COVER STORY

Florida campus expands water reclamation

The reuse of potable supply plays a key role in university water conservation plans.

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Courtesy University of Central Florida.

The University of Central Florida in Orlando.

With any goal must come a plan. The University of Central Florida (UCF), the second-largest university in the nation, is in pursuit of research preeminence. The challenge? How to balance the energy- and water-intensive nature of campus research facilities with the university's commitment to carbon neutrality by 2050 and a rising scarcity of regional potable water resources – all while supporting an increasing university population. Such a challenge necessitates creating a strategic future-ready plan and strong partnerships to ensure that any campus expansion is sustainable and resilient. It also requires the institution of strong policies to support progress toward environmental consciousness.

Among the priorities reflected in UCF's plans, partnerships and policies is the conservation, appropriate management and protection of the quantity and quality of regional water sources. The university's comprehensive water conservation program includes a wide range of measures – from using flow-monitoring timers in irrigation systems and installing low-flush plumbing to planting drought-resistant landscaping and requiring compliance with water-saving LEED certification standards in new construction and renovations. Another key element is the utilization of reclaimed water in the campus cooling system. Following a successful pilot project, the Utilities and Energy Services (UES) department recently expanded this use of reclaimed water, decreasing potable water purchase and treatment costs and helping protect the natural resources of the Central Florida region.

CAMPUS GROWTH

Since its founding in the 1960s, UCF has in many ways evolved into a small city. The public university began as Florida Technical University to supply the U.S. Space Program with aerospace and material engineers at the Kennedy Space Center and Cape Canaveral Air Force Station. In the 1970s and 1980s, the university advanced in its partnerships, notably creating the Institute for Simulation and Training and the Center for Research and Education in Optics and Lasers in partnership with Lockheed Martin and the U.S. Navy. Today, UCF's path to research preeminence is supported by its traditionally high enrollment of National Merit Scholarship recipients.

The UCF main campus is currently home to 212 buildings within its 1,415-acre footprint, including student housing, instructional, research, office and athletic facilities – all of which accommodate 9,662 full-time employees and 69,525 enrolled students. Since 2005, university facilities have grown by approximately 5 million gross sq ft, along the way considerably increasing the amount of space connected to the campus chilled-water system.

to chilled-water operations

Courtesy University of Central Florida.

The University of Central Florida's 1,415-acre main campus in Orlando.

When the university was first constructed, east Orange County was predominately undeveloped, with no access to municipal water supply. This prompted the construction of a water treatment facility on campus to support UCF's potable demands. Since that time, the university has extracted raw groundwater from the Floridan Aquifer via multiple 400-ft wells and then treated and distributed this potable water to campus buildings as well as to the campus district energy system. Various public-private partnerships located near campus also receive water from this source.

SEEKING ALTERNATIVE WATER SOURCES

The university has long placed a premium on the judicious use of water for its growing campus. The St. John's River Water Management District, which regulates UCF's groundwater use, allows the university to extract up to 256.5 million gal annually per its consumptive use permit that expires in 2034. Currently, the campus's process water consumption exceeds 150 million gal per year, or roughly 58 percent of the permitted level. With process water being the largest consumer of the allotment, UCF has sought alternative water sources.

In 2009, the university began tapping reclaimed water for irrigation use, piped in from the regional wastewater treatment facility operated by UCF's host government, Seminole County. The county has also been providing UCF with bulk wastewater collection of effluent since 1999.

After switching the irrigation supply to 100 percent reclaimed water, saving approximately 221,000 gal of potable water per day, UCF was motivated to develop more aggressive policies and plans to drive water efficiency and conservation to ensure a future-ready campus. A next step was to begin exploring the potential for using reclaimed water in the campus cooling system, which represented 53 percent of UCF's potable water use.

This 200,000-gal tower and an adjacent 100,000-gal storage tank regulate and store UCF's potable water supply.

CREATIVE REUSE IN CAMPUS ENERGY

Located in the Central Florida climate of ASHRAE zone 2A, UCF experiences a large quantity of wet bulb/evaporative hours, averaging only 275 hours (or 3 percent) per year that do not require mechanical cooling. Moreover, in 2019, Orlando averaged 3,795 cooling degree days. In this hot and humid environment, the campus is primarily provided with comfort cooling by four central chilled-water generation facilities. The system supplies up to 21,150 tons of chilled-water capacity to over 4.3 million gross sq ft in 63 buildings via more than 16 miles of networked below-ground piping mains. Across the system, there is physical space to install an additional 4,160 tons of chiller capacity.

A 3 million-gal thermal energy storage tank also provides cold storage in response to time-of-day purchased power price signals. While most of the chilled-water capacity is produced using electric centrifugal chillers, more than 900 tons of cooling capacity is contributed by an absorption chiller in the campus's 5.5 MW combined heat and power plant. Added with the opening of District Energy Plant IV in 2018, a heat recovery chiller simultaneously generates up to 160 tons of cooling and up to 5,862 MMBtu/hr of 143 degree F heating hot water supplied to a campus research facility.

In 2015, UES instituted a study to understand the operational profiles and water chemistry impacts of using reclaimed water for condenser makeup to support the campus's evaporative cooling portfolio. Discharge monitoring reports reviewed 87 different contaminant concentrations. The UES department partnered with its chemical treatment provider, Kurita America, to perform water sample tests at the point-of-use targets for conversion in effort to benchmark total dissolved solids, forming agents and pH.

In 2016, UCF further studied the feasibility of connecting each of its district energy plants (i.e., three in operation at the time plus the proposed District

WATER CONSERVATION, A REGIONAL AND UNIVERSITY PRIORITY

In 2017, the state of Florida experienced the most severe drought of the decade paired with above-average temperatures. Consequently, curtailment of municipal water use was mandated in the north, central and south-central Florida regions by each water management district. This kick-started numerous local water conservation initiatives and reestablished alliances among the managing water districts and water utilities.

In 2020, the Central Florida Water Initiative prioritized groundwater conservation, with plans to manage the scarce resource by addressing the built environment, irrigation supply and process water systems. Most notably, the plan capitalized on the input and collaboration from various municipal utilities and state agencies, including the St. John's River Water Management District (SJRWMD) that regulates UCF's groundwater extraction.

After decades of expansion, UCF is approaching the limit of its potable water consumptive use permit of 256.5 million gal per year, expiring in 2034. Requests to add to the current groundwater capacity allowance are not considered by the SJRWMD without demonstration of a strong commitment to water conservation and water efficiency.

THE UNIVERSITY'S POTABLE WATER USE HAS BEEN REDUCED IN EDUCATIONAL AND GENERAL FACILITIES BY 18 PERCENT TO 33 PERCENT.

Nearing the consumptive use permit capacity has uncovered the need for new university policies, partnerships and progressive design and construction standards. In 2008, stakeholder advocacy and administrative support solidified the adoption of the university's energy and water efficiency policy that mandates the application of water use guidelines for all new construction and renovation projects according to LEED v4 and ANSI/ASHRAE/USGBC/IES Standard 189.1-2014 (Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings). As a result, since 2010, potable water use has been reduced in educational and general facilities by 18 percent to 33 percent compared to an ANSI/ASHRAE/IES Standard 90.1-compliant baseline building.

In addition, the UCF 2020-2030 Campus Master Plan Update, adopted in November 2019, features the strong water conservation and efficiency goals, objectives and policies for future development that must be met prior to approval of additional consumptive use permits. (To learn more, see https://www.fp.ucf.edu/mp2020.)

System snapshot: University of Central Florida

	Hot water heating system	Chilled-water/combined heat and power system
Startup year	2018 – Heating hot water service begins to one research building from heat recovery chiller in District Energy Plant (DEP) IV chiller plant	1969 – Campus chilled-water service begins 2013 – CHP plant commissioned and put into service 2018 – Fourth chiller plant opens (DEP IV)
Number of buildings served	1	63
Total square footage served	105,775 sq ft	4.3 million sq ft
Plant capacity	DEP IV: 5,862 MMBtu/hr hot water	Total four chilled-water plants and CHP plant: 21,150 tons chilled water plus 35,000 ton-hr thermal energy storage CHP plant: 5.5 MW electricity
Number of boilers/chillers	DEP IV: 1 heat recovery chiller (same unit operates simultaneously in water chilling and heating modes)	Total four chilled-water plants and CHP plant: 10 electric centrifugal chillers (2,000 tons each), 1 absorption chiller (990 tons), 1 heat recovery chiller (160 tons) CHP plant: Natural gas reciprocating engine coupled to generator
Fuel types	Electricity	Electricity, natural gas
Distribution network length	1.2 miles	16.2 miles
Piping type	Direct-buried ductile iron, insulated carbon steel and high-density polyethylene	Direct-buried ductile iron, insulated carbon steel and high-density polyethylene
Piping diameter range	6 inches	1 to 24 inches
System pressure	30 to 50 psig	40 to 62 psig
System temperatures	143 F	42 F supply/56 F return
System water volume	N/A	3.2 million gal

Source: Utilities and Energy Services, University of Central Florida.

DISTRICT ENERGY PLANT IV Another milestone in UCF's commitment to sustainability

District Energy Plant IV.

Reclaimed water line (purple) feeding DEP IV.

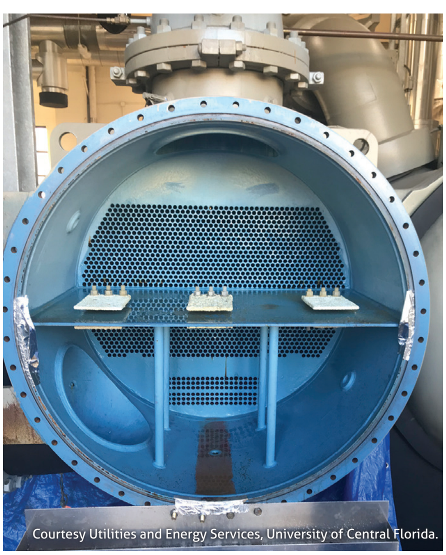
- Opened in 2018, increasing campus cooling capacity by 4,000 tons, expandable to 8,000 tons
- Produces 143 F hot water heating for one research building
- First industrial building on campus to earn LEED Gold certification
- Converted in 2020 to use reclaimed water in its two cooling towers, reducing potable water use by 25-30 million gal/year
- Has specialty windows to allow easy removal of chillers for maintenance
- Uses 30 fans in each cooling tower for improved resilience
- Designed with color-coded piping for use in teaching about the chilled-water system

Photos Courtesy Utilities and Energy Services, University of Central Florida.

Energy Plant IV) to a reclaimed supply to feed the condenser water makeup. The university also reviewed the preliminary cost implications of expanding the dedicated distribution pipe that already supplied reclaimed water from the regional treatment facility to campus for irrigation purposes. Variables analyzed included the availability of reclaimed water from the regional facility, availability of service pressure, capacity of existing UCF reclaimed mains, ability of system isolation, sizing of service main extensions and suitability of chemical makeup. The challenging climate required a thorough review of historical potable water demands, paired with a hydraulic water model to confirm that the reclaimed system could maintain pressure during peak cooling season (May-September) without negatively impacting the use of reclaimed water for irrigation.

IN 2017, UES IMPLEMENTED THE FIRST COOLING TOWER CONVERSION, UTILIZING OVER 5 MILLION GAL OF RECLAIMED MAKEUP WATER.

The reclaimed water quality results and feasibility study demonstrated strong potential for utilizing reclaimed water for process use on a large scale. In 2017, UES successfully embarked on a pilot project implementing the first cooling tower conversion, utilizing over 5 million gal of reclaimed makeup water in that first year. The project involved switching to reclaimed water use in one tower of District Energy Plant II.



After the use of 1.8 million gal of reclaimed water in the pilot project, a condenser tube punch revealed no heat transfer issues or fouling.

PARTNERSHIPS WITH HOST GOVERNMENTS

Despite the notable scale and engineering rigor of UCF's water conservation efforts, tapping a reclaimed source water supply of this magnitude required renewing an 18-year partnership with Seminole County. In lockstep with Seminole County Environmental Services, UCF approached the regional wastewater treatment facility to negotiate a new long-term reclaimed water supply contract. On Sept. 11, 2018, the county Board of Commissioners unanimously approved a bulk wholesale wastewater and reclaimed supply agreement, allotting the university up to 2 million gal of reclaimed water supply per day at an operating pressure of 70-90 psi for campus irrigation and nonpotable water demands.

Additionally, perhaps the most important partnership for infrastructure development and return on investment was UCF's ability to tie into the city of Orlando's 48-inch county reclaimed water transmission line at two geographical points on university property. This provided UCF with access to the county's reclaimed water system, in exchange for perpetual easements to feed other portions of Orange County. The close proximity of the interconnection relative to District Energy Plant IV was able to reduce capital expenditure on pipe and installation costs, reducing the project cost and creating a positive return on investment.

CONDENSER WATER TREATMENT

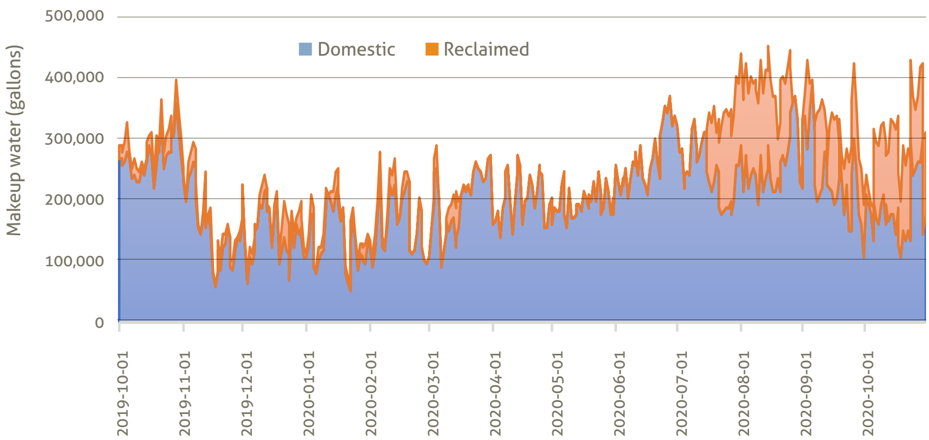
With the launch of the pilot project and use of reclaimed water as the tower water source, the entire condenser water treatment program had to be evaluated. Based on multiple water analyses and prior experience, Kurita America identified the necessary adjustments in the water treatment chemistry and automation control to minimize deposition and biological fouling on the chiller condenser tubes and ensure operation at the highest cycles of concentration.

The analyses showed that the reclaimed water had high levels of calcium, total alkalinity, phosphorus and biological activity that, if left untreated, would lead to greater deposition and fouling on the heat transfer surfaces. Therefore, the treatment program required the use of an acid trim protocol to run a minimum of four cycles of concentration (<25 percent blowdown rate), allowing the scale control chemistry (PBTC phosphonate plus advanced dispersants) to minimize both calcium carbonate and calcium phosphate deposition. The primary mechanism to minimize calcium phosphate deposition was pH control and phosphate-specific dispersants.

The program adjustment produced a successful chemistry by trimming the pH to 8.4-8.6 using sulfuric acid, compared to running pH of 8.9-9.1. Feeding sulfuric acid safely was a critical concern for the university; as such, a safe acid feed system was developed in conjunction with the current chemical controller system. This was accomplished by injecting acid using a dilution method and then adding the diluted acid into a rapid mixing area within the tower basin. Other safety precautions included double-contained chemical tubing and pump box, paired with leak detection and dual-pH probes. This ensured the monitoring program by the Kurita America delivery specialist was managing the acid accurately and safely in the tower via a double-walled tank. The biocide program used a dual oxidant that fed continuously based on oxidation reduction potential and weekly feed of a nonoxidizing biocide. Additionally, filtration was used to minimize suspended solids.

Today, each tower system is monitored 24/7 through remote communications. The data from the controller is stored in a web-based data management system for operator review and response, should conditions be outside acceptable parameters. The chemical program is reviewed by a Kurita America representative weekly through on-site testing and monitoring of controller performance. The program modifications allow the continued use of reclaimed water at a reduced cost, minimize water usage via

FIGURE 1. Campus condenser makeup water sources, Oct. 1, 2019-Oct. 1, 2020, University of Central Florida.



Source: Utilities and Energy Services, University of Central Florida.

higher cycles of concentration, and prevent scale and biological fouling in the towers and condensers.

POTABLE WATER CONSIDERATIONS

Another important challenge for the success of UCF's water conservation program was addressing the possible impacts of reduced water use on the potable water system. The university understood that the plan for moving to a lower carbon footprint, with such measures as improving building energy efficiencies and decreasing cooling demand, could lead to lower potable water flows conveyed in water transmission mains and buildings designed to manage higher flows. In turn, these lower flows influence water quality, costs, energy consumption and public health. The possible impacts were of concern to UCF as longer water residence times could result in an increase in disinfection byproducts, which as suspected carcinogens are regulated by the federal and state government.

This challenge was addressed in late 2018 when UCF management, operations and academic staff partnered to eliminate concerns over potable water quality. Water quality engineering studies were conducted in-house on campus where UCF water operations staff and environmental engineering students determined how changes to water disinfection and treatment practices would lower chemical demand and increase treatment of disinfection byproducts.

These efforts resulted in a modified water treatment, storage and operations plan that was accepted in 2019 by the Florida Department of Environmental Protection. This plan proved useful, not only in the university's water conservation efforts but also in maintaining safe drinking water, especially during the COVID-19 campus shutdown, which created stagnant water conditions in buildings.

DRIVING RESILIENCY, ADDING VALUE

A sustainable campus development is one that meets the needs of the present without compromising the future ability to meet expansion requirements, especially given finite regional water resources. To that end, since 2017, UCF's cooling tower conversion pilot has used over 22 million gal of reclaimed water annually. In 2020, following the success of that project, the university also converted all of District Energy Plant IV over to reclaimed water. Using reclaimed water in both plant cooling towers has reduced potable water use in the campus cooling system by an additional 25-30 million gal per year.

Figure 1 illustrates campus condenser water makeup sources from Oct. 1, 2019, to Oct. 1, 2020. As shown, reclaimed water use increased significantly in late 2020 following the conversion of District Energy Plant IV's makeup water source.

From a resiliency perspective, UCF's dedicated reclaimed water infrastructure provides the university with an N+1 operational model for condenser water makeup supply to two of the four district cooling facilities.

At an upfront cost of $520,000, the District Energy Plant IV conversion is anticipated to avoid $76,900 in purchased potable water, providing a 6.75-year simple payback, and to decrease the annual water treatment cost for reclaimed water by 23 percent. As of September 2020, the project had used over 12.9 million gal of reclaimed water on a monthly basis. This effort alone will conserve 10 percent to 13 percent of the university's permitted potable water capacity for future use. This is crucial, not only for future academic and research space but also for helping the university to fulfill its commitment to conserve regional water sources.

With the pilot project's success, pipe design is underway to fully transition to reclaimed water at District Energy Plant II and District Energy Plant III. Conservation initiatives will only continue and expand in coming years. The future holds opportunity for new technologies to use all available lower-quality sources of water, including reclaimed water, surface water and storm water before using precious potable water. The resulting potable water conservation, paired with stringent campus building standards, aim to set a precedent for other municipalities and universities to follow as they strive toward more sustainable growth.

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