## 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 the 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

## Progress Summary

Water use analysis is typically done using utility-wide data since it is to difficult to organize and evaluate customer level attribute and water billing data. A major breakthrough in the research of the CFWC 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. Florida, is unusual, if not unique, in making parcel level information public as part of its open government and public records laws. 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. For example, Alachua County reports which parcels have irrigation systems. 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 90 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) 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. Ten 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). This information can be used to evaluate historical trends and to project future growth patterns.

A detailed, customer level analysis of monthly water use, has been done for SFRs in Gainesville Regional Utilities using data for a recent year. A customer's water use pattern provides a signature of the nature of their water use. The vast majority of customers have a single meter that records their total water use. Our research indicates that indoor water use is constant throughout the year whereas outdoor water use varies widely based on the lot size, type of irrigation system, and customer preferences. Thus, it is possible to partition the total water use signal into its indoor and outdoor components.

**References**

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## 2010 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 two year study beginning July 1, 2009 will be conducted 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. Its current funding level is $425,000 per year. Many 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). People can survive without water for a few days. Contemporary people are totally dependent on energy to grow food, run computers, or power homes, schools or offices. Demand for energy and water continues to increase due to growing population and affluence. 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.

***Background and Significance***

The energy-water nexus for Florida is shown in Table 1. Water use 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 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. Nonpoint pollution associated with irrigated agriculture is also a significant additional cost to control. For example, excess nitrogen in the Mississippi River system is a major cause of the oxygen starved "dead zone" in the Gulf of Mexico. Nonpoint pollution from agriculture is a major component of this problem (National Research Council 2008).

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).

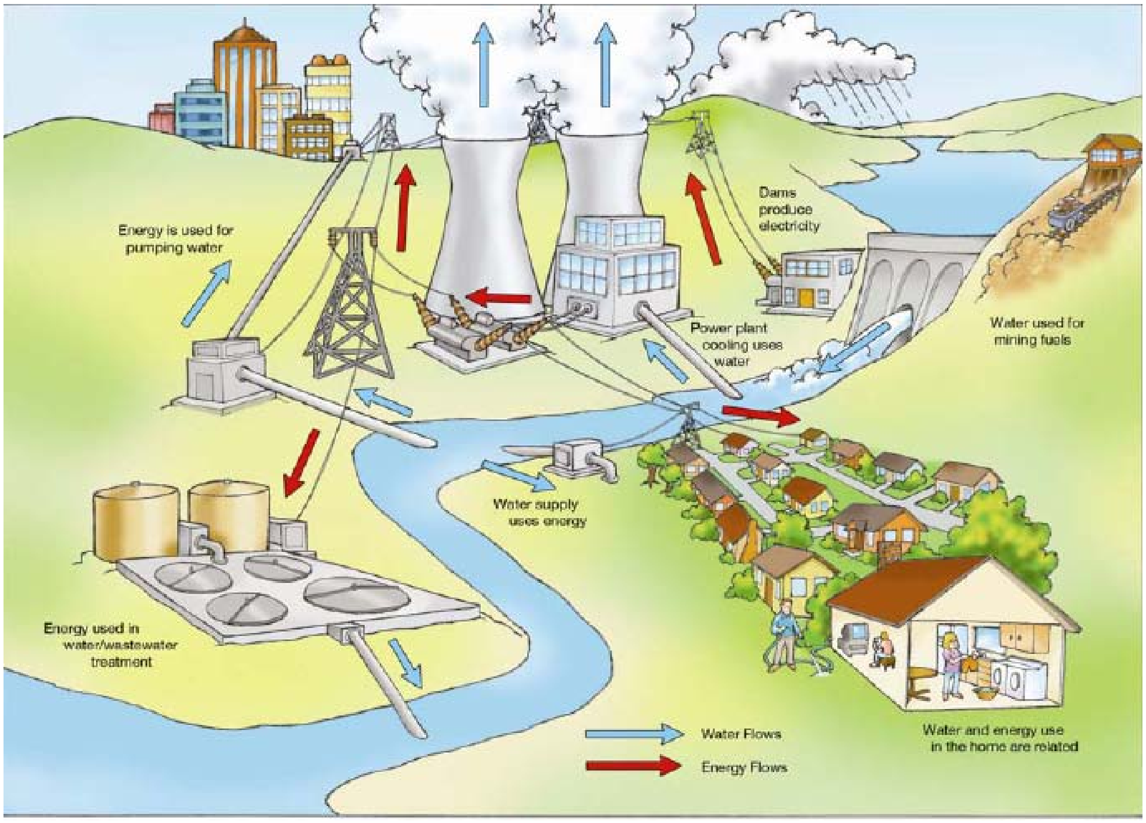


Figure 1. Examples of interrelationships between water and energy (Sandia 2007).

## Project Plans

### *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 will focus 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 will include 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.

### *Energy-water efficiency simulation model*

We have developed an urban water conservation evaluation model for Florida called EZ Guide as part of ongoing research. EZ Guide evaluates urban water conservation programs in the following steps:

1. Using historical daily and monthly water use records for the past several years and a water use data base and activity sizes obtained from the Florida Department of Revenue database, calibrate EZ Guide to provide the best estimate of recent water use patterns at the end use level. The calibrated model includes the impacts of historical interventions by the water utilities such as outdoor water use restrictions during droughts.

2. Using the calibrated end use model, project future water use without intervention by the utility as a base case.
3. Using a library of water conservation options, their expected effectiveness and costs, prioritize among the available water conservation options using optimization techniques.
4. Find the optimal blend of conservation practices by comparing the cost of the conservation program with the utility's alternative cost for the next increment of water supply.
5. Implement the conservation program, track its actual performance, and adapt the program as needed.

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. The key additional elements for adding an energy component to EZ Guide are to incorporate energy utilization and cost information into the existing EZ Guide to allow joint evaluation of water and energy systems.

***Energy-water efficiency optimization model***

The Energy-Water Efficiency Simulation Model (EWESM) provides the essential detailed process information for evaluating the nature of water and energy use in urban areas. The inclusion of an optimization capability will allow us to go from *what if* to *what's best* evaluations. Key additional inputs for the optimizer are cost-performance relationships that provide the basis for doing trade-off analysis. A spreadsheet platform will be used for the simulation and optimization models to allow easy access to powerful traditional optimization tools like linear and nonlinear programming as well as newer evolutionary algorithms that can solve more complex optimization problems.

***Model testing and utilization***

Several detailed test bed case studies have been developed as part of ongoing Conserve Florida Water Clearinghouse activities. These detailed datasets for a given urban utility are used to provide a benchmark for testing the validity of simpler models that are often used for estimating water use patterns. These databases include a large amount of the essential information that is needed to evaluate energy systems as well as water systems including parcel size, detailed information regarding the physical features of the property (from the County Tax Assessor's database), climatic data for estimating water and energy use. The existence of this extensive water and demographic data warehouse for every parcel in the State of Florida provides a unique opportunity to do advanced energy-water evaluations.

**Existing collaborations**

This project is made feasible by the research efforts during the past three years by the Conserve Florida Water Clearinghouse (CFWC) that is directed by Professor Heaney, the P.I. on this project. CFWC receives $425,000 per year in support from the Florida Department of Environmental Protection, three water management districts and a professional water supply organization. Details about CFWC can be found at our web site (www.conservefloridawater.org). CFWC provides a variety of resources including a library on water conservation, databases of key information, the EZ Guide Model, and links to information about water conservation. The scope of activities is on water use and energy has not been a funded component of our studies to date. 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.

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