

The Sustainability “Hat Trick”: Reclaimed Water, Pelletization of Biosolids, and Biogas To Energy

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The Palm Beach County Water Utilities Department (utility) will become one of the few utilities to complete the “hat trick” of recycling wastewater effluent, biosolids, and biogas when the biogas reciprocal engine generator sets complete operational testing in April of 2013 at the Southern Region Water Reclamation Facility (facility). The utility is a leader in becoming a green utility and has adopted the mission statement, “Best Water, Best Customer Service, and Best Environmental Stewardship.” The foundation of becoming a green utility is reduction of its environmental footprint through conservation, sustainability, energy efficiency, and greenhouse gas reduction.

The utility promotes conservation through its alternative water resources program, which includes the largest reclaimed water system in southeast Florida. The facility has 22 million gallons per day (mgd) of reclaimed water filters that can be blended with an additional 4 mgd of nanofiltration membrane concentrate. Additionally, 150 acres of created wetlands use secondary treated wastewater effluent for rehydration.

Palm Beach County has a mandatory reclaimed water service area that is strategically located to recharge wellfields, providing sustainability to the surficial aquifer. Biosolids are pelletized for soil supplement as a long-term sustainable disposal method under an agreement with the Palm Beach County Solid Waste Authority. The facility’s biogas project, which is under construction, is partially funded by green stimulus funds. The project includes two methane gas reciprocal engine generator sets installed at the facility in 2012. Reciprocal engines were chosen over fuel cells or gas turbines due to their reliability and cost. The electricity generated will be paralleled with the facility’s 4,160 volt main switchgear. When the methane flare is extinguished and the generators turned on, the “hat trick” will be complete.

Reclaimed Water and Wetlands

The utility supplies reclaimed water through approximately 55 mi of piping to over 90 residential communities and golf courses, and has created two wetlands using

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secondary effluent water. Additionally, nanofiltration membrane concentrate is used for blending with reclaimed water at the facility to supplement demand.

The facility was completed in 1991 to replace several smaller wastewater treatment plants (WWTP). The initial phase of the reclaimed water program consisted of sand filters, a chorine contact chamber, and high service pumps for a total production capacity of 4 mgd. The reclaimed water was pumped on-site to provide recycled water for plant processes and irrigation. A key to the success of the program was the location of the facility in a farm area west of Water Treatment Plant (WTP) 3 within the urban residential service area. This allowed reclaimed water to be implemented as development occurred in the vicinity of the facility, which provided recharge to the WTP 3 well field. Decommissioning the percolation ponds at Wastewater Treatment Plant (WWTP) 3 provided land for the first wetlands project.

In 1996, the utility actively sought to increase local use of reclaimed water. The golf courses and large residential communities near the facility provided a source of reclaimed water users. Additional sand filters and transmission pipelines were constructed at the facility to increase the reclaimed water production capacity to 6 mgd from 4 mgd ⁽¹⁾.

In 1997, Palm Beach County adopted a reclaimed water ordinance and established a mandatory reclaimed water service area surrounding the facility. The mandatory service area required new developments within a 1-mi radius of the facility to install and utilize reclaimed water. This innovative local government initiative is a model for other governments. The mandatory reclaimed water



Photo 1 - Southern Region

zone was increased in 2005 from the original 4 sq mi to 10 sq mi.

In 1998, the utility added 16 mgd of reclaimed water capacity by using cloth filters, resulting in a total capacity of 22 mgd. The expansion was required to accommodate demand projections from increased development, residential usage, and golf courses.

The Wakodahatchee Wetlands (Seminole for “created waters”) were constructed in 1997 adjacent to WTP 3 at the former site of the WWTP 3 percolation ponds. The 39-acre wetlands utilize secondarily treated wastewater, which reduces the amount of effluent disposed through deep well injection. The wetlands were designed to treat the highly treated secondary effluent with natural biological processes to further reduce nutrient levels. Treated water from the wetlands percolates into the surficial aquifer to recharge the local groundwater. This recharging reduces reliance on water from the groundwater wells and the regional surface water system. The Wetlands are considered a significant wildlife refuge, providing habitat for 119 bird species. A 1-mi boardwalk has a series of interpretive signage panels designed to inform and educate the public on the natural systems and wildlife.

The County has also built a second wetland system known as Green Cay. The first phase of the Green Cay Wetlands was completed in 2004 and includes 26 acres of open water for water fowl; 17.5 acres of uplands for nesting, resting, breeding, and feeding activities; and emergent marsh for attracting wading birds and other wetland-dependent birds. The walking trails along the two mi of boardwalk provide significant recreational opportunities for the community. The County’s Parks and Recreation Department constructed a 10,000 sq ft world-class Interpretive Center at the Green Cay Wetlands. The center provides a living laboratory for school groups and community organizations to study the hydrology, ecology, and restoration of southern Florida ecosystems.

As demand for reclaimed water has increased, the utility has utilized innovative methods to meet the needs of its customers. In 1999, the utility began routing a portion of the nanofiltration membrane treatment waste stream (membrane concentrate) produced at WTP 3 to the facility. The membrane concentrate flow contains concentrated organics and minerals removed from the surficial aquifer raw water. It is blended with the filtered secondary effluent upstream of the reclaimed water chlorine contact basins. A maximum blend ratio of at least 5.24 parts reclaimed water to one part

membrane concentrate is maintained per the Florida Department of Environmental Protection (FDEP) permit conditions.

The utility’s alternative water resources program is multifaceted in the benefits it brings:

- ◆ Minimizes dependence upon surficial aquifer and regional water supply system.

- ◆ Maintains a steady raw water supply for water treatment plants.
 - ◆ Reduces the amount of fresh water drained from the land and discharged into the ocean.
 - ◆ Minimizes stress on wellfields.
 - ◆ Minimizes the “net” quantity of water
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Photo 2 - Wakodahatchee Wetlands



Figure 1
Green Cay Wetlands



Photo 3 - SWA Pelletizer Facility



Photo 4 - SWA Pelletizer Rotary Dryer

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withdrawn from the surficial aquifer.

- ◆ Provides landscaping water supply during drought conditions.
- ◆ Reduces reliance on deep injection well systems.
- ◆ Educates the public on the importance of water conservation in south Florida.
- ◆ Increases carbon absorption by creation of wetlands.
- ◆ Provides habitat for migratory birds, waterfowl, and endangered species.
- ◆ Provides passive recreation opportunities for the public.
- ◆ Increases suburban green space.



Photo 5 - Biosolid Pellets

Pelletization of Biosolids

The utility, working with the staff of the County's Solid Waste Authority (SWA) and five other public wastewater utilities in the County, developed the concept of constructing a regional Biosolids Processing and Recycling Facility (BPF) to process wastewater residuals into a Class "AA" material for beneficial reuse. The utility previously processed its wastewater biosolids to Class "B" standards, and these biosolids were land-applied. Concerns on the sustainability of land application and the increasingly stringent regulatory environment resulted in fewer land application sites and higher costs.

On April 12, 2005, SWA approved a contract with the New England Fertilizer Company (NEFCO) to design/build/operate the BPF. Under the interlocal agreement, the SWA is responsible for the design, construc-

tion, operation, and maintenance of the regional BPF, and in addition, will market the biosolids pellets to various fertilizer manufacturers to be used for energy production.

Screw and belt conveyors transport the material into two 460-cu-yd bins, and then into a pug mill, which mixes oversized and fine dried pellets with the incoming sludge. The mixture then enters one of the two rotary drum dryers, which evaporates the moisture and condenses the remaining solid material into 2-cm pellets. Methane from the adjacent Class I landfill is used for the two 300-ton/day Baker-Rullman Mfg. Inc. dryers, rather than flaring it off, reducing dependence on natural gas and operating costs⁽²⁾. A separator cyclone then screens the dried solids. Pellets meeting the size criteria are cooled and transported to storage silos, ready to be sold. The SWA pelletization facility became operational in 2009.

Biogas to Energy

The Digester Biogas Renewable Energy Project will generate 20 percent of the facility's power requirements from the methane biogas that is currently flared and wasted. Upon completion of this third component, all of the waste products generated at the facility will be recycled, providing environmental stewardship (reclaimed water for irrigation and constructed wetlands, biosolids for fertilizer pellets, and biogas for energy production). This project is partially funded by the United States Department of Energy's Energy Efficiency and Conservation

Block Grant (EECBG) Program Assistance Agreement in the amount of \$1.6 million, which covers a portion of the \$3,529,000 project cost. This project demonstrates environmental stewardship per the utility's mission statement and is essential to the Department's green initiatives.

The facility is a conventionally activated, sludge domestic wastewater treatment facility rated at 35 mgd, three-month average daily flow (TMADF), and is currently operating at approximately 60 percent of the rated capacity. Sludge is collected in the existing clarifiers and transferred to three gravity belt thickeners where the sludge is thickened to approximately 5 percent solids before being stabilized through anaerobic digestion. There are two digester groups, each with three 65-ft diameter digesters. Each group has two primary digesters with fixed covers and one secondary digester with a floating cover. These gas holder covers permit a cover travel of about 6 ft, and thus pro-

vide up to 20,000 ft³ of biogas storage per secondary digester. (There is no other digester gas storage at the plant.) The facility digesters receive an average of 86,000 gal of solids per day with an average volatile solids concentration of 4.24 percent. This equates to an average of 30,000 lbs per day of volatile solids fed into the digesters. On average, the volatile solids destruction for the SRWRF digesters was 15,800 lbs per day, or 53 percent. It was assumed that 15 ft³ of gas is produced per pound of volatile solids. Gas samples were sent several times to determine the British thermal units (BTU) available for combustion, and to measure hydrogen sulfide and siloxanes. The digester heating requirements were subtracted from the gas production to determine the available gas flow for the renewable generators. The criteria for sizing of the generators focused on minimizing flaring and maximizing energy production, while considering seasonal flow variations. Using two 375-kW internal combustion engines provided 96 percent gas utilization. To maximize the use of the 460V three-phase renewable generators, the power produced will be paralleled to the plant electrical grid. The power will be increased to 4,160V through the use of transformers and then paralleled using the existing Russ Electric switchgear.

The initial plan for the biogas-to-energy project was to utilize energy performance contracting (ESCO) with Florida Power and Light (FPL) Services LLC. An investment-grade audit was completed by FPL to convert the existing wasted methane flare into generated electricity to be used on site. Analysis of ESCO's cost estimate for the completion of design and construction determined that utilizing a traditional design/build approach had significant cost savings. The CDM Constructors Inc. was the design-build partner with the ESCO contract with FPL. The utility had an existing design-build contract with CDM, which was utilized for completion of the project. The contract provided for final design, permitting, and construction of the facility's Digester Biogas Renewable Energy Project, which will capture digester biogas and combust it to produce electric power. This electric power will be used on site, reducing the purchase of electric power that is produced using fossil fuels, and will generate an average of 455 kW of continuous electrical power that will provide 20 percent of the required electrical power for the facility.

This waste gas-to-energy recapture is an innovative project that demonstrates sustainable use at a wastewater treatment facil-

ity. This has potentially widespread application in similar wastewater treatment facilities, as well as other industrial facilities located throughout Florida. Upon completion of this project, the utility will be one of only a few to reuse all three wastewater treatment process byproducts. In addition, this project provides the facility with additional electrical generation capacity in the event of an emergency, or during a disaster.

The utility is a proactive utility that values improvements that can increase positive public perception, and embraces environmental stewardship. There are six objectives

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Photo 6 - Biogas Flare

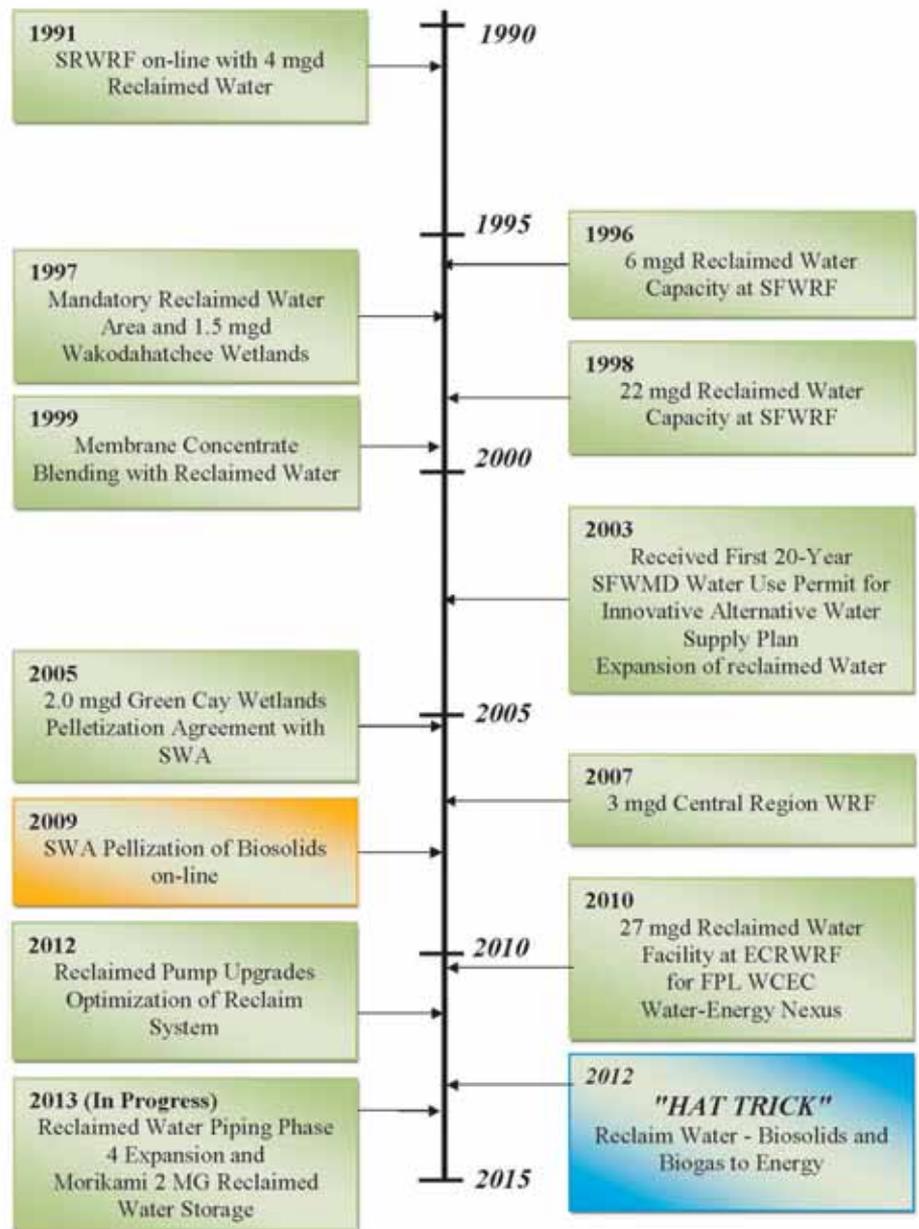


Figure 2. Timeline of Palm Beach County's Sustainability "Hat Trick"

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that will be accomplished:

- Objective 1: Complete the waste reclamation cycle at the facility by utilizing up to 100 percent of the biogas created at the facility.
- Objective 2: Reduce energy supplied by the power grid.
- Objective 3: Provide source green power to meet the utility's 5 percent alternative energy goal.
- Objective 4: Increase electrical system flexibility.
- Objective 5: Reduce greenhouse gas emissions.
- Objective 6: Become a model for other utilities to recover and utilize biogas for energy production.

Critical decisions in the design process included determination of the gas volume, gas BTU quality and contaminants, operational protocol for digester pressures, sizing of gas pretreatment system, type of equipment for electrical generation, sizing and number of generators, how to connect the generated power to the plant power system, process control system for operations, and maintenance requirements.

During predesign, engineering evaluations included scenarios using both internal combustion engines, as well as microturbines. The internal combustion engine was chosen based upon higher efficiency and minimal gas preparation. The gas pretreatment system consists of only moisture and particulate removal with minimal gas compression. The facility will have two Waukesha Power Systems 375-kW internal combustion engine generator sets, while maintaining the use of digester biogas as a fuel for the existing boiler systems. This combination results in utilization of over 96 percent of the current biogas generated at the facility, with an energy cost savings of \$283,000 per year. Each renewable generator is housed in a separate hurricane-rated enclosure.

The Sustainability "Hat Trick" or "Trifecta"

The San Antonio Water System (SAWS) claims on its website to be the only city in the United States that has completed the "trifecta" of recycled water, organic biosolids, and methane gas⁽³⁾. The choice here is the sustainability "hat trick." To complete the recycling of all three phases (liquid, solids, and gas), San Antonio used a different variation

than the utility. The SAWS solids are composted and the gas is sold in a commercial pipeline, rather than used to generate electricity. Some of the SAWS reclaimed water is used for power plant cooling similar to the utility's reclaimed water project at the East Central Water Reclamation Facility, which serves the Nextera Energy (FPL) West County Energy Center.

The utility will complete the sustainability "hat trick" in April of 2013 after the final operation testing of the biogas renewable energy generators (Figure 2)⁽⁴⁾. The "hat trick" or "trifecta" should be encouraged as a high standard for utility sustainability, notably comparable to the Leadership in Energy and Environmental Design (LEED) certification program.

The Water—Energy Nexus

The utility has established two energy goals: Reduce energy consumption 10 percent per customer by 2020, and produce 5 percent alternative energy by 2020⁽⁵⁾. Meeting these goals will also reduce the utilities greenhouse gas emissions. The biogas-to-energy project is a key to meeting these energy goals. The utility uses an average of 10,300 kW continuous power usage. The 455 kW to be produced by the biogas-to-energy project will meet the utilities alternative energy goal and provide one half of the overall energy reduction goal.

To produce and pump water or reclaimed water requires energy that is part of the water—energy nexus. Thermoelectric energy plants require water to produce energy. The FPL West County Energy Center (WCEC) will generate a maximum of 3,750 mw and will consume a maximum of 27 mgd of reclaimed water from the East Central Regional Water Reclamation. The net efficiency of the WCEC is estimated to be 0.30 gal per kW/hr⁽⁶⁾. The facility's biogas reciprocal engines will generate an average of 455 kW without consuming water for cooling, as a closed loop radiator set outside the generator enclosure will be utilized. The net water savings by using internal combustion engines versus FPL power generation with evaporative cooling is 455 kW x 0.30 gal per kW = 136.5 gal per hour or 3,276 gal per day.

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