FESC
Florida Energy Systems Consortium

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

Progress Summary

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 about 65 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 included in EZ Guide. The next stage in the analysis is to include embedded energy that is expended in treating and transporting the water from its source to the customer. This procedure will be added to the existing 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 will build on our earlier research on water distribution systems (Lippai et al. 1999) and include a case study of the Hillsborough County water system. A state of the art hydraulic simulation model will be used that calculates the spatial and temporal variability in flows, pressures, and water quality.

Funds leveraged/new partnerships created: 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, we are working with a firm in Adelaide, Australia on a possible joint software development project to develop and apply agent based modeling to water demand management.

2011 Annual Report

Impact

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 three year study beginning July 1, 2009 seeks to integrate 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. Some of these water utilities also provide energy services, e.g., Jacksonville Electric Authority, Gainesville Regional Utilities. These utilities will be targeted for more in-depth evaluations of energy and water use since they already have in-house expertise in both areas. The results of this study will be disseminated in the form of software tools and technical support to allow users to do accurate integrated evaluations of water and energy systems.

Description

Statement of the Purpose and Objectives of the Program:

Water and energy are fundamental necessities of modern civilization (Webber 2008). At the beginning of this project in July 2009, the economic recession was beginning to cause a reduction in water demand. Thus, the initial thrust of the research shifted from primary concern about inadequate water and energy to ways to stimulate the economy and reduce the costs of energy and water to free up resources for expenditures in other areas. Energy is a vital input to water infrastructure systems and vice versa and major tradeoffs exist. The overall purpose of this program is to develop new ways to integrate the evaluations of energy and water systems that recognize the tradeoffs that exist in satisfying needs in both areas with emphasis on better utilization of the these resources through improved efficiency and conservation. The importance of addressing the energy-water nexus issue was reaffirmed recently by a joint statement from the Alliance for Water Efficiency and the American Council for an Energy-Efficient Economy (2011)

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).

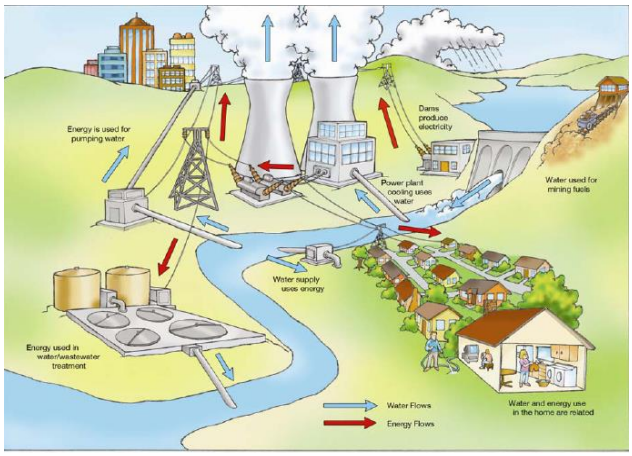

Figure 1: Examples of interrelationships between water and energy (Sandia 2007).

Project plans and activities:

The four project activities are described below. The key deliverable will be a public domain energy and water evaluation model that reflects Florida conditions and that can be used to do integrated evaluations of energy and water programs. Two manuscripts will be submitted for publication in archival journals. These manuscripts will provide detailed descriptions of the methods used and the key results.

Literature review

The literature review is focusing on assembling the results of previous energy-water studies that have been done at the national level and in other states, most notably California. The literature review includes a focus

on developing energy and water use coefficients for various key activities. Available models for analyzing water-energy systems will be included in the review. The output of the literature review will be a recommended modeling approach for Florida.

Tampa Bay Water has developed and implemented a method to estimate energy use for water supply and greenhouse gas (GHG) emission rates associated with water production. Tampa Bay Water provides wholesale water for six utilities: Hillsborough County, Pasco County, Pinellas County, New Port Richey, St. Petersburg, and Tampa. The initial annual report on energy use and GHG emissions was presented in 2007 (Tampa Bay Water 2008). The most recent information for 2010 on the methodology and the results for the six utilities is presented in Tampa Bay Water (2011). The Tampa Bay Water method uses national databases for its model.

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. During the past year, 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.

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 will be done by Mr. John McCary who is an engineer with Hillsborough County and a part-time PhD student at the U. of Florida.

Existing collaborations:

This project is made feasible by the research efforts during the past four years by the Conserve Florida Water Clearinghouse (CFWC) that is directed by Professor Heaney, the P.I. on this project. Details about CFWC can be found at our web site (www.conservefloridawater.org). The support from this project will allow us to expand our activities to incorporate the critical energy-water nexus that needs to be an integral part of evaluations of both water and energy options. Due to severe state budget cuts to Florida water agencies, our funding for 2011-13 has been reduced to $162,000 per year. Fortunately, other funding from the city of Sanford and the St. Johns River Water Management District, and the Water Research Foundation of the American Water Works Association will allow our research activities to continue.

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