University of Florida
Joint Optimization of Urban Energy-Water Systems in Florida

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Description: Urban water infrastructure systems for providing water supply, collecting and treating wastewater, collecting and managing stormwater, and reusing wastewater and stormwater require major energy inputs. End users of the water require even more energy to heat this water for showers and baths, clothes washing, cooking and other uses. Increasingly, cities will rely on alternative water supplies such as desalination that require much more energy per gallon of water produced. Conservation is an ideal way to save energy and water by managing the demand for these precious commodities. Major strides have been made in reducing indoor water use from about 75 gallons per person per day to as low as 40 gallons per person per day. However, these gains are being offset by concurrent increases in outdoor water use for irrigation that range from 30 to 300 gallons per person per day depending on irrigation practices and the size of the landscape. From a water use perspective, perhaps the greatest challenge will be the expected growing competition for water if certain energy options are implemented in order to reduce our current dependence on foreign oil. Several recent national studies warn of this impending energy-water crisis. This project will build on our extensive experience in evaluating urban water conservation options to include the implications for energy use and to develop integrated energy-water management systems that are compatible.

Budget: $72,000
Universities: UF
External Collaborators: Florida Department of Environmental Protection, South Florida, Southwest Florida and St. Johns River Water Management Districts, Gainesville Regional Utilities, Hillsborough County Water Utility Department, Sanford Water Utility, Water Research Foundation, Austin, Texas, Intelligent Software Development, United States Geological Survey

Background and Significance
The energy-water nexus for Florida is shown in Table 1. Water for power generation is a large user of fresh surface water and the dominant use of saline surface water. Agriculture is the largest user of fresh water and this use could grow significantly to support biofuel initiatives. All public water supply and most other water uses require that the water be delivered under pressure. Public water supplies consume about 4% of the nation's electricity (Sandia 2007). Per capita energy demands for supporting water supplies in Florida are expected to increase since cities are being required to meet future increases in water demand from more energy intensive alternative sources such as desalination and reuse.

[Compiled by the U.S. Geological Survey, Tallahassee; all values in million gallons per day]

Florida 2000	Freshwater			Saline Water		
	Ground	Surface	Total	Ground	Surface	Total
Public Supply	2,199.36	237.43	2,436.79	0.00	0.00	0.00
Domestic self-supplied	198.68	0.00	198.68	0.00	0.00	0.00
Commercial-industrial self-supplied	430.70	132.60	563.30	0.00	1.18	1.18
Agricultural self-supplied	1,989.95	1,933.06	3,923.01	0.00	0.00	0.00
Recreational irrigation	230.45	181.28	411.73	0.00	0.00	0.00
Power generation	29.53	628.73	658.26	3.82	11,950.82	11,954.64
TOTALS	**5,078.67**	**3,113.10**	**8,191.77**	**3.82**	**11,952.00**	**11,955.82**

Table 1. Total water withdrawals in Florida by category in the year 2000 (Marella 2004).

All electric vehicles are estimated to withdraw ten times as much water and consume up to three times as much water per mile as gasoline powered vehicles (Webber 2008). Biofuels have an even bigger impact on water supplies due to increases in irrigation water demand, and crop processing for conversion to biofuels can consume 20 or more times as much water for every mile traveled than the production of gasoline (Webber 2008). Low cost irrigation water is no longer available in most parts of the United States.

Examples of the interrelationships between energy and water are shown in Figure 1. Energy use for supporting public water supply activities can be divided into two major components: 1) the energy needed to deliver the water to the end user; and 2) the additional energy use by the end user for water heating, clothes washing and drying. Energy use at the end use level is the greater of the two components in California accounting for 14% of California's electricity consumption and 31% of its natural gas consumption, mostly in the residential sector (Electric Power Research Institute 2003).

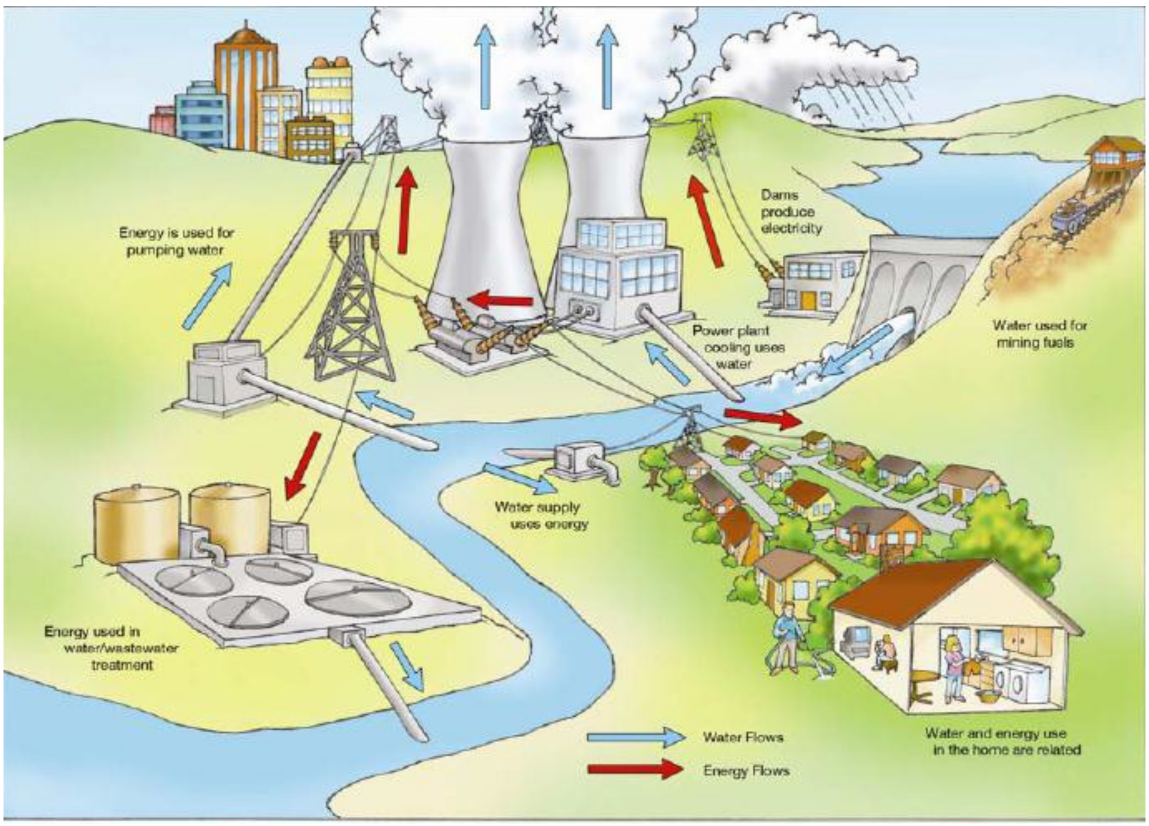

Figure 1. Examples of interrelationships between water and energy (Sandia 2007).

Energy-water efficiency simulation/optimization model

We have developed an urban water conservation evaluation model for Florida called EZ Guide as part of ongoing research. Three papers were accepted for publication in a national journal (Friedman et al. 2011, Morales et al. 2011) and a Florida water journal (Heaney et al. 2011) that describe the EZ Guide methodology. More complete information is available at web site for the Conserve Florida Water Clearinghouse (www.conservefloridawater.org). The current version of EZ Guide is available online and the data are uploaded automatically once the water utility boundaries are specified. The current funding does not provide support to include energy considerations in an in-depth manner. The funding from this project will allow us to add this critical element in our June 2013 release of EZ Guide. The water-energy methodology is described in a water-energy nexus paper by Morales et al. (2013) that has been submitted for publication to a national journal.

Energy Management in Water Systems

Urban water systems are required to deliver adequate quantities of water to customers continuously. The quality of this water must be suitable for drinking. This water must be delivered at suitable pressures. Sophisticated hydraulic simulation models are available to evaluate the flow rates, water quality, and pressures throughout the network. A current goal is real-time control of energy expenditures to meet these demands. We have partnered with Hillsborough County Water Utility Department to evaluate energy management options for their system. The primary work was done by Mr. John McCary who is an engineer with Hillsborough County and a part-time PhD student at the U. of Florida. The results of this analysis showed the potential energy savings in the distribution system of an actual test utility in Hillsborough County (McCary and Heaney 2012).

Accomplishments

Water use analysis is typically done using utility-wide data since it is too difficult to organize and evaluate customer level attribute and monthly water billing data. A major breakthrough in the research of the Conserve Florida Water Clearinghouse has been the acquisition and use of customer level attributes including land use information, and utility level monthly water use data for every utility in the State of Florida. Thus, annually updated attribute and GIS data are available for nine million parcels in Florida and can be downloaded from the Florida Department of Revenue (FDOR) web site (ftp://sdrftp03.dor.state.fl.us/). Each of Florida's 67 counties has a property tax assessor's (CPTA) database that contains information that is included in the FDOR database and other attributes that are of interest in that county. The information in the county databases varies from county to county but the county data can be linked to the state database with a Unique Parcel Number. This information is of high quality since it is the basis for estimating property taxes. The key land use information for a parcel is its impervious and pervious areas. This information can be extracted directly from the FDOR/CPTA databases. The type of land use is available for 64 land uses based on an FDOR land use code. Population information can be obtained from US Census data at the Census Block level of aggregation. Water utility service areas may not be contiguous with the political boundaries of the cities. Fortunately, the three largest of the five water management districts have developed GIS coverage that enables one to assign parcels to the appropriate utility. These data sources can be combined to estimate the long-term trends in attributes of interest.

All utilities in Florida are required to submit Monthly Operating Reports (MORs) to the Florida Department of Environmental Protection (FDEP) that include information on daily water supplied by each treatment plant, water quality data, and information on the population served and the number of connections. Twelve years of monthly water use data are available for each utility from the FDEP web site (http://www.dep.state.fl.us/water/drinkingwater/download.htm) for every water treatment plant in Florida. This information can be used to evaluate historical trends and to project future growth patterns.

This information is compiled into software called EZ Guide that is used to find the optimal water conservation plan. Energy costs associated with end uses, e.g., showers, is being included in EZ Guide. This valuable additional information allows for a much more accurate bottom up assessment of the interdependencies between water and energy.

The other initiative is to evaluate how to minimize energy costs associated with urban water supply. The methodology builds on our earlier research on water distribution systems (Lippai et al. 1999) and includes a case study of the Hillsborough County water system. A state of the art hydraulic simulation model is used that calculates the spatial and temporal variability in flows, pressures, and water quality.

Benefits to the state

Florida seeks to be a leader in developing innovative energy systems that will reduce our dependence on foreign oil and generate energy related jobs. The Florida Energy Systems Consortium will develop numerous innovations to address our needs for more energy. Concurrently, we face unprecedented challenges to meet our growing needs for more water. Florida is blessed with a relative abundance of high quality water, especially ground water. These water sources have been a major component of the economic engine that has nurtured Florida's development over the past century. However, beginning in 2013, Florida water users will not be allowed to tap traditional low cost, high quality, water supply sources to meet their new needs because their supply has dwindled to low levels. Thus, we are running out of low cost energy and water at about the same time. Worse yet, many of the newer energy and water sources require more intensive use of these two resources, e.g., desalination of sea water is much more energy intensive than pumping from a nearby groundwater source; biofuel production requires far greater amounts of water to grow the crops and support the conversion process. National studies warn of the impending energy-water conflict (Cohen et al. 2004, Electric Power Research Institute 2003, National Research Council 2008, Navigant Consulting 2006, Sandia 2007, Webber 2008). Facing such dire circumstances, attention is shifting to developing more efficient systems and reducing our demands, where possible, through conservation. This project addresses how to evaluate energy-water linkages and find better ways to manage the demands for energy and water as a cost-effective way to reduce our future needs. It is essential for Florida to understand these water-energy trade-offs so that it can avoid myopic solutions that address one problem to the detriment of the other.

This study integrates energy evaluations into our ongoing Conserve Florida Water Clearinghouse (CFWC) project that is addressing water use efficiency and conservation. CFWC already has a network of state agencies, water management districts, water utilities and professional water organizations. The results of this study will be disseminated in the form of software tools and technical papers to allow users to do accurate integrated evaluations of water and energy systems.

How funds were leveraged

The inclusion of energy evaluations in the EZ Guide model will help minimize the damage to our base funding for the Conserve Florida Water Clearinghouse. We incurred a 60% reduction in base funding in June 2011, primarily due to the major budget cuts suffered by the water management districts. Fortunately, we were successful in obtaining new funding from St. Johns River Water Management District and the city of Sanford to develop new methods for water loss management. At present, Sanford has unaccounted for water in the range of 20-25% resulting in excess energy demand and reduced revenue. The goals of energy conservation and water loss control are synergistic. We also competed successfully for a national study of commercial, industrial, and institutional water use sponsored by the Water Research Foundation of the American Water Works Association. We are collaborating with Hazen and Sawyer, Inc., a recognized leader in this field. We are also collaborating with Austin, Texas, a leader in water conservation, in adapting our Florida methods for other utilities. Finally, the United States Geological Survey is supporting the research of one doctoral student related to urban infrastructure optimization

Reference to full report

A more complete description of the results of this project are contained in the final report.

This project has been completed. The final report can be found here.