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Integrated Policy and Planning for Water and Energy

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Young-Doo Wang, Associate Director
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Preface

It is a pleasure to present you with this report of the 2008 Science, Engineering & Technology (SET) Services Program. The report is designed to provide the Delaware General Assembly and the citizens of this State with an overview of the efficiency and environmental benefits associated with the integration of water and energy planning.

CEEP received valuable assistance in preparing this report from many individuals in various state and local governments. In the acknowledgments section to this report, we have provided a complete listing. Here, we would like to express special thanks to a few key individuals: Gerald (Gerry) Kauffman and the staff of the Water Resources Agency, and Stewart Lovell of Delaware Department of Natural Resources and Environmental Control (DNREC), Program Manager of the Delaware Water Resources for their help with information on the water resources of Delaware. In addition, we are grateful to Mashiur Bhuiyan of Exelon Corporation for providing us with electricity data for power plants in Delaware.

We hope that this report will be useful to you in your discussions and deliberations relating to both water and energy policies in the State of Delaware.

John Byrne
Director and
Distinguished Professor

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ACKNOWLEDGMENTS

We would like to acknowledge all of the various state contacts that provided information on the status of their energy and water programs. The Center for Energy and Environmental Policy (CEEP) is solely responsible for the findings and recommendations of the report.

CEEP received invaluable support in preparing this report from many individuals in state and local governments. We are extremely grateful to the following people and organizations: Joseph Cantwell (Wisconsin); Gary Klein, Sylvia Bender, Ted Howard and Thomas Pape (California); Peter Young and Theodore Em-Po Liu (Hawaii); Michael Linder and Brian McManus (Nebraska); Judith Wilkins, Mark Harrison, Monte Elder and Seneca Scott (Oklahoma); Dub Taylor, Jorge Valle and William Mullican (Texas); Alaska's Department of Environmental Conservation, Division of Water; Arkansas' Energy Office; Colorado's Office of Energy Management and Conservation; Connecticut's Energy Conservation Management Board; Idaho Department of Water Resources; Kentucky's Division of Conservation; Louisiana's Department of Natural Resources, Energy Office; Maine Energy Resources Council; Massachusetts' Division of Energy Resources; Nevada State Office of Energy; New Hampshire Office of Energy and Planning; New Jersey's Division of Water Quality; Rhode Island's Water Resources Board; South Carolina's Natural Resources Conservation District; Tennessee's Emergency Management Agency; Utah's Division of Water Resources; Vermont's Department of Public Services; and, Virginia Department of Environmental Quality.

We hope that this report will be useful to your discussions and deliberations on the issue of water and energy supply in the State of Delaware. With an understanding of the nexus that exists between water and energy, the State can develop policies that will exploit the synergies that exist between these two sectors, resulting in significant economic, equity, and environmental benefits to Delawareans.

Executive Summary

1. Overview

Energy and water are two of the most important elements of human survival, and modern society depends upon sophisticated infrastructures for their widespread use. There is a growing concern that our society is experiencing increased chronic water and energy vulnerabilities on local, regional, national, and global scales. Some argue that we will face two crises in the 21st century: a water crisis and an energy crisis (Brown, 1998, 2003; Flavin, 1999; Feffer, 2008). Water is becoming scarce as water tables are falling because of over-consumption, and water quality is threatened by contamination. Further, the present energy regime's dependence on non-renewable sources has led to high costs and added considerable stress to the environment, including the prospect of climate change (IPCC Summary for Policymakers, 2007). If we do not improve our handling of energy and water resources, it is likely that we will hurt the ability of future generations to meet their needs.

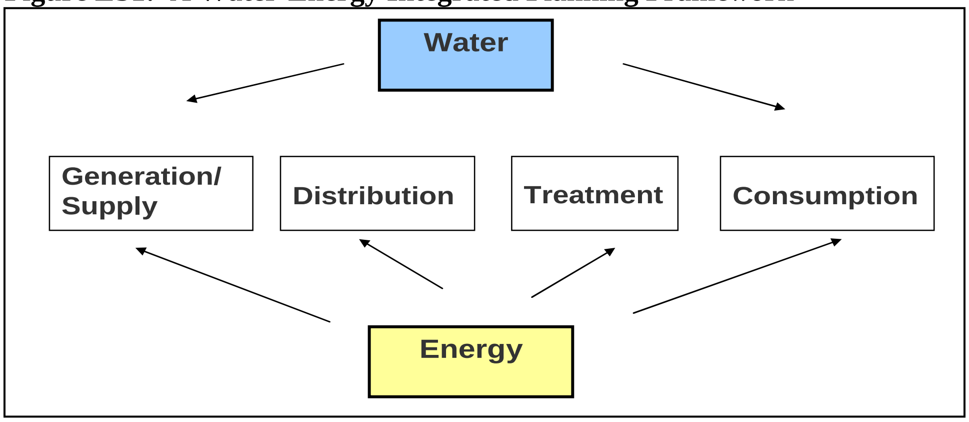
Given the present context, there is a need for a greater understanding of the energy-water linkage in order to develop more effective policies to address their mutual vulnerabilities. Approaches to resolving the issue will have to embrace concepts of integrated planning which take advantage of synergies that exist between the two sectors.

A major challenge of integrated planning is to provide sufficient clean freshwater while maintaining adequate energy supplies to sustain healthy and secure societies and ecosystems. Following the U.S. Energy Policy Act of 2005, the U.S. Department of Energy's (DOE's) national laboratories and the Electric Power Research Institute (EPRI) initiated a multi-year water-energy program that includes R&D and outreach which is expected to cost $30 million annually through 2009. This federal effort promotes an integrated planning approach through the National Energy-Water Roadmap Program led by Sandia National Laboratory. Regional workshops have been held to identify region-specific issues and needs associated with the energy and water nexus. Individual states may have to pursue similar efforts in order to address their own water-energy situations.

2. Water-Energy Integration: An E^4 Framework

A simplified schematic of the energy-water linkage can be seen in Figure ES1. The inter- and intra-sectoral interactions between water and energy are complex, but the figure illustrates the core relationships. Water use is central to energy generation and production/refining while energy utilization can impact all aspects of the water sector. For example, 19% of all energy consumed in California is attributable to the collection, extraction, conveyance, distribution, use, and treatment of water (House, 2007). Also, the production of energy from fossil fuels and nuclear power is inextricably linked to the availability of adequate and sustainable supplies of water. In the U.S., thermoelectric power generation is one of the largest users of water, accounting for 39% (135 billion gallons per day) of the total water withdrawal in 2001 (U.S. DOE, 2006). As a result of these and other linkages, there is the potential for mutual benefits to be accrued if an integrated planning approach is pursued in the management of both sectors.

Figure ES1: A Water-Energy Integrated Planning Framework



The integration of water and energy sector planning and management can have positive impacts on the economy, the environment, energy and equity (E^4). Water and energy conservation improves the balance among the E^4 elements, enhancing sustainability, particularly during drought events in urban areas (Wang et al, 2006). Many of these benefits are interlinked and depend on the extent of the implementation of integrated efficiency improvements. The framework in Figure ES2 conceptualizes the benefits of integration from economic, energy, equity and environmental (E^4) perspectives. Each of the E^4 advantages is briefly noted below.

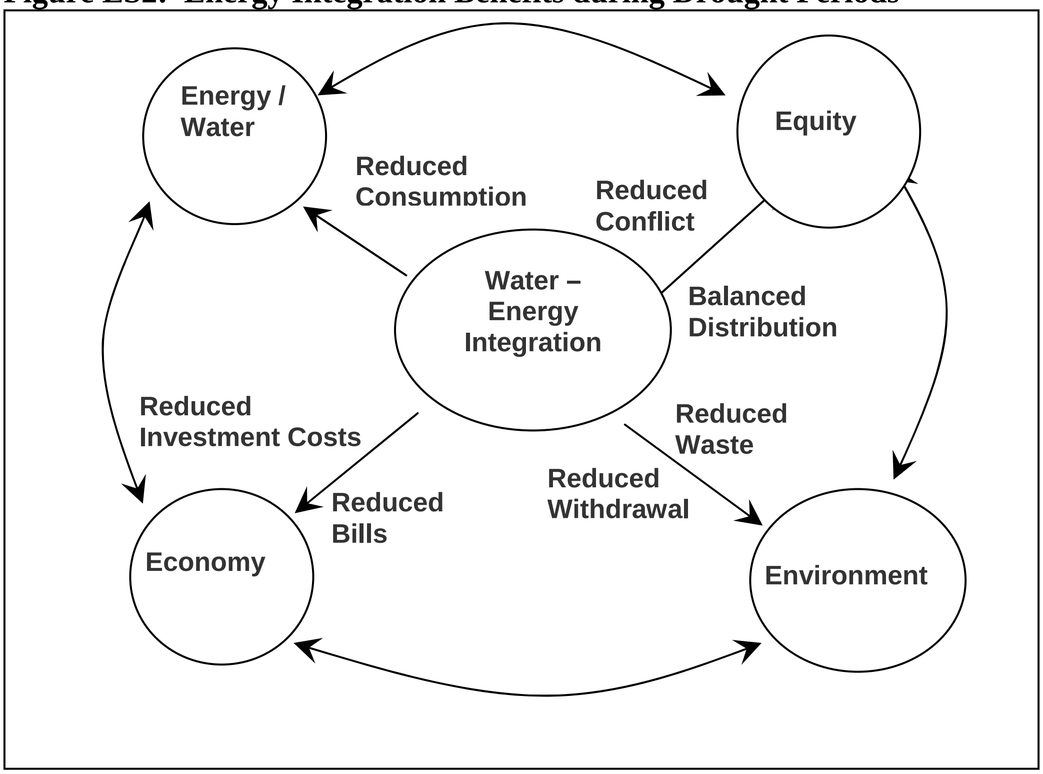
The efficient use of water and energy will result in lower utility bills and lower costs of drought management. It can also bring long-term economic benefits, such as reducing or even eliminating the need for costly supply-side or wastewater and sewage facility additions (Featherstone, 1996; U.S. EPA, 1998; Wang et al, 2004) (**Economy**).

Reduced wastage of water will lower the amount of energy that is needed to supply water. In turn, this reduction in energy use will result in decreased pollution emissions from power plants (Wang et al, 2006). Conservation measures as well as the efficient use of water will also directly benefit the environment by increasing the availability of surface and ground water for ecological functions. This would also restrict the incidence of saltwater intrusion into coastal areas (CEEP, 2001; U.S. EPA, 1999) (**Environment**).

In the U.S., approximately 4% of all electricity consumed is used to deliver water and treat wastewater (House, 2007). In California, water related energy use consumes 19% of the state's electricity, 30% of its natural gas, and 88 billion gallons of diesel fuel annually (House, 2007). When users adopt water efficient appliances, energy consumption is reduced in two ways: directly, by the appliances themselves; and indirectly, as water utilities use less energy for surface and ground water withdrawal and wastewater treatment and discharge (Cohen et al, 2004; U.S. EPA, 1998). Thus, conservation eliminates all of the “upstream” energy required to bring the water to the point of end use, as well as all of the “downstream” energy that would otherwise be spent to treat and dispose of this water (Cohen et al, 2004) (**Energy**).

Conserving water and energy increases their affordability by lowering demand relative to supply, especially during droughts (Wang et al, 2006). Successful conservation efforts will reduce conflicts over in-stream flow rights and competing uses of water, including power plants that are downstream. These kinds of conflicts are occurring with increasing frequency (Vickers, 2000) (**Equity**).

Figure ES2: Energy Integration Benefits during Drought Periods



3. National Survey

CEEP conducted a national survey of energy and water departments and discovered that only three states – California, New York, and Wisconsin – had programs explicitly addressing the water-energy nexus (Wang et al, 2007 – Appendix B). Nine states had limited programs or were part of a regional initiative focusing on the issue of water-energy interactions (Alaska, Connecticut, Hawaii, Idaho, Maine, Nebraska, Nevada, Texas and Virginia) and 11 states responded that they had no integrated energy-water programs. While no response was received from the remaining states, a search of state literature and websites suggests that none have integrated planning programs.

A principal finding of our survey of the states is the neglect of programs designed specifically to address the energy-water linkage, although there is an assortment of initiatives addressing some element of the issue. In addition, the three cases detailed in this study illustrate different approaches to integrating energy-water planning at a statewide level. It is notable that in all three states, energy-water programs were developed primarily as a result of *energy* conservation efforts.

- In the case of California, a high-level state agency – the Public Utilities Commission – used its authority to require energy utilities to work cooperatively with major water suppliers in the utilities' jurisdictions, thus creating a mandatory program for integrating these sectors. This is a pilot program and the results have not yet been demonstrated. However, this effort is only one among a wide range of strategies that the state is pursuing in order to integrate water and energy planning.

- In Wisconsin, the state adopted a voluntary energy conservation program that included drinking water and wastewater utilities. The 'Focus on Energy Program' is incentive-based, rather than regulatory, providing technical support and small grants to encourage energy efficiency. Results to date indicate that the wastewater treatment utilities have been the most receptive actors and have shown measurable energy and water savings as a result of improvements in system efficiencies.

- The state of New York administers its energy conservation programs through a state agency – the New York State Energy Research and Development Authority – and uses it to support research and energy efficiency in the water and wastewater sectors. Like California, the 'Energy Smart Program' works collaboratively with the state Public Service Commission. In addition, New York administers a water conservation program through its Department of Environmental Protection that has both regulatory and incentive measures (requirement of low-flow fixtures in new construction and renovations and rebates for fixture replacement in existing buildings, respectively).

4. Major Findings of Case Studies

Integration of water and energy planning is found to enhance all elements in the E^4 framework, yet these synergic benefits often are not fully explored at the state level. The cases of California, New York, and Wisconsin provide guidance regarding the elements of planning integration needed to be successful. Broadly, our research was able to identify six focus areas: 1.) information dissemination; 2.) planning and program development; 3.) institutional coordination; 4.) funding and financial incentives; 5.) legislation and regulations; and 6.) auditing and evaluation.

4.1. Information Dissemination

- The California Energy Commission (CEC) has held workshops on water and energy, conducted research on technologies designed to reduce water and energy use, and has a website containing information about water and energy conservation technologies. (California)

- San Diego Gas & Electric (SDG&E) and Southern California Gas Company (SoCalGas) implemented a Joint Marketing and Outreach Program, which leverages existing training and outreach programs conducted separately by utility and water suppliers. (California)

- SDG&E's Green Schools/Green Campus with Water Efficiency provides water conservation education for K-12 and college students and oversees the installation of high-efficiency toilets (HETs) in schools. It also expands existing Green Schools and Green Campus energy efficiency programs by adding a water conservation component. (California)

- The Water and Wastewater Program offers technical assistance to encourage water and wastewater service providers to improve energy efficiency by 1.) conducting energy surveys to identify and evaluate energy-saving opportunities, 2.) developing energy management plans for water/wastewater facilities, and 3.) providing information, education, and training resources. (Wisconsin)

- New York State has sponsored a regional workshop to examine the energy-water nexus. Regional energy-water issues were identified based on the experiences and expertise of local stakeholders such as state agencies, utilities, and environmental groups. (New York)

- One of the New York State Energy Research and Development Authority's (NYSERDA) environmental programs is to develop and demonstrate energy-efficient technologies associated with waste management and pollution control, including drinking water and wastewater treatment. The principal goals of the water/wastewater program are to: 1.) establish baseline energy use/cost data; 2.) assess potential for energy savings; 3.) provide strategic planning input for future programs; and 4.) disseminate results to stakeholders and market participants. (New York)

4.2. Planning and Program Development

- In October 2006, the California Public Utilities Commission (CPUC) issued a ruling which directs the state's four investor-owned energy utilities to work with water providers to develop pilot programs to reduce energy consumption associated with water supply, distribution, treatment, and end use. (California)

- A Pacific Gas & Electric (PG&E) pilot program focuses on elements of the commercial, institutional and industrial sectors, including schools, food processing plants, food service facilities, large commercial laundries, manufacturing plants, health service facilities, and low-income institutions. (California)

- San Diego Gas & Electric (SDG&E) and Southern California Gas Company (SoCalGas) have expanded a low-income energy efficiency program to include replacing conventional toilets with high-efficiency toilets (HETs). (California)

- In addition to assisting local government and industrial water and wastewater facilities under the 'Focus on Energy Program,' households are also provided weatherization services, which include the implementation of water saving measures. (Wisconsin)

- The Water and Wastewater Program began including drinking water facilities in its energy reduction program in 2002.[1] (Wisconsin)

- NYSERDA has been designated as the procurement administrator of the State Renewable Portfolio Standard (RPS) and aims to diversify the power generation resource mix and lessen stresses on water resources by achieving the mandatory RPS target of 25% of electricity consumption. (New York)

- New York State Department of Environmental Conservation (NYSDEC) is involved in minimizing water use by power plants and improving the quality of water discharged by the power plants. (New York)

4.3. Coordination

- The Water-Energy Partnership (WEP) is a group of public and private sector organizations that meets regularly to address water and energy issues, particularly to quantify energy savings resulting from water conservation and efficiency, as part of the CPUC proceeding detailed in section 4.2. Members of WEP include private and public energy and water companies, customer-based organizations, environmental groups, consultants, universities, and various state agencies. (California)

- Wisconsin's 'Focus on Energy Program' is a statewide public-private partnership program that offers services to a range of business sectors including agriculture, commercial, industrial, education, and local government. Within the industrial

[1] Wisconsin drinking water facilities consumed a statewide average of 1.3 kWh of energy per 1,000 gallons of water produced, at a cost of approximately 9.4 cents per 1,000 gallons of water. The difference between the amount of water produced and amount sold ("water lost") was 23.5 billion gallons per year, at an energy cost of $2 million per year.

sector, there is a Water and Wastewater Program, which provides energy efficiency and conservation assistance to water and wastewater facilities. (Wisconsin)

- A number of stakeholders including NYSERDA participated in the regional energy-water nexus workshop (see section 4.1) including Brookhaven National Laboratory, Columbia University Earth Institute, NY State Department of Environmental Conservation, NYC Department of Environmental Protection, Consolidated Edison Company of NY, and Long Island Power Authority (New York)

- NYSERDA partnered with the American Water Works Association (AWWA) to develop utility energy indices to measure the results of water and wastewater utility's energy management strategy. The measurements of operational performance will be used to compare utilities, to establish performance targets and budgets, and to assess the operational progress. (New York)

4.4. Funding &Financial Incentives

- The Water and Wastewater Program offers technical assistance and financial incentives to encourage water and wastewater service providers to improve energy efficiency and reduce operating expenses and/or costs. Financial incentives include small grants (typically 5-7% of total project costs) for efficiency improvements. (Wisconsin)

- Wisconsin's 'Focus on Energy Program' is paid for by rate payers and administered by the state's Department of Administration, Division of Energy. Implementation of specific portions of the program is conducted by private firms, selected by the state through a Request for Proposals process. (Wisconsin)

- NYSERDA manages the New York Energy $smart^{SM}$ Program in collaboration with the State's Public Service Commission. One element of the program supports projects within the water and wastewater sector through the Municipal Water and Wastewater Treatment Plant Program Assistance, which is a public benefit energy research and energy-efficiency services initiative funded through the state's System Benefits Charge. (New York)

- New York is among the first states to offer tax incentives for green buildings or sustainable designed buildings. To be eligible for the credit, a building must meet a list of green standards, including water conservation, energy and indoor air quality. (New York)

- New York City's Department of Environmental Protection has a water conservation program that initiates Fixture Replacement Incentives. Rebates range from $50-$200 to replace old water-wasting fixtures with efficient fixtures such as clothes washers and flapper-less, gravity-flush toilets. (New York)

4.5. Legislation/Regulations

- Title 6 of the New York Codes, Rules and Regulations (6 NYCRR) governs the standards for thermal discharges of water by the power plants. In particular, §704.5 governs the location, design, construction and capacity of cooling towers, which emit point source discharges in the form of hot water. The Division of Environmental Enforcement works closely with the Division of Law Enforcement to enforce the state and federal laws pertaining to the DEC regulations. (New York)

- For a building within the state to be eligible for a "green building" credit, it must meet a list of standards related to energy, indoor air quality, material, commissioning, appliances and water conservation. (New York)

- Green building standards have been mandated to address energy and water use in the built environment of the state. The standards include that all new construction must not exceed 65% of energy use allowed under the New York State Energy Conservation and Construction Code, and that in the rehabilitation of old buildings, no more than 75% of energy use is allowed. Among other things, the Code addresses energy compliant plumbing fixtures and water heating equipment. (New York)

4.6. Audits & Evaluation

- The pilot program detailed in section 4.2 will use existing PG&E audits and design assistance which will incorporate water efficiency analysis as well as the existing energy analysis. Most participants will receive on-site audits of their facilities and/or operations. A unique package of water-use efficiency improvements will be recommended and pursued for each selected site. (California)

- The CPUC is currently determining the metrics for quantifying energy savings from water conservation and efficiency as per R. 06-04-010 (Energy Efficiency Proceeding). The regional estimates (kWh/MG) for northern and southern California calculated by Navigant Consulting for the CEC are being refined to the extent possible, and would ideally be refined down to each service territory of the energy investor-owned utilities. These kWh/MG estimates are broken down at a minimum into 1.) supply & conveyance, 2.) water treatment, 3.) distribution, and 4.) wastewater treatment. (California)

- SDG&E conducts "large" customer audits that combine energy and water audits now being conducted separately by a utility and water supplier. They also follow up on implementation of previous water conservation audits. (California)

- SDG&E has implemented an industrial water efficiency program. To do this, they formed a partnership with the Metropolitan Water District of Orange County and expanded an existing industrial process water use reduction program that focuses on the textiles, food processing, metal plating, and electronics industries. This program coordinates water suppliers and utilities to provide technical audits for energy and water savings. (California)

- Prior to their baseline evaluation research, 'Focus on Energy' had commissioned the development of energy consumption guidelines for water and wastewater facilities in Wisconsin to include energy efficiency components into the design practices of these facilities. (Wisconsin)

- Statewide, the Division of Energy tracks energy savings in all sectors of the 'Focus on Energy Program.' A 20% - 40% reduction in energy use has been estimated among wastewater utilities participating in this program. (Wisconsin)

5. Lessons Learned

The synergic benefits of water-energy planning, particularly in terms of efficiency improvements and alternative technological developments in both water and energy production need to be fully understood, especially during drought events. These benefits are becoming increasingly important to understand in light of the seeming inevitability of climate change. Considering that the six hottest years on record have occurred in the last ten years (GISS, 2007), and taking into account the recent droughts in Delaware, it seems that we are all vulnerable to the vicissitudes of climate variability.

The case studies detailed in this report may be useful to the State of Delaware in developing an integrated energy-water planning initiative. The following are examples of program specifics found in the case studies that could serve as useful guidelines for planning and program development in Delaware:

- Information dissemination is a key tool for initiating integrated water-energy planning. By sponsoring workshops, undertaking research, and developing websites, the State of Delaware could begin the process of building public interest in water-energy conservation. Education of K-12 and college students about integrated conservation of energy and water opportunities could be specifically developed. Delaware could consider sponsoring workshops and educational and research initiatives to disseminate information about the synergic benefits of water-energy integration.

- A pilot program in California has been used to evaluate the energy impacts of water resources (see section 4.6). It also analyzed water-energy savings in the commercial, institutional and industrial sectors, and evaluated the impact of the Renewable Portfolio Standard (RPS) on water resources. Delaware could also undertake research to evaluate the impact on water resources in achieving their mandatory RPS target of 20% of electricity consumption from qualifying renewable energy sources by 2019.

- Water-energy conservation partnerships have been formed in the case study states to address water and energy issues. The partnerships offer services to a range of sectors including agriculture, commercial, industrial, schools, and local government. Members of the partnerships include private and public energy and water utilities (including wastewater utilities), customer-based organizations, environmental groups, consultants, universities and various state agencies. Delaware could create a water-energy conservation partnership involving a variety of actors to take advantage of the synergic benefits of integrated conservation efforts.

- Technical and financial incentives, tax incentives, rebates, and system benefits charges have been used in the case study states to support integrated water-energy planning. These and other financial mechanisms could be used to promote and attain benefits associated with integrated water-energy conservation. Delaware's Sustainable Energy Utility (SEU) could consider an integrated water-energy savings program as a funding target. In addition, the partnership between the SEU and lower-income weatherization in Delaware could be used to incorporate water savings measures, which would add to energy savings and further ease the financial burden associated with water utility costs.

- In the case study states, no legislation has been enacted to promote water-energy integration except for regulations on thermal discharges of water by power plants. However, green building standards, which generally focus on measures to reduce energy use, can also address water use, including water conservation. Green building initiatives enacted in Delaware with SEU support could include a water conservation element along with the usual energy conservation components.

- Combining energy and water audits for large customers, including industrial process units, has proven effective in the case study states. Metrics for quantifying energy savings from water conservation and efficiency in water utility supply and conveyance, treatment, distribution, end use, and wastewater treatment have been carefully defined in California, Wisconsin and New York. Delaware could also consider combined auditing programs by energy and water utilities and could develop utilize metrics for energy savings via water conservation (kWh/MG) and vice versa (MG/kWh) that the case study states have developed.

Water and energy resources are essential to human survival. A general conclusion of the analysis of the energy-water conservation programs examined in this report is that a wide range of knowledge, receptivity, and applications of practices/programs can alleviate stresses on both the water and energy sectors. Additionally, the assessment of these programs reveals that integrating energy and water planning has the potential to save money, reduce waste, protect the environment, improve equity, and strengthen the economy. Delaware could utilize elements of programs and planning approaches in the case study states as models to assist in the construction of its own framework for the integration of water and energy conservation. The need for this integration seems all the more important in light of the recent droughts in Delaware, the potential for more extreme weather due to climate change, and the demonstrated economic, environmental, equity, and energy benefits of such an integration.

Section I
Introduction

I.1. Background

Energy and water are two of the most fundamental and important elements of human survival, and are integral aspects of the evolution of modern civilization. There is a growing concern that our global community is facing chronic water and energy vulnerabilities. Some would argue that we will face two crises in the 21st Century – a water crisis and energy crisis (Brown, 1998, 2003; Flavin, 1999; Feffer, 2008). Water is becoming scarce as water tables are falling due to over-consumption, and water quality is deteriorating as a result of excessive contamination. Further, the present energy regime's growing dependence on non-renewable sources has added considerable stress to the environment. We are in the midst of a situation where we could justifiably be blamed for compromising the ability of future generations to meet even their basic needs.

Given this context, a greater understanding of the energy-water linkage is needed in order to develop effective policies to manage the impact of water and energy vulnerabilities, as well as to prevent some of them from occurring in the first place. The approach to resolving the issue must be an integrated one which takes advantage of or exploits the synergies that exist between the energy and water sectors. Synergic benefits derived from water and energy integration are especially significant during droughts, which are expected to intensify as a result of global climate change, which it should be noted is primarily the result of fossil fuel consumption.

The main challenge that these integrated policies must address is providing sufficient clean freshwater while maintaining adequate energy supplies to sustain economic health and security of supply. Following the U.S. Energy Policy Act of 2005, DOE's national laboratories and the Electric Power Research Institute (EPRI) initiated a multi-year water-energy program that included R&D and outreach at a cost of $30 million annually through 2009.[2] This is a federal effort to promote a holistic approach through the National Energy-Water Roadmap Program led by Sandia National Laboratory. Regional workshops have been held to identify specific regional issues and needs associated with the energy and water nexus. Individual states may have to pursue similar or parallel efforts in order to address their own water-energy situation.

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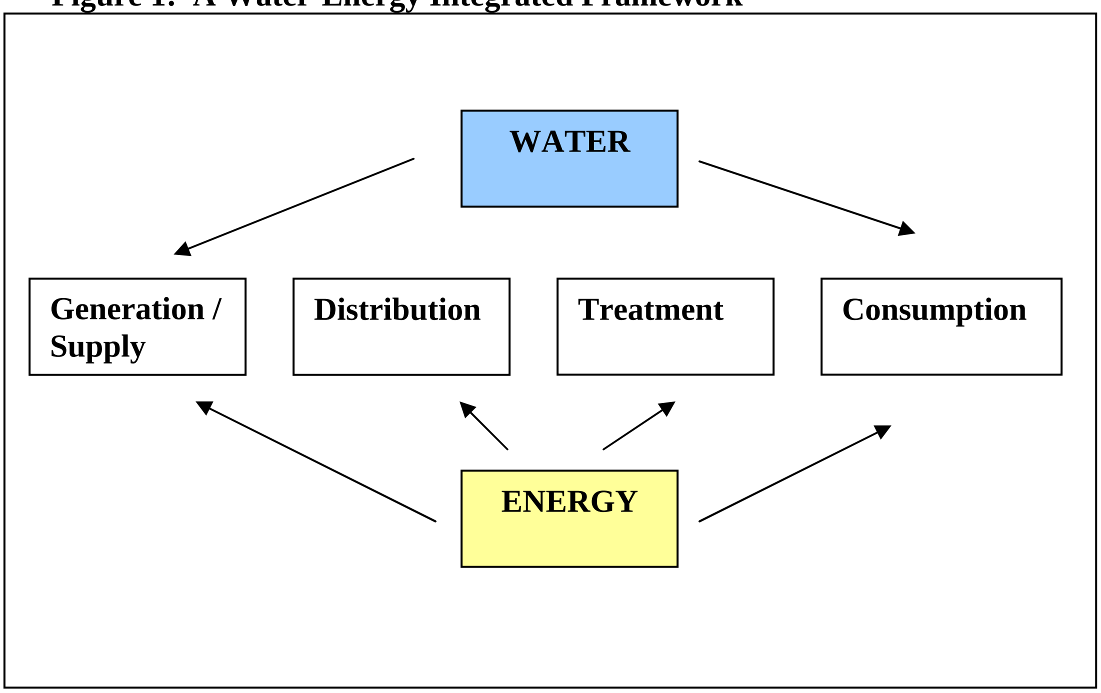
[2] For instance, Sandia National Laboratory leads the National Energy-Water Roadmap Program. Regional workshops have been held to identify specific regional issues and needs associated with the energy and water nexus.

I.2. Water-Energy Linkages: E^4 Framework

A simplified schematic of the energy-water linkage can be seen in Figure 1, though it must be noted that the inter- and intra-sectoral interaction between water and energy is much more complex. It has been found that water use affects primarily the generation and consumptive aspects of the energy sector, whereas energy utilization impacts all aspects of the water sector. For example, 19% of all energy consumed in California is attributable to the collection, extraction, conveyance, distribution, use, and treatment of water (House, 2007). Also, the production of energy from fossil fuels and nuclear power is inextricably linked to the availability of adequate and sustainable supplies of water. In the U.S., thermoelectric power generation is one of the biggest non-consumptive users of water, accounting for 39% (135 billion gallons per day) of the total water withdrawal in 2001 (U.S. DOE, 2006). As a result of these linkages, there is the potential for mutual benefits to be accrued if an integrated approach is implemented in the management of both sectors.

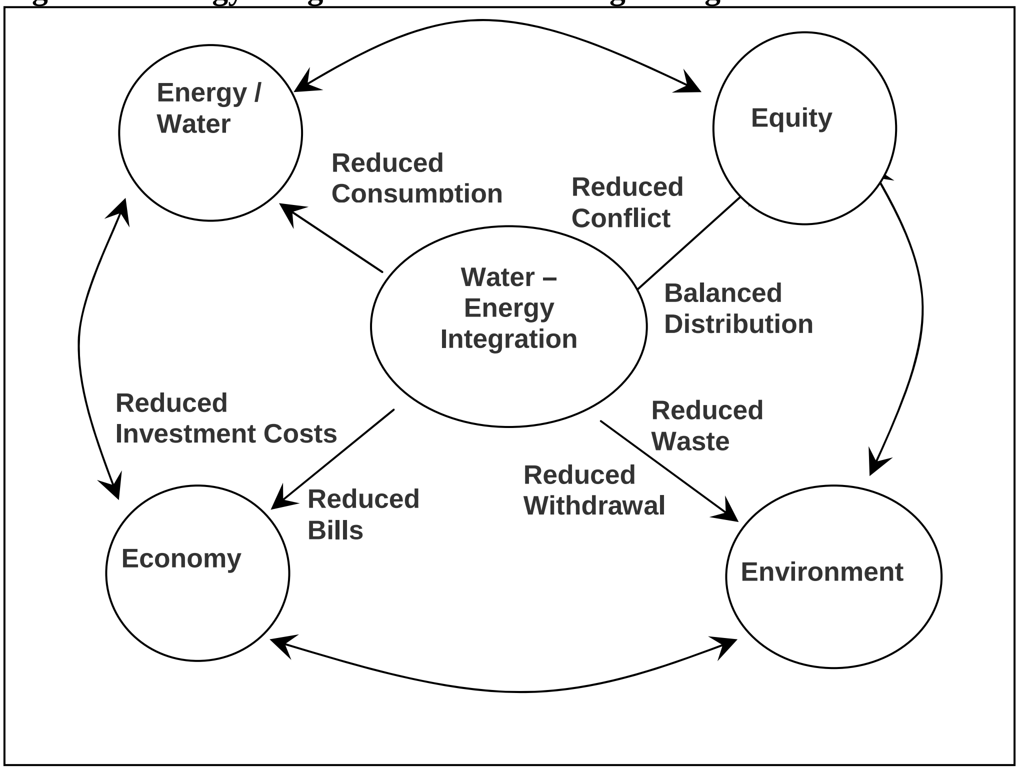
Figure 1: A Water-Energy Integrated Framework



The integration of water and energy sector planning and management can have positive impacts on the economy, the environment, energy and equity (E^4). Water and energy conservation improves the E^4 balance, enhancing sustainability, particularly during drought events in urban areas (Wang et al, 2006). Many of these benefits are interlinked and depend on the extent of the implementation of efficiency improvements that are possible through integration. The framework in Figure 2 conceptualizes the benefits of integration from an economic, energy, equity and environmental (E^4)

perspective. The E^4 advantages of energy-water management would be especially beneficial during drought periods.

Figure 2: Energy Integration Benefits during Drought Periods



The efficient use of water and energy can result in lower utility bills for customers and lower the costs of management of droughts. It can also bring other long term economic benefits, such as reducing or even eliminating the need for costly supply-side facilities or wastewater and sewage facilities (Featherstone, 1996; U.S. EPA, 1998; Wang et al, 2004) (**Economy**).

The efficient use and reduced wastage of water will lower the amount of energy that is needed to supply water - this reduction in energy use will result in decreased polluting emissions from power plants (Wang et al, 2006). Conservation measures as well as the efficient use of water will also directly benefit the environment, as they will reduce the need for withdrawal from surface and ground water supplies, thereby increasing the availability of these water supplies for ecological functions. Reduced withdrawal will also slow the process of saltwater intrusion into coastal areas (CEEP, 2001; U.S. EPA, 1999) (**Environment**).

In the U.S. approximately 4% of all electricity consumed is used to deliver water and treat wastewater (House, 2007). In California, water related energy use consumes 19% of the state's electricity, 30% of its natural gas, and 88 billion gallons of diesel fuel annually (House, 2007). When users adopt water efficient appliances, energy consumption is often reduced in two ways: directly, by the appliances themselves; and indirectly, as water utilities use less energy for surface and ground water withdrawal and wastewater treatment and discharge (Cohen et al, 2004; U.S. EPA, 1998)[3]. Thus, end-of-pipe conservation eliminates all of the "upstream" energy required to bring the water to the point of end use, as well as all of the "downstream" energy that would otherwise be spent to treat and dispose of this water (Cohen et al, 2004) (**Energy**).

Conserving water and energy increases their availability, which makes it easier to optimize their allocation between competing users (Wang et al, 2006), especially during droughts. Successful conservation efforts will reduce conflicts over in-stream flow rights and competing uses of water including power plants that are downstream. These kinds of conflicts are occurring with increasing frequency (Vickers, 2000) (**Equity**).

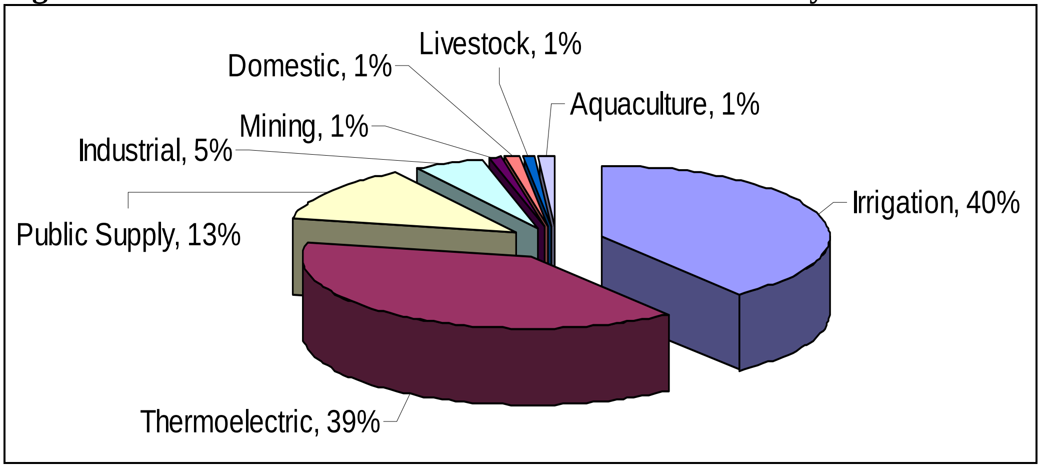
I.3. Water Use for Energy Generation and Extraction

The production of energy from fossil fuels (coal, oil, and natural gas) is inextricably linked to the availability of adequate and sustainable supplies of water. While providing the United States with almost 60% of its annual energy needs, fossil fuels also place a high demand on the nation's water resources in terms of both quantity and quality impacts (Feeley et al, 2005). In the U.S., thermoelectric power generation and irrigation are the biggest (non-consumptive) users of water. In 2000, they accounted for 79% (273 billion gallons per day) of the total water withdrawal (U.S. DOE, 2006).

The pie chart in Figure 3 depicts the freshwater withdrawals by different sectors in the year 2000. It is important to note that although water *withdrawal* for thermoelectric generation is very high, it only *consumes* approximately 3.3% of its withdrawals, the remaining being returned to the source, albeit with environmental impacts as a result of changes to the water temperature. This alteration of the natural temperature becomes critical in areas where the aquatic environment is highly sensitive to temperature changes, especially during dry hot weather. Figure 4 describes the freshwater consumption by sector in 1995.

[3] It is estimated that water utilities in the U.S. could easily reduce their electricity consumption by 15% through energy efficiency improvements, saving approximately $1 billion (Alliance to Save Energy, 2002).

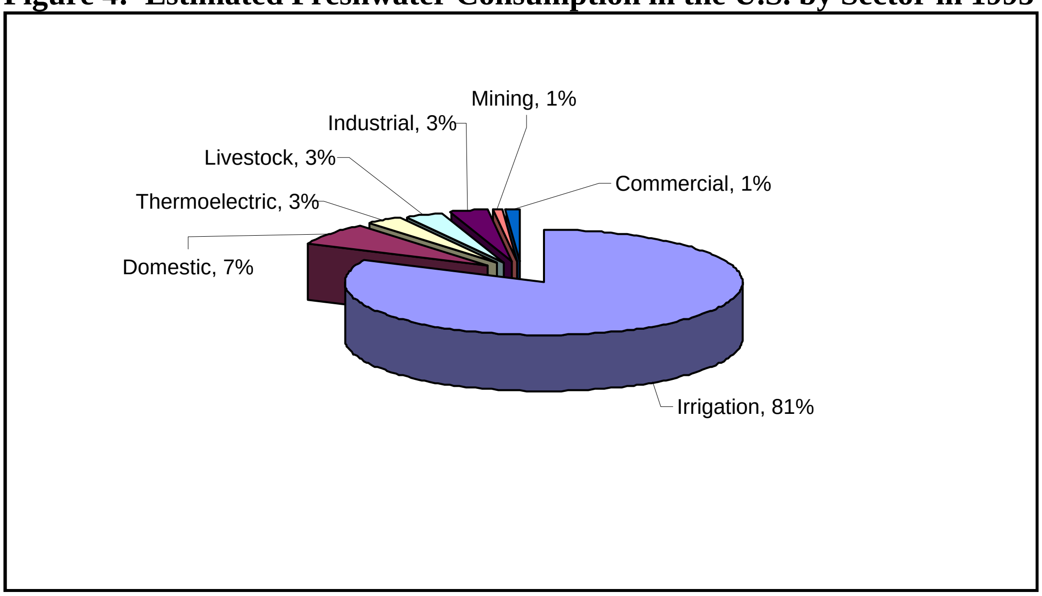
Figure 3: Estimated Freshwater Withdrawals in the U.S. by Sector in 2000



Source: Feeley et al., 2005 (Figures do not equal 100% due to rounding errors).

Water is also required in the mining, processing, and transportation of coal to generate electricity, all of which can have direct impacts on water quality. Surface and underground coal mining can result in acidic, metal-laden water that must be treated before it can be discharged to nearby rivers and streams. In terms of water quantity, the US Geological Service (USGS) estimates that in 2000 the mining industry withdrew approximately two billion gallons per day of freshwater. Further, although not directly affecting water quality, about 10% of total U.S. coal shipments were delivered by barge in 2003. Consequently, low river flows can create shortfalls in coal inventories at power plants (Feeley et al, 2005).

Figure 4: Estimated Freshwater Consumption in the U.S. by Sector in 1995



Source: Feeley et al, 2005 (Figures do not equal 100% due to rounding errors.)

As the U.S. population increases and economic development continues, the demand for fossil energy will grow, putting additional stress to the nation's water resources. At the same time, fossil energy's demands for water will increasingly compete with demands from other sectors of the economy such as public supply, agriculture, livestock, industrial, and in-stream non-consumptive use – particularly in regions of the country with limited freshwater supplies.

I.4. Energy for Water Supply

Satisfying the nation's water needs requires energy for supply, purification, distribution, and treatment of water and wastewater. In the U.S., 4% of the nation's electricity use goes towards moving (3.2%) and treating (.8%) water and wastewater. Furthermore, approximately 80% of municipal water processing and distribution costs are for electricity (EPRI, 2002). The availability of electricity is itself a key component of economic development. Water resources also play an important role in such development, as they are necessary for industrial, commercial and domestic activities, and they affect the overall production of electricity for human activities which depend on water availability (as will be seen later in this report).

Supply and conveyance can be the most energy- intensive portion of the water delivery chain compared to treatment and distribution of water, as well as wastewater collection, treatment and discharge. Energy requirements to pump water from surface waters can be negligible if users are located close to the source, but if water must be pumped over long distances, the energy requirements will be much higher. In California, water is conveyed 400 miles from Northern California via the State Water Project to the cities of Southern California (DOE, 2006). In fact, a study by the California Energy Commission found that supply and conveyance consumes 68% of the total energy supplied to a typical water delivery chain. The next largest segment was wastewater collection and treatment (19%). Overall, accounting for the total energy consumed the study revealed that California uses about 5% of its electricity consumption for water supply and treatment (CEC, 2005).

Population growth will create an increased demand for water. As freshwater supplies become more limited, conveying water from greater distances, purmping from greater depths, and the extra treatment of water necessary to utilize alternative sources (e.g. desalination) will increase energy consumption in response to meeting future water demands. Additionally, emerging water treatment requirements (e.g., standards for arsenic removal) are becoming more stringent, which will increase the energy consumption needed for both purification and wastewater treatment.

I.5. Purpose of Report

The interdependency between water and energy will increase, and become increasingly critical in the future due to growing population and scarce resources. This has created, and will continue to create a gap between the need for and availability of energy for water use, and vice-versa, in the U.S. A few reasons for this gap are the lack of collaboration on energy and water resources at all levels of government, lack of a systemic (holistic) approach to the introduction of new policies and technologies, and a lack of synergy between water and energy infrastructure planning.

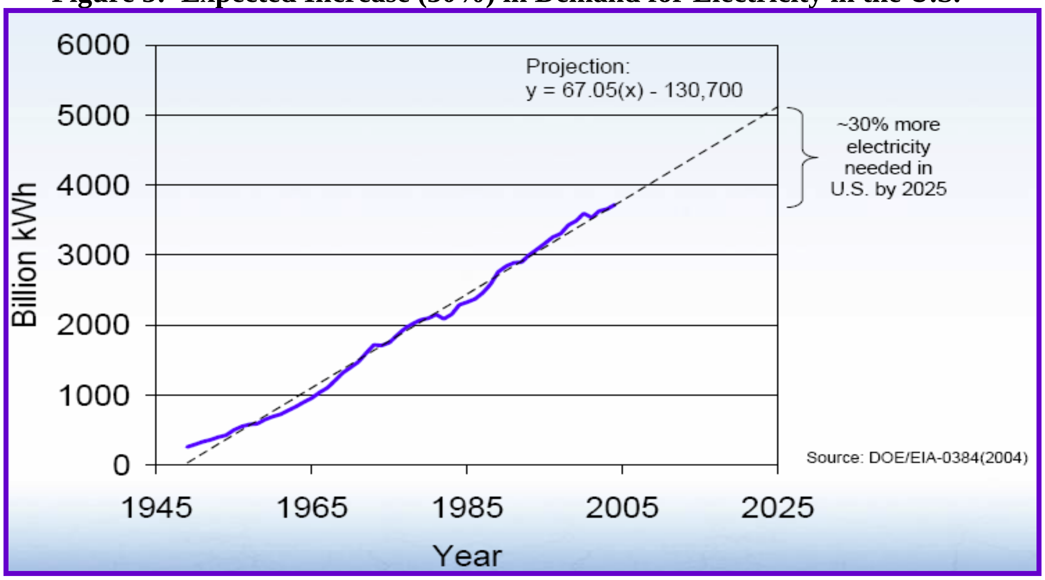
One method identified to address these issues is an integrated approach to the management of water and energy use, as there exists a strong interconnection between these sectors. The main purpose of this report is to analyze this approach by examining the current efforts by states to address the energy-water nexus and determining what lessons can be learned from these efforts and how they may be applied in the state of Delaware.

The following is an in-depth review of water-energy linkages, followed by the results of our national survey and case studies of water-energy programs by state. Guidelines for consideration by the state of Delaware are drawn based on the survey and the case studies. Potential synergic benefits of the application of water-energy integration are also presented as a reference based on efficiency improvements in residential water appliances in Delaware. For this application, water and energy profiles are constructed, and the profiles and application results are appended (Appendix A).

Section II
Water and Energy Nexus

Water and energy security are basic to human survival and the evolution of modern civilization, but population growth and economic development are steadily increasing the demands for both resources. The U.S. is projected to require over 5,000 billion kWh of electricity by 2025 (Figure 5), which would not only compromise the ability to furnish an adequate supply of energy, but would place greater demands on water supply as well.

Figure 5: Expected Increase (30%) in Demand for Electricity in the U.S.



Source: U.S. DOE/EIA, 2005a.

Our current lifestyles are stressing the long-term sustainability of the nation's energy and water resources, as the rate of consumption continues to exceed the natural regeneration capacity. Without a combined focus on energy and water resource management, catastrophic depletion cannot be prevented. The inextricable linkage between energy, water, and the environment necessitates addressing the problems by forming new partnerships between entities responsible for energy and water procurement and supply. Addressing these issues separately will simply not be as effective as addressing them in combination.

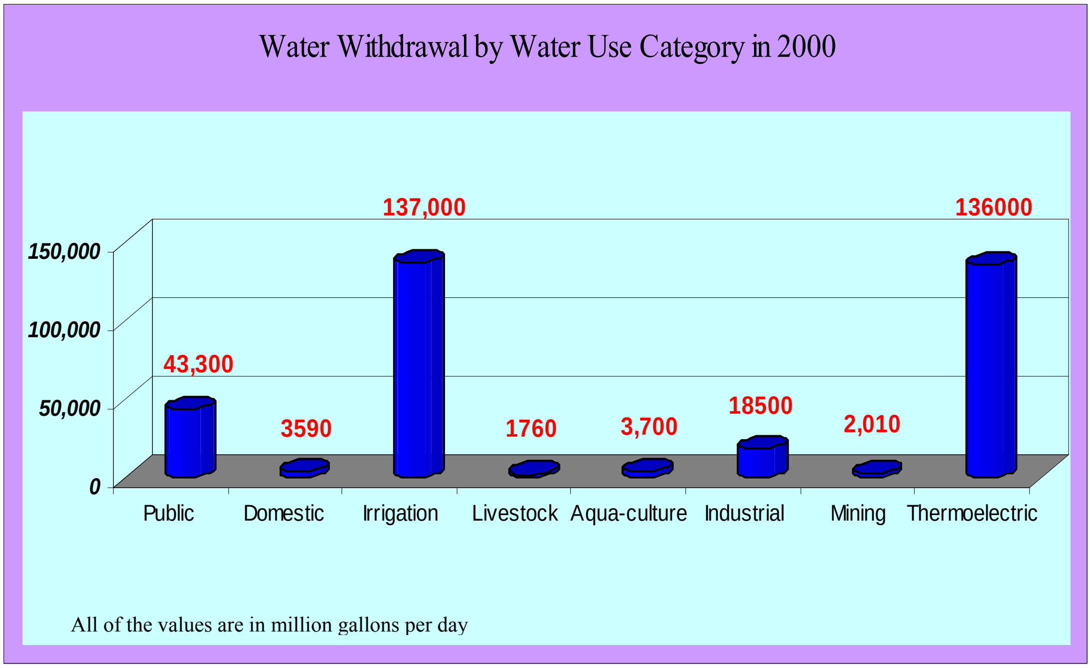
II.1. Water Use and Energy Production

Total water use (both freshwater and saline water) in United States for 2000 was estimated at 408 billion gallons per day, with freshwater withdrawals accounting for 85% of this total (Hutson et al, 2004).[4] Of the total water withdrawn, irrigation and

[4] The 2005 estimates are currently being prepared.

thermoelectric generation used by far the largest portion (Figure 6). If both saline and freshwater withdrawals are considered, then thermoelectric generation is the lead water user, with a withdrawal rate of 195,500 million gallons per day (note that much of this is non-consumptive use). In terms of freshwater only, irrigation is the largest user at 137,000 million gallons per day (Hutson et al, 2004).

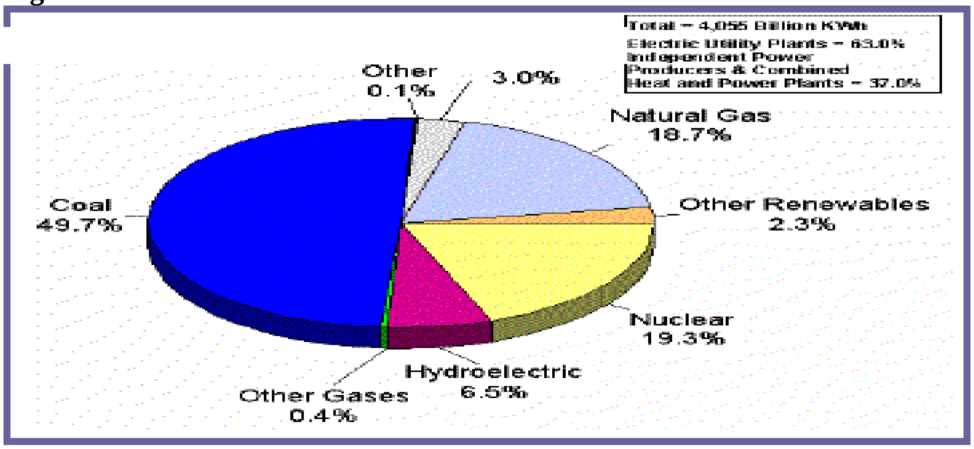
Figure 6: Freshwater Withdrawal by Water Use Category in 2000



Source: Hus\tson et al., 2004.

Greater than 70% of the electricity generated in 2000 was from coal and nuclear power plants, with hydroelectric power accounting for 7.2% of total electricity generated. In 2005, this trend continued with coal and nuclear power plants accounting for approximately 68% of electricity generation, while hydropower dropped to 6.5% of energy production (Figure 7). The water withdrawal estimates for 2005 are unavailable, but it is expected that they will be similar to the 2000 estimates.

Figure 7: Fuel Sources for Electric Generation



Source: U.S. DOE/EIA, 2005a.

There is a direct relationship between power generation and water consumption, as large amounts of water are needed for thermoelectric cooling systems and directly for generation by hydropower plants. In the case of thermoelectric power, water is evaporated during the cooling process whereas in the case of hydroelectric plants, water evaporates from the large surface areas of reservoirs (Table 1). It has been estimated that two gallons of water are evaporated per kilowatt hour of electricity generated from hydroelectric power plants (Torcellini et al, 2003).

Table 1: Total Consumptive Use of Water for U.S. Power Plants

Power Provider	Gallons Evaporated per kilowatt hour at thermoelectric plant	Gallons Evaporated per kilowatt hour at hydroelectric plant	Weighted Gallons evaporated per kWh of Site Energy
Western Interconnect	0.38	12.4	4.42
Eastern Interconnect	0.49	55.1	2.33
Texas Interconnect	0.44	0.0	0.43
America Aggregate	**0.47**	**18.0**	**2.00**

Source: Torcellini et al, 2003.

II.1.1. Water Use for Thermoelectric Power Plants

Thermoelectric power plants (coal, nuclear, oil, natural gas) that use a steam turbine system require significant quantities of water to generate electricity. For example, each kWh of electricity generated from a coal plant requires the withdrawal of 25 gallons of water, which are primarily used for cooling purposes (Sandia Laboratory, 2005). According to a recent USGS survey, thermoelectric power plants withdraw approximately 136 billions of gallons of water per day (BGD) of freshwater, which represents approximately 3% of total withdrawal of freshwater in U.S. (Hutson et al, 2004).

There are two basic types of cooling systems: once-through (open-loop) and re-circulating wet (closed loop). Once-through systems have very high water use requirements but since nearly all withdrawn water is returned to its source, only a small percentage of the water is actually consumed. Re-circulating wet systems have a lower water-use requirement but the consumptive loss through direct evaporation can be relatively high. Once-through systems consume over 10 times less water than re-circulating wet systems (Table 2). The USGS estimates that approximately 88% of power plants use once-through cooling technology (Feeley et al, 2005).

Table 2: Water Consumption for Cooling System

Fuel Source	Technology	Withdrawal (gal/kWh)	Consumption (gal/kWh)
Fossil	Once-through	37.7	0.1
	Re-circulating wet (tower)	1.2	1.1
Nuclear	Once through	46.2	0.1
	Re-circulating wet (tower)	1.5	1.5

Source: Hoffman et al, 2004 and Feeley et al, 2005.

II.1.2. Water Use for Coal Mining

Coal continues to be extensively used as a source of fuel in power generation in the U.S. It is expected that this trend will continue even if greenhouse gas emissions constraints are imposed on the electricity sector. The use of coal in power plants has a direct impact on water consumption not only at the energy generation end of the process but also as a result of the extraction of coal deposits, as significant amounts of water are needed to mine and wash coal. Coal can be mined either through surface mining or underground mining operations. Typical mining processes that require water include coal cutting in underground operations and coal washing to increase heat content by removing impurities.

Based on 2003 National Coal Production Statistics, a rough estimate of total water required for coal extraction (mining and washing) could range from 89-235 million gallons per day, which equates to approximately 4-12 percent of freshwater withdrawals for the mining water-use sector in 2000 (NETL, 2006). In addition to the *quantity* of water being used during the coal mining process, the residuals of the coal mining process also impact local water *quality*. Acid mine drainage (water discharge from mine pools in abandoned underground coal mines) is largely uncontrolled, and is therefore one of the major pollutants to nearby water sources. It has been estimated by the EPA that approximately 10% of the 270,000 miles of pollution-impaired rivers and streams in the U.S. are the result of natural resource extraction operations (EPA, 2002).

II.1.3. Water Consumption by Hydroelectric Power Plants

Hydroelectric power is the fourth largest source of electricity, providing approximately 7-10% of the U.S. electricity needs. Although the production of hydroelectric power depends on water availability, its consumption of water is negligible, though as noted previously, retention of water results in increased water evaporation relative to a free flowing river (Torcellini et al, 2003). Torecellini's study also revealed that behind the Hoover Dam, the evaporation of water is 2.4% higher than the free-flowing portion of the Colorado River. Similarly, Glen Canyon Dam has a 4% higher evaporation rate than the corresponding free-flowing river**.**

Lack of available water during periods of low rainfall and drought can have direct impacts both on hydropower electricity generation and conventional sources of generation. During low rainfall periods, the water level in a river decreases, which curtails the amount of water available for energy production. A reduction in surface water flow not only impacts hydropower output but it also can cause a reduction in electricity generated by coal-fired and nuclear power plants. The reduction in electricity production from the latter two sources is related to the availability of water for cooling purposes.

Hydropower generation represents a renewable resource, though it should be noted that large hydropower installations can result in significant environmental impacts. For example, during the California energy crisis in 2001, California had to import large quantities of electricity from the North Pacific region. At the same time, the North Pacific region was experiencing drought. These two factors combined resulted in the highest number of salmon ever killed in one year in the Columbia River (Curlee and Sale, 2003). In addition, the flooding of non-aquatic habitats by dammed water behind newly built hydroelectric dams destroys these habitats, forcing a completely new ecological regime in their stead. Though a new and possibly productive aquatic habitat may result, there is nonetheless damage inflicted upon the natural habitat that it replaced.

II.1.4. Water Consumption in Oil Production

The production of oil both from conventional and unconventional sources is also dependant on vast amounts of water resources. In a conventional oil extraction system, water is injected into the oil well to increase the pressure in order to provide extra force to bring more oil to the surface. Likewise, in unconventional sources of oil (oil shale, tars sands) huge amounts of water are injected in the bitumen so that the oil shale and tar becomes soft and easier to extract. According to Curlee and Sale, depending on the process, 1-10 barrels of water can be required to produce one barrel of oil particularly in the case of extraction of oil from unconventional sources (2003).

II.1.5. Water Consumption in Alternative Sources of Energy Production

The increased demand for electric power has the potential to increase water resource use by power sources other than thermoelectric. In the case of the pursuit of the use of hydrogen as an energy source, it is uncertain what the water requirements for the production of hydrogen will be. As noted by Curlee and Sale, if the United States was to replace all petroleum imports currently used for transportation (some 10 million barrels per day) and conventional electrolysis was used to produce the hydrogen required, the United States would roughly have to triple our domestic electric generation capacity (2003). An associated increase of water use will also be needed to accompany the tripling of the electricity needed to produce the hydrogen.

In addition to the production of hydrogen, the use of biomass (corn, soybeans, cordwood, etc.) as alternative fuel sources also places pressure on water resources. In the case of ethanol, the use of water is an integral part of the production process and it has been estimated that for every gallon of ethanol produced, approximately three gallons of water are used (Fatigati, 2006). Thus, although the development of alternative energy sources are very important initiatives, the water use associated with each alternative fuel source will have to be assessed in order to improve efficiency of use and reduce consumption.

II.2. Energy Intensity of Water Supply

II.2.1. Energy consumed by the Desalination Process

Desalination of water is becoming necessary to support the demands for freshwater due to population and economic growth in many parts of the world. The desalination process may utilize reverse osmosis, electro-dialysis, distillation and capacitive deionization technologies. Depending on the technology employed, the quality of the source water, the plant capacity, and the temperature of water, the process can be very energy intensive. The process can consume as much as 3,900 to 9,759 kWh of electricity per million gallons of brackish water and even greater amounts of electricity if seawater is used, 9,780 to 16,500 kWh per million gallons (Trask, 2005).

II.2.2. Energy consumed by Recycling Water

Recycled water generally refers to the water produced from wastewater treatment systems, and which is suitable for a direct beneficial or controlled use. Recycled water is commonly used for groundwater recharge, landscape watering and for agricultural purposes, depending on the quality of water recovered from the wastewater treatment facilities. Even though energy is consumed during the treatment process, the recycled use of water can be substituted for freshwater wherever it is needed and can be applied.

II.3. Transmission and Distribution of Water and Energy

It has been estimated that the average drinking water utility consumes 94% of its energy while pumping water in its distribution and transmissions operations (AWWA, 2007a). This has an economic effect as well - for example, an analysis of California's East Bay Municipal Utility District found that electricity purchases were the single largest non-labor O&M expense (AWWA, 2007a). Some distribution networks require constant pumping to transport water from treatment plants to customers at adequate pressures, although other municipal water networks can use gravity to pressurize their mains. Many utilities must also pump untreated water from reservoirs or ground water sources to treatment plants.

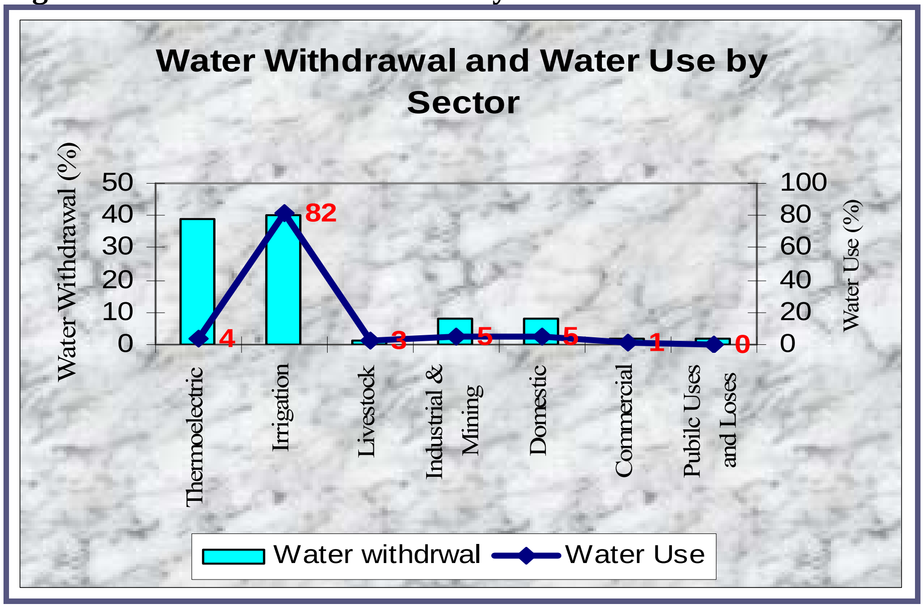
In addition, energy consumption in older water conveyance systems tends to be higher because they (1) are more likely to have inefficient pumps, (2) are more prone to leaks and (3) often have corroded, high friction water mains (Corum, 2006). Infrastructure upgrades and aggressive leak detection programs could significantly reduce energy consumption and costs for many such utilities (Lahlou, 2001).

II.4. Consumption of Water and Energy

II.4.1. Water Consumption Contrasted with Water Withdrawal

In the U.S., it is estimated that approximately 136 billion gallons of freshwater are used to generate electricity daily from coal, gas and nuclear power plants, which equates to approximately 39% of the total national freshwater withdrawal (Shephard, 2005). Although thermoelectric power plant withdrawal is extremely large, it represents only 4% of national freshwater *consumption* (due to evaporation during the cooling processes), while the remaining water is discharged into surrounding water bodies (Hutson *et al*, 2004). Irrigation withdraws approximately 40% of the total freshwater, but unlike thermo-electric power, has a very high water consumption rate. In fact, as of 2006, 82% of the total freshwater consumed in the U.S. was used for irrigation (Figure 8). This is due to the fact that irrigation consumes nearly all of the water it withdraws – the water used in photosynthesis cannot be readily reused.

Figure 8: Freshwater Withdrawal by Water Use



Sources: McMahon *et al*, 2006 and Hutson *et al*, 2004.

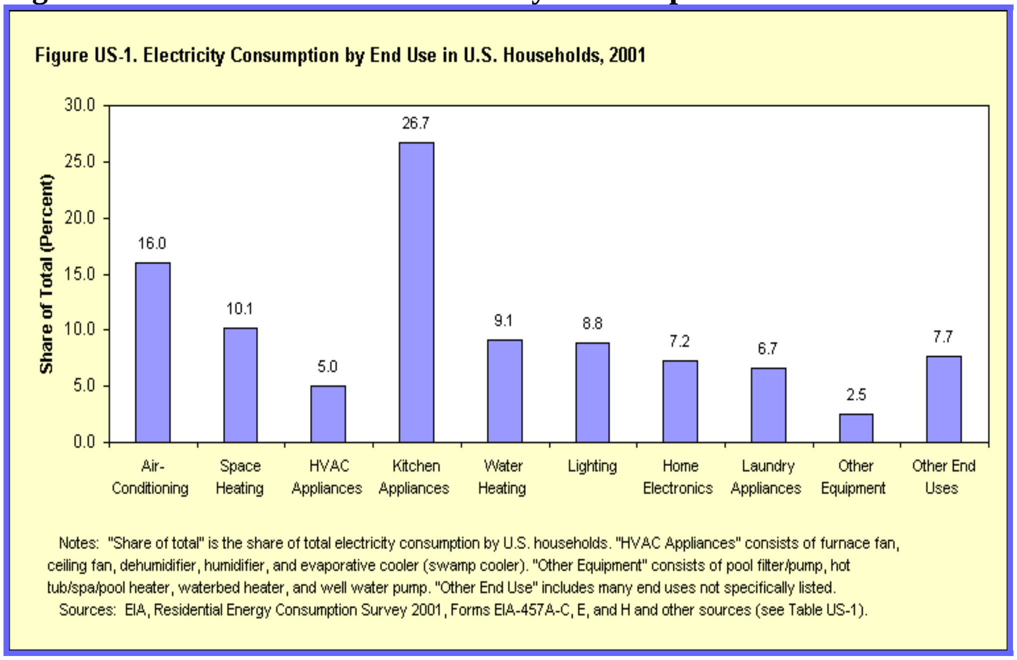
II.5. Household Consumption of Water and Energy

II.5.1. Household Energy Consumption

U.S. households rely primarily on three sources of energy: natural gas, electricity, and fuel oil. In the past several decades, electricity's share of household consumption has grown dramatically to reach a total of 1,140 billion kWh in 2001 (USDOE/EIA(b), 2005). The most significant end uses were central air-conditioning and refrigerators, each accounting for approximately 14 percent of the national total (see Figure 9 for details of other household uses).

Nationally, space heating was predominantly fueled by natural gas but in almost 31 million households, electricity was the source of energy for the main heating system, which resulted in the consumption of 116 billion kWh or 10% of total electricity consumption. Home electronics such as color TVs, VCRs/DVDs, cable boxes, PCs, printers, fax machines, etc., consumed 82 billion kWh or 7.2% of household electricity. With retail sales of home electronics increasing, the EIA projects the electric consumption in that household sector to more than double by 2025.

Figure 9: End-user Domestic Electricity Consumption



Source: USDOE/EIA, 2005b.

II.5.2. Household Water Consumption

It has been reported that the U.S. per capita water use within a single family home without any water-conserving fixtures is 74 gallons per day (AWWA, 2006). The major uses of indoor water use are listed in Table 3. The American Water Works Association (AWWA) noted that by installing more efficient water fixtures and promptly fixing leaks, households can reduce their daily water use by approximately 30 percent, which would result in an average savings of 22 gallons per person per day.

The development of water-related technologies are currently focused on two areas - more efficient use of water, and treatment of untreated water to make it usable. For household equipment and appliances that use both energy and water, such as clothes washers, dishwashers, and showerheads, new technologies that reduce hot water consumption will save both water and energy. For those items that consume cold water such as toilets, the increase in water efficiency will directly save water and indirectly save the energy used to supply and dispose of water.

Another linkage between water use and energy consumption in households is that associated with the production of food for household consumption. Gleick (2002) indicates that per capita household daily use of water is 100 gallons[5] but an additional 510 gallons of water per day is consumed in food production (Figure 10).

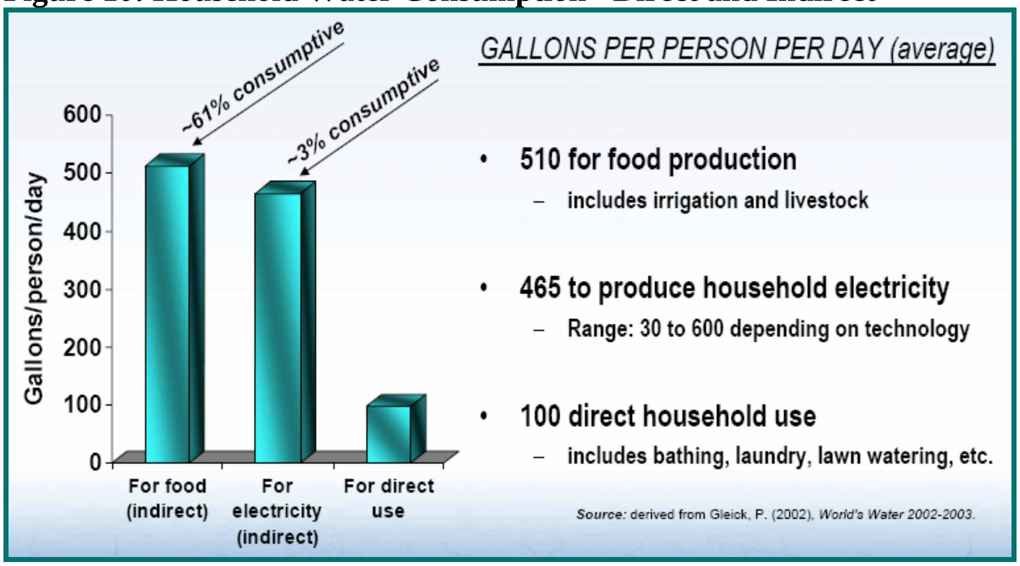
[5] This is a higher estimation than the AWWA per capita daily use estimate of 74 gallons

Table 3: Indoor Daily Water Use per Person

Use	Gallons per Capita	Percentage of Total Daily Use
Showers	12.6	17.3%
Clothes Washers	15.1	20.9%
Dishwashers	1.0	1.3%
Toilets	20.1	27.7%
Baths	1.2	2.1%
Leaks	10.0	13.8%
Faucets	11.1	15.3%
Other Domestic Uses	1.5	2.1%

Source: AWWA, 2006.

Figure 10: Household Water Consumption - Direct and Indirect

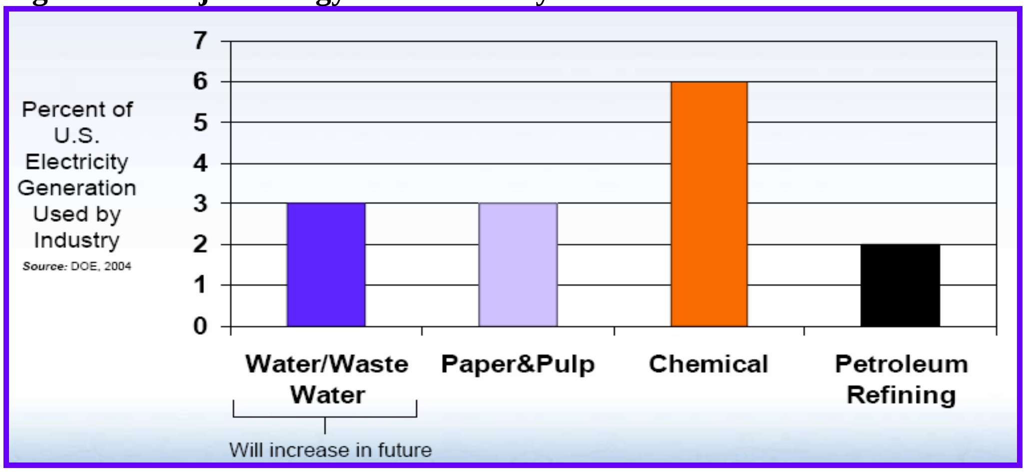


Source: Gleick, 2002.

II.6. Industrial Consumption of Energy

Various industrial sectors are major consumers of electricity. Growth in the U.S. industrial sector requires increased consumption of electricity, which places greater demands on water resources. Water and wastewater treatment is currently one of the major users of electricity within the industrial sector (Figure 11). This type of energy consumption is expected to increase as the population increases, especially as freshwater requirements demand desalination of brackish water and seawater. If the population and its current consumption rates continue, energy consumption by municipal water utilities will double within the next 40 years (Alliance to Save Energy, 2002). Population increases are very difficult to address from a policy standpoint, thus consumption rates must be addressed. As will be seen in the case studies contained within this report, some states are doing just that.

Figure 11: Major Energy Consumers by Industrial Sector



Source: Newmark, 2005.

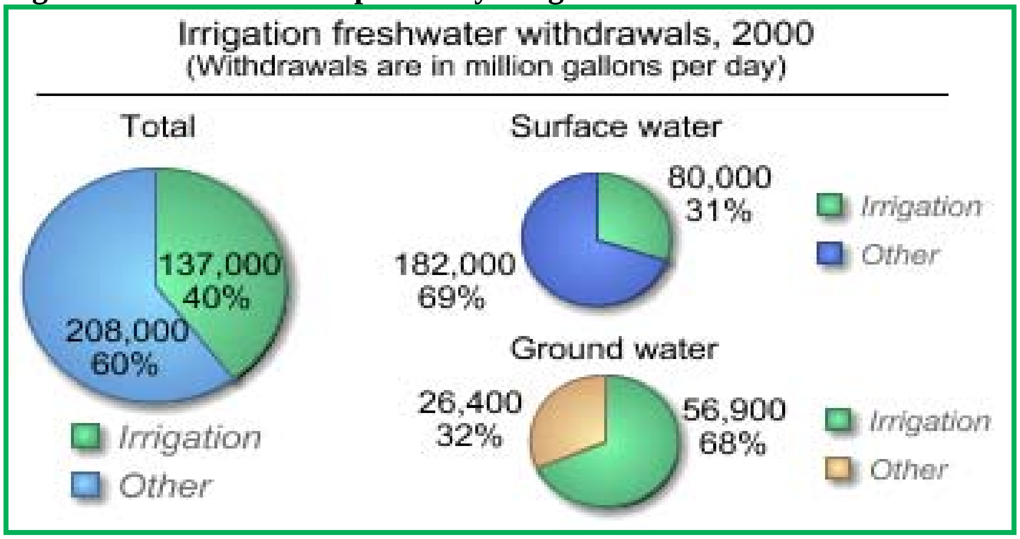
II.7. Agricultural Consumption of Water

Agriculture is a major user of ground and surface water in the United States. Irrigation is critical to agriculture with approximately half of the value of all crops sold being harvested from cropland that is irrigated (Brown, 1998). Irrigation water use includes water that is applied by an irrigation system to sustain plant growth in agricultural and horticultural practices, as well as self-supplied withdrawals and deliveries from irrigation companies, irrigation districts, cooperatives, or governmental entities.

During the year 2000, irrigation withdrawals were estimated at 137,000 million gallons per day, or 40% of total national freshwater withdrawals (Figure 11). In terms of percentages of surface water and ground water used to support irrigation, more than twice as much groundwater than surface water is being withdrawn (68% vs. 31%). Thus, the overall irrigation process is both energy intensive by nature of the extraction process (pumping groundwater often requires substantial energy), and water intensive, as evidenced by the tremendous percentage consumption of the nation's freshwater.

Most of the water that is withdrawn for agricultural purposes is consumed by elements of the water environment immediately surrounding the area in which water is applied through evaporation, plant transpiration, or by livestock ingestion. To further contrast water withdrawals with water consumption between sectors, Figure 13 illustrates the radical difference in water use between the thermoelectric and agricultural sectors. Although the thermoelectric and irrigation freshwater withdrawals are approximately equal, the consumptive rate of irrigation is 80% of the U.S. total, whereas thermoelectric water consumption is approximately 3%. The consumptive water use of irrigation rises to over 90% in many western states (USDA, 2004a).

Figure 12: Freshwater Depletion by Irrigation



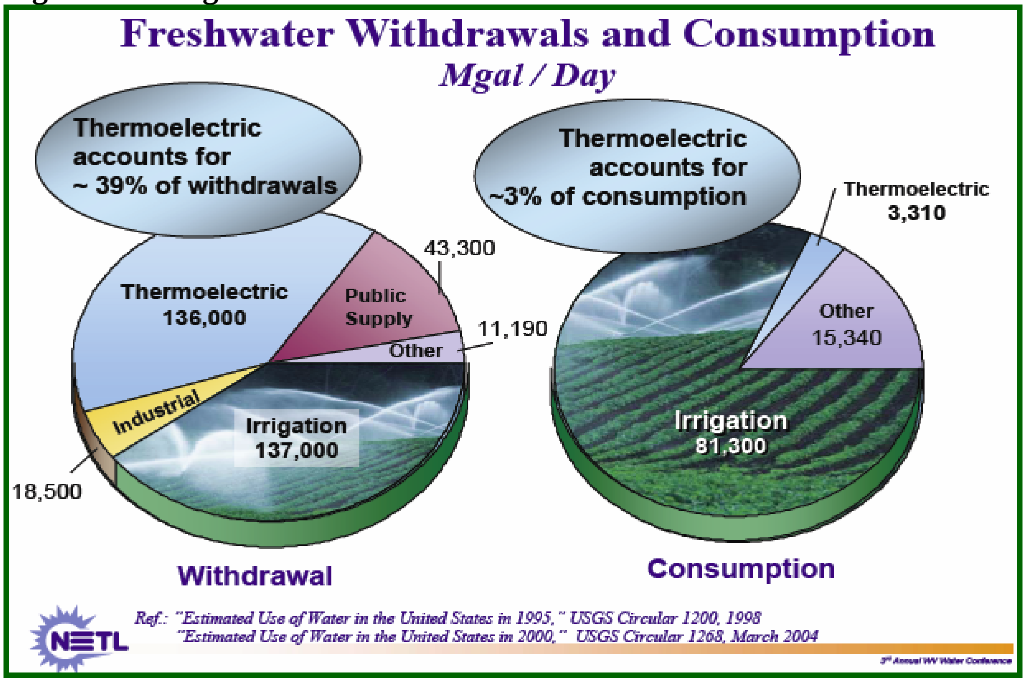
Source: USDA, 2004a.

The increasing needs for urban, industrial, and domestic water uses, as well as ecological needs, compete with the agricultural needs for freshwater. Since it accounts for such a large share of the total water consumption, agriculture is critical to the challenge of balancing water demands among alternative uses and end users. To improve irrigation efficiency, federal and state agencies and local water management districts have provided cost-share payments to improve water delivery on farms such as the lining of open-ditch irrigation systems, and by promoting more efficient technologies such as low-pressure sprinkler irrigation systems (USDA, 2006b). Since the larger farms ($500,000 or more in annual sales) use the most irrigation water, cost-share programs are most effective at helping to conserve water when they are targeted at the larger farm owners.

II.7.1. Concentrated Animal Feeding Operations (CAFO)

To operate CAFOs, a constant year-round supply of fresh water is essential for the animals, sanitation, workers, and for fire protection. In addition to the water consumed by the livestock, water is used to dilute animal manure and to flush-clean the facilities. A few examples of the daily water needs are: 29-45 gallons per dairy cow, 8-22 gallons per cattle, 14-30 gallons per bull, 1-3 gallons per ewe, and 3-7 gallons per chicken (Pfost and Fulhage, 2003). The CAFOs are often responsible for contaminating shallow wells via surface runoff and deep percolation. This results in increased energy usage as freshwater is brought from distant, uncontaminated sources. A large amount of energy is also consumed by pumping, grinding, materials handling, and ventilation. As Delaware produces an enormous amount of mass-produced poultry, any initiatives undertaken to reduce water and energy consumption on poultry CAFOs would potentially be very effective in reducing consumption statewide.

Figure 13: Irrigation versus Thermoelectric Water Use



Source: Feeley, 2004.

II.7.2. Complexity of Combined Water and Energy Conservation

Although water conservation goals are important for all types of water consumers (household, industrial, agricultural, municipal, and CAFOs), reduction of water from an energy-consumption standpoint may be slightly different than simply reducing water consumption in general. Some consumers will use more energy than others for an equivalent amount of water use. For example, increasing efficiency and conservation of hot water is an effective step in decreasing energy intensity per gallon used. Although agricultural consumption of water is high, it is less energy intensive than urban water uses because it does not require treatment following its use. Therefore reducing urban water consumption may provide a greater energy savings per gallon than conserving irrigation water (Boone, 2006). This is only one example of the complexity inherent in the water-energy nexus. It is important to robustly analyze the reduction potential of each source in specific situations in order to maximize their conservation.

Section III
National Survey of State Government's Water-Energy Programs

An examination was made of water-energy programs in the U.S., as these can provide possible guidelines or suggest practices for the development of similar types of programs in the state of Delaware. Two surveys were conducted. First, a general fact finding survey (Appendix C) which attempted to ascertain which states had a water–energy interaction program. The results of this survey informed the implementation of another more specific survey which focused on those states that actually had a program (Appendix D). As there was a dearth of state programs, a decision was made to include some municipality programs in the analysis. The following sections present the findings of both surveys.

III.1. Generalized State Programs Survey Results

It was found from the responses from the fifty states that very few had any integrated energy–water programs. Appendix E is a summary of the responses received from the various states. The main findings are as follows:

- There are three states that have integrated water-energy programs - California, Wisconsin and New York;

- There are nine states that either have limited programs or are part of a regional initiative focusing on the issue of water and energy interactions - Alaska, Connecticut, Hawaii, Idaho, Maine, Nebraska, Nevada, Texas and Virginia;

- Eleven states who responded indicated that they did not have any integrated energy-water programs - Arizona, Arkansas, Colorado, Indiana, Kentucky, Louisiana, Michigan, New Hampshire, South Carolina, Tennessee and Utah.

- The remaining states did not respond and it was inconclusive as to whether or not they had any programs, but a search of the literature and state websites suggested that there were none. These states are - Alabama, Florida, Georgia, Illinois, Iowa, Kansas, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Montana, North Carolina, North Dakota, New Jersey, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Vermont, Washington, West Virginia and Wyoming.

A principal finding of our survey of the various states shows that there is a paucity of programs designed specifically to address the issue of the energy-water linkage, although there is an assortment of portions of programs, initiatives or legislation that are addressing some element of the issue.

III.2. State Case Studies

Only three states, California, New York and Wisconsin, had established, state-sponsored, integrated water-energy programs (Wang et al., 2007 – see Appendix B). Case studies of these states illustrate different approaches to integrating energy and water at a statewide level. It is notable that in all three states, energy-water programs developed primarily out of energy conservation efforts. The water and wastewater utilities were the primary focus of integrating water and energy conservation.

- In California, a high-level state agency – the Public Utilities Commission – used its authority to require energy utilities to work cooperatively with major water suppliers in the utilities' jurisdictions, thus creating a mandatory program for integrating these sectors. This is a pilot program and the results have not yet been demonstrated. However, this effort is one of a wide range of strategies that the state is pursuing in relation to the water-energy nexus.

- In Wisconsin, the state adapted a voluntary energy-conservation program to include drinking water and wastewater utilities. The 'Focus on Energy Program' is incentive-based, rather than regulatory, providing technical support and small grants to encourage energy efficiency. Results to date show that the wastewater treatment utilities have been most receptive and shown energy and water savings as a result of their improvements in system efficiencies.

- The state of New York administers its energy conservation programs through a state agency– the New York State Energy Research and Development Authority (NYSERDA)– and has used them to support research and energy efficiency in the water and wastewater sectors. Like California, the 'Energy Smart Program' works collaboratively with the state Public Service Commission. In addition, New York has a water conservation program through its Department of Environmental Protection that has both regulatory and incentive measures (requirement of low-flow fixtures in new construction and renovation, and rebates for fixture replacement in existing buildings).

III.2.1. California

In October 2006, the California Public Utilities Commission (CPUC) issued a ruling to direct the state's four investor-owned energy utilities to work with water providers to develop pilot programs to reduce energy consumption associated with water supply, distribution, treatment, and end-use.[6] The programs were to include low-income community assistance, together with evaluation, measurement, and verification (EM&V) methodologies. The pilot programs were proposed to the Public Utilities Commission on January 15, 2007 and implemented on July 1, 2007.

[6] http://www.cpuc.ca.gov/EFILE/RULINGS/60817.PDF.

III.2.1.1. Energy-Water Integration Program Goals

The goal of the pilot program is to find the most cost-effective way to reduce energy consumption through water conservation and efficiency. According to a California Energy Commission (CEC) study, about 19% of all energy consumed in California is attributable to the collection, extraction, conveyance, distribution, treatment, and use of water (CEC, 2005). Thus, addressing energy consumption in the water and wastewater sectors is an effective way of conserving electricity as well.

III.2.1.2. Stakeholder Participation

There are a number of groups, organizations and government agencies involved in the program including the four investor-owned utilities:

- Pacific Gas & Electric (PG&E)
- San Diego Gas & Electric (SDG&E)
- Southern California Edison Company (SCE)
- Southern California Gas Company (SCGC)

The pilot program is related to several statewide planning and coordination efforts. There is a CPUC Water Action Plan that identifies water policies for regulated water utilities in California, including water conservation and related energy conservation[7]. There is also an Integrated Energy Policy Report of the CPUC and CEC that addresses water and energy policies for California.[8]

The CEC has also held workshops on water and energy, undertakes research on technologies designed to reduce water and energy use, and has a website with information about water and energy conserving technologies.[9] The California Department of Water Resources (DWR) is also implementing policies designed to reduce water use, including discouraging greenhouse gas emissions to reduce the impact of global warming on evapotranspiration and snowpack in the Sierras Nevada Mountains. The reduction of snowpack concomitant with higher average temperatures would severely affect freshwater supply for much of California. In addition, the Pacific Institute and Natural Resources Defense Council issued a report in 2004 on the water and energy interrelationship[10].

California also formed a Water-Energy Partnership (WEP) as part of the CPUC proceeding, which is a group of public and private sector organizations that meet regularly to address water and energy issues, particularly to quantify energy savings

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[7] Water Action Plan. http://www.cpuc.ca.gov/Static/hottopics/3water/water_action_plan_final_12_27_05.pdf.
[8] Integrated Energy Policy Report 2005. http://www.energy.ca.gov/2005publications/CEC-100-2005-007/CEC-100-2005-007-CMF.PDF.
[9] http://www.energy.ca.gov/research/iaw/index.html.
[10] Energy Down the Drain: The hidden cost of California's water supply. http://www.nrdc.org/water/conservation/edrain/edrain.pdf.

resulting from water conservation and efficiency. Members of WEP include private and public energy and water companies; customer-based organizations; environmental groups; consultants; universities; and various state agencies. There is no single lead role, as the informal organization shares the responsibilities and objectives equally among all members.

The public is involved directly and/or indirectly at all stages of decision-making through representation by the CPUC's Division of Ratepayers Advocates (DRA) and other consumer-based-organizations. These representatives are involved in CPUC General Rate Cases, and the CPUC Energy Efficiency proceeding, workshops, and other CPUC and CEC proceedings. This group is important because it allows the public to become directly involved in energy and water conservation in the state.

III.2.1.3. Conservation Strategies

The California Urban Water Conservation Council (CUWCC) has established Best Management Practices (BMP 11) for water utilities to implement to achieve water use efficiency (see Appendix F). The CPUC is responsible for implementing the water and energy conservation policies, particularly with respect to retail rates, for the state's privately-owned water and energy utilities. This equates to a significant portion of California's residents served by privately-owned water utilities is about 20%, and roughly 80% of residential customers are served by privately-owned energy utilities.

The CPUC required in its Water Action Plan (WAP was approved 12/15/05) that all Class A privately-owned water utilities (Class A water utilities have at least 10,000 customers) sign the CUWCC Memorandum of Understanding (MOU), which includes complying with BMP 11. Also, the WAP requires the Class A water utilities to file for increasing block rates, a water revenue adjustment mechanism, and other conservation-encouraging policies.

The CPUC's current energy efficiency proceeding (R. 06-04-010) includes a water and energy segment. The pilot program is part of this phase, in which the state's major privately owned energy utilities were asked to develop pilot programs which will save energy as a result of water conservation and efficiency.

III.2.1.4. Legislation

Specific legislation and/or regulations that have been used to promote and develop energy and water programs include:

- **AB 1881** (5/30/86): addressed water conservation in landscaping, including a provision requiring new retail water service as of 1/1/08 to have meters installed to measure water used for landscaping; also residential clothes washers manufactured as of 1/1/07 must be as water-efficient as commercial clothes washers; and

- **AB 2515** (9/28/06): requires CPUC to report on the progress of WAP, which includes the water conservation objectives.

III.2.1.5. Evaluation

Water and energy issues are generally considered by local agencies, such as Local Agency Formation Commissions and municipal utilities. The CPUC will monitor the degree to which Class A water utilities follow BMPs, especially in terms of deploying meters, implementing increasing block rates, and implementing water revenue adjustment mechanisms and other policies which conserve water.

The CPUC is currently determining the metrics for quantifying energy savings from water conservation and efficiency in R. 06-04-010 (Energy Efficiency proceeding). The regional estimates (kWh/MG) for northern and southern California calculated by the consulting firm Navigant Consulting for the CEC are being refined to the extent possible, and ideally would be refined down to each service territory of the investor-owned energy utilities. These kWh/MG estimates are broken down at a minimum into 1) supply & conveyance, 2) water treatment, 3) distribution, and 4) wastewater treatment. Currently, there are separate estimates of these categories only for northern versus southern California, as the energy intensity of water consumed in southern California is about 2-3 times higher than northern California. This is primarily due to the conveyance of water from northern California to southern California over the Tehachapi mountain range.

III.2.1.6. Administration

There area a few critical questions to be addressed in the aforementioned pilot programs, including:

- How to quantify and verify the energy savings resulting from water conservation and efficiency, and where those energy savings occur (i.e. refinement of the CEC estimates);

- How to allocate those savings across jurisdictional service boundaries of the various utilities through which the water and energy are collected, conveyed, distributed, and used (and in the case of water only, treated);

- How to ensure that the utility ratepayers who are subsidizing the pilot programs are beneficiaries;

- How to ensure that there are no free riders;

- How to determine the marginal source of water supply for each water utility;

- Whether the energy savings resulting from the pilot programs should be counted towards the energy IOUs' 2006-008 Energy Efficiency goals, or not until the 2009-2011 Energy Efficiency program;

- How to involve the wastewater agencies in the pilots;

- How to involve the private water companies (and not just the public municipal suppliers) in the pilots;

- Whether the CPUC will allow retroactive reimbursement of pilot expenses, or will only reimburse for previously-approved expenses;

- To what degree will paper studies (as opposed to actual programs) be allowed by the CPUC;

- How to ensure that low-income ratepayers are equitably included in the program;

- Whether or not water and energy utilities will share sufficient information with each other to enable accurate measurement and assessment of energy savings;

- What pilot programs are feasible given the short time frame (starting the pilots in July 2007 with a 12 month completion target);

- Whether the approximately $10 million approved by the CPUC is sufficient for statewide assessment of energy savings.

These questions are all being addressed within the CPUC proceeding, including the comments which will be filed regarding the pilot programs proposed on 1/16/07. Simultaneously, a consultant who has been contracted to estimate the energy savings statewide by CEC, Navigant Consulting, is refining those estimates. Also, the Water-Energy Partnership mentioned above is addressing these issues.

III.2.1.7. Proposed Pilot Programs

There are various pilot programs that have been proposed by the electric utilities in partnership with the water utilities which will focus on the benefits of the integration of energy and water programs. For example, Pacific Gas & Electric (PG&E) has undertaken a water-embedded one year pilot program in partnership with East Bay Municipal Water District (EBMUD), Sonoma County Water Agency (SCWA), and the Santa Clara Valley Water District (SCCWD), serving the San Francisco Bay area.[11] This

[11] Water-Embedded Energy: Policy Activity in California. http://www.pge.com/003_save_energy/003c_edu_train/pec/water/docs/presentations/Hamilton-Water_Cons_Showcase.pdf.

pilot program focuses on the commercial, institutional and industrial sectors, including: schools, food processing plants, food service facilities, large commercial laundries, manufacturing plants, health service facilities, and low-income institutions. In addition, low-income communities selected for the pilot may include: large multifamily housing complexes, assisted-living communities, or other institutional facilities.

The pilot will use existing PG&E audits and design assistance which will incorporate water efficiency analysis as well as the existing energy analysis. Most participants will receive on-site audits of their facilities and/or operations. A unique package of water-use efficiency improvements will be recommended and pursued for each selected site. Program participants will be offered calculated savings incentives for large, specific projects as opposed to prescribed or deemed measure rebates.

San Diego Gas & Electric (SDG&E) has proposed pilot programs in partnership with the San Diego County Water Authority (SDCWA). The five components of the programs are:

- Low-Income Multifamily High Efficiency Toilet Replacement - expanding the low-income energy efficiency program to include replacing up to 2,500 toilets with high-efficiency toilets (HET)

- Managed Landscape - analysis of before-and-after audits of water efficiency on up to 20 sites of four acres each, using irrigation timers and other water-saving measures

- Large Customer Audits - combining energy and water audits now conducted separately by utility and water suppliers. Follow-up on implementation of previous water-conservation audits

- Recycled Water - implementing retrofits for users who can convert from potable water to recycled water source

- Joint Marketing and Outreach - leverage existing training and outreach programs conducted separately by utility and water suppliers.

Southern California Edison (SCE) has proposed pilot programs in partnership with the Metropolitan Water District of Southern California (MWD) and the Lake Arrowhead Community Services District (LACSD). The five components of these programs are:

- Low-Income Direct Install High Efficiency Toilets (HET) - provide high-efficiency toilets in single and multifamily homes in low-income neighborhoods and in schools with dense low-income populations

- Industrial Water Efficiency - partnership with the Metropolitan Water District of Orange County to expand the existing Industrial Process Water

Use Reduction program, which focuses on the textiles, food processing, metal plating, and electronics industries. Coordinates water supplier and utility to provide technical audits for energy and water savings

- Express Water Efficiency - delivers advanced PH controllers for cooling towers and Weather Based Irrigation Controllers (WBIC) to commercial customers with chilled water HVAC and/or large irrigation systems. Expands an existing non-residential retrofit rebate program

- Lake Arrowhead Water Conservation - delivers water-conserving devices to year-round residents and outdoor landscaping retrofits to the 1,000 largest residential consumers of water. Indoor devices include HETs, low-flow shower heads and sink aerators; outdoor devices include sprinkler heads and Smart controllers

- Green Schools/Green Campus with Water Efficiency - provides water conservation education for K-12 and college students and the direct installation of HETs in schools. Expands existing Green Schools and Green Campus energy efficiency programs by adding a water conservation component.

Southern California Gas Company (SoCalGas) has proposed a partnership with the Metropolitan Water District of Southern California (MWD), in coordination with Southern California Edison (SCE). SoCalGas wants to implement the pilot primarily in municipal electric utility service areas where SCE does not provide electric service.[12] The proposed pilot program includes two components, essentially identical to two of those proposed by San Diego Gas & Electric (SDG&E):

- Low-Income Multifamily High Efficiency Toilet Replacement - expanding low-income energy efficiency program to include replacing up to 3,500 toilets with high-efficiency toilets (HET);

- Joint Marketing and Outreach - leverage existing training and outreach programs conducted separately by utility and water suppliers.

III.2.2. New York

The State of New York exhibits a need for enormous quantities of energy and water, which is demonstrated particularly in the New York City area where population growth increases the demand for both freshwater and energy. It is estimated that drinking water and wastewater treatment facilities in New York consume more than 3 billion kWh of electricity per year (NYSERDA, 2004a) and cooling water for thermo-electric power

[12] Testimony of Mark F. Gaines to CPUC in application by Southern California Gas Company. Mr. Gaines also provided testimony for San Diego Gas & Electric Company's application.

plants accounted for 57% of all freshwater withdrawals in New York during 2000 – this demand alone equates to 4,036 Mgal/d (USGS, 2005). As far back as 1995, significant statewide energy savings were estimated for wastewater treatment facilities if demand side management (DSM) practices were implemented at the various state facilities (Pakenas, 1995) as shown in Table 4, and this is undoubtedly still the case.

Table 4: Statewide Energy Impacts of DSM Technologies

Technology	Energy Impact
Cogeneration	85 MW of utility Power displaced 0.27 TBtu Natural gas per year purchased for fuel Up to 3.5 million gallons of fuel saved per year after sludge drying
Effluent Hydro	8 MW (16 MW Peak) of Utility Power Displaced
Fine-Pore Aeration	45 MW (90 MW Peak) of Utility Power Displaced
Aeration Controls	14 MW (28 MW Peak) of Utility Power Displaced
Sludge Age Reduction	20 MW (40 MW Peak) of Utility Power Displaced

Source: Pakenas, 1995.

Concerns continue to exist regarding levels of energy and water use, and New York State has sponsored a regional workshop to examine the energy-water nexus. During these workshops, regional energy-water issues were identified based on the experience and expertise of local stakeholders such as state agencies, utilities, and environmental groups.

III.2.2.1. Energy-Water Integration Program Goals

One of the main avenues through which New York addresses the water-energy nexus issue is the New York State Energy Research and Development Authority's (NYSERDA) environmental program. The main goal of the program is to develop and demonstrate energy-efficient technologies associated with waste management and pollution control, which includes drinking water and wastewater treatment (NYSERDA, 2004b). Under its Municipal and Community sub-program, it targets municipal water, wastewater and solid waste facilities to improve energy efficiency and reduce operational costs. The principal goals of the water/wastewater program are to:

- Establish baseline energy use/cost data.
- Assess potential for energy savings.
- Provide strategic planning input for future programs.
- Disseminate results to stakeholders and market participants (Joseph, 2004)

NYSERDA also manages the New York Energy $mart^{SM} Program in collaboration with the state's Public Service Commission. The program is a public benefit energy research and energy efficiency services initiative, which is funded through the state's System Benefits Charge.[13] The program has supported demonstration projects, a statewide assessment of energy efficiency potential and technical feasibility, and technology transfer studies (NYSERDA, 2006). In particular, the program has supported projects within the water and wastewater sector through the Municipal Water and Wastewater Treatment Plant Program Assistance (NYSERDA, 2003). This provides cost sharing opportunities for:

- Energy studies – There is a FlexTech Program which pays for of the cost of hiring a consultant to perform technical studies on building operations; the Technical Assistance Program which allows municipalities to select their own contractors to perform energy-efficient improvement studies; the Combined Heat & Power and Renewable Generation Technical Assistance Program which funds studies focusing on evaluating "the feasibility of on-site electrical generation either using co-generation or an alternative energy source."

- Financial assistance to projects – There is the Smart Equipment Choices Program that "provides preset incentives for installing high-efficiency motors, variable speed drives, HVAC, and lighting measures;" the Commercial/Industrial Performance Program provides performance-based incentives to contractors for implementing electric efficiency measures; the Peak-Load Reduction Program provides incentives for projects resulting in reduced peak load demand; and the New York Energy $mart Loan Fund which "buys down the interest rate on loans for energy efficiency improvement projects."

- Research and development – There is the Municipal Water and Wastewater Technology Program that provides financial assistance for the research and development, demonstration, and deployment of underutilized and innovative technologies for water and wastewater treatment plants."

III.2.2.2. Stakeholder Participation

As of July 2007, NYSERDA had about 20 municipalities participating in its Water and Wastewater program[14] but this does not include municipalities that would be participating in its New York Energy $mart[SM] Program. In addition there were a number of stakeholders including NYSERDA that participated in the regional energy-water nexus workshop including Brookhaven National Laboratory, Columbia University Earth Institute, NYS Department of Environmental Conservation, NYC Department of Environmental Protection, Consolidated Edison Company of NY, and the Long Island Power Authority.

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[13] http://www.getenergysmart.org/AboutNYES.asp.
[14] http://www.nyserda.org/Programs/Environment/participatingmunicipalities.asp.

III.2.2.3. Conservation Strategies and Legislation

There are various strategies employed by state agencies to conserve water and energy in the state. These include:

- Reducing water use and consumption by increasing the use of renewable power sources. NYSERDA has been designated as the procurement administrator of the State Renewable Portfolio Standard (RPS) and aims to diversify the power generation resource mix and lessen the impact on water resources in achieving the mandatory RPS target of 25% of electricity consumption;

- New York State Department of Environmental Conservation (NYS DEC) is involved in minimizing water use by the power plants and improving the quality of the water discharged by the power plants

    1. In accordance with the federal permit program, each state can issue a State Pollution Discharge Elimination System (SPDES) permit based on its particular specifications;

    2. Title 6 of the New York Codes, Rules and Regulations (6 NYCRR) governs the standards for thermal discharges. In particular, §704.5 governs the location, design, construction and capacity of cooling towers that emit water as point source discharges. The Division of Environmental Enforcement works closely with the Division of Law Enforcement to enforce the state and federal laws pertaining to the DEC regulations;

- Use of green building initiatives to address among other things, energy and water use within the built environment of the state. New York State is one of the first states to offer tax incentives for green buildings or sustainable designed buildings.[15] For a building within the state to be eligible for the credit, it must meet a list of green standards related to energy, indoor air quality, building materials, commissioning, appliances and water conservation. The standards related to energy and water use include:

    1. An energy and energy efficiency criteria, in which all new construction must not exceed 65% of energy use allowed under The New York State Energy Conservation and Construction Code and for the rehabilitation of old buildings, no more than 75% of energy use is allowed under the Energy Conservation and Construction Code

[15] For information regarding New York's Green Building Programs, see http://www.dec.ny.gov/energy/218.html.

2. Energy compliant plumbing fixtures

3. Appliances and any heating, cooling and water heating equipment

4. Facilitating recycling of wastes.[16]

Aside from what occurs at the state level, there are additional conservation strategies being employed by urban centers within the state to reduce energy and water use. The New York City Department of Environmental Protection has a water conservation program that requires:

- Low-flow fixtures (toilet, shower-heads, and faucets) installed in all new construction and for building renovations

- Comprehensive Water Re-Use Program (CWRP) - NYC reduces the water bill by 25% for property owners who purchase equipment that treats a portion of the wastewater created within their building and re-uses that treated water within the building

- Fixture Replacement Incentives, - rebates range from $50 to $200 for replacing old water-wasting fixtures with efficient fixtures such as clothes washers, flapper-less, gravity-flush toilets, etc.

- Effective Market Pricing, - NYC will transition from flat-fee water/sewer billing to metered billing which is based on actual water consumption (~2008).

III.2.2.4. Evaluation

NYSERDA undertakes evaluation of its programs on the basis of a series of metrics, including: (1) kWh saved, (2) total kW reduced, (3) reduced energy costs, (4) jobs developed/retained, (5) increased hydraulic capacity, (6) reduced chemical use, (7) reduced sludge quantity. However, it is currently developing a method to more thoroughly measure the non-energy benefits of their programs. One of the recent evaluation metrics that is being developed for the energy-water interrelationship is as follows:

- NYSERDA is partnered with the American Water Works Association (AWWA) to develop utility energy indices to measure the results of a water utility's or a wastewater utility's energy management strategy. The measurements of operational performance will be used to compare utilities, to establish performance targets and budgets, and to assess the operational progress (AWWA, 2007b). NYSERDA has also set up a

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[16] New York State Green Building Tax Credit Legislation Overview. http://www.dec.ny.gov/energy/1540.html

System Benefits Charge Advisory Group as an independent evaluator of its Energy \$mart^{SM} program.[17]

- NYSERDA has also set up a System Benefits Charge Advisory Group as an independent evaluator of its Energy \$mart^{SM} program.[18]

III.2.2.5. Administration

There is currently no overall integrated water-energy plan that has been developed by the New York state agencies and therefore no administration of such a plan. However, there is some cross-program coordination through working groups that NYSERDA has established in order to explore the synergies that exist between programs. These working groups encompass various sectors including schools, municipal water and wastewater facilities and renewable energy programs.[19]

III.2.2.6. Barriers to Implementation

There are a few barriers to the implementation of a water-energy program in New York State that have been identified (mainly from participants in the regional energy conference). The primary barriers are:

- Aging infrastructure, dense populations and constrained land use
- Lack of integrated energy-water planning
- Municipalities are primarily focused on producing high quality water and not reducing their energy consumption
- Funding - most municipalities are, for the most part, cash strapped.

III.2.3. Wisconsin

The Focus on Energy (FOE) Program in Wisconsin is a statewide public-private partnership program that supports energy reduction in residential and business sectors.[20] The program offers services to a range of business sectors including: agriculture, commercial, industrial, education, and local government. Within the Industrial sector, there is a Water and Wastewater Program, which provides energy efficiency and conservation assistance to water and wastewater facilities, linking water and energy use. The program provides information, resources and financial incentives in order to help install cost-effective energy efficiency and renewable energy technologies.[21]

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[17] http://www.nyserda.org/Energy_Information/evaluation.asp.
[18] http://www.nyserda.org/Energy_Information/evaluation.asp.
[19] System Benefits Charge. Proposed Plan for New York Energy Smart^{SM} Programs (2006-2011). http://www.dps.state.ny.us/SBCIII_Amended_Plan_3-2-06.pdf.
[20] http://www.focusonenergy.com/
[21] Water and Wastewater Facilities Program. http://www.focusonenergy.com/data/common/pageBuilderFiles/WW.PDF?

The FOE Program began including drinking water facilities in its energy reduction program in 2002. In order to develop a baseline evaluation of energy use at these facilities, the Energy Center of Wisconsin and the FOE Program undertook a study that quantified the energy consumption at the various facilities and the energy saving options available to reduce consumption levels (ECW, 2003). Among the main findings of the report were:

- Energy costs typically ranged from 20% to 60% of a utility's annual operating budget, costs that are likely to rise further with new federal and state regulations requiring additional treatment methods such as ozonation and irradiation

- Most energy consumption in drinking water systems was associated with pumping:

    1. For typical surface water systems, 85% of energy costs are from pumping;
    2. For groundwater systems, almost all energy costs are from pumping

- Over the four-year study period, Wisconsin drinking water facilities consumed a statewide average of 1.3 kWh of energy per 1000 gallons of water produced, at a cost of approximately 9.4 cents per 1000 gallons of water

- During the study period, the difference between the amount of water produced and amount sold ("water lost") was 23.5 billion gallons per year, at an energy cost of $2 million per year

- The largest drinking water facilities (Class AB, serving more than 4000 customers) had the lowest rates of energy consumption and water loss

- The highest rates of energy consumption were among water utilities drawing from groundwater sources where water table drawdown is a problem (requiring more energy for pumping).

The report also reviewed energy reduction measures that water utilities could use to reduce energy consumption. These included electric billing and audits, equipment improvements (motors, pumps, valves, etc.), and water treatment processes (disinfection and filtration). Among its recommendations:

- Opportunities for energy savings in demand-side management include:

    1. Shifting energy consumption from on-peak to off-peak hours
    2. Adding storage for off-peak/emergency pumping.

- Improving the efficiency of the largest utilities results in greatest overall energy savings, even though larger facilities tended to be most efficient energy users.

Prior to the baseline evaluation research, FOE had commissioned the development of energy consumption guidelines for water and wastewater facilities in Wisconsin in order to include energy efficiency components into the design practices of these facilities (Energenecs Incorporated *et al*, 2003).

III.2.3.1. Energy-Water Integration Program Goals

The overall goals of the Focus on Energy Program are to lower cost of living and operational cost, increase electric reliability, improve energy efficiency, reduce the need for fossil fuels, improve the economy, and improve environmental health. In addition to assisting local government and industrial water and wastewater facilities under this program, households are also provided weatherization services, which include the implementation of water saving measures.

III.2.3.2. Stakeholder Participation

As of 2003, the Water and Wastewater Program had over 130 program partners, most of which were local (city/village) water and wastewater utilities. Overall, more wastewater utilities than drinking water suppliers have participated in the program. In order to bring more facilities across the state (and therefore more partners) into the Waste and Wastewater Program, the Focus on Energy program is collaborating with the Wisconsin Rural Water Association (WRWA).[22]

III.2.3.3. Conservation Strategies

The Water and Wastewater Program offers technical assistance and financial incentives to encourage water and wastewater service providers to improve energy efficiency and thus reduce operating expenses and/or operating costs. Financial incentives include small grants (typically 5-7% of total project costs) for efficiency improvements. Technical assistance includes:

- conducting energy surveys to identify and evaluate energy-saving opportunities
- developing energy management plans for water/wastewater facilities
- introducing facility operators to new technologies
- locating contractors and evaluating proposals
- providing information, education, and training resources.

[22] http://www.focusonenergy.com/page.jsp?pageId=684.

A program called Conserve Wisconsin was launched in 2005 by the Governor of Wisconsin to safeguard Wisconsin's environmental conditions. The focus of the program is on the protection of waterways, conservation of land space, revitalization of urban neighborhoods and the promotion of energy conservation and innovation.[23] A key component of the program has been the development of a series of demand-side initiatives for water utilities (PSCW and WDNR, 2006).[24] One consideration identified under this study was the need for water utilities to work with other organizations regarding the synergies that exist between water and energy efficiency.

III.2.3.4. Legislation

In 1999, state legislation was enacted (Act 9/Reliability 2000) to reassign administration of energy efficiency programs from energy utilities, which had managed these programs since the 1980s, to the state, through the Department of Administration (DOA). In 2006, legislation was passed that revised program funding and administration to prevent funding from being diverted to other uses under budget constraints. Act 9 also included new requirements related to renewable energy sources and the creation of two public benefits programs to provide assistance to low income households for weatherization and other energy conservation services, and grants for energy conservation and efficiency services and renewables.[25]

III.2.3.5. Evaluation

Statewide, the Division of Energy tracks energy savings in all sectors of the Focus on Energy Program. PA Government Services, Inc., part of the PA Consulting Group, has been hired by the Wisconsin Department of Administration (DOA), to evaluate the program's performance and document its benefits. It has been estimated that there has been a 20% to 40% reduction in energy use among wastewater utilities participating in the program.

III.2.3.6. Administration

The Focus on Energy Program is paid for by rate payers and administered by the state's Department of Administration Division of Energy. Implementation of specific sectors of the program is conducted by private firms, which are selected by the state through a Request for Proposals process.

III.2.3.7. Barriers to Implementation

While Wisconsin has a long history of implementing energy efficiency programs through energy utilities, there is little history of implementing water conservation through

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[23] For more details of PSC's water conservation initiatives, see http://psc.wi.gov/conservationWater/index-waterConservation.htm.

[24] For details of demand-side initiatives for water conservation in Wisconsin, see http://psc.wi.gov/conservationWater/documents/WaterConservationReport.pdf.

[25] http://www.legis.state.wi.us/LRB/pubs/budbriefs/99bb1.pdf

water utilities and this may limit the success of the Conserve Wisconsin program. It may also impact on the Focus on Energy Program.

Section IV
Summary and Conclusions

A principal finding of our survey of the various states shows that there is a paucity of programs designed specifically to address the energy-water linkage, although there is an assortment of portions of programs and initiatives, some regulations, as well as one piece of legislation that are addressing some element of this important issue. Where there are dedicated programs, a number of lessons can be learned from their development and implementation that will be useful to the State of Delaware if it chooses to develop an energy-water program.

Integration of water and energy is demonstrated to enhance all elements in the E^4 framework, yet it has become apparent through the extensive research undertaken in this study that these synergic benefits are not fully explored at the state or municipal levels. In light of this, an important question to be answered is, "why have they not been fully explored and implemented?" The cases of California, New York, and Wisconsin provide some answers to this question, in six areas: 1.) information dissemination, 2.) planning and program, 3.) institutional coordination, 4.) funding and financial incentives, 5.) legislation and regulations, and 6.) auditing and evaluation.

IV.1. Information Dissemination

The utility commissions, states, and energy and water utilities play important roles in information dissemination through sponsoring workshops, undertaking research, and website maintenance in the case studies. Education of K-12 and college students about the integrated conservation of energy and water has also been conducted. Delaware could consider sponsoring similar workshops and educational and research initiatives to disseminate information about the synergic benefits of water-energy integration, especially during droughts.

- The California Energy Commission (CEC) has held workshops on water and energy, conducted research on technologies designed to reduce water and energy use, and has a website containing information about water and energy conservation technologies. (California)

- San Diego Gas & Electric (SDG&E) and Southern California Gas Company (SoCalGas) implemented a Joint Marketing and Outreach Program, which leverages existing training and outreach programs conducted separately by utility and water suppliers. (California)

- SDG&E's Green Schools/Green Campus with Water Efficiency provides water conservation education for K-12 and college students and oversees the installation of high-efficiency toilets (HETs) in schools. It also expands existing Green

Schools and Green Campus energy efficiency programs by adding a water conservation component. (California)

- The Water and Wastewater Program offers technical assistance to encourage water and wastewater service providers to improve energy efficiency by: 1.) conducting energy surveys to identify and evaluate energy-saving opportunities; 2.) developing energy management plans for water/wastewater facilities; and 3.) providing information, education, and training resources. (Wisconsin)

- New York State has sponsored a regional workshop to examine the energy-water nexus. Regional energy-water issues were identified based on the experiences and expertise of local stakeholders such as state agencies, utilities, and environmental groups. (New York)

- One of the New York State Energy Research and Development Authority's (NYSERDA) environmental programs is to develop and demonstrate energy-efficient technologies associated with waste management and pollution control, including drinking water and wastewater treatment. The principal goals of the water/wastewater program are to: 1.) establish baseline energy use/cost data; 2.) assess potential for energy savings; 3.) provide strategic planning input for future programs; and 4.) disseminate results to stakeholders and market participants. (New York)

IV.2. Planning and Programs

A pilot program in California has been used to evaluate the energy impacts of water resources (see section 4.6). It also analyzed water-energy savings for major commercial, institutional and industrial sectors, and evaluated the impact of the Renewable Portfolio Standard (RPS) on water resources. Delaware could also undertake research to evaluate the impact on water resources of achieving their mandatory RPS target of 20% of electricity consumption by 2019. In addition, lower-income weatherization in Delaware could include water savings measures. Other relevant planning and programs found in the case studies include:

- In October 2006, the California Public Utilities Commission (CPUC) issued a ruling to direct the state's four investor-owned energy utilities to work with water providers to develop pilot programs to reduce energy consumption associated with water supply, distribution, treatment, and end-use. (California)

- A Pacific Gas & Electric (PG&E) pilot program focuses on elements of the commercial, institutional and industrial sectors, including: schools, food processing plants, food service facilities, large commercial laundries, manufacturing plants, health service facilities, and low-income institutions. (California)

- San Diego Gas & Electric (SDG&E) and Southern California Gas Company (SoCalGas) have expanded a low-income energy efficiency program to include replacing conventional toilets with high-efficiency toilets (HETs). (California)

- In addition to assisting local government and industrial water and wastewater facilities under the 'Focus on Energy Program,' households are also provided weatherization services, which include the implementation of water saving measures. (Wisconsin)

- The Water and Wastewater Program began including drinking water facilities in its energy reduction program in 2002[26] [27]. (Wisconsin)

- NYSERDA has been designated as the procurement administrator of the State Renewable Portfolio Standard (RPS) and aims to diversify the power generation resource mix and lessen stresses on water resources by achieving the mandatory RPS target of 25% of electricity consumption. (New York)

- New York State Department of Environmental Conservation (NYS DEC) is involved in minimizing water use by power plants and improving the quality of water discharged by the power plants. (New York)

IV.3. Coordination

Water-energy partnerships that have been formed to address water and energy issues are detailed in the case studies. The partnerships offer services to a range of sectors including agriculture, commercial, industrial, education, and local governments. Members of the partnerships include private and public energy and water utilities (including wastewater utilities), customer-based organizations, environmental groups, consultants, universities and various state agencies. Delaware could also create water-energy partnerships involving a variety of actors to take advantage of the synergic benefits of the integration.

- The Water-Energy Partnership (WEP) is a group of public and private sector organizations that meets regularly to address water and energy issues, particularly to quantify energy savings resulting from water conservation and efficiency, as part of the CPUC proceeding detailed in section IV.2. Members of WEP include private and public energy and water companies, customer-based organizations,

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[26] Most energy consumption in drinking water systems was associated with pumping. For typical surface water systems, 85% of energy costs are from pumping; for groundwater systems, almost all energy costs are from pumping.

[27] Wisconsin drinking water facilities consumed a statewide average of 1.3 kWh of energy per 1,000 gallons of water produced, at a cost of approximately 9.4 cents per 1,000 gallons of water. The difference between the amount of water produced and amount sold ("water lost") was 23.5 billion gallons per year, at an energy cost of $2 million per year.

environmental groups, consultants, universities, and various state agencies. (California)

- Wisconsin's 'Focus on Energy Program' is a statewide public-private partnership program that offers services to a range of business sectors including agriculture, commercial, industrial, education, and local government. Within the industrial sector, there is a Water and Wastewater Program, which provides energy efficiency and conservation assistance to water and wastewater facilities. (Wisconsin)

- A number of stakeholders including NYSERDA participated in the regional energy-water nexus workshop (see section 4.1) including Brookhaven National Laboratory, Columbia University Earth Institute, NY State Department of Environmental Conservation, NYC Department of Environmental Protection, Consolidated Edison Company of NY, and the Long Island Power Authority. (New York)

- NYSERDA partnered with the American Water Works Association (AWWA) to develop utility energy indices to measure the results of water and wastewater utility's energy management strategy. The measurements of operational performance will be used to compare utilities, to establish performance targets and budgets, and to assess the operational progress. (New York)

IV.4. Funding &Financial Incentives

Various financial mechanisms could be used to promote and attain benefits associated with water-energy integration. Technical and financial incentives, tax incentives, rebates, and system benefits charges have been used in the case studies. Delaware's Sustainable Energy Utility (SEU), as well as other public and private entities, could consider the integrated water-energy savings as a funding target. In addition, already existing lower-income weatherization assistance in Delaware could be expanded to include water savings measures. The following are examples of funding and financial incentives found in the case studies. Many of these could inform any future financial incentive policies to be implemented by the state of Delaware.

- The Water and Wastewater Program offers technical assistance and financial incentives to encourage water and wastewater service providers to improve energy efficiency and reduce operating expenses and/or costs. Financial incentives include small grants (typically 5-7% of total project costs) for efficiency improvements. (Wisconsin)

- Wisconsin's 'Focus on Energy Program' is paid for by rate payers and administered by the state's Department of Administration, Division of Energy. Implementation of specific portions of the program is conducted by private firms, selected by the state through a Request for Proposals process. (Wisconsin)

- NYSERDA manages the New York Energy $mart℠ Program in collaboration with the state's Public Service Commission. One element of the program supports projects within the water and wastewater sectors through the Municipal Water and Wastewater Treatment Plant Program Assistance, which is a public benefit energy research and energy-efficiency services initiative funded through the state's System Benefits Charge. (New York)

- New York is among the first states to offer tax incentives for green buildings or sustainable designed buildings. To be eligible for the credit, a building must meet a list of "green" standards, including water conservation. (New York)

- New York City's Department of Environmental Protection has a water conservation program that initiates Fixture Replacement Incentives. Rebates range from $50-$200 to replace old water-wasting fixtures with efficient fixtures such as front-loading clothes washers and flapper-less, gravity-flush toilets. (New York)

IV.5. Legislation/Regulations

No legislation has been enacted to promote water-energy integration in the case studies except for regulations on thermal discharges of water by power plants. However, green building standards have addressed energy and water use, including water conservation and energy savings. Any green building initiatives enacted in Delaware could include a water conservation element along with the usual energy conservation element.

- Title 6 of the New York Codes, Rules and Regulations (6 NYCRR) governs the standards for thermal discharges of water by power plants. In particular, §704.5 governs the location, design, construction and capacity of cooling towers, which emit point source discharges in the form of hot water. The Division of Environmental Enforcement works closely with the Division of Law Enforcement to enforce the state and federal laws pertaining to the DEC regulations. (New York)

- For a building within the state to be eligible for a "green building" credit, it must meet a list of standards related to energy, indoor air quality, building materials, commissioning, appliances and water conservation. (New York)

- Green building standards have been mandated to address energy (mostly) and water use in the built environment of the State. The standards include that all new construction must not exceed 65% of energy use allowed under the New York State Energy Conservation and Construction Code, and that in the rehabilitation of old buildings, no more than 75% of energy use is allowed. Among other things, the Code addresses energy compliant plumbing fixtures and water heating equipment. (New York)

IV.6. Audits & Evaluation

The combination of energy and water audits for large customers, including industrial process units, has been found to occur in states detailed in the case studies. Metrics for quantifying energy savings from water conservation and efficiency in its supply and conveyance, treatment, distribution, end use, and wastewater treatment have been derived. Delaware could consider the combined auditing of energy and water utilities and develop the metrics for energy savings from water conservation, (kWh/MG) and vice versa (MG/kWh). Ascertaining the amount of energy used by water utilities and water used by energy utilities would provide a solid foundation for quantifying the results of conservation efforts in Delaware.

- The pilot program detailed in Section III.2.1 will use existing PG&E audits and design assistance which will incorporate water efficiency analysis as well as the energy analysis already being used. Most participants will receive on-site audits of their facilities and/or operations. A unique package of water-use efficiency improvements will be recommended and pursued for each selected site. (California)

- The CPUC is currently determining the metrics for quantifying energy savings from water conservation and efficiency in (Energy Efficiency Proceeding: R. 06-04-010). The regional estimates (kWh/MG) for northern and southern California calculated by Navigant Consulting for the CEC are being refined to the extent possible, and would ideally be refined down to each service territory of the energy investor-owned utilities. These kWh/MG estimates are broken down at a minimum into 1.) supply & conveyance, 2.) water treatment, 3.) distribution, and 4.) wastewater treatment. (California)

- SDG&E conducts "large" customer audits that combine energy and water audits now being conducted separately by a utility and water supplier. They also follow up on implementation of previous water conservation audits. (California)

- SDG&E has implemented an industrial water efficiency program. To do this, they formed a partnership with the Metropolitan Water District of Orange County and expanded an existing industrial process water use reduction program that focuses on the textiles, food processing, metal plating, and electronics industries. This program coordinates water suppliers and utilities to provide technical audits for energy and water savings. (California)

- Prior to their baseline evaluation research, 'Focus on Energy' had commissioned the development of energy consumption guidelines for water and wastewater facilities in Wisconsin to include energy efficiency components into the design practices of these facilities. (Wisconsin)

- Statewide, the Division of Energy tracks energy savings in all sectors of the 'Focus on Energy Program.' A 20% - 40% reduction in energy use has been estimated among wastewater utilities participating in this program. (Wisconsin)

- Wisconsin drinking water facilities consumed a statewide average of 1.3 kWh of energy per 1000 gallons of water produced, at a cost of approximately 9.4 cents per 1000 gallons of water. The difference between the amount of water produced and amount sold ("water lost") was 23.5 billion gallons per year, at an energy cost of $2 million per year. (Wisconsin)

IV.7. Lessons Learned

The impacts on the synergic benefits of water-energy planning, particularly in terms of efficiency improvements and alternative technological developments in both water and energy production need to be fully understood, especially during drought events, when water availability is an extremely pressing need. These benefits are becoming increasingly important to understand in light of the seeming inevitability of climate change and recent climatic events in Delaware. Considering that the six hottest years on record have occurred in the last ten years (GISS, 2007), and taking into account the two major droughts that have occurred in Delaware in the past 10 years, it appears that Delawareans are vulnerable to the effects of climate variability.

The case studies detailed in this report provide a number of examples of integrated water-energy initiatives that could potentially be used as models if the State of Delaware should choose to develop an energy-water program. As detailed in the previous section, these initiatives address the areas of information dissemination, planning, coordination, funding and financial initiatives, legislation and regulation, and auditing and evaluation. The State could review relevant programs from these states before initiating their own integrated water-energy programs. Such a review would potentially be helpful in choosing an effective combination of strategies.

The availability of water and energy is essential to human survival and is an integral contributor to the evolution of modern civilization. Simply put, no modern society can survive without adequate supplies of energy and fresh water. An important conclusion of this analysis is that there is a wide range of knowledge, receptivity, and application of practices and programs that can alleviate the stresses on these two resources. In addition, the assessment of the programs detailed in this report reveals that integrating energy and water use and planning has the potential to save money, reduce waste, protect the environment, promote equity, and strengthen the economy. It is recommended that Delaware utilize elements of these case studies as models to assist in the construction of their own framework for integration of water and energy. The need for this integration seems all the more important in light of the recent statewide droughts, the potential for more extreme weather due to climate change, the increasing stresses placed on energy and water resources by the growing population of Delaware, and the demonstrated economic, environmental, equity, and energy benefits of these programs.

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Appendix A

Delaware's Water and Energy Profile

A.1. Delaware Water Profile

The state of Delaware encompasses all or parts of five river basins (Piedmont, Delaware Bay, Chesapeake Bay, Inland Bay and Delaware Estuary) and is delineated into 45 watersheds (Figure A-1). Piedmont accounts for 6 watersheds, Delaware Bay accounts for 16 watersheds, Chesapeake Bay for 15 watersheds and Inland Bay accounts for remaining 8 watersheds of State of Delaware (DNREC, 2007). A brief outline of water body sizes is summarized in Table A-1.

Table A-1: Water Bodies of the State of Delaware

State Surface Area	1981 square miles
Number of basins	5
Number of watersheds	45
Total number of streams and river miles	2509
Number of perennial river miles	1778
Number of intermittent stream miles	405
Number of ditches and canals	326
Number of border miles	87
Acres of lakes/reservoirs/ponds	2954
Square miles of estuarine water	841
Number of ocean coastal miles	25
Acres of freshwater wetlands	226,530
Acres of tidal wetlands	127,338

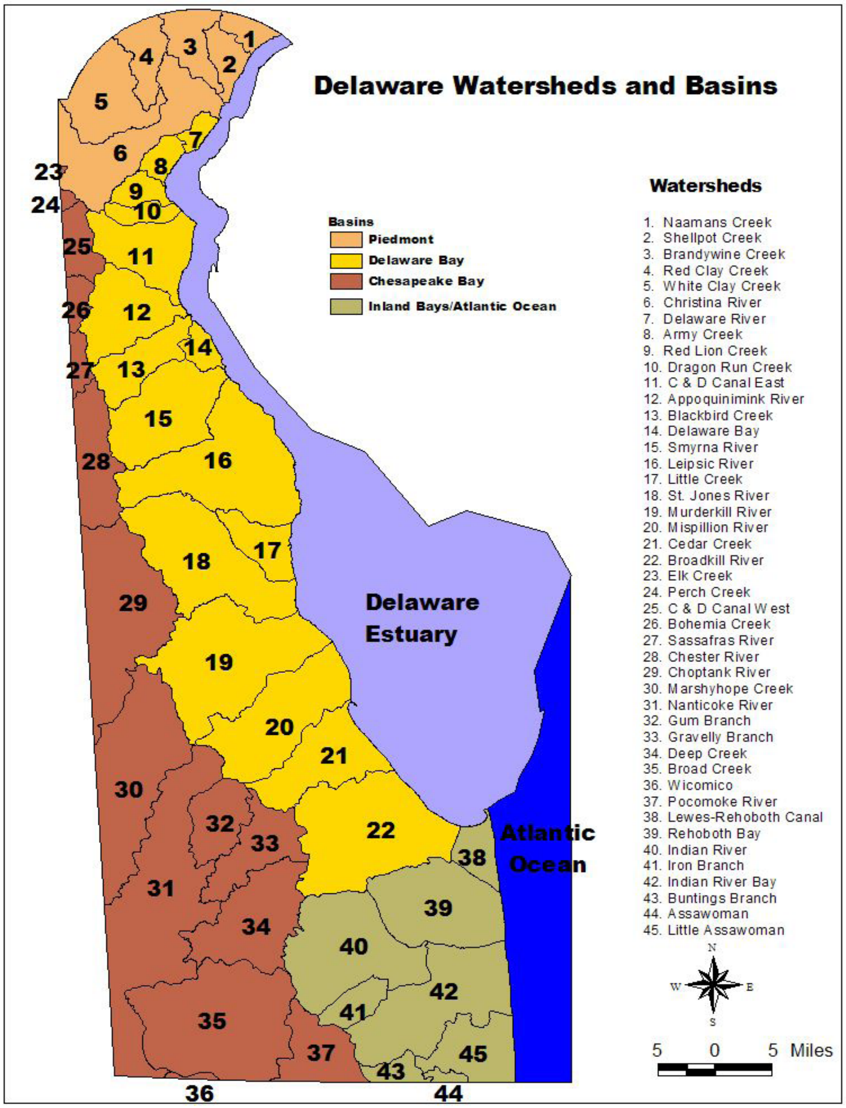
Source: DNREC, 2007

A.1.1. Freshwater Sources and Uses

Eighty percent of the freshwater used in Delaware is provided by surface water sources, primarily from the Christina River Basin in northern New Castle County. The remaining 20% of freshwater use is provided by groundwater sources (Table A-2). Both surface and groundwater sources are within watersheds and aquifers that are shared with neighboring states. Thus, water supply and distribution issues that affect the larger mid-Atlantic region can also affect freshwater use in Delaware.

Water is distributed through both public and private supply systems. Self-supplied water users include homes and small communities that rely on groundwater from individual wells. While groundwater withdrawals accounts for a relatively small proportion of statewide water use, it should be noted that this represents many individual wells operated and maintained by many different public and private users. Statewide in 1998-1999, 4,656 permits were issued for domestic wells and 148 permits were issued for public supply wells. Total freshwater withdrawals in Delaware in 2000 measured 584 million gallons per day (Wheeler, 2003). More than three fourths of the state's freshwater use – some 462 million gallons per day – is in New Castle County (Table A-2).

Figure A-1: River Basin and Watersheds of State of Delaware



Source: DNREC, 2007.

Table A-2: Freshwater Withdrawal in the State of Delaware (2000)

By Source	Million gallons per day	Percentage of total
Surface water withdrawals	467	80
Groundwater withdrawals	117	20
By County:	**Million gallons per day**	**Percentage of total**
New Castle County	462	79
Kent County	31	5
Sussex County	91	16

Source: Wheeler, 2003

The largest water use by far is for thermoelectric power (366 million gallons/day), nearly all of which is from surface water sources (Table A-3). The four thermoelectric facilities operating in Delaware are located along rivers[28] and after the water is used for cooling, much of it is returned to the water source. Thus, the figures shown here represent water use, not water consumption. This use may have environmental effects on the river ecosystem by effectively sterilizing the water as it passes through the system but the net water consumption is not likely to reduce freshwater supplies for other human uses.

Table A-3: Freshwater Uses in the State of Delaware (2000)

By Use	Million gallons/day	Source
Thermoelectric power	366	Mostly surface water
Public Supply	95	Half surface water
Industrial	73	43 Mgal/d surface water
Irrigation	43	8 Mgal/d surface water
Domestic	63	13 Mgal/d self-supplied (groundwater)
Commercial	23	2 Mgal/d self-supplied (groundwater)
Livestock	4	3.77 Mgal/d self-supplied (groundwater)

Source: Wheeler, 2003

A.1.2. Drinking Water Sources and Suppliers

There are three suppliers providing drinking water to about 53% of the state's population. These are:

[28] Three of the power plants are on the Delaware River, where water withdrawals are largely from the tidal Delaware River estuary, and therefore water supply issues are not relevant to other human uses.

- City of Wilmington Department of Public Works ─ It serves 140,000 customers (per USEPA's Safe Drinking Water Information System - SDWIS) (17% of the state population)

- Artesian Water Company ─ Serves 200,234 customers (24% of the state population)

- Artesian Water, the utility subsidiary of Artesian Resources, obtains most of its supply from groundwater wells. The oldest and largest public water utility in Delaware, it supplies water to residential, commercial, industrial, governmental, municipal and utility customers throughout the state

- United Water Delaware ─ Serves 105,270 customers (12% of the state population). United Water Delaware, a subsidiary of United Water Resources, supplies water to customers in Delaware and Pennsylvania. In Delaware, United Water Delaware obtains water from surface sources. Most customers are supplied with water from White Clay Creek and Red Clay Creek, which is treated at the Stanton Water Treatment Plant, the only surface water treatment facility in the United States utilizing a very particular upflow clarification process along with the standard multimedia filtration process. United Water Delaware also obtains water from the Christiana River, which is processed at the Christiana water treatment plants for customers in the southern portion of their distribution area.

In addition, the municipal water systems provide dinking water to another 24% of the state population (not including Wilmington) (Table A-4).

A.1.3. Trends and Existing Condition of Drinking Water Supply

A network of municipal and investor-owned utilities provides public drinking water supply in the State of Delaware. In New Castle County, streams are the major source of water supply whereas in the case of Kent and Sussex Counties, groundwater is the major source for the water supply. Seventy-five percent of public drinking water demand in northern New Castle County is supplied from streams of the Christiana Basin (see Figure A-1), whereas groundwater sources supplies provides all of the public drinking water for southern New Castle County (Table A-5). Similarly, in Kent and Sussex Counties both investor and municipal owned utilities use groundwater wells as public water supply sources (Table A-6 and Table A-7, respectively).

Table A-4: Municipal Water Suppliers

Municipal water system	Population served	Primary water source type
New Castle County		
Delaware City	2,220	Groundwater
Middletown	9,900	Groundwater
New Castle	6,000	Groundwater
Newark	36,130	Groundwater
Townsend	660	Groundwater
Kent County		
Clayton	2,250	Groundwater
Dover	33,765	Groundwater
Felton	1,591	Groundwater
Frederica	870	Groundwater
Harrington	3,174	Groundwater
Magnolia	1,065	Groundwater
Milford	11,275	Groundwater
Sussex County		
Bethany Beach	9,201	Groundwater
Blades	1,200	Groundwater
Bridegeville	1,350	Groundwater
Dasgboro	360	Purchase & Groundwater
Dewey Beach	400	Purchase & Groundwater
Frankford	900	Groundwater
Georgetown	6,000	Groundwater
Greenwood	800	Groundwater
Henlopen Acres	999	Groundwater
Laurel	3,668	Groundwater
Lewes	9,200	Groundwater
Millsboro	3,825	Groundwater
Milton	2,400	Groundwater
Rehoboth Beach	46,495	Groundwater
Seaford	8,000	Groundwater
Selbyville	1,645	Groundwater
Total	**205,343***[*]*	

[*] 24% of the state population.
Source: U.S. EPA, 2006.

Table A-5: Drinking Water Supply of New Castle County

Northern New Castle County				
Purveyor	**Type**	**Source**	**Capacity (mgd)**	**Population**
Artesian Water	Investor	Wells	25	207,000
Delaware City	Municipal	Wells	2	2,000
Newark	Municipal	Stream/Wells	7	36,000
New Castle	Municipal	Wells	2	6,000
United Water, DE	Investor	Stream	30	103,000
Wilmington	Municipal	Stream	35	140,000
Southern New Castle County				
Purveyor	**Type**	**Source**	**Capacity (mgd)**	**Population**
Artesian Water	Investor	Wells	2	8,100
Middletown	Municipal	Wells	2	3,000
Tidewater utilities	Investor	Wells	2	2,200

Source: DEDO, 2005a.

Table A-6: Drinking Water Supply of Kent County

Purveyor	Type	Source	Capacity (mgd)	Population
Artesian Water	Investor	Wells	3	27,000
Camden-Wyoming	Municipal	Wells	1.4	3,500
Clayton	Municipal	Wells	1.4	2,200
Dover	Municipal	Wells	8	34,000
Felton	Municipal	Wells	1.2	1,600
Frederica	Municipal	Wells	1.4	900
Harrington	Municipal	Wells	1.0	4,200
J.H Wilkerson	Municipal	Wells	--	--
Magnolia	Municipal	Wells	1.7	1,100
Milford	Municipal	Wells	5.9	6,900
Pickering Beach	Municipal	Wells	0.4	--
R.B Outten	Municipal	Wells	--	--
Smyrna	Municipal	Wells	5.3	7,500
Tidewater Utilties	Investor	Wells	7.0	6,000

Source: DEDO, 2005b

Table A-7: Drinking Water Supply in Sussex County

Purveyor	Type	Source	Capacity (mgd)	Population
Artesian Water	Investor	Wells	5.5	27,000
Bethany Beach	Municipal	Wells	N/A	10,000
Blades	Municipal	Wells	N/A	10,000
Bridgeville	Municipal	Wells	N/A	1,400
Dagsboro	Municipal	Wells	N/A	10,000
Delmar	Municipal	Wells	N/A	2,500
Frankford	Municipal	Wells	N/A	10,000
Gerorgewood	Municipal	Wells	N/A	6,000
Greenwood	Municipal	Wells	N/A	700
J.H Wilkerson	Municipal	Wells	N/A	10,000
Laurel	Municipal	Wells	N/A	3,800
Lewes	Municipal	Wells	N/A	9,000
Longneck	Municipal	Wells	N/A	10,000
Milford	Municipal	Wells	N/A	6,900
Millsboro	Municipal	Wells	N/A	3,100
Milton	Municipal	Wells	N/A	2,400
Rehoboth	Municipal	Wells	N/A	70,000
Sea Colony	Municipal	Wells	N/A	10,000
Seaford	Municipal	Wells	N/A	8,000
Selbyville	Municipal	Wells	N/A	2,100
Sussex County	Municipal	Wells	N/A	10,000
Sussex Shore	Municipal	Wells	N/A	10,000
Tidewaters	Investor	Wells	N/A	19,300

Source: DEDO, 2005c

A.1.4. Groundwater Issues

Although groundwater provides only 20 percent of the state's total freshwater withdrawals in volume, it is the primary water source for much of southern Delaware, especially in southern New Castle County, and most of Kent and Sussex Counties. Groundwater users include not only the municipal suppliers as shown above but also many small, private systems that provide water to as few as 25 consumers each. Permitting for these systems is managed by the Delaware Department of Natural Resources and Environmental Control's Division of Water Resources.

Maintaining base flow groundwater is important as it is also a major supplier of water to streams. In times of drought, almost all surface water flow comes from groundwater discharge. Therefore, preventing overdraft of aquifers is essential to maintaining surface water supplies that provide much of the state's water. Groundwater can be less costly than surface water as a drinking water source because groundwater is generally of good quality and requires little treatment compared to surface water, and because groundwater can often be developed close to its end use, reducing the need for long-distance transport.

Nevertheless, groundwater is vulnerable to contamination due to the shallow water table and high soil permeability across much of the Delmarva Peninsula. Aquifers can be affected by many sources of pollution, including domestic septic systems, landfills, underground storage tanks and agricultural and industrial activities. Saltwater intrusion is another potential problem in coastal areas caused by overdraft of groundwater.

The seasonality of water demands is significant in Kent and Sussex counties. Water demand increases in the summer because of irrigation needs (it is an important stretch of the growing season) and the increased population of vacationers and summer residents. This stress on water resources is compounded because the increased demand coincides with lower groundwater levels, a result of increased evapotranspiration rates and reduced rainfall.

A.1.5. Delaware Drought Profile

In 1999 Delaware was hit by a severe drought, which severely stressed Delaware's water supply. It was realized with this drought that water supply for Northern Delaware was barely adequate to meet the demands of consumers and would not be sufficient to cope with the population growth and economic development predicted for this part of the state. Unlike the southern part of the state, northern Delaware is especially susceptible to drought because its water supply comes mainly from surface water (75%) rather then ground water sources.

The drought of 1999 prompted Governor Carper to dedicate a Water Supply Task Force (WSTF) to endorse additional water supply sources and appoint a new Water Coordinator and Water Supply Coordinating Council (WSCC). In December of 1999, the WSTF submitted their first report, recommending options to increase and secure northern Delaware's water supply (WSCC, 2000). Based on projected 2020 water deficits, the goal was to increase the supply and storage of water to an additional 1,180 million gallons to meet the predicted water deficit for northern Delaware (Table A-8).

Table A-8: New Castle County Water Supply and Demand Projections

New Castle County - Supply and Demand Projections through 2020				
Scenario/Year	**Supply (mgd)**	**Demand (mgd)**	**+/-(mgd)**	**Volume(mg)**
2000	73.0	86.0	-13.0	-780
2010	73.0	88.0	-15.0	-900
2020	73.0	90.0	-17.0	-1,020

Source: DEDO, 2005a.

In 2002, the worst drought on record hit Delaware, with northern New Castle County being the hardest hit area in the state. Stream flows reached an all time low for the County with brackish waters encroaching into freshwater areas and reservoirs. The 2002 drought revealed that the supply and demand projections for droughts were too low and had to be reconfigured. The supply of water had to be increased by another 262 to 450mg to meet peak demands during the stress of a drought lasting 75 days (WSCC, 2004).

In response to the new peak demand, the Delaware Water Supply Self-Sufficiency Act, House Bill 118 was passed into law on July of 2003. As a result of this legislation, utilities adopted conservation rates, which increased charges to customers if they exceeded a certain level of water use. Under the Act, water utilities had to ensure there were sufficient sources of water supply to withstand another 100 year drought like that of 2002. Also established under the legislation was the Drinking Water Well Replacement and Rehabilitation Loan/Grant Program. The Loan/Grant program provides low interest loans or hardship grants to individuals with older leaking plumbing systems, in an effort to expedite their repair, which would help reduce state-wide water loss.

As of June 2005, northern Delaware increased its water supply by 1,014 million gallons since the original 1999 goal of 1,020 million gallons. However, in order to meet the new goal reset after the 2002 drought, northern Delaware needs to increase its water supply by a total of 1,470 million gallons (WSCC, 2005). Thus, it needs to increase its total reserves by an additional 456 million gallons to avoid drought risk. This goal is critical in light of the fact that southern New Castle County is expected to more than double in population, from 41,000 to 96,000 by 2030. It is likely that water supply will increase at a rate similar to population growth (WSCC 2006).

As for the drought situation in the rest of the state, although affected by droughts, southern Delaware is less vulnerable compared to northern Delaware because it obtains most of its water from groundwater. The decreases in groundwater are typically not as dramatic as surface water decreases, and are thus easier to cope with. In addition, the northern part of Delaware has had the largest population and development growth, making water supply issues more pressing. As a result, the WSCC has focused most of its attention on the Northern part of the state and has not yet put together a drought plan for the Southern Delaware.

A.1.6. Oversight of Wastewater Systems in Delaware

Like freshwater supply systems, wastewater treatment systems are managed by both public and private entities. Wastewater services include collection, transport, and treatment of wastewater from municipal, residential, and industrial sources. Several state agencies have responsibility for regulating wastewater treatment providers:

- The Delaware Public Service Commission (DPSC) has authority for setting rates on water and wastewater services provided by non-governmental utilities. The

Commission sets rates to cover the cost of water collection, treatment, testing, and delivery.

- The Delaware Department of Natural Resources and Environmental Control (DNREC) oversees pollution regulation for both surface water and groundwater discharges. The U.S. Environmental Protection Agency has delegated authority to DNREC to administer permits under the National Pollutant Discharge Elimination System (NPDES) pursuant to Section 402 of the Clean Water Act.

- DNREC's Surface Waters Discharges Section (SWDS) issues permits for municipal and industrial wastewater treatment systems (including storm water), sludge management, and construction permits for wastewater transport and treatment. Technical assistance is provided directly to wastewater treatment facilities to help address operational problems.

While the urban portions of the state are served by wastewater treatment facilities, many small communities and rural areas rely on septic systems. As of 2000, there were approximately 78,600 septic systems statewide. Of these, 20 percent were in New Castle County, 27 percent in Kent County, and 53 percent in Sussex County. As of 2000, there were approximately 72 large septic systems (>2,500 gallons/day) statewide. 51 of these were in Sussex County.

DNREC's Ground Water Discharges Section (GWDS) is responsible for overseeing all aspects of the siting, design and installation of on-site wastewater treatment and septic systems. The GWDS also issues waste transporter permits and licenses to percolation testers, designers, soil scientists, system contractors, liquid waste haulers and system inspectors. The Small Systems Branch reviews and approves site evaluations and permit applications, and conducts installation and compliance inspections of systems with daily flows equal to and less than 2,500 gallons per day. The Large Systems Branch reviews and approves spray irrigation wastewater systems, on-site wastewater treatment and disposal systems with daily flows greater than 2,500 gallons per day, Experimental/Alternative Technologies, Advanced Treatment Units, underground injection wells, and other means associated with land application wastewater treatment.

It is important to note that there are thousands of septic systems still extant in Delaware. While the urban portions of the state are served by wastewater treatment facilities, many small communities and rural areas rely on septic systems. As of 2000, there were approximately 78,600 septic systems statewide. Of these, 20 percent were in New Castle County, 27 percent in Kent County, and 53 percent in Sussex County. As of 2000, there were approximately 72 large septic systems (>2,500 gallons/day) statewide. Fifty-one of these were in Sussex County.

A.1.7. Effects of Climate Change on Delaware's Hydrology

In reviewing Delaware's water profile, consideration must be given to the effect of climate change on the water regime of the state. Predictions have been made concerning the type of changes that are expected in various sections of the world, and it is anticipated that by the end of the 21st Century, the mid-Atlantic coast of the United States will experience a rise both in sea levels and stream levels (Kempton and Dhanju, 2007). As a result of these changes violent storm surges will increase and '100-year flood' events will occur three to four times more frequently (Najjar *et al*, 2000). It is estimated that 1.6% of Delaware's land and 21% of its wetlands could be submerged by the end of the century (Wolock *et al*, 1993). Over the next couple of centuries, the sea level rise will likely intensify and will result in the loss of a significant portion of the state (Figure A-2).

In the more immediate future, the Delaware River Basin along with other watersheds will have increasingly less freshwater as the saltwater wedge moves further up the estuary. The intrusion of saltwater into the Delaware River Basin is of particular concern for those depending on its freshwater supply. Far upstream in the basin, New York City has channels diverting basin flows to the city's drinking water supply. The ratio of surface freshwater to saltwater for states like Delaware will continue to drop as a result if New York City continues to withdraw as much freshwater out of the basin as it currently does (Wolock *et al*, 1993).

The other effect of climate change will be a direct change in weather patterns. For different parts of the world, this will mean significantly more or less precipitation. The exact effect of climate change on the precipitation for Delaware is uncertain. As a result, most reports tend to develop models based on a wide range of precipitation change scenarios. However, it should be noted that some models consider up to a 20% decrease in precipitation for the state (Wolock, 1993). In the short term, this potential decrease in overall precipitation for the state could have devastating effects in nearly all sectors, and will affect a variety of uses, from agriculture, to drinking water, to power generation.

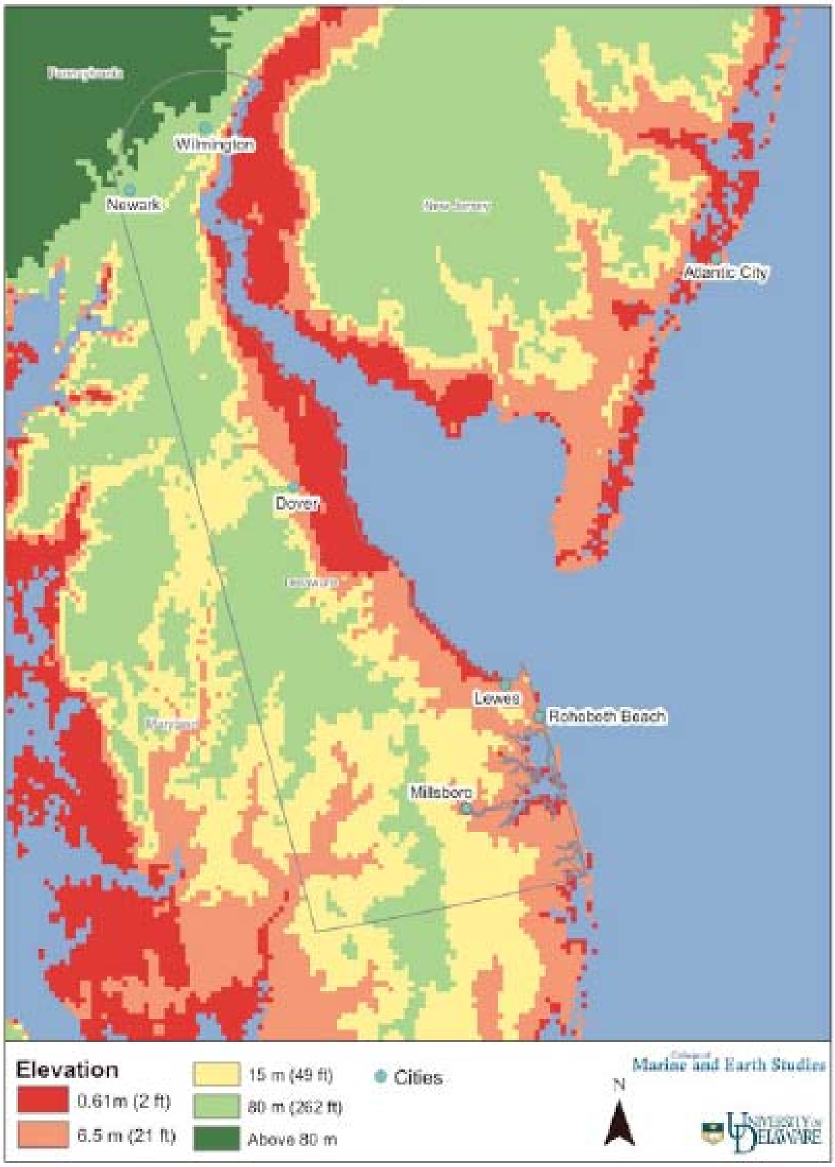
A.2. Delaware's Energy Profile

Delaware has a population of 0.9 million, and the GDP of the state as of last year (2006) stood at $56.5 billion (EIA, 2006). In 2004, its per capita personal income was $33,259, ranking 8th in the nation[29]. Its median household income in 2005 was $52,499 and it ranked 10th just after California (Webster & Bishaw, 2006). The decennial growth rate in population from 1990 to 2000 was 17.6% and from 2000 to 2006 the growth rate has been 8.6%[30]. The increase in population has required, and will continue to require

[29] U.S. Census Bureau, http://www.census.gov/statab/ranks/rank29.html (Last accessed on: 07/27/2007)
[30] U.S. Census Bureau, http://factfinder.census.gov/servlet/SAFFPopulation?_event=Search&_name=&_state=04000US1

expansion of services and infrastructure. Energy is one such service that will continue to need attention.

Figure A-2: Areas of Delaware Inundated by Expected Sea Level Rise in this Century



Source: Kempton and Dhanju, 2007.

The Delaware Energy Task Force's (DETF) final report to the governor, released in 2003, found that (1) increased energy demand, (2) increased energy cost, and (3) environmental issues are the major challenges that are affecting the state's current energy

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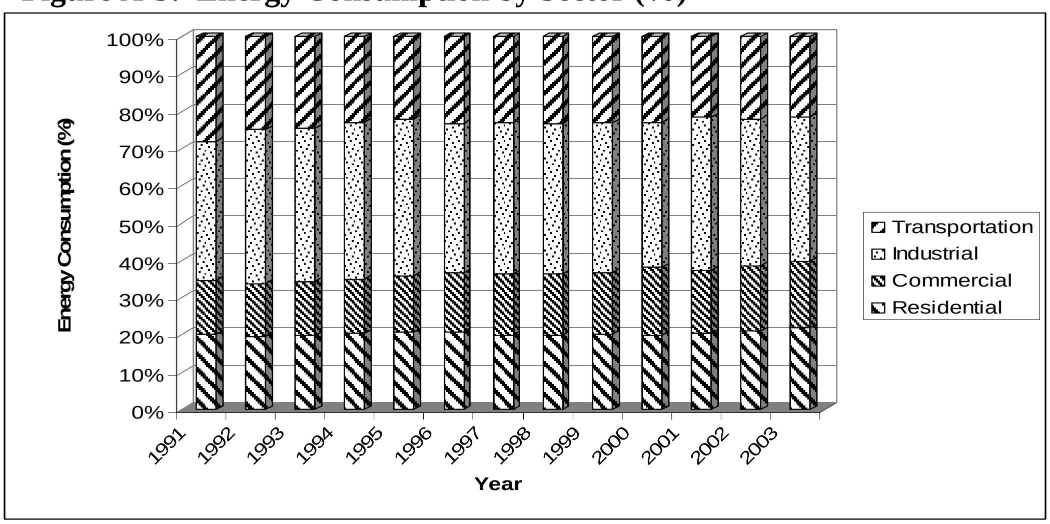
0&_county=&_cityTown=&_zip=&_sse=on&_lang=en&pctxt=fph (Last accessed on: 03/13/2007) system. The following is a review of the state's energy profile, and examines the various components of the energy sector.[31]

A.2.1. Energy Consumption in Delaware by Sector

Energy in the state of Delaware is consumed by four sectors: residential, commercial, industrial and transportation. The largest consumer of electricity is the industrial sector, in part because Delaware is home to several energy-intensive industries including a major petroleum refinery, chemical plants and large manufacturers. The transportation sector is the second largest and is almost completely dependent on petroleum fuels, mainly gasoline and diesel fuel. The commercial and residential sectors account for the remainder of the state's energy consumption. They include a wide range of end-uses including lighting, space heating, air conditioning, water heating and an array of electric appliances and equipment.

Figure A-3 shows the percentage level of consumption of energy by the different sectors. There has not been a significant change in the energy consumption profile since 1995. Energy consumption (in trillions of Btu) as presented in Figure A-4 shows that since 1991, consumption has steadily increased in the industrial sector, increased slightly in the residential and commercial sectors, and stayed relatively steady in the transportation sector.

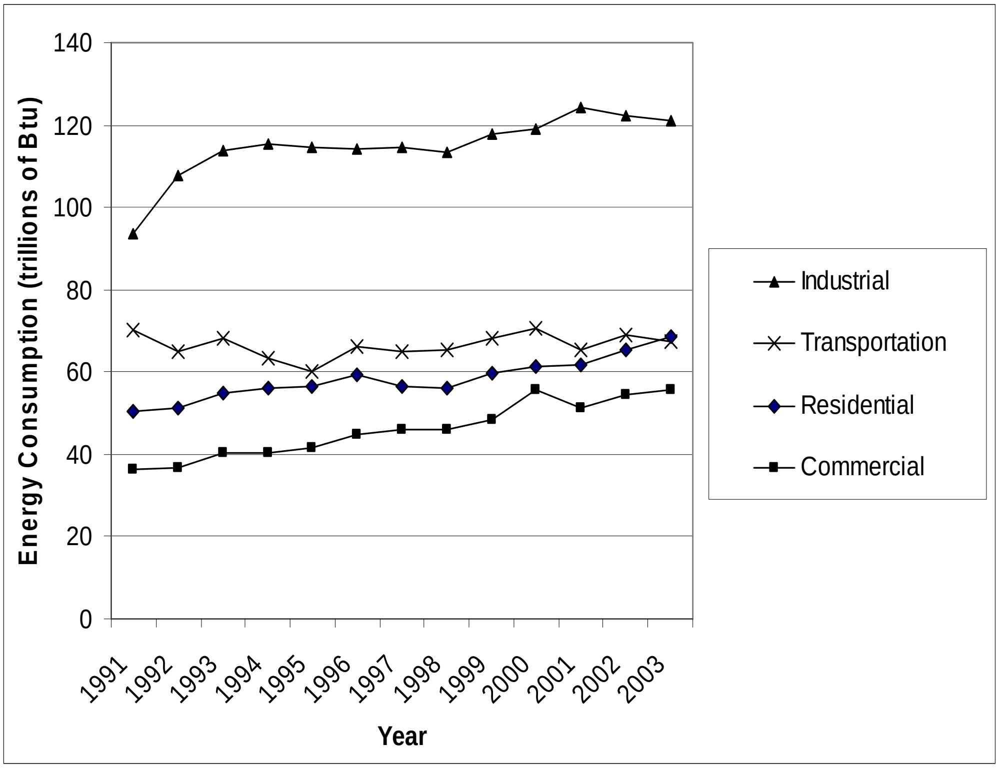
Figure A-3: Energy Consumption by Sector (%)



Source: EIA, 2006.

[31] For more information on the 2003 report, see http://www.dnrec.delaware.gov/Admin/Pages/DelawareEnergyPlan.aspx.

Figure A-4: Energy Consumption by Sector (trillions of Btu)



Source: EIA, 2006.

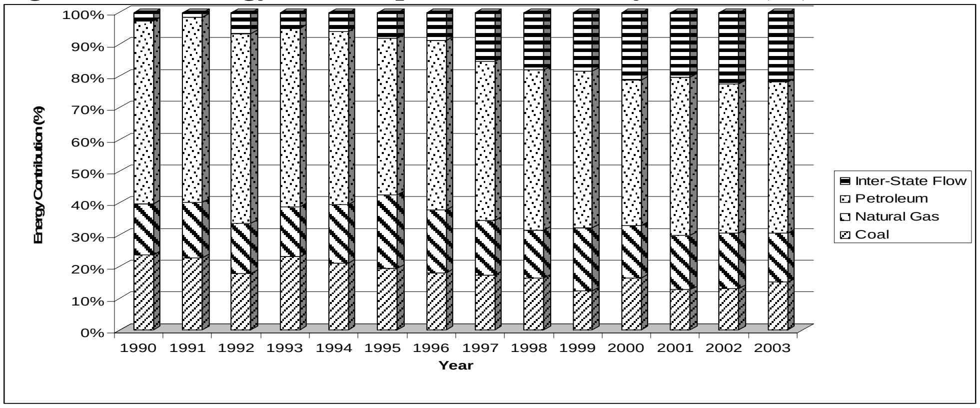
A.2.2. Energy Supply in Delaware

A.2.2.1. Sources of Energy

Delawareans currently consume approximately 280 trillion BTUs of energy in different forms every year - this is equivalent to approximately 7.4 gallons of oil per person per day (Delaware Energy Task Force, 2003). Eighty-four percent of this energy is derived from coal, petroleum products and natural gas, and is delivered and used to fuel homes, businesses, industry and transportation, as well as to generate a significant portion of the state's electricity. Another 15%, nearly all of the remainder, is delivered in the form of electricity generated mainly by out-of-state and nuclear-fueled power plants.

Figure A-5 and Figure A-6 show the energy produced and consumed by source in both percentage terms as well as trillions of Btu. The figures indicate that from 1990 to 2004, the usage of petroleum as a percentage of total energy consumed has decreased from 57.1% to 47.3% (though its total use has increased slightly), whereas the interstate flow of energy increased from 2.7% to 21.8%. During this same period, the consumption of natural gas and coal both as a percentage of total energy consumed and in absolute terms has remained flat or has marginally decreased.

Figure A-5: Energy Consumption Estimates by Source (%)

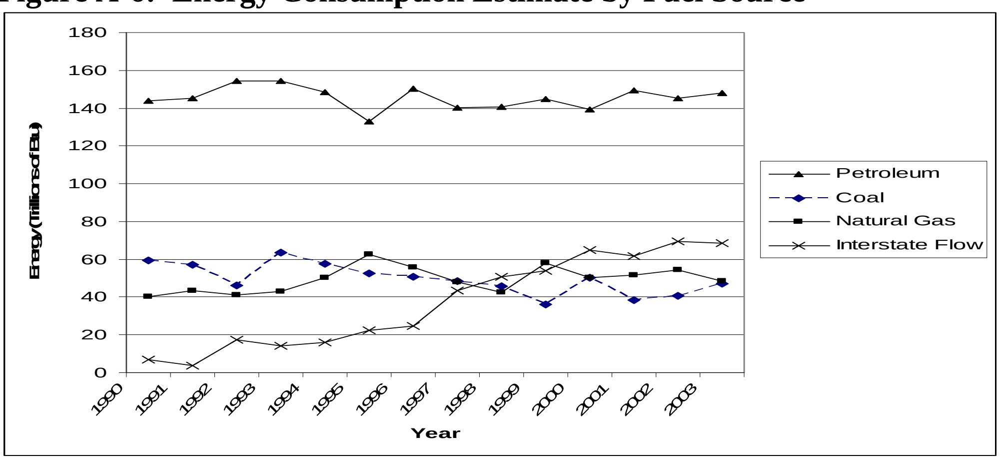


Source: (EIA, 2006).

A.2.2.2. Sources of Electricity

Delaware electricity plays a critical role as an "energy carrier," meaning its main function is to deliver energy to users in a more usable form than the primary energy resources used to produce it. Because of its convenience and versatility, electricity use is growing at a faster rate than any other form of energy. Investor-owned electric utilities, municipally-owned electric utilities, federally-owned electric utilities and member-owned rural electric cooperatives are the four main types of electric utilities generating electricity in Delaware.

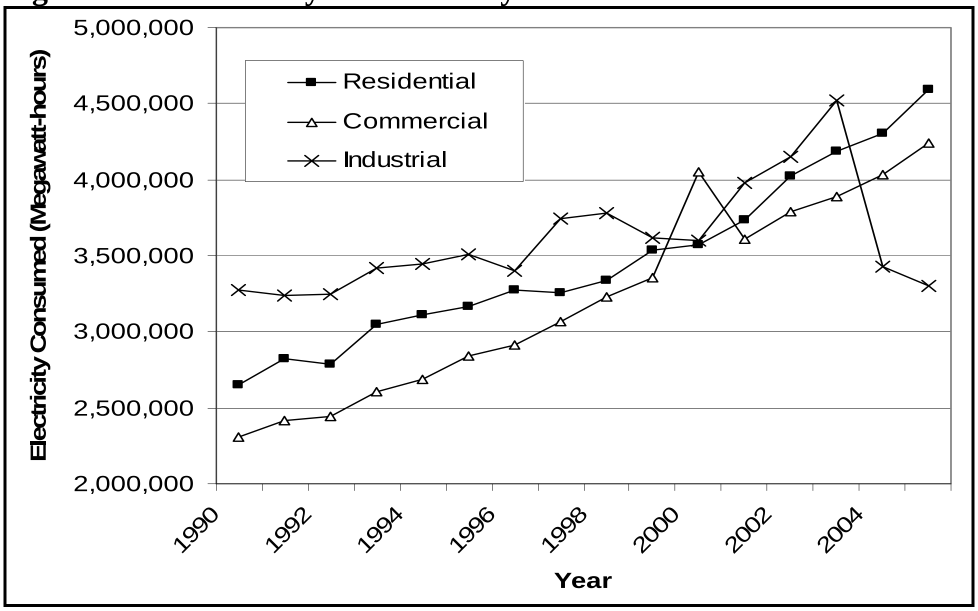
Figure A-6: Energy Consumption Estimate by Fuel Source



Source: EIA, 2006.

On average, fuels lose approximately 70% of their embodied energy when they are converted to electricity through combustion (Delaware Energy Task Force, 2006). Smaller amounts of additional energy are lost in transmission and distribution to customers. The sum of these losses is an important factor in developing recommendations to improve the efficiency of electrical appliances and equipment. The consumption of electricity in three different sectors of Delaware - residential, commercial and industrial - is shown in Figure A-7. All three sectors have experienced growth in the consumption of electricity over the past 15 years. Whereas the residential and the commercial sectors have experienced an average yearly growth rate of 4.9% and 5.6%, respectively, the industrial sector has only increased marginally, which can be explained by the large drop in consumption from 2003 to 2006.

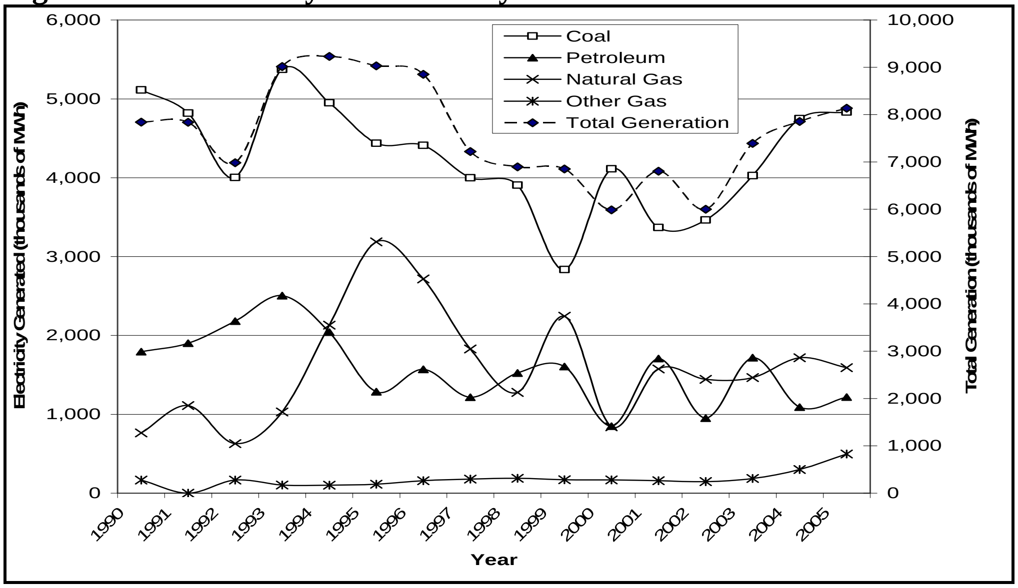
Figure A-7: Electricity Consumed by the Three Sectors in MWh



Coal has been, and still is the main source of the electricity generated in the state of Delaware. Although its overall contribution has been reduced from 65% in 1990 to 59% in 2005, it still accounted for 4.8 million MWhs of electricity generated in 2005. During the same time, the contribution of natural gas has more than doubled and currently accounts for 19.6% of the electricity generated in the state. NRG Energy's Indian River plant (752 MW) and Pepco Holding Inc.'s (PHI) Edge Moor plant (174 MW) are the main coal plants located in the state of Delaware. PHI's Hay Road plant (545 MW) is the largest natural gas plant in Delaware.

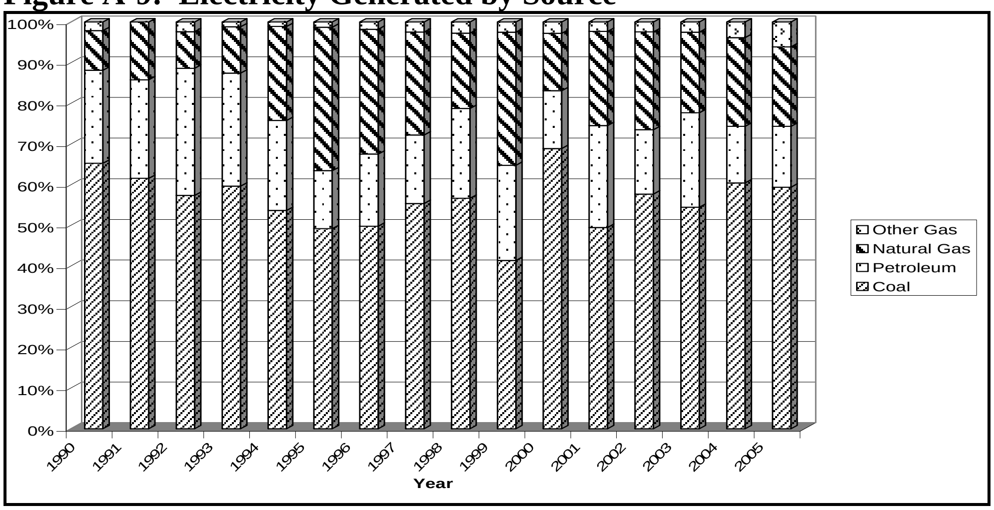
Figure A-8 shows the amount of electricity generated by source from the year 1990 to 2005. The amount of electricity generated has increased by 0.25% every year since 1990 and as of 2005, the amount of electricity generated by all the sources stood at 8.14 Million MWhs. During the same time, the electricity generated by coal has diminished by 5.5%. The reduction in coal has come at the expense of an increase in the utilization of natural gas, which has been trend with the industry since the mid-1990s as most of the new plants that have been commissioned are of the Combined Cycle Gas Turbine (CCGT) type. Figure A-9 shows the amount of electricity generated by source as a percentage of total electricity generated since 1990.

Figure A-8: Electricity Generated by Sources in MWh



Note: The "Other Gas" fuel used in electricity generation consists of blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

Figure A-9: Electricity Generated by Source



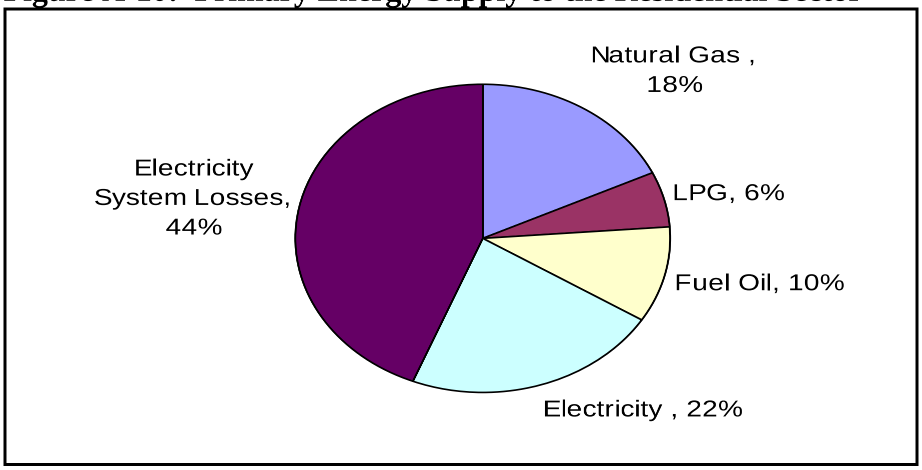
Note: Unit as a % of total electricity generated.

A.2.3. Energy Demand in Delaware

A.2.3.1. Residential Sector Energy Consumption

Two-thirds of the primary energy that is consumed by Delaware's residential sector is used to provide electricity (Figure A-10). This includes the electricity directly consumed by end-users and electricity system losses. Natural gas, fuel oil and propane (LPG) that are used directly in homes account for the remainder of energy resources consumed in the residential sector.

Figure A-10: Primary Energy Supply to the Residential Sector

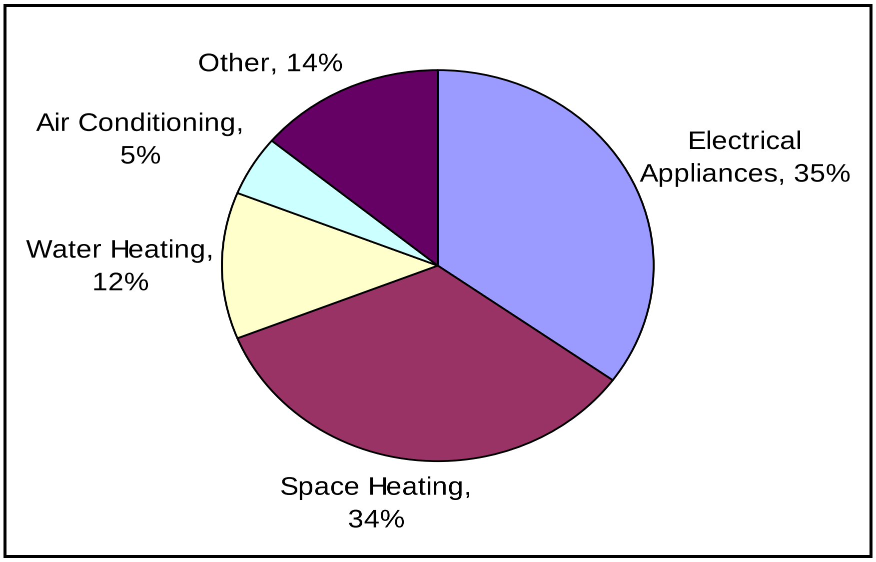


Source: DETF, 2003.

Of the end uses in the residential sector, space heating is the largest single one, using 34% of all primary energy output. However, the use of various household electronic appliances accounts for another 35% of the total use. Water heating and air-conditioning are also major end uses. Overall, figure A-11 will be helpful in identifying those areas where end-use energy efficiency would have the greatest impact.

An important question to be answered, based on the trends in the consumption of electricity within the residential sector, is where efforts should be made in order to optimize the use of electricity efficiency measures. According to Figure A-12, approximately one third of residential electricity consumption can be traced to space heating, water heating and air conditioning, with the rest of residential electricity consumption due to the use of a wide array of appliances, and miscellaneous end-uses.

Figure A-11: Major End-uses of Residential Energy



Source: DETF, 2003.

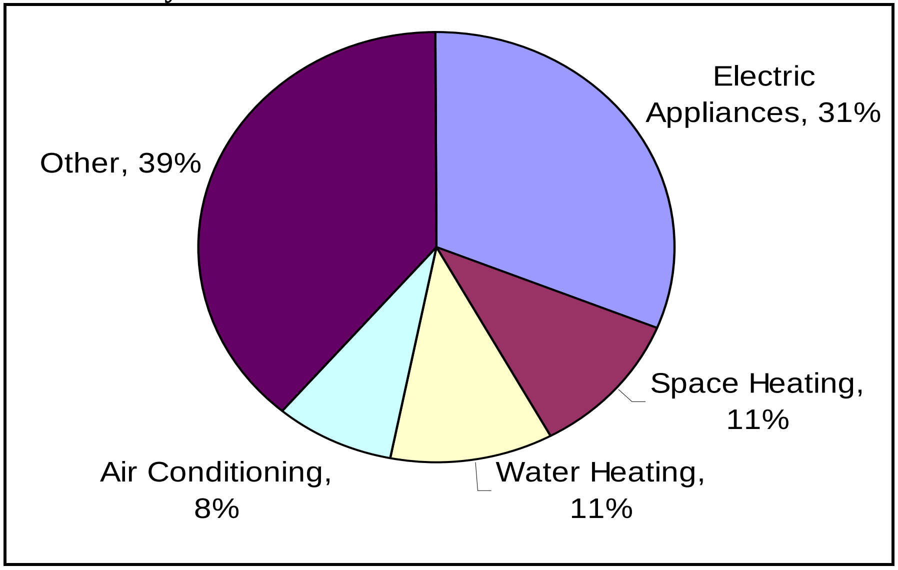
Consequently, if the focus of attention is narrowed to these three uses (water heating, space heating and air conditioning), it is anticipated that the efforts would result in a significant reduction in electricity use. This would mitigate the need to increase energy production in and importation to the state. In short, focusing on these three uses should be the most efficient and effective way to reduce electricity use in the state.

A.2.3.2. Commercial Sector Energy Consumption

In the commercial sector, electricity is by far the greatest type of energy consumed (Figure A-13), with 80% of the sector's energy being used (or lost) as electricity. Natural gas accounts for most of the remaining energy consumption, which is mostly consumed for space heating (DETF, 2003).

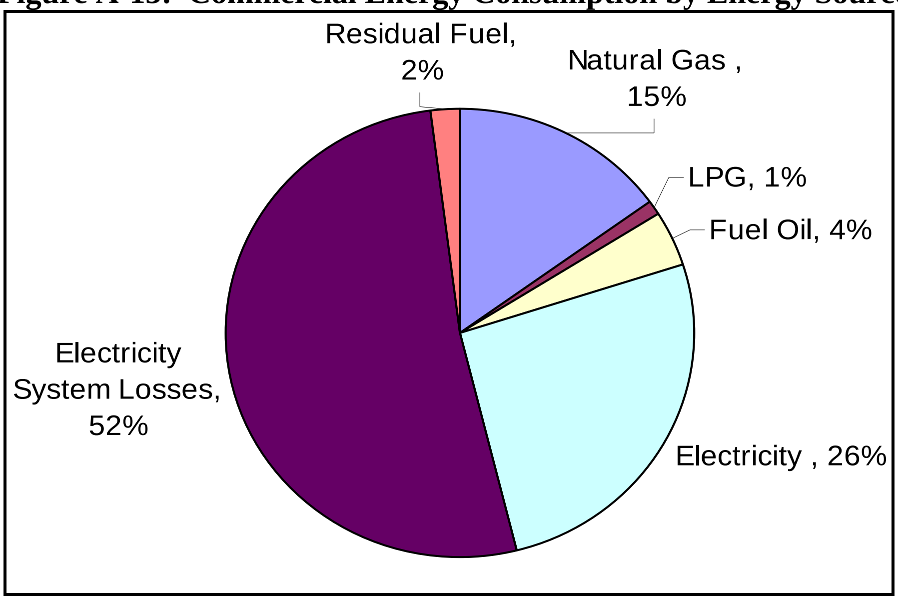
A little more than one-third of the electricity used in the sector is consumed by lighting, making it the most consumptive end use (Figure A-14). The next largest end-use is space heating, which accounts for approximately 19% of the total energy use. At over half of the electricity use combined, it follows that significant demand side efficiency gains in these two end-uses would result in a significant reduction in overall electricity consumption.

Figure A-12. Residential Energy Consumption: A Closer Look at Electricity Use



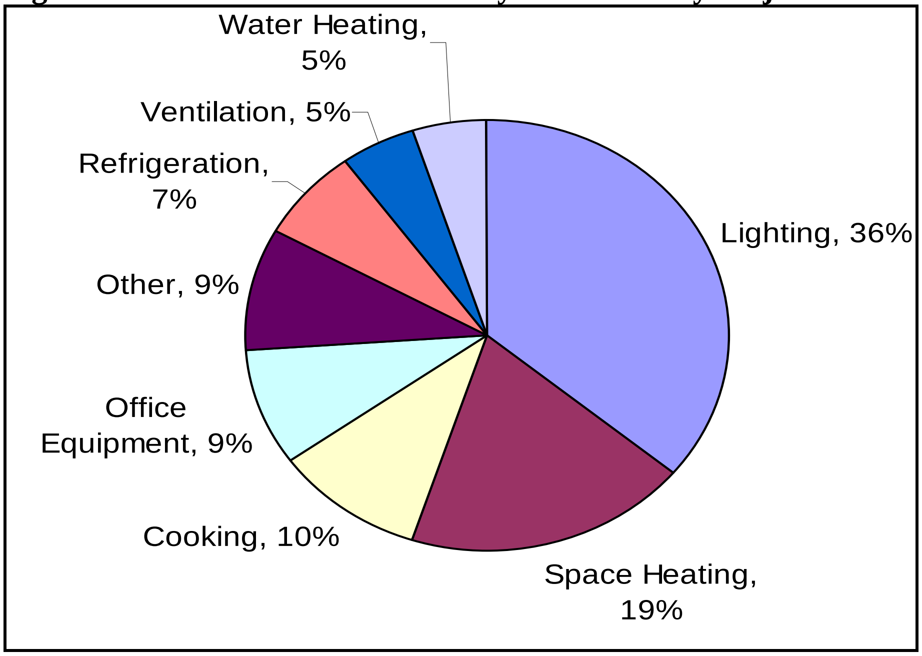
Source: DETF, 2003.

Figure A-13: Commercial Energy Consumption by Energy Source



Source: DETF, 2003.

Figure A-14: Commercial Electricity Consumed by Major End Uses



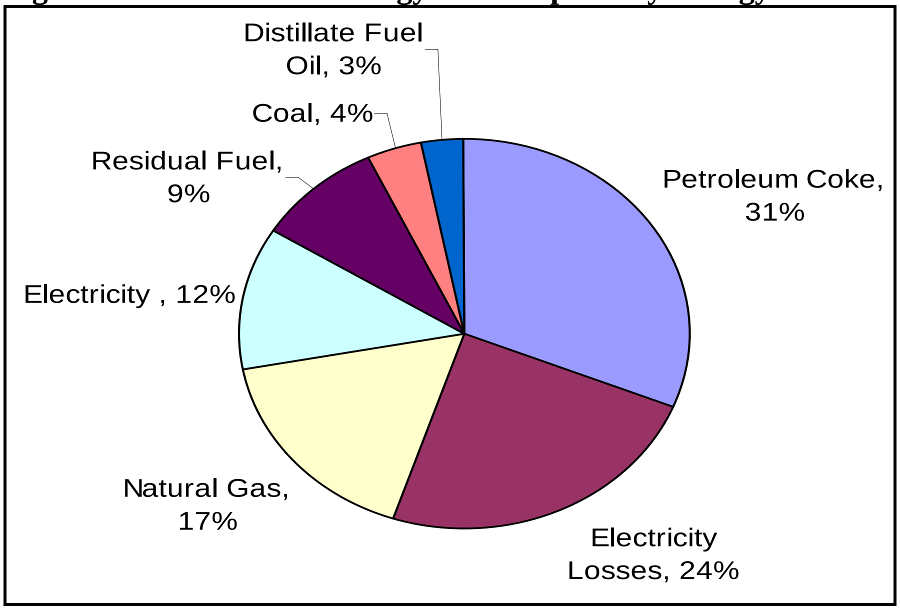
Source: DETF, 2003.

A.2.3.3. Industrial sector energy consumption

The industrial sector in Delaware is the largest end-user of energy in the state (DETF, 2003). In 2003, industrial end-users consumed a total of approximately 121.1 trillion BTUs of energy from all sources, nearly twice as much as the sectors with the next highest consumption (EIA, 2006). As is to be expected, the sector consists of a diverse group of energy end-users, ranging from automobile and chemical manufacturers to petroleum refineries. Energy intensive industries, especially those owned by large parent companies, tend to be very sophisticated in terms of energy use and generally have access to vast technical and capital resources. This is very important, as in very large and/or energy-intensive industrial plants, many of the opportunities for efficiency improvements are in areas that require highly specialized expertise.

The industrial sector in Delaware is generally less electricity intensive than the residential and commercial sectors because fuels like natural gas and oil are used directly to provide process heat instead of electricity. Further, as outlined in Figure A-15, a significant feature of industrial energy use is the large amount of petroleum coke consumed, which accounts for about 31% of total energy consumption in this sector. In Delaware, petroleum coke (a byproduct of oil refining) is used at the Motiva refinery mainly to generate process heat and steam that are used in the refinery. Finally, like the residential and commercial sectors, electricity losses and natural gas account for a large portion of the energy used in the industrial sector.

Figure A-15. Industrial Energy Consumption by Energy Source



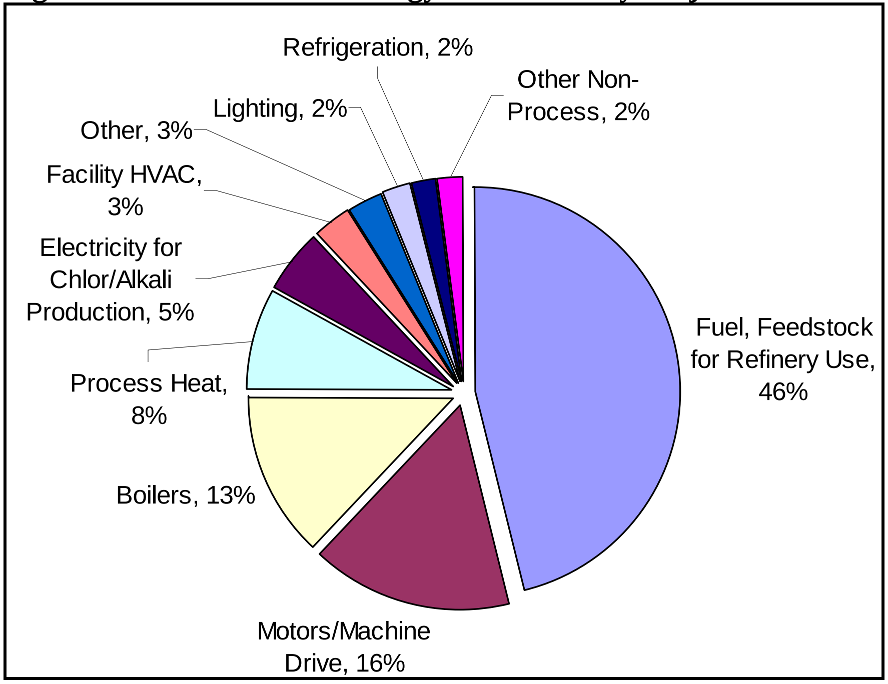
Source: DETF, 2003.

Figure A-16 delineates the percentage of industrial energy consumed by major end uses in Delaware. Forty-six percent of all primary energy input in Delaware's industrial sector is either feedstock or fuel for the Motiva industrial plant. It can be readily inferred that in the absence of Motiva's consumption, the share of energy consumed for specific end uses would shift significantly. For example, if Motiva's energy consumption is removed from the energy equation, then energy consumption by the second largest end users - motors/machine drives, would shift from 16% to 33%. On a similar note, consumption by boilers would increase from 13% to 25%. Consequently, it can be inferred that a significant amount of total consumption could be reduced if energy efficient motors/machine drives and boilers are incorporated into the industrial sector.

A.3. Energy and Water Savings: Use of Efficient Household Appliances

There is a close relationship between energy and water conservation. Reducing water consumption reduces energy input in the water distribution system. This in turn reduces the need for water to produce energy. Simply making household appliances more efficient can provide significant savings in water and energy usage. As of 2000, only about 20-23% of Delaware households used efficient water-using appliances such as dishwashers, laundry machines, etc. (Wang et al., 2006). It is assumed that about 20% of the households in Delaware used efficient appliances that used only energy. Therefore, there is significant potential for saving water and energy in the residential sector of the state.

Figure A-16: Industrial Energy Consumed by Major End Uses



Source: DETF, 2003.

An analysis of energy and water use in Delaware's residential sector showed that if all the households that have appliances switched to energy and water efficient appliances, there was a possibility of saving approximately 1,400-2,600 million gallons of water a year with an additional saving of 700-825 million gallons a year by 2010. Recall from section A.1.5 that only a 456 million gallon increase of fresh water capacity is needed to address future drought risks. Thus, it appears that these risks could be adequately addressed simply by replacing less than half of the remaining water-inefficient appliances in the state with efficient ones. Also, assuming that the energy consuming appliances' efficiencies can be improved by 10-25%, there was a possibility of saving of roughly 280-600 GWh of electricity. By 2010 there could be additional 38-78 GWh savings, which amounts to 2-3 percent of the residential energy use in the state (see Table A-9 for details) (based on 2003 energy consumption of 68,614 billion BTU for residential sector – Energy Information Agency data).

Number of Households in 2000 = 189017[1]
Persons per Household = 2.65[1]
Number of Households in 2010 = 207988[1]
Increase in number of households from 2000 to 2010 = 18971

Table A-9. Analysis of Possible Energy and Water Savings in Delaware Households by using Efficient Household Appliances (2000 – 2010)

2000											
	% of HH using appliances	**% of HH using eff. Sys.**	**HH not using eff. Sys.**	**Water saving**				**Energy saving**			
				Min Eff.	**Max Eff.**	**Min**	**Max**	**Min Eff.**	**Max Eff.**	**Min**	**Max**
	%age	**%age**	**Number**	**Gallons /capita /day**	**Gallons /capita /day**	**MG /day**	**MG /day**	**KWh / day**	**KWh / day**	**MWh/ day**	**MWh/ day**
Appliances using water and Energy											
Clothes Washer	0.99[1]	0.20[1]	149701	4.00[1]	6.50[1]	1.59	2.58	1.52[2]	2.49[2]	226.81	372.41
Dishwasher	0.77[1]	0.20[1]	116434	0.40[1]	1.00[1]	0.12	0.31	0.45[3]	0.48[3]	52.00	55.51
Appliances using only water											
Faucet restrictors	1.00	0.23[1]	43474	1.20[1]	2.70[1]	0.14	0.31	-	-	0.00	0.00
Toilets	1.00	0.23[1]	43474	16.00[1]	23.00[1]	1.84	2.65	-	-	0.00	0.00
Shower heads	1.00	0.23[1]	43474	0.56[1]	10.09[1]	0.04	0.72	-	-	0.00	0.00
Appliances using only energy (*Assuming a minimum saving of 10% and a maximum saving of 25%*)											
Refrigerators	1.00	0.20	151214					0.40[4]	1.00[4]	60.57	151.42
Air Conditioning(2 types)	1.00	0.20	151214								
Central Air conditioners	1.00	0.20	151214					0.77[4]	1.92[4]	115.83	289.58

Room air conditioners	1.00	0.20	151214					0.26[4]	0.65[4]	39.36	98.39
Space Heating	1.00	0.20	151214					0.97[4]	2.41[4]	145.99	364.98
Lighting	1.00	0.20	151214					0.26[4]	0.64[4]	38.94	97.36
Clothes Dryer	1.00	0.20	151214					0.30[4]	0.74[4]	44.70	111.75
Other Appliances (TV ,VCR,DVD, computer laptop, ceiling fan)	1.00	0.20	151214					0.27[4]	0.67[4]	40.48	101.19
TOTAL						3.73	6.57			764.68	1642.59
Total per year						1362.1	2397.3			279106.8	599546.4
Energy usage for conveyance treatment distribution and disposal of water per year	3.21(MWh / MG)[a, b]									4372.06	7694.81
						MG/yr	**MG/yr**			**MWh/yr**	**MWh/yr**
Total Energy Saving (MWh) per year										**283478.8**	**607241.2**
Water usage in energy production (MG/MWh)[c]	0.00038					106.59	228.32				
Total Water Saving (MG) per year						**1468.7**	**2625.6**				

2010

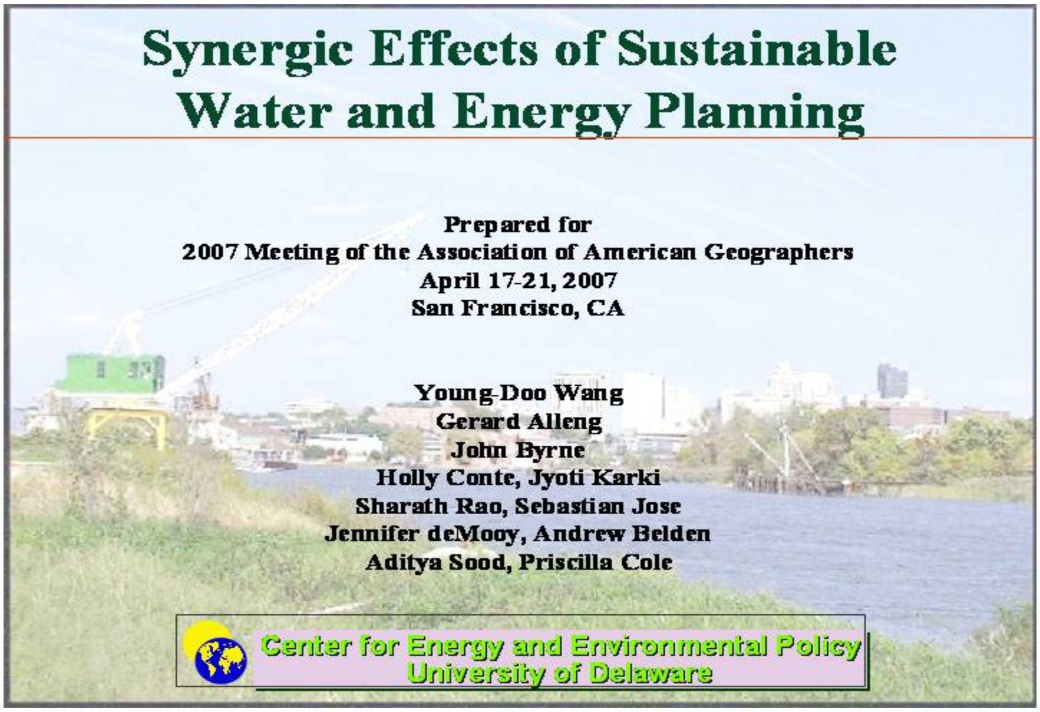
	Increase in appliance	Water savings		Energy Savings	
		Min	**Max**	**Min**	**Max**
		MG/day	**MG/day**	**MWh /day**	**MWh /day**
Appliances using water and Energy					
Clothes Washer	18781.29	0.20	0.33	28.74	47.19
Dishwasher	14607.67	0.02	0.05	8.47	9.04
Appliances using only water					
Faucet restrictors	18971.00	0.60	0.14	0.00	0.00
Toilets	18971.00	0.80	1.16	0.00	0.00
Shower heads	18971.00	0.28	0.51	0.00	0.00
Appliances using only energy (*Assuming a minimum saving of 10% and a maximum saving of 25%)*					
Refrigerators				7.60	19.00
Air Conditioning(2 types)					
Central Air conditioners				14.53	36.33
Room air conditioners				4.94	12.34
Space Heating				18.32	45.79
Lighting				4.89	12.21
Clothes Dryer				5.61	14.02
Other Appliances (TV ,VCR,DVD, computer laptop, ceiling fan)				5.08	12.69
TOTAL		1.91	2.18	98.17	208.63
Total per year		697.43	794.44	35832.42	76149.59
Energy usage for conveyance treatment distribution and disposal of water per year				2238.62	2549.97
		MG /yr	**MG /yr**	**MWh/yr**	**MWh/yr**
Total Energy Saving (MWh) per year				**38071.04**	**78699.57**
Water usage in energy production		14.31	29.59		

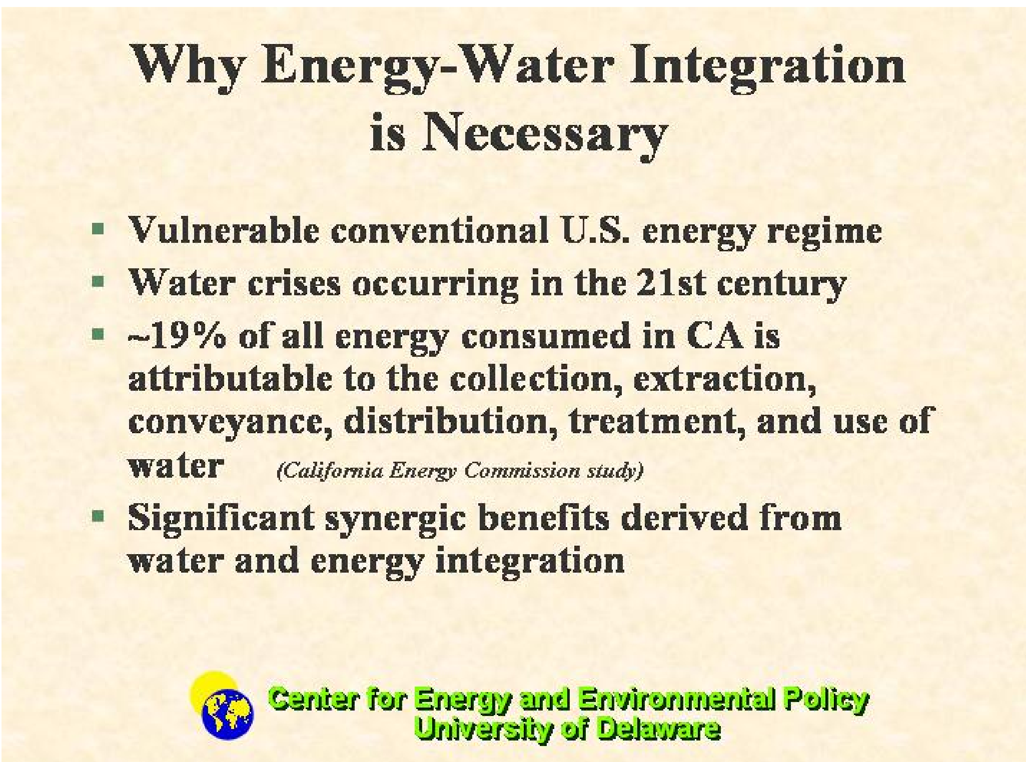
(MG/MWh)[c]					
Total Water Saving (MG) per year		**711.75**	**824.03**		

[a] Energy usage for conveyance, treatment and distribution (MWh/MG) 1.77143 Source:Public Utility Department, City of Dover
[b] Energy usage for treatment of wastewater (MWh/MG) 1.44 Source:Center for Sustainable Systems, Univ. of Michigan. http://css.snre.umich.edu/css_doc/CSS04-14.pdf
[c] Water consumption of a nuclear/fossil fuel power plant (G/MWh) 376.00 Source : http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf

[1] Source: Wang, Young Doo, William J. Smith, John Byrne, Michael Scozzafava, and Jae-Shuck Song. Freshwater Management in Industrialized Urban Areas: The Role of Water Conservation.Water Global Common and Global Problems, 2006. Science Publishers, NH, USA
[2] Source:Cohen, R., Nelson, B. and Wolff,G., 2004. "Energy Down The Drain: The Hidden Costs of California's Water Supply." Natural Resources Defense Council, Pacific Institute,California, USA
[3] Source :http://www.jennair.com/assets/product/JDB1270AW_EG1.PDF
[4] Source : http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html#table2

Appendix B
AAG Presentation





Federal Initiative: Water-Energy Nexus

- Established by DOE's national laboratories with participation by EPRI
- To address the challenges of providing:
  - Abundant clean fresh water and
  - Adequate energy to sustain U.S. economic health and security
- To develop and carry out a multi-year program encompassing R&D and outreach

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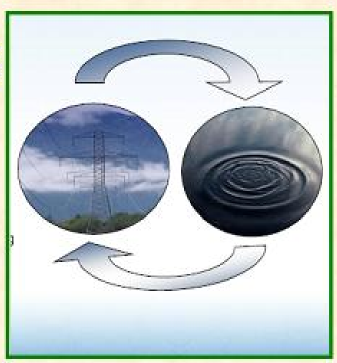
Linkage between Energy and Water

Water for Energy

Electricity and energy production require water

- Thermoelectric Power
- Hydropower
- Fuel Production (Fossil fuel, H_2, Biofuels, Ethanol)
- Mineral Extraction/Mining



Energy for Water

Water production, processing and distribution require energy

- Pumping
- Conveyance and Transport
- End-Use
- Treatment

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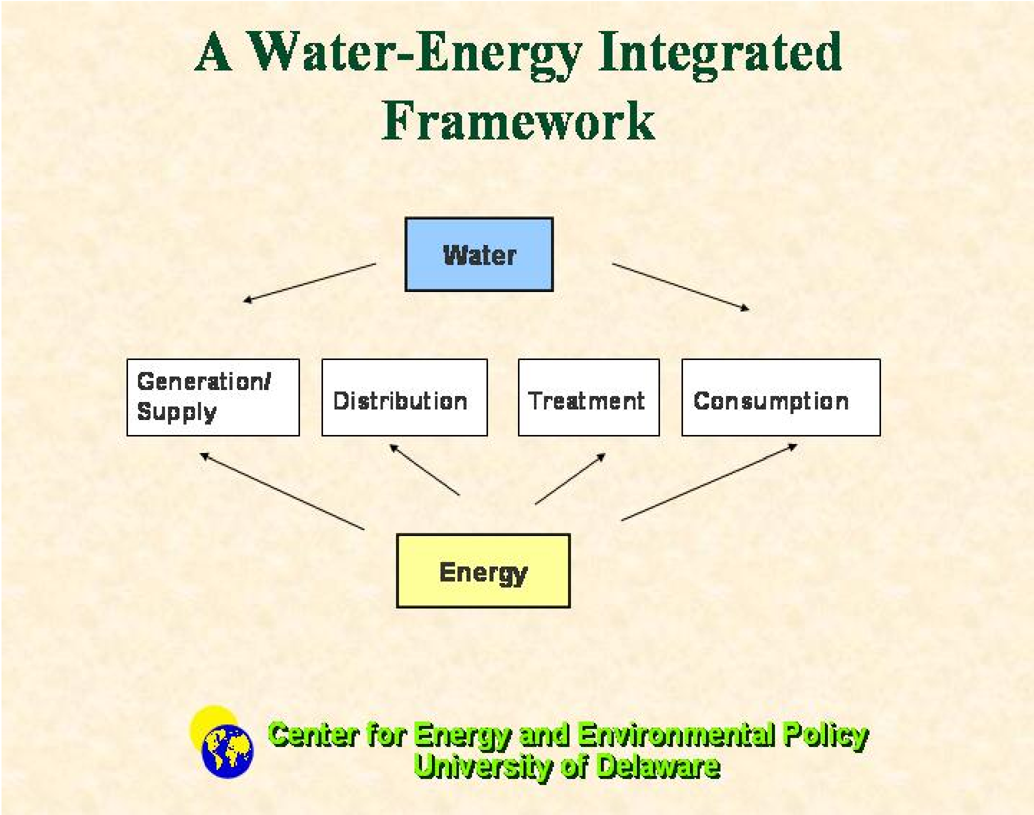
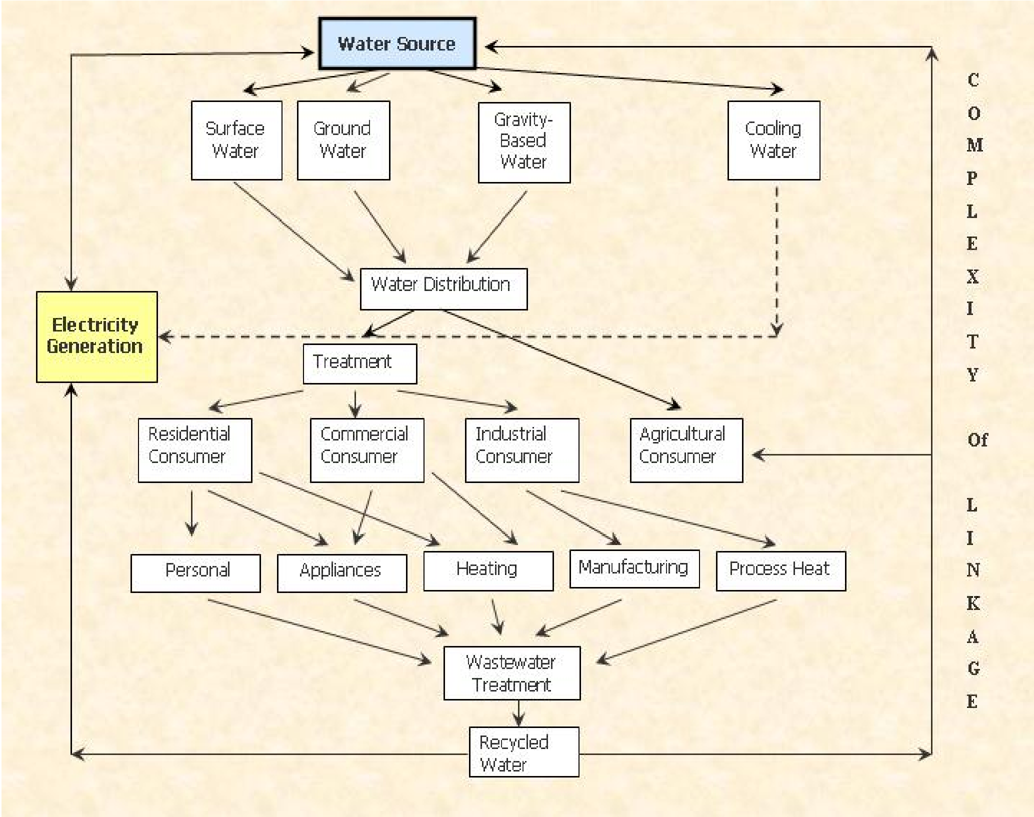
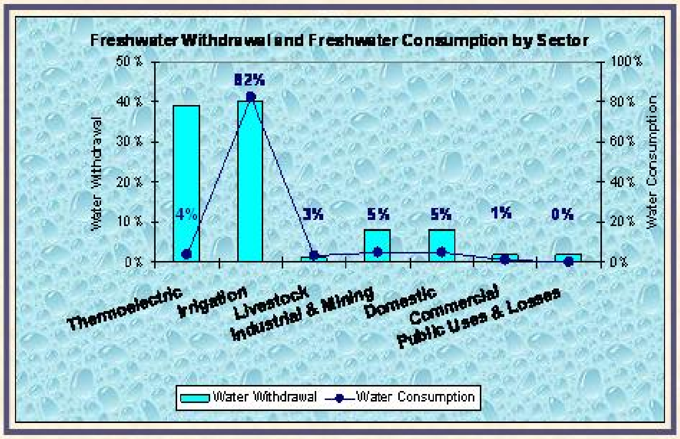

A Water-Energy Integrated Framework
Water
Generation/ Supply
Distribution
Treatment
Consumption
Energy
Center for Energy and Environmental Policy
University of Delaware


Water Source
Surface Water
Ground Water
Gravity-Based Water
Cooling Water
Water Distribution
Electricity Generation
Treatment
Residential Consumer
Commercial Consumer
Industrial Consumer
Agricultural Consumer
Personal
Appliances
Heating
Manufacturing
Process Heat
Wastewater Treatment
Recycled Water
COMPLEXITY Of LINKAGE

Water Consumption Contrasted with Water Withdrawal



Contrast

- Irrigation
  - Withdraws ~40% of total water
  - Consumes 82% of water withdrawn
- Thermoelectric
  - Withdraws ~40% of total water
  - Consumes 4% of water withdrawn

Source: McMahon, 2006 and the Hutson et al, 2004

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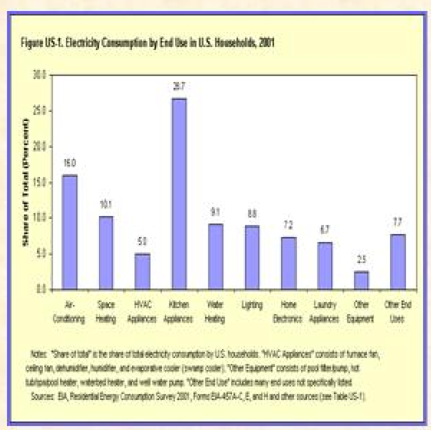
Significant Growth in Domestic Water and Energy Consumption

- Indoor daily water use per person

Use	Gallons per Capita	Percentage of Total Daily Use
Showers	12.6	17.3%
Clothes Washers	15.1	20.9%
Dishwashers	1.0	1.3%
Toilets	20.1	27.7%
Baths	1.2	2.1%
Leaks	10.0	13.8%
Faucets	11.1	15.3%
Other Domestic Uses	1.5	2.1%

Source: AWWA, 2006

- Household electricity consumed yearly, 2001



Source: EIA, 2005

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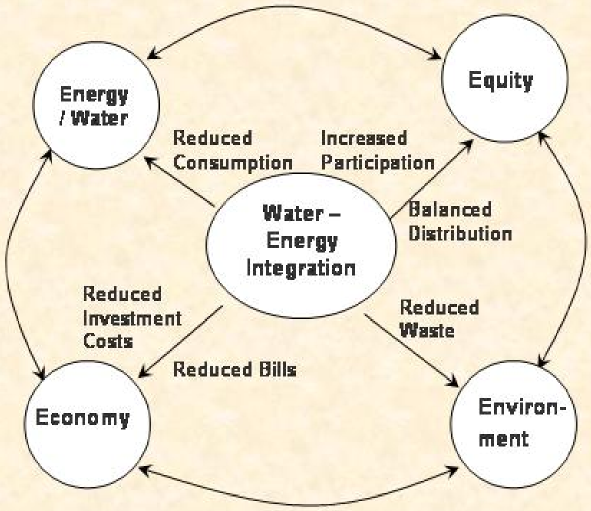
Water-Energy Integration Benefits



Benefits will be reduced during drought periods

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Nation-Wide Survey
Water-Energy Programs

Overview of the preliminary responses from 50 states

- **4 - States have integrated energy-water programs**
  - California, New Mexico, New York, and Wisconsin
- **9 - States have regional/limited programs or initiatives**
  - Alaska, Connecticut, Hawaii, Idaho, Maine, Nebraska, Nevada, Texas, and Virginia
- **11 - States responded that they have no integrated energy-water program**
  - Arizona, Arkansas, Colorado, Indiana, Kentucky, Louisiana, Michigan, New Hampshire, South Carolina, Tennessee, and Utah
- **25 - Results are not comprehensive because we have not yet received responses from these states**
  - Alabama, Florida, Georgia, Illinois, Iowa, Kansas, Maryland, Minnesota, Mississippi, Missouri, Montana, North Carolina, North Dakota, New Jersey, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Vermont, Washington, West Virginia, and Wyoming

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Case Study I: California
California Public Utilities Commission (CPUC) Pilot Program

- October 2006 - CPUC issued a ruling to direct the State's four investor-owned energy utilities to work with water providers to develop Pilot Programs to reduce energy consumption

- Goal - To determine the most cost-effective way to reduce energy consumption through water conservation and efficiency

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Case Study I: California
CPUC Pilot Program (cont.)

What does the CPUC Pilot Program include?

- Industrial water efficiency projects
- High-Efficiency Toilet (HET) replacement
- Combining energy and water audits
- Water conservation devices for outdoor landscaping
- Retrofits for uses of recycled water

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Case Study II: New York

Energy-Water Nexus Initiative

- **April 2004 – Brookhaven National Laboratory, Columbia University Earth Institute and the EPRI jointly sponsored the NY Regional Workshop to identify effective linkages between energy and water**
- **Innovative contributions being made by NYCDEP, NYSDEC, NYSERDA, regional utilities and many others**
- **Brookhaven National Laboratory is developing a tool that will determine the optimization of energy and water use to support urban planning**

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Case Study II: New York (cont.)

New York State Energy Research and Development Authority (NYSERDA) water-energy related programs

- **Reduce water consumption by power plants**
  - NYSERDA awarded a grant to NRG to develop a large Coal Gasification Plant to lower the CO_2 and SO_2 emissions
  - Power plant will use a closed-loop cooling system which re-circulates the cooling water, resulting in water use being reduced by 95%
- **Reduce energy consumption by water facilities**
  - NYSERDA demonstrated a treatment technology for WWTFs that reduces energy use, increases capacity

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Case Study III: Wisconsin
"Focus on Energy" Program

- Statewide public-private partnership program that supports energy reduction in residential and business sectors

- The Program provides information, resources, and financial incentives to help install cost-effective energy efficiency and renewable energy projects

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Case Study III: Wisconsin (cont.)
Water and Wastewater Program

- 2002 - Water and Wastewater Program added to the industrial sector of "Focus on Energy"

- Goal – to help water and wastewater facilities reduce energy use and operating costs

- 2003 – program increased to 130 program partners, most of which are local water and wastewater utilities

- Results - ~20% to 40% reduction in energy use among utilities participating in program

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Lessons Learned From Case Studies

Barriers experienced in energy-water programs

- Failure to recognize the social and economic repercussions when technology is the sole focus for "fixing" the energy-water problems
- Perceived communication disconnects exist between laboratory research and real-world application needs
- Municipalities and private utilities tend to focus on either producing high quality water and/or large volumes of electricity without forecasting the interrelated impacts on these resources
  - Lack of a state-wide agency that fosters cooperation between sectors
- Lack of funding within the municipal/regional/state budgets
  - Economic and environmental values/priorities do not support the criticality of joint programs
- Lack of regulations that provide adequate incentives

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Lessons Learned From Case Studies

Strategies employed to overcome the barriers

- Tailor/refine the energy-water programs to meet the specific needs of the region
- Provide training and outreach programs
- Ensure adequate support from high authority to help enforce new policies/regulations
- Require data monitoring and combine water and energy audits to measure progress and assess economic and social values
- Create an "energy-water" (integrated) statewide agency that will set the rates for both energy and water utilities
  - Assess regional consumer usage and add charges associated with energy-water program to the utility billings

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Conclusions

- State survey responses demonstrated a wide range of knowledge, receptivity, and application of practices/programs that would alleviate the stresses on the two resources that are basic to human survival and evolution of the modern civilization
- Integrating energy use into water planning and vice versa has been demonstrated to save money, reduce waste, protect the environment, and strengthen the economy.
- Based on our preliminary studies, only California and New York involve exclusive partnerships with investor owned utilities.
- NYSERDA has been the longest active program (legislated in 1975) and serves as a model for "Monitoring and Evaluation" and similar lessons dissemination efforts.

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Thought to ponder

"An aggressive conservation program is the most cost-effective and environmentally responsible source of water that any water purveyor can develop."

(San Antonio Water System, 1998)

San Antonio Water System

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Appendix C
Fact-finding Survey of State Programs on Energy–Water Connection

The Center for Energy and Environmental Policy (CEEP) at the University of Delaware is conducting a fact-finding survey for the State of Delaware on programs focused on the interaction between energy and water and the benefits accrued from an integrated approach in planning and management. It would be extremely helpful if you could assist us by completing this survey. We would also like to request any materials you have that explain or provide further details on program/initiatives/missions in your state (e.g. guidelines, background information, reports etc.).

If you have any questions, please feel free to call me, (name), at (302)831-****. Thank you for your time and attention. Please feel free to attach any additional names and addresses of other individuals who could provide valuable insight to these questions.

Name:
Position:
Agency/Organization:
Phone:
Fax:
E-mail:

1. a. Is there any statewide or local/city integrated water-energy program?
No [ ]
Yes [ ]

If no, skip to Question 3.
If yes, please briefly describe the program or provide materials or website link that outlines the program?
____
____
____
____
____
____

b. Is your state/city or local entity planning to create an integrated water-energy program?
No [ ]
Yes [ ]

If no, skip to Question 3.
If yes, please describe what the plans are.

2. Which state agencies are involved in the program?

3. Is there any program that assesses future water needs for energy or future energy needs for water use (e.g. for water purification, waste treatment, electricity generation etc.)?

Yes [ ]
No [ ]

If yes, please describe how you plan to meet these needs.

On behalf of the Center for Energy and Environmental Policy, please accept our appreciation for your time and effort. Please check below if you would like to receive a copy of our report.

Yes [ ]
No [ ]

Appendix D
Survey of Energy – Water Nexus

The Center for Energy and Environmental Policy (CEEP) at the University of Delaware is currently conducting a survey for the State of Delaware on "best practices" in the integration of energy and water issues from other states/cities/municipalities. We have sending you this survey as we have identified your state/city/municipality as having a program that integrates energy and water. It would be extremely helpful if you could assist us by completing this survey. We would also like to request any materials you have that explain the sustainable communities program in your state (e.g. guidelines, background information, reports etc.).

If you have any questions, please feel free to call me, (name), at (302)831-****. Thank you for your time and attention. Please feel free to attach any additional names and addresses of other individuals who could provide valuable insight to these questions

---

Name:
Position:
Agency/Organization:
Phone:
Fax:
E-mail:

PROGRAM GOALS

1. What are the goals/missions of the program that integrates energy and water concerns/issues/management?

   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____

2. What are the groups, organizations and government agencies that are involved in the program?

   ____
   ____
   ____
   ____

3. How are the efforts of the above listed groups, organizations and government agencies coordinated? Which department has the lead role in coordination efforts?

____
____
____
____
____
____

4. Please describe the strategies used to encourage energy efficiency within the state/city/ community?

____
____
____
____
____
____

5. What are the water conservation measures / technologies implemented in your program?

    __Irrigation restrictions   __Price systems
    __Usage metering

    Other_____________________________
____
____
____
____

STAKEHOLDER INVOLVEMENT

6. Is the public (individuals, NGOs, CBOs etc.) involved in the planning process?

    Yes or No

    If yes, how?

    __ Town meetings   __ Surveys
    __ Referendums   __ Workshops
    __ Task Forces   Other________________________
____
____
____

At what stage(s) in the planning process is the public involved?

____
____
____
____
____
____

LEGISLATION

7. Please describe any specific legislation and/or regulations that have been used to promote/develop your energy and water program.

____
____
____
____
____
____
____
____
____

EVALUATION

8. Has the local government implemented water and energy practices in its operation e.g. in its procurement practices? Yes or No

   If yes, please describe.

____
____
____
____
____

9. What indicators or performance metrics are used in your plan to determine the success of the program?

____
____
____
____
____
____

ADMINISTRATION

10a. Please describe any barriers did you experience or are experiencing in the planning or implementation of your energy water program?

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b. What strategies were employed or are being employed to over the barriers identified above?

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Thank you for your time. If you would like to receive a copy of our report upon completion, please indicate so?

Yes [ ]
No [ ]

Appendix E
Summary of General Survey State Responses

State	Agency Website	Summary
Alaska	Department of Environmental Conservation, Division of Water http://www.dec.state.ak.us/water/index.htm	• Although Alaska does not have an integrated energy-water plan, there is one significant and combined energy-water issue that is handled by the AK Division of Water. • This agency manages a state matching grant program for the design and construction of rural sewer and water treatment systems. Since many of the Alaskan rural communities are off the road system and are only accessible by boat or air, they are also not connected to a centralized power grid. Therefore the grant program usually needs to incorporate the power needs with the water needs for these rural communities, which can be met by diesel generators, wind power, geothermal, or small nuclear packages. This agency has had continued success in addressing this combined energy-water issue for its rural communities that need funding for their drinking water, wastewater, solid wastes or non-point source pollution projects.
Connecticut	Energy Conservation Management Board http://www.ctsavesenergy.org/ecmb/index.php	• This program is an initiative to help homeowners and renters, small and large businesses, and state and local governments alike get in the habit of using energy more efficiently. Within that context, this initiative also funds wastewater systems and water supply systems to improve energy efficiency. This program is not responsible for water conservation.
Hawaii	Department. of Land and Natural Resources http://www.hawaii.gov/dlnr/	• Although Hawaii does not have a formal energy-water integrated plan, there are many separate water-energy integrated projects. For example: • The following three state agencies work in close collaboration to control the amount of water use and to review the well and water use permits. 1. The Commission on Water Resource Management issues permits (statewide) for wells to manage the water use by power plants and industry. 2. The Department of Health issues permits associated with injection wells through their Underground Injection Control Program. 3. The Engineering Division of the Department of Land and Natural Resources administers the Geothermal Well program for geothermal energy.

	Natural Energy Laboratory of Hawaii Authority (NELHA) http://www.nelha.org/	• NELHA responded to the survey to confirm the existence of many coordinated energy-water efforts. NEHLA receives state and federal funding to provide energy and ocean related research and to develop new technologies that use seawater and other island resources. • For example, in 2006 NEHLA returned to its original founding purpose of developing ocean thermal energy using two sources of ocean water (cold from 2,000 ft. below and warm sea surface water). Electricity from large ocean thermal energy conversion plants will be able to produce hydrogen fuel as well as electricity. Scientists claim that in 50 years the majority of the energy in the world will be from ocean thermal energy because it is the only one large enough to replace oil.
	Honolulu Board of Water Supply (BWS) http://hbws.org/cssweb/	• The BWS also supports statewide energy-water integrated efforts including: a. Honolulu Water Recycling Facility provides two qualities of recycled water, (1) irrigation grade for urban landscaping and (2) industrial grade for refineries and power generation plants. b. Partnering with the Hawaiian Electric Co. (HECO) in water and energy conservation programs for residential, commercial and industrial uses such as joint audits, rebates on high efficient fixtures and retrofits. c. Island-wide water demand has been reduced through water conservation efforts (converting of low-flow toilets and water fixtures) and has achieved producing potable water at 1990 levels. d. Planning to build a 5 mgd seawater desalination plant. e. Partnering with HECO on the construction of solar, wind, wave, and pumped hydropower projects to provide supplemental renewable energy supplies and alternative methods of producing potable water.
Idaho	Idaho Department of Water Resources http://www.idwr.idaho.gov	• There currently are no statewide integrated water-energy programs but the Energy Division has been part of the Water Resources Department since 1982. Their activities are separate though they do work together on water issues related to irrigation, hydroelectric power, and geothermal energy. The Division and Department are working on efforts to be more involved with issues related to power plant water uses and energy fuel production (ethanol, biodiesel, etc.). The Energy Division and Water Resources Department also work with the Idaho Water Resources Research Institute.
Maine	Office of Energy Independence and Security (OEIS)	• The OEIS works with the Energy Resource Council to promote energy efficiency and conservation across the state. In other program, OEIS

	http://www.maine.gov/governor/baldacci/cabinet /energy_independence.html	implements water conservation measures and technologies through irrigation restrictions, usage metering, and price systems. However, these energy and water conservations are separate programs and not integrated.
Nebraska	Natural Resources Planning, Department of Natural Resources	• There are several integrated efforts that govern the energy and water resources in Nebraska. The integration efforts were necessitated by multiple interest groups competing for the limited water resources within the Platte River Basin (flowing through most of the central portion of NE). There has been and still is insufficient water available to meet both the instream ecological demands and the out-of-stream economic needs of generating electricity from hydropower, supplying water to meet the irrigation needs of millions of acres of farmland, supplying cooling water to thermoelectric plants, and supplying water to ~3.5 million people. To reduce the impacts of future water development several cooperative agreements have been signed by the Secretary of the Interior, the Governors of the States of WY, CO and NE, FERC and others. Many of the Platte River sub-basins are fully or over appropriated and are challenged by the growing number of ethanol plants which require more water from the river. • One of NE's southwestern watershed districts is the recipient of the "2004 Water and Energy Conservation Award" given by the Irrigation Association. Several NE counties collaborated to require pumpage meters on wells, establishing maintenance programs, and implementing water allocation programs that led to the conversion of 90% of the irrigation systems from flood irrigation to more efficient center pivot irrigation.
	Nebraska Energy Office http://www.dnr.state.ne.us/	• The NEO cited the same energy-water integration program along the Platte River as did the NE Department of Natural Resources (see above).
Nevada	Nevada State Office of Energy http://energy.state.nv.us/	• The Office of Energy is responsible for energy and water conservation under a state law adopting Green Building Standards for public buildings. The program is under development but has not been implemented due to limited funding and manpower. The Office of Energy works with the State Commission on Economic Development, Nevada Division of Environmental Protection, the Office of the Governor, and the State Water Engineer.
Texas	Texas Water Development Board (TWDB) http://www.twdb.state.tx.us/home/index.asp	• Texas does not have an integrated energy-water plan. The TWDB manages conservation of water programs and prepares for and responds to drought conditions. TWDB projects the state's future water needs and considers the water required to produce energy. TWDB is the lead agency for 16 regional

		water planning groups. TWDB provides education and financial assistance to encourage conservation, and provides resources to support rainwater harvesting, desalination, and various ways of recycling and reusing wastewater.
	Railroad Commission of Texas (RRC) http://www.rrc.state.tx.us/	• The RRC has received Texas grant money to develop produced water treatment technologies for the oil and gas industries - i.e. recover produced water and make it suitable for reuse. • New legislation is requiring oil and gas companies to report the amount of water they are using to local districts each month. Those oil and gas companies that are "fracturing" aquifers need to report the total amount of water to the local groundwater district.
Virginia	Virginia Department of Environmental Quality http://www.dcr.virginia.gov/sw/	• There are no direct programs that address energy and water integration, but some of the programs, such as the Virginia Green Lodging Program and the Ground Water Withdrawal Permitting program are intended to promote conservation of water and energy.

Appendix F
Summary of Best Management Practices (BMPs)

The California Urban Water Conservation Council (CUSCC) developed 13 BMPs for the planning and integration of California's water resources. The BMPs are defined as follows:

BMP 1: Residential Water Survey Programs (Single- and Multi-Family)

Conduct residential surveys of indoor and outdoor water use. Indoor survey includes checking for leaks (toilets, faucets) and showerhead and toilet flow rates, and recommending repairs or replacement as necessary. Outdoor survey includes checking irrigation system and timers, measuring landscaped area, and reviewing irrigation schedule.

BMP 2: Residential Plumbing Retrofit

Identify single-family and multi-family residences constructed prior to 1992. Develop a targeting and marketing strategy to distribute or directly install high-quality, low-flow showerheads (rated 2.5 gpm or less), toilet displacement devices (as needed), toilet flappers (as needed) and faucet aerators (rated 2.2 gpm or less) as practical to residences requiring them.

BMP 3: System Water Audits

Conduct annual prescreening audit to determine if full audit is needed. Prescreening audit consists of: calculating metered sales and other system verifiable uses; determining total supply into the system; dividing the former by the latter to evaluate total system efficiency. If calculation is less that 0.9, then a full system audit should be conducted, based on the American Water Works Association Water Audit and Leak Determination Guidebook.

BMP 4: Metering

Require meters for all new connections, and billing by volume of use. Establish program for retrofitting existing unmetered connections. Identify intra- and inter-agency disincentives or barriers to retrofitting mixed use commercial accounts with dedicated landscape meters, and conduct a feasibility study to assess the merits of a program to provide incentives to switch mixed use accounts to dedicated landscape meters.

BMP 5: Large-Scale Landscaping

For accounts with dedicated irrigation meters, establish a water budget based on evapotranspiration rates per landscaped area, and provide notice with each billing cycle of actual use compared to water budget. For non-residential accounts (commercial, industrial, institutional) with no meters or with mixed-use meters, offer water conservation measures, including: landscape water use survey, water use budget, installation of dedicated landscape meters, and financial incentives (loans, rebates, grants) to purchase/install water efficient irrigation systems.

BMP 6: High-Efficiency Clothes Washing Machines

Offer financial incentives for the purchase of high-efficiency washing machines with a water factor value of 9.5 or less. The goal for this BMP is to at least triple the market share of HEWs purchased for use inside residential dwelling units, where no incentive program exists. For purposes of determining coverage requirements, the Council's estimates a non-incentive market share of HEWs at 12% of all clothes washing machine sales (derived from year 2000 Energy Star data). The coverage requirements are based upon the goal of increasing the market share of HEWs to thirty-six percent (36%) of all clothes washing machine sales.

BMP 7: Public Information

Implement a public information program to promote water conservation and water conservation related benefits, including: providing speakers to employees, community groups and the media; using paid and public service advertising; using bill inserts; providing information on customers' bills showing use in gallons per day for the last billing period compared to the same period the year before; providing public information to promote water conservation practices; and coordinating with other government agencies, industry groups, public interest groups, and the media.

BMP 8: School Education

Implement a school education program to promote water conservation and water conservation related benefits, including: working with school districts and private schools in the water suppliers' service area to provide instructional assistance, educational materials, and classroom presentations that identify urban, agricultural, and environmental issues and conditions in the local watershed. Education materials shall meet the state education framework requirements, and grade appropriate materials shall be distributed to grade levels K-3, 4-6, 7-8, and high school.

BMP 9: Commercial, Industrial and Institutional (CII) Accounts

Implement program to accelerate replacement of existing high-water-using toilets with ultra-low- flush (1.6 gallons or less) toilets in commercial, industrial, and institutional facilities. In addition, target 10% of CII accounts for water use surveys, to include a site visit, an evaluation of all water-using apparatus and processes, and a customer report identifying recommended efficiency measures, their expected payback period and available agency incentives.

BMP 10: Wholesalers

Wholesale water suppliers should provide financial, technical and program support to retail water agencies to support water conservation measures. Wholesalers should support BMPs implemented by retail water agency customers that can be shown to be cost-effective in terms of avoided cost of water. Wholesale and retail agencies will retain maximum local flexibility in designing and implementing locally cost-effective BMP conservation programs. In addition, wholesale agencies shall work in cooperation with their customers to identify and remove potential disincentives to long-term conservation created by water shortage allocation policies.

BMP 11: Conservation Pricing

This BMP applies to both water and sewer services. It recognizes that non-conserving pricing provides no incentives to customers to reduce use. (Examples of non-conserving pricing include: rates in which the unit price decreases as the quantity used increases, e.g. declining block rates; fixed rates per billing cycle regardless of the quantity used, e.g. non-metered rates; pricing in which the typical bill is determined by high fixed charges and low commodity charges.) Conservation pricing, by contrast, provides incentives to customers to reduce average or peak use, or both. Such pricing includes rates designed to recover the cost of providing service; and billing for water and sewer service based on metered water use. Conservation pricing is also characterized by: rates in which the unit rate is constant regardless of the quantity used (uniform rates) or increases as the quantity used increases (increasing block rates); seasonal rates or excess-use surcharges to reduce peak demands during summer months; rates based upon the long-run marginal cost or the cost of adding the next unit of capacity to the system.

BMP 12: Conservation Coordinator

Designate a water conservation coordinator and support staff to provide coordination and oversight of conservation programs and BMP implementation.

BMP 13: Water Waste

Enact and enforce measures prohibiting gutter flooding, single pass cooling systems in new connections, non-recirculating systems in all new conveyer car wash and commercial laundry systems, and non-recycling decorative water fountains. In addition, support efforts to develop state law regarding exchange-type water softeners to allow the sale of only more efficient, demand-initiated regenerating (DIR) models. Develop standards to: increase regeneration efficiency; set maximum number of gallons discharged per gallon of soft water produced; allow ban of water softeners if there is an adverse effect on groundwater supply.

BMP 14: Residential Ultra-Low Flow Toilets (ULFTs)

Implement programs for replacing existing high-water-using toilets with ultra-low- flush (1.6 gallons or less) toilets in single-family and multi-family residences.