduction)," and "joint water and electric utility demand management programs (e.g., devices, incentives, energy and water efficiency programs, joint metering, customer awareness programs)."

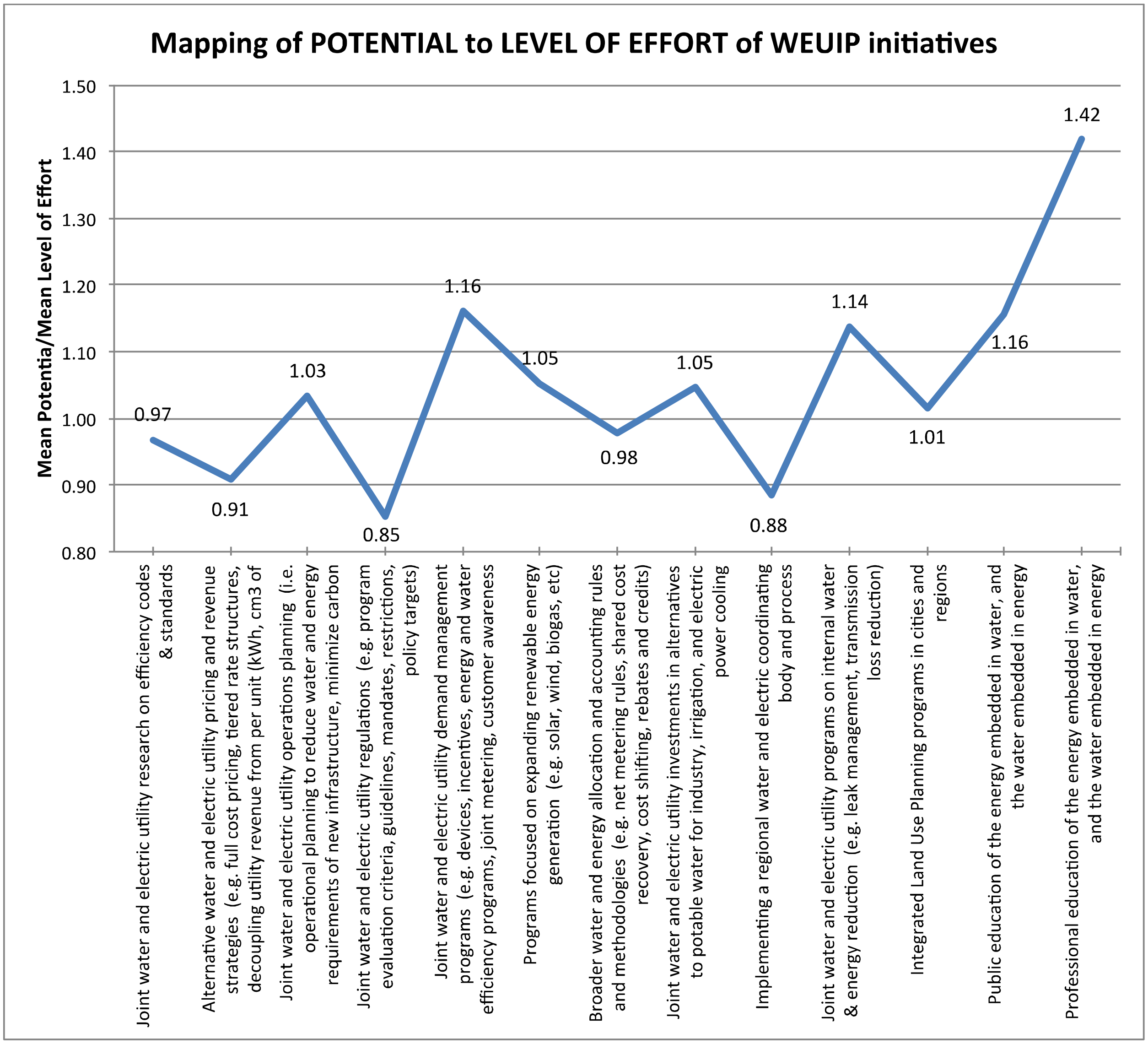

Figure 5.1 Mapping of potential to level of effort of WEUIP initiatives

Opinions on the Needs of WEUIP

The final question of the survey asked respondents to rank the importance (from 1 - low to 5 - high) of the needs (see Appendix H for a listing of needs) in the water and electric utility sector that would be required to progress WEUIP. Respondents indicated high importance (mean > 3.0 out of 5.0) for all needs but indicated a significant importance to "create regulatory structures that provide incentives for investing in water and energy efficiencies" (mean 4.12 out of 5.0) and to "identify specific areas where there is overlap of water and electric utility jurisdiction and interest" (mean 4.03 out of 5.0). Least important among the listed needs, yet still considered important overall, was to "develop joint accounting methodologies to expose and plan for unexpected expenditures" with a mean ranking of 3.28 out of 5.0.

Differences by Utility Size, Sector Focus, and Organization Type

One-way ANOVA Kruskal Wallis H, and Pearson Chi-Square tests were performed on the survey data to determine differences in responses by utility size, sector focus (water or energy) and organization type (utility or non-utility). Significant differences at the 95% level are described in the following sections.

Differences by Utility Size

Overall, there were few differences in how different sized utilities (both water and electric) viewed WEUIP benefits and the potential and level of effort of WEUIP initiatives. Differences were noted for how utilities viewed the benefits "Increases utility financial stability" and "Improves environmental management through a total system view of the environment and its resources." Smaller utilities (serving populations from 3,301 to 10,000) and larger utilities (serving populations greater than 500,001) were more likely to have the opinion that WEUIP would lead to improving environmental management, whereas these same utilities were less likely to perceive WEUIP leading to increasing financial stability. Medium sized utilities (serving populations between 100,001 to 500,000) on the other hand were more likely to agree that WEUIP would increase utility financial stability. On the potential of WEUIP, smaller utilities and larger utilities were more likely to perceive that implementing a regional water and electric coordinating body and process would facilitate more WEUIP activities.

Differences by Sector Focus

There were several differences in opinion between water and electric sector professionals on the benefits of WEUIP and the potential and level of effort and WEUIP initiatives. First, water sector respondents were more likely to agree with the benefit that WEUIP "increases data availability through integrated billing and customer metering." Water sector respondents were also more likely to agree with the potential that "joint water and electric utility demand management programs" would facilitate more WEUIP activities. Conversely, individuals in the electric sector were more likely to agree with the potential that "implementing a regional water and electric coordinating body and process" would facilitate more WEUIP activities. Electric sector professionals were also more likely to perceive a greater level of effort required to implement the WEUIP initiatives "joint water and electric utility programs on internal water & energy reduction" and "professional education of the energy embedded in water, and the water embedded in energy."

Differences Between Utility and Non-Utility Respondents

Just one difference was noted between utility and non-utility respondents. Utility respondents were more likely than non-utility respondents to perceive a greater level of effort required to implement the WEUIP initiative "professional education of the energy embedded in water, and the water embedded in energy."

CHAPTER 6
DISCUSSION AND RECOMMENDATIONS

To consider WEUIP, the researchers first defined WEUIP as the process by which water and electric utilities jointly develop plans to maintain and/or improve the delivery of water and electric power services. In its simplest form, WEUIP involves four steps:

1. Identifying the vision, goals, and objectives desired
2. Assessing the options for achieving goals and objectives and delivering the desired outcomes
3. Prioritizing and implementing the options selected
4. Evaluating and monitoring the outcomes of the plan

This report was then prepared following four distinct explorations of WEUIP:

1. A review of the water-energy nexus literature
2. Case studies on WEUIP activities
3. A WEUIP Tournament
4. An industry survey on WEUIP benefits, initiatives and needs

The results of these explorations highlight that integrated approaches to address the challenges and opportunities of WEUIP are needed. The interdependency of water and energy resources was most often discussed in the research, along with the need to use both resources efficiently. The researchers noted that water and electric utilities continually mentioned that increasing energy costs and energy dependency are impacting and will continue to impact the water sector. Likewise, their research noted that increasing energy demands would continue to exert pressure on electric utilities' water supplies. Effects of climate change (e.g., extreme weather, water scarcity, drought, increased temperatures) were also cited as a significant concern affecting both water and electric utilities along with changes in population, more restrictive standards, extreme weather events, water scarcity, droughts, and overall uncertainty for the future.

The challenge of how to respond to an increasingly uncertain resource future is a problem with no easy solution. However, there was broad agreement perceived by water and electric utilities in building partnerships, capacity and skills (and terminology) across the multiple dimensions relevant to WEUIP. The need for collaboration was a central theme throughout the project findings. This includes collaboration between water and electric power sectors, federal, local and regional governments, research and academic institutions, nongovernmental organizations, industry stakeholders, and end users.

The findings highlight that while there is a need to address water and energy interactions and dependencies, and water and electric utilities see benefit in WEUIP, few have implemented full integrated planning efforts. In general, cross-utility partnership and planning is not common. Integrated approaches, and consideration of water and energy exists, however water and electric utilities are more often noted as separately investing in water and energy efficiency planning options as well as electric power generation.

OPPORTUNITIES FOR WEUIP

A review of literature (see Appendix A) provides background on the water-energy relationships driving potential opportunities for WEUIP. Literature discusses the opportunities:

- collaboration on joint programs, research and policies, planning and implementing programs, learning from and replicating best practice programs, and educational opportunities;
- development of integrated standards, guidelines, and cross-institutional funding and planning;
- collaboration between the water and energy sectors on policy/codes, research, and programs to increase resource use efficiency;
- management of the demand and use of water and energy at the local level;
- co-location of water and energy facilities and improvements to water and energy facilities;
- generation of onsite renewable energy.

In reviewing the various planning frameworks (see Appendix B), the researchers noted many planning approaches incorporated several different types of interactions between water and energy utilities. These interactions include complex collaboration that brought together joint funding (Kenway et al. 2013a, A4WE and ACEEE 2011, Cooley and Donelly 2013) or multiple government agencies or regulatory bodies (Dyballa 2013, Scott et al. 2011). Other practices included utilizing codes and standards that address both water and electric utility systems (Dengig-Chakroff 2008). Of interest were decision-making processes that used: least-cost planning to minimize operation costs of facilities while maximizing social and environmental benefits (Kenway et al. 2007); technical models to help predict the interaction between water and electric utility systems, or scenario planning to inform and prepare utilities for future situations (Bolger et al. 2009). Also, adaptive management practices have been attributed to setting a foundation for planning for uncertainty (Conrad et al. 2013). Participatory processes can also inform stakeholders of joint planning benefits as a means to counter perceptions of increased complexity (Wilson and Biewald 2013).

The literature review identified a multitude of planning frameworks and supporting processes used by water and electric utilities. In fact, 30 were identified and are discussed in Appendix B. Currently, no single framework functions as a model for WEUIP. However, a combination of elements from several frameworks might serve to illustrate the required components of a WEUIP framework, should one be developed. These elements are listed below:

- Includes state and federal level policy support (Scott et al. 2011)
- Includes regular communication among water and energy regulators (A4WE and ACEEE 2011)
- Includes integrated standards, guidelines, and cross-institutional funding and planning (Kenway et al. 2013b)
- Considers institutions and decision-making and not just input–output relationships between water and energy (Scott et al. 2011)
- Includes multi-level government collaboration (e.g., regional, provincial, and federal) with industry and other stakeholders on integrated resource planning (Merson 2006)

- Accounts for the interactions between water and energy for both water and electric utilities
- Includes complex collaboration (e.g., between NGOs, government agencies at every level, trade associations, local and regional water and energy utilities, consumer groups, business, regulatory agencies, universities, national laboratories, and policymakers) (A4WE and ACEEE 2011)

In consideration of the above elements, one can note significant gaps in the current state of water and electric power sectors. Specifically, state and federal policy support for WEUIP is lacking and often regulations encourage water and electric utilities to plan in isolation. Moreover, collaboration efforts may conflict with a need for internal planning efficiency and regulatory reporting. Knowledge gaps also exist on how water and electric utilities would include each other in planning efforts as well as awareness of the benefit of including multiple parties.

CHALLENGES FACING WEUIP

The challenges key focus list included in Appendix C and the barriers collected at the WEUIP Tournament describe the various challenges facing WEUIP. These challenges include overcoming differing priorities between water and electric utilities, a lack of understanding about operational needs and constraints of their counterpart utility, different values and priorities surrounding resource scarcity, and different business models and structures that do not recognize efficiency benefits similarly. Water utilities are often concerned with drought preparedness and overall supply resiliency, whereas electric utilities may also focus on reducing their reliance on water supplies through water reuse programs, dry cooling technologies, and alternative energy sources such as solar and natural gas combined cycle plants. Decentralized power generation is changing the nature of electric power planning, while water utilities are facing substantial investments in buried asset renewal.

Water and electric utilities routinely noted that when they attempted to engage their local counterpart, differences in priorities, whether goals or timeframes, often presented challenges. One utility noted "I'm not sure how we'd balance differing priorities between utilities" and another shared "We're looking at the next 5 years and they don't want to discuss anything before [the next seven years]." Other challenges discussed included differences between water and electric utility regulations, business models, accountability, and end users. One significant difference was rate structures. Electric utilities shared that "rate competitiveness" greatly influenced their planning decisions and as such were hesitant to acquire surplus assets. Water utilities noted that while they did not need to compete in their local market, their rates have been impacted due to reduced revenue from water conservation programs. Both water and electric utilities noted that long-term rate assumptions influenced their capital investments.

SIMILARITIES BETWEEN WATER AND ELECTRIC UTILITIES

The project findings do identify similarities between water and electric utilities that may provide significant opportunity to foster WEUIP. For instance, water and electric utilities seek to use resources (water or energy) efficiency and minimize cost, are facing growing demand pressures with limited or fixed supplies, are impacted by climate uncertainties, depend on water availability, and a changing energy sector will affect water and electric service delivery. The researchers found that water availability was a significant driver for both water and electric utilities in that alternative water supply sources from wastewater recycling or stormwater capture and reuse are being used to diversify water supply sources, and reduce demand for energy intensive water supplies. These alternative water services are also creating opportunities to promote water and energy efficiency. The researchers noted other similarities related to increasing demand for water and electric services due to urbanization and population growth, improvements in resources efficiencies benefit both utilities, and both provide services to the same customers.

The findings also highlighted similarities across business and planning tools and processes. Water and electric utilities utilized many of the same planning frameworks such as benefit cost analysis, structured decision making, scenario planning, multi-criteria decision making, and least cost planning. Likewise, water and electric utilities often plan to minimize costs, consider scenario predictions, and at times solicit input from stakeholders and the public.

WEUIP FUTURE DIRECTIONS

When asked initially, few of the interviewed utilities could cite an example of WEUIP within their organization. However, as the project progressed, utilities began to reconsider past experiences with their counterparts. One area of WEUIP often overlooked was electric power load management or demand response. The majority of water utilities interviewed participated in some form of load management program through their local electric power provider, regional independent system operator, or third party intermediary. Although many utilities considered these programs to be routine, they in fact present examples of informal WEUIP. As a way to clarify avenues of WEUIP, the researchers focused on highlighting common pathways between water and electric utilities. These pathways were originally outlined in Figure 1.1 and include cogeneration, water supply for drinking, hydroelectric generation and cooling, resource efficiencies, demand management and end user/retail collaborations.

Overall, the researchers found examples of WEUIP do exist, but lack formalized integration across the full WEUIP process. They suspect that for many water and electric utilities the barriers and challenges seem daunting and perhaps limit desires to investigate WEUIP opportunities or do not simply provide a financial incentive to modify their routine planning process.

Considering the 10 WEUIP Themes

A range of common themes were echoed in the research findings from the survey, case-studies, and at the WEUIP Tournament, forming ten WEUIP themes between water and electric utilities:

1. Alternative Water Supply & Wastewater Services
2. Demand Management and Demand Response
3. End Use Efficiency
4. Infrastructure Resiliency & Operational Efficiency
5. Regional Planning
6. Regulation of the Water-Energy Nexus
7. Renewable Energy
8. Collaboration and Research on Embedded Water & Energy
9. Watershed Planning
10. Public and Professional Education on the Water-Energy Nexus

Theme #10 was found in the literature, the survey, and the WEUIP Tournament, but was not highlighted in a case study prepared for this report. For each of the above themes, a brief discussion on key observations from the research is provided.

Alternative Water Supply & Wastewater Services

The case studies for Los Angeles Department of Water and Power and Yarra Valley Water highlight utility programs on preparing alternative water supplies. Regional plans provided a driving force for both. For LADWP it was the One-Water LA approach that brought multiple City departments together to assess the overall water mass balance of the city. In these regional planning opportunities, scenario planning can be used by utilities considering WEUIP plans. The researchers illustrated the power of scenarios during the WEUIP Tournament to drive conversation and drive consideration of innovations around WEUIP.

Demand Management and Demand Response (Including Alternative Pricing Strategies)

As noted above, many water utilities are engaged in a form of WEUIP through partnering with electric utilities who offer demand response programs or tiered rate structures that encourage users to conserve water during drought or dry periods or conserve energy during times in the day when there is a peak demand. For example, Monroe County Water Authority (Authority) in New York (an interviewed utility) engages in a load shedding program managed through the New York Independent System Operators. The NY ISO will make a request to the Authority and the Authority will bid on how much it believes it can reduce demand through storage or by shifting to on site generation. The Authority receives compensation based on how much load they drop. Likewise, Newport News Waterworks in Virginia (an interviewed utility) participates in peak shaving and standby generation programs with Virginia Power and load curtailment with PJM Interconnection, a regional transmission organization that provides wholesale electricity to areas of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

In response to demand response programs, water utilities are operating and at times planning for their water systems to enable capacity to reduce demand. For example, Monroe County Water Authority monitors the NY ISO website for real-time energy pricing and increases storage in response to increasing energy prices. Demand response programs have also provided continual incentive to continue the WUA's programs for operating pumps to off-peak pricing and increase pump efficiency.

These types of established ongoing water and electric utility collaborations can evolve further by integrating more water and wastewater operations into existing energy efficiency programs, and integrating energy into existing water and wastewater efficiency programs. A demand response program may also help separate water utility revenues from unit sales, and creates a structure that provides an incentive for investing in end use water and energy efficiency.

End Use Efficiency

There is the opportunity for water utilities and electric utilities to jointly address and message water and energy end user efficiency. In Melbourne, the water corporations have been proactive at linking water and energy efficiency audits and incentives to achieve significant water and energy savings for commercial, industrial and institutional customers through the Business

Resource Efficiency Program. In California, there has been coordinated delivery of water and energy efficiency programs between LADWP and Investor-Owned Southern California Gas.

These joint programs can lead to a deeper understanding of the energy embedded in water systems and the water embedded in energy systems and help resolve a barrier to WEUIP regarding a lack of information. Water and electric/energy utilities can also learn from each other in replicating best practice integrated water-energy efficiency programs.

Infrastructure Resiliency & Operational Efficiency

Ongoing collaboration between water and electric utilities on full WEUIP infrastructure planning was not observed, however the regional planning efforts by Duke Energy, NYCDEP, and Seqwater provide illustration of how water and electric utility system boundaries can cross when considering and planning for infrastructure resiliency and operational efficiency. For instance, an informal WEUIP activity that was shared during interviews was related to how infrastructure investment would affect their counterpart's revenue. An example of this is seen in the investment in water reuse systems by an electric utility. One electric utility shared that they consulted with their water provider during the design and construction phases so that the water utility could prepare for the drop in revenue when the water reuse facility was brought online. Correspondingly, one water utility shared an example where they consulted with their electric power providers during a significant facility overhaul that was going to reduce energy demand. Managing water and electric utility system boundaries can be complex and going forward water and electric utilities considering WEUIP in these areas could use elements from adaptive management as a foundation for planning to ensure that decision-making is flexible and that utilities can adapt to future situations and uncertainty. The value in operational collaboration was evident for the project findings, as joint water and electric utility operational planning was ranked first in potential to promote WEUIP by survey respondents.

Regional Planning

An important component of gaining efficiency, as well as optimizing water, wastewater and energy generation is coordinating with land use and water use activity at a regional and local scale. Linking up with land use authorities, particularly in new growth areas, supports WEUIP for water, wastewater and energy infrastructure and reduces investment costs. For instance, Ergon Energy in Queensland, in managing their energy demand management programs, is taking advantage of growth to influence energy efficiency in new development and reduce the need to build distribution network capacity for new energy demands. Moreover, Green Mountain Power in Vermont routinely considers water-energy-land use in their capital siting projects so that once sited, water permitting is not a constraint on future development.

Regulation of the Water-Energy Nexus

The researchers saw in the CPUC study that CPUC is implementing a number of regulations on water and energy efficiency. And regulations are one way to drive WEUIP. Other development based regulations can also drive WEUIP. For instance, Vermont has an energy efficient requirement to consider non-transmission alternatives any time a new electric generation facility is proposed. Efficiency is considered first as the least cost way to serve electric customers and Green Mountain Power offers efficiency subsidies in geographic areas expected to see a future generation need. As result of this requirement, efficiency measures include water and thermal (heating oil/propane) savings in the metrics for evaluating future land use development projects. Water and electric utilities do not need to wait for mandatory regulations but are also encouraged to leverage existing and upcoming voluntary standards that address the water-energy nexus.

Renewable Energy (Including Co-Generation)

Energy generation projects were ranked second overall to end user management by survey respondents but were also ranked lowest in terms of its potential to promote WEUIP. Despite the lower potential ranking (which is only low in comparison to the list of WEUIP initiatives but actually expresses high potential if viewed apart from these initiatives), renewable energy opportunity from water and wastewater systems is likely the next step for the water industry to take to reduce waste and improve total resource management at water utilities. While, energy generation projects (such as co-generation) are often costly and face a number of regulatory hurdles, energy costs within the water system are anticipated to increase making these options more viable. The generation of energy from wastewater treatment processes in excess of the energy needed onsite may provide sufficient incentive for WEUIP.

Collaboration and Research on Embedded Water & Energy

Some water and wastewater utilities attempt to measure embedded energy in water and wastewater processes and reduce the energy and carbon emissions from these processes. The challenge in this approach is clearly identifying the system boundary, and gaining credit for reduction of energy outside the direct system boundary. For instance, LADWP has worked to reduce the amount of water supplied by MWD to reduce the amount of energy intensive water it imports. But who accounts for the reduction of energy when the energy is embedded in water conveyance outside a utility's system boundary? Developing consistent and comparable methods for measuring embedded water and energy and developing baseline estimates of total energy use by water and wastewater utilities and water use by electric utilities is needed to remove the barriers to WEUIP associated with lack of accounting methods. Developing an accounting method is just one way utilities could partner on research to provide information supportive of WEUIP. Direct involvement of utility staff in the research program can also support incorporating research outputs and recommendations into existing relevant planning instruments.

Watershed Planning

Collaboration between utilities and other stakeholders (industry, NGOs, the public, and all levels of government) can open dialogue on future WEUIP efforts. In the example discussed in Chapter 3, Duke Energy engaged multiple water users along the Catawba River to prepare a new license valid until 2058. The conclusion of this work indicated that future water extractions would exceed the safe yield of the system, jeopardizing municipal water supplies and capacity to generate electric power, and guiding principles on the future management of the Catawba-Wateree River Basin. Successful collaborations like this example can help illustrate the role of partnership and encourage WEUIP.

Public and Professional Education on the Water-Energy Nexus

Pursuing education and awareness opportunities for various audiences and stakeholders and developing education materials for water/electric utilities on the water-energy nexus was discussed in literature, the survey, and the WEUIP Tournament. Public and professional education was also viewed as having the highest potential to level of effort by survey respondents. However, the researchers did not find a program of education on the water-energy nexus at any of the water and electric utilities researched for this study. One explanation as to the absence of this theme in the case studies is that the utility participants were not aware of these types of education programs, if they exist, as most participants were from operations or engineering sections of the utility and educational programs are managed in different departments. Another explanation is that utility respondents believe, based on survey results, that the level of effort for water-energy education programs is greater than that believed by non-utility participants suggesting that utilities may not undertake these programs due to the level of effort required.

RECOMMENDATIONS

The aim of this study was to investigate integrated planning across water and electric utility systems, to present and evaluate a range of activities that feature integrated planning efforts between water and electric utilities, to identify barriers, opportunities, and sector needs for WEUIP, to help water and electric utilities understand the similarities in their respective planning goals, and to provide recommendations for water and electric utilities to engaged in activities.

In this section, the researchers discuss and present recommendations for utilities, for the water and electric utility sector, and for research on identifying further components of WEUIP. The goal of these recommendations is to help utilities engage in the full range of the WEUIP process, from goal setting to evaluation of plan outcomes, so that water and electric utilities jointly develop plans to maintain and/or improve the delivery of water and electric power services.

Utility Recommendations

The project findings suggest water and electric utilities would most likely undertake WEUIP projects when considering:

- watershed planning,
- demand management or demand response programs,
- joint water and electric end use efficiency programs,
- alternative water & wastewater supplies, and
- renewable energy.

The findings suggest that water and electric utilities should first focus their conversation with their counterpart utility on the above areas and gradually broaden the conversation to other WEUIP initiatives. Utilities are encouraged to open conversations with their counterpart on designing and creating joint water and electric utility demand management programs and explore additional ways they can engage in joint water and electric utility operations planning.

Utilities may also encourage WEUIP activities by applying existing and future national standards that link water and energy management and developing land-use and planning codes that account for water and energy efficiency. Utilities are also encouraged to utilize scenario planning as it was demonstrated to be successful in leading diverse stakeholder groups through a WEUIP exercise. Overall, while energy generation projects ranked second to opportunity presented by joint end user management, the generation of energy from wastewater treatment processes in excess of the energy needed onsite may provide sufficient incentive for WEUIP. And as noted earlier, renewable energy investments from water and wastewater systems are likely the next step for the water industry to take to reduce waste and improve total resource management at water utilities and water utilities are encouraged to involve their counterpart electric and gas utilities in these plans.

Throughout the study, the researchers found that statements by utilities and other sector professionals identified a planning environment thick with challenges (e.g., lack of communication channels, institutional isolation, regulatory inflexibility). The importance of having a direct communication channel between water and electric utilities was repeated throughout all interviews. Whether as a customer to supplier (water to electric utility or electric utility to water utility) or as a potential stakeholder in a new development, the existence of a permanent communication pathway between utilities corresponds to opportunities for future collaborations and water and electric utilities are encouraged to establish these communication channels.

Future Tournaments to Lead WEUIP Engagements

The WEUIP Tournament was successful in encouraging conversation and exchange of knowledge between diverse sector representatives, and in addressing the challenge of terminology often noted in literature when considering joint collaborations between water and electric utilities. Participants noted that the tournament format enhanced discussion and appreciation of unique sector viewpoints.

For the future, the researchers believe the WEUIP Tournament structure provides an opportunity for water and electric utility participants to share knowledge and experiences, learn terminology, and collaborate in developing realistic water and electric integrated plans to respond to possible scenarios affecting communities. The tournament process also provides an opportunity for social learning and allows players to holistically consider the impact of scenarios affecting water and energy resources. The WEUIP Tournament is recommended for utilities (and other utility sector representatives) as an application to facilitate dialogue and plan development across a number of WEUIP areas.

Water and Electric Sector Needs and Recommendations

The researchers found that across their research findings the most significant changes needed to promote WEUIP are:

- creating regulatory structures that provide incentives for investing in water and energy efficiencies
- identifying specific areas where there is overlap of water and electric utility jurisdiction and interest
- developing consistent and comparable methods for measuring embedded water and energy, and
- allowing alternative cost accounting and cost effectiveness frameworks in regulatory rate setting and planning review.

Sector investment in the above areas would significantly improve the environment conducive for WEUIP. It is also recommended that water and electric sector professionals consider the potential of public and professional education on the energy embedded in water and the water embedded in energy.

Research Directions

Throughout this research, a number of opportunities for water and electric utilities to engage in WEUIP were identified. In this process, the researchers also identified a set of potential research directions for future research. They are presented below without reference to priority:

- There is a need for research on the collaboration between the water and energy sectors to investigate policy/codes, research, and programs to increase resource use efficiency. This would assist utilities in the exploration of cross-sectorial policies and programs that would increase the development of resource use efficiency and resource recovery.
- There is a need to research data sharing projects between water and electric utilities to identify best-practice examples and develop a framework for collecting integrated data.
- It is important to build a database of existing water-electric utility related research to identify high priority research needs and develop energy footprinting methods for facility management, land use planning, and new development permitting.
- The future of systemic (dynamic) modeling of water and energy also needs to focus greater attention on clarifying the energy system as well as taking into account the uncertainty of quantifying water and energy use. There is a need to research models and methods for developing dynamic models of water-electric utility systems to support WEUIP. Such analysis and models are also necessary in order to answer questions relating to specific options and the influence of scale, such as: "Is it better (from a water and energy perspective) to recycle water locally (e.g., through in-home options such as recirculating showers) or regionally?"
- There is a need to examine these systemic models of water-energy boundaries and their implication for urban water decision-making. For example, how well are the benefits of water end use studies (e.g., water-conservation plans or rebates) considered, both to customers, and to water supply and wastewater utilities? What strategies could be implemented to most cost-effectively reduce energy use influenced by water in the region? How will benefits of energy management accrue to various parties to manage the regional water balance for energy efficiency? Supplementing this need is the need to identifying specific areas where there is overlap of water and electric utility jurisdiction and interest.
- The researchers believe that utilizing models in a future tournament is possible and could be implemented if access to data and testing of the model was conducted prior to the tournament. Research is needed on the development of and inclusion of a systems dynamic model in the tournament process to promote immediate feedback on the outcomes of the WEUIP plans and help participants focus on long-term goals.
- There is a need to develop consistent and comparable methods for measuring embedded water and energy and developing baseline estimates of total energy use by water and wastewater utilities and water use by electric utilities to remove the barriers to WEUIP associated with lack of accounting methods.

- There is a need to develop methods for joint water-electric utility operations management, regional planning, and new development planning. This would provide utilities with water and energy inclusive templates for WEUIP engagements.
- As water and electric utilities consider joint demand management (resource efficiency) programs there is a need to research the communication needs, user focuses, incentives (rebates, subsidies) and accounting (who receives credit for improving efficiency) for resource efficiency improvements.
- There is also a need to note examples and document the similarities between water and electric internal efficiency programs.
- This research identified a number of opportunities and benefits, but there is a need to quantify the scale and range of these opportunities and benefits as they relate to cost, efficiency improvements, risk reductions, and other factors.
- To fully facilitate WEUIP, it is important to develop a glossary of cross sector terminology and research combined performance criteria.
- There is a need to research what would be a compatible regulatory environment for WEUIP, what would be the appropriate jurisdictions, incentives, and requirements. In addition, there is a need to examine what would be required to develop joint water and electric utility regulations and implement a regional water and electric coordinating body and process.
- Finally, alongside this regulatory research is needed research into the governance models that would support regional planning inclusive of water and energy interactions and supportive of WEUIP.

APPENDIX A
FOCUSED LITERATURE REVIEW

Table A.1
Table of literature highlighting issues, opportunities and challenges for WEUIP

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
1	Water and Energy Utilities: Improving Collaboration	This article presents how the number and success of programs positioned to address both energy savings in water systems and water savings in the energy sector is growing but the water and energy sectors still operate in different worlds. Utilities differ in underlying corporation (public/private), pricing and rate structures, utility size and numbers, and state regulatory structures, organizations, and constraints. These differences affect utilities' "objectives, finances, and how demand management and efficiency are treated within each sectors."	Challenges include a lack of "existing cross-sector working relationships," different business models and structures that do not recognize efficiency benefits similarly.	Opportunities for collaboration on joint programs, research and policies, planning and implementing programs, learning from and replicating best practice programs, and educational opportunities. Also, state and federal level policy support such as "a platform to enable communication of energy and water regulators; increased federal and state coordination in grant funding, research, regulation, and technical assistance; regulatory structures and incentives that reward water and energy efficiency; specific energy-water elements added to existing federal legislation; state and federal tax incentives; and federal collection of water and energy end use data across sectors" (A4WE and ACEEE, 2011). "Opportunities for utility collaboration on end use efficiencies may be most immediate in situations with: - Municipally owned joint utilities; - Energy cooperatives with similar scale as mid-size municipal water providers; - State energy efficiency resource standards and/or other policies to promote robust utility energy efficiency programs; - Utilities in any sector that need to go beyond low hanging fruit; - States and regions with persistent drought and water shortages; and - Water and wastewater utilities facing significant energy costs or capital costs for expansion. State policies can strongly support stronger program collaboration, although these policies are not easily adopted. Interviews and formal studies have suggested an array of potential methods to encourage partnership efforts: - Individual agency actions that address cost-benefit issues; - Regular communication among energy and water regulators; -Water-saving targets for water utilities, just as many states have energy-saving targets; - Integration of state goals for water and energy efficiency and climate change; - In-state coordination of various agency mechanisms that support water or energy efficiency such as best management practices, planning, and

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
				energy efficiency resource standards; - Water and energy end use data collection efforts that cut across sectors; - Use of existing funding mechanisms to jumpstart increased collaboration; and - Formal mechanisms to recognize the broader benefits of programmatic water and energy savings."
2	Building Resilient Utilities: How Water and Electric Utilities Can Co-Create Their Futures	This report discusses how water and electric utilities can work through collaborative planning to build resilient utilities and communities. While not offering any particular planning approach, the report highlights the opportunities for water utilities to reduce energy use as well as electric utilities to efficiently use water. The report proposes a three phase framework for change, phase 1 includes optimizing systems, phase 2 suggests utilities move toward Resilient systems that incorporated green infrastructure, linking water/wastewater treatment nodes into the electric grid as renewable energy systems. Phase 3 involves using technology to demonstrate new opportunities for integrated resource management.	"• Lack of cross-sector understanding about operational needs and constraints, • The nonstandardized nature of water sector energy projects, • Traditional organizational structures, • Lack of incentives to take risks, • Financing challenges, and • Regulatory and policy constraints"	"Technological innovations and enhanced energy efficiency offer opportunities for utilities to significantly reduce or eliminate their net energy use while also achieving more efficient use of water itself."
3	Managing water related energy in future cities - a research and policy roadmap.	An international workshop established a vision of future cities and designed a roadmap including elements of success, research needs, and barriers. The roadmap suggests developing educational programs, combining standards, guidelines, funding and planning for water and energy efficiency, improving understanding and management of factors motivating consumers, and improving methods for quantifying and tracking targets of "water-related energy and related greenhouse gas emissions."	Lack of progressive regulatory environments - including the development of accountability of combined water and energy performance. "There is a lack of trust between the public and government, between component institutions, and between regulators and institutions, and existing control is held dearly." Lack of common institutional language.	• (A) Integrated standards, guidelines, and cross- institutional funding and planning. • (B) Education. • (F) Water-related energy is defined and tracked. • (G) Human motivation for water and energy consumption is understood and managed.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
4	The Water-Energy Nexus and Urban Metabolism. Connections in Cities.	Water related energy in Australian cities is equivalent to one-third of the total energy use of all the country's industry excluding transport, is equal to about half of the energy usage of the residential sector, and is over four times the direct energy use of the agricultural sector. Also, for a single household that was studied in detail, water related energy accounts for over half of household energy use (excluding transport), and over a third of GHG emissions.		
5	Water-Energy Nexus Survey Summary Report	Recommendations from the survey report include that more integrated research is needed on water/energy operations at the utility level, more education/outreach about the water-energy nexus to utilities, public officials, and the general public is required, energy data could be provided to customers via a utility's annual water quality report, and more detailed breakdowns of energy use data throughout each step of the water supply process is needed.		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
6	Implementing Renewable Energy at Water Utilities [Project #4424]	Findings from this study include that solar photovoltaic technology is the most prevalent technology choice among water utilities as it is a mature technology that is easy to install and operate. Other implemented technologies include wind, micro-hydro, and geothermal. Also, government provided funding and grant opportunities (e.g., power purchase agreements with third-party energy utilities) promote the use of renewable energy systems by water utilities. Conserving energy and utilizing renewable energy sources can help utilities reduce their carbon foot print. Challenges for water utilities include growing populations, new regulations, and increasing demand for water. All of these challenges will increase the energy required to provide water to customers. Renewable energy technologies that can be utilized by water utilities include solar photovoltaic technology, wind, micro-hydro, geothermal, and tidal and wave energy harvesting. Funding and grant		Recommendations include: water utilities should use energy audits, energy benchmarking, and demand management to explore reducing their energy costs and improving energy efficiency. Utilities should also review the available renewable energy generation technologies that are applicable to the utility's available energy resources and evaluate how the energy generated will be used to provide the highest benefit to the utility.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		opportunities through government and private agencies can promote the use of renewable energy systems. Power purchasing agreements can allow utilities to sell excess energy to third-parties.		
7	The Energy-Water Nexus: Managing the Links between Energy	This paper outlines 4 steps for achieving sustainable energy and water security 1) reviewing the carrying capacity of a given region in relation to water supply and energy production; 2) collaboratively reviewing data needs, availability, knowledge, and quality with other jurisdictions and stakeholders; 3) undertaking basic scenario analysis integrating existing water and energy forecasting data; 4) reviewing existing policies to identify where negative incentives or positive synergies may exist; and 5) promoting the use of existing or emerging technologies that exploit the potential for more efficient, cost effective, sustainable, and local closed-looped solutions.		
8	Energy-Water Nexus Coordinated Federal Approach Needed to Better Manage Energy and Water Tradeoffs	Federal agencies should consider the effects that national energy production and water use policies can have at the local level because location greatly		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		influences the extent to which energy and water affect one another. Improved energy/water planning will require better coordination among federal agencies and other stakeholders (state/local agencies, academia, industry and environmental groups). Uncertainties affecting energy/water resources could significantly affect future supply and demand for both resources and, therefore, should not be ignored.		
9	The Water-Energy Nexus and Urban Metabolism Identification, Quantification and Interpretation of the Connections in Cities	This paper outlined a vision for cities seeking greater efficiency in water and energy. The study recommends that priority actions include creating education programs and developing combined water and energy standards, guidelines and planning processes. Also, an improved understanding of what motivates people and their consumption of water and energy is necessary. To achieve this, collaboration across the water and energy sectors (research, industry, government, not-for profit, private sectors) is required.		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
10	Quantifying the links between water and energy in cities.	From 2006-2007, water related energy use in Australian cities accounted for 13% of the total electricity and 18% of the natural gas use. Together, this represented 9% of the primary energy use and 8% of total national greenhouse gas emissions.		
11	Addressing the Energy- Water Nexus: A Blueprint for Action and Policy Agenda	This study recommends that cost-effective energy and water efficiency measures should be incorporated into building codes, equipment standards, and tax credits. Other recommendations include surveying existing programs that clearly address the energy-water nexus to identify examples of best practice programs; preparing a report for local and state policymakers and water utilities that identifies lessons learned from energy experiences, addresses rate related barriers to efficiency program Implementation, and helps to clarify utility disincentives for encourage efficiency; developing a baseline of total energy use by water and wastewater utilities and water use by electric utilities (e.g., raw water transmission and treatment, treated water distribution, and wastewater collection, treatment and	Energy and water sectors generally work separately.	Opportunities for collaboration between the water and energy sectors on policy/codes, research, and programs to increase resource use efficiency. The blueprint provides a framework for collaborative action, funding, and policy development.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		disposal energies); establishing ongoing water and energy workgroups to increase cooperation among energy and water agencies, utilities, and communities.		
12	Domestic Wastewater Treatment as a Net Energy Producer – Can This Be Achieved?	Energy can be obtained from wastewater's organic as well as from its thermal content. To help offset the high energy costs of producing synthetic fertilizers, wastewater's N and P nutrients can be used for plant fertilization. Microbial fuel cells offer the potential for direct biological conversion of wastewater's organic materials into electricity but this process is not completive current practices yet. Couple with complete anaerobic treatment of wastewater, newer membrane processes have the potential for wastewater treatment to become a net generator of energy.		
13	The connection between water and energy in cities - a review	This study identifies major knowledge gaps associated with the connection between municipal water and energy. Gaps include the energy use associated with water in industrial and commercial operations as well as socio-political perspectives and the lack of a unifying theoretical framework and consistent		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		methodology for analysis of trans-city comparisons.		
14	Policy and institutional dimensions of the water–energy nexus	Three water-energy nexus examples in the U.S. Were explored in this study: 1) Water and energy development in the water-scarce Southwest; 2) Conflicts between coal development, environmental quality, and social impacts in the East; and 3) Tensions between environmental quality and economic development of shale natural gas in the Northeast and Central U.S. The authors found that, when considering broader perspectives, localized challenges are diminished and regionally important challenges are not prioritized locally. Also, because many of the impacts to water availability and quality remain localized, the transportability of electricity makes energy more suitable than water to regionalized global change adaptation. The study also emphasizes that there is a need for to improve the coordination between water and energy policy.	Managing water and energy together presents institutional challenges. Conflict may occur as nations vie for resources and communities seek to make tradeoffs between the differing values and priorities surrounding resource scarcity.	There are opportunities to manage the demand and use of energy and water at the local level "considering the regional, national, and global scales of the development and supply of resources together with associated human and environmental impacts." Regarding institutions and policy dimensions of the water energy nexus, four assertions were developed: 1) consider institutions and decision-making and not just input–output relationships between water and energy; 2) energy policy offers more opportunities for global-change adaptation than water policy due to the transportability of electricity makes energy more suitable to regionalized global-change adaptation; 3) seeking mechanisms to internalize environmental, water, and social impacts of energy development can help align water and energy policy; 4) tensions between water and energy resource use can be minimized "by cross-scale resource substitution (e.g., additional energy for water reclamation where primary water sources are scarce) and multi-tiered institutional solutions (e.g., 'regulatory cooperation')."

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
15	Energy for Water - Water for Energy	In the U.S., generation choices impact water use, climate change strategies likewise impact water usage, cooling tech equally alter water withdrawals and consumption. Solutions to address water and energy concerns include new federal and state government actions, better governance strategies, effective regulations, accounting for electric generation impacting water demand, changing cooling methods, in plan water conservation technologies, water pricing policies, and other innovative solutions and resources.		
16	Water for Energy: Future Water Needs for Electricity in the Intermountain West	Water scarcity affects energy production and sustainable water and energy use requires integrated study and management. Fuel extraction and energy production increase water use and have associated water costs. To manage water sustainably, data, information, and education on the impact of the energy sector on water resources should be improved. Other solutions include accelerating efficiency improvements, promoting renewable energy systems, establishing cooling-technology		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		requirements, promoting switching to alternative water sources, and expanding research and development efforts.		
17	Ontario's Water-Energy Nexus - Will We Find Ourselves in Hot Water... Or Tap into Opportunity?	In Ontario, energy embedded in water for pumping, treating and heating water and generating steam consumes 40% of natural gas and12% of electricity. Providing water services consumes more natural gas than any single economic sector in the province. Also, 80% of energy used for water services is generate by fossil fuels which lead to substantial costs for energy to pump and treat water, increase greenhouse gas production, increases water/energy costs, and significantly impacts the environment, society, and the economy through the development of new energy source to increase water provisioning.	Providing water services is energy-intensive and is often unrecognized. In Ontario, the energy embedded in water used for pumping, treating, and heating water and generating steam consumes 40% of the natural gas and 12% of the electricity in the province. 80% of energy used for water services is generated by fossil fuels which increase costs for municipalities and individuals while increasing GHG emissions.	Water saving opportunities in Ontario could reduce water use for the residential sector by 46%, the commercial and institutional sector by 36%, the manufacturing sector by 16%, and municipal systems by 41%. Provincial water efficiency programs and policies can encourage energy savings that are economically comparable to current energy efficiency programs.
18	Future U.S. Water Consumption: The Role of Energy Production	Arizona's climate is conducive to solar energy production. However, conventional concentrating solar power (CSP) consumes more water per megawatt-hour than other alternatives for thermal energy production. If power produced by CSP in Arizona is exported to other states,		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		Arizona's water will be effectively exported to the rest of the country. Therefore, to protect Arizona's limited water supply, federal policymakers should ensure that energy policy factors in the amount of water required to produce solar energy and does not contribute to existing water constraints.		
19	Challenges at Energy-Water-Carbon Intersections	This report outlines recommendations for energy-water-carbon resilience for Australia. These recommendations span sectors and industries and include: 1) consistent principles for the use of water and carbon: 2) improving the distribution and use of energy and water with smart networks; 3) enhancing the energy-water-carbon sustainability of landscapes and built environments; and 4) enhancing Australia's knowledge and learning capabilities to meet new demands for integrative knowledge.	Economic growth has encouraged increased use of fossil fuels which led to increased CO_2 and GHG emissions and climate change. Demand for resources such as water is approaching the supply from nature. There is a need to decarbonize the economy. Linkage between water and energy presents a challenge because they affect each other. Other challenges include social barriers, institutional distortions, technological inertia and lock-in, and insufficient investment in innovation.	Need to adopt a whole-of-system approach to energy-water-carbon challenges involving both market and non-market strategies. Market based: pricing on water and carbon to "reflect the full, linked costs and benefits of energy, water and carbon." Non-market: "-regulation of water consumption and GHG emissions, such as mandated efficiency standards of measure to limit peak usage rates - facilitation of behavioral change through education and incentives - support for effective innovation, through knowledge generation and application to diversify the range of available options."

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
20	Sustainable Water Systems: Step One - Redefining the Nation's Infrastructure Challenge	Important recommendations from this study are emphasized below. To ensure sustainable water systems, federal, state, and local officials should adopt watershed-oriented policies and regulations that incorporate Sustainable Path into funding decisions. Also, resource management entities and water utilities should adopt Sustainable Path in their operations and build partnerships that use integrated water resource planning as a principal tool for preserving and restoring water resources while meeting human and ecosystem needs for water in the context of climate change.		
21	Cities of Gloversville-Johnstown Joint Wastewater Treatment Facility Biogas-Fired Engine Electricity Generation and Heat Recovery	In 2007, 10% of the biogas from the digesters of the Gloversville-Johnstown Joint Wastewater Treatment Facility was flared and by midyear 2008, 50% of biogas was flared. This study recommends that two new higher kW engine generators replace the existing generations to handle the peak electric load. Also, the waste heat recovery components of the new engines will recover engine heat for supply to the digesters.		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
22	City of Thousand Oaks Uses Innovative Power Purchase Agreements for Renewable Energy at its Hill Canyon Wastewater Treatment Plant	Through innovative power purchase agreements where both systems were owned and operated by private parties, both solar and cogeneration opportunities were implemented by the City of Thousand Oaks without any capital costs for the city. Generating onsite renewable energy without capital outlay has been copied by other water and wastewater agencies throughout California and could be adapted elsewhere.	Rising electrical costs	Opportunities for solar and cogeneration to produce onsite renewable power. Opportunities for generating onsite renewable energy without capital outlay through energy production opportunities being owned and operated by private parties.
23	Water and Energy: Leveraging Voluntary Programs to Save Both Water and Energy	Water and energy resources are inter-related and, therefore, increased attention is needed to improve the efficiency of both resources simultaneously. Energy and water efficiency initiatives such as the ENERGY STAR and WaterSense programs provide an opportunity to increase resource efficiency. For example, some of ENERGY STAR's tools can be extended to encompass water efficiency opportunities. Conversely, water savings from WaterSense's product labeling efforts and its new home initiatives have associated energy savings that can be emphasized. As a cost effective option for achieving resource	Challenges include meeting growing demand for water and energy, addressing scarcity, and improving the efficiency and use of these resources.	National water efficiency program to collect and distribute information on water savings policies, strategies, and options could significantly impact growing water supply and infrastructure issues. Voluntary water and energy efficiency programs such as labeling initiatives can incentivize people and businesses to save resources.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		efficiencies, cooperative efforts between ENERGY STAR and WaterSense as well as all the various institutions involved in energy and water efficiency should be explored.		
24	Reducing Electricity Used for Water Production: Questions State Commission Should Ask Regulated Utilities	Water utilities should conduct comprehensive energy audits. To promote energy efficiency, regulatory commissions can establish standards, evaluate energy adjustment clauses, promote energy saving projects, increase economies of scale, and require energy audits.		
25	Water-energy futures for Melbourne: the effect of water strategies, water use and urban form	Several spatial/temporal water conservation strategies could increase water and energy efficiency in Melbourne, Australia. For example, by 2045, a compact urban for over the city could reduce growth in residential water consumption by approximately 100 GL/yr. due to reduced outdoor water use. Water demand management strategies that reduce energy consumption could save 45 GL/yr. of water and increase energy efficiency compared to "business as usual" scenarios. Strategies include using solar hot water systems in new and existing	Population growth and climate change constrain water availability for cities. Alternative water supplies such as desalination, water recycling, and water transfers over long distances are energy intensive.	Urgency for policy development that offers long-term solutions for the security of Melbourne's water supply. A compact urban form could reduce residential water consumption growth. Water demand management strategies can lead to water savings. Solar hot water systems could reduce residential electricity demand.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		dwellings. Desalination can also increase water supplies while the increased energy use is marginal in the context of Melbourne's estimated residential/total urban energy use growth.		
26	Overview of Energy-Water Interdependencies and the Emerging Energy Demands on Water Resources	The U.S. Is at a critical crossroads in the development, utilization, and management of water and energy. For instance, population growth will increase water demand for direct use as well as for energy and agriculture. If new power plants include traditional evaporative cooling systems, consumption of water for electrical energy production could more than double by 2030. Further, climate change and declines in groundwater supplies suggest that less water will be available in the future. Therefore, a more proactive approach to energy and water development and management is required. New technologies can reduce water use but cost more than traditional technologies. An integrative approach to water and energy management is needed to meet the country's growing water and energy needs.		

(continued)

Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
27	In Hot Water: Water Management Strategies to Weather the Effects of Global Warming	Climate change will affect water management but immediate and sustained action can reduce future impacts. Recommendations include providing vulnerability analysis through local, regional, state, and federal analysis and evaluations. Water planning should incorporate climate and energy issues and encourage collaboration with energy utilities.		
28	Energy self-sufficiency as a feasible concept for wastewater treatment systems	Examples from Central Europe indicate that large energy savings potentials of 30-50% can be achieved in wastewater treatment facilities through energy self-sufficiency.	Costs and concerns about greenhouse gas emissions create an impetus for increase energy use efficiency in wastewater treatment.	Key factors for energy efficiency are 1) two-stage biological WWT, 2) on-line control of intermittent aeration for enhanced nitrogen removal, 3) latest generation for coupled-heat-power plants, 4) deammonification of sludge. These key factors increase electricity generation to a point where the plant can be self-sufficient.
29	Program on Technology Innovation: An Energy/Water Sustainability Research Program for the Electric Power Industry	This study explored the highest priority water resource challenges as identified through interviews with power generators. The author concluded that the greatest potential for water savings is for new facilities rather than for retrofitting old facilities.		
30	California's Water Energy Relationship: Improving the Efficiency of California's Water and Energy Systems	Common issues between energy and water are growing demand, resource adequacy, resource quality, infrastructure, cost, environmental protection and long-term uncertainty. Water-energy synergy opportunities include end	regulatory challenges (e.g., Self-generation impediments and system constraints), developing better data and information	Coordinate utilities' programs (e.g., Upgrading infrastructure), develop renewable portfolio standards and utility efficiency programs

(continued)

Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		user water and energy efficiency, infrastructure improvements, improved price signals, water storage, and renewable and self-generation.		
31	Energy Demands on Water Resources: Report to Congress	involved. To address water availability and value issues, it is possible that major changes in the approaches to electric generation, transmission and distribution will need to be supported in different regions of the U.S. Increasing cooperation within Federal agencies may improve the country's ability to address issues relating to development, utilization, and management of water and energy.	Competing demands for water impact the value and availability of the resource. Consumption of water in the electric sector could grow substantially in a business-as-usual scenario. Technologies that can reduce water consumption in the electric sector exist but can be costly, limiting deployment. Climate change and ecological water demands coupled with population growth could reduce available freshwater supplies. "Changes in energy strategies in the electricity of transportation sectors could put an even larger burden on freshwater supplies and consumption." The value of water could increase which would increase energy costs.	The U.S. Should ensure that energy and water management and development utilizes each resource to its full value. The federal government should collaborate with regional and state agencies as well as industry and other stakeholders on integrated resource planning. Regional natural resources planning groups could foster collaboration between stakeholders. There are opportunities for system-level evaluations of natural resource policies and regulations by stakeholders and government agencies. Opportunities for co-location of energy and water facilities and improvements to energy and water facilities. Incentives to decrease consumption and develop water efficient technologies.

(continued)

Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
32	Water Energy Roadmap 2006: Integrated Planning Group	This study outlines findings in the areas of integrated planning, policy development, long term water/energy planning, economic policy models, hydro power, and other integrated planning.	Water challenges are present throughout the U.S. Due to increased demand from population growth and irrigation. Electricity demand will also increase by 30% by 2025. This energy demand will put new demands on water. Oil shale development could impact both water quality and availability.	Science and technology research can help improve resource use efficiency (e.g., Improved sensors and database management systems to improve our understanding of water use and availability, improved decision support tools to enable stakeholder collaboration, improved modeling of resources to aid planning, developing new tech to reduce water consumption in alternate energy and bioenergy production, new water efficient tech, etc.)
33	California's Water-Energy Relationship, Prepared in Support of Energy Policy Report the 2005 Integrated Proceeding	Water related energy consumption needs to be proactively managed. To achieve this, increased understanding of the California's water-energy relationship is required. Also, statewide integrated water and energy resource management should be implemented and water utilities' energy self-sufficiency should be increased.		
34	Energy Down the Drain - The Hidden Costs of California`s Water Supply	Water conservation lowers energy use and energy bills and water recycling is a highly energy efficient source of water. Retiring agricultural lands may increase energy use when the water is transferred to other agricultural or urban uses but decrease energy use if the water is reserved for the environment. Energy use		At the federal level, planning should promote performing energy 'intensity' studies, change energy use reporting requirements and include energy in the National Environmental Policy Act (NEPA) evaluation. At the state level, planning should integrate energy costs in the economic analysis of water management alternatives, coordinate between resource management agencies and revise the urban water management planning act to include energy intensity. At the local/regional level, planning should investigate the energy implications of dry-year strategies, and include energy in integrated resource planning.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		varies widely in the agricultural sector and decision makers at all levels of government should ensure that energy issues and water issues are integrated.		
35	Municipal Wastewater Treatment Plant Energy Baseline Study	Secondary treatment is the largest energy consumer in wastewater treatment plants and there is an opportunity to utilize efficient technologies to reduce this energy need. However, the lack of standardization and regulations make it impractical to develop performance metrics for wastewater facilities.		The paper recommends that PG&E participate in the design phase of new plants or retrofits to identify options for energy efficiency improvements.
36	Water & Sustainability: U.S. Electricity Consumption for Water Supply & Treatment - The Next Half Century	Electric requirements were estimated for all end use sectors and for thermal power generation with respect to water supply and treatment. Electricity demand associated with water supply and treatment for various end use sectors will track population growth projections. However, electric requirements for irrigation pumping and industrial uses will triple. Approximately 80% of municipal water processing and distribution costs are attributed to electricity and water availability is a key constraint on economic development. Compared to		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		surface water, ground water supply from public sources requires approximately 30% more electricity on a unit basis due to higher energy requirements of groundwater pumping systems. While electricity availability is not a constraint on water supply and treatment capabilities, electricity supply and demand depends on water availability.		
37	Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century	Trends in the power industry, such as the predominance of natural gas combined-cycle plants for new capacity, are decreasing both the quantity of water withdrawn and the quantity consumed (evaporated to the atmosphere) per MWh. Further, total water consumption in the U.S. by the power generation sector may increase or decrease over the next 20+ years depending on the rate of growth of MWh produced.		
38	Case Studies in Residual Use and Energy Conservation at Wastewater Treatment Plant	Energy recovery from biogas is universally cost effective and has gained widespread acceptance as the extra costs of incorporating this energy source into a system are relatively small. Further, recovery and use of biogas increases energy conservation, decreases pollution, and decreases		

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		management costs. Energy conservation efforts do not adversely affect water quality. When designing water reclamation projects, plans should ensure that water is reclaimed as a valuable resource and opportunities to substitute effluent heating and/or cooling for nonrenewable energy sources are taken advantage of.		
39	Alternative Energy Sources for Wastewater Treatment Plants	Based on an assessment of alternative energy sources for wastewater treatment plants, the following technologies are potentially cost effective: 1. Heat pumps which use influent or effluent wastewater as their heat source, for supplying process or building heat. 2. Geothermal direct-use systems for large energy loads when geothermal source is adequate. 3. Wind power systems for large electrical loads when annual wind flux is adequate. 4. Passive solar systems where cost-effectively integrated into the overall architectural design of a facility. 5. Low-head hydro systems may be appropriate for		

(continued)

Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		smaller plants which have an available head greater than three meters.		
40	Technology Assessment of Solar Thermal Energy Applications in Wastewater Treatment	Three major areas have the potential for solar thermal energy usage application in POTW's including: space and domestic water heating, anaerobic digester heating, and sludge drying. For context, a 3,785 m3/d (1 MGD) facility could save about 31% t of its total energy-usage by converting these three processes to solar thermal energy. A 378,500 m3/d (100 mgd) facility would save approximately 10 percent of its total energy requirement. However, solar-aided anaerobic digester heating is quite uneconomical. To make the systems economically viable, collector system costs need to be decreased.	Energy prices rise as conventional sources of energy become more scarce.	Solar thermal energy can be applied in wastewater treatment to save energy in space and domestic water heating, anaerobic digesting heating, and sludge drying.
41	Water-Energy Synergies: Coordinating Efficiency Programs in California	Nine recommendations were made from a survey of water and energy managers in California: 1. One or more staff members in a utility should take on a leadership role to pursue water-energy program opportunities 2. Water and energy utilities should discuss how existing programs and processes might be coordinated	Five barriers were identified as moderate or significant: 1) insignificant funding available for the water sector to invest in combined programs, 2) limited staff time, 3) lack of guidance about how to allocate costs and benefits among project partners, 4) "Water-related pricing policies,	In California, several water-energy efficiency programs have been successful including a high-efficiency clothes washer rebate program, a landscape efficiency program, a commercial kitchen audit program, and a master inter-utility agreement facilitating efficiency programs. Though find funding can present a challenge, utilities have overcome this by pulling funding from multiple sources.

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
		3. Water utilities should explore energy efficiency programs 4. "Utilities should seek ways to streamline offerings to customers through better coordination, especially for audits" 5. Utilities should explore whether a third-party could administer programs and ease the burden on staff time 6. "Water utilities should address long-term water savings and revenue stability as part of their best management practices" 7. State agencies should create guidelines for allocating energy, water, and cost savings amongst stakeholders 8. "Utilities should consider adopting standard agreements to facilitate the coordination of existing programs and the development of new programs" 9. "Utilities, trade organizations, and non-governmental organizations should help improve communication and networking opportunities between water and energy utilities in the same region"	e.g., few mechanisms for cost recovery and concern about revenue stability," and 5) lack of established relationships between water and energy utilities.	

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
42	Triple Bottom Line Reporting of Sustainable Water Utility Performance	Triple Bottom Line reporting and management allows utilities to address future challenges through helping utilities attract and retain staff, communicate both holistically and consistently about complex issues, articulate the rationale behind decisions and strategies to the community, improve both co-ordination with regulations as well as legislative decisions, provide clear information and accountability to customers and stakeholders, and find "connections to improve performance and strategies, reduce risks and access investment markets."		
43	Water and Energy Nexus: A Literature Review	Offers a snapshot, broad review of the current understanding of the water-energy nexus. Cited extensive coverage of the embedded energy within the water and wastewater sectors, sources of energy use within the water sector (e.g., energy for water conveyance, treatment and distribution) and water use within the energy sector (coal extraction and processing, thermoelectric generation).	Challenges of developing a more robust database of groundwater supplies across the US. Noted a challenge in engaging water sector operators and managers in the energy savings potential of new optimization technologies and practices. As whole, the report cited a need to investigate the water use of alternative energy sources, specifically biofuels. Noted difficulties in harmonizing metrics for describing water and energy use.	Noted opportunities for reducing energy use in wastewater treatment. Also noted a need to identify and optimize existing policies and practices to lower energy consumption, along with the development of energy optimization policies and practices. Noted an opportunity to develop a comprehensive water accounting system for the energy sector along with improve metrics for describing the water intensity of energy sources (e.g., L water/kcal or L water/kWh). Noted the need to develop and improve technologies that reduce water requirements in the energy sector (such as dry and hybrid cooling technologies) (continued)

Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
44	Best Practices in Electric Utility Integrated Resource Planning	Concludes that for Integrated resource planning to be effective it must include a meaningful stakeholder process and oversight from public utilities commissions. Elements of the plan should include "a load forecast, reserves and reliability, demand-side management, supply options, fuel prices, environmental costs and constraints, evaluation of existing resources, integrated analysis, time frame, uncertainty, valuing and selecting plans, action plan, and documentation"		
45	California's Water Energy Nexus: Pathways to Implementation	Concludes that the investments in energy efficiency and renewable energy generation, matter to California. Argues there is no other sector in which "such a positive and powerful impact – improvements in energy efficiency, renewable energy generation and reduction in greenhouse gases – concentrated into one sector."	"True optimization of the state's [California's] water and energy resources will require new policy frameworks and investment mechanisms." Utilities look to their commissions for guidance on where the synergies lie between water and energy resources. Lack of utility commission support can challenge adoption of water and energy efficient measures.	Financial incentives provide an important policy tool for encouraging adoption of water-energy strategies. "New decision-making frameworks, metrics, methods and tools developed for water-energy programs and measures can set the stage for additional cross-cutting programs that have not yet even begun to be formulated"

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Table A.1 (Continued)

#	Title	Key Findings	Challenges Noted (if any)	Opportunities/Directions Noted (if any)
46	Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources	Provides guidance on energy alternatives such as demand response (DR) and energy efficiency (EE) to maintain reliable power while reducing the environmental impacts of traditional electricity generation. Outlines a roadmap for developing a work plan and progress toward implementation of these approaches.		Provides a set of goals and monitoring points including: Ensure consistent assumptions in ISO, CEC, and CPUC planning and procurement processes, Modify load shape to reduce resource procurement requirements, mitigate over-generation, and moderate ramp, Clarify ISO needs for DR and EE to be most effective in planning and operations, Ensure resources are procured and developing to meet capability, timing, and location needs; Increase DR program and pilot participation in ISO market developing operations experience and providing feedback for policy refinement
47	Grid Un-Lock: Leveraging Electric Smart Grid Systems for the Water Sector	Smart Grid technologies (such as smart meters) can prove beneficial for water and electric utilities. Benefits include reduction in labor costs and improved information for planning and operations. Focuses on IT system benefits.		While not implicitly discussed, author mentions synergies between water and electric utilities use of smart metering technologies. Such synergies could support additional points of collaboration.

Table A.2
Table of references for literature review

#	Title	Author	Organization/Publication	Date
1	Water and Energy Utilities: Improving Collaboration	Cindy Dyballa		2013
2	Building Resilient Utilities: How Water and Electric Utilities Can Co-Create Their Futures	The Johnson Foundation at Wingspread	The Johnson Foundation at Wingspread	2014
3	Managing water related energy in future cities - a research and policy roadmap.	Kenway, S., J. McMahon, V. Elmer, S. Conrad, and J. Rosenblum.	Journal of Water and Climate	2013
4	The Water-Energy Nexus and Urban Metabolism. Connections in Cities.	Kenway, S.J.	The University of Queensland	2012
5	Water-Energy Nexus Survey Summary Report		Illinois Section American Water Works Association	2012
6	Implementing Renewable Energy at Water Utilities [Project #4424]	Bryan Lisk, Ely Greenberg, Frederick Bloetscher	Water Research Foundation	2012

(continued)

Table A.2 (Continued)

#	Title	Author	Organization/Publication	Date
7	The Energy-Water Nexus: Managing the Links between Energy	Karen Hussey; Jamie Pittock	Ecology and Society	2012
8	Energy-Water Nexus Coordinated Federal Approach Needed to Better Manage Energy and Water Tradeoffs	U.S. Government Accountability Office	U.S. Government Accountability Office	2012
9	The Water-Energy Nexus and Urban Metabolism Identification, Quantification and Interpretation of the Connections in Cities	Kenway, S.J.	The University of Queensland	2012
10	Quantifying the links between water and energy in cities.	Kenway, S. J., P. Lant, and A. Priestley	The University of Queensland	2011
11	Addressing the Energy- Water Nexus: A Blueprint for Action and Policy Agenda		Alliance for Water Efficiency	2011
12	Domestic Wastewater Treatment as a Net Energy Producer – Can This Be Achieved?	Perry L. McCarty; Jaeho Bae; and Jeonghwan Kim	Stanford	2011
13	The connection between water and energy in cities - a review	Kenway, S. J., P. Lant, A. Priestley, and P. Daniels	The University of Queensland	2011
14	Policy and institutional dimensions of the water–energy nexus	Christopher A. Scott, Suzanne A. Pierce, Martin J. Pasqualetti, Alice L. Jones, Burrell E. Montz, Joseph H. Hoover	Energy Policy	2011
15	Energy for Water - Water for Energy		Atlantic Council - ideas, influence and impact	2011
16	Water for Energy: Future Water Needs for Electricity in the Intermountain West	Heather Cooley; Julian Fulton; Peter H. Gleick	Pacific Institute	2011
17	Ontario's Water-Energy Nexus - Will We Find Ourselves in Hot Water... Or Tap into Opportunity?	Carol Maas	POLIS	2010
18	Future U.S. Water Consumption: The Role of Energy Production	Deborah Elcock	Journal of the American Water Resources Association	2010
19	Challenges at Energy-Water-Carbon Intersections	PMSEIC Expert Working Group	Australian Government	2010
20	Sustainable Water Systems: Step One - Redefining the Nation's Infrastructure Challenge	R. Bolger, D. Monsma, R Nelson	The Aspen Institute	2009
21	Cities of Gloversville-Johnstown Joint Wastewater Treatment Facility Biogas-Fired Engine Electricity Generation and Heat Recovery	David Terry	Association of State Energy Research and Technology Transfer Institutions	2009
22	City of Thousand Oaks Uses Innovative Power Purchase Agreements for Renewable Energy at its Hill Canyon Wastewater Treatment Plant	Chuck Rogers, Mark D. Wakins	City of Thousand Oaks	2008
23	Water and Energy: Leveraging Voluntary Programs to Save Both Water and Energy		US Environmental Protection Agency	2008
24	Reducing Electricity Used for Water Production: Questions State Commission Should Ask Regulated Utilities	David Denig-Chakroff	Natural Resources Research Institute	2008
25	Water-energy futures for Melbourne: the effect of water strategies, water use and urban form	Kenway, S. J., & CSIRO.	Commonwealth Scientific and Industrial Research Organisation	2007

(continued)

Table A.2 (Continued)

#	Title	Author	Organization/Publication	Date
26	Overview of Energy-Water Interdependencies and the Emerging Energy Demands on Water Resources	Ron Pate, Mike Hightower, Chris Cameron, Wayne Einfeld	Sandia National Laboratories	2007
27	In Hot Water: Water Management Strategies to Weather the Effects of Global Warming	Barry Nelson, Monty Schmitt, Ronnie Cohen, Noushin Ketabi, Robert C. Wilkinson	NRDC	2007
28	Energy self-sufficiency as a feasible concept for wastewater treatment systems	B. Wett, K. Buchauer, C. Fimml	Asian Water	2007
29	Program on Technology Innovation: An Energy/Water Sustainability Research Program for the Electric Power Industry	J. Wolfe	Electric Power Research Institute	2007
30	California's Water Energy Relationship: Improving the Efficiency of California's Water and Energy Systems	California Energy Commission	California Energy Commission	2006
31	Energy Demands on Water Resources: Report to Congress	Merson, J	Department of Energy	2006
32	Water Energy Roadmap 2006: Integrated Planning Group	Sandia National Laboratories, American Water Works Association, American Society of Civil Engineers, American Society of Mechanical Engineers, Department of Energy	Sandia National Laboratories, AWWA, American Society of Civil Engineers, American Society of Mechanical Engineers, Dept. of Energy	2006
33	California's Water-Energy Relationship, Prepared in Support of Energy Policy Report the 2005 Integrated Proceeding	California Energy Commission	California Energy Commission	2005
34	Energy Down the Drain - The Hidden Costs of California`s Water Supply	Ronnie Cohen; Barry Nelson; Gary Wolff	Natural Resources Defense Council	2004
35	Municipal Wastewater Treatment Plant Energy Baseline Study	M/J Industrial Solutions	PG&E	2003
36	Water & Sustainability: U.S. Electricity Consumption for Water Supply & Treatment - The Next Half Century	B. Applebaum	Electric Power Research Institute	2002
37	Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century	R. Myhre	Electric Power Research Institute	2002
38	Case Studies in Residual Use and Energy Conservation at Wastewater Treatment Plant	Diane Stewart	US Environmental Protection Agency	1995
39	Alternative Energy Sources for Wastewater Treatment Plants		US Environmental Protection Agency	1988
40	Technology Assessment of Solar Thermal Energy Applications in Wastewater Treatment	Roy F. Weston, Inc. Designers-Consultants	US Environmental Protection Agency	1982
41	Water-Energy Synergies: Coordinating Efficiency Programs in California	Cooley, H. & Donelly, K.	Pacific Institute	2013
42	Triple Bottom Line Reporting of Sustainable Water Utility Performance	Kenway, S., Howe, C., and Maheepala, S.	Water Research Foundation	2007
43	Water and Energy Nexus: A Literature Review		Water in the West	2013
44	Best Practices in Electric Utility Integrated Resource Planning	Wilson, R., Biewald, B.	Synapse Energy Economics	2013
45	California's Water Energy Nexus: Pathways to Implementation	Park, L., Croyle, K., White, L.	GEI Consultants, Inc.	2012
46	Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources		California Independent System Operator Corporation	2013
47	Grid Un-Lock: Leveraging Electric Smart Grid Systems for the Water Sector	Tellez, J.	Waterworld	n.d.

APPENDIX B
PLANNING FRAMEWORKS AND PROCESSES USED BY WATER AND ELECTRIC UTILITIES

Table B.1
Table of planning frameworks and processes

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
Benefit cost analysis	A comprehensive method of economic evaluation that attempts to place monetary values on the inputs (costs) and outcomes (benefits) on the components of utility planning. Can be used to evaluate multiple planning alternatives.	X	X		**(Electric Utility Planning) EUP**: evaluating options for maintaining reliability in major load centers, evaluating alternative designs for proposed additions to a transmission station (Neudorf et al. 1995), regional infrastructure development (ECA 2010)**. (Water Utility Planning) WUP**: Flushing programs to maintain water quality (Hasit et al. 2004), regional infrastructure development (ECA 2010).	Neudorf et al. 1995; Hasit et al. 2004; ECA 2010
Simple decision analysis	"a philosophy, articulated by a set of logical axioms, and a methodology and collection of systematic procedures, based upon those axioms, for responsibly analyzing the complexities inherent in decision problems" (Keeney 1982). Used to evaluate planning alternatives. The attractiveness of an alternative depends on the likelihood of its possible consequences and the preferences of the decision maker(s) for those consequences. Decision analysis breaks all decision problems into 5 components: 1. A perceived need to accomplish some objectives; 2. Several alternatives, one of which must be selected; 3. The consequences associated with alternatives are different; 4. Uncertainty usually about the consequences of each alternative; and 5. the possible consequences are not all equally valued	X	X		**EUP/WUP**: All aspects of utility planning	Keeney 1982
Structured Decision Making	SDM focuses on combining analytical methods from decision sciences with insights from cognitive psychology and the experience of facilitators and negotiators to make meaningful decisions in group settings. Seeks to include opportunities for stakeholders	X	X		**EUP/WUP:** Water Use Planning Process in BC to manage water allocations between electricity generation and ecological needs (Arvai et al. 2001). Inform the design of a utility's operating plan (McDaniels et al. 1999)	McDaniels et al. 1999; Arvai et al. 2001; Gregory 2012

(continued)

Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
	to participate in the decision making process through public meetings, workshops, etc. Stakeholders' concerns are explicitly incorporated into the decision process.					
Scenario planning	Originally developed for forecasting military situations for the U.S. government (Kahn and Wiener 1967). Explores the long-term consequences of current decisions to decision makers by exploring the impacts of different contextual factors on current and future situations (Bryson 1995). Decision makers examine alternative models of future situations and develop plans to address these alternatives (Peterson et al. 2003). Scenario planning is often a facet of other planning frameworks (e.g., integrated resource planning, multi-criteria decision making, etc.)	X	X	X[1]	**EUP:** long-term transmission planning, demand side management, risk management (NARUC Grants & Research 2012) **WUP:** Overall guiding plan for a utility - e.g., American Water Works Association Research Foundation used scenario planning to define 9 attributes of success that would help a water utility succeed in the future (Means et al. 2005). In BC, technical models are used to predict the effect of policies on regional water supplies, infrastructures, and demands (Langsdale et al. 2009).	Kahn and Wiener 1967; Bryson 1995; Peterson et al. 2003; Means et al. 2005; Langsdale et al. 2009, NARUC Grants & Research 2012
Triple bottom line	Based on the notion that an organizations success should be measured by the combination of economic, social/ethical, and environmental performance. Similar to financial performance, social and environmental performance should be measured, calculated, audited and reported to ensure that a corporation, utility, community, etc. is managed sustainably (Norman and Macdonald 2004)	X	X	X	**EUP:** Utility regulation through (a) affordable electricity, (b) reliable electricity and (3) public health and environmental protection (Monast and Adair 2013). **WUP:** water distribution system design, wastewater management, supply management	Norman and Macdonald 2004; Monast and Adair 2013; Kang and Lansey 2012; Kenway et al. 2007.
Command and control	Traditional planning framework that utilizes expert opinion to manage supply and demand. Focuses on an outcome at a point in time. Utility forecasts demand then identifies supply options, estimates economic consequences of these options and evaluates the options, and then approves and implements an option.	X	X		**EUP:** Supply management., infrastructure development **WUP:** Supply management, infrastructure development	Hanson et al. 1991; Pearson et al. 2010.
Adaptive Management (AM)	Based on the "incorporation of evolving knowledge and understanding of what, how and why decisions are made" (Pearson et al. 2010). AM is critical to the strategic level (macro scale) of decision making. "Adaptive management is an	X	X		**EUP:** Supply and demand management, infrastructure development (power generation sites and transmission systems) **WUP:** New South Wales Metropolitan Water Plan (NSW 2006); British Columbia's Water	Holling 1978: EC 2000; Allan and Curtis 2003; Lawrence and Bennett

(continued)

[1] depending on scenario used

Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
	iterative process for improving and revisiting management policies and practices by learning through monitoring and from outcomes of rigorously designed investigations. It explicitly recognizes uncertainty and utilizes flexible decision making to promote resilient systems." (Conrad et al. 2013)				Use Plan process	2002; NSW 2006; Hatfield-Dodds et al. 2007; Pahl-Wostl and Borowski 2007; Pearson et al. 2010. Soumonni 2013; Conrad et al. 2013.
Multi-criteria decision making (MCDM, or multi-criteria decision analysis e.g., multi-attribute utility theory, analytical hierarchy process)	The process of making decision in the presence of multiple objectives. These objectives are often conflicting and therefore, the solution is dependent of the decision maker(s) preferences. Often, different groups of decision-makers are involved in the process and each group brings along different criteria preferences that must be resolved within a framework of understanding and mutual compromise. Uses decision matrices to compare project alternatives.	X	X		**EUP:** optimal electrical dispatch scheduling, deciding power generation mix, optimum electricity supply planning; WUP: infrastructure selection (Eder et al. 1997), water allocation for competing uses (Agrell et al. 1998), water supply planning (Joubert et al. 2003), water quality management (Lee and Chang 2005). **WUP:** analyzing water uses such as consumption, recreation, conservation, and power generation (Özelkan and Duckstein 1996; Joubert et al. 1997)	Pohekar and Ramachandran 2004; Hajkowicz and Collins 2007; Agrell et al. 1998; Eder et al. 1997; Joubert et al. 2003; Lee and Chang 2005; Özelkan and Duckstein, 1996; Joubert et al., 1997.
Multi Attribute Utility Theory (MAUT)	Based on the utility theory of von Neumann and Morgenstern (1947) with procedures developed by Keeney and Raiffa (1976). Multi Attribute Utility Theory (MAUT) requires decision makers to assign utility values to alternatives by evaluating these outcomes and combining individual assignments to obtain overall utility values" (Pohekar and Ramachandran 2004). Decision makers evaluate alternatives by making trade-offs between attributes that make up these alternatives (Keeney and Wood 1977).	X	X		**WUP:** Evaluating long-term water resource development plans (Keeney and Wood 1977); compare current and alternative water control plans (Prato 2003), wastewater planning management, water supply expansion consideration, designing water quality monitory networks, water use planning, regulation of water flow, consensus building for water resource management (Linkov et al. 2006)	Keeney and Wood 1977; Linkov et al. 2006; Prato 2003; Pohekar and Ramachandran 2004; Özelkan and Duckstein, 1996; Joubert et al., 1997; von Neumann and Morgenstern 1947; Keeney and Raiffa 1976;

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Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
						Kim et al. 1998.
Analytical Hierarchy Process	Relies on converting a complex problem into a simple hierarchy based on ranking different dimensions of a problem by their effect on other items as well as the overall goal of the plan. "Criteria weights and scores are based on pairwise comparisons of criteria and alternatives, respectively" (Linkov et al. 2006)	X			**EUP**: Electric power systems planning - Monitoring electric power network systems (e.g., Each primary controller utilizes its own local measurement and each control area utilizes measurements in its own utility (Ilic 2007)	Wedley 1990; Linkov et al. 2006, Ilic 2007.
Outranking	Compare the performance of two alternatives at a time. Criteria for options are weighted and one option outranks another if it outperforms another option on enough important criteria (Kangas et al. 2001). A single best alternative may not necessarily be identified. "Allows for inferior performance on some criteria to be compensated for by superior performance on others." Outranking methods include ELECTRE and PROMETHEE.	X	X		**EUP:** Project selection (e.g., selecting capital and maintenance projects) (Buchanan and Vanderpooten 2007) **WUP:** ELECTRE - Wastewater recycling and reuse, regional water allocation (Linkov et al. 2006); PROMETHEE - prioritization of wastewater projects, determining the extent of groundwater protection vs. economic development	Linkov et al. 2006; Buchanan and Vanderpooten 2007; Kangas et al. 2001
Robust Decision Making	Characterizes uncertainty with multiple future alternatives using robustness rather than optimality as a decision criterion. "Robust approaches seek solutions that work well enough across a wide range of futures" (Lempert and Collins 2007).	X	X		**EUP:** Investments in facilities, supply, and assets portfolios. **WUP:** Southern California Inland Empire Utilities Agency used this technique for developing its long term urban water management plan.	Kangas et al. 2001; Lempert and Collins 2007; World Bank. 2010.
Least-cost planning	Determines a least-cost, long-term resource plan to meet future needs and can be broadened to apply to a small group of projected trends (e.g., "variations in future loads, fuel costs, resource construction or purchased power costs") (Boonin 2011). Least-cost planning encompasses a wider set of objectives, develops a more complete set of supply and demand options, and includes a larger variety of stakeholders compared to traditional planning processes. Goal is to provide energy services at the minimum cost based on supply and demand options (Hanson et al. 1991). Encourages public participation.	X	X	X	**EUP:** long-term supply and demand management - BC Hydro's IRP is a 20-year plan detailing how the utility will meet future electricity demands through conservation and clean energy generation. The plan focuses on ensuring a reliable, cost-effective electricity supply (BC Hydro 2014), Supply and demand management (Hanson et al. 1991), resource pricing **WUP:** Supply and demand management, water pricing	Hanson et al. 1991; Boonin 2011; BC Hydro 2014

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Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
Water-Energy-Food Nexus Frameworks	Assumes that water, energy, and food security are related and interdependent and that frameworks that focus only on one aspect of the water-energy-food nexus without considering interactions can lead to serious consequences (WEF 2011).				No known application of water-energy-food nexus frameworks at this date.	WEF 2011
WEF: Bonn2011 Nexus Conference	Centered on water supply, energy and food security being connected to available water resources (Bizikova et al. 2013). "Goal is to promote water, energy, and food security for all; equitable and sustainable growth; and a resilient, productive environment" (Bizikova et al. 2013).			X	**EUP/WUP:** Increasing resource productivity, using waste as a resource in multi-use systems	Bizikova et al. 2013
WEF: World Economic Forum 2011	WEF presented as a major risk area. Food and water security are linked to economic disparity while energy security is linked to economic risks such as energy shortages that can impact growth and social stability. Accounts for population and economic growth as well as environmental pressures affecting the WEF nexus.			X	**EUP/WUP:** integrated and multi-stakeholder resource planning, regional infrastructure development, market-led resource pricing, community-level empowerment and implementation (WEF 2011)	WEF 2011
WEF: IISD's Water-Energy-Food Security Analysis Framework	Centered on ecosystem management emphasizing implementation, ecosystem goods and services, biotic components of the landscape increasing human well-being, place-based focus, collaborative visioning and planning at various levels of decision making relevant to the context of the problem. Goal is to increase the security of water, energy and food by focusing on security for each component first then building on and accounting for interactions.			X	**EUP/WUP:** Land use planning including determining the particular type of energy system that is appropriate for a community, types of water use, developing investment strategies for energy and water systems	Bizikova et al. 2013
Integrated Urban Water Management (IUWM) Planning Framework	Planning and managing urban water systems to maximize their contribution to social and economic vitality and to promote community improvement while minimizing their impact of the environment (Maheepala and Blackmore 2007). Considers all parts of the water cycle (both natural and man-made) as integral to the system. Also considers anthropogenic and ecological water demands, reducing potable water demand, overall city management and planning, sustainability of water		X	X	**WUP:** managing water supply, wastewater and stormwater, demand management, providing water security through diversification of water sources (increasing water supply) while promoting efficient demand (reducing water use), land management to improve habitat for native flora and fauna in urban water ways and estuaries, system-wide management	Maheepala and Blackmore 2007; Maheepala 2010

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Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
	servicing provision, local context and stakeholder opinions, functional aspects of water systems, and the impact of water cycle management (Maheepala 2010).					
Energy-Water Nexus	A framework assuming planning can positively impact the economy, environment, energy and equity (E4). Conserving water and energy enhances sustainability particularly during drought evens in urban areas (Smith and Wang 2007; Wang et al. 2006) and can result in lower utility bills for customers (Wang 2009)			X	**EUP/WUP:** Conservation programs, long-term planning, demand management	Smith and Wang 2007; Wang et al. 2006; Wang 2009
WEAP-LEAP integration	WEAP - an integrated water resource planning and management modeling tool. Accounts for the physical processes governing the availability and movement of water including the interactions of water use and management activities in a watershed. LEAP - a long-range integrated energy planning and greenhouse gas mitigation modeling system that outputs an integrated cost-benefit analysis of different energy portfolios including their environmental effects (Yates et al. 2005). The WEAP-LEAP model estimates electricity demand associated with a given water management pattern (including the treatment and transmission of water) at different time steps. "A fully integrated WEAP and LEAP model would converge on a consistent set of water management demands for energy, energy, supplies, and opportunities to create energy in conjunction with managing water" (Yates et al. 2005)	X	X	X	**EUP/WUP:** demand management, supply management, Changes in Electricity Use from Desalination, Changing Fuel Mix in Drought	Yates et al. 2005
Natural Step	Natural Step - a comprehensive model for planning and decision making in complex systems based on whole systems thinking. It comprises 5 levels: 1) System, 2) Success, 3) Strategic, 4) Actions and 5) Tools.	X	X	X	**EUP:** BC Hydro offered education as part of an effort to embed a comprehensive understanding of sustainability into its operations. - See more at: http://www.naturalstep.ca/bc-hydro#sthash.dOPL4IC7.dpuf, **WUP:** Tualatin Valley Water District utilizes the natural step to address water conservation and energy efficiency - see http://www.naturalstep.org/en/usa	Robèrt 1997

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Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
					/tualatin-valley-water-district-Oregon-usa	
Shared Vision Planning	Shared vision planning was developed by the U.S. Army Corps of Engineers to respond to national droughts. Considered a form of Collaborative planning, the planning process has three elements 1) following the systems approach to water resource management 2) involve the public in the planning process and 3) collaboratively built computer models.		X		**WUP:** Evaluating long-term water resource development plans; compare current and alternative water management plans and drought response options	Palmer et al. 2013.
Soft Path	Managing demand to make water use more efficient while managing supply (e.g., Increasing supply infrastructure) to satisfy demand based on what is actually needed to satisfy demand sustainably		X	X	**WUP:** Supply and demand management, improving water use efficiency through technology, and behavior	Gleick 2002
Real options	Real Options planning is a method used to identify resource supply strategies that adjust over time and balance risks. The process determines a set of strategies that maximize value by discounting supplies and investment strategies. Uncertainties are incorporated by probabilities and phasing in of projects.		X		**WUP:** Supply management through the improved allocation of facilities over time. There are no known applications of this method.	Means et al. 2010
Portfolio planning	Portfolio planning is an economic approach containing a mix of assets and strategies that minimize financial risk to future scenarios. Uncertainty is managed through Monte Carlo simulations and hedging investments. Electric utilities utilize this approach extensively.	X			**EUP:** Investments in facilities, supply, and assets portfolios.	Means et al. 2010
collaborative planning	Collaborative planning is a consensus-based planning process unique from other methods of public participation in some key features. The basic assumption of CP is that those best suited to decision-making are the individuals or groups who will be most impacted by the planning outcome. CP brings all relevant stakeholders together for face-to-face negotiations that result in administrative decisions around a particular issue. Applied to Water and Utility Integrated planning, CP would require stakeholders from each utility	X	X		**EUP/WUP**: Urban development and resource management plans. Remains a widely theoretical framework with limited application, often due to the complexity of developing binding agreements between invested stakeholders.	Ellis 1989; Healey 1997

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Table B.1 (Continued)

Process/ Framework	Description	Electric	Water	Review of W&E	Areas of Application	References
	to work with regional stakeholders to develop a comprehensive resource plan. CP agreements may be binding (regulatory or contractually enforced) or non-binding. CP process may use a variety of other planning frameworks.					
Water Research Foundation's Sustainable Energy Management DSS	Provides a comprehensive framework and decision support system (DSS) to help water utilities make better and more sustainable energy management decisions. The DSS allows utilities to evaluate financial, environmental, and social issues associated with energy management options, while considering the supply, operational, and demand side of energy management.		X	X	**WUP:** All areas of utility planning	Conrad et al. 2011
Electric Power Research Institute's Water Prism	"A decision support system (DSS) that evaluates alternative management plans to obtain water resource sustainability at the regional, watershed, or local levels. It considers surface, ground, and impoundment waters and all water-using sectors (industrial, agricultural, municipal, electric power, and the environment)" Water Prism incorporates collaborative planning, basin-wide perspective of water demands, and analysis of water use across all sectors.	X		X	**EUP:** Industry tool to help identify and quantify water risk on a local or regional level. Supports water benchmarking, reporting, and footprinting. Evaluates potential risk to ground and surface water supplies and to explore savings through water savings strategies.	EPRI 2012

APPENDIX C
LITERATURE KEY FOCUS LISTS

CHALLENGES AND OPPORTUNITIES FOR WATER AND ELECTRIC UTILITIES TO UNDERTAKE INTEGRATED PLANNING

Challenges

- Lack of existing cross-sector working relationships (Dyballa 2013, McCarty et al. 2011) and understanding about operational needs and constraints (Johnson Foundation 2013).
- Different business models and structures that do not recognize efficiency benefits similarly (Dyballa 2013)
- Lack of a common institutional language (Kenway et al. 2013b)
- The non-standardized nature of water sector energy projects (Johnson Foundation 2013)
- Lack of incentives to take risks (Johnson Foundation 2013)
- Financing challenges (Johnson Foundation 2013)
- Regulatory and policy constraints (Johnson Foundation 2013)
- Regulatory challenges (e.g., self-generation impediments and system constraints) (CEC 2005)
- Lack of progressive regulatory environments including the development of accountability of combined water and energy performance (Kenway et al. 2013b)
- "There is a lack of trust between the public and government, between component institutions, and between regulators and institutions, and existing control is held dearly" (Kenway et al. 2013b)
- Different values and priorities surrounding resource scarcity (Scott et al. 2011)
- Social barriers (lack management adaptation due to lack of education or incentives) (PMSEIC 2010)
- Institutional distortions (market failures e.g., imperfect information) (PMSEIC 2010)
- Technological inertia and lock-in (significant investment in current processes and technologies creating an unwillingness to change) (PMSEIC 2010)
- Insufficient investment in innovation (PMSEIC 2010)
- Competing challenges meeting growing demand for water and energy (EPA 2008, Kenway et al. 2008)
- Costs and concerns about greenhouse gas emissions and environmental protection (CEC 2005)

Opportunities

- State and federal level policy support (A4WE and ACEEE 2011).
  - A platform to enable communication of energy and water regulators;
  - Increased federal and state coordination in grant funding, research, regulation, and technical assistance;
  - Regulatory structures and incentives that reward water and energy efficiency;

- Specific energy-water elements added to existing federal legislation;
- State and federal tax incentives; and
- Federal collection of water and energy end use data across sectors"

- Utility collaboration on end use efficiencies (A4WE and ACEEE 2011; EPA 2008)
- Interdependence of water and energy (PMSEIC 2010)
- Regular communication among energy and water regulators (A4WE and ACEEE 2011)
- Use of existing funding mechanisms to facilitate increased collaboration (A4WE and ACEEE 2011)
- Integrated standards, guidelines, and cross-institutional funding and planning (Kenway et al. 2013b)
- Educating (Kenway et al. 2013b) the public and utilities about how to efficiently use water and energy (e.g., through provincial or national resource efficiency programs) (EPA 2008)
- Demand management exploring how utilities can reduce their resource costs and improve efficiency (Lisk et al. 2012) including Water and energy end use data collections efforts across sectors (A4WE and ACEEE 2011)
- Collaboration between the water and energy sectors on policy/codes, research, and programs to increase resource use efficiency (A4WE and ACEEE 2011)
- Opportunities to manage the demand and use of energy and water at the local level "considering the regional, national, and global scales of the development and supply of resources together with associated human and environmental impacts" (Scott et al. 2011)
- Consider institutions and decision-making and not just input–output relationships between water and energy (Scott et al. 2011)
- Energy policy offers more opportunities for global-change adaptation than water policy due to the transportability of electricity makes energy more suitable to regionalized global-change adaptation (Scott et al. 2011)
- Seek mechanisms to internalize environmental, water, and social impacts of energy development to help align water and energy policy (Scott et al. 2011)
- Tensions between water and energy resource use can be minimized "by cross-scale resource substitution (e.g., additional energy for water reclamation where primary water sources are scarce) and multi-tiered institutional solutions (e.g., 'regulatory cooperation')" (Scott et al. 2011)
- Onsite renewable energy generation (e.g., solar and cogeneration) for utilities to become self-sufficient (Kenway et al. 2011)
- Voluntary water and energy efficiency programs (e.g., labeling initiatives) to incentivize individual organizations to save resources (EPA 2008)
- Coordinate utilities' programs (e.g., upgrading infrastructure) (CEC 2005)
- Develop renewable portfolio standards and utility efficiency program (CEC 2005)
- Co-location of water and energy facilities (Merson 2006)
- Multi-level government collaboration (e.g., regional, provincial, and federal) with industry and other stakeholders on integrated resource planning (Merson 2006)

INTEGRATED PLANNING ELEMENTS

- Accounts for the interactions between water and energy for both water and electric utilities
- Includes complex collaboration. Examples of collaborators are funding sources, NGOs, government agencies at every level, trade associations, water and energy utilities, consumer groups, business, regulatory agencies, universities, national laboratories, and policymakers (A4WE and ACEEE 2011).
- Successful integrated/collaborative planning between utilities requires
  - Increasing collaboration between the water and energy communities in planning and implementing programs
  - Deeper understanding of the energy embedded in water and the water embedded in energy
  - Learning from and replicating best practice integrated energy-water efficiency programs (A4WE and ACEEE 2011; EPA 2008)
  - Integrating water into energy research efforts and vice versa
  - Separating water utility revenues from unit sales, and considering regulatory structures that provide an incentive for investing in end use water and energy efficiency
  - Leveraging existing and upcoming voluntary standards that address the energy-water nexus (EPA 2008)
  - Implementing codes and mandatory standards that address the energy-water nexus (Kenway et al. 2013b)
  - Pursuing education and awareness opportunities for various audiences and stakeholders (Kenway et al. 2013b, EPA 2008)

Examples

- Establishing ongoing water and energy working groups, integrating water and wastewater into existing energy efficiency programs, and integrate energy into existing water and wastewater efficiency programs
- Developing consistent and comparable methods for measuring embedded water and energy and developing baseline estimates of total energy use by water and wastewater utilities and water use by electric utilities
- Researching existing programs that clearly address the energy-water nexus to identify best-practice examples and developing a framework for collecting integrated data
- Building a database of existing nexus-related research to identify high priority research needs and developing energy footprinting methods for facility management, land use planning, and new development permitting.
- Developing education materials for water utilities and prepare a report for local and provincial policymakers and water utilities identifying lessons learned from energy experiences
- Use existing and future national standards that link water and energy management and developing land-use and planning codes that account for water and energy efficiency
- Modifying national building codes to better incorporate water efficiency.

- Promoting utility education, outreach, and training programs to educate water utilities on energy efficiency tools and technologies that they can use, developing knowledge sharing programs between sectors, and creating partnerships between water and energy utilities, industry, and NGOs to instigate join public education programs.
- Should utilize frameworks such as benefit cost analysis to fully account for environmental, economic, and social costs of utilities operations.
- Existing planning frameworks used by the electric and water sectors – such as Triple Bottom Line planning or the Natural Step – should be utilized to account for all electric and water resources used by a utility as well as the social, environmental and economic impacts of the utility's processes.

Processes

- Collaborative planning between utilities and other stakeholders (industry, NGOs, the public, and all levels of government) should be emphasized
- Can utilize least-cost planning to minimize operational costs of facilities. However, social and environmental costs should be considered along with economic costs.
- Technical integrated models such as WEAP-LEAP integration can help predict the interactions and impacts of water and energy resources on one another and help utilities better manage water supplies while mitigating greenhouse gas emissions.
- Scenario planning can be used to prepare utilities for future situations. Also, the scenarios that are developed can be used to engage stakeholders and facilitate meaningful discussions.
- Utilities should use adaptive management as a foundation for planning to ensure that decision making is flexible and that utilities can adapt to future situations and uncertainty.
- Education programs should be used to teach utilities and stakeholders (industry, NGOs, the public, etc.) about the use and impacts of water and energy resources in the water and electric sectors and how to improve resource use efficiency.
- Optimize the freshwater efficiency of energy production, electricity generation, and end use systems
- Optimize the energy efficiency of water management, treatment, distribution, and end use systems
- Enhance the reliability and resilience of water and energy systems
- Increase safe and productive use of nontraditional water sources
- Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts
- Exploit productive synergies among water and energy systems

SIMILARITIES BETWEEN WATER AND ELECTRIC UTILITIES

- Growing demand for water and energy due to urbanization, population growth, etc. (EPA 2008, Kenway et al. 2008)
- Energy supply and demand depends on water availability (Lisk et al. 2012). Uncertainties affecting water and energy resources could significantly affect futures supply and demand for both resources

- Each utility uses the others' resource (e.g., water utilities use electricity to power their facilities) and the efficient use of this resource can affect costs (A4WE and ACEEE 2011)
- Need to transport resources to customers (Scott et al. 2011)
- Use of fossil fuels has negative impacts on climate change through GHG production
- Data collection and future predictions inform decision making (Cooley et al. 2011)
- Voluntary programs such as labeling initiatives (e.g., ENERGY STAR and WaterSense) can encourage resource use efficiency (EPA 2008)

Shared Planning Frameworks

- Benefit cost analysis
- Simple decision analysis
- Structured decision making
- Scenario planning (to plan for alternative future scenarios, can require for a comprehensive review of electric and water resources)
- Triple bottom line (requires a comprehensive review of electric and water resources)
- Adaptive management
- Multi-criteria decision making
- Multi-attribute utility theory
- Outranking
- Robust Decision making
- Least-cost planning (requires a comprehensive review of electric and water resources)
- WEAP-LEAP integration
- Natural Step (requires a comprehensive review of electric and water resources)
- Collaborative Planning

Shared Planning Processes

- Participatory, consensus-based decision making
- Stakeholder and public engagement
- Scenario predictions
- Considering the complexity of decisions including objectives, alternatives, consequences, uncertainty, etc.
- Rely on multiple planning frameworks to guide management
- Minimizing costs
- Considering the economic, environmental and social impacts of decisions and processes.
- Adapting and iterating on decisions and planning processes

APPENDIX D
UTILITY INTERVIEW SCRIPT

PART 1: DISCUSSION OF INTEGRATED PLANNING

1. Describe how infrastructure investments are planned and made at your utility, explain the process of decisions and who is involved?
   a. For example, describe how a new pump station/generation station is designed and put in place?
2. How difficult or easy is it for your utility to consider and adopt alternative planning methods?
3. What have you heard about integrated water and electric planning? Can you provide any examples you may have come across?
4. How do you feel the relationship between water and energy resources has already affected your infrastructure planning decisions?
5. Can you describe your utility's current activities to integrate water and electric planning?
6. Considering your utility's institution arrangements, can you describe any issues with undertaking integrated water electric planning activities?
7. What are the greatest challenges you have had in planning for integrated water electric activities?
   a. What about infrastructure investment in general?
8. Are there any integrated planning activities that you feel are important but are not being addressed by your utility?
9. Here are some following water electric planning opportunities that may apply to your utility, have you included any of these in your current planning activities (yes/no, how)?

PART 2: IDENTIFICATION OF CURRENT ACTIVITIES

	Yes or No	**Jointly (water and electric) Y/N?**	**If yes, describe**
Include drought and climate change in planning for water supplies for your utility (either for power generation or direct service delivery).			
Include climate change in planning for electric supplies for your water facility			
Coordinate your planning efforts in order to take into account for possible tradeoffs and interrelationships of water and electric planning			

	Yes or No	Jointly (water and electric) Y/N?	If yes, describe
Undertake service metering programs			
Undertake demand management programs			
Generate power at any core water facility (e.g., hydroelectric, biogas energy generation)			
Supply water from any core electric facility (e.g., for water reuse)			
Integrate water into electric research efforts and vice versa			
Map peak water and/or electric demand magnitudes and seasonality differences (e.g., demand profiling)			
Educate end users about the energy use related to water consumption and vice versa			
Other(s):			

10. Here are some tools and techniques that utilities have developed to support integrated planning, which if any does your utility utilize (currently or in the past)?

	Yes or No
Joint community development plans that include integrated resource (e.g., water, electric, etc…) planning.	
Perform a formal trade off assessment or management exercises related to water and electric resources.	
Consider different integrated water electric scenarios or models for design, maintenance, or planning.	
Review existing practices and consider new practices to accommodate integrated water electric resources use.	
Develop additional contingency plans for infrastructure failure of both core and related energy/water systems.	
Identify infrastructure that is at risk because of a changing resource availability, both related water and electric systems.	
Design infrastructure that can be modified over time as resource availability changes.	
Consider integrated resources (e.g., water and electric) in land use planning.	
Consider water and electric relationships in core business/strategic planning efforts.	
Consider access to water and electric resources in site planning and mapping.	
Adjust capital planning criteria to include integrated resource criteria.	
Other(s):	

APPENDIX E
PARTICIPANT CONSENT FORMS

EXPLANATORY STATEMENT
for Persons Participating in Research Interview

This information sheet is for you to keep.

Project Title: Water and Electric Utility Integrated Planning

This project originates from the realization that water and electric utilities plan separately, yet share the same water resource, a resource that is increasingly scarce. In Australia this is perhaps best evident in the rapidly rising energy demand for urban water: energy use for urban water is anticipated to grow 200-250% between 2007 and 2030 yet Australia now aims to cut greenhouse gas emissions to 20% of 2000 levels by 2050.

This creates a massive challenge. It also creates the opportunity for a high level of innovative solutions of which planning needs to be at the forefront. Despite numerous management similarities between drinking water, wastewater, and electric utilities many manage, operate, and plan in separate silos. Today the effort bridging related water-energy management issues is minor and at best uncoordinated. There is a lack of shared resources, knowledge and approaches. With such examples, there are appreciable opportunities for integrated water / electric planning and this gives cause for further investigation.

With funding for further investigation provided by: the Water Research Foundation, the American Water Works Association, and the New York State Energy Research and Development Authority, the objective is to:

- Present and evaluate a range of examples of interdisciplinary, integrated planning efforts between water and electric utilities, and identify costs and benefits;
- Identifying barriers, means to overcome barriers, opportunities, and critical elements of success for integrated planning;
- Provide recommendations for water and electric utilities to continue to engage in integrated planning;
- Help water and electric utilities understand commonalities and differences in their respective planning needs and goals; and
- Provide a resource that offers insights on who, what, why, and how water utilities (drinking water, wastewater and storm water) and electric utilities engage in integrated planning.

One component of this investigation is to develop illustrative case studies that capture observations and experiences of water and electric utilities' integrated planning efforts. Case studies selected are related to integrated water electric utility planning across a range of connection points in the delivery of water and electric service from source to customer and back to source. They help identify best practices, the drivers, barriers, and success factors associated with past experiences, as well as gather input on any cost benefit analysis conducted as part of the integrated planning effort.

We are therefore requesting your participation in the development of these illustrative case studies in order to further understand your experience and resulting outcome of integrated planning within your organization. The duration of the interview is expected to be between 45-60 minutes, with follow-up questions and documents, as needed.

Potential benefits, as an expert utility participant, include increased awareness of the methods and processes of integrated water electric utility planning, increasing organization's profile with regard to integrated planning efforts, networking and connection with peers, and a broader societal benefit of dissemination of knowledge and improved resource management processes.

The potential risks of participating are minimal, and will not be different than the day-to-day risk of harm encountered by daily operations and life. Yet, expert utility participants may face some risk of loos of reputation by participating in this study. To reduce this risk, we provide you the opportunity to review and seek consent to the release of data identifiable to your organization.

The interview is voluntary and anonymous and you have the right not to answer any questions for any reason. You can choose to withdraw from the research at any time by contacting the researchers (listed below). Your permission will be sought to audio-record your interview for subsequent written transcription. After the interview, the case study outline, along with a copy of the interview transcript and notes will be forwarded to you for review and approval. Only if permission has been sought, will the quotations from interviews and data solicited from utilities be reported in a final research report, journal articles, conference presentation, and/or future research projects. As such, the interviews, internal reports and any other data you provide will only be available to our research team. Storage of the data will adhere to University regulations and kept on University premises in a locked filing cabinet for 5 years.

Thank you for your time. Your input into this research is very much appreciated.

<table>
<tr><td>If you would like more information about any aspect of this study, please contact the researchers:</td><td>If you have a complaint concerning the manner in which this research is being conducted, please contact:</td></tr>
<tr><td colspan="2">Australia</td></tr>
<tr><td>Dr. Steven Kenway
Research Group Leader, Water-Energy-Carbon

School of Chemical Engineering,
Postal Address: Level 3, Chemical Engineering Building (74)
University of Queensland, St Lucia, 4072 Australia
s.kenway@uq.edu.au
+61(0) 419 979 468</td><td>University of Queensland Ethics Coordinator: +61 33 653 924."</td></tr>
<tr><td colspan="2">US and Canada</td></tr>
<tr><td>Dr. Steve Conrad
Water Energy Nexus & Governance</td><td>Simon Fraser University Ethics Coordinator:</td></tr>
</table>

Instructor, Pacific Institute for Climate Solutions (PICS) fellow Chair, REM Water Research Working Group http://www.rem.sfu.ca/water/ Simon Fraser University School of Resource and Environmental Management Burnaby, BC Canada Cell: 604.649.6746 email: steve_conrad@sfu.ca	Dr. Jeffrey Toward, Director, Office of Research Ethics at jtoward@sfu.ca or 778-782-6593. Concerns or complaints about this research can be addressed to Dr. Wolfgang Haider, the project supervisor and primary contact, at wolfgang_haider@sfu.ca or 778-782-3066

CONSENT FORM
for Persons Participating in Research Interview

Title: Water and Electric Utility Integrated Planning

Consent Form for **(participant name)** of **(organization)**

I agree to take part in the research project specified above. I have had the project explained to me, and I have read the Explanatory Statement, which I keep for my records.

I understand that agreeing to take part means that:

- I agree to be interviewed by the researcher
- I agree to allow the interview to be audio-taped
- I give permission for quotes from my transcript to be reported in publications of the research findings
- I agree to make myself available for a further interview, if required.

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalized or disadvantaged in any way.

I understand that any data that the researcher extracts from the interview for use in reports or published findings will not, under any circumstances, contain names or identifying characteristics.

I understand that any information I provide is anonymous, and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party.

I understand that data from the interview will be kept in a secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5-year period unless I consent to it being used in future research.

Participant's name:

Signature:

Date:

Principal Investigator's contact information:

Dr. Steve Conrad
Water Energy Nexus & Governance
Instructor, Pacific Institute for Climate Solutions (PICS) fellow
Chair, REM Water Research Working Group
http://www.rem.sfu.ca/water/

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APPENDIX F
WEB SURVEY QUESTIONNAIRE

Introduction

This survey will take approximately **10 minutes** to complete and consists of the following sections.

1. Your organization and knowledge of the water-energy nexus

2. Your opinion on the benefits and potential of water and electric integrated planning initiatives

3. Your opinion on actions and outstanding needs for water and electric integrated planning

Overview

On October 16 and 17, 2014 the Water Research Foundation hosted a Water and Electric Utility Planning Tournament in Denver, Colorado. Approximately 32 people from the United States, Canada, and Australia and representing water and electric utilities, water and energy sector professionals, federal and state regulators, and academic institutions took part in a simulated planning tournament in order to identify opportunities and barriers to water and electric utility integrated planning.

The tournament was held as part of the Water Research Foundation project 4469: Water and Electric Utility Planning, and led by Simon Fraser University and the University of Queensland. This project originates from the realization that water and electric utilities plan separately, yet share the same water resource; a resource which is increasingly scarce.

New water supplies require more energy. Increased energy supplies require more water. This is just one example of the positive feedback cycle existing with regard to water and energy management, and there are many more. This creates a massive challenge. It also creates the opportunity for a high level evaluation of innovative solutions of which planning needs to be at the forefront. There are appreciable opportunities for water / electric integrated planning and this gives cause for further investigation.

But how can water and electric utilities work together to manage scarce resources? Water and electric utilities often operate in silos, even in combined utilities, and many barriers do exist to such initiatives.

This survey discusses opportunities and needs related to water and electric utility integrated planning. In this survey we encourage you to consider all aspects of water and electric utility systems. Your response will support prioritizing the opportunities and options available to water and electric utilities and a summary of responses will be incorporated into the final report. We would truly appreciate your support.

To begin, please tell us about your Organization

What best describes your organization?

* *Please select one response only.*

- Water Utility
- Wastewater Utility
- Electric Utility
- Joint Water and Wastewater Utility
- Joint Water (and/or Wastewater) and Electric Utility Educational Institution
- Research Organization
- Consulting or other Professional Agency Government Agency
- Non-Government Agency
- Other ________________________

Please describe your role in your organization (e.g., management, field staff, planner).

____

Please enter your postal (ZIP) code.

This will be used to evaluate responses by region; all results of this survey will otherwise remain anonymous

____

Please tell us about your utility systems

Which of the following service functions does your utility provide or manage?

Please select all that apply.

- Electric power generation
- Electric power transmission
- Electric power wholesale
- Electric power distribution
- Electric power retail (end customer)
- Raw water supply
- Raw water transmission
- Water treatment
- Treated water wholesale
- Treated water retail (end customer)
- Stormwater collection
- Stormwater treatment
- Wastewater collection
- Wastewater treatment
- Water reuse
- Other ___________________

How many people does your utility serve?

Please select one response only.

- Less than 25
- 25 to 500
- 501 to 3,300
- 3,301 to 10,000
- 10,001 to 100,000
- 100,001 to 500,000
- 500,001 to 1,000,000
- More than 1,000,000

Water and Electric Utility Integrated Planning and Management Overview

Water and electric utility integrated planning and management can cover a broad set of interactions, from strategic long-term systems design and operation, through to day-to-day maintenance or river- operations control. For this project, three principal areas of integrated planning are emerging of particular interest (Figure F.1):

1. retail, or end user management: This includes consideration of the interconnections with customers for example including combined water and energy metering, demand management programs, or customer service databases.
2. energy generation: for example, including creation of energy via hydroelectric power, micro- turbines within water supply systems, green energy generation (e.g., from biogas at wastewater treatment plants), or green energy use (e.g., wind/tidal) for desalination facilities.
3. electric power cooling: for example, the provision of river flow patterns necessary to provide for thermally cooled power stations.

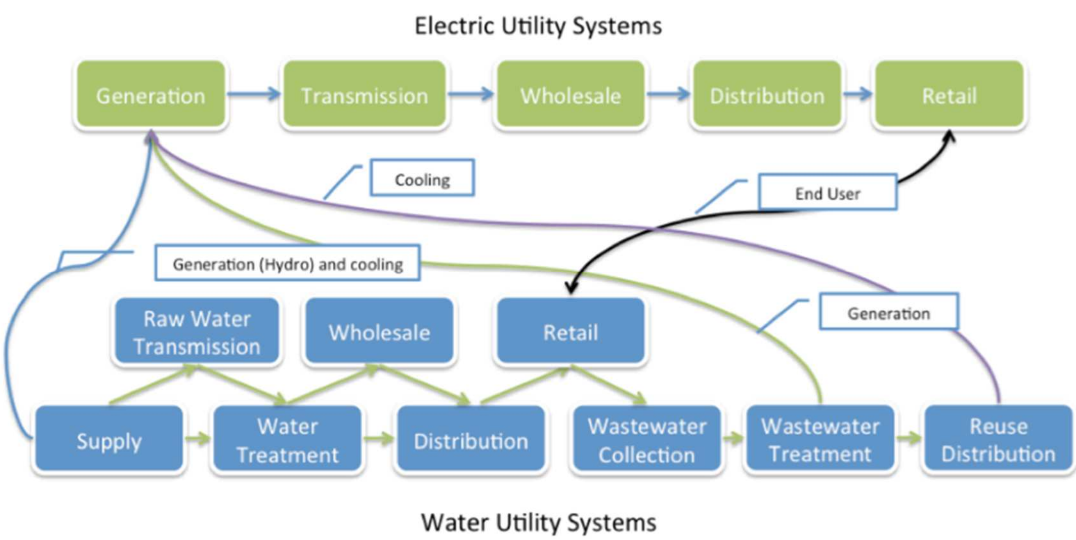


Figure F.1 Principal areas of integrate planning

Choosing only one area, which of the above areas represents the greatest opportunity for water and electric utility integrated planning?

Please select one response only.

- retail, or end user management
- energy generation
- electric power cooling

Please tell us your opinions on the benefits of water and electric utility integrated planning

To what extent do you agree that the following are BENEFITS of water and electric utility integrated planning?

For each statement, please select one option.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	No Opinion
Provides water and energy savings	☐	☐	☐	☐	☐	☐
Provides cost savings – *e.g., through shared infrastructure, joint efficiency programs, common metering*	☐	☐	☐	☐	☐	☐
Increases data availability through integrated billing and customer metering	☐	☐	☐	☐	☐	☐
Enhances utility system resiliency and response to uncertainties	☐	☐	☐	☐	☐	☐
Improves environmental management through a total system view of the environment and its resources	☐	☐	☐	☐	☐	☐
Reduces points of system weakness and risk of failure	☐	☐	☐	☐	☐	☐
Provides cross training of water and electric utility staff	☐	☐	☐	☐	☐	☐
Increases utility financial stability	☐	☐	☐	☐	☐	☐
Enhances communication among water and electric sector professionals	☐	☐	☐	☐	☐	☐
Incentivizes transition to renewable energy systems	☐	☐	☐	☐	☐	☐
Improves service delivery	☐	☐	☐	☐	☐	☐
Increases utility accountability to the public	☐	☐	☐	☐	☐	☐

Please describe any OTHER BENEFITS you believe water and electric utility integrated planning would provide to water and electric utilities:

Please tell us your opinions on water and electric integrated planning initiatives

On a scale of 1 – 5, to what extent do you believe the following initiatives have POTENTIAL to support progress toward water and electric utility integrated planning and realize benefits? (Where 1 means no potential and 5 means significant potential)

For each statement, please select one option.

	No Potential				Significant Potential
Joint water and electric utility research on efficiency codes & standards	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Alternative water and electric utility pricing and revenue strategies *(e.g., full cost pricing, tiered rate structures, decoupling utility revenue from per unit (kWh, cm3 of water) sales)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Public education of the energy embedded in water, and the water embedded in energy	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Professional education of the energy embedded in water, and the water embedded in energy	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Joint water and electric utility operations planning *(i.e. operational planning to reduce water and energy requirements of new infrastructure, minimize carbon emissions, respond to drought, and manage peak demand)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Joint water and electric utility regulations *(e.g., program evaluation criteria, guidelines, mandates, restrictions, policy targets)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Joint water and electric utility demand management programs *(e.g., devices, incentives, energy and water efficiency programs, joint metering, customer awareness programs)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Programs focused on expanding renewable energy generation *(e.g., solar, wind, biogas, etc)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Broader water and energy allocation and accounting rules and methodologies *(e.g., net metering rules, shared cost recovery, cost shifting, rebates and credits)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Joint water and electric utility investments in alternatives to potable water for industry, irrigation, and electric power cooling	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Implementing a regional water and electric coordinating body and process	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Joint water and electric utility programs on internal water & energy reduction *(e.g., leak management, transmission loss reduction)*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
Integrated Land Use Planning programs in cities and regions	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐

Given the same initiatives, on a scale of 1 - 5 how significant a LEVEL OF EFFORT do you think is needed for the initiative to influence progress toward water and electric utility integrated planning and realize benefits? (Where 1=little or no effort and 5=significant effort)

For each statement, please select one option.

	Little or No Effort				Significant Effort
Joint water and electric utility research on efficiency codes & standards	☐	☐	☐	☐	☐
Alternative water and electric utility pricing and revenue strategies *(e.g. full cost pricing, tiered rate structures, decoupling utility revenue from per unit (kWh, cm3 of water) sales*	☐	☐	☐	☐	☐
Public education of the energy embedded in water, and the water embedded in energy	☐	☐	☐	☐	☐
Professional education of the energy embedded in water, and the water embedded in energy	☐	☐	☐	☐	☐
Joint water and electric utility operations planning *(i.e., operational planning to reduce water and energy requirements of new infrastructure, minimize carbon emissions, respond to drought, and manage peak demand)*	☐	☐	☐	☐	☐
Joint water and electric utility regulations *(e.g., program evaluation criteria, guidelines, mandates, restrictions, policy targets)*	☐	☐	☐	☐	☐
Joint water and electric utility demand management programs *(e.g., devices, incentives, energy and water efficiency programs, joint metering, customer awareness programs)*	☐	☐	☐	☐	☐
Programs focused on expanding renewable energy generation *(e.g., solar, wind, biogas, etc)*	☐	☐	☐	☐	☐
Broader water and energy allocation and accounting rules and methodologies *(e.g., net metering rules, shared cost recovery, cost shifting, rebates and credits)*	☐	☐	☐	☐	☐
Joint water and electric utility investments in alternatives to potable water for industry, irrigation, and electric power cooling	☐	☐	☐	☐	☐
Implementing a regional water and electric coordinating body and process	☐	☐	☐	☐	☐
Joint water and electric utility programs on internal water & energy reduction *(e.g., leak management, transmission loss reduction)*	☐	☐	☐	☐	☐
Integrated Land Use Planning programs in cities and regions	☐	☐	☐	☐	☐

Please describe any challenges or concerns your organization faces in achieving water and electric utility integrated planning in your region:

Please tell us your opinions on the needs of water and electric utility integrated planning

On a scale of 1 – 5, to what extent do you believe the following NEEDS are important to progress water and electric utility integrated planning? (Where 1 means not important and 5 means a very important).

For each statement, please select one option.

There is a need too ...	Not Important				Very Important
... identify specific areas where there is overlap of water and electric utility jurisdiction and interest	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... present a joint community agenda identifying prospective opportunities for collaboration on capital improvement projects	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... recognize the full water and electric power system cycle	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... develop joint accounting methodologies to expose and plan for unexpected expenditures	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... recognize wastewater generated electricity as renewable	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... incentivize the relationship between water and electric utilities through *regulations*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... incentivize the relationship between water and electric utilities through *funding*	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... expand and revise political dimensions governing water and electric utilities	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... support formal joint trade relationships between water and electric industry associations	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... allow alternative cost accounting and cost effectiveness frameworks such as Triple Bottom Line in regulatory rate and planning review	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... develop consistent and comparable methods for measuring embedded water and energy	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... develop methods for joint facility management, land use planning, and new development permitting	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐
... create regulatory structures that provide incentives for investing in water and energy efficiencies	☐ ☐	☐ ☐	☐ ☐	☐ ☐	☐ ☐

Please describe any OTHER NEEDS you believe are important for the water and electric utility industry in order to achieve benefits from water and electric utility integrated planning:

If you have any suggestions or additional comments regarding this survey, we would appreciate to know about it.

Thank you for Taking our Water and Electric Planning Survey

Your input has been recorded and we thank you for your input. You may enter your email to receive a summary of research results or close this window to complete the survey.

Provide your contact information below if you wish to be contacted to receive a summary of results.

Any **personal identifying information** you provide will be used only to contact you when a summary of results is prepared and **will not be associated with your answers**.

Enter your full name here

Enter your email address here

☐Notify me when a summary of results is prepared

APPENDIX G
WATER AND ELECTRIC UTILITY INTEGRATED PLANNING TOURNAMENT WORKBOOK

The following sections were included in the Water and Electric Integrated Planning Tournament workbook distributed to participants prior to the start of the WEUIP Tournament. The following does not include the list of planning options, or the scenarios prepared, that were originally provided as part of the workbook. A copy of the full WEUIP Tournament report, including a list of participants, the agenda, list of planning options and tournament scenarios is available on the #4469 project page of the Water Research Foundation website, under Project Papers.

BACKGROUND

The Integrated Planning Tournament is a concept based on the Invitational Drought Tournament (IDT) developed at the Science and Technology Branch (STB) of Agriculture and Agri-Food Canada (AAFC). Using a simulation gaming concept, a tournament helps actors discuss opportunities for future planning efforts. More specifically, it supports “the improved assessment of policies, programs and management strategies at a range of spatial scales.”

For the Integrated Planning Tournament, multiple water and electric power sector actors are invited and grouped into teams consisting of approximately five players. The teams are guided through two integrated planning scenarios set in a fictitious city (Meadowlands) and region. The scenario includes information about the city and its biophysical, political, and social environment (e.g., demographics, temperature, precipitation, water and energy demand projections). Teams are provided a technical memo and guided through each scenario round. Through discussion, teams work together to develop an integrated water and electric utility plan consisting of several planning alternatives. Teams score each other based on their integrated plan’s abilities to meet the goals of the scenario, minimize economic impact and maximize system resiliency (capacity to deliver service efficiently and reliably while maintaining system security) in both the short and long term.

WELCOME TO MEADOWLANDS

Welcome to the water and electric utility integrated planning tournament and the fictitious city Meadowlands! This is a game handbook that provides all the information you will need to play the game. Please note: the information and materials for the tournament are based on real data but do not pertain to any specific city.

RULES

1. Respect other people’s opinions and perspectives and be inclusive
2. Play as if the game were reality
3. Cast your scores honestly
4. Do not get hung up on the numbers
5. Consult a referee when something is not clear
6. Have fun!

PROCESS

A round in the Tournament will go as follows (illustrated in Figure G.1): The tournament facilitators will distribute a series of technical briefings at the beginning of the scenario. Your task, as the members of a joint water and electric planning group, is to make strategic decisions about water and electric power resources. Your groups' decisions must please a newly formed regional water-electric governing board, which are a group of elected officials that have a variety of stakeholder interests.

Time will be given for team discussion and planning options will be chosen; teams may select options from a list provided to them, or they can propose innovations (or new planning strategies not on the list), for which they must assign a realistic cost and benefits accepted by the referees. Teams will provide their initial selection of options to the Tournament referees. Each team will then prepare and present a short (4-5 minute) summary of their integrated plan. Individuals in the room will score the other teams.

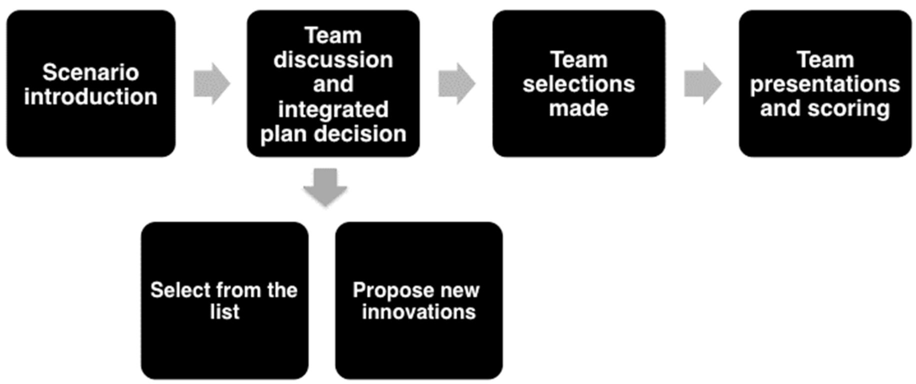


Figure G.1 Tournament round process

ROLES

Each actor in this tournament has a unique perspective and input on water and electric utility integrated planning. The following is a list of roles people will play in the tournament:

- Team Players
  - Actively participate in the WEUIP tournament
  - Score other teams' integrated plans each round
    - Team spokesperson: prepares presentation (using template) and presents plan at the end of the round
    - Recorder: records selected planning options on worksheet and submits them to the referees
    - Time keeper and facilitator: monitors time and ensures team completes required task
    - Documenter(s): Records discussion (using template)
- Referees (Research team)
  - "Content" experts that can be consulted by teams
  - Evaluate the cost and benefits of innovative options
- Judges
  - Engage in the scoring process along with the players

    - Review scores and ranks team
- Spectators (Observers)
    - Experts in a range of fields observing for a variety of reasons: potential future WEUIP tournament application, out of interest, for feedback on the process, etc.
    - Engage in the voting process along with the referees, judges and players
- Organizers
    - Facilitate the event

DETERMINING THE WINNER

At the end of each round teams will present their final choices for the scenario (a team must justify any change made to their plan after submitting decisions to referees). Teams will be scored on how well it meets the goals of the scenario, supports the teams' long term management goal, and meets the goals of the scenario, minimize economic impact and maximize system resiliency (capacity to deliver service efficiently and reliably while maintaining system security) in both the short and long term. Every individual player, observer, and judge will score the integrated plan presented by each team. The final team scores will comprise the cumulative averages from each round, and will be weighted; the judge's scores have a greater influence on the final team scores than the individual players. Scores of 1 to 7 will be assigned to criteria shown in Figure G.2. The sum of all of these scores represents the total score of the team in that round.

Team: ____________________ Budget: ____________________ Spent: ____________________

When filling out the sheet, ask yourself three questions.

. 1) How effective is their overall integrated plan in reducing environmental impacts in the region? (reducing impact is more effective than avoiding environmental impacts)

. 2) How effective is their overall integrated plan in addressing societal impacts in the region? Are there expected gains for society?

. 3) How effective is their overall integrated plan in addressing economic impacts in the region? Are there expected gains, economically?

Please provide a score from 1 (very ineffective) to 7 (very effective) for the following criteria.

Criteria	Score (1 to 7)
The plan is comprehensive and incorporates options that meet a variety of sectors' needs	
The plan addresses the ***Goals*** of the scenario	
The plan addresses the vulnerabilities and conflicts presented in the scenario	
The plan improves customer service delivery	
The plan improves regional water and electric system reliability and security	
The plan improves the region's ability to adapt to future conditions	
TOTAL	

Figure G.2 Tournament scorecard

MEADOWLANDS BACKGROUND INFORMATION

Overview

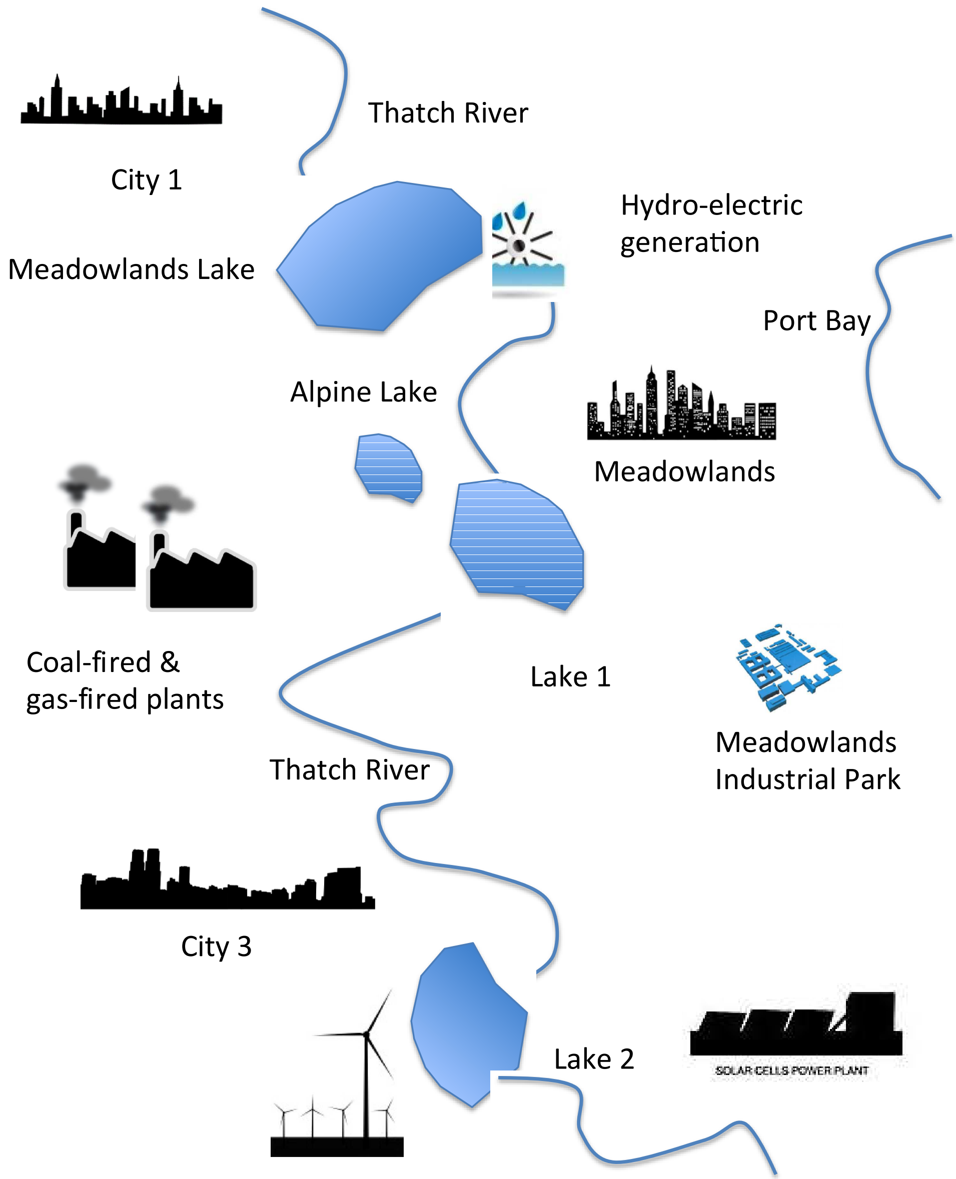
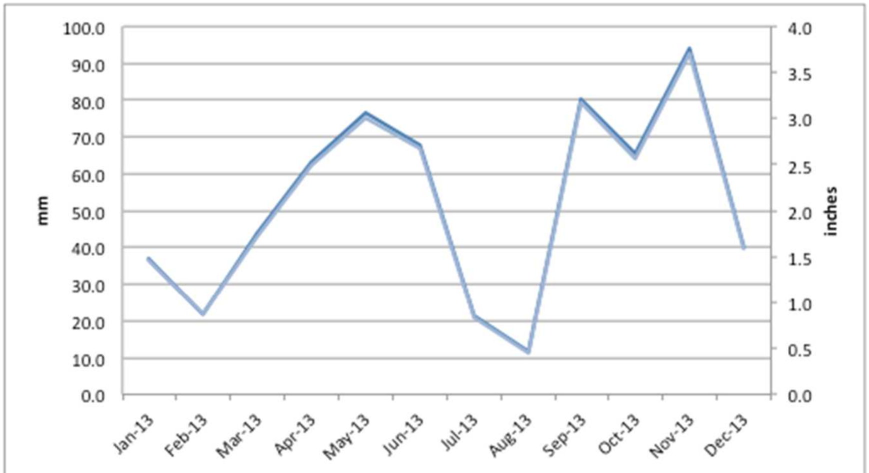


Figure G.3 Meadowslands overview

Meadowlands (see Figure G.3) is located on a moderately-sized river 12.5 miles (20 km) upstream from the coast. Three regional lakes (a fourth alpine lake is not currently utilized) provide drinking water resources to the region's three cities (of which Meadowlands is one) as well as water resources to the region's electric generation facilities. An allocation system ensures that each city has a share of available water following priority allocation to agriculture and electric facilities. Good quality groundwater from a regional aquifer provides 35% of the cities drinking water and is not used by the region's electric power providers.

Climate and Ecology

The region has a relatively warm but not hot climate, with average summer temperatures in the high 80's °F (26 °C). The region receives 25 inches (635 mm) of rain annually with variability and at its lowest in January, February, and June – August (see Figure G.4).



	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13
mm	36.9	21.9	43.8	63.0	76.4	67.8	21.3	11.4	80.4	65.3	93.9	40.2
inches	1.5	0.9	1.7	2.5	3.0	2.7	0.8	0.4	3.2	2.6	3.7	1.6

Figure G.4 Meadowlands' 2013 regional precipitation

Fish protection, water quality, and instream flows are important to the people of region. To manage the region's ecology, water use agreements help balance agricultural and industrial water use with instream flows – this is essential in dry years to help prevent user conflicts.

Demographics

In 2014, Meadowlands' population exceeded 1 million, contributing to the region's 3.4 million citizens. Large industry is moving into the city and there have been some major resources developments. The population is expected to grow at much higher rates than previously predicted. This increasing demand will take the city beyond its sustainable yield (a figure representing an amount of water that can be withdrawn from the region's water sources without exceeding the capacity of the systems to maintain water levels and stream flows) within 10 years, presuming historic rainfall patterns continue.

Meadowlands' utility customers have some awareness of water supply issues and have been concerned with increasing maintenance costs. However, the community is unaware of the interconnections between water use and electric generation.

Due to the dry conditions of the region, large water allotments and the sprawling nature of the city, per capita water use is high, particularly in the summer when the community is proud and protective of its green landscapes. Air conditioning use, which until recently was isolated to new development, is on the rise as more and more customers retrofit existing structures.

Water and Electric Power Systems Overview

The City of Meadowland's water department manages both water and wastewater services for the city. Other departments within the City manage stormwater, solid waste, and related services including land use planning. A regional grid is supplied by two electric generation (one private and one municipal) utilities; electricity is distributed by a third independent utility.

Economic Overview

The city has enjoyed a moderately prosperous decade. As water scarcity has not been an issue previously water is priced using a single tiered rate structure with a set charge for access and a set charge for usage. Residential electricity is priced at $0.110 per kWh but expected to rise dramatically as regional electric utilities replace aging infrastructure.

Water and Energy Demand

Demand management has not been aggressively implemented and no rebates have been provided for water or energy efficient approaches. Current water use per capita is approximately 400 liters (105 gallons) per day. However, the city council has implemented water and energy efficiency design standards, on par with recommendations from the US Environmental Protection Agency.

Table G.1
Meadowlands actual/projected maximum week water demand

	2006	2011	2016	2021	2031	2041
ML/D	327.5	350.8	373.1	395.8	445.8	500.8
MG/D	86.5	92.7	98.6	104.6	117.8	132.3

Table G.2
Meadowlands actual/projected groundwater withdraw capacity

	2006	2011	2016	2021	2031	2041
ML/D	77.1	85.3	90.4	100.3	86.4	75.7
MG/D	20.4	22.5	23.9	26.5	22.8	20.0

Table G.3
Meadowlands actual/projected peak energy demand (peak consumption)

	2006	2011	2016	2021	2031	2041
Peak Demand (MW)	10,600	11,023	12,148	12,269	12,470	12,719

SCENARIOS INTRODUCTION

The Meadowlands region is unusual in that a newly appointed regional water and electric governing board oversees water and electric planning. You have been given endorsement by the governing board to consider a number of engineering, economic, political, and regulatory options; independent of whether they currently exist. At the beginning of each round you will be provided a technical memo, detailing a future condition and a request by the governing board. You are to consider water and electric planning options and present a joint plan to meet the goals of the scenario and reduce any economic, social, or environmental impacts presented in the scenario.

While you evaluate your planning options you should consider the benefit and impact of each option on Meadowlands' citizens and the region and the relationships of each option to your organization (e.g., water or electric utility, government) and others, for example:

- What can your team's represented organizations do (e.g., water utility, electric utility, government agency, researcher, etc…)? What do you need others to do?
- What could you ask the community or wider society to do?
- What skills and people do you need to make decisions?
- How can you go about prioritizing your choices?
- What are the performance indicators of success?

PLANNING OPTIONS

A list of planning options (included in the full WEUIP Tournament report available on the Water Research Foundation website) your team may wish to consider is provided in this workbook. This list does not represent all options available and your team is encouraged to include additional options. If your team does include options not on the list, it will need to estimate the cost for the program or project, and what changes in water and electric supply (or demand) is assumed.

TOURNAMENT PROCESS OBSERVATIONS

The WEUIP Tournament, an innovation in the field of planning and simulation gaming, provided the opportunity for water and electric utility sector participants to share knowledge and experiences, learn terminology, and collaborate in developing realistic water and electric integrated plans to respond to possible scenarios affecting communities. The tournament process provides opportunities for social learning and allows players to holistically consider the impact of scenarios affecting water and energy resources. It supports players' consideration of planning options and facilitates communications between diverse stakeholders, in an environment that is fun for participants. Below we provide observations and suggestions for improvement on the Tournament process.

Internal Planning

For future tournament sessions, participants would benefit from a synthesis of barriers, opportunities, and reasons for coordinating and clear descriptions of methods used to integrate planning.

Context Presentations

An opportunity for Tournament participants to share integrated planning work was useful, including sharing the political officials mandate to begin integrating water and energy planning. A stronger context-setting presentation for future tournaments would be helpful. The context setting should include clear examples of:

- What integrated water-electric planning looks like;
- Why integrated planning is needed;
- The barriers that have to be overcome and
- Some opportunities that can be taken advantage of (or that have been pursued).

The classification of water electric utility interactions should be simplified by defining and discussing the key measures currently used in water/energy nexus arena such as:

- Embedded Energy
- Avoided Costs
- Marginal Water Supply
- Water Balance
- Urban Metabolism

Tournament Workbook

Directions for how the tournament would operate were provided including a recommendation to focus on strategies not numbers and data included in the tournament workbook. Yet despite this recommendation, tournament participants continued reviewed the data before considering planning options. Sufficient time should be allotted for participants to review the data included in the tournament workbook before the workshop in order for participants to gain familiarity with the data and feel comfortable working through the WEUIP planning options. It would also be useful to include a glossary of terms in the workbook, highlighting differences between water and electric utilities.

Tournament Documentation

Utilizing usb drives and copying presentations from one computer to another, was cumbersome, but necessary. External team scribes are needed to capture all discussion.

Participant Interactions

Team interaction was high and conversation was active, more than fulfilling the expectations of participants in coming to networking events. Further interaction could have been arranged by grouping people from different sectors and regions. For example, one comment shared by tournament participants was how much individuals benefited from the opportunity to learn new language and nomenclature in order to understand energy processes or water processes.

Tournament Tools

Participants found it challenging to balance the higher goal to create an integrated plan vs. determine the details of the options. Initially, a systems dynamic model was planned to support the workshop; however, the need to completely create a hypothetic city and region from scratch to support the scenarios was onerous. Initial testing of the model proved problematic and the research team felt that the use of the model at the first tournament would complicate the process. However, the research team believes that utilizing models in future tournaments is possible and could be implemented if access to data and testing of the model was conducted prior to the tournament. Including a systems dynamic model would promote immediate feedback on the outcomes of the WEUIP plans and help participants focus on long-term goals.

APPENDIX H
THEMATIC ANALYSIS AND SURVEY QUESTIONNAIRE LISTS

This appendix provides a complete listing of the themes identified during the studies thematic analysis and a listing of benefits, WEUIP initiatives, and needs that formed the survey questionnaire.

PREPARING WEUIP INITIATIVES

To prepare the list of WEUIP initiatives for evaluation in the survey, the researchers conducted a thematic analysis of themes identified across literature, at the WEUIP tournament, and from case studies (see Chapter 2). Table H.1 lists these themes in similar groupings.

Table H.1
WEUIP themes across literature, tournament, and case studies

Literature Review Theme	Tournament Theme	Case Study Theme
Increasing collaboration between the water and energy communities in planning and implementing programs	End use efficiencies through joint water and electric utility conservation and rebate programs	End Use Efficiency
Deeper understanding of the energy embedded in water and the water embedded in energy	Internal energy reduction through leak management, water use improvements in electric utility operations	Operational Efficiency
Learning from and replicating best practice integrated energy-water efficiency programs (A4WE and ACEEE 2011, EPA 2008)	Investing in alternatives to potable water supply for irrigation, industrial uses, and electric power cooling	Infrastructure Resiliency & Operational Efficiency; Alternative water supply and wastewater services
Integrating water into energy research efforts and vice versa	Water and energy restrictions; Opportunity to focus on non or low carbon generation with no increase in water demand	Regional Planning; Regulation of the Water-Energy Nexus
Separating water utility revenues from unit sales, and considering regulatory structures that provide an incentive for investing in end use water and energy efficiency	Alternative water pricing strategies	Demand Management and Demand Response (including alternative rates)
Leveraging existing and upcoming voluntary standards that address the energy-water nexus (EPA 2008)	Renewable power generation (co-generation, solar, wind)	Renewable Energy
Implementing codes and mandatory standards that address the energy-water nexus (Kenway et al. 2013b)		Regulation of the Water-Energy Nexus
Pursuing education and awareness opportunities for various audiences and stakeholders (Kenway et al. 2013b, EPA 2008)	Opportunity for education and public outreach and efficiency and conservation	

Listing of WEUIP Initiatives

Similar themes from Table H.1 were combined to create the final initiatives for the WEUIP survey questionnaire included as Appendix F. These initiatives are listed below:

- Joint water and electric utility research on efficiency codes & standards
- Alternative water and electric utility pricing and revenue strategies (e.g., full cost pricing, tiered rate structures, decoupling utility revenue from per unit (kWh, cm3 of water) sales
- Joint water and electric utility regulations (e.g., program evaluation criteria, guidelines, mandates, restrictions, policy targets)
- Joint water and electric utility demand management programs (e.g., devices, incentives, energy and water efficiency programs, joint metering, customer awareness programs)
- Programs focused on expanding renewable energy generation (e.g., solar, wind, biogas, etc.)
- Broader water and energy allocation and accounting rules and methodologies (e.g., net metering rules, shared cost recovery, cost shifting, rebates and credits)
- Joint water and electric utility investments in alternatives to potable water for industry, irrigation, and electric power cooling
- Implementing a regional water and electric coordinating body and process
- Joint water and electric utility programs on internal water & energy reduction (e.g., leak management, transmission loss reduction)
- Integrated Land Use Planning programs in cities and regions
- Public education of the energy embedded in water, and the water embedded in energy
- Professional education of the energy embedded in water, and the water embedded in energy

Listing of WEUIP Benefits

Similar benefits across literature, the WEUIP tournament, and case studies formed the list of benefits assessed in the industry survey. These benefits are listed below:

- Increases data availability through integrated billing and customer metering
- Incentivizes transition to renewable energy systems
- Provides water and energy savings
- Provides cost savings (e.g., through shared infrastructure, joint efficiency programs, common metering)
- Enhances utility system resiliency and response to uncertainties
- Improves environmental management through a total system view of the environment and its resources
- Reduces points of system weakness and risk of failure
- Provides cross training of water and electric utility staff
- Increases utility financial stability
- Enhances communication among water and electric sector professionals
- Improves service delivery

- Increases utility accountability to the public

Listing of WEUIP Needs

Specific needs (or changes to the water and electric utility sector) were identified at the WEUIP Tournament. These benefits are listed below:

- Need to identify specific areas where there is overlap of water and electric utility jurisdiction and interest
- Need to present a joint community agenda identifying prospective opportunities for collaboration on capital improvement projects
- Need to develop joint accounting methodologies to expose and plan for unexpected expenditures
- Need to recognize wastewater generated electricity as renewable
- Need to expand and revise political dimensions governing water and electric utilities
- Need to support formal joint trade relationships between water and electric industry associations
- Need to allow alternative cost accounting and cost effectiveness frameworks such as Triple Bottom Line in regulatory rate and planning review
- Need to develop consistent and comparable methods for measuring embedded water and energy
- Need to develop methods for joint facility management, land use planning, and new development permitting
- Need to create regulatory structures that provide incentives for investing in water and energy efficiencies
- Need to incentivize the relationship between water and electric utilities through funding
- Need to incentivize the relationship between water and electric utilities through regulations

APPENDIX I
DETAILED SURVEY RESULTS

The questionnaire contained four sections and the following results are presented in order of the questionnaire.

- A short introduction to water and electric integrated planning and the purpose of the survey
- Questions about the respondent's organization, location, and sector to assist in segmenting responses
- A section for utilities only and includes a question about the utility's systems to assist in segmenting responses (e.g., raw water transmission, etc.)
- A section with questions on validating themes pulled from literature, case studies, and the WEUIP Tournament

RESPONDENT DETAILS

Question: What Best Describes Your Organization?

To categorize respondents' organizations, the researchers asked respondents to select their organization from one of the organizations listed in Table I.1 and Figure I.1. The majority of respondents (59.6%) represented water and electric utilities. Research Organizations represented the second most frequent response indicated by respondents (13.1%).

Table I.1
Respondents' organization

Organization	Frequency (%)
Electric Utility	22.6
Joint Water and Wastewater Utility	15.5
Water Utility	14.3
Research Organization	13.1
Consulting or other Professional Agency	9.5
Government Agency	7.1
Educational Institution	6.0
Joint Water (and/or Wastewater) and Electric Utility	3.6
Wastewater Utility	3.6
Non-Government Agency	2.4
Other	2.4

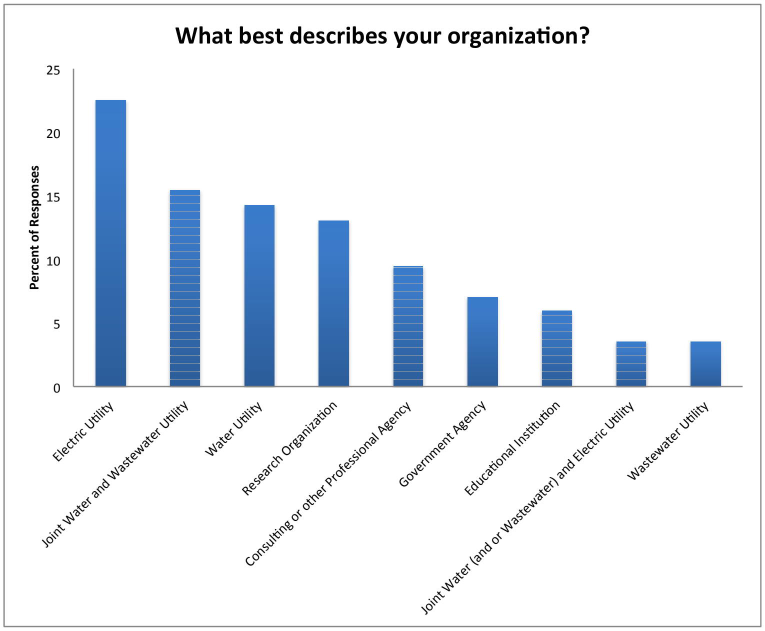


Figure I.1 Respondents' organization

Which of the Following Service Functions Does Your Utility Provide or Manage?

For utility organizations, the researchers further asked respondents to indicate which service functions their utility provides from those indicated in Table I.2 and Figure I.2. Water treatment was the largest represented function, followed by treated water retail and electric power generation.

Table I.2
Utility service functions represented by respondents

Utility Service Functions	Frequency (#)
Water treatment	25
Treated water retail (end customer)	23
Electric power generation	22
Wastewater collection	21
Wastewater treatment	21
Electric power transmission	17
Electric power distribution	17
Electric power retail (end customer)	17
Raw water supply	16
Treated water wholesale	15
Water reuse	15
Electric power wholesale	14
Raw water transmission	13
Stormwater collection	10
Stormwater treatment	6

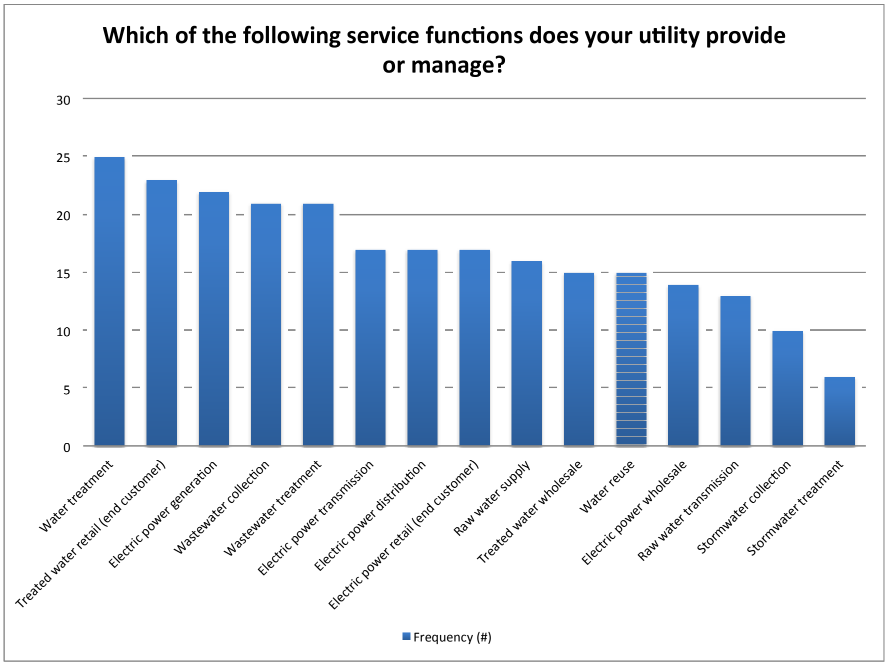


Figure I.2 Utility service functions represented by respondents

Question: How Many People Does Your Utility Serve?

The questionnaire asked 63 utility respondents (59.6% of total respondents) to indicate how many people their utility served. Table I.3 and Figure I.3 indicate that near half of the utility respondents (51.0%) serve populations greater than 1,000,000.

Table I.3
Population served by utility respondents

People served	Frequency (%)
3,301 to 10,000	8.2
10,001 to 100,000	6.1
100,001 to 500,000	18.4
500,001 to 1,000,000	16.3
More than 1,000,000	51.0

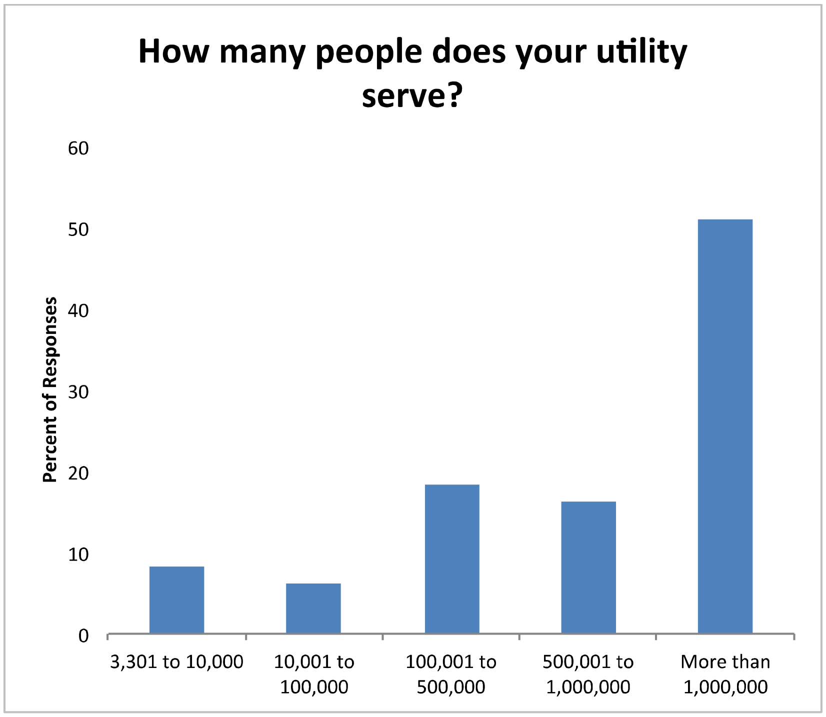


Figure I.3 Population served by utility respondents

Question: Which of the Following (Water, Electric, or Both), Best Describes Your Primary Work Focus?

For 41 non-utility organizations the questionnaire asked respondents to indicate their primary work focus. Table I.4 and Figure I.4 indicate that the majority (75%) of non-utility respondents represent the water/wastewater sector.

Table I.4
Non-utility respondents' sector focus

Primary Work Focus	Frequency (%)
Water/Wastewater	75.0
Electric	3.6
Equally both Water/Wastewater and Electric	3.6
Other	17.9

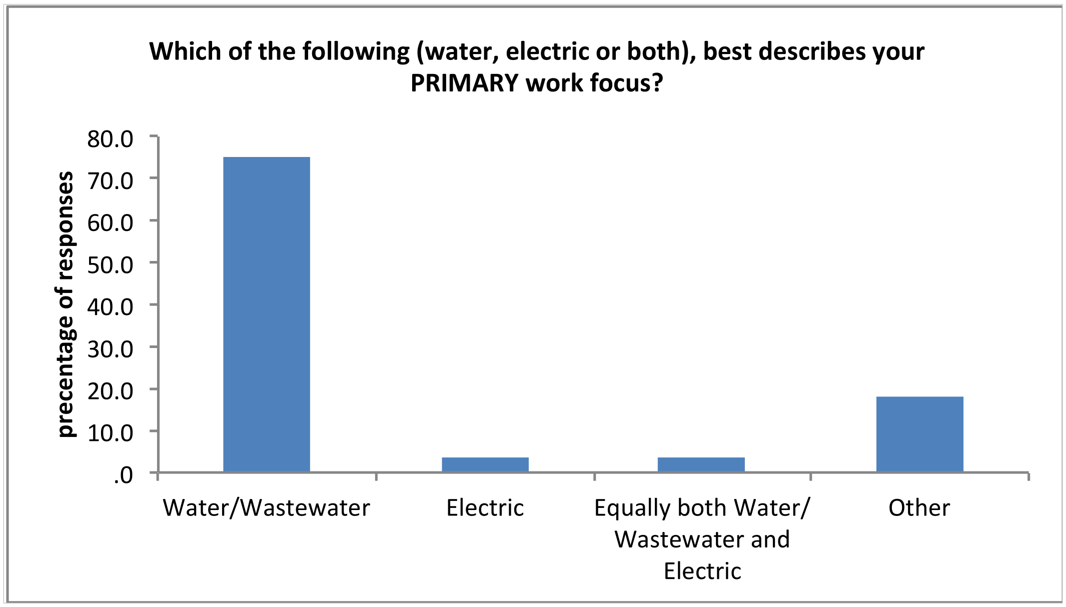


Figure I.4 Non-utility respondents' sector focus

WATER AND ELECTRIC UTILITY INTEGRATED PLANNING AND MANAGEMENT OVERVIEW

Question: Choosing Only One Area, Which of the Above Areas Represents the Greatest Opportunity for Water and Electric Utility Integrated Planning?

In order to examine overall belief in the opportunities for water and electric utility integrated planning, the questionnaire asked respondents to indicate which of the three areas indicated in Table I.5 and Figure I.5 represents the greatest opportunity. Retail, or end user management, was identified as the greatest opportunity (48.8%), yet energy generation represented a strong second option for 37.5% of respondents.

Table I.5
Respondents' perception of the greatest opportunity for WEUIP

Greatest Opportunity for water and electric utility integrated planning	Frequency (%)
retail, or end user management	48.8
energy generation	37.5
reduction in water use for electric power cooling	13.8

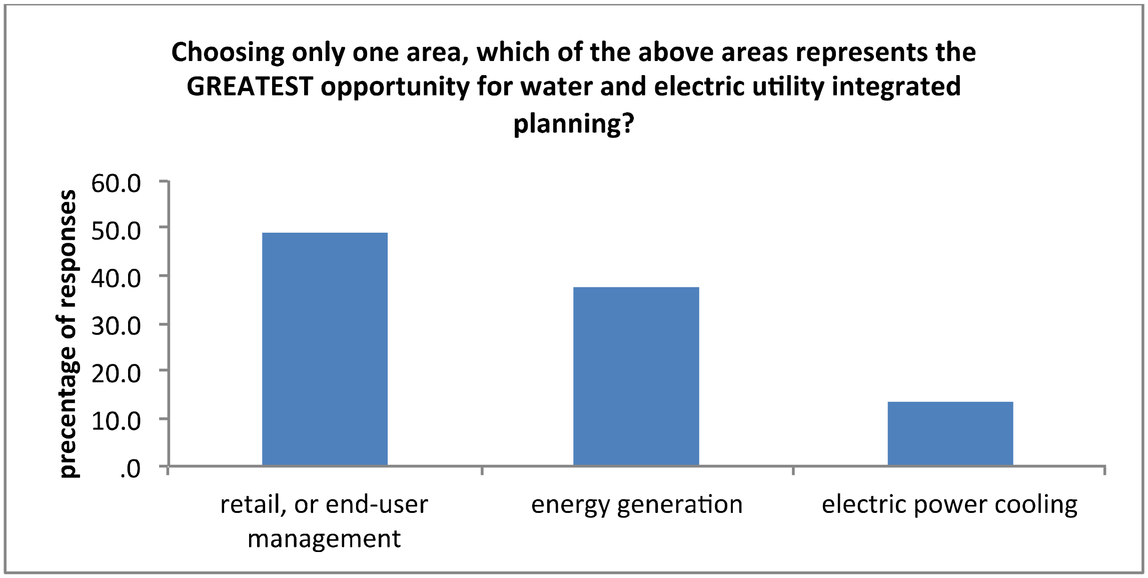


Figure I.5 Respondents' perception of the greatest opportunity for WEUIP

OPINIONS ON THE BENEFITS OF WATER AND ELECTRIC UTILITY INTEGRATED PLANNING

Question: To What Extent Do You Agree That the Following Are Benefits of Water and Electric Utility Integrated Planning?

Respondents were asked to what extent they agree or disagree with the statements in Figure I.6 and Table I.6 about the benefits of water and electric utility integrated planning. The question asked respondents to select if they "strongly agree," "agree," "neither agree nor disagree," "disagree," or "strongly disagree." There was significant agreement with all statements except the statement "increases utility accountability to the public" where only 47.8 % of respondents strongly agreed or agreed with the statement, instead showing neutral opinions (42.1%). Respondents indicated strong disagreement with just the statements "incentivizes transition to renewable energy systems" (2.9%), "enhances utility system resiliency and response to uncertainties" (4.3%), and "increases utility financial stability" (1.4%). Respondents were most likely to agree with the statement of the benefits "provides water and energy savings" (88.6% net agreement) and "enhances communication among water and electric sector professionals" (87.1% net agreement).

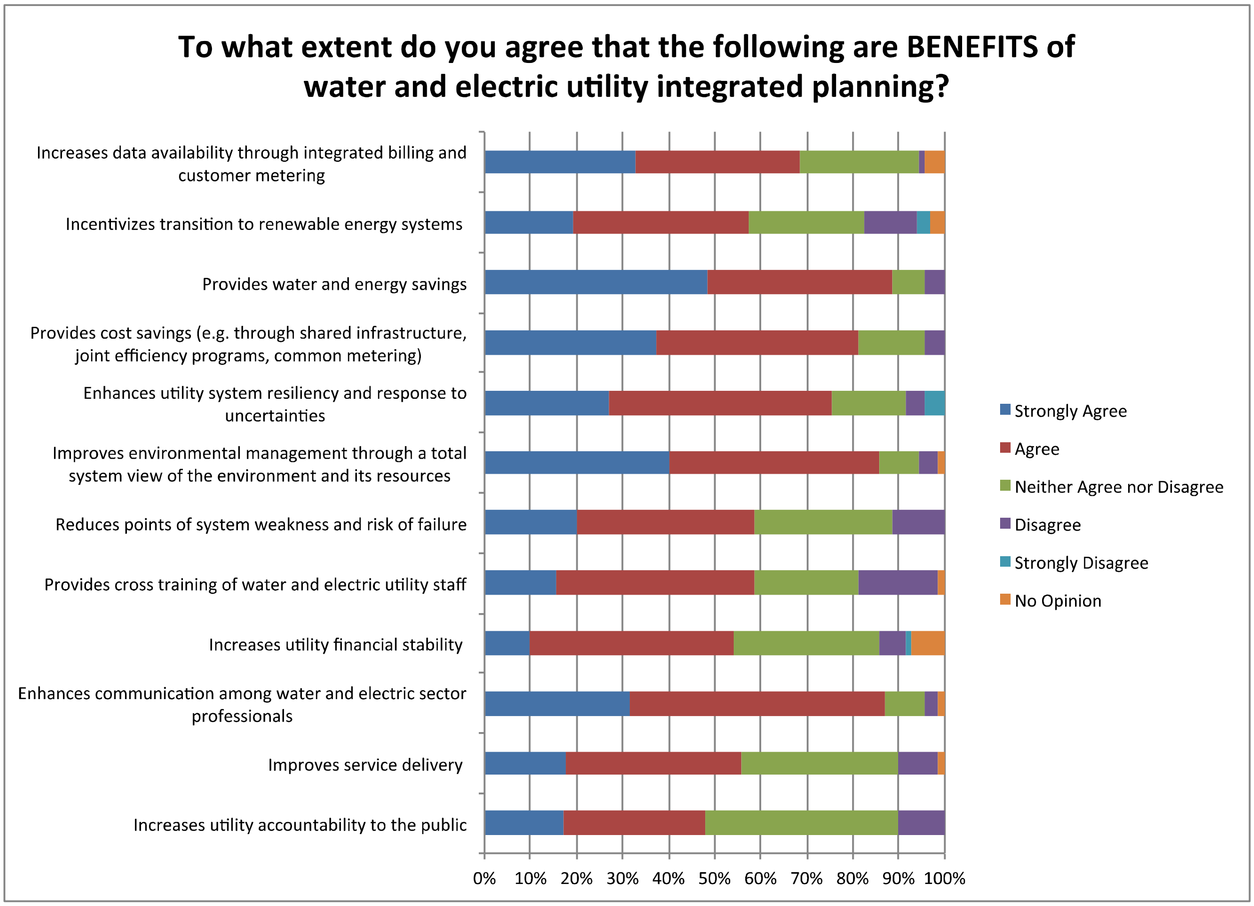


Figure I.6 Respondents' beliefs about benefits of WEUIP

Table I.6
Respondents' beliefs about benefits of WEUIP

	Strongly Agree (%)	Agree (%)	Neither Agree nor Disagree (%)	Disagree (%)	Strongly Disagree (%)	No Opinion (%)
Increases data availability through integrated billing and customer metering	32.9	35.7	25.7	1.4	0.0	4.3
Incentivizes transition to renewable energy systems	19.1	38.2	25.0	11.8	2.9	2.9
Provides water and energy savings	48.6	40.0	7.1	4.3	0.0	0.0
Provides cost savings *e.g., through shared infrastructure, joint efficiency programs, common metering*	37.1	44.3	14.3	4.3	.0	.0
Enhances utility system resiliency and response to uncertainties	27.1	48.6	15.7	4.3	4.3	.0
Improves environmental management through a total system view of the environment and its resources	40.0	45.7	8.6	4.3	.0	1.4
Reduces points of system weakness and risk of failure	20.0	38.6	30.0	11.4	.0	.0
Provides cross training of water and electric utility staff	15.7	42.9	22.9	17.1	.0	1.4
Increases utility financial stability	10.0	44.3	31.4	5.7	1.4	7.1
Enhances communication among water and electric sector professionals	31.4	55.7	8.6	2.9	.0	1.4
Improves service delivery	17.6	38.2	33.8	8.8	.0	1.5
Increases utility accountability to the public	17.4	30.4	42.0	10.1	.0	.0

OPINIONS ON WATER AND ELECTRIC INTEGRATED PLANNING INITIATIVES

Question: On a Scale of 1 – 5, To What Extent Do You Believe the Following Initiatives Have Potential to Support Progress Toward Water and Electric Utility Integrated Planning and Realize Benefits?

Respondents were asked to rank the initiatives, identified previously from literature, case studies, and following outcomes of a WEUIP Tournament, listed in Figure I.7 and Table I.7 on the potential they believe the initiatives would support progress toward WEUIP and realize benefits, including those previously provided. Respondents indicated high potential for “Joint water and electric utility operations planning” (mean 4.12) and “Joint water and electric utility demand management programs” (mean 4.04). While respondents indicated that all initiatives had potential, the initiative with the least potential was “Programs focused on expanding renewable energy generation (e.g., solar, wind, biogas, etc.)” (mean 3.54).

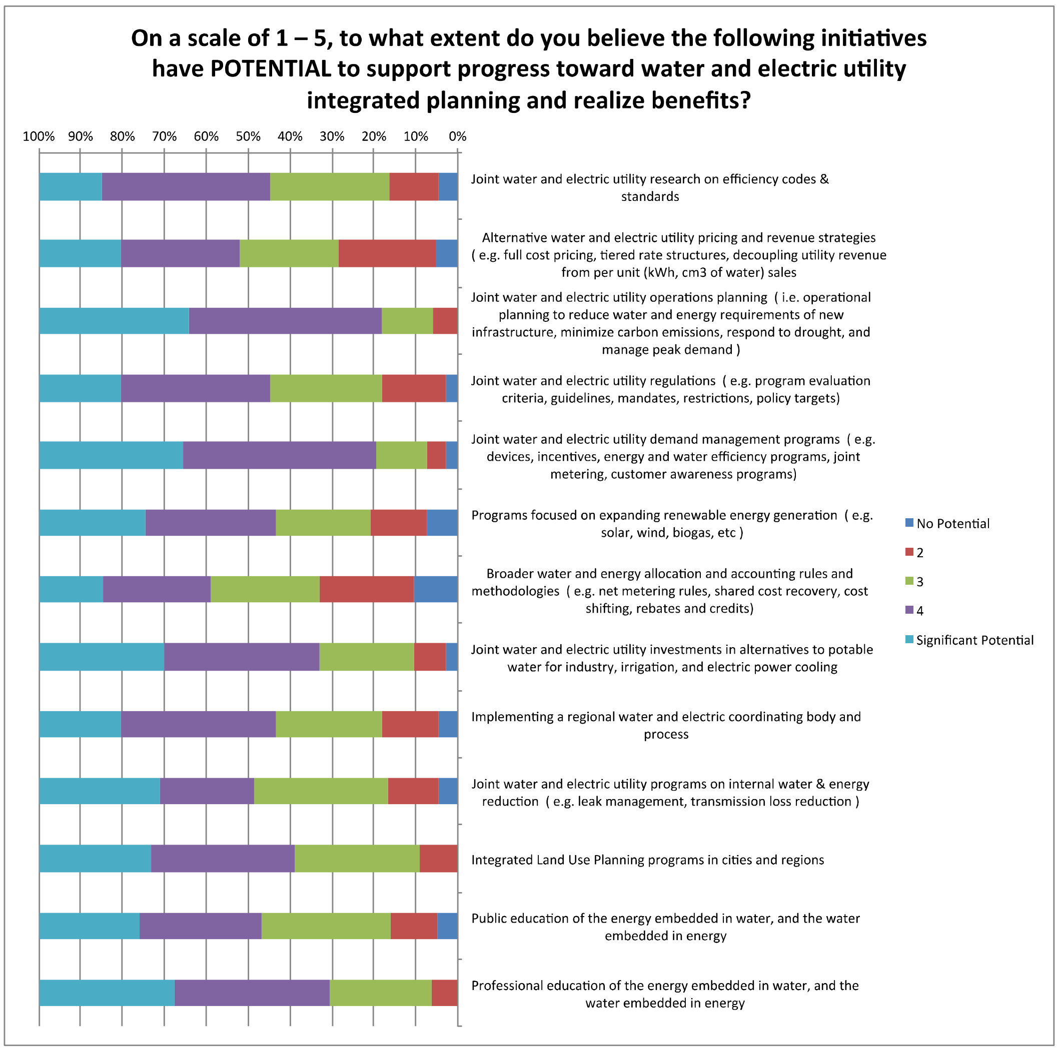


Figure I.7 Respondents' estimate of potential for WEUIP initiatives to realize benefits

Table I.7
Respondents' estimate of potential for WEUIP initiatives to realize benefits

	1 (No Potential) (%)	2 (%)	3 (%)	4 (%)	5 (Significant Potential) (%)	Mean
Joint water and electric utility research on efficiency codes & standards	4.5	11.9	28.4	40.3	14.9	3.49
Alternative water and electric utility pricing and revenue strategies (e.g., full cost pricing, tiered rate structures, decoupling utility revenue from per unit (kWh, cm3 of water) sales	6.0	11.9	26.9	32.8	22.4	3.54
Joint water and electric utility operations planning (i.e., operational planning to reduce water and energy requirements of new infrastructure, minimize carbon emissions, respond to drought, and manage peak demand)	0.0	6.0	11.9	46.3	35.8	4.12
Joint water and electric utility regulations (e.g., program evaluation criteria, guidelines, mandates, restrictions, policy targets)	3.0	14.9	26.9	35.8	19.4	3.54
Joint water and electric utility demand management programs (e.g., devices, incentives, energy and water efficiency programs, joint metering, customer awareness programs)	3.0	4.5	11.9	46.3	34.3	4.04
Programs focused on expanding renewable energy generation (e.g., solar, wind, biogas, etc.)	7.5	13.4	22.4	31.3	25.4	3.54
Broader water and energy allocation and accounting rules and methodologies (e.g., net metering rules, shared cost recovery, cost shifting, rebates and credits)	4.5	13.6	28.8	33.3	19.7	3.50
Joint water and electric utility investments in alternatives to potable water for industry, irrigation, and electric power cooling	3.0	7.5	22.4	37.3	29.9	3.84
Implementing a regional water and electric coordinating body and process	4.5	13.4	25.4	37.3	19.4	3.54

(continued)

Table I.7 (Continued)

	1 (No Potential) (%)	2 (%)	3 (%)	4 (%)	5 (Significant Potential) (%)	Mean
Joint water and electric utility programs on internal water & energy reduction (e.g., leak management, transmission loss reduction)	4.5	12.1	31.8	22.7	28.8	3.59
Integrated Land Use Planning programs in cities and regions	0.0	9.0	29.9	34.3	26.9	3.79
Public education of the energy embedded in water, and the water embedded in energy	4.8	11.3	30.6	29.0	24.2	3.56
Professional education of the energy embedded in water, and the water embedded in energy	0.0	6.5	24.2	37.1	32.3	3.95

Question: Given The Same Initiatives, on a Scale of 1 - 5 How Significant a Level of Effort Do You Think is Needed for The Initiative to Influence Progress Toward Water and Electric Utility Integrated Planning and Realize Benefits?

Respondents were then asked to rank the initiatives on the level of effort they believe is needed for the initiatives to support progress toward WEUIP and realize benefits. Figure I.8 and Table I.8 illustrate respondents' beliefs. Respondents indicated that many initiatives would require effort including significant effort for "Joint water and electric utility regulations" (mean 4.15) and "Implementing a regional water and electric coordinating body and process" (mean 4.0). The initiative that respondents felt would require the least effort was "Professional education of the energy embedded in water, and the water embedded in energy" (mean 2.79).

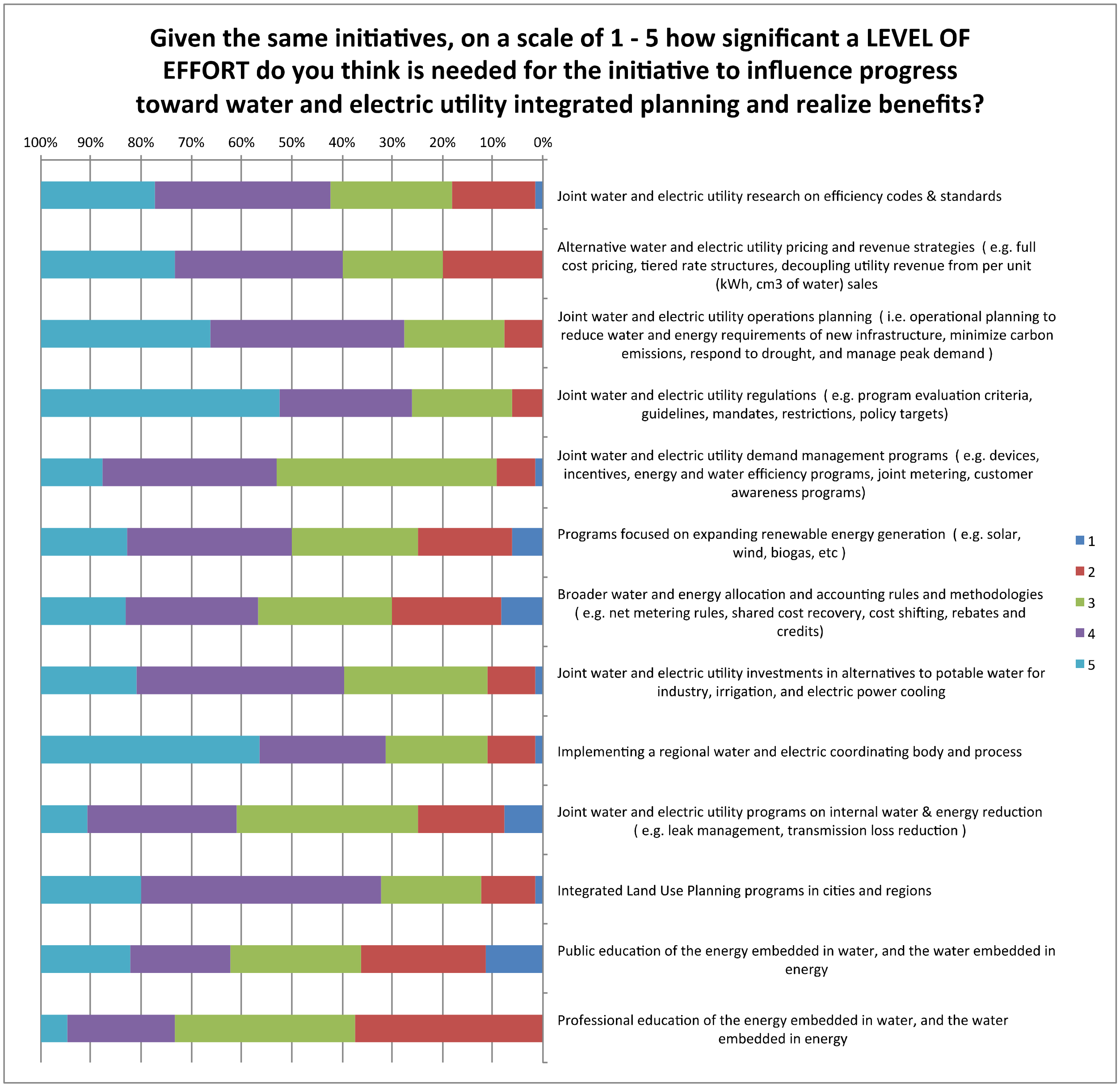


Figure I.8 Respondents' estimate of the level of effort for WEUIP initiatives to realize benefits

Table I.8
Respondents' estimate of level of effort for WEUIP initiatives to realize benefits

	1 (Little or No Effort) (%)	2 (%)	3 (%)	4 (%)	5 (Significant Effort) (%)	Mean
Joint water and electric utility research on efficiency codes & standards	1.5	16.7	24.2	34.8	22.7	3.61
Alternative water and electric utility pricing and revenue strategies (e.g., full cost pricing, tiered rate structures, decoupling utility revenue from per unit (kWh, cm3 of water) sales	0.0	9.1	22.7	37.9	30.3	3.89
Joint water and electric utility operations planning (i.e., operational planning to reduce water and energy requirements of new infrastructure, minimize carbon emissions, respond to drought, and manage peak demand)	0.0	7.7	20.0	38.5	33.8	3.98
Joint water and electric utility regulations (e.g., program evaluation criteria, guidelines, mandates, restrictions, policy targets)	0.0	6.2	20.0	26.2	47.7	4.15
Joint water and electric utility demand management programs (e.g., devices, incentives, energy and water efficiency programs, joint metering, customer awareness programs)	1.6	7.8	43.8	34.4	12.5	3.48
Programs focused on expanding renewable energy generation (e.g., solar, wind, biogas, etc.)	6.3	18.8	25.0	32.8	17.2	3.36
Broader water and energy allocation and accounting rules and methodologies (e.g., net metering rules, shared cost recovery, cost shifting, rebates and credits)	4.7	10.9	28.1	34.4	21.9	3.58

(continued)

Table I.8 (Continued)

	1 (Little or No Effort) (%)	2 (%)	3 (%)	4 (%)	5 (Significant Effort) (%)	Mean
Joint water and electric utility investments in alternatives to potable water for industry, irrigation, and electric power cooling	1.6	9.5	28.6	41.3	19.0	3.67
Implementing a regional water and electric coordinating body and process	1.6	9.4	20.3	25.0	43.8	4.00
Joint water and electric utility programs on internal water & energy reduction (e.g., leak management, transmission loss reduction)	7.8	17.2	35.9	29.7	9.4	3.16
Integrated Land Use Planning programs in cities and regions	1.5	10.8	20.0	47.7	20.0	3.74
Public education of the energy embedded in water, and the water embedded in energy	11.5	24.6	26.2	19.7	18.0	3.08
Professional education of the energy embedded in water, and the water embedded in energy	8.2	34.4	32.8	19.7	4.9	2.79

OPINIONS ON THE NEEDS OF WATER AND ELECTRIC UTILITY INTEGRATED PLANNING

Question: On a Scale of 1 – 5, to What Extent Do You Believe the Following Needs Are Important to Progress Water and Electric Utility Integrated Planning?

The final question asked respondents to consider NEEDS in the water and electric utility sector that would be required to progress WEUIP. Figure I.9 and Table I.9 present respondents' responses and ranking of importance. Respondents indicated high importance (mean > 3) for all NEEDS but indicated significant importance to "create regulatory structures that provide incentives for investing in water and energy efficiencies" (mean 4.12) and to "identify specific areas where there is overlap of water and electric utility jurisdiction and interest" (mean 4.03). Least important among the needs, just still considered important, was to "develop joint accounting methodologies to expose and plan for unexpected expenditures."

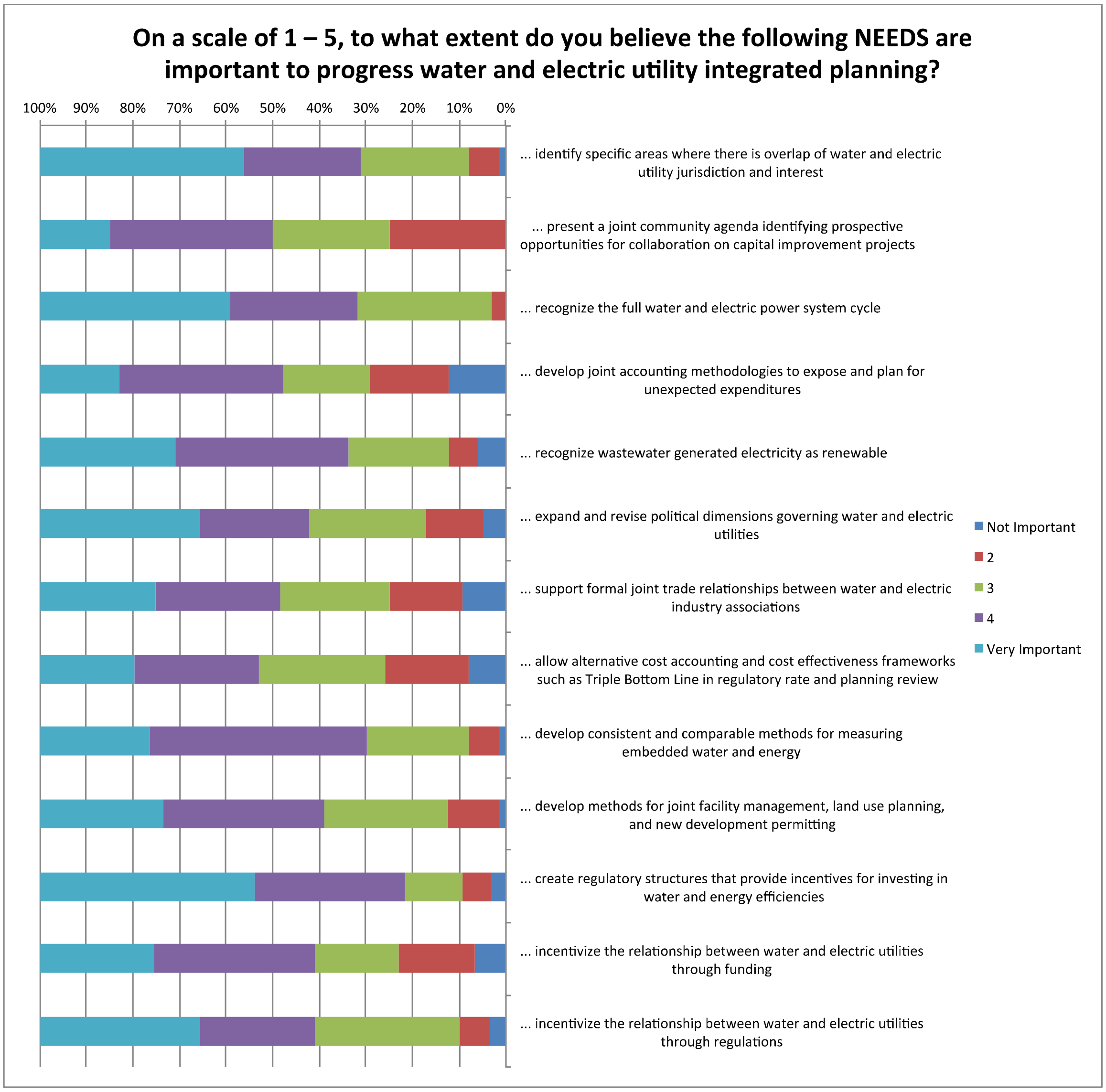


Figure I.9 Respondents' estimate of the importance for needs to progress WEUIP

Table I.9
Respondents' estimate of the importance for needs to progress WEUIP

	1 (Not important) (%)	2 (%)	3 (%)	4 (%)	5 (Very Important) (%)	Mean
... create regulatory structures that provide incentives for investing in water and energy efficiencies	3.1	6.2	12.3	32.3	46.2	4.12
... identify specific areas where there is overlap of water and electric utility jurisdiction and interest	1.6	6.3	23.4	25.0	43.8	4.03
... develop consistent and comparable methods for measuring embedded water and energy	1.6	6.3	21.9	46.9	23.4	3.84
... allow alternative cost accounting and cost effectiveness frameworks such as Triple Bottom Line in regulatory rate and planning review	0.0	10.8	24.6	36.9	27.7	3.82
... incentivize the relationship between water and electric utilities through regulations	3.3	6.6	31.1	24.6	34.4	3.80
... recognize wastewater generated electricity as renewable	6.2	6.2	21.5	36.9	29.2	3.77
... develop methods for joint facility management, land use planning, and new development permitting	1.6	10.9	26.6	34.4	26.6	3.73
... expand and revise political dimensions governing water and electric utilities	4.7	12.5	25.0	23.4	34.4	3.70
... present a joint community agenda identifying prospective opportunities for collaboration on capital improvement projects	0.0	14.3	28.6	39.7	17.5	3.60
... incentivize the relationship between water and electric utilities through funding	6.6	16.4	18.0	34.4	24.6	3.54
... support formal joint trade relationships between water and electric industry associations	9.4	15.6	23.4	26.6	25.0	3.42
... develop joint accounting methodologies to expose and plan for unexpected expenditures	12.3	16.9	18.5	35.4	16.9	3.28

DIFFERENCES BY CLASS

One-way ANOVA Kruskal Wallis H, and Pearson Chi-Square tests were performed on the survey data to determine differences in responses by utility size (see Figure I.10), sector focus (water or energy – see Figure I.11 and Figure I.14) and organization type (utility or non-utility).

Statistically significant differences at the 95% confidence level are reported. A Kruskal Wallis H test did not reveal a statistically significant difference between respondents categorized by sector focus use or organization type, however a chi-squared test of independence did reveal a relationship between utility size, sector focus and organization type for benefit perceptions, potentials, and efforts for WEUIP initiatives. These differences are reported in the following section.

Differences in Benefit Perceptions by Utility Size and Sector Focus

The relationship between utility size was significant for the benefits "Increases utility financial stability" (FinStability), and "Improves environmental management through a total system view of the environment and its resources" (ENVMGMT). Smaller utilities and larger utilities are more likely to perceive that WEUIP would lead to improving environmental management, whereas they were less likely to perceive WEUIP leading to increasing financial stability (see Figure I.10).

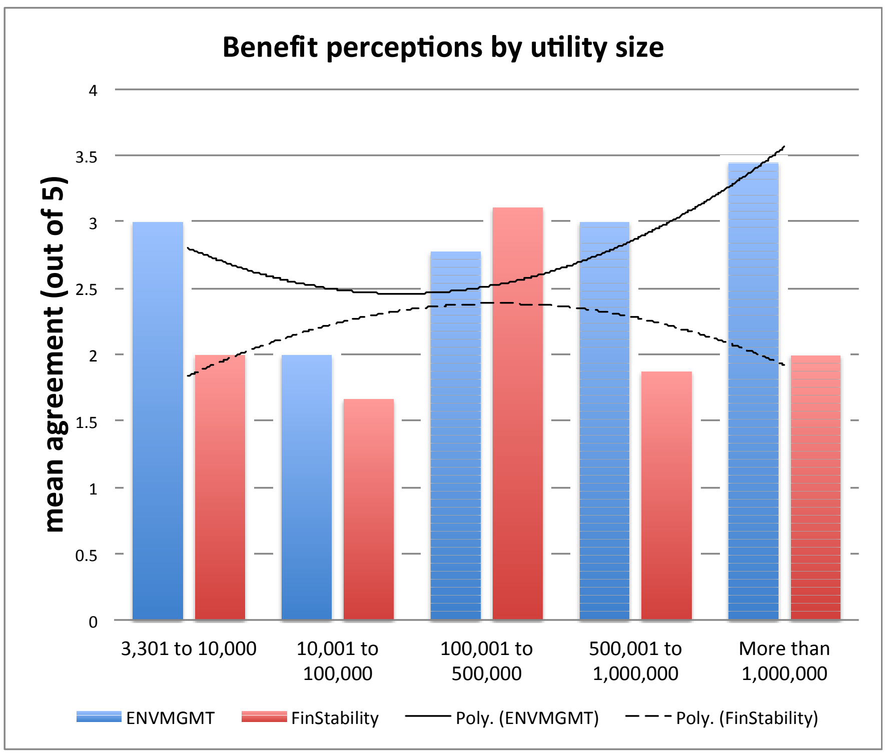


Figure I.10 Benefit perceptions by utility size, significant benefits only

The relationship was also significant between sector class and the benefit "increases data availability through integrated billing and customer metering" (see Figure I.11).

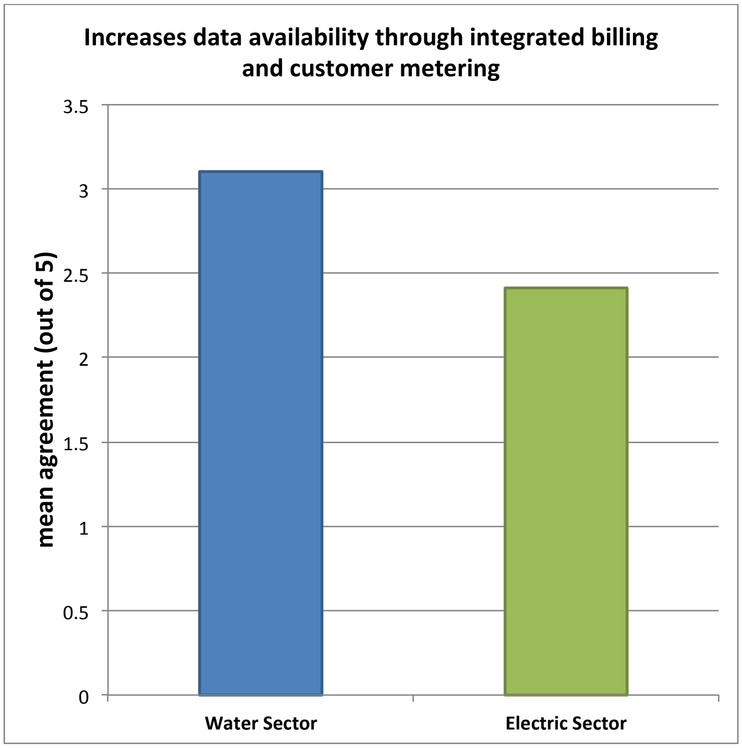


Figure I.11 Differences in perception of benefit of integrated customer billing by sector

Differences in Potential Perceptions by Utility Size and Sector Focus

The relationship between utility size was significant for the measurements of "potential for implementing a regional water and electric coordinating body and process." Smaller utilities and larger utilities were more likely to perceive greater potential that implementing a regional coordinating body would facilitate more WEUIP activities (see Figure I.12). The relationship between sector focus was significant for the measurements of potential of "joint water and electric utility demand management programs", and "implementing a regional water and electric coordinating body and process." Individuals in the water sector are more likely to perceive greater potential that joint water and electric utility demand management programs would facilitate more WEUIP activities (see Figure I.13). Whereas individuals in the electric sector are more likely to perceive greater potential that implementing a regional water and electric coordinating body and process would facilitate more WEUIP activities (see Figure I.14).

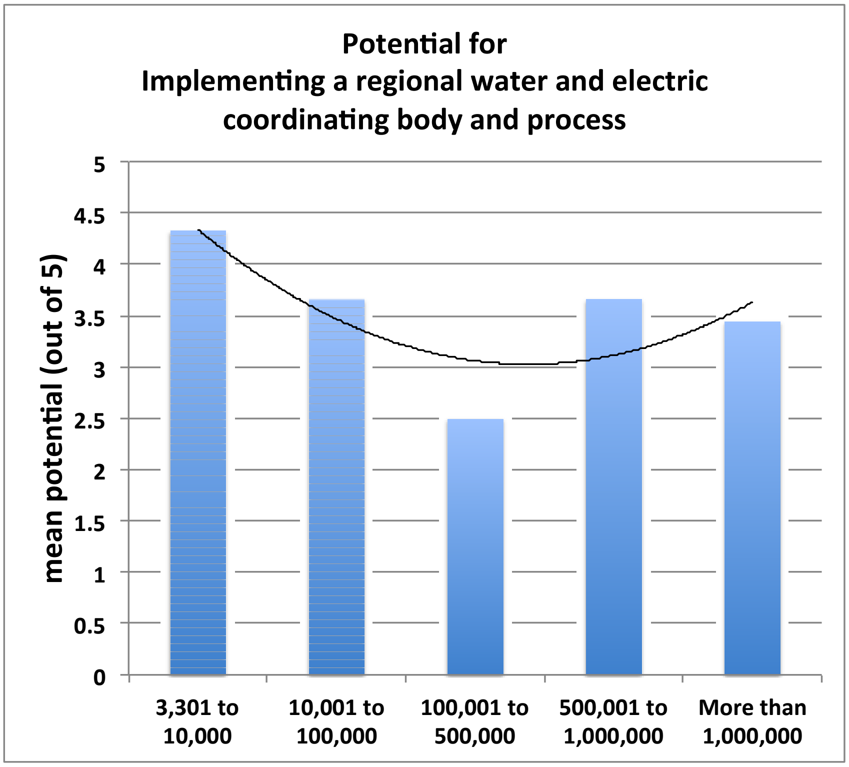


Figure I.12 Differences in potential perceptions by utility size

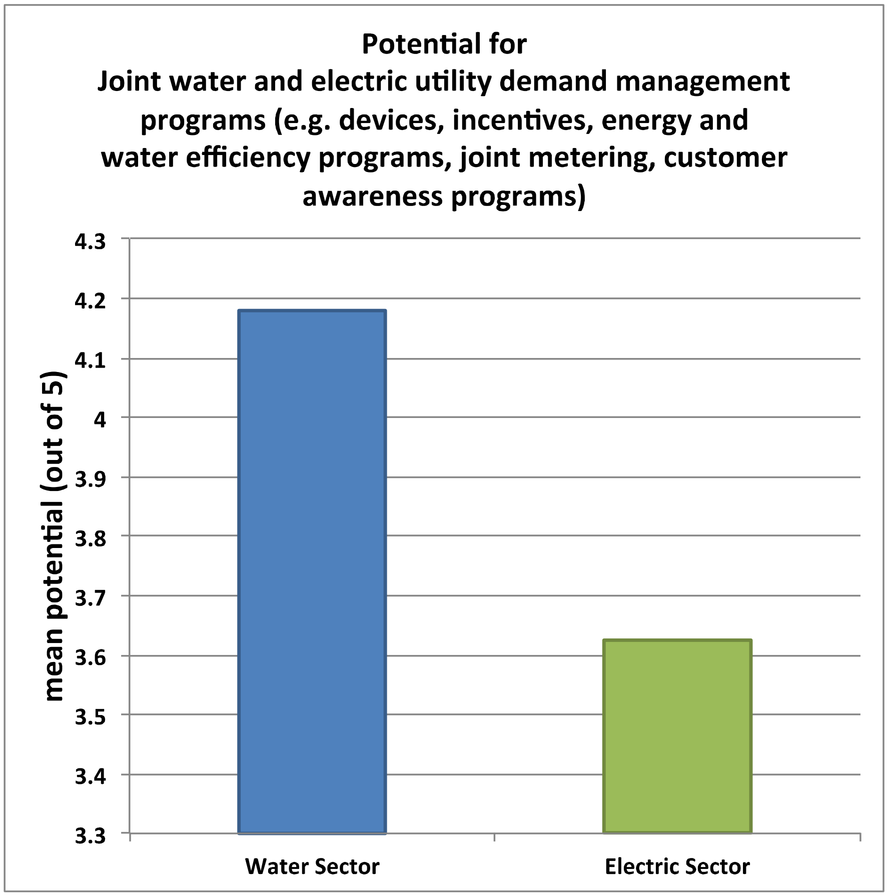


Figure I.13 Differences in demand management programs potential perceptions by sector focus

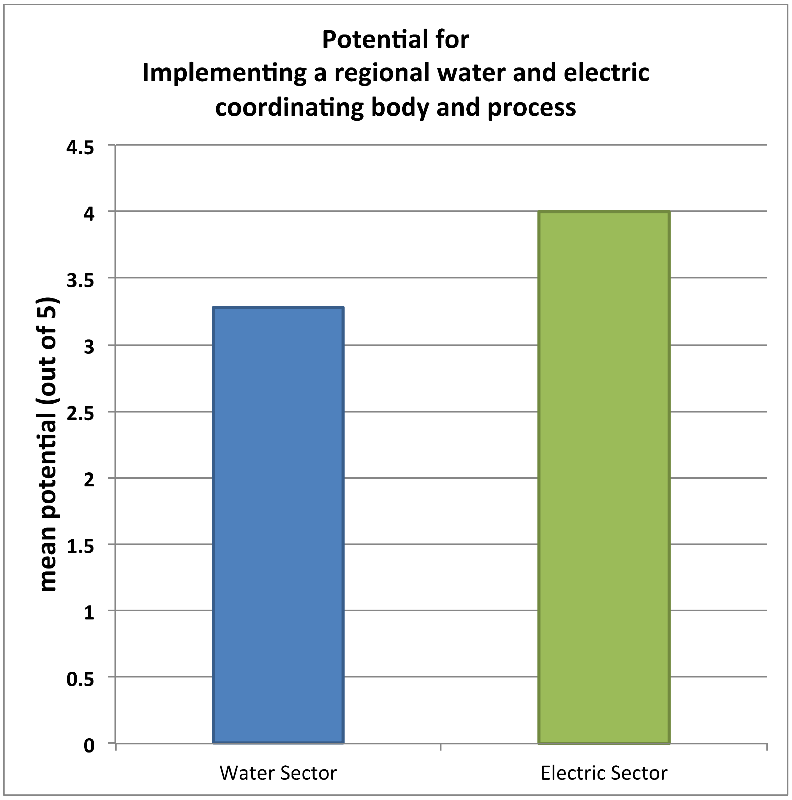


Figure I.14 Differences in regional coordinating potential perceptions by sector focus

Differences in Level of Effort Perceptions by Sector Focus and Organization Type

The relationship between sector class and organization type (utility vs. non-utility professionals) was significant for the measurements of Level of Effort of "joint water and electric utility programs on internal water & energy reduction" and "professional education of the energy embedded in water, and the water embedded in energy." Electric sector professionals were more likely to perceive a greater level of effort required for joint water and electric utility programs on internal water and energy reduction (see Figure I.15) and professional education of the embedded water and energy vis-a-vi each system (see Figure I.16). Utility professionals were also more likely (than non-utility professionals) to perceive a greater level of effort required for professional education of the embedded water and energy (see Figure I.17).

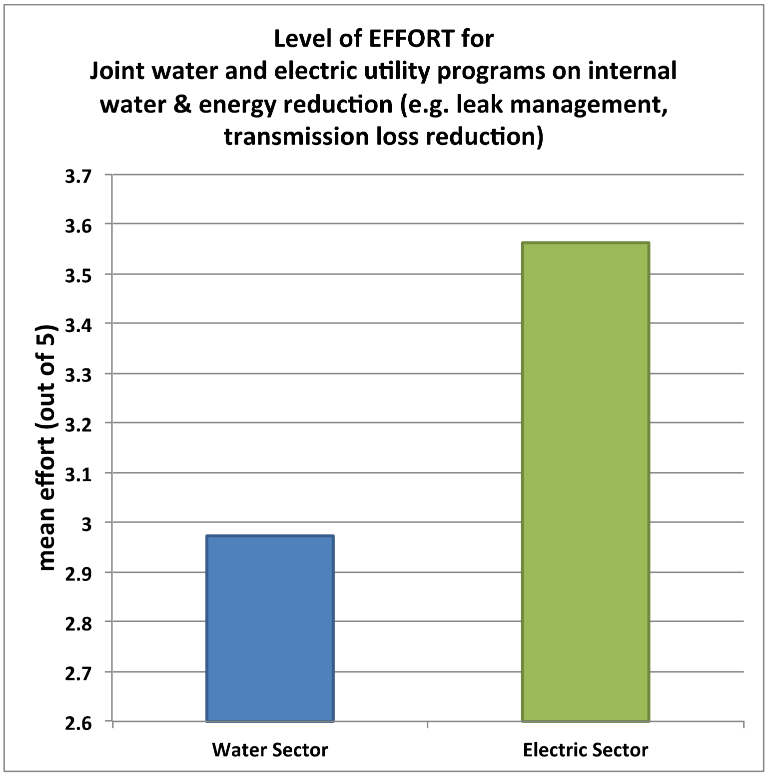


Figure I.15 Differences in level of effort perceptions for internal efficiency programs by sector focus

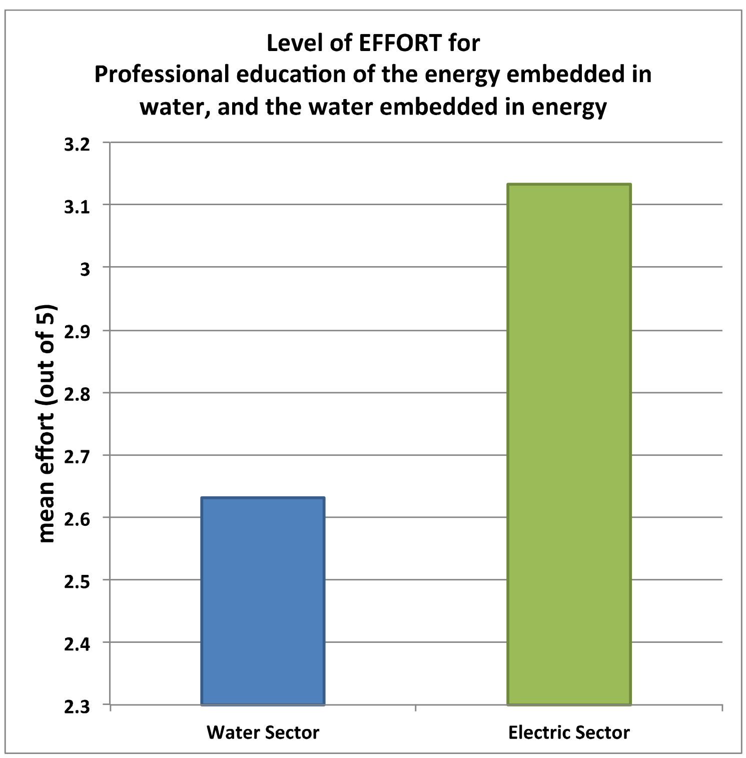


Figure I.16 Differences in level of effort for professional education perceptions by sector focus

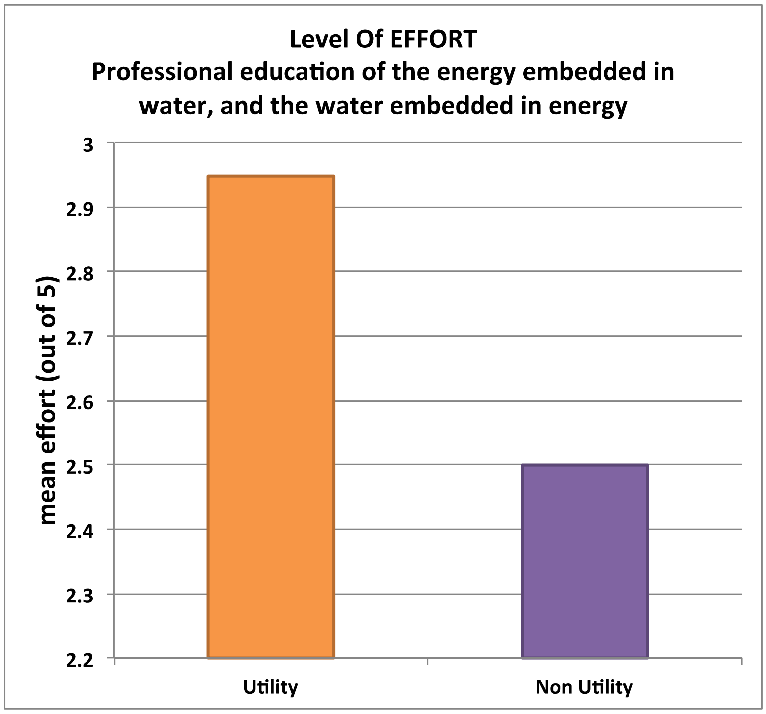


Figure I.17 Differences in level of effort for professional education perceptions by utility vs. non-utility respondents

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ABBREVIATIONS

ACEEE	American Council for Energy-Efficient Economy
AF	Acre-Foot
AFY	Acre-Foot per Year
AIG	Australian Industry Group
ASR	Aquifer Storage and Recovery
AUD	Australian Dollar
AW4E	Alliance for Water Efficiency
AWA	Australian Water Association
AWWA	American Water Works Association
BCA	Building Code of Australia
BMP	Best Management Practices
BREP	Business Resource Efficiency Program
CAD	Canadian Dollar
CEC	California Energy Commission
CFCs	chlorofluorocarbon
CII	Commercial, Industrial and Institutional customers
Cmmr.	Commissioner
CO2	Carbon Dioxide
CPUC	California Public Utility Commission
CRA	Colorado River Aqueduct
CRC	Cooperative Research Center
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSP	Concentrating Solar Power
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project
CWW	City West Water
DEWS	Queensland Department of Energy and Water Supply
DMM	Demand Management Measures
DR	Demand Response
DRED	Demand Response Enabling Devices
DRIM	Demand Reduction Incentive Map
DWC	Deep Lake Water Cooling
DWMP	Drinking Water Management Plan
DWR	Department of Water Resources
ED-5	State of California Executive Directive No 5
EE	Energy Efficiency
EI	Energy Intensity
ENVMGMT	Environmental management
EPA	United States Environmental Protection Agency
EUP	Electric Utility Planning

EWQMS	Energy Water Quality Management System
FCNEU	False Creek Neighborhood Energy Utility
FERC	United States Federal Energy Regulatory Commission
FinStability	financial stability
FTE	Full Time Equivalent
FY	Fiscal Year
GCAP	Vancouver Greenest City 2020 Action Plan
GHG	Greenhouse Gas
GL	Gigalitre
GVWD	Greater Vancouver Water District
GW	Ground water
GWh	Gigawatt hour
GWR	Ground Water Recharge
HET	High-Efficiency Toilets
IDT	Invitational Drought Tournament
IOU	Investor-Owned Utility
IPCC	Intergovernmental Panel on Climate Change
IRP or P-IRP	Power - Integrated Resource Plan
ISO	Independent System Operators
Km	Kilometer
kWh	Kilowatt hour
LA	Los Angeles
LADWP	Los Angeles Department of Water and Power
LCA	Life Cycle Approach/Assessment
MCDM	Multi-criteria decision making
MG	Million Gallons
MGD	Million Gallons Per Day
ML	Megalitre
MW	Megawatt
MWD	Metropolitan Water District of Southern California
MWh	Megawatt hour
MWhe	Megawatt hour electrical energy
MWhth	Megawatt hour thermal
NARUC	National Association of Regulatory Utility Commissioners
NEM	Australian National Energy Market

NEPA	National Environmental Policy Act
NER	Australian National Electricity Rules
NGO	Non-Governmental Organization
NNA	Non-Network Alternative
NPV	Net Present Values
NRDC	Natural Resources Defense Council
NY	New York
NYCDEP	New York City – Department of Environmental Protection
NYSERDA	New York State Energy Research and Development Authority
OTC	Once-Through-Cooling
PAC	Program Administrator Cost
PCG	Project Coordination Group
PGC	Public Goods Charge
PGE	Pacific Gas-Electric Company
pLAn	The Sustainable pLAn for Los Angeles
PNM	Public Service of New Mexico
POU	Publically-Owned Utility
PV	Photovoltaics
RIM	Ratepayer Impact Measure
ROI	Rate on Investment
RPS	Renewables Portfolio Standard
SB	System Boundary
SCADA	Supervisory Control and Data Acquisition
SDM	Structured Decision Making
SEQ	South East Queensland (Australia)
SFU	Simon Fraser University
SOP	Standard Operating Procedure
SPM	Standard Practice Manual
SRI	Sustainable Region Initiative
STB of AAFC	Science and Technology Branch of Agri-Food Canada
SWP	California State Water Project
TOU	Time of Use
TOO	Transmission Operations Optimizer
TRC	Total Resource Cost
UQ	University of Queensland

USD	United States Dollar
UV	Ultraviolet
VEET	Victoria's Energy Efficiency Target
VOC	Volatile Organic Compounds
WaterMAP	Water Management Action Plans
WET-CAT	California Water Energy Team of the Climate Action Team
WEUIP	Water and Electric Utility Integrated Planning
WEUIP Tournament	Water and Electric Utility Integrated Planning Tournament
WRF	Water Research Foundation
WSAA	Water Services Association of Australia
WSUD	Water Sensitive Urban Design
WUA	Albuquerque Bernalillo County Water Utility Authority
WUP	Water Utility Planning
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant
YVW	Yarra Valley Water