The Polk Power Station is a unique power plant. Built in 1996 and co-funded by the U.S. Department of Energy, it is one of the world’s few integrated gasification combined-cycle (IGCC) power plants, a first-of-its-kind combination of coal gasification and combustion turbine combined-cycle technologies. Four simple-cycle peaking units also are on site. To cool the five units at the Polk Power Station, Tampa Electric uses a cooling reservoir that requires about 3 million gallons of groundwater every day as makeup for evaporation. The company knew it needed to expand generation at Polk in coming years, which would require additional makeup cooling water. But increasing the amount of groundwater would prove difficult. Tampa Electric needed a creative solution.

The solution turned out to be every bit as innovative and groundbreaking as the original plant.

Tampa Electric forged creative regional relationships with the Southwest Florida Water Management District (SWFWMD or “Swiftmud”), Polk County and the cities of Lakeland and Mulberry – forming a first-of-its-kind partnership. The company designed and built an innovative reclaimed water-treatment project that has dramatic environmental benefits. Polk became the first power plant in the United States to combine reclaimed water and clarification, filtration and reverse-osmosis technology to produce a new source of cooling water with on-site, deep-well disposal of wastewater.

The result is a state-of-the-art system that has taught lessons to both the electric utility industry as well as the water-treatment industry – plus it provides significant environmental benefits that will impact multiple generations of the community.
The Challenges

Tampa Electric, one of Florida's largest investor-owned electric utilities, is part of the TECO Energy family of companies. Tampa Electric operates three power plants that produce nearly 4,700 megawatts of electricity to serve more than 700,000 customers in West Central Florida.

The Polk Power Station sits on 2,800 acres of land that was formerly mined for phosphate. It includes a 260-MW IGCC unit, four simple-cycle peaking units (each between 160 and 180 MW) and a 750-acre cooling reservoir. The power station produces enough electricity to serve 75,000 homes. The Polk site is large enough to accommodate several generating units to meet the future demand of customers. Additional units would require additional water.

In 2006, water availability issues had not reached the critical level they have today - in fact, it was not even on the radar of most industries. Most power companies assumed they would manage their cooling with groundwater. But Tampa Electric was forward-thinking enough to identify water availability as an emerging issue - and addressed it head-on.

The Polk Power Station sits inside the 5,100-square-mile Southern Water Use Cautionary Area, which means the Floridan Aquifer is dangerously low in those eight counties (in some places up to 50 feet low). In this cautionary area, water regulators try to limit the withdrawal volume from the aquifer, especially in light of increased demands for public use, including agriculture, mining and power generation.
It became clear to the utility that in future years, Tampa Electric would face difficulty trying to secure more groundwater to cool the plant.

SWFWMD is responsible for managing and protecting the water resources in West Central Florida. This district includes 16 counties and nearly 10,000 square miles.

SWFWMD and other environmental agencies (such as the Florida Department of Environmental Protection) wanted Tampa Electric to exhaust all possible alternative sources of water before SWFWMD would allow the utility to draw more water from the aquifer. The cost of those alternate sources of water was not supposed to be a key factor in Tampa Electric’s research — the utility was to focus on the technical viability and availability of alternate water sources.

Tampa Electric considered:

• Petitioning SWFWMD to allow Tampa Electric to increase its use of groundwater. Although this would be the most cost-effective solution if allowed by the agency, it would not have been the best solution for the environment and its constituents in the region.

• Building “dry” cooling towers. However, the technology is not effective in the Florida climate.

• Shutting off the plant’s discharge and recirculating the water in the reservoir. This was cost-prohibitive and would have affected the minimum-flow levels of a nearby creek, causing environmental concerns. This was not a viable long-term solution.

• Buying land with available water credits. This was the most expensive option and would reduce groundwater use.

• Using reclaimed water to cool the plant. This had the most environmental benefit, and it was the best strategic solution for the utility and its partners. (Tampa Electric ultimately chose this option.)

An Innovative Solution

Polk County and the cities of Lakeland and Mulberry treat their wastewater and use some of it for irrigation. However, they have more wastewater than they can reuse. Together, they were discharging about 9 million gallons of excess wastewater — enough to fill nearly 14 Olympic-sized pools — into the Alafia River every day, which ultimately wound up in Tampa Bay. This increased the amount of nitrogen in Tampa Bay’s water, which inhibits growth of sea grasses, fish and other sea life.

The conversation with these municipal partners began in 2006. When the economic downturn and reduced demand for electricity occurred in 2007, the need for generation expansion was delayed. The partners kept talking — because everyone recognized the value of joining together. Tampa Electric was prescient enough to know a strong partnership could allow potential for future expansion at the Polk site — whenever it was needed.

Because water resources were limited and shared, the partners collaborated to manage those resources. Tampa Electric, SWFWMD and the municipalities cooperated to develop shared goals to maximize the beneficial use of the available water resources. For example, although each partner had its own goals, they all wanted to benefit the environment.
This project was forward-thinking. Although the need for the cooling water was delayed because of changing generation demands, company leadership saw how this project could benefit the existing plant along with our community partners. Plus it could accommodate future generation expansion at the existing site.

That potential expansion became clear when Tampa Electric announced plans to convert the four simple-cycle peaking units at Polk to a more efficient combined-cycle unit (a four-on-one). The expansion would require 6 million to 8 million gallons of cooling water. The reclaimed water project, already under way, would supply the water that the plant would need.

The final reclaimed water project design allowed Tampa Electric to pipe the water 15 miles to the power plant, treat it, and use it to cool the power plant. This project helped Tampa Electric reach all its goals:

• Ensure adequate makeup water supplies are available.
• Maintain and improve water quality for the existing cooling reservoir.
• Maintain the viability of the Polk Power Station for expansion.

As a bonus, Tampa Electric received the wastewater at no cost for at least two decades - eliminating $4 million of water charges the utility would have paid over a 20-year period.

In addition, the project has tremendous long-term benefits for the environment and the municipal partners. It will:

• Clean up Tampa Bay by diverting previously discharged wastewater. This will remove nitrogen from the water.
• The sea grasses will be healthier, and populations of small fish, crabs and oysters will increase.
• This project will help both Hillsborough and Tampa bays, which are currently impaired by nitrogen.
  ▪ In one year, this project will meet Hillsborough Bay's five-year nutrient-removal goal and half of Tampa Bay's five-year nutrient-removal goal.
• Minimize any future withdrawals of groundwater to cool Polk Power Station.
• Allow the city of Lakeland to get a new drinking-water permit because they are no longer discharging reclaimed water into a river. (With later phases, Polk County and the city of Mulberry will see similar benefits.)
  ▪ This gives the city better flexibility over its growth plans.
  ▪ It also gave the city a strategic advantage for economic development.

Because of the combination of benefits, including the reduction of future groundwater withdrawals, SWFWMD agreed to partially fund the project by investing about $45 million. With that funding, this option became the best investment for Tampa Electric customers. To date, this is the single largest project that SWFWMD has co-funded.

The plant's sustainability also will improve. As demand for power continues to grow in Florida, water demands will increase. Water is a finite resource - and finding innovative new sources will make power production more sustainable. Tampa Electric decided to move ahead with the $120 million project that would benefit the utility, the county, nearby cities and the environment.
TAMPA ELECTRIC’S POLK POWER STATION
Regional Reclaimed Water Project

With this unique public-private partnership, Tampa Electric was a pioneer. The partnership not only solved Tampa Electric’s cooling-water problem, it also solved the municipal partners’ discharge issues – plus it had tremendous environmental benefits.

**State-of-the-Art Engineering and Lessons Learned**

Tampa Electric installed 15 miles of 30-inch diameter plastic pipe (PVC and HDPE), connecting Lakeland’s Wetland Treatment System on State Road 60 with the Polk Power Station. Construction of the pipeline took 18 months and included river crossings, multiple road and railroad crossings as well as construction through open land.

One of the most challenging aspects of the pipeline was the environmental sensitivity of the route. The path between Lakeland and Polk Power Station includes many wetlands and threatened or endangered species. Also, the path was near residential and commercial properties. Construction had to be carefully coordinated to prevent impacts to the community.

Another challenge faced by the team was designing the water-treatment plant to be built on the Polk site. Water from the Lakeland Wetland Treatment System must be treated to bring it to the level of purity required for use in the Polk Power Station’s cooling reservoir.

Experts consulted historical data on the quality of Lakeland’s wastewater discharge, and engineers designed the plant based on those statistics. However, the city of Lakeland discharged its wastewater only during three months of the year – which made the water quality appear better than it was, especially during dry periods. This discovery made it clear that reverse osmosis treatment, by itself, would be inadequate without pre-treatment of the wastewater.

Tampa Electric’s planned treatment system was insufficient to treat the inconsistent water quality from Lakeland. The utility conducted pilot testing to determine which treatment combination was the most appropriate. That study showed the utility needed to remove more solids than originally anticipated. Redesigning the water-treatment plant added significant costs to the process, but it was necessary to meet the requirements of cooling-reservoir makeup. The final selection of treatment technology was based on effectiveness and cost.

The final design included three stages of treatment:

- High-rate settling and clarification, to remove organics and suspended solids, such as algae or dirt.
- Gravity-flow filtration, to prepare for the final step of treatment.
- Reverse osmosis, which removes the dissolved impurities, such as salt and other minerals.

At the end of treatment, there are two streams of water. The clean water – nearly clean enough to drink – goes into the plant’s cooling reservoir and is used to cool the plant. The disposal stream is concentrated with impurities, and it is sent more than 1.5 miles underground through two underground wastewater-injection wells.
Tampa Electric drilled two state-of-the-art deep-injection wells 8,000 feet underground for disposal of concentrated wastewater. This is an environmentally friendly alternative to disposing of it in surface waters – when the geology is suitable. While drilling the wells, Tampa Electric learned that the geology in the area includes a 1,000-foot thick layer of impervious limestone (about ¾ of a mile deep) called a “confining layer” that will keep the disposal stream from getting into or damaging the Floridan Aquifer. The disposal stream is released into a briny water solution that exists naturally. Drilling the wells helped advance the geological industry by providing detailed information that was previously unknown. (See sidebar on page 6.)

With some modification, the wells could also be used for injection and storage of carbon dioxide captured from the IGCC unit at the Polk site. In fact, in anticipation of that, the wells were installed using a special concrete epoxy that is resistant to carbonic acid, which is produced during the carbon-sequestration process and which can degrade other materials. The company worked with a team of experts at the University of South Florida to evaluate carbon sequestration. (The option of carbon sequestration was removed from the original scope of the project due to long-term funding issues.) At a later date, if federal regulations make it appropriate, Tampa Electric may re-evaluate the wells for that potential use.

The water pipeline began initial operations in 2014, and the project was fully commissioned in March 2015.

Initially, the system is transporting and treating 5 million gallons of reclaimed water a day from Lakeland, with the ability to expand to 17 million gallons per day. Phase II – connecting to Polk County and the city of Mulberry – is under water-use contract, and the engineering plans are being developed. It is scheduled to be operational in 2017.

It would take nearly five Willis Towers (formerly known as the Sears Tower) – one of the tallest buildings in the United States, at 1,729 feet - to fill the 8,000-foot-deep injection well.
To drill a 52-inch diameter well a mile and a half into the earth, a first-of-its-kind electric drill rig was custom-built especially for the Polk Reclaimed Water Project. This type of drill rig is typically used in oil fields, not for water-related drilling.

The innovative multi-million-dollar electric drill rig was so quiet that operators could hold a conversation standing next to it. It’s environmentally friendly because it has fewer emissions than standard construction equipment, and it includes ultra-safe automated systems for safety and efficiency. Specialized $250,000 drill bits were created because of the width and depth of the well.

**Journey to the center of the Earth**

When Tampa Electric dug the deep-injection wells, the geology industry took notice.

The geology of Central Florida was not well known at any relevant depth because of a lack of recent data. The most recent wells dug in Central Florida were in the 1970s, during the bygone era of oil and gas exploration. Digging these wells at Polk Power Station advanced the industry by more than 40 years.

Geologists and universities were excited by the prospect of peering deep into the earth. It was an opportunity to verify the geology of Central Florida and confirm presumptive models. Geologists from the United States Geological Service, the Florida Department of Environmental Protection, the University of Florida and Florida State University inquired about studying the core samples.
In 2010, Tampa Electric was beginning to install the first deep-injection well. Typically, for the first portion of the well, called the upper casing, crews have two choices:

- Vibrate or “shake” it with a pile driver, or
- Drill it with an auger.

Shaking is faster and cheaper than drilling— and Florida is one of the states where this technique usually works well. The company proceeded with pile-driving the upper casing into the earth, and for about eight weeks, things went well.

Until they didn’t.

About 280 feet into the ground, the equipment hit a shallow aquifer. The earth collapsed as if a drain had been pulled out of a bathtub. A huge sinkhole opened up, eventually growing to 100 feet in diameter. The huge multi-million-dollar crane—custom-built only a few weeks earlier specifically for this project—shifted toward the hole, until it was balanced precariously on its four corners.

Crews followed proper safety procedures, and no one was hurt.

Florida’s geology presents unique construction challenges, including karst formations, or “honeycombs” of rocks that can collapse to create sinkholes—underground caverns that can be unpredictable in their size, depth and timing. They can be difficult to detect—and sometimes they are caused by human activity, such as drilling. Drilling experts had not anticipated sinkhole activity at this location.

Crews spent days and weeks to ensure the sinkhole was safe. The custom-built crane was disassembled and removed from the scene, but a $250,000 custom drill bit was abandoned in place (it could not be safely removed). The sinkhole was stabilized with 200 cubic yards of concrete.

After a one-month delay, crews broke ground on a new well about 1,000 feet away.

No vibrated casings were used in the construction of the remainder of the project.
CONCLUSION

A Win-Win-Win Scenario

With the Polk Power Station Regional Reclaimed Water Partnership Initiative, Tampa Electric is on the leading edge of innovative water use.

Water will become more scarce – but the demand for power will continue to increase. That will make the need for recycling water more common across the industry. Tampa Electric has proven the innovative technology and learned key lessons about how the wastewater treatment and utility industries can work together. This success helps educate both industries on alternate disposal methods.

In fact, so other companies can benefit from its knowledge, Tampa Electric is sharing details of this project at leading industry conferences, including WEFTEC 2014 (Water Environment Federation’s Technical Exhibition and Conference) in New Orleans; WEFTEC 2015 in Chicago; Industrial and Commercial Water Reuse Conference in Austin, Texas; Florida Water Environment Association Reuse Seminar in Orlando, Fla.; and Water & Energy 2015 in Washington, D.C.

The project helped the cities and county, the water regulators and the utility to be better community partners. And most importantly, the Tampa Bay waterways will benefit from this project – for generations to come.

Don’t other power plants use reclaimed water?

Yes, reclaimed wastewater is a viable alternative source of water for power generation, and is used by a number of power plants in the United States for cooling or other purposes.

Polk Power Station’s use of reclaimed water for cooling is highly unusual, mostly because of the innovative engineering involved:

• Tampa Electric built an extensive pipeline to transport the reclaimed water to the plant’s site.
• When all phases are complete, it will use reclaimed water from three different municipal sources.
• It uses reverse osmosis (right) technology for its water treatment.
• It uses deep-well injection for disposal.
• It eliminates a surface-water discharge, which has tremendous environmental benefits.
• The utility could have pursued groundwater options, but voluntarily chose this alternate path.